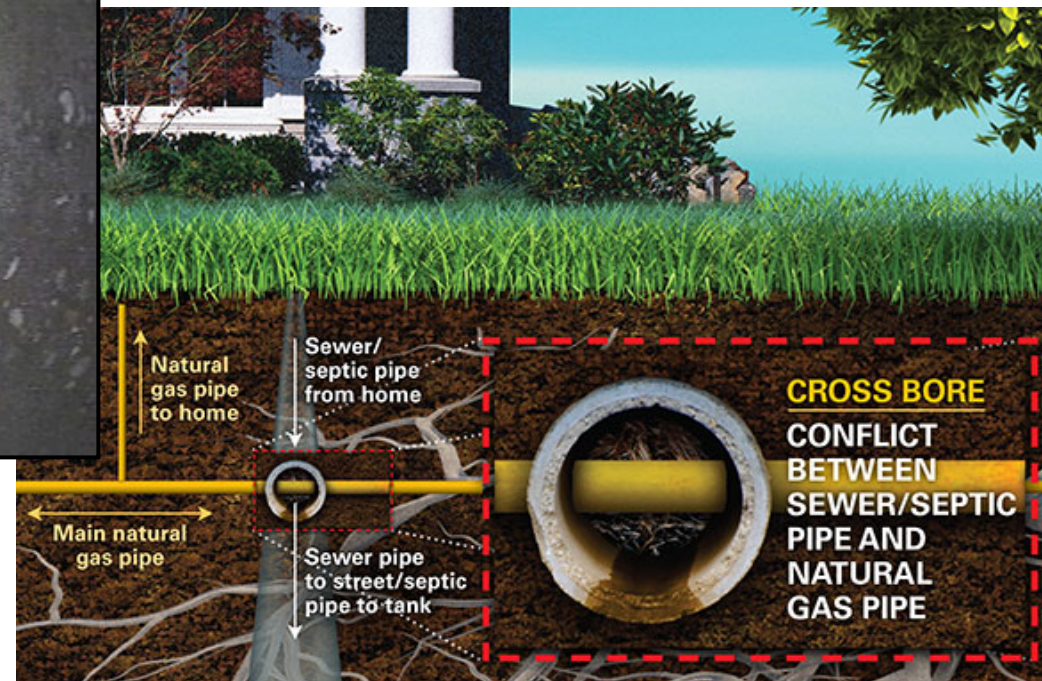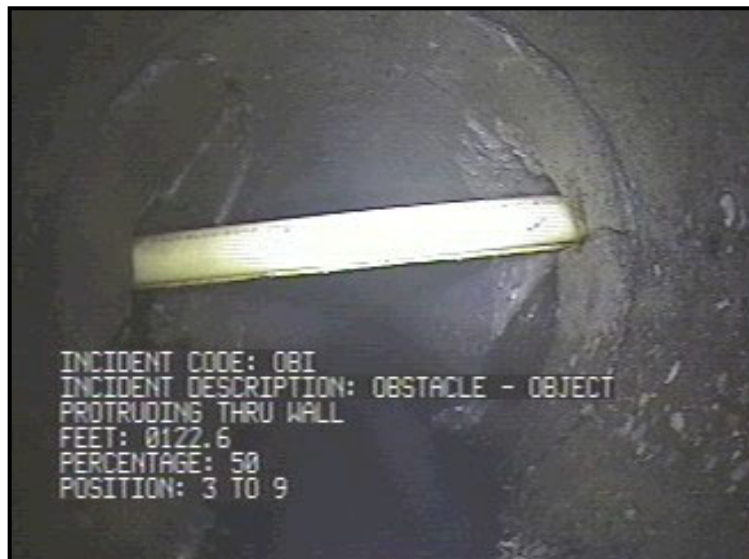# Cross Bore Risk Modelling

Overview

- Background on Cross Bores

- Cross Bore Risk Model
    - Detailed Description of Components
    - Probability of Failure
    - Consequence of Failure

Cross Bores

- Natural gas line bored through a gravity drain system
  - Cleaning operations can damage natural gas line
  - Gas can travel through drain into structure

Risk of Legacy Cross Bores

- Kenosha, Wisconsin
  - August 29, 1976
  - Drain cleaner punctured 2" plastic main
    - Plastic main had penetrated 6" sewer lateral
  - Resulting explosion killed two people
    - Injured four others

  The home did not have natural gas service

Cross Bore Investigations

- **Minnesota Public Utilities Commission**
  - 27 cross bores reported in a 6 month period
  - 6 punctures from 2000-2010, half resulting in ignitions
- **Palo Alto, CA**
  - 4 blocks inspected – 24 cross bores found
- **City A**
  - 2 cross bores per mile in 200 miles of sewer main
  - One cross bore at a school
- **City B**
  - 3 cross bores per mile of sewer main
  - One cross bore at a hospital
- **City C**
  - 2% cross bores out of 11,000 sewer laterals inspected

Industry Actions

- Cross Bore Best Practices (OTD-12/0003)
  - Avoiding New Cross Bore Installations
  - Public Awareness Campaigns
  - Addressing Legacy Cross Bores
    - Inspection programs to find and eliminate
    - Risk-based approach recommended
- CSA Z662 (Clause 12.10.13.1.3)
  - Specific requirements for gas distributors around cross bores
  - Risk assessment and mitigation plan required

Cross Bore Risk Model

Cross Bore Risk Model

- Mechanistic-Probabilistic Models
  - Developed based on underlying mechanisms of failure
  - Statistical models to determine risk probabilities
- True measure of Risk
  - Quantitative
  - Mechanistic
  - Probabilistic
  - Able to address data uncertainty
- Enables comparison across different assets
  - Results in absolute, as opposed to relative, terms

Cross Bore Risk Model

- Risk = Probability of Failure x Consequence of Failure

- Key factors for cross bore risk in existing installations
  - Probability cross bore exists
  - Probability incident will occur given cross bore exists
  - Consequences of possible incidents

- Absolute Cross Bore Risk =
$$(P_{CB} \cdot P_{CBP}) \cdot ((P_{NI} \cdot C_{NI}) + (P_I \cdot C_I) + (P_E \cdot C_E))$$

Probability of Failure

$$PoF = (P_{CB} \cdot P_{CBP})$$

- Probability of Cross Bore x Probability of Puncture

- Probability that a cross bore exists
  - Installation Method/Practices
  - Asset Characteristics
  - Location

- Likelihood of a puncture
  - How likely is the sewer to require cleaning?
  - What mitigation measures are in place?

Probability of Cross Bore

$$P_{CB} = P_T \cdot P_S \cdot P_{INT} \cdot (1 - P_{CBDI})$$

- Incorporates each circumstance required for cross bore
  - Were trenchless installation methods used?
  - Is a sewer system present?
  - How likely are sewer and gas lines to intersect?
  - Will it be detected after installation?

Probability of Puncture (P$_{CBP}$)

$$P_{CBP} = P_{CLOG} \cdot (1 - CLOG_{MIT})$$

- Chance that a sewer/drain line is cleaned (P_{CLOG})
  - *The cross bore is not always the reason for the clog*

- Mitigation Measures to Avoid Puncture ($CLOG_{MIT}$)
  - One-Call Programs (811)
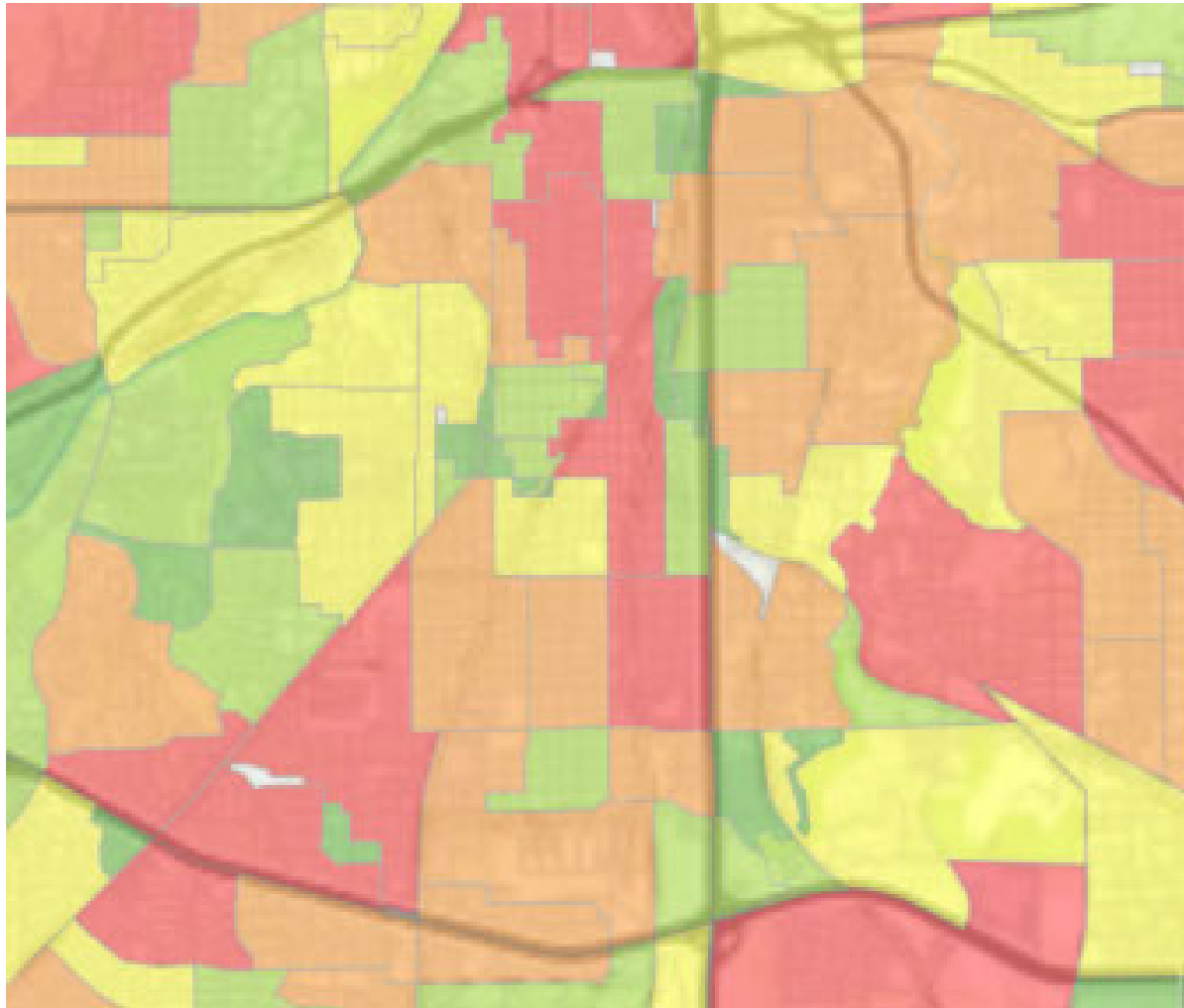 - Public awareness campaigns

Consequence of Failure

$$CoF = ((P_{NI} \cdot C_{NI}) + (P_I \cdot C_I) + (P_E \cdot C_E))$$

- Sum of probabilities of scenarios with their consequence
- Scenarios: No Ignition, Ignition, Explosion
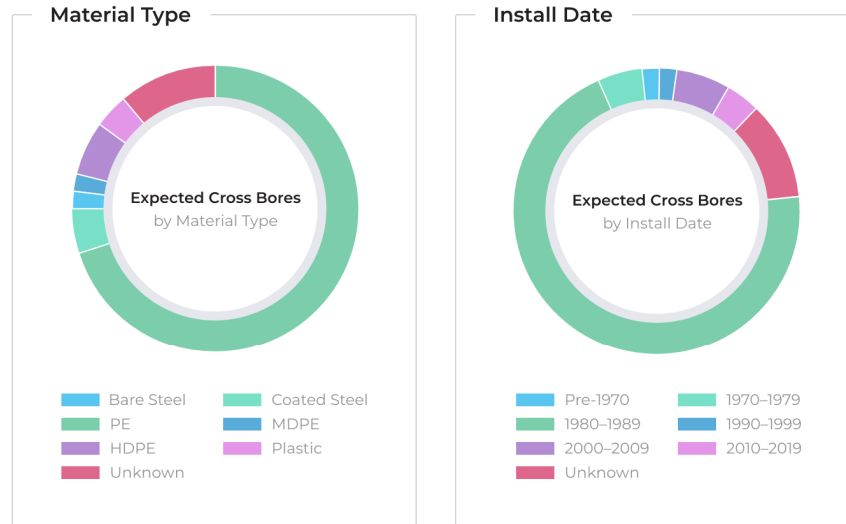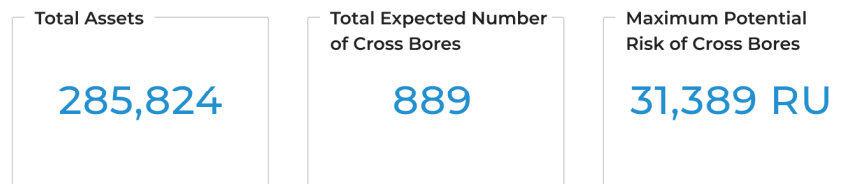
Example Heat Map Results

Example of Cross Bore Risk Modelling Software

Dashboard

Last Updated: April 29, 2019, 5:30 PM

Total Assets

285,824

Total Expected Number of Cross Bores

889

Maximum Potential Risk of Cross Bores

31,389 RU

Summary

Total Length of Mains	2,465 Miles
Total Services	171,660

Updates Since Last Run

Length of new mains	4.52 Miles
Number of new services	674
Length of updated mains	2.30 Miles
Number of updated services	42
Number of new regions added	15
Number of regions updated	16

View Full Report

Material Type

Expected Cross Bores
by Material Type

- Bare Steel
- Coated Steel
- PE
- MDPE
- HDPE
- Plastic
- Unknown

Install Date

Expected Cross Bores
by Install Date

- Pre-1970
- 1970–1979
- 1980–1989
- 1990–1999
- 2000–2009
- 2010–2019
- Unknown

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Example of Cross Bore Risk Modelling Software

Filter by Region

All Regions ▼

Export Current Report

285,824
Total Assets

889
Total Expected Number of Cross Bores

31,389 RU
Maximum Potential Risk of Cross Bores

Mains

2,465 Miles
Length of Mains

0.103
Expected # of Cross Bores per Mile of Mains

3.89 RU
Cross Bore Risk per Mile of Mains

Services

171,660
Number of Services

0.0037
Expected # of Cross Bores per Service

0.127 RU
Cross Bore Risk per Service

Asset Type

Expected Cross Bores by Asset Type

Mains   Services

Cross Bore Risk by Asset Type

Mains   Services

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Example of Cross Bore Risk Modelling Software

Imports

[Import New Dataset]

Recent Imports

Import ID ↓	Data Type	Import Date	Status	Records Imported	Imported By
25	Services & Mains	Monday, April 29, 2019	Success	28,805	isuzu
24	Services & Mains	Tuesday, March 12, 2019	Success w/ Minor Error ⓘ	27,952	elau
23	Inspection Data	Tuesday, March 12, 2019	Success	28,805	jdoe
22	Region Data	Tuesday, March 12, 2019	Success	6,412	msmith
21	Sewer Data	Tuesday, March 12, 2019	Success	23,547	cbing
20	Inspection Data	Tuesday, March 12, 2019	Complete	4,486	vgoyal
19	Services & Mains	Monday, March 11, 2019	Success	28,805	mbentley
18	Sewer Data	Monday, March 11, 2019	Error ⓘ	11	sevans
17	Region Data	Monday, March 11, 2019	Complete	5,875	isuzu
16	Services & Mains	Friday, February 22, 2019	Complete	1,850	jsmith
15	Inspection Data	Friday, February 22, 2019	Complete	1	jdoe
14	Region Data	Friday, February 22, 2019	Complete	5,875	vgoyal
13	Services & Mains	Thursday, February 21, 2019	Error ⓘ	28,805	msmith

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Example of Cross Bore Risk Modelling Software

Assessments

Create New Assessment

Recent Assessments

Publish Latest Assessment to Esri ArcGIS

Name	Date ↓	Start Time	End Time	Status	
2019 Yearly Cross Bore Full Network	Monday, April 29, 2019	4:14:00 PM	4:24:51 PM	Complete	📊 View Report
2018 Q4 Update	Monday, March 11, 2019	11:14:27 AM	11:20:00 AM	Complete	📊 View Report
Inspection Upload1 - Spotlight Run	Friday, February 22, 2019	4:14:00 PM	4:14:20 PM	Complete	📊 View Report
Inspection Upload2 - Spotlight Run	Thursday, February 18, 2019	9:18:18 AM	9:24:51 AM	Complete	📊 View Report
2018 Q3 Update	Thursday, February 18, 2019	11:14:27 AM	11:20:00 AM	Complete	📊 View Report
Region A10 Project Run	Wednesday, February 10, 2019	2:24:36 PM	2:28:21 PM	Complete	📊 View Report
2019 Yearly Cross Bore Full Test	Monday, February 8, 2019	9:18:18 AM	9:24:51 AM	Complete	📊 View Report
2018 Q4 Update	Monday, February 8, 2019	11:14:27 AM	11:20:00 AM	Complete	📊 View Report
Inspection Upload1 - Spotlight Run	Friday, February 5, 2019	2:24:36 PM	2:28:21 PM	Complete	📊 View Report
Inspection Upload2 - Spotlight Run	Thursday, February 4, 2019	9:18:18 AM	9:24:51 AM	Complete	📊 View Report
2018 Q3 Update	Tuesday, February 2, 2019	11:14:27 AM	11:17:00 AM	Complete	📊 View Report
Region A10 Project Run	Monday, February 1, 2019	10:24:36 AM	10:25:21 PM	Complete	📊 View Report
2019 Yearly Cross Bore Full Network	Monday, February 1, 2019	9:18:18 AM	9:24:51 AM	Complete	📊 View Report

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Questions