Pipeline Weld Failure Consequence Analysis

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Abstract

In the oil gas industry, innovation and technology have forged ahead at a tremendous pace. Alongside this advancement, all sectors in the engineering industry must take careful consideration of the risks associated with each project. Consequence analysis is a necessary component as it allows engineers to investigate previous incidents in order to prevent future occurrences. Stantec has presented the task of developing an automated workflow to assist with a pipeline consequence analysis of a pipeline network that exists within Calgary given the pipeline and girthweld data. This workflow calculates the probable damage costs and affected population in a certain area in the instance of a weld failure. This task was broken into 5 separate sub tasks, those being:

- Obtain and classify structures and dwellings surrounding the pipeline network
- Establish leak/rupture radii and determine affected dwellings
- Estimate damage cost of the affected areas
- Determine closest shutoff valves and calculate the volume of product lost
- Display results in an effective manor

Structure and dwellings data was obtained from Open Calgary and open satellite imagery and was batch classified, the data processing component was achieved using Feature Manipulation Engine and the display method being used is ArcGIS. The end product of this project is the ArcGIS display, a girthweld damage assessment of the network in the city of Calgary as well as an FME workflow that can be applied to future similar datasets.

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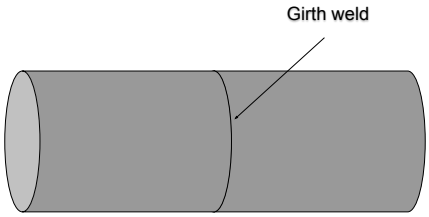
Background

- A Girth weld is a part of a pipeline where two different pipes have been welded together along the circumference.
- They experience large amounts of stress and pressure making them more susceptible to leakage or ruptures.



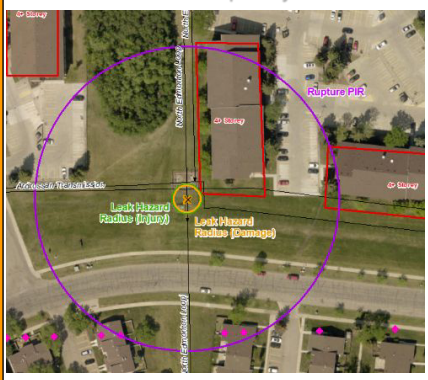
Tasks & Objectives

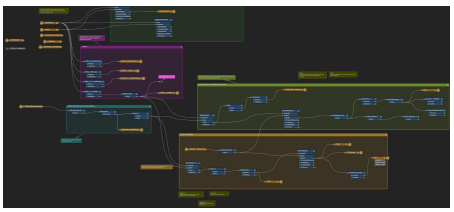
- Initially given pipeline network, girth weld, and shut-off valve data as well as structure valuation.
- Create an automated workflow that takes in classified structures and dwellings data, as well as given data and calculates the damage cost and number of people injured by a leak or rupture at any given girth weld.
- The workflow should also identify closest upstream, and downstream shut-off valves and determine the volume of product lost in the result of a leak or rupture

Building Type	Structure Value	Avg. # Occupants (Inside)	Avg. # Occupants (Outside)
Small apartment building	$4,518,000.00	25.992	1.368
Concrete apartments	$47,848,500.00	162.45	8.55
Outdoor Recreation Area	$18,600.00	0	2.97
Campground	$1,500,000.00	16	16
Church	$1,312,125.00	4.212	0.468
Medium Commercial building	$2,713,250.00	12.019	2.121
Large commercial building	$22,640,000.00	91.834	16.206
Small commercial building	$566,000.00	14.6455	2.5845
Medium Industrial building	$2,688,250.00	11.9795	0.6305
Small Industrial building	$268,825.00	1.19795	0.06305
Large Industrial building	$20,349,375.00	427.5	22.5
House	$269,868.00	2.166	0.114
Large Townhouse Complex	$3,439,350.00	43.32	2.28
Small Townhouse Complex	$859,837.00	10.83	0.57
Semi-detached house	$359,825.00	4.332	0.228
School	$14,421,750.00	176.477	31.143
Golf Course Clubhouse	$339,600.00	0.684	3.298
Community Centre	$6,560,625.00	8.541	0.949
Senior Citizen's Home	$11,295,000.00	93.7365	4.9335
Correctional Institution	$15,456,000.00	278.6635	14.6665
Hospital	$137,160,000.00	772.2	7.8
Hotel (including built-in café)	$27,342,000.00	40.05865	2.10835
College / University	$43,265,250.00	626.1865	110.5035
Daycare	$566,000.00	10	2

Problem

- In the event of a leak or rupture, lost product has the potential to do harm to both surrounding infrastructure and bystanders in the area.
- Understanding the severity of this potential damage allows us to identify and highlight areas of high risk that need to monitored and/or checked more frequently.



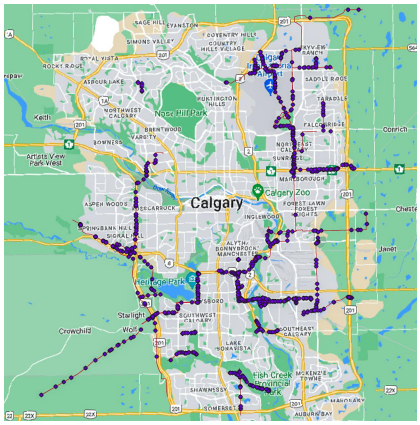


Methods

- A set of properly classified structures and dwellings data was required to complete this project
  - A dataset was obtained through Open Calgary that contained the desired metadata and gaps were filled using open satellite imagery
  - Data was batch classified using ArcGIS and Google Maps
- Automated workflow was developed and executed in Feature Manipulation Engine (FME)
- ArcGIS was chosen for displaying shapefiles

Results

- Each girth weld has a unique ID along with information surrounding its rupture/leak radius, volume of product lost in the event of an incident, number of people injured, number and type of structures impacted, and monetary value of damages
- Results have been outputted to ArcGIS as well as Excel in tabular form for viewing and interpretation
- The worst case scenarios for single girth weld ruptures is:
  - ~774 people injured
  - ~ $60-$80 million in damages
  - 85 residential buildings damaged



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Conclusion

- The primary end deliverable of this project is the FME workflow that was developed
- This workflow can be adapted and applied in situations where similar datasets are available or obtainable
- There are a number of girth welds in the city of Calgary that should be considered "high risk" based on the the potential to injure and cost of damages in the event of a rupture