Gas Pipeline Incidents at State Highway Crossings

Philip W. Johnson, P.E., Ph.D.
Department of Civil, Construction and Environmental Engineering
The University of Alabama
pjohnson@ua.edu

Agenda

- Introduction
  - What is PHMSA?
  - What were our objectives in the data study?
- Culling the data
  - Why?
  - How?
- Culled data
  - Incident by pipeline type
  - Incidents at crossing
- Conclusions and further research questions....

PHMSA

- US Department of Transportation **Pipeline and Hazardous Materials Safety Administration (PHMSA)**
  - Collects and publishes incident reports for pipelines
  - Superb public resource
  - Can download into EXCEL
  - Can be overwhelming!

OPERATOR_CITY_NAME	OPERATOR_STATE_ABBREVIATION	LOCAL_DATETIME	FATALITY_IND	INJURY_IND	SHUTDOWN_DUE_ACCIDENT_IND	INCIDENT_AREA_TYPE	INCIDENT_AREA_SUBTYPE	CROSSING
HOUSTON	TX	4/2/2012 2:00	NO	NO	YES	UNDERGROUND	UNDER PAVEMENT	YES
SAINT LOUIS	MO	1/5/2012 14:10	NO	NO	YES	UNDERGROUND	UNDER PAVEMENT	YES
HOUSTON	TX	12/13/2011 20:00	NO	NO	YES	UNDERGROUND	UNDER PAVEMENT	YES
SAN FRANCISCO	CA	9/19/2011 18:45	NO	NO	NO	UNDERGROUND	UNDER PAVEMENT	YES
HOUSTON	TX	8/16/2011 14:58	NO	NO	YES	UNDERGROUND	OTHER	YES
BIRMINGHAM	AL	2/10/2011 22:30	NO	NO	YES	UNDERGROUND	UNDER SOIL	YES
HOUSTON	TX	11/30/2010 6:20	NO	NO	YES	UNDERGROUND	UNDER PAVEMENT	YES
BIRMINGHAM	AL	9/21/2010 8:13	NO	NO	YES	UNDERGROUND	UNDER SOIL	YES
HOUSTON	TX	9/26/2012 8:20	NO	NO	NO	UNDERGROUND	UNDER SOIL	YES
HOUSTON	TX	9/14/2012 11:55	NO	NO	NO	ABOVEGROUND	IN OR SPANNING AN OPEN DITCH	YES

Study objectives

- What types of failures are common in pipelines?
- Is there a subset of PHMSA data that can be used to evaluate the usefulness of encasement?
- If so,
  - Are failures types at crossings the same as in regular pipelines?
  - What failure types predominate at crossings?
  - Do failures differ between cased and uncased crossings?

Incident Data

- Data taken from incident reports submitted to PHMSA
- Reports grouped by type of pipeline and year submitted:

Hazardous Liquid	1/2010 to Present	1/2002 to 12/2009	1986 to 1/2002	Pre-1986
Distribution	1/2010 to Present	3/2004 to 12/2009	Mid-1984 to 2/2004	1970 to Mid-1984
Transmission Gathering	1/2010 to Present	2002 to 12/2009	Mid-1984 to 2001	1970 to Mid-1984

Incident Data

- Different forms for each type of pipeline and date range
- Only most recent data indicates cased/uncased
- Most state highway crossings are transmission and gathering or hazardous liquid
- Crossing data set is incomplete
- Not many crossing failures

Incident Data

Type of Pipeline	Crossing Incidents	Total Incidents	% at Crossings	K-Miles	Incidents per k-Mile
Hazardous Liquid	18	3182	0.6	108	29.5
Distribution	14	1228	1.1	1,850	0.66
Transmission/Gathering	12	1208	1.0	300	4.03
Total	**44**	**5618**	**0.8**	**2,308**	**2.43**

PHMSA Pipeline Types

- Hazardous Liquids – all types together
- Gas:

	Distribution	Transmission and Gathering
Location	Mostly in cities and towns	Mostly rural
Road crossings	Many, Dominant type	Fewer, Less common
State Highway Crossings	Fewer	Dominant type
Pipe Material	Moving to plastic	Mostly steel
Pressure	Low Pressure is common	High pressure is common
Diameter	Mostly small	Mostly large
K-Miles of Pipeline	1,850	300

Culling Incident Data

- Focusing on crossings required a culling process
- Eliminated:
  - Anything that could not be inside a road crossing (valves, stopples, sumps, etc.)
  - Pipes located above ground, under water, or under buildings
  - Pipes with diameter < 4” (eliminates mostly distribution)
  - Pipes with pressure > 1500 psi
  - Cast iron pipes (eliminates distribution incidents)
- After culling comparisons more reasonable

Culling Incident Data

- Results of culling:

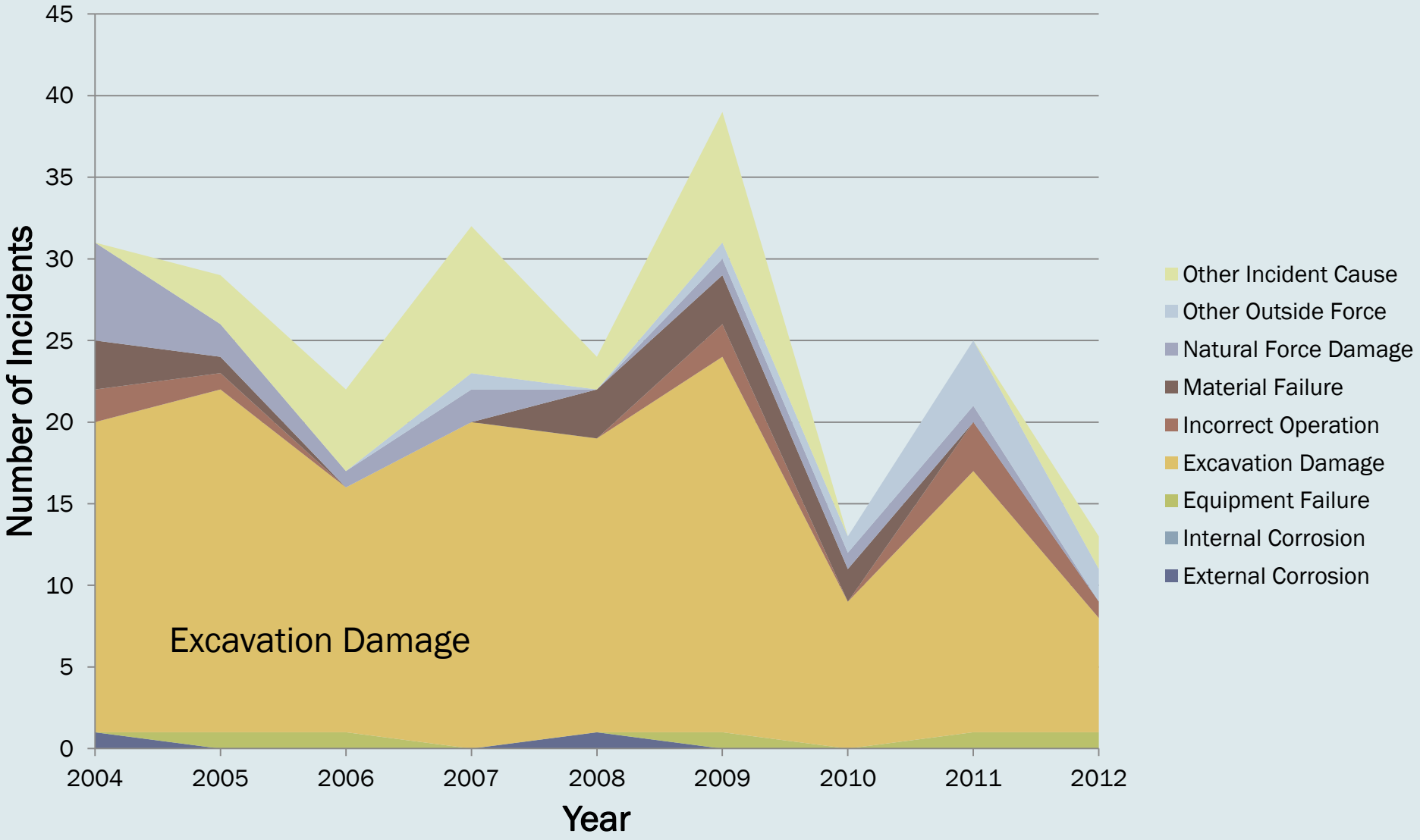
Type of Pipeline	Crossing Incidents	Total Incidents	% at Crossings
Hazardous Liquid	18	1736	1.0
Distribution	14	228	6.1
Transmission/Gathering	12	387	3.1
Total	**44**	**2351**	**1.9**

- Further culling: focused on gas pipelines, except at crossings

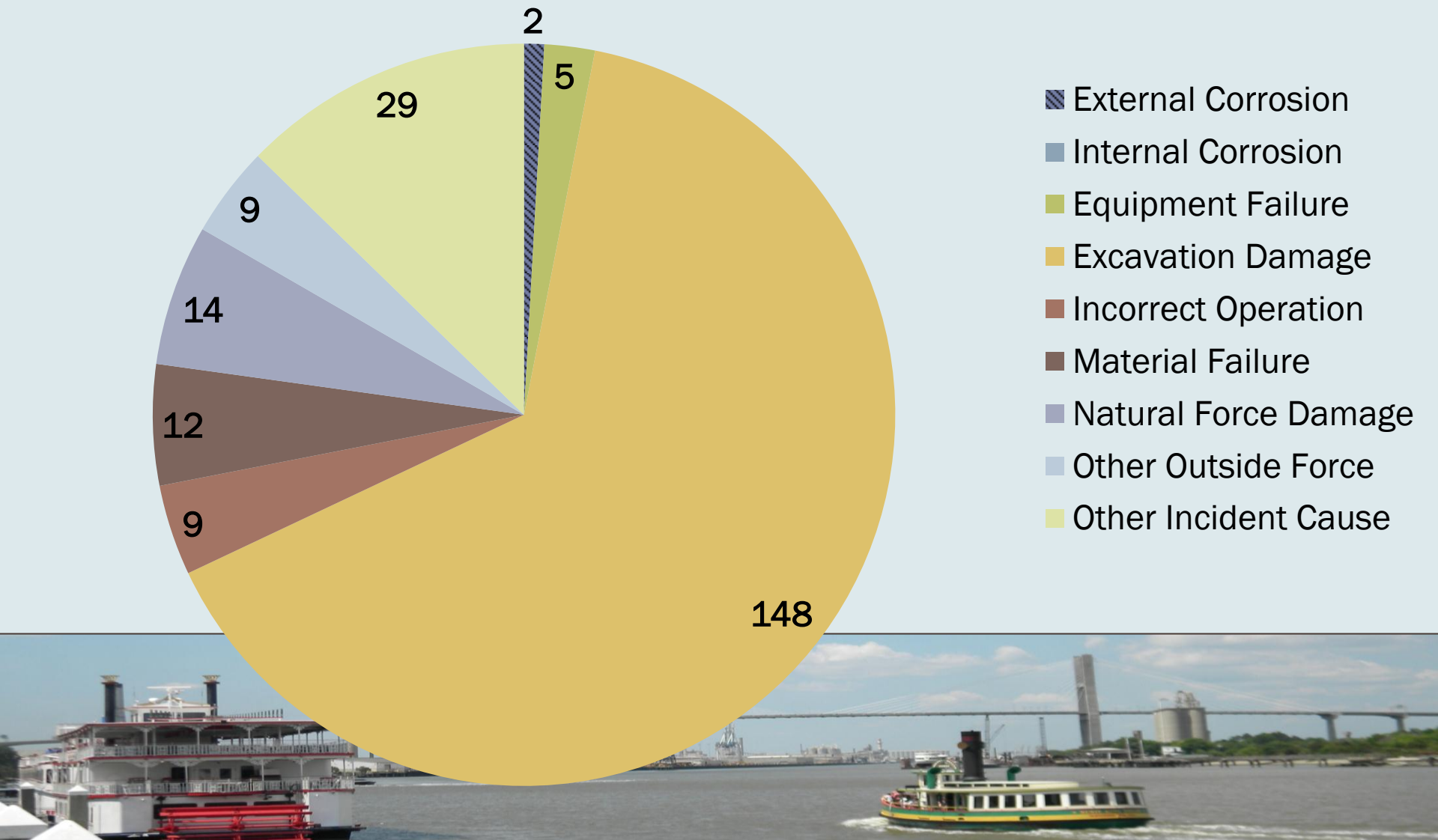
Incident Types – the major categories

- Technical
  - Material
  - Equipment
  - Internal corrosion
  - External corrosion
- Operations and management
  - Excavation damage
  - Incorrect operation
- Other
  - Natural force
  - Other outside force
  - Other incident cause

Distribution (228 Incidents)

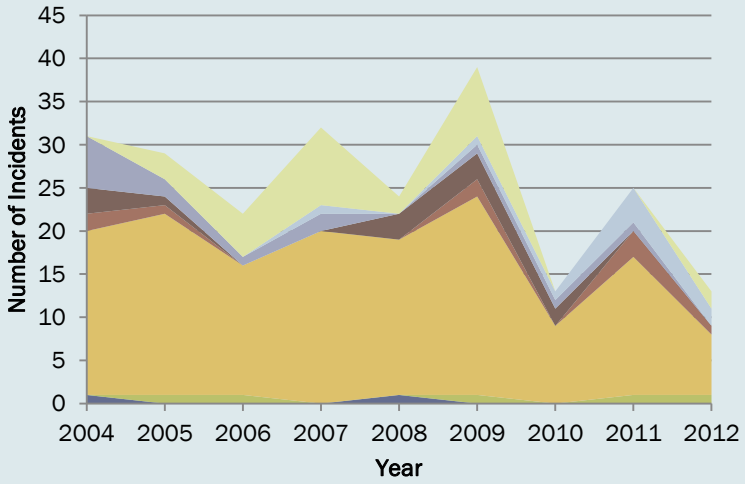


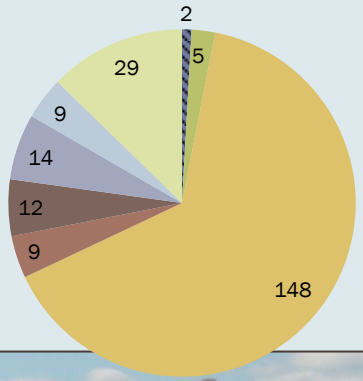
Distribution, 2004 - 2012 (228 Incidents)



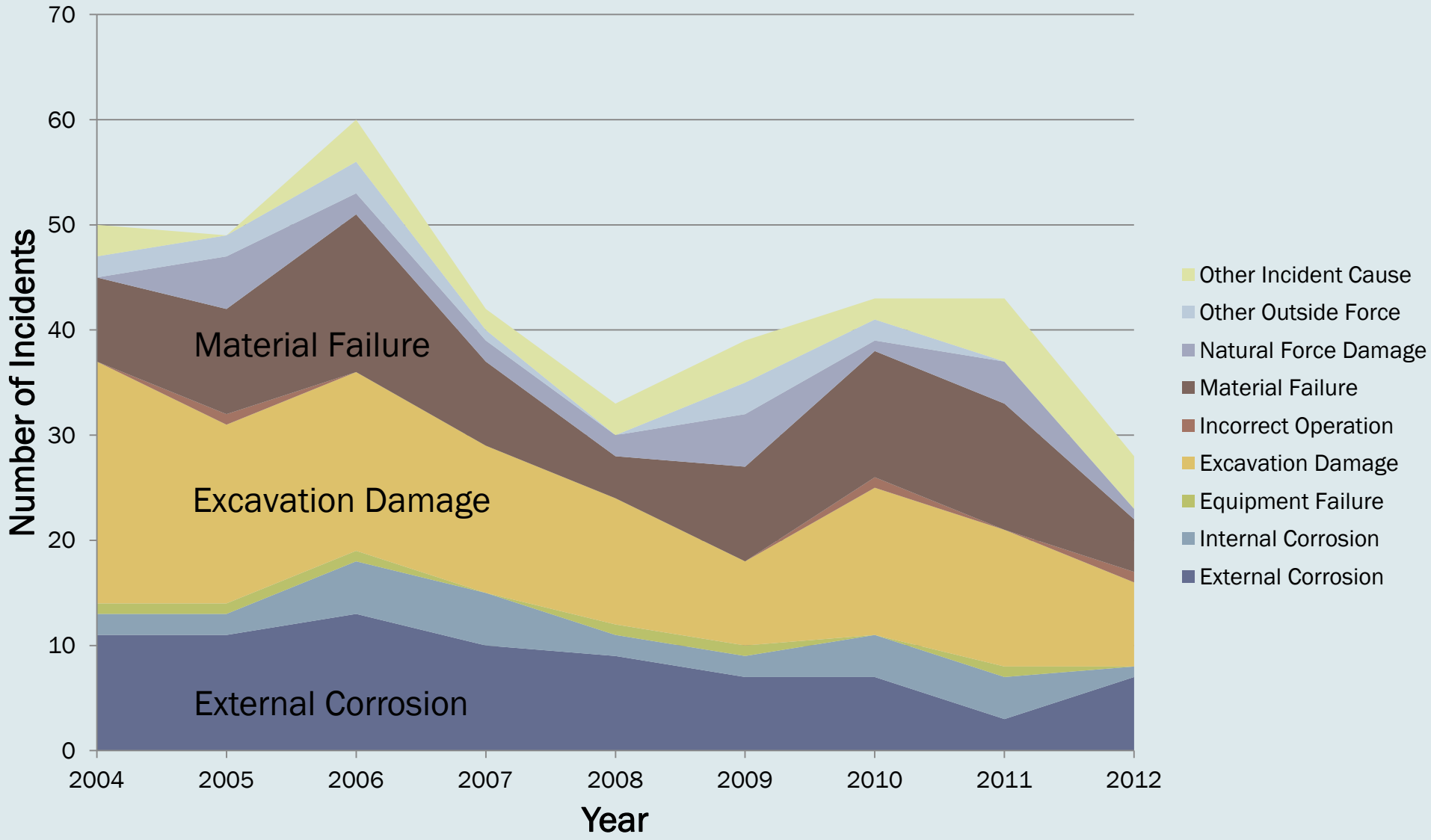
Distribution (228 Incidents)

- Situation is probably improving
  - Data not normalized by
    - Miles of pipe
    - Pipe material
    - Installation activity
- Recession impacted construction
- Dig-ins is a huge problem
  - Standards won't fix this
  - Management and regulation problem
    - Prosecute?

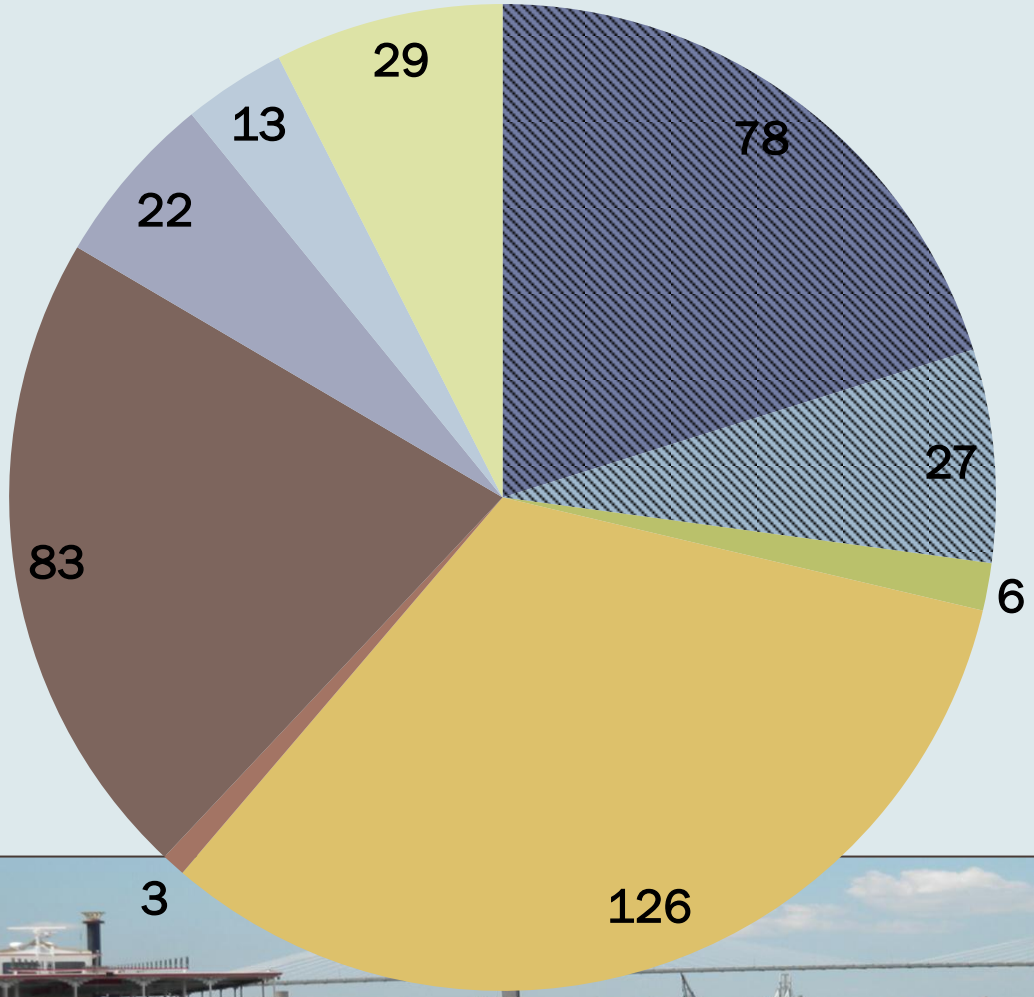




Transmission/Gathering (387 Incidents)



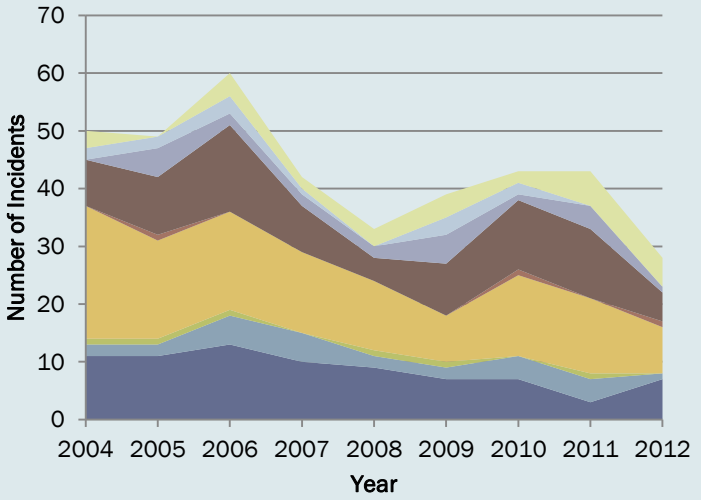
Transmission/Gathering, 2004 - 2012 (387 Incidents)

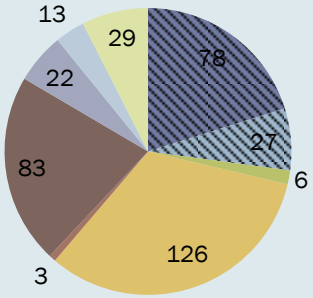


- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Outside Force
- Other Incident Cause

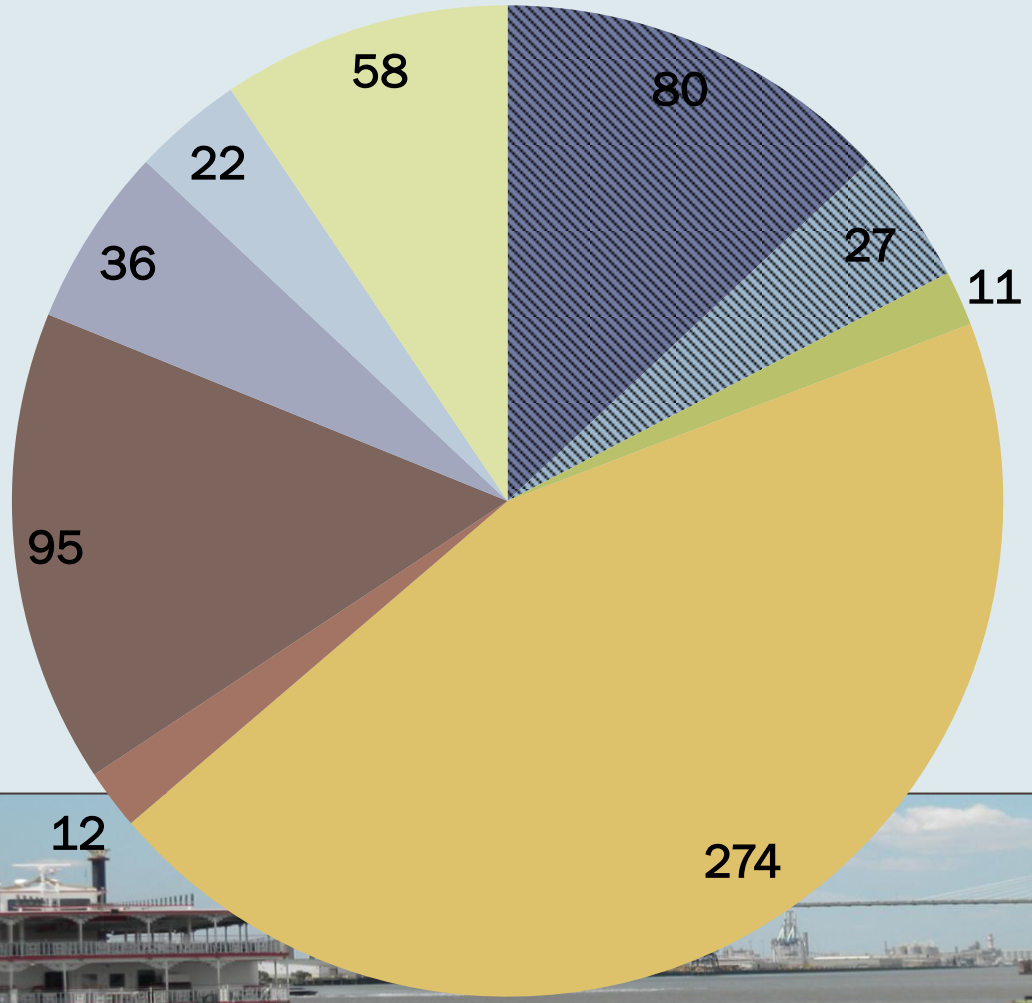
Transmission/Gathering (387 Incidents)

- Data not normalized
- External corrosion and dig-ins probably declining
- Dig-ins are the biggest problem
- Why the surge in material failures?





Combined Gas, 2004 – 2012(615 Incidents)

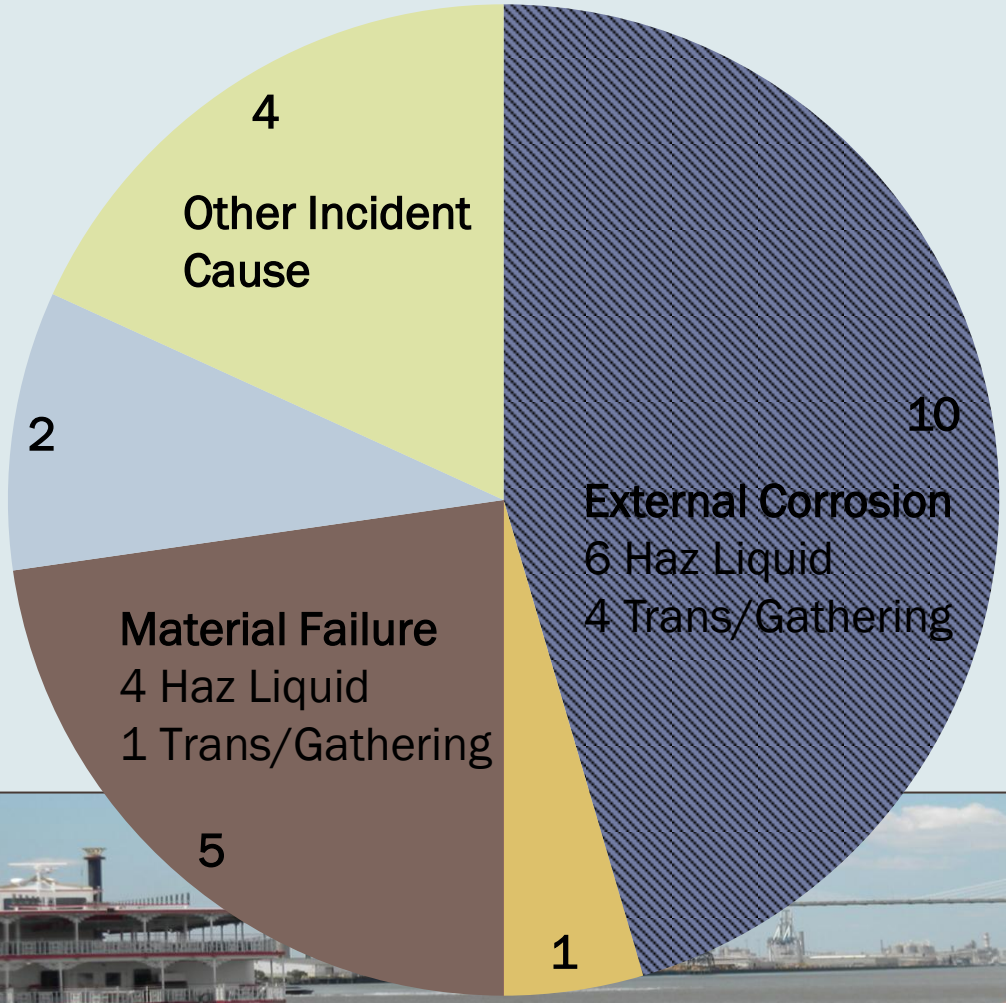


- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Outside Force
- Other Incident Cause

Road crossing incidents

- Relatively rare
- 44 at road crossings out of 2,231 (<2%)
- Probably more crossing incidents, but data is not clear
- How many miles of crossing per mile of pipe?

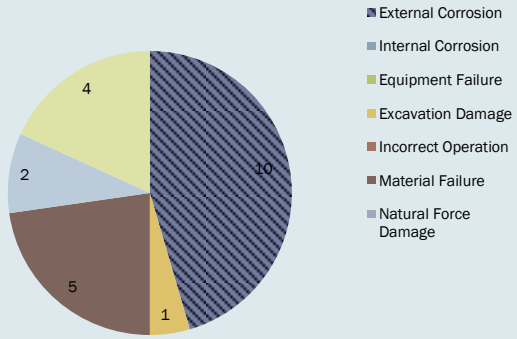
Cased Pipe Summary (22 Incidents)

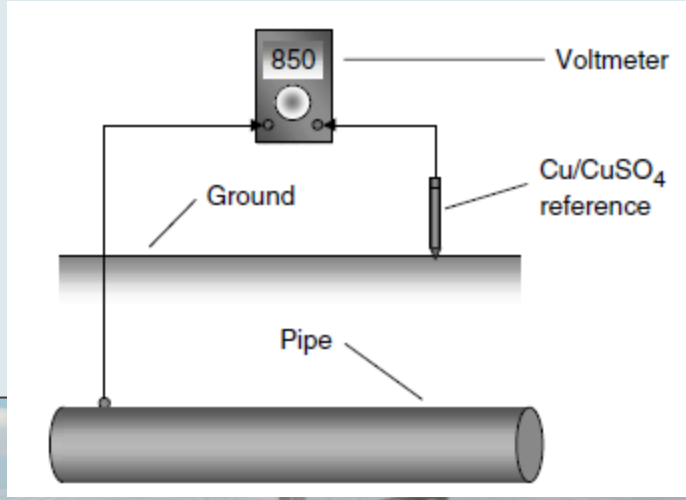


- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Outside Force
- Other Incident Cause

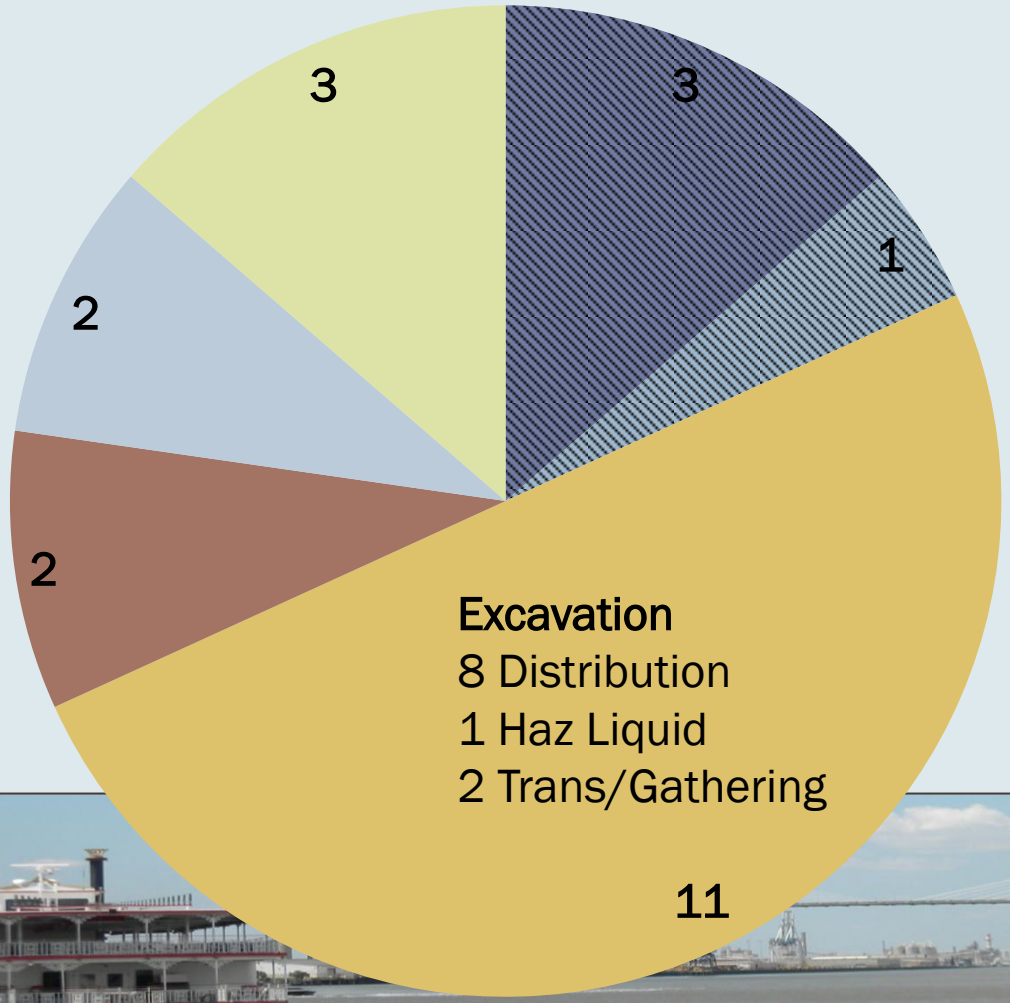
Cased Pipe Summary (22 Incidents)

- External corrosion dominates
  - Can't monitor directly inside casing
  - Other studies also find corrosion worse inside casing

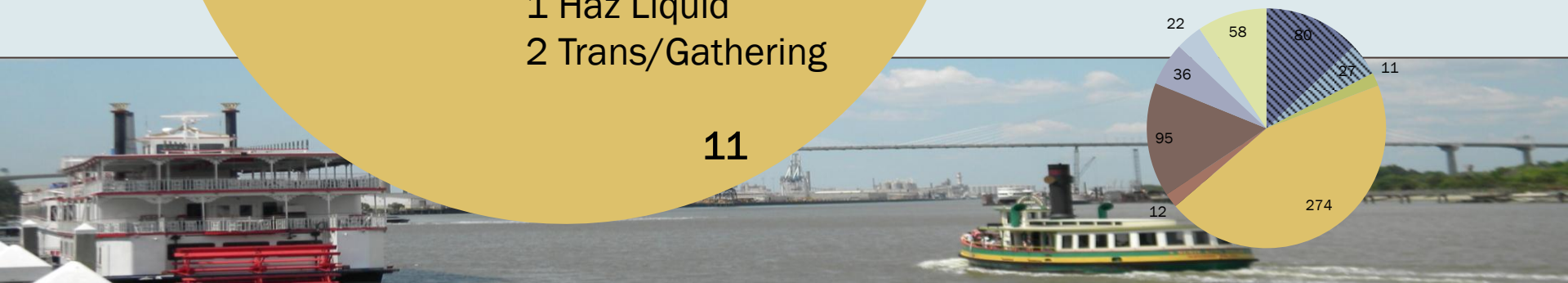




Uncased Pipe Summary (22 Incidents)

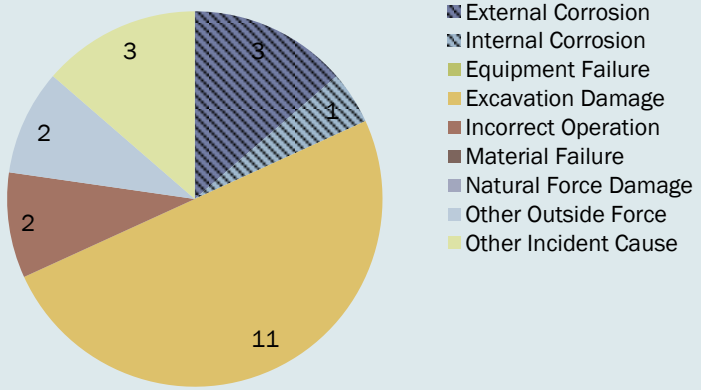


- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Outside Force
- Other Incident Cause



Uncased Pipe Summary (22 Incidents)

- Excavation dominates
- External corrosion less common
- Too many questions
  - Was dig-in under pavement?
  - Would casing have protected?
  - Miles of lines, casing, crossings?

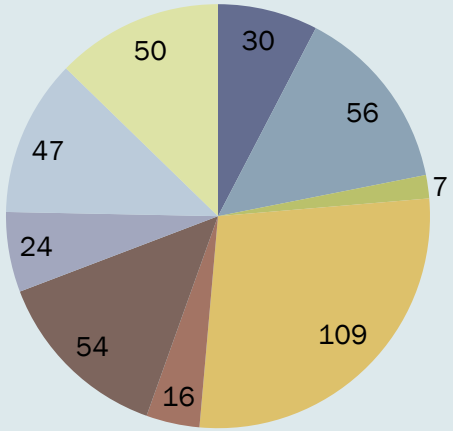


The Most Recent Data

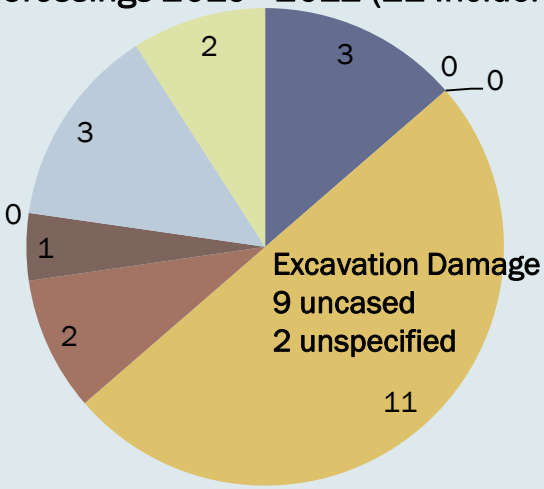
- Also looked at just the 2010 to present data
  - Includes incidents at crossings
  - Shows cased versus uncased
- Culled from the data
  - All cast or wrought-iron pipe
  - Incidents at
    - Valves
    - Compressor stations
    - Metering stations
    - 3rd party facilities
    - Other appurtenances

The Most Recent Data

Gas Incidents 2010 - 2012 (393 Incidents)



Gas Incidents at Road Crossings 2010 - 2012 (22 Incidents)



- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Incident Cause

*Data also included 3 bridge crossings, 1 railroad crossing, and 3 water crossings.

The Most Recent Data

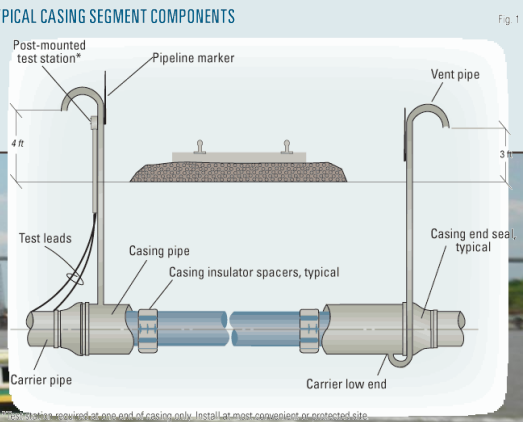
	Cased	Uncased	Uncategorized
Corrosion, external	1	1	1
Corrosion, internal			
Equipment failure			
Excavation damage	2	9	
Incorrect operation		2	
Material failure	1		
Natural force damage			
Other Cause	1	4	
Total	5	16	

The Most Recent Data

- Small data set on crossing failures
  - To small to draw firm conclusions
  - Probably more than 10 times as many uncased as cased crossings
    - Most crossings in cities are uncased distribution lines
    - Crossings in cities are more frequent per mile than in rural areas
    - Distribution line length is 5 times that of transmission & gathering
- About 5% of failures in the pipe are at crossings
- Dig-ins are clearly the most common crossing failure
- By far the most dig-ins are at uncased crossings
  - Are they actually where casing would have protected the pipe?

Conclusions

- Failures at road crossings are probably rare
- Cased crossings
  - Corrosion
    - The main problem
    - Casing probably increases the likelihood of corrosion failure
    - The biggest issue is monitoring inside casing
  - Only one reported dig-in
- Uncased crossings
  - Dig-ins are the most reported problem
    - Could be in ROW, outside of zone normally cased
  - Apparently less corrosion



Further research questions

- How many miles of pipeline and crossings are there by type?
  - State versus city
  - Pipe, steel or plastic
  - Cased versus uncased
  - Gas (transmission and distribution) versus liquid
- Uncased crossing dig-ins – what really happened?
- How does plastic compare to steel?
- What is the story on hazardous liquid pipelines?