APPENDIX C

Analysis of
Fatality and Injury Counts Data
for
Natural Gas Distribution Pipeline Systems
1990 – 2002

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PART 1

BASES FOR ANALYSES OF F&I COUNTS DATA

Introduction

This appendix presents the details of the data analyses described in Section 4 of the report body. The figures and tables in the preceding table of contents are the fatality and injury counts data sets that were analyzed in this study. These sets were selected from many possible ways that the incident database could be sorted, as shown in Appendix G. Representatives of the distribution pipeline operators and both state and federal regulatory agencies made the selection.

The basis of the analyses are discussed in this part of the appendix, followed by the figures and tables upon which the analyses were based, in Part 2 and Part 3 respectively.

The analyses address the fatality and injury counts by part of system, material of construction, and cause from January 1, 1990 through December 31, 2002.

Study Period

Data are available from 1970 through the present. In 1985, reporting requirements based on the value of property damage was changed from $5,000 to $50,000. Because of this, it was originally decided to analyze data only beginning in 1985. The cutoff year for the end point of the analysis was chosen as 2002 to ensure that all reports had been submitted and all adjustments had been made; in other words the data was reasonably final for the end period. Subsequently, at the request of the DIGIT group, the period for analysis was restricted to 1990 through 2002. This is the study period used in this report.

Data Normalization

The F&I counts data can be evaluated in terms of the absolute number of incident counts per year or the number of incident counts per mile or part count based on the total mileage or number of items in each part of the distribution infrastructure. The number of incident counts per year alone is not an appropriate unit of measure when the mileage changes over time. With no change in the number of counts, say per 100,00 miles of system, if only the number of counts per year was used as a performance indicator, the indicator would increase as the mileage increases, or decrease as the mileage decreased, even if there were no change in the fundamental count rate or frequency over time. Therefore, to compensate for this effect, the data in this report have been normalized to the appropriate number of miles associated with data set being analyzed for each year in the 1990 – 2002 period; i.e. total miles of distribution system for all incident counts regardless of part of system; miles of mains when addressing counts associated with mains; miles of a particular material of construction when addressing that material; etc. The mileage used for normalization was obtained from the DOT/OPS Annual Reports Data. The mileage associated with each data set is tabulated in Part 3 of this appendix. The year-by-year incident counts and computed normalized values, used in the time series graphs of counts over the study period, for

the various data sets, are also given in Part 3. Depending on the data set, data are normalized for each year in the study period using one of the following, appropriate mileage counts:

- Total distribution mileage for 1990 – 2002;
- Mains;
- Services;
- Steel mains;
- Polyethylene mains;
- Cast iron mains;
- Other materials mains;
- Steel services:
- Polyethylene services;
- Cast iron not applicable for services; and
- Other services.

Counts values are expressed on a per 100,000 mile basis. One hundred thousand miles of pipe was selected for normalizing the data because it conveniently yields whole numbers as opposed to fractional numbers for many of the data analyses in the study and makes data interpretation and comparisons easier to communicate. This was also applied to meter set assemblies because there are no data in the OPS databases for meter counts, and those counts are fairly consistently proportional to the counts of services connections, to which services miles are also proportional. Therefore, it made sense to normalize the meter set assembly data on the same basis as services, a basis of services miles.

The remainder of this appendix – Part 1 provides an overview of some key previous studies and the results of the current effort. The topics discussed below cover the major points of the study with details relegated to Part 2.

Data Analysis

The F&I counts data analysis was divided into several parts: total counts, counts by part of system, counts by material of construction, and counts by cause. Table 1 provides a summary of the F&I counts analysis matrix with the number of F&I counts shown for various cross-sections of the data.

Major parts of the system, based on definitions in the OPS database are:

- Mains;
- Service Lines;
- Meter Set Assemblies; and
- Other.

Table 1. F&I Counts Analysis Matrix

Analysis Description	No. of F&I				
Total Incidents (1985 - 2002)	2,467				
Total Incidents (1985 - 1989)	888				
Total incidents (1990 - 2002)	1,579				
Total Incidents with no F&Is (1990 - 2002)	978				
Total Incidents with F&Is (1990 - 2002)	601				
	Period 1990-2002 Only				
In the 601 Incidents — Fatalities	205				
Injuries	883				
F&Is	**1,088**				
F&Is on Mains	446				
F&Is on Service Lines	298				
F&Is on Meter Set Assembly	65				
F&Is on Other / No Data Pipe	279				
F&Is caused by corrosion	66				
F&Is caused by outside force	497				
3rd Party		379			
Earth Movement		84			
Frost					
Landslide / Washout					
Subsidence					
Other / No Data					
Other / No Data		34			
F&Is caused by construction/ operating error	93				
F&Is caused by accidentally caused by operator	85				
F&Is caused by other / no data	347				
F&Is on Mains	446				
Steel Pipe		161			
Corrosion			28		
Outside force			64		
3rd Party				56	
Earth Movement				5	
Other / No Data				3	

Table 1. (continued)

Analysis Description	No. of F&I				
Construction/ operating error			17		
Accidentally caused by operator			21		
Other / no data			31		
Cast Iron Pipe		130			
Corrosion			6		
Outside force			84		
3rd Party				25	
Earth Movement				57	
Frost					22
Landslide / Washout					0
Subsidence					12
Other / No Data					23
Other / No Data				2	
Construction/ operating error			1		
Accidentally caused by operator			8		
Other / no data			31		
Polyethylene Plastic Pipe		130			
Corrosion			0		
Outside force			63		
3rd Party				55	
Earth Movement				2	
Other / No Data				6	
Construction/ operating error			37		
Accidentally caused by operator			16		
Other / no data			14		
Other Plastic Pipe		2			
Corrosion			0		
Outside force			1		
3rd Party				1	
Earth Movement				0	
Other / No Data				0	
Construction/ operating error			0		
Accidentally caused by operator			0		
Other / no data			1		

Table 1. (continued)

Analysis Description	No. of F&I				
Other / No Data Pipe		23			
Corrosion			2		
Outside force			2		
3rd Party				2	
Earth Movement				0	
Other / No Data				0	
Construction/ operating error			12		
Accidentally caused by operator			5		
Other / no data			2		
F&Is on Service Lines	298				
Steel Pipe		144			
Corrosion			14		
Outside force			93		
3rd Party				85	
Earth Movement				4	
Other / No Data				4	
Construction/ operating error			5		
Accidentally caused by operator			17		
Other / no data			15		
Cast Iron Pipe		0			
Corrosion			0		
Outside force			0		
3rd Party				0	
Earth Movement				0	
Other / No Data				0	
Construction/ operating error			0		
Accidentally caused by operator			0		
Other / no data			0		
Polyethylene Plastic Pipe		109			
Corrosion			0		
Outside force			83		
3rd Party				76	
Earth Movement				1	
Other / No Data				6	

Table 1. (continued)

Analysis Description	No. of F&I				
Construction/ operating error			3		
Accidentally caused by operator			2		
Other / no data			21		
Other Plastic Pipe		7			
Corrosion			0		
Outside force			5		
3rd Party				1	
Earth Movement				3	
Other / No Data				1	
Construction/ operating error			0		
Accidentally caused by operator			2		
Other / no data					
Other / No Data Pipe		38			
Corrosion			13		
Outside force			16		
3rd Party				14	
Earth Movement				1	
Other / No Data				1	
Construction/ operating error			0		
Accidentally caused by operator			4		
Other / no data			5		
F&Is on Meter Set Assemblies	65				
Steel Pipe		40			
Cast Iron Pipe		0			
Polyethylene Plastic Pipe		4			
Other Plastic Pipe		2			
Other / No Data Pipe		19			
F&Is on Other / No Data Pipe	279				
Steel Pipe		30			
Cast Iron Pipe		4			
Polyethylene Plastic Pipe		6			
Other Plastic Pipe		0			
Other / No Data Pipe		239			

Table 1. (continued)

Analysis Description	No. of F&I				
Incidents Caused By Corrosion	66				
Main		36			
Steel Pipe			28		
Cast Iron Pipe			6		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			2		
Service Lines		27			
Steel Pipe			14		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			13		
Meter Set Assembly		0			
Steel Pipe			0		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			0		
Other / No Data		3			
Steel Pipe			2		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			1		
Incidents caused By Outside Force	497				
3rd Party		379			
Main			139		
Steel Pipe				56	
Cast Iron Pipe				25	
Polyethylene Plastic Pipe				55	
Other Plastic Pipe				1	
Other / No Data Pipe				2	
Service Lines			176		
Steel Pipe				85	

Table 1. (continued)

Analysis Description	No. of F&I			
Cast Iron Pipe				0
Polyethylene Plastic Pipe				76
Other Plastic Pipe				1
Other / No Data Pipe				14
Meter Set Assembly			37	
Steel Pipe				27
Cast Iron Pipe				0
Polyethylene Plastic Pipe				4
Other Plastic Pipe				0
Other / No Data Pipe				6
Other / No Data			27	
Steel Pipe				15
Cast Iron Pipe				1
Polyethylene Plastic Pipe				0
Other Plastic Pipe				0
Other / No Data Pipe				11
Earth Movement		84		
Main			64	
Steel Pipe				5
Cast Iron Pipe				57
Polyethylene Plastic Pipe				2
Other Plastic Pipe				0
Other / No Data Pipe				0
Service Lines			9	
Steel Pipe				4
Cast Iron Pipe				0
Polyethylene Plastic Pipe				1
Other Plastic Pipe				3
Other / No Data Pipe				1
Meter Set Assembly			3	
Steel Pipe				3
Cast Iron Pipe				0
Polyethylene Plastic Pipe				0
Other Plastic Pipe				0
Other / No Data Pipe				0

Table 1. (continued)

Analysis Description	No. of F&I				
Other / No Data			8		
Steel Pipe				1	
Cast Iron Pipe				1	
Polyethylene Plastic Pipe				0	
Other Plastic Pipe				0	
Other / No Data Pipe				6	
Other / No Data		34			
Main			11		
Steel Pipe				3	
Cast Iron Pipe				2	
Polyethylene Plastic Pipe				6	
Other Plastic Pipe				0	
Other / No Data Pipe				0	
Service Lines			11		
Steel Pipe				4	
Cast Iron Pipe				0	
Polyethylene Plastic Pipe				6	
Other Plastic Pipe				0	
Other / No Data Pipe				1	
Meter Set Assembly			9		
Steel Pipe				4	
Cast Iron Pipe				0	
Polyethylene Plastic Pipe				0	
Other Plastic Pipe				0	
Other / No Data Pipe				5	
Other / No Data			3		
Steel Pipe				0	
Cast Iron Pipe				0	
Polyethylene Plastic Pipe				0	
Other Plastic Pipe				0	
Other / No Data Pipe				3	
Incidents Caused By Construction / Operating Error	93				
Main		67			
Steel Pipe			17		
Cast Iron Pipe			1		

Table 1. (continued)

Analysis Description	No. of F&I		
Polyethylene Plastic Pipe			37
Other Plastic Pipe			0
Other / No Data Pipe			12
Service Lines		8	
Steel Pipe			5
Cast Iron Pipe			0
Polyethylene Plastic Pipe			3
Other Plastic Pipe			0
Other / No Data Pipe			0
Meter Set Assembly		4	
Steel Pipe			2
Cast Iron Pipe			0
Polyethylene Plastic Pipe			0
Other Plastic Pipe			0
Other / No Data Pipe			2
Other / No Data		14	
Steel Pipe			4
Cast Iron Pipe			0
Polyethylene Plastic Pipe			3
Other Plastic Pipe			0
Other / No Data Pipe			7
Incidents Caused By Accidentally Caused By Operator	85		
Main		50	
Steel Pipe			21
Cast Iron Pipe			8
Polyethylene Plastic Pipe			16
Other Plastic Pipe			0
Other / No Data Pipe			5
Service Lines		25	
Steel Pipe			17
Cast Iron Pipe			0
Polyethylene Plastic Pipe			2
Other Plastic Pipe			2
Other / No Data Pipe			4
Meter Set Assembly		2	

Table 1. (continued)

Analysis Description	No. of F&I				
Steel Pipe			1		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			1		
Other / No Data		8			
Steel Pipe			1		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			1		
Other Plastic Pipe			0		
Other / No Data Pipe			6		
Incidents Caused By Accidentally Other / No Data	347				
Main		79			
Steel Pipe			31		
Cast Iron Pipe			31		
Polyethylene Plastic Pipe			14		
Other Plastic Pipe			1		
Other / No Data Pipe			2		
Service Lines		42			
Steel Pipe			15		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			21		
Other Plastic Pipe			1		
Other / No Data Pipe			5		
Meter Set Assembly		10			
Steel Pipe			5		
Cast Iron Pipe			0		
Polyethylene Plastic Pipe			0		
Other Plastic Pipe			0		
Other / No Data Pipe			5		
Other / No Data		216			
Steel Pipe			7		
Cast Iron Pipe			2		
Polyethylene Plastic Pipe			2		
Other Plastic Pipe			2		
Other / No Data Pipe			203		

Major materials of construction, primarily associated with the pipe, valves, and pipe components are:

- Steel;
- Polyethylene Plastic; and
- Cast Iron.

The highest level of incident cause categories is:

- Corrosion;
- Outside forces;
- Construction operating error;
- Accidentally caused by operator; and
- Other and no data.

The analyses were taken to a given level of detail by the scope definition for this particular study agreed upon between representatives of industry, NAPSR and OPS. More analyses are possible but are beyond the scope of the present study. The analyses were selected based on interest in specific issues and were intended to answer a first round of questions about performance of gas distribution systems examined from several perspectives. The OPS F&I data were examined by sorting the data based on the above parts of system, materials of construction, and causes of incidents in a number of different combinations to reveal performance with regard to the specific parameters over the study period.

The data analyses graphs in Part 2 are presented as figures with accompanying tables in three types of displays:

- Bar charts;
- Line graphs; and
- Long term trend graphs.

The bar charts show a profile or distribution of incidents by various categories into which the data were sorted. In many cases, these data represent a subset of the total 1,088 F&I counts for distribution systems. Most figures express the incident counts as a percentage of the incidents within the subcategory or sorting group rather than as a percentage of all 1,088 F&I counts. Note that some figures will also report zero incidents for a given cause, part of system or material of construction category. This is a valid result and simply reflects the relatively small number of incidents analyzed within some of the subcategory data sorts.

In addition, the category "other" is often shown on many of the figures for cause, part of system, or material of construction. This is a category specified as part of the DOT/OPS incident database and in the case of "other" causes, no additional information is available to discern the particular cause of the incident. "No data" is another category often shown on the Part 2 analysis figures and simply reflects those incidents for which the DOT/OPS incident database has a null entry (i.e., nothing provided by operator) or the "no data" category was selected by the operator in their incident report.

The line graphs show the fluctuations in counts from year to year. Trend graphs show whether there is a generally upward or downward trend, when supported by a formal statistical test. If a trend could not be proven to a confidence level of at least 90%, then no trend graph was plotted. The variability from year to year makes it difficult to clearly discern whether or not there is an overall trend in incident rates. A visual suggestion of a trend from a graph is not always supported by a formal statistical test. This is important for two reasons. A clear determination of a real trend for the degree of variability in incident rates from year to year means that a few years of data are inadequate to tell anything definitive about whether performance is improving or getting worse. Additional discussion of statistical analysis techniques is found in Appendix D.

The types of graphs of data by year are referred to as time series. It is in the nature of time series that to determine a trend, one fits a mathematical function that smoothes the short-term variations. This is typically done with a regression analysis by one or more mathematical functions. The function chosen depends on the nature of the phenomenon being observed. A function is chosen and fit to the data such that a general trend direction can be observed. This is not the same as curve fitting the data to replicate the exact pattern of the data. All that accomplishes is to develop an empirical equation that cannot be extrapolated beyond the range represented by the data. Rather, a trending function provides some sense of direction and can be extended to a limited extend beyond the range of the data.

In the figures that follow in Part 2, data are plotted in line graphs that show the data points and fluctuations form year to year over the study period. Trending functions were fitted to every graph. However, a trending function is not shown for every graph. They are only shown for graphs that passed a specific statistical test. That test was the Mann-Kendall (MK) test for determining if an upward or downward trend was like to exist at two specified levels of confidence: 90% and 95%. Only if a trend line passed this test was it plotted in a companion figure to the line graph. If it did not meet the test criterion, no trend plot was made.

Table 2 summarizes the results of the MK test for all figures included in this analysis. Analyses showing a statistically significant trend at 90% and/or 95% confidence are highlighted.

Table 2. Summary of Results from Mann-Kendall Test for F&I Counts Analysis

Report Figure No.	Type	Number of Samples	p-value for Mann-Kendall Test	Conclusion of Mann-Kendall Test (90% confidence)	Conclusion of Mann-Kendall Test (95% confidence)
B30	F&I Counts	13	0.150		
B31	F&I Counts-Main	13	0.025	Downward	Downward
B31	F&I Counts-Meter	13	0.100		
B31	F&I Counts-Other	13	0.427		
B31	F&I Counts-Service	13	0.476		
B32	Mains F&I Counts-Cast Iron	13	0.214		
B32	Mains F&I Counts-Poly Plastic	13	0.016	Downward	Downward
B32	Mains F&I Counts-Steel	13	0.100		
B36	Service Lines F&I Counts-Poly Plastic	13	0.050	Downward	Downward
B36	Service Lines F&I Counts-Steel	13	0.291		
B41	F&I Counts-Accident	13	0.357		
B41	F&I Counts-Construct/Oper Error	13	0.009	Downward	Downward
B41	F&I Counts-Corrosion	13	0.476		
B41	F&I Counts-Outside Force	13	0.050	Downward	Downward
B42	Corrosion F&I Counts-Main	13	0.078	Downward	
B42	Corrosion F&I Counts-Service	13	0.285		
B45	Outside Force F&I Counts-Main	13	0.080	Downward	
B45	Outside Force F&I Counts-Service	13	0.080	Downward	
B46	Mains Outside Force F&I Counts-Cast Iron	13	0.251		
B46	Mains Outside Force F&I Counts-Poly Plastic	13	0.064	Downward	
B46	Mains Outside Force F&I Counts-Steel	13	0.312		
B47	Main, 3rd Party F&I Counts-Cast Iron	13	0.349		
B47	Main, 3rd Party F&I Counts-Poly Plastic	13	0.357		
B47	Main, 3rd Party F&I Counts-Steel	13	0.476		
B48	Mains Earth Movement F&I Counts-Cast Iron	13	0.357		
B49	Service Lines Outside Force F&I Counts-Poly Plastic	13	0.016	Downward	Downward
B49	Service Lines Outside Force F&I Counts-Steel	13	0.196		
B50	Service 3rd Party F&I Counts-Poly Plastic	13	0.016	Downward	Downward
B50	Service 3rd Party F&I Counts-Steel	13	0.312		

A similar analysis was conducted for fatality and injury incidents, the details of which are presented in Appendix B.

Trends that were determined by the test are discussed along with each of the ensuing figures within Part 2. Data sets for which trending was indeterminate at a 90% to 95% confidence level, arranged by part of system, and also shown in the ensuing figures in Part 2 are:

<u>All parts of distribution infrastructure</u>

- F&I incident counts on whole distribution system;
- "Other" part of system category (other than: main, service line, and meter set assembly);
- Accident on whole distribution system;
- Corrosion on whole distribution system.

<u>Mains</u>

- Cast iron mains;
- Steel mains;
- Outside force, earth movement on cast iron mains;
- Outside forces on steel mains;
- Outside forces on cast iron mains;
- Third party damage on cast iron mains;
- Third party damage on steel mains;
- Third party damage on polyethylene mains.

<u>Services</u>

- Service lines, all parts of service line subsystem;
- Service lines, steel systems;
- Outside forces on steel service lines;
- Third party damage on steel service lines;
- Corrosion on service lines.

<u>Meter Set Assemblies</u>

- Meter set assemblies, all parts of meter set assembly subsystem.

When a trend is reported as indeterminate, it simply means that an upward or downward trend could not be verified at either the 90% or 95% level of confidence.

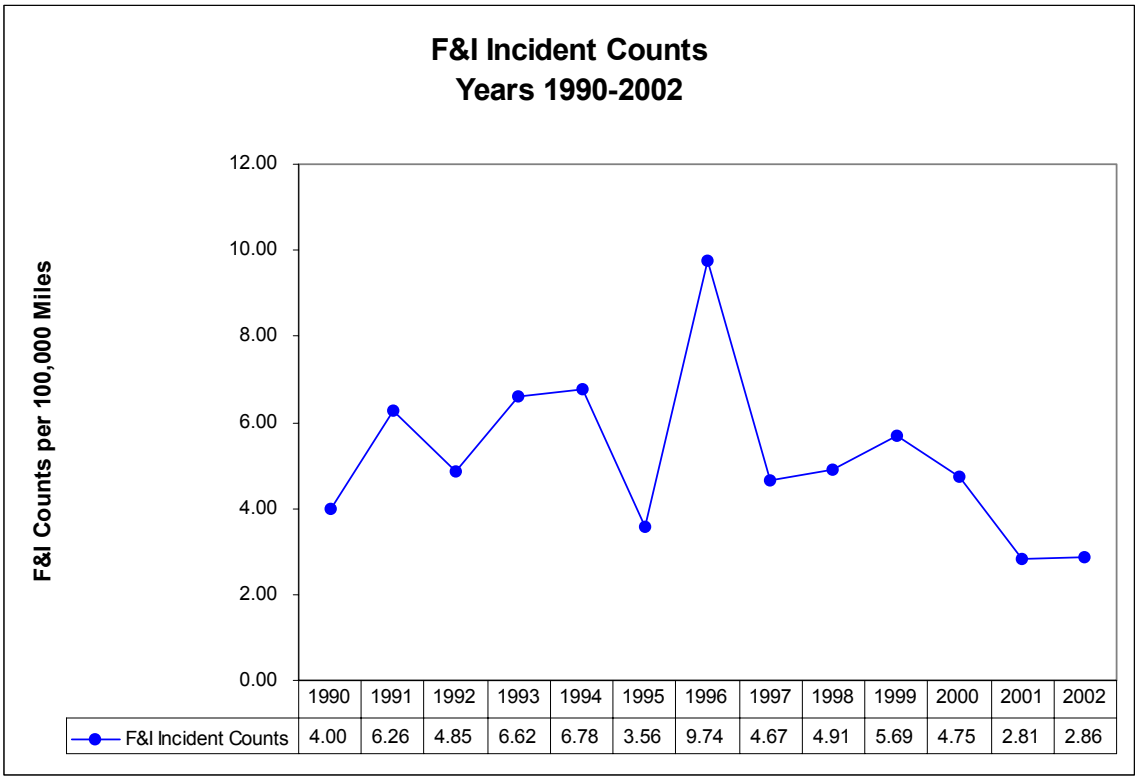
PART 2

F&I COUNT FIGURES AND ANALYSIS

Fatality and Injury Counts

Figure C30 is a plot of F&I counts per 100,000 miles of total distribution piping mileage (mains and service lines) from 1990 through 2002. This time series shows that the year-to-year variation in normalized incidents can be quite large, varying from a high in 1996 of 9.7 to a low of 2.8 in 2001 and 2002.

However, a trend analysis using the MK statistical test at 90% and 95% confidence yielded an indeterminate result. That means that no trend could be shown at those confidence levels.



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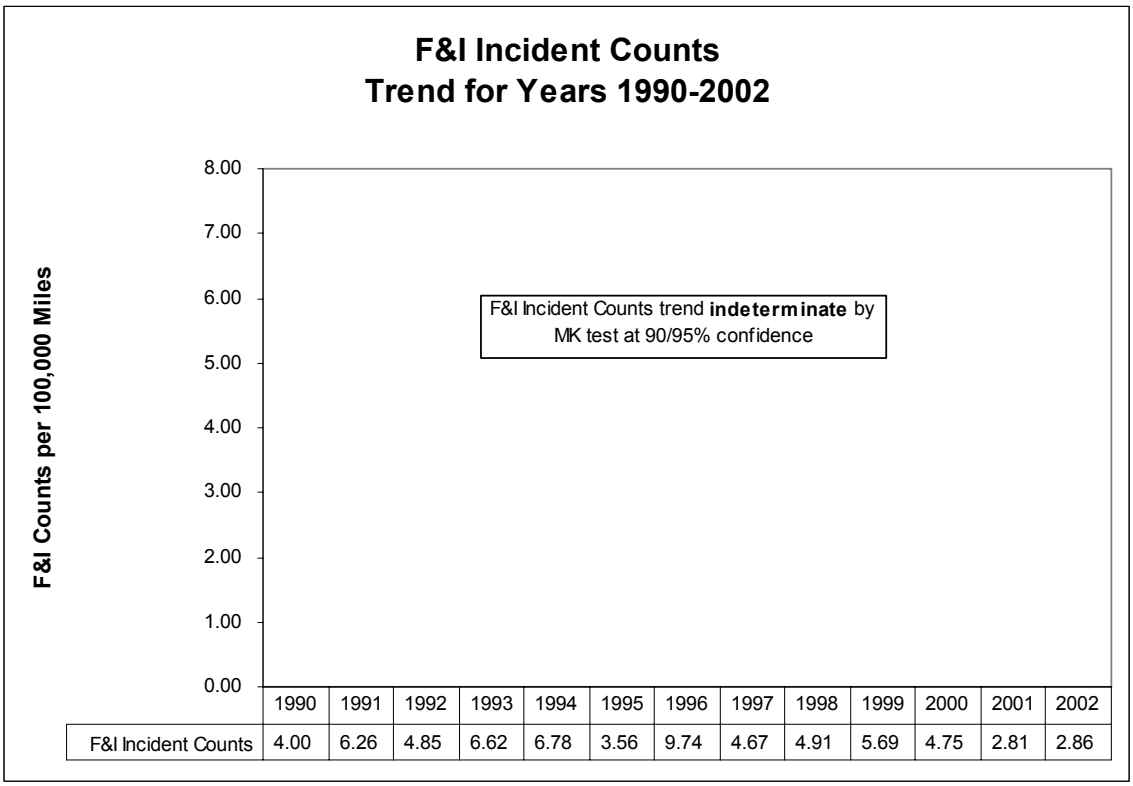


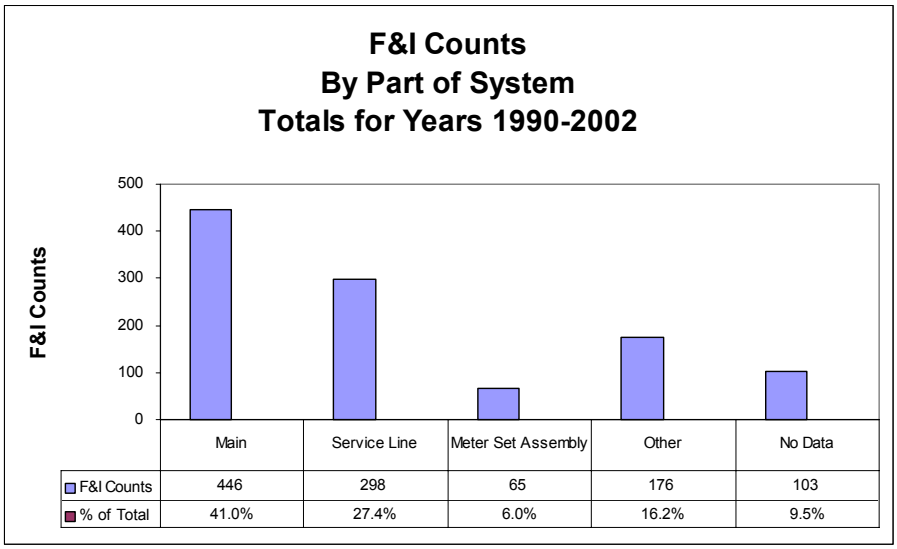
(b)

Figure C30. F&I Counts

Figure C31 shows the F&I counts by part of system from 1990 through 2002. Mains and services account for most of the incidents with 41.0% and 27.4% respectively. The next largest category is other, followed by no data and meter set assemblies.

A time series of these data for each part of the system based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C31(b).

A trend plot is shown in Figure C31(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for all parts except Mains. No trend can be shown for service lines, meter set assemblies, and other. The MK test yields a downward trend for mains at both the 90% and 95% confidence levels with approximately a 54% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.



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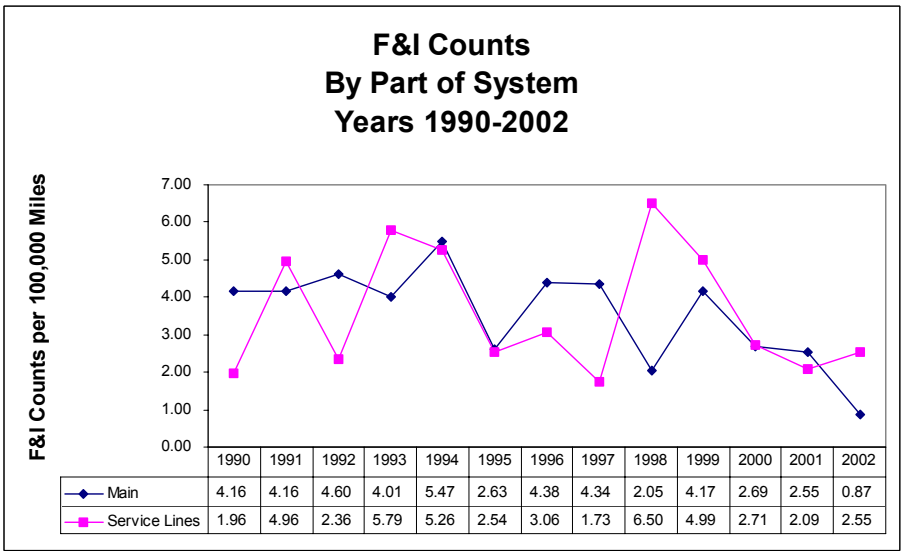

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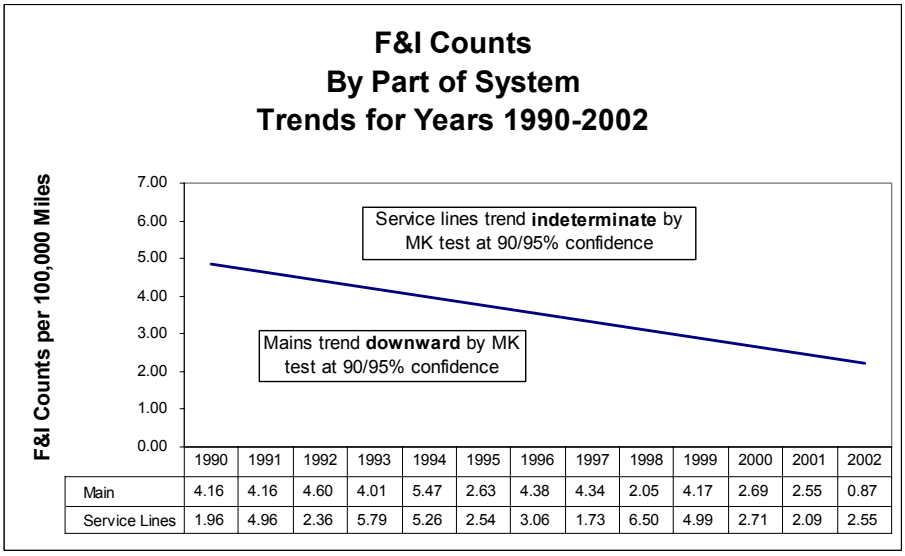


(c)

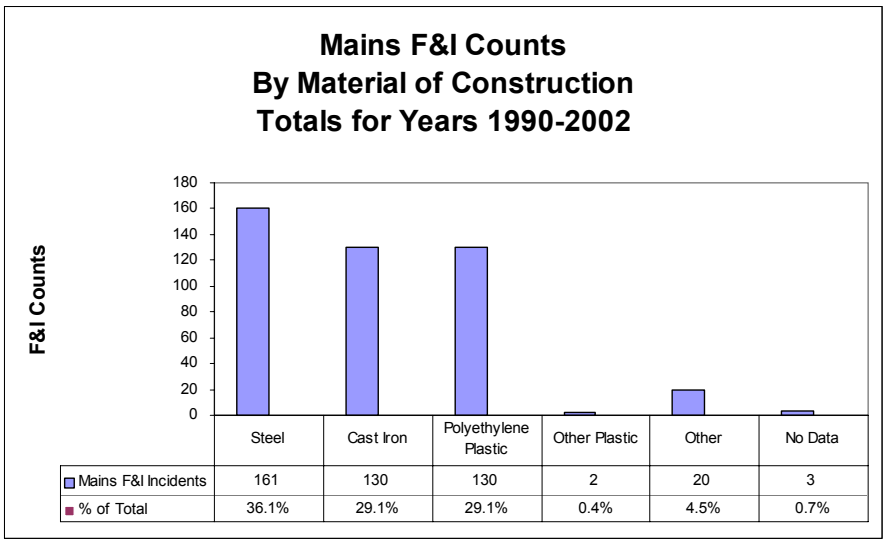
Figure C31. F&I Counts by Part of System

Fatality and Injury Counts by Material of Construction

Figure C32 displays the F&I counts for mains by material of construction from 1990 through 2002. Steel, cast iron, and polyethylene plastic account for most of the incidents with 36.1%, 29.1%, and 29.1% respectively. The next largest category is other, followed by no data and other plastic.

A time series of these data for each material of construction based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C32(b). This time series shows great variation in cast iron from year to year while the steel and polyethylene counts remain more consistent.

A trend plot is shown in Figure C32(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for steel and cast iron. No trend can be shown for these materials. The MK test does show a downward trend for polyethylene plastic at both the 90% and 95% confidence levels with approximately a 71% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.



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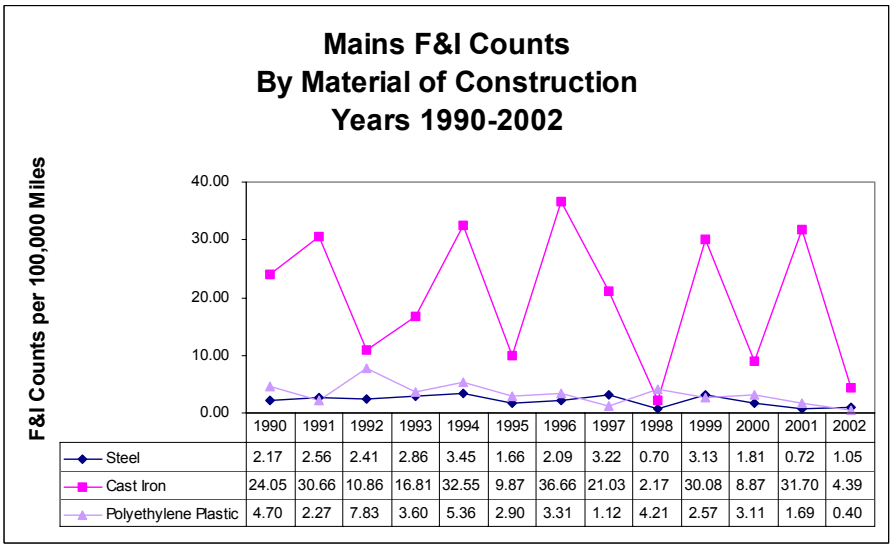
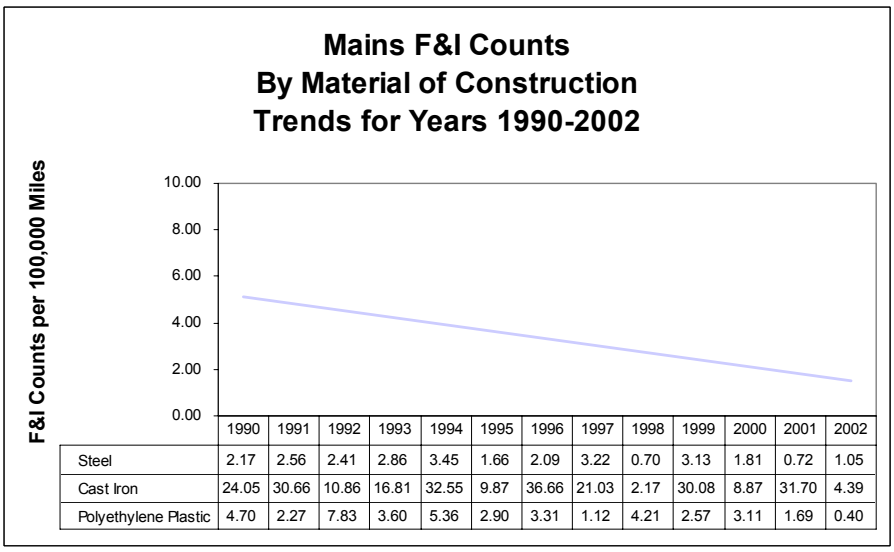


(b)



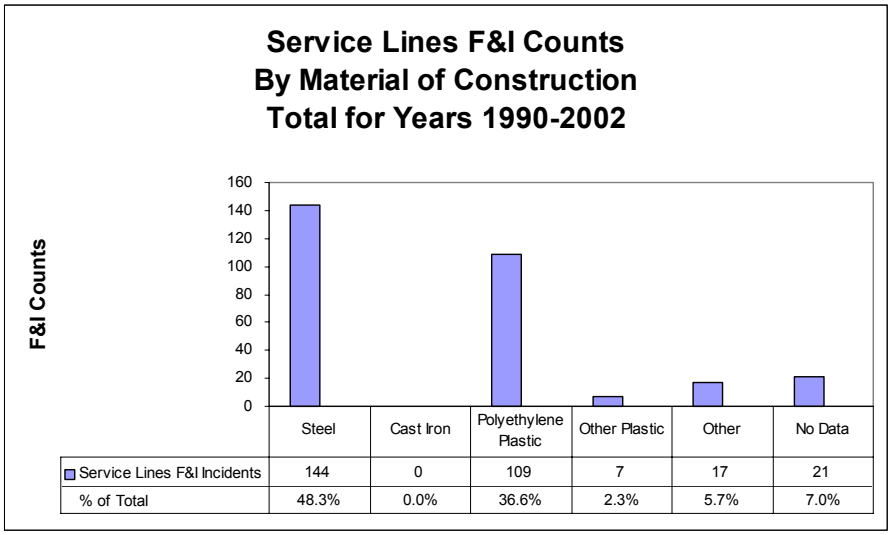
(c)

Figure C32. Mains F&I Counts by Material of Construction

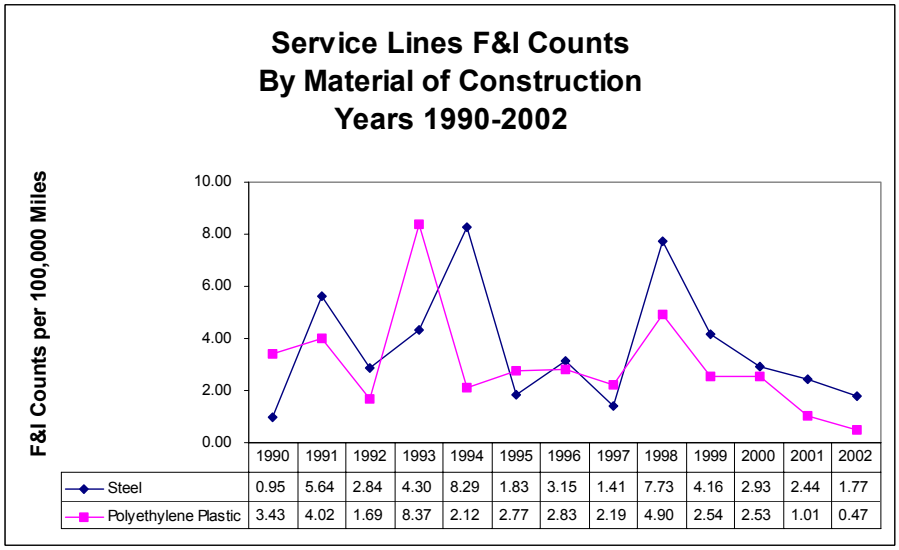
Figure C36 displays the F&I counts for service lines by material of construction from 1990 through 2002. Steel and polyethylene plastic account for most of the incidents with 48.3% and 36.6% respectively. There were no fatalities and injuries associated with cast iron service lines and only minimal contributions from other plastic, other, and no data.

A time series of these data for each material of construction based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C36(b). This time series shows steel and polyethylene.

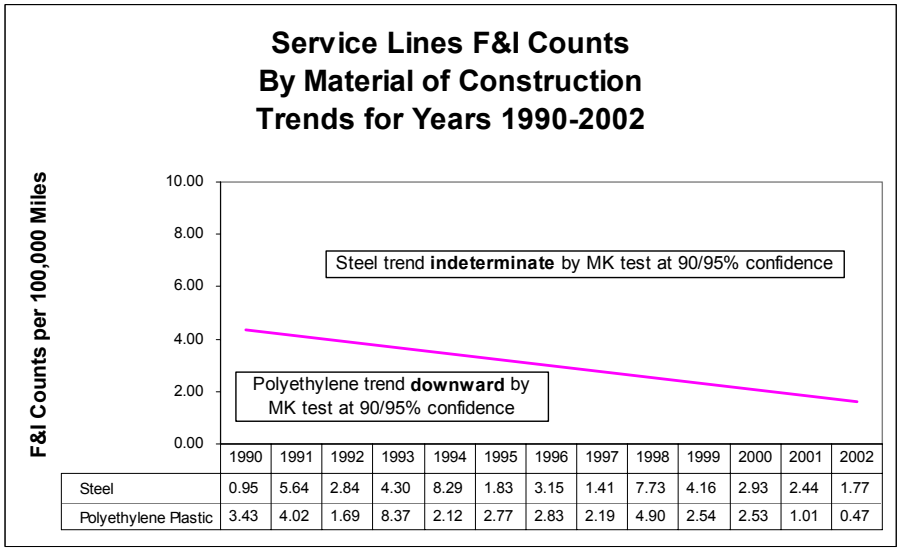
A trend plot is shown in Figure C36(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for steel. No trend can be shown. The MK test does show a downward trend for polyethylene plastic at both the 90% and 95% confidence levels with approximately a 63% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.



(a)



(b)



(c)

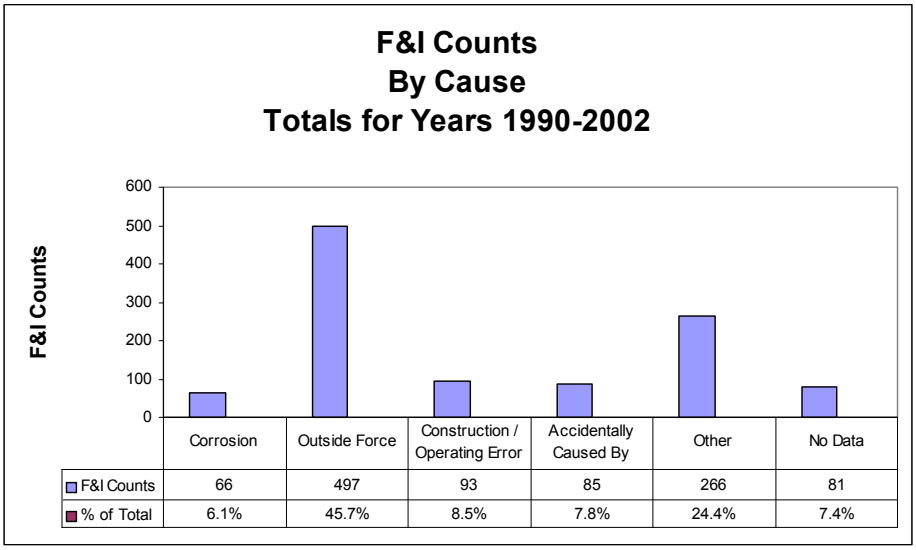
Figure C36. Services F&I Counts by Material of Construction

Fatality and Injury Counts by Cause

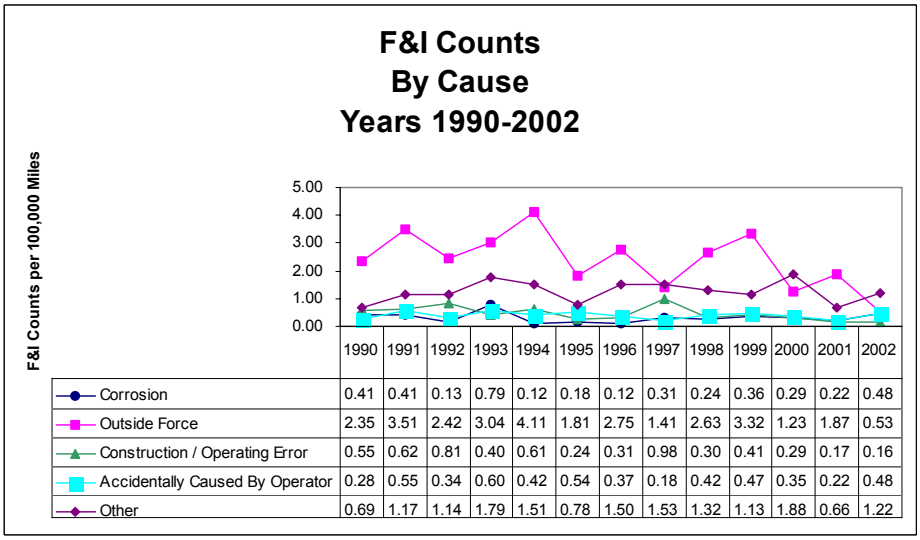
Figure C41 displays all the F&I counts by cause from 1990 through 2002. Outside force and other account for most of the incidents with 45.7% and 24.4% respectively. Corrosion, construction/operating error, accidentally caused by operator, and no data each contribute less than 10% to the total number of fatalities and injuries over the time period studied.

A time series of these data for each material of construction based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C41(b).

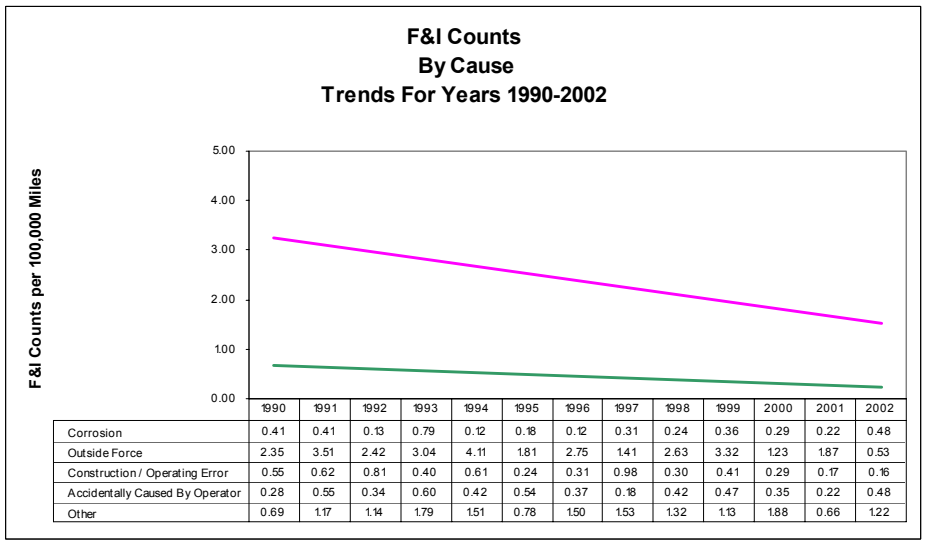
A trend plot is shown in Figure C41(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for corrosion and accidentally caused by operator. No trend can be shown for these two causes. The MK test does show a downward trend for outside force and construction/operating error at both the 90% and 95% confidence levels. Fatalities and injuries caused by outside force decreased by approximately 54% during the 1990 to 2002 time period based on beginning and end points of the trend line, and those caused by construction/operating error declined by approximately 65%. No statistical analysis was conducted on other and no data.



(a)



(b)



(c)

Figure C41. F&I Counts by Cause

Figure C33 shows the F&I counts for steel mains by cause from 1990 through 2002. Outside force represents the largest number of fatalities and injuries with 39.8%. Corrosion, construction/operating error, accidentally caused by operator, and other share the remainder of the events more evenly (each between 10% and 20%).

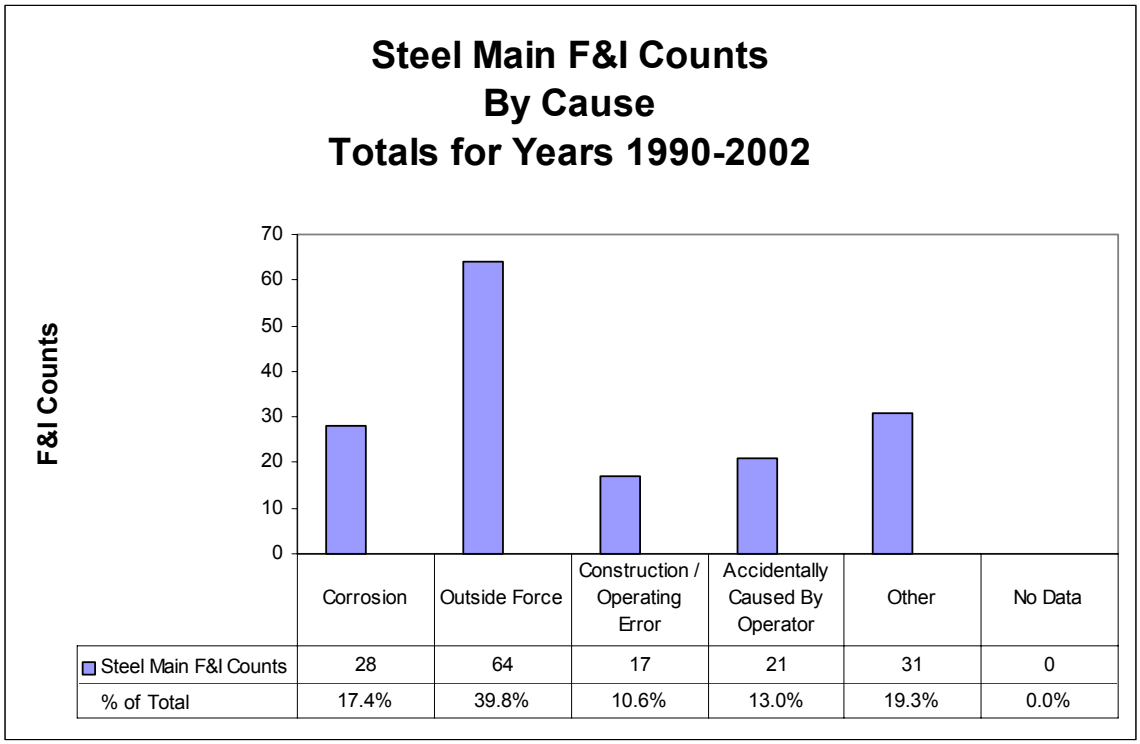


Figure C33. Steel Main F&I Counts by Cause

Figure C34 is a bar graph of the F&I counts for cast iron mains by cause from 1990 through 2002. Outside force again contains the largest number of fatalities and injuries with 64.6%. Other has the next greatest percentage at 23.8%. Corrosion, construction/operating error, and incidents accidentally caused by operator each contribute minimally to the total number of cast iron mains fatalities and injuries.

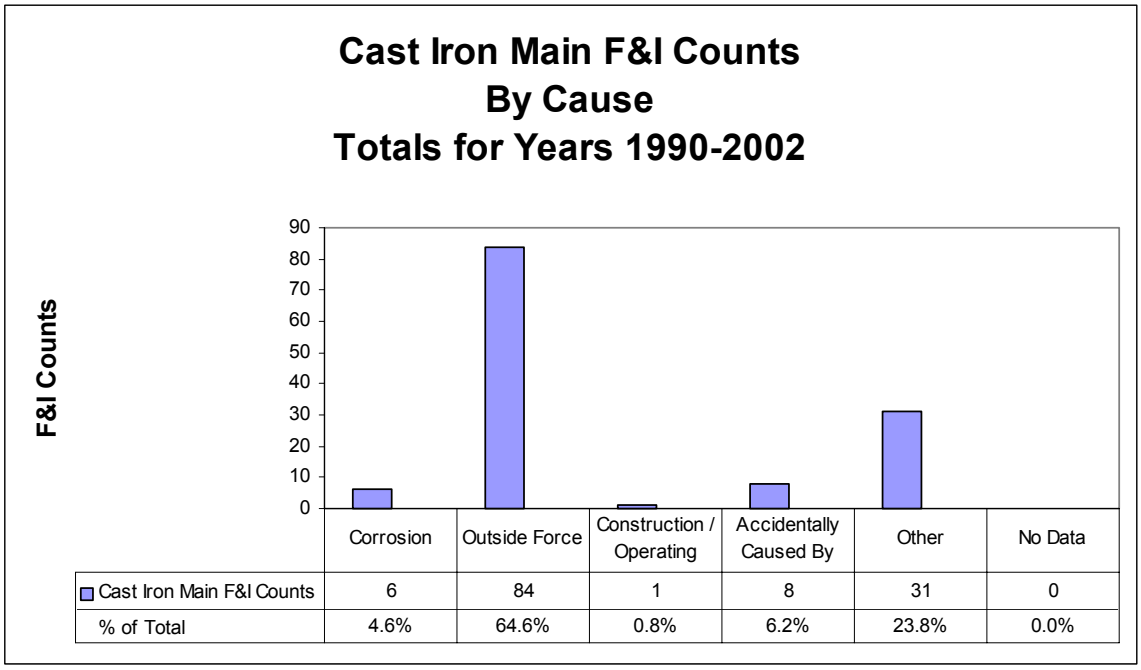


Figure C34. Cast Iron Main F&I Counts by Cause

Figure C35 shows the F&I counts for polyethylene mains by cause from 1990 through 2002. Outside force accounts for the largest number of fatalities and injuries with 48.5%, followed by construction/operating error with 28.5% and accidentally caused by operator with 12.3%. Other and no data each contribute minimally to the total number of polyethylene mains fatalities and injuries.

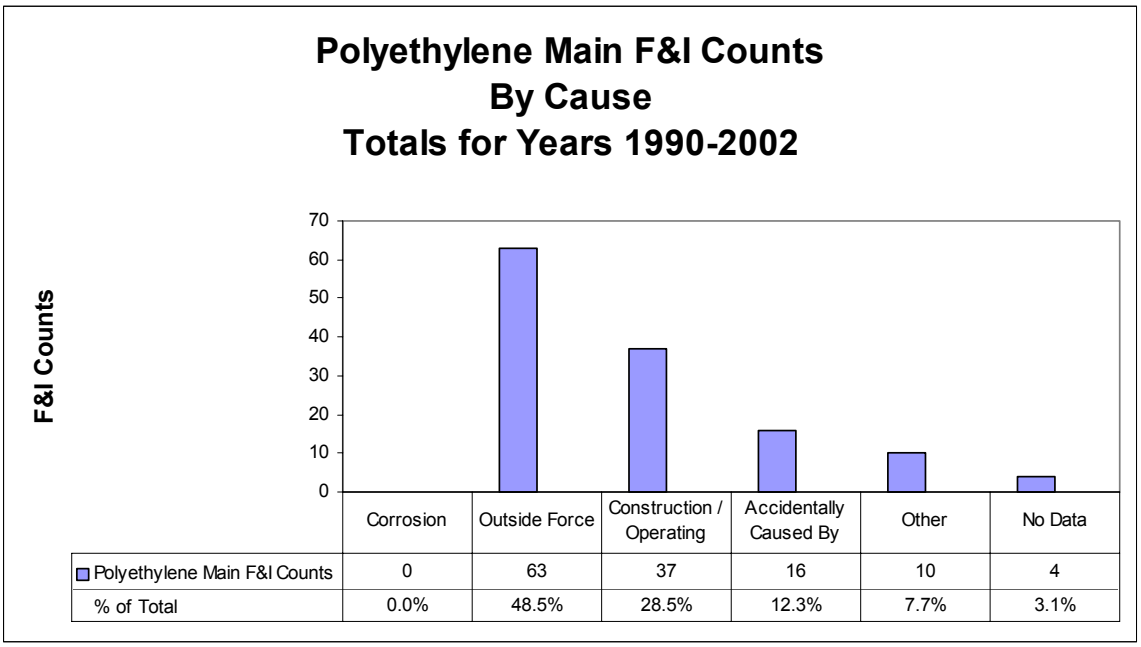


Figure C35. Polyethylene Main F&I Counts by Cause

Figure C37 shows the F&I counts for steel service lines by cause from 1990 through 2002. Outside force accounts for the largest number of fatalities and injuries with 64.6%. Corrosion, construction/operating error, accidentally caused by operator, and other each contribute in a smaller proportion to the total number of steel service line fatalities and injuries.

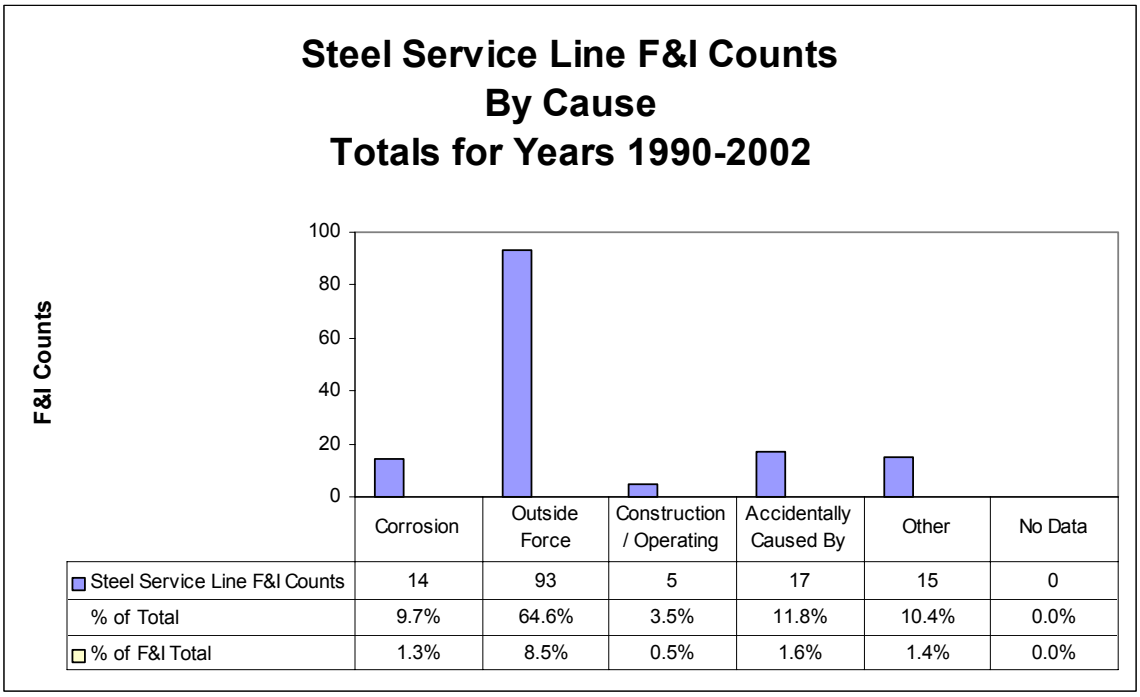


Figure C37. Steel Service Line F&I Counts by Cause

Figure C38 shows the F&I counts for polyethylene service lines by cause from 1990 through 2002. Outside force dominates the number of fatalities and injuries with 76.1%, distantly followed by other with 19.3%. Construction/operating error and accidentally caused by operator contribute minimally to the total number of polyethylene service line fatalities and injuries.

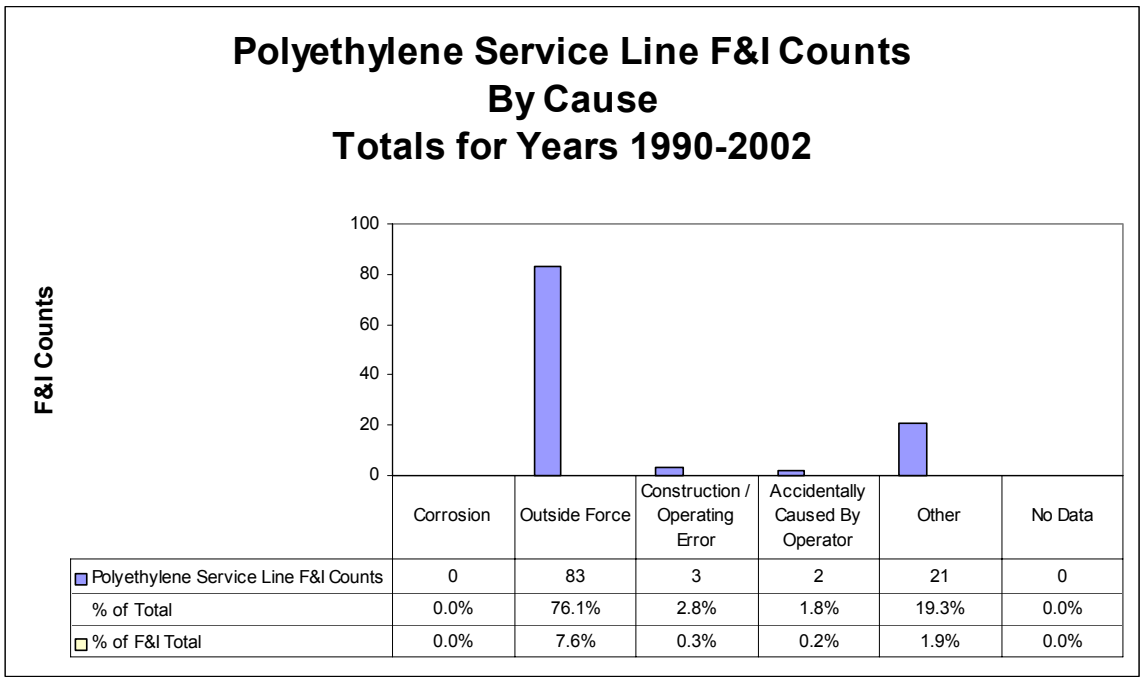
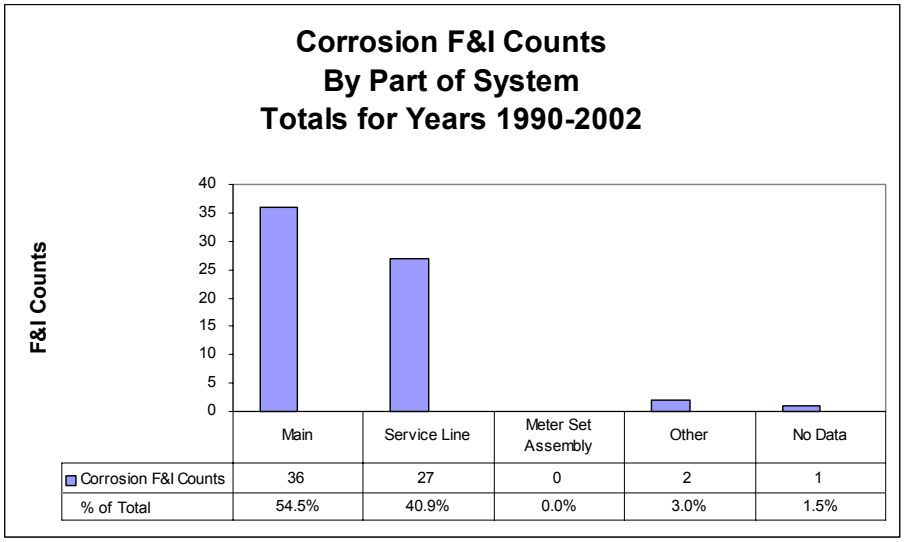


Figure C38. Polyethylene Service Line F&I Counts by Cause

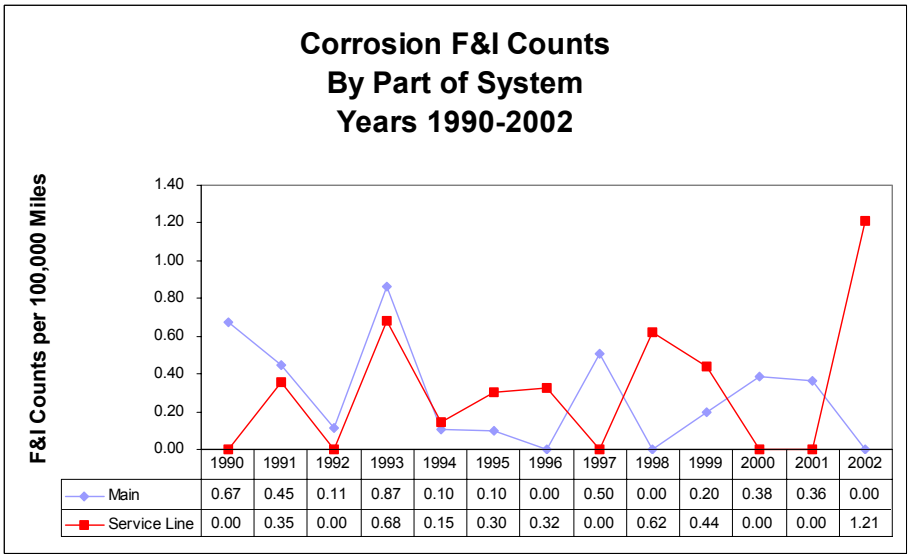
Figure C42 displays the corrosion F&I counts by part of system from 1990 through 2002. Mains and service lines account for almost all of the incidents with 54.5% and 40.9% respectively. There were only minimal contributions from other and no data, and there were no fatalities and injuries associated with corrosion of meter set assemblies over the time period studied.

A time series of these data for mains and service lines based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C42 (b).

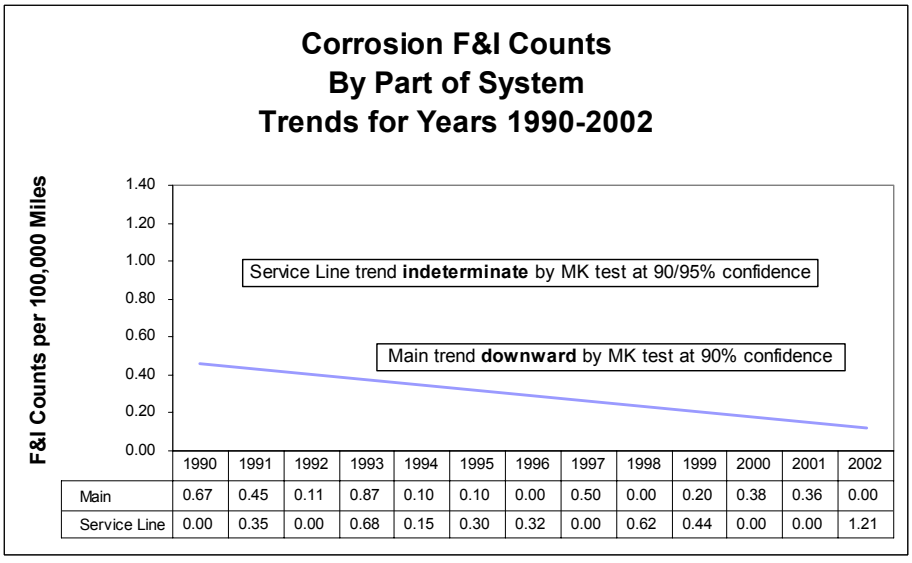
A trend plot is shown in Figure C42(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for service line, so no trend can be shown. The MK test does give a downward trend for mains at only the 90% confidence level with approximately a 75% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.



(a)



(b)



(c)

Figure C42. Corrosion F&I Counts by Part of System

Figure C43 shows the mains corrosion F&I counts by material of construction from 1990 through 2002. Steel dominates with the largest share of fatalities and injuries at 77.8%. Cast iron and no data each contribute in a smaller proportion to the total number of fatalities and injuries. There were no fatalities and injuries associated with polyethylene plastic, other plastic, or other materials.

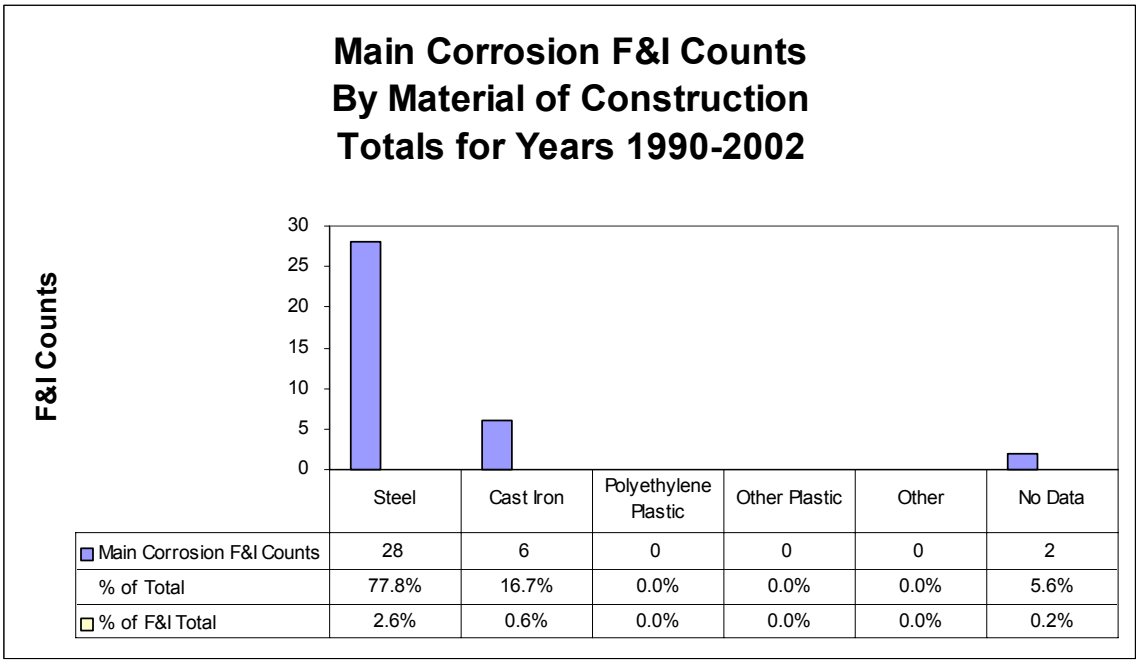


Figure C43. Mains Corrosion F&I Counts by Material of Construction

Figure C44 shows the service line corrosion F&I counts by material of construction for the period of 1990 through 2002. Steel and no data dominate the number of fatalities and injuries with 51.9% and 33.3%, respectively. Other contributes to the total number of fatalities and injuries with 14.8% while cast iron, polyethylene plastic, and other plastic are associated with no F&I incidents at all.

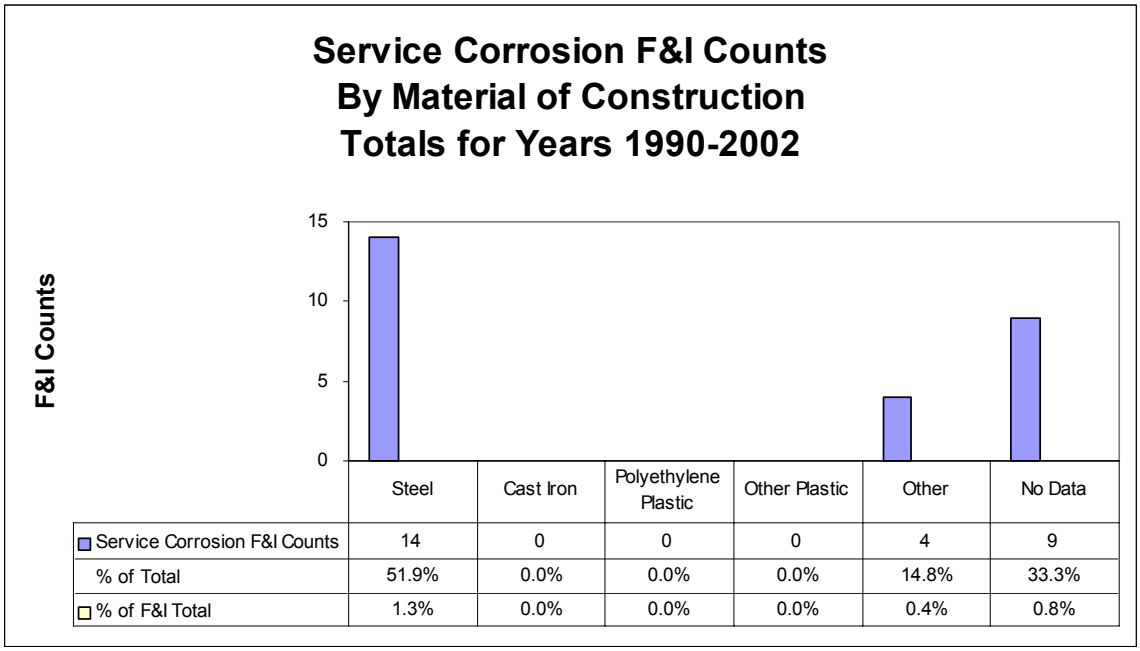
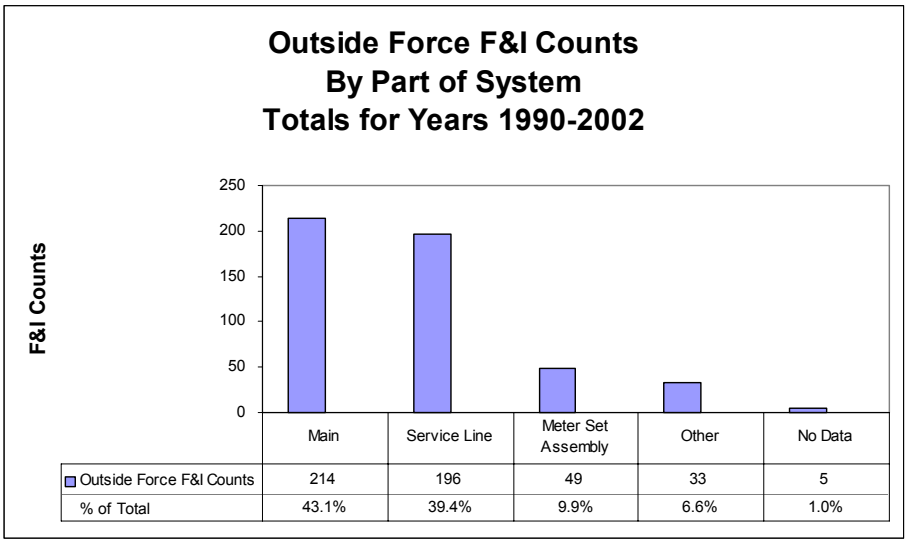


Figure C44. Service Line Corrosion F&I Counts by Material of Construction

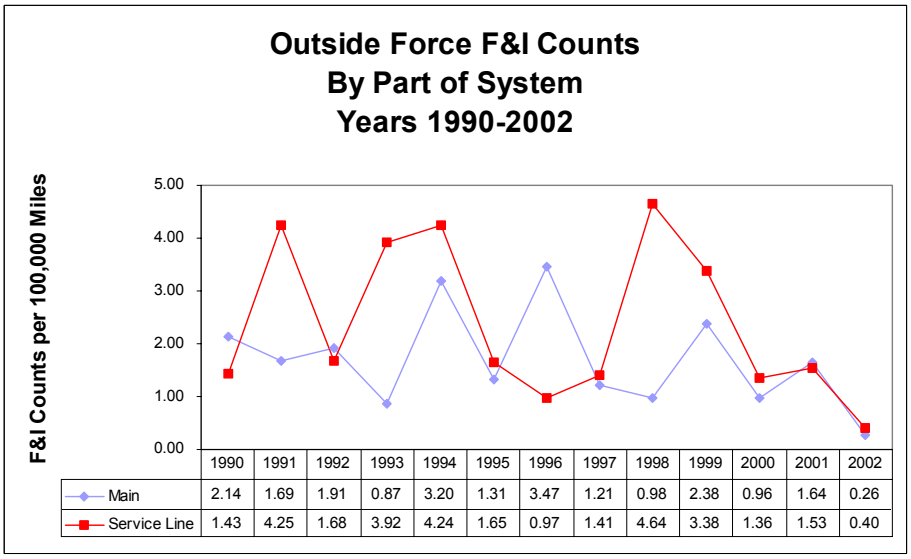
Figure C45 shows the outside force F&I counts by part of system from 1990 through 2002. Mains and service lines compose most of the incidents with 43.1% and 39.4% respectively. Meter set assemblies, other, and no data each contribute less than 10% to the total number of fatalities and injuries over the time period studied.

A time series of these data for mains and service lines based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C45(b).

A trend plot is shown in Figure C45(c). The MK test, at 90% and 95% confidence limits, yields a downward trend for mains and service lines at only the 90% confidence level. Fatalities and injuries caused by outside force on mains decreased by approximately 47% during the 1990 to 2002 time period based on beginning and end points of the trend line, and those caused by outside force on service lines declined by approximately 46%. No statistical analysis was conducted any other part of the distribution system.



(a)



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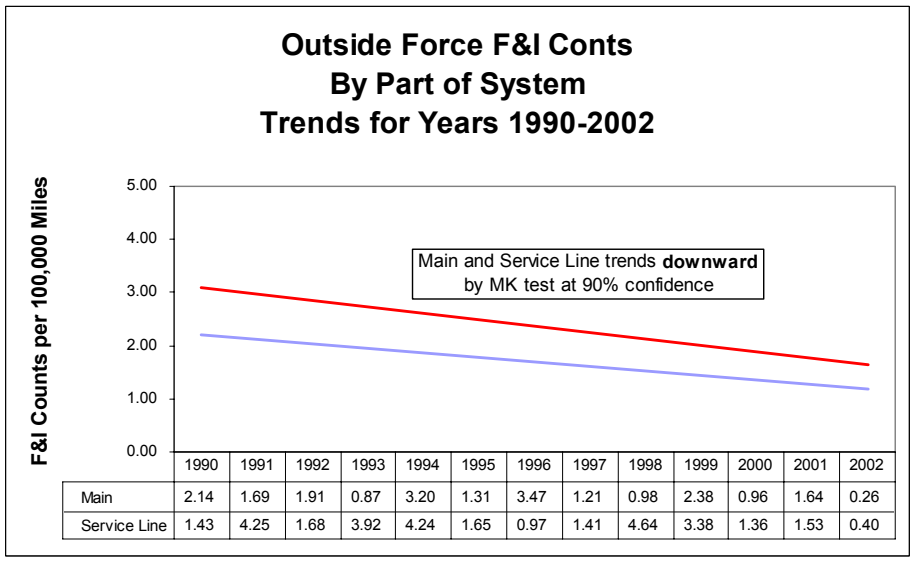


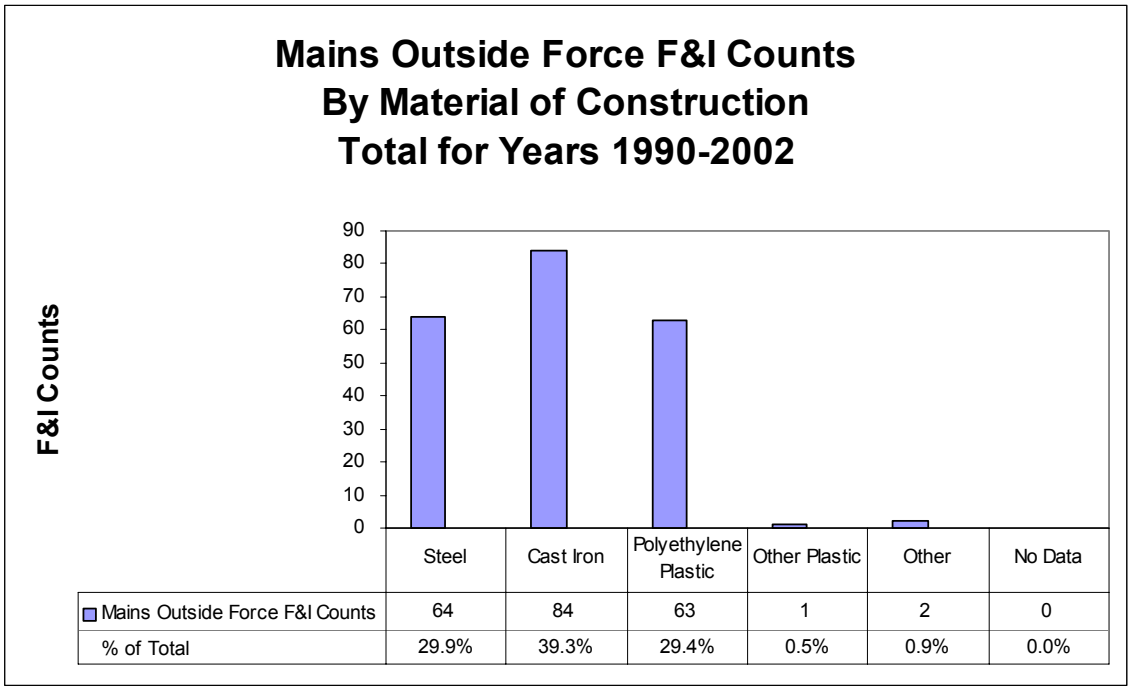
(c)

Figure C45. Outside Force F&I Counts by Part of System

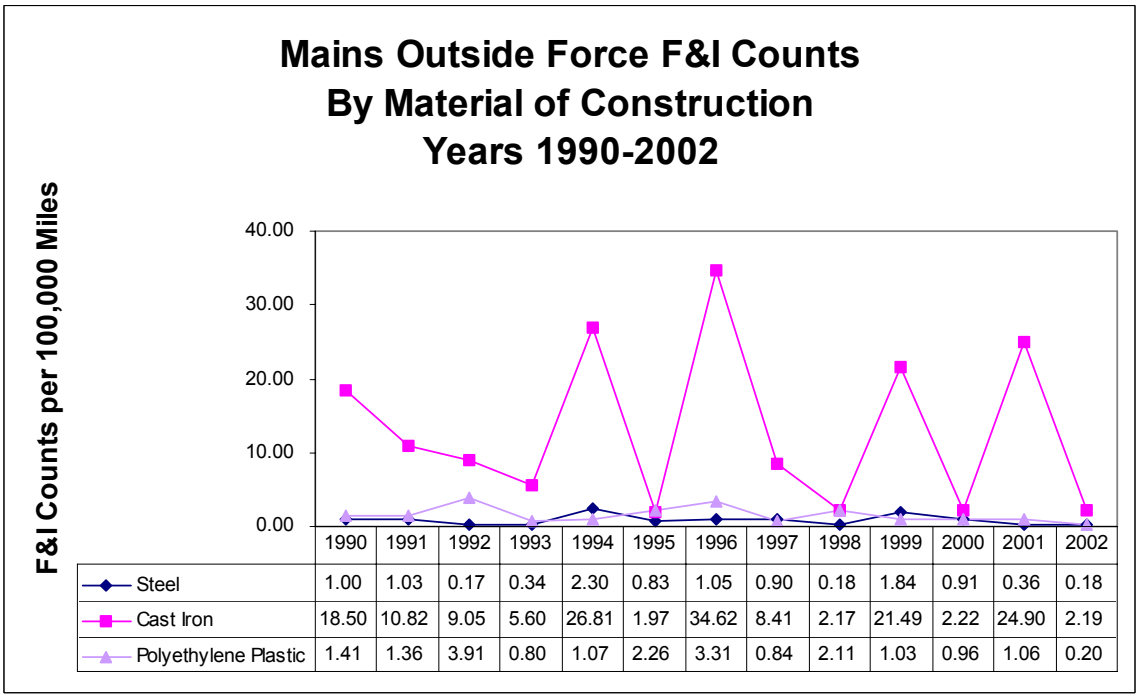
Figure C46 displays the mains outside force F&I counts by material of construction from 1990 through 2002. Steel, cast iron, and polyethylene plastic account for almost all of the incidents with 29.9%, 39.3%, and 29.4% respectively. There were only minimal contributions from other plastic and other, and there were no fatalities and injuries associated with mains outside force incidents for which there were no data.

A time series of these data for steel, cast iron, and polyethylene based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C46(b).

A trend plot is shown in Figure C46(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for steel and cast iron, so no trends can be shown. The MK test does give a downward trend for polyethylene plastic at only the 90% confidence level with approximately a 58% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.

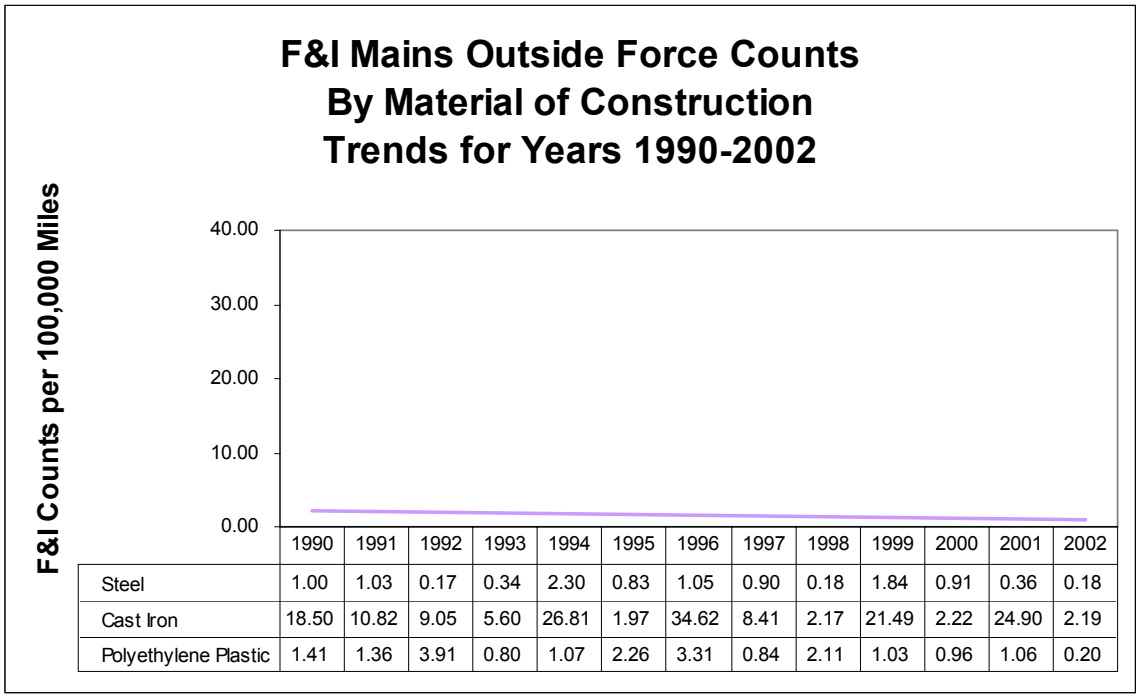


(a)



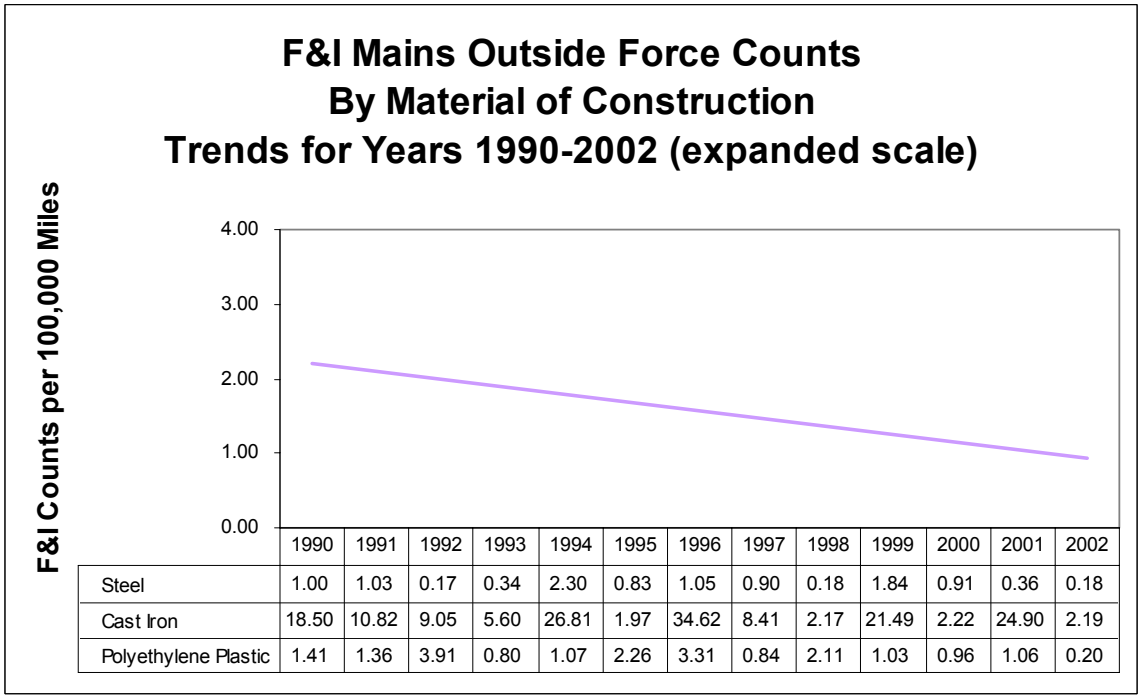
(b)

Figure C46(a) and (b). Mains Outside Force F&I Counts by Material of Construction



(c)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Steel	1.00	1.03	0.17	0.34	2.30	0.83	1.05	0.90	0.18	1.84	0.91	0.36	0.18
Cast Iron	18.50	10.82	9.05	5.60	26.81	1.97	34.62	8.41	2.17	21.49	2.22	24.90	2.19
Polyethylene Plastic	1.41	1.36	3.91	0.80	1.07	2.26	3.31	0.84	2.11	1.03	0.96	1.06	0.20



(d)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Steel	1.00	1.03	0.17	0.34	2.30	0.83	1.05	0.90	0.18	1.84	0.91	0.36	0.18
Cast Iron	18.50	10.82	9.05	5.60	26.81	1.97	34.62	8.41	2.17	21.49	2.22	24.90	2.19
Polyethylene Plastic	1.41	1.36	3.91	0.80	1.07	2.26	3.31	0.84	2.11	1.03	0.96	1.06	0.20

Figure C46(c) and (d). Mains Outside Force F&I Counts by Material of Construction

Figure C49 displays the outside force F&I counts for service lines by material of construction from 1990 through 2002. Steel and polyethylene plastic account for most of the incidents with 47.4% and 42.3% respectively. Other plastic, other, and no data contribute minimally to the total outside force fatalities and injuries involving service lines.

A time series of these data for steel and polyethylene based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C49(b).

A trend plot is shown in Figure C49(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for steel. No trend can be shown. The MK test does show a downward trend for polyethylene plastic at both the 90% and 95% confidence levels with approximately a 66% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.

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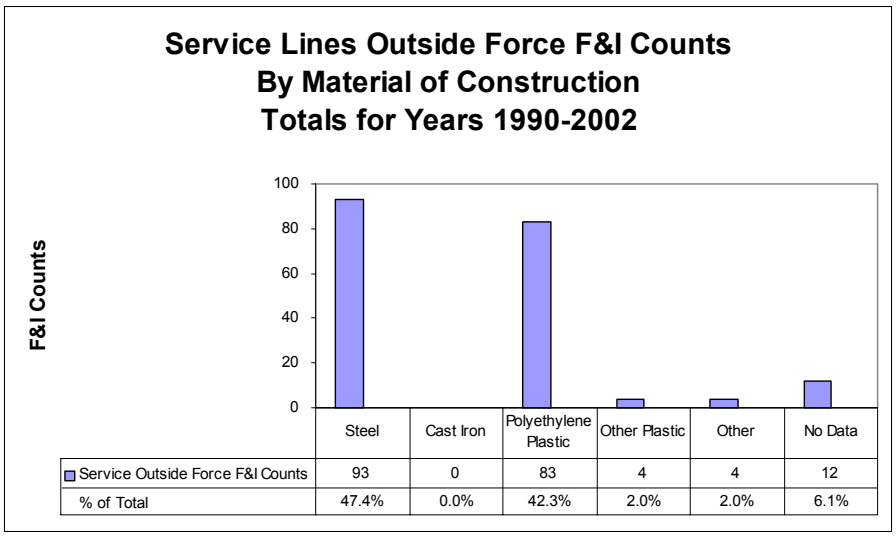
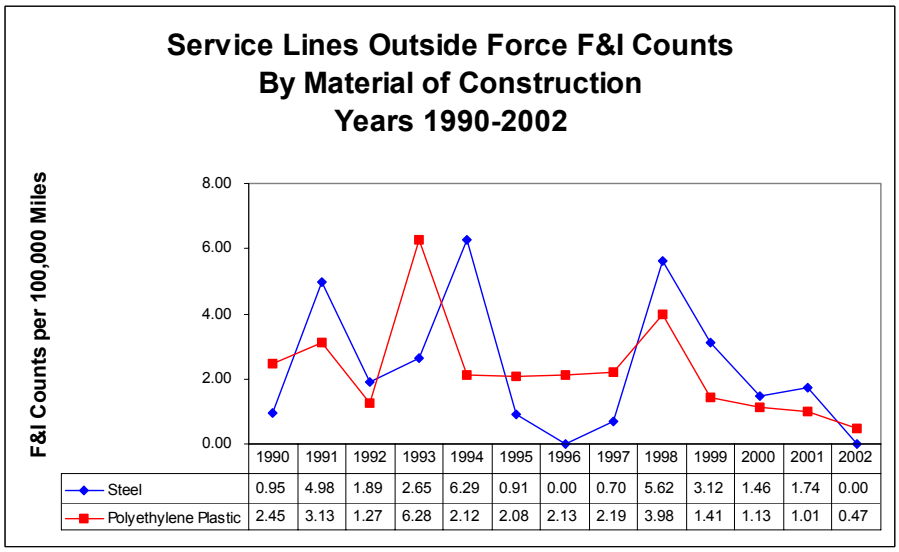
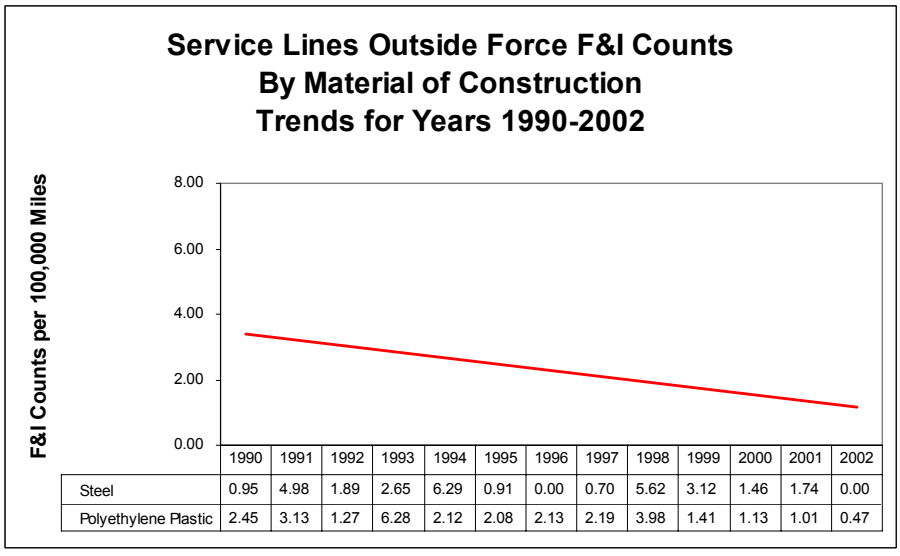


(a)



(b)



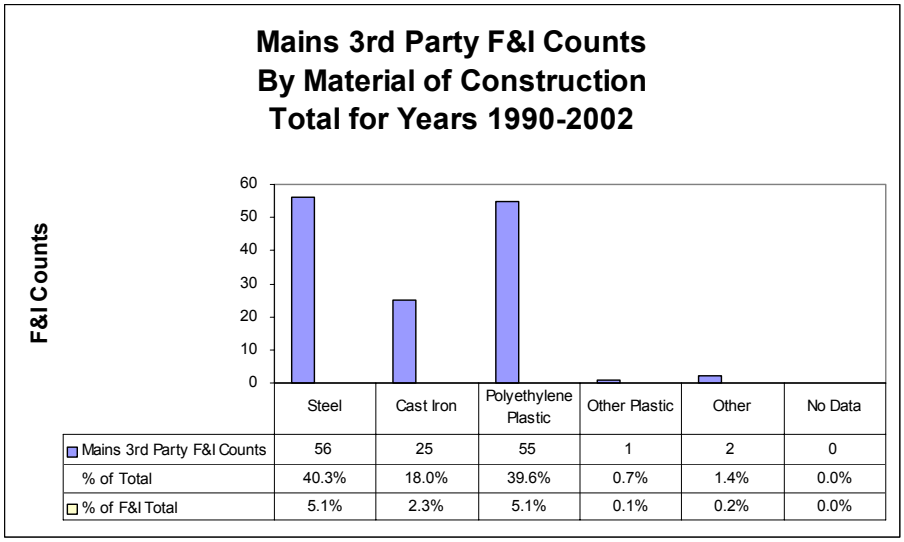
(c)

Figure C49. Service Lines Outside Force F&I Counts by Material of Construction

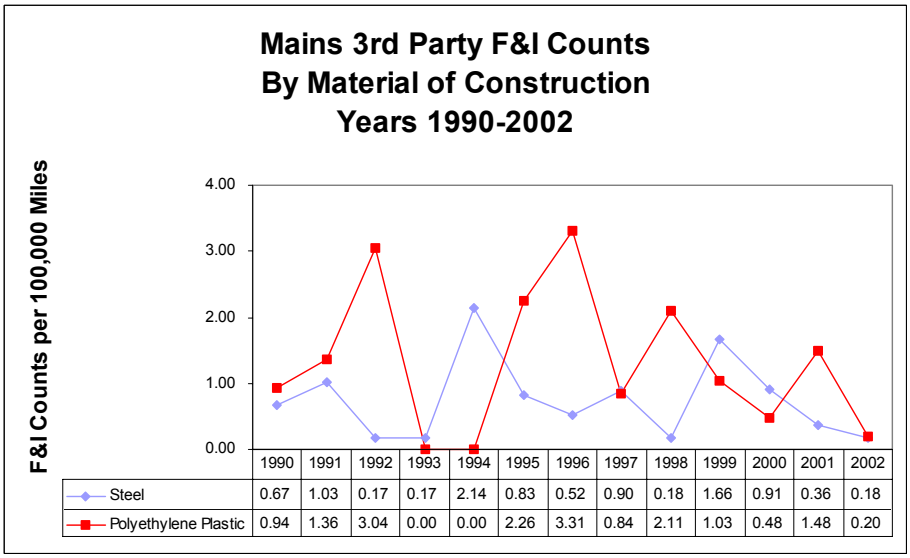
Figure C47 displays the mains third party F&I counts by material of construction from 1990 through 2002. Steel, cast iron, and polyethylene plastic account for most of the incidents with 40.3%, 18.0%, and 39.6% respectively. The categories of other plastic and other have a minimal contribution to the total number of mains third party fatalities and injuries over the time period of this study.

A time series of these data for only steel and polyethylene plastic based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C47(b). This time series shows great variation in both materials from year to year. Cast iron is not included on this plot since the scale for cast iron was much greater than that for the other two materials.

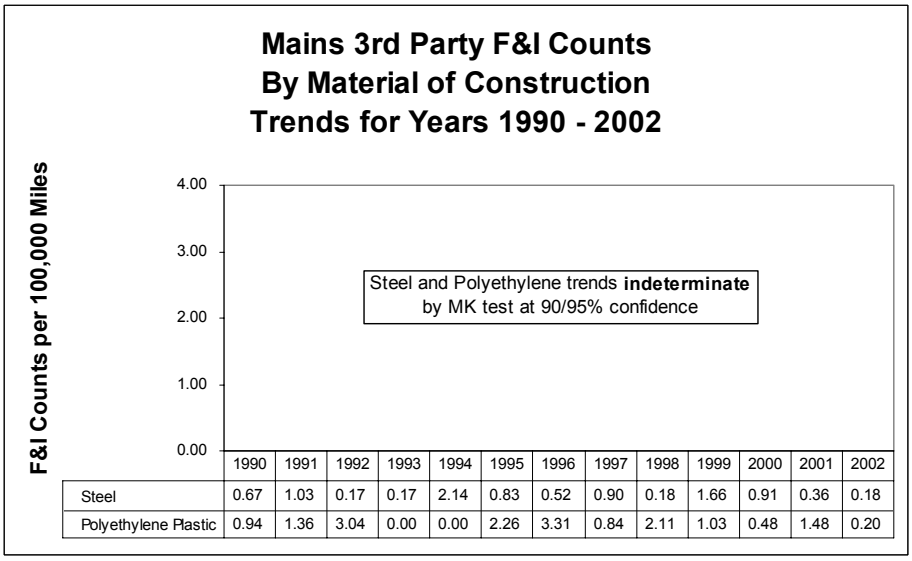
A trend plot is shown in Figure C47(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for both steel and polyethylene. Cast iron was also tested and found to be indeterminate. No trend can be shown for these materials.



(a)



(b)



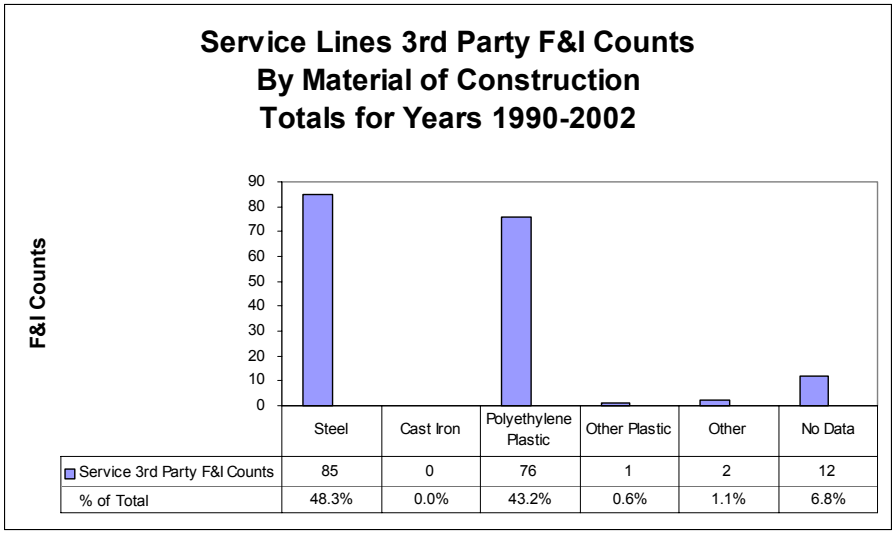
(c)

Figure C47. Mains Third Party F&I Counts by Material of Construction

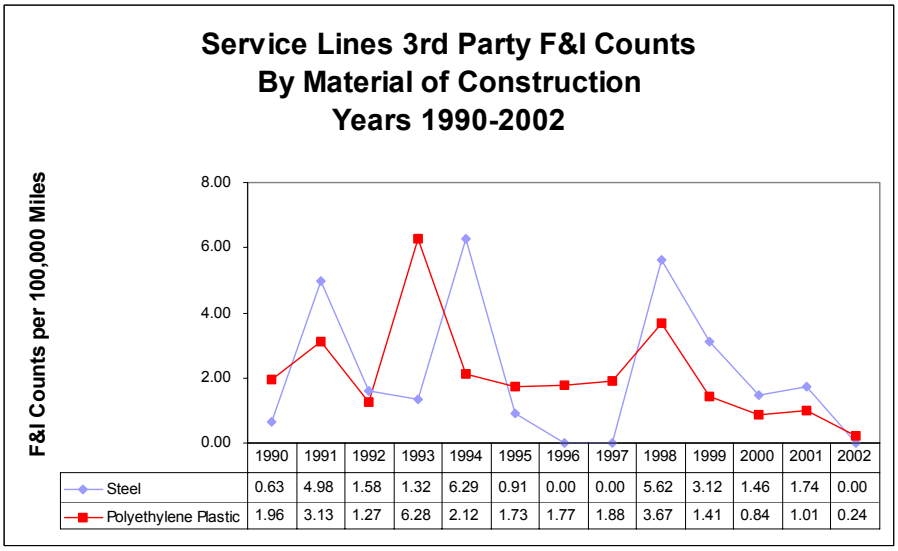
Figure C50 displays the third party F&I counts for service lines by material of construction from 1990 through 2002. Steel and polyethylene plastic comprise most of the incidents with 48.3% and 43.2% respectively. The next largest category is no data, followed by other plastic and other. Cast iron does not have any fatalities and injuries associated with third party service line incidents.

A time series of these data for steel and polyethylene based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C50(b).

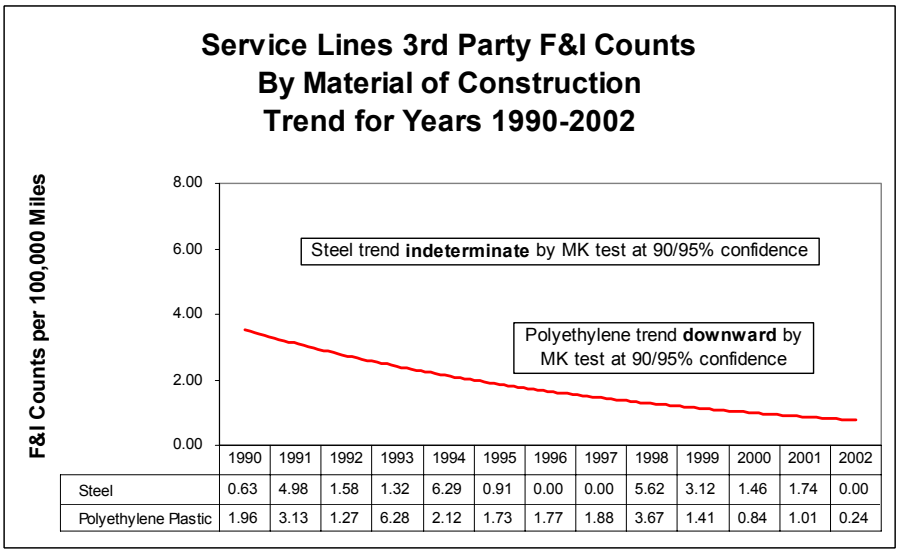
A trend plot is shown in Figure C50(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for steel. No trend can be shown. The MK test does show a downward trend for polyethylene plastic at both the 90% and 95% confidence levels with approximately a 78% decrease in fatalities and injuries during the 1990 to 2002 time period based on beginning and end points of the trend line.



(a)



(b)



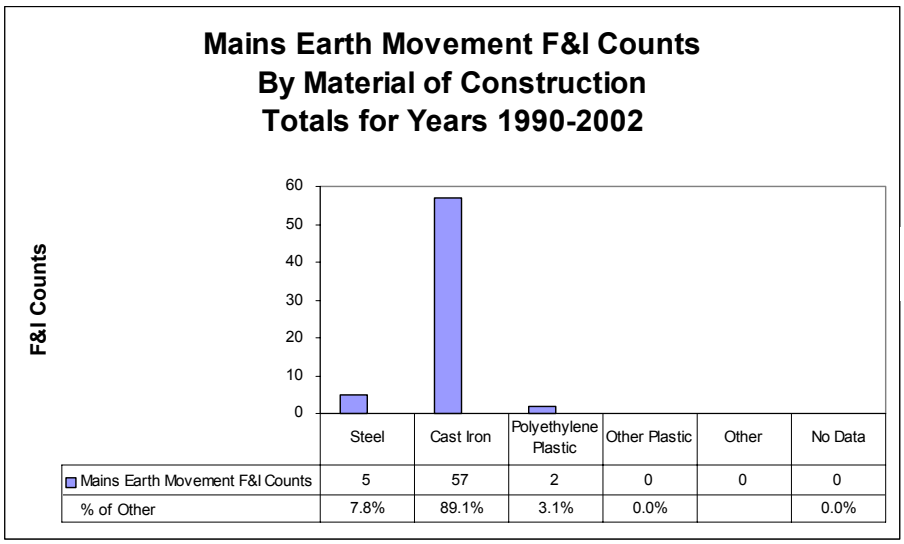
(c)

Figure C50. Service Lines Third Party F&I Counts by Material of Construction

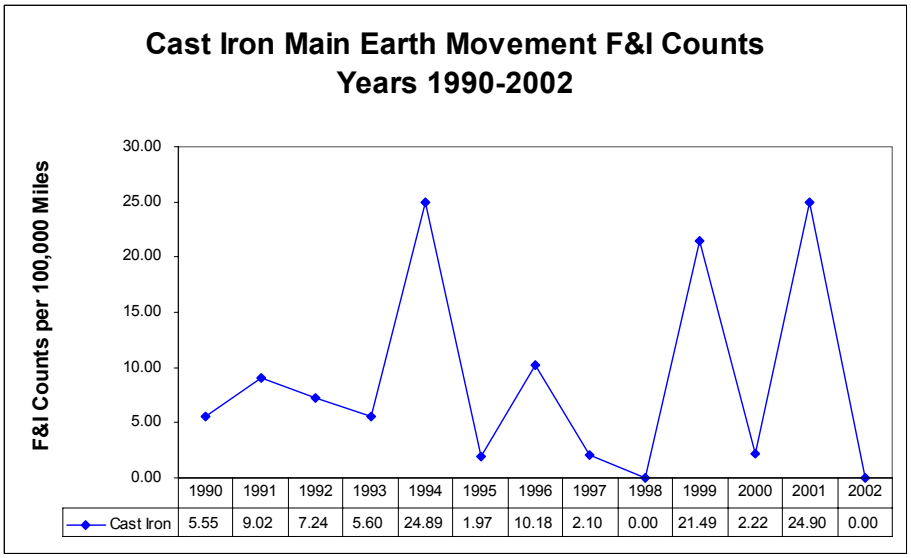
Figure C48 displays the earth movement F&I counts for mains by material of construction from 1990 through 2002. Cast iron contributes the greatest proportion of incidents with 89.1%. The next largest category is steel, followed by polyethylene plastic.

A time series of the cast iron data based on 100,000 miles of the appropriate mileage, as discussed in Part 1 of this appendix, is shown in Figure C48(b). This time series shows great variation in cast iron from year to year.

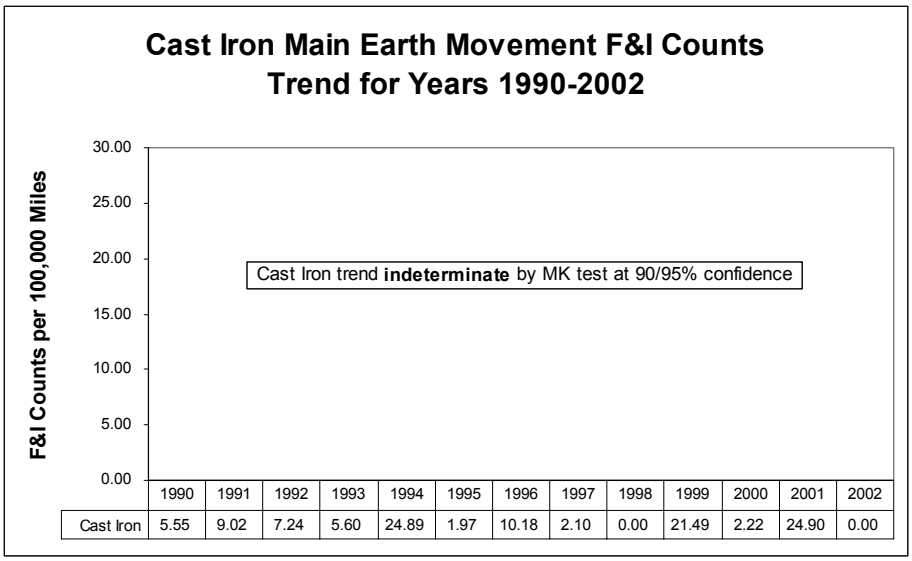
A trend plot is shown in Figure C48(c). The MK test, at 90% and 95% confidence limits, yields an indeterminate result for cast iron. Therefore, no trend is shown.



(a)



(b)



(c)

Figure C48. Mains Earth Movement F&I Counts by Material of Construction

Figure C51 shows the earth movement F&I counts for service lines by material of construction from 1990 through 2002. Steel and other plastic compose most of the fatalities and injuries at 44.4% and 33.3%, respectively. Polyethylene plastic and other each contribute in a smaller proportion to the total number of fatalities and injuries. There were no fatalities and injuries associated with cast iron or no data for earth movement of service lines.

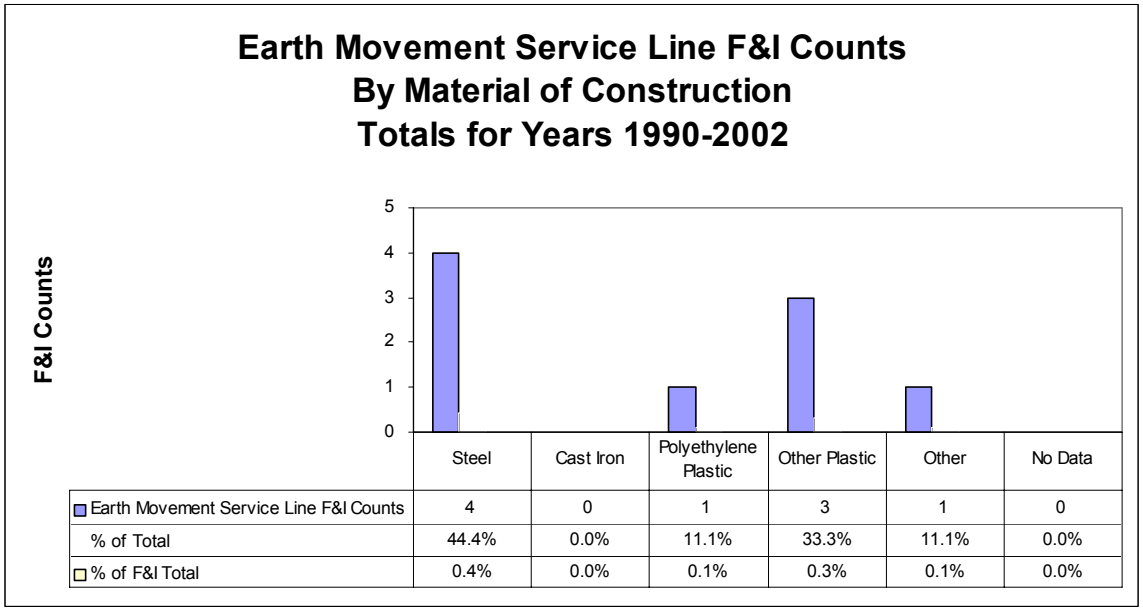


Figure C51. Service Line Earth Movement F&I Counts by Material of Construction

Figure C52 shows construction/operating error F&I counts by part of system for the period of 1990 through 2002. Mains dominate the number of fatalities and injuries with 72.0%. Other composes 14.0% of the fatalities and injuries associated with this particular cause of construction and operating error. Service line, meter set assembly, and no data each contribute minimally to the total number of fatalities and injuries.

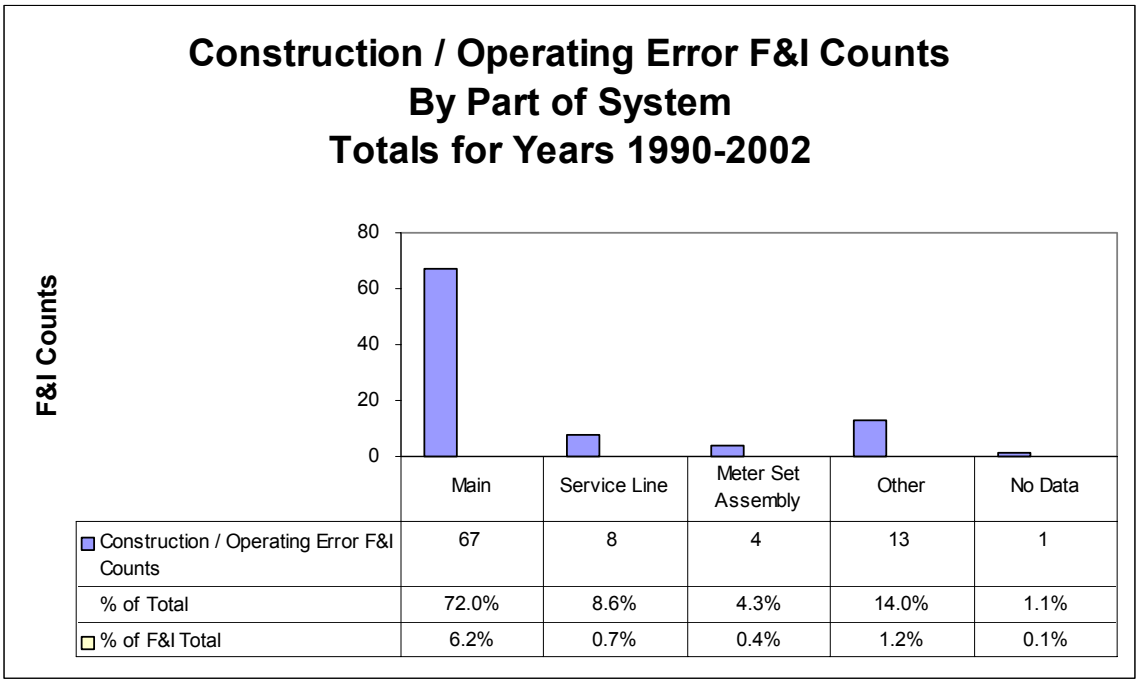


Figure C52. Construction/Operating Error F&I Counts by Part of System

Figure C53 shows the accidentally caused by operator F&I counts by part of system from 1990 through 2002. Mains, service lines, and other contribute to the counts of fatalities and injuries at 58.8%, 29.4%, and 9.4%, respectively. Meter set assemblies contribute in a smaller proportion to the total number of fatalities and injuries.

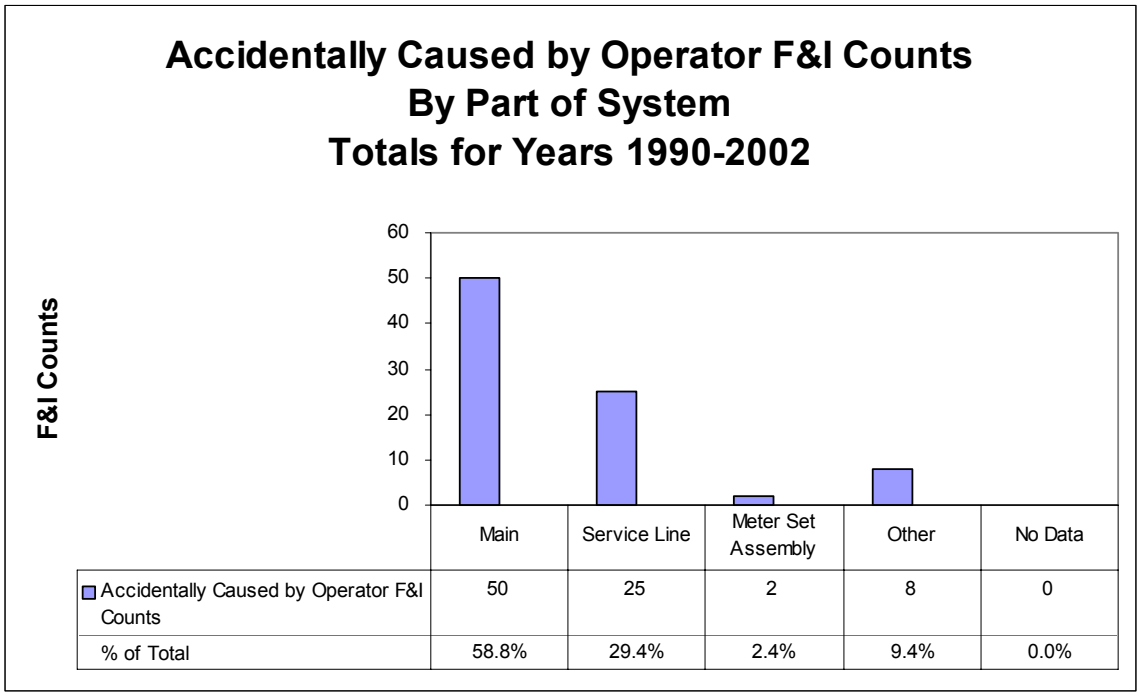


Figure C53. Accidentally Caused by Operator F&I Counts by Part of System

Figure C54 shows the F&I counts which were classified as a cause of other and no data by part of system for the period of 1990 through 2002. The parts of the distribution system most frequently identified for these types of events were other, no data, mains, and service lines with 34.6%, 27.7%, 22.8%, and 12.1%, respectively. Meter set assemblies contribute very minimally to the total number of fatalities and injuries with 2.9%.

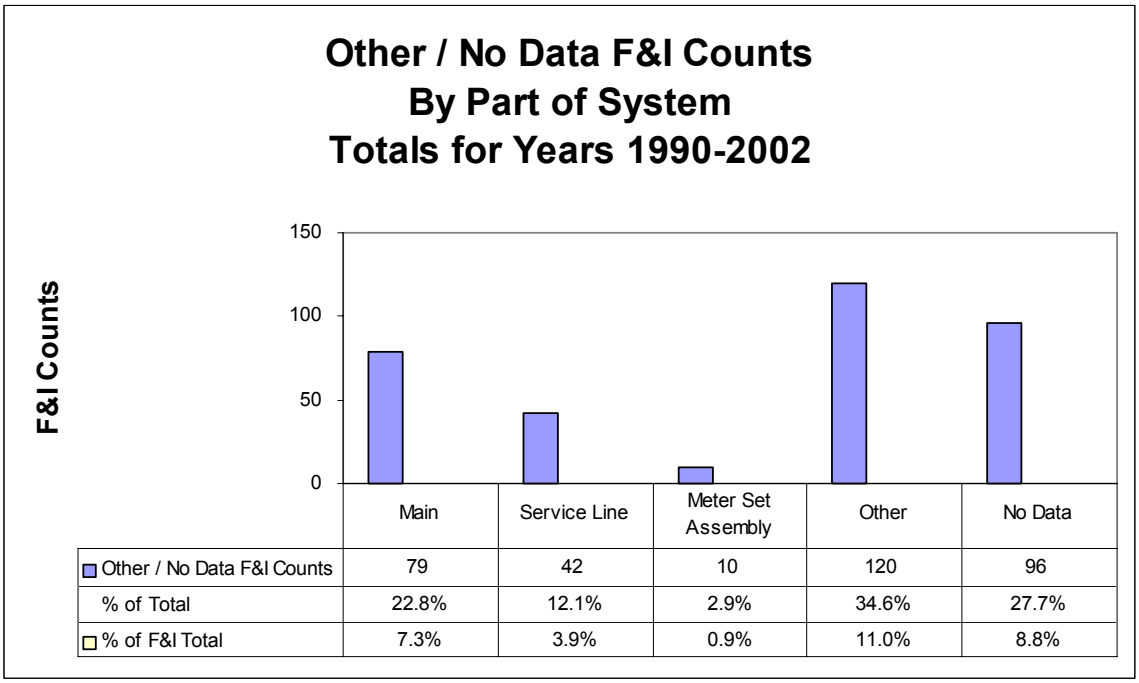


Figure C54. Other/No Data F&I Counts by Part of System

PART 3

F&I COUNT TABLES

Fatality and Injury Counts

Table C30. F&I Counts

	Total
1990	58
1991	91
1992	72
1993	100
1994	112
1995	59
1996	156
1997	76
1998	82
1999	96
2000	81
2001	51
2002	54
	1,088

	Total Mileage	Main Mileage	Estimated Service Mileage	Total Mileage
1990	1,449,399	889,566	559,833	1,449,399
1991	1,452,922	888,558	564,364	1,452,922
1992	1,484,975	891,171	593,804	1,484,975
1993	1,510,696	923,670	587,026	1,510,696
1994	1,652,703	968,193	684,510	1,652,703
1995	1,656,857	988,818	668,039	1,656,857
1996	1,601,556	980,900	620,657	1,601,556
1997	1,628,880	991,390	637,490	1,628,880
1998	1,671,461	1,025,492	645,969	1,671,461
1999	1,687,403	1,006,580	680,823	1,687,403
2000	1,704,334	1,041,159	663,175	1,704,334
2001	1,816,409	1,099,500	716,909	1,816,409
2002	1,888,882	1,143,949	744,933	1,888,882

	Normalized Total
1990	4.00
1991	6.26
1992	4.85
1993	6.62
1994	6.78
1995	3.56
1996	9.74
1997	4.67
1998	4.91
1999	5.69
2000	4.75
2001	2.81
2002	2.86

Table C31. F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990	37	11	6	4	0	54
1991	37	28	6	20	0	71
1992	41	14	11	6	0	66
1993	37	34	7	22	0	78
1994	53	36	2	21	0	91
1995	26	17	4	11	1	47
1996	43	19	4	15	75	66
1997	43	11	1	14	7	55
1998	21	42	3	12	4	66
1999	42	34	7	7	6	83
2000	28	18	2	27	5	48
2001	28	15	6	1	2	49
2002	10	19	6	16	3	35
	446	298	65	176	103	1088
	Main	**Service Lines**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	889,566	559,833	559,833			
1991	888,558	564,364	564,364			
1992	891,171	593,804	593,804			
1993	923,670	587,026	587,026			
1994	968,193	684,510	684,510			
1995	988,818	668,039	668,039			
1996	980,900	620,657	620,657			
1997	991,390	637,490	637,490			
1998	1,025,492	645,969	645,969			
1999	1,006,580	680,823	680,823			
2000	1,041,159	663,175	663,175			
2001	1,099,500	716,909	716,909			
2002	1,143,949	744,933	744,933			
	Main	**Service Lines**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	4.16	1.96	1.07			
1991	4.16	4.96	1.06			
1992	4.60	2.36	1.85			
1993	4.01	5.79	1.19			
1994	5.47	5.26	0.29			
1995	2.63	2.54	0.60			
1996	4.38	3.06	0.64			
1997	4.34	1.73	0.16			
1998	2.05	6.50	0.46			
1999	4.17	4.99	1.03			
2000	2.69	2.71	0.30			
2001	2.55	2.09	0.84			
2002	0.87	2.55	0.81			

Fatality and Injury Counts by Material of Construction

Table C32. Mains F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	No Data	Total
1990	13	13	10				
1991	15	17	5				
1992	14	6	18				
1993	17	9	9				
1994	21	17	15				
1995	10	5	9				
1996	12	18	11				
1997	18	10	4				
1998	4	1	16				
1999	17	14	10				
2000	10	4	13				
2001	4	14	8				
2002	6	2	2				
	161	130	130	2	20	3	446
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other / No Data**		**Total**
1990	600,000	54,053	212,800				
1991	585,000	55,450	220,000				
1992	580,000	55,242	230,000				
1993	593,940	53,543	250,000				
1994	607,880	52,223	280,000				
1995	603,396	50,660	310,000				
1996	573,136	49,106	332,000				
1997	558,550	47,551	356,000				
1998	569,908	46,023	380,000				
1999	542,289	46,541	388,686				
2000	551,865	45,105	417,660				
2001	554,855	44,169	472,082				
2002	569,000	45,577	505,000				
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other / No Data**		**Total**
1990	2.17	24.05	4.70				
1991	2.56	30.66	2.27				
1992	2.41	10.86	7.83				
1993	2.86	16.81	3.60				
1994	3.45	32.55	5.36				
1995	1.66	9.87	2.90				
1996	2.09	36.66	3.31				
1997	3.22	21.03	1.12				
1998	0.70	2.17	4.21				
1999	3.13	30.08	2.57				
2000	1.81	8.87	3.11				
2001	0.72	31.70	1.69				
2002	1.05	4.39	0.40				

Table C36. Services F&I Counts by Material of Construction

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other	Total
Steel	28	64	17	21	31	161
% of Total	17.4%	39.8%	10.6%	13.0%	19.3%	
Cast Iron	6	84	1	8	31	130
% of Total	4.6%	64.6%	0.8%	6.2%	23.8%	
PE Plastic	0	63	37	16	14	130
% of Total	0.0%	48.5%	28.5%	12.3%	10.8%	421

Fatality and Injury Counts by Cause

Table C41. F&I Counts by Cause

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other	No Data	Total
1990	3	21	6	4	6	0	40
1991	5	26	5	4	13	0	53
1992	2	25	7	3	13	0	50
1993	5	20	5	7	14	0	51
1994	2	32	7	6	13	0	60
1995	3	22	3	6	9	0	43
1996	1	22	4	4	15	1	47
1997	3	17	3	3	14	0	40
1998	3	25	4	6	16	0	54
1999	5	25	6	5	11	0	52
2000	3	17	5	4	15	3	47
2001	3	18	2	3	8	0	34
2002	1	10	2	4	13	0	30
	39	280	59	59	160	4	601

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other / No Data		Total
1990	1,449,399	1,449,399	1,449,399	1,449,399	1,449,399		
1991	1,452,922	1,452,922	1,452,922	1,452,922	1,452,922		
1992	1,484,975	1,484,975	1,484,975	1,484,975	1,484,975		
1993	1,510,696	1,510,696	1,510,696	1,510,696	1,510,696		
1994	1,652,703	1,652,703	1,652,703	1,652,703	1,652,703		
1995	1,656,857	1,656,857	1,656,857	1,656,857	1,656,857		
1996	1,601,556	1,601,556	1,601,556	1,601,556	1,601,556		
1997	1,628,880	1,628,880	1,628,880	1,628,880	1,628,880		
1998	1,671,461	1,671,461	1,671,461	1,671,461	1,671,461		
1999	1,687,403	1,687,403	1,687,403	1,687,403	1,687,403		
2000	1,704,334	1,704,334	1,704,334	1,704,334	1,704,334		
2001	1,816,409	1,816,409	1,816,409	1,816,409	1,816,409		
2002	1,888,882	1,888,882	1,888,882	1,888,882	1,888,882		

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other / No Data		Total
1990	0.21	1.45	0.41	0.28	0.41		
1991	0.34	1.79	0.34	0.28	0.89		
1992	0.13	1.68	0.47	0.20	0.88		
1993	0.33	1.32	0.33	0.46	0.93		
1994	0.12	1.94	0.42	0.36	0.79		
1995	0.18	1.33	0.18	0.36	0.54		
1996	0.06	1.37	0.25	0.25	1.00		
1997	0.18	1.04	0.18	0.18	0.86		
1998	0.18	1.50	0.24	0.36	0.96		
1999	0.30	1.48	0.36	0.30	0.65		
2000	0.18	1.00	0.29	0.23	1.06		
2001	0.17	0.99	0.11	0.17	0.44		
2002	0.05	0.53	0.11	0.21	0.69		

Table C33/34/35. Steel, Cast Iron, and Polyethylene Main F&I Counts by Cause

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other	Total
Steel	28	64	17	21	31	161
% of Total	17.4%	39.8%	10.6%	13.0%	19.3%	
Cast Iron	6	84	1	8	31	130
% of Total	4.6%	64.6%	0.8%	6.2%	23.8%	
PE Plastic	0	63	37	16	14	130
% of Total	0.0%	48.5%	28.5%	12.3%	10.8%	421

Table C37/38. Steel and Polyethylene Service Line F&I Counts by Cause

	Corrosion	Outside Force	Construction / Operating Error	Accidentally Caused By Operator	Other	Total
Steel	14	93	5	17	15	144
% of Total	9.7%	64.6%	3.5%	11.8%	10.4%	
Polyethylene Plastic	0	83	3	2	21	109
% of Total	0.0%	76.1%	2.8%	1.8%	19.3%	253

Table C42. Corrosion F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990	6	0				
1991	4	2				
1992	1	0				
1993	8	4				
1994	1	1				
1995	1	2				
1996	0	2				
1997	5	0				
1998	0	4				
1999	2	3				
2000	4	0				
2001	4	0				
2002	0	9				
	36	27	0	2	1	66
	Main	**Service Line**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	889,566	559,833				
1991	888,558	564,364				
1992	891,171	593,804				
1993	923,670	587,026				
1994	968,193	684,510				
1995	988,818	668,039				
1996	980,900	620,657				
1997	991,390	637,490				
1998	1,025,492	645,969				
1999	1,006,580	680,823				
2000	1,041,159	663,175				
2001	1,099,500	716,909				
2002	1,143,949	744,933				
	Main	**Service Line**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	0.67	0.00				
1991	0.45	0.35				
1992	0.11	0.00				
1993	0.87	0.68				
1994	0.10	0.15				
1995	0.10	0.30				
1996	0.00	0.32				
1997	0.50	0.00				
1998	0.00	0.62				
1999	0.20	0.44				
2000	0.38	0.00				
2001	0.36	0.00				
2002	0.00	1.21				

Table C43/44. Mains and Service Line Corrosion F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other / No Data	Total
Main	28	6	0	0	2	36
% of Total	77.8%	16.7%	0.0%	0.0%	5.6%	
Service Lines	16	0	0	0	14	30
% of Total	53.3%	0.0%	0.0%	0.0%	46.7%	66

Table C45. Outside Force F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990	19	8	5	2	0	34
1991	15	24	4	8	0	51
1992	17	10	9	0	0	36
1993	8	23	6	9	0	46
1994	31	29	2	6	0	68
1995	13	11	3	3	0	30
1996	34	6	3	1	0	44
1997	12	9	1	1	0	23
1998	10	30	3	1	0	44
1999	24	23	4	0	5	56
2000	10	9	1	1	0	21
2001	18	11	5	0	0	34
2002	3	3	3	1	0	10
	214	196	49	33	5	497
	Main	**Service Line**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	889,566	559,833				
1991	888,558	564,364				
1992	891,171	593,804				
1993	923,670	587,026				
1994	968,193	684,510				
1995	988,818	668,039				
1996	980,900	620,657				
1997	991,390	637,490				
1998	1,025,492	645,969				
1999	1,006,580	680,823				
2000	1,041,159	663,175				
2001	1,099,500	716,909				
2002	1,143,949	744,933				
	Main	**Service Line**	**Meter Set Assembly**	**Other**	**No Data**	**Total**
1990	2.14	1.43				
1991	1.69	4.25				
1992	1.91	1.68				
1993	0.87	3.92				
1994	3.20	4.24				
1995	1.31	1.65				
1996	3.47	0.97				
1997	1.21	1.41				
1998	0.98	4.64				
1999	2.38	3.38				
2000	0.96	1.36				
2001	1.64	1.53				
2002	0.26	0.40				

Table C46. Mains Outside Force F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990	6	10	3			
1991	6	6	3			
1992	1	5	9			
1993	2	3	2			
1994	14	14	3			
1995	5	1	7			
1996	6	17	11			
1997	5	4	3			
1998	1	1	8			
1999	10	10	4			
2000	5	1	4			
2001	2	11	5			
2002	1	1	1			
	64	84	63	1	2	214
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**Total**
1990	600,000	54,053	212,800			
1991	585,000	55,450	220,000			
1992	580,000	55,242	230,000			
1993	593,940	53,543	250,000			
1994	607,880	52,223	280,000			
1995	603,396	50,660	310,000			
1996	573,136	49,106	332,000			
1997	558,550	47,551	356,000			
1998	569,908	46,023	380,000			
1999	542,289	46,541	388,686			
2000	551,865	45,105	417,660			
2001	554,855	44,169	472,082			
2002	569,000	45,577	505,000			
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**Total**
1990	1.00	18.50	1.41			
1991	1.03	10.82	1.36			
1992	0.17	9.05	3.91			
1993	0.34	5.60	0.80			
1994	2.30	26.81	1.07			
1995	0.83	1.97	2.26			
1996	1.05	34.62	3.31			
1997	0.90	8.41	0.84			
1998	0.18	2.17	2.11			
1999	1.84	21.49	1.03			
2000	0.91	2.22	0.96			
2001	0.36	24.90	1.06			
2002	0.18	2.19	0.20			

Table C49. Service Lines Outside Force F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	No Data	Total
1990	3		5				
1991	15		7				
1992	6		3				
1993	8		15				
1994	22		6				
1995	3		6				
1996	0		6				
1997	2		7				
1998	16		13				
1999	9		5				
2000	4		4				
2001	5		4				
2002	0		2				
	93	0	83	4	4	12	196
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**No Data**	**Total**
1990	315,247		204,063				
1991	301,203		223,807				
1992	316,760		237,149				
1993	302,419		238,862				
1994	349,680		283,500				
1995	328,093		288,494				
1996	285,584		282,322				
1997	284,407		318,910				
1998	284,784		326,566				
1999	288,180		354,209				
2000	273,335		355,201				
2001	286,651		394,091				
2002	282,614		423,655				
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**No Data**	**Total**
1990	0.95		2.45				
1991	4.98		3.13				
1992	1.89		1.27				
1993	2.65		6.28				
1994	6.29		2.12				
1995	0.91		2.08				
1996	0.00		2.13				
1997	0.70		2.19				
1998	5.62		3.98				
1999	3.12		1.41				
2000	1.46		1.13				
2001	1.74		1.01				
2002	0.00		0.47				

Table C47. Mains Third Party F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990	4	6	2			12
1991	6	1	3			10
1992	1	0	7			8
1993	1	0	0			1
1994	13	1	0			14
1995	5	0	7			12
1996	3	12	11			26
1997	5	3	3			11
1998	1	1	8			10
1999	9	0	4			13
2000	5	0	2			7
2001	2	0	7			9
2002	1	1	1	1	2	6
	56	25	55	1	2	139

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990	600,000	54,053	212,800			
1991	585,000	55,450	220,000			
1992	580,000	55,242	230,000			
1993	593,940	53,543	250,000			
1994	607,880	52,223	280,000			
1995	603,396	50,660	310,000			
1996	573,136	49,106	332,000			
1997	558,550	47,551	356,000			
1998	569,908	46,023	380,000			
1999	542,289	46,541	388,686			
2000	551,865	45,105	417,660			
2001	554,855	44,169	472,082			
2002	569,000	45,577	505,000			

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990	0.67	11.10	0.94			
1991	1.03	1.80	1.36			
1992	0.17	0.00	3.04			
1993	0.17	0.00	0.00			
1994	2.14	1.91	0.00			
1995	0.83	0.00	2.26			
1996	0.52	24.44	3.31			
1997	0.90	6.31	0.84			
1998	0.18	2.17	2.11			
1999	1.66	0.00	1.03			
2000	0.91	0.00	0.48			
2001	0.36	0.00	1.48			
2002	0.18	2.19	0.20			

Table C50. Service Lines Third Party F&I Counts By Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	No Data	Total
1990	2		4				
1991	15		7				
1992	5		3				
1993	4		15				
1994	22		6				
1995	3		5				
1996	0		5				
1997	0		6				
1998	16		12				
1999	9		5				
2000	4		3				
2001	5		4				
2002	0		1				
	85	0	76	1	2	12	176
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**No Data**	**Total**
1990	315,247		204,063				
1991	301,203		223,807				
1992	316,760		237,149				
1993	302,419		238,862				
1994	349,680		283,500				
1995	328,093		288,494				
1996	285,584		282,322				
1997	284,407		318,910				
1998	284,784		326,566				
1999	288,180		354,209				
2000	273,335		355,201				
2001	286,651		394,091				
2002	282,614		423,655				
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**No Data**	**Total**
1990	0.63		1.96				
1991	4.98		3.13				
1992	1.58		1.27				
1993	1.32		6.28				
1994	6.29		2.12				
1995	0.91		1.73				
1996	0.00		1.77				
1997	0.00		1.88				
1998	5.62		3.67				
1999	3.12		1.41				
2000	1.46		0.84				
2001	1.74		1.01				
2002	0.00		0.24				

Table C48. Mains Earth Movement F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990		3				3
1991		5				5
1992		4				4
1993		3				3
1994		13				13
1995		1				1
1996		5				5
1997		1				1
1998		0				0
1999		10				10
2000		1				1
2001		11				11
2002		0				0
	5	57	2	0	0	64
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**Total**
1990		54,053				
1991		55,450				
1992		55,242				
1993		53,543				
1994		52,223				
1995		50,660				
1996		49,106				
1997		47,551				
1998		46,023				
1999		46,541				
2000		45,105				
2001		44,169				
2002		45,577				
	Steel	**Cast Iron**	**Polyethylene Plastic**	**Other Plastic**	**Other**	**Total**
1990		5.55				
1991		9.02				
1992		7.24				
1993		5.60				
1994		24.89				
1995		1.97				
1996		10.18				
1997		2.10				
1998		0.00				
1999		21.49				
2000		2.22				
2001		24.90				
2002		0.00				

Table C51. Service Line Earth Movement F&I Counts by Material of Construction

	Steel	Cast Iron	Polyethylene Plastic	Other Plastic	Other	Total
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
	4	0	1	3	1	9

Table C52. Construction/Operating Error F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
	67	8	4	13	1	93

Table C53. Accidentally Caused by Operator F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
	50	25	2	8	0	85

Table C54. Other/No Data F&I Counts by Part of System

	Main	Service Line	Meter Set Assembly	Other	No Data	Total
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
	79	42	10	120	96	347