Assessing risk in abandoned and suspended wells in close proximity to urban development.

Outline

- Risky abandoned and suspended wells: what is problem? What should municipalities and developers be aware of?
- Background: Cross section of a typical wellbore
- How do we assess abandoned and suspended wells in close proximity to urban development?
- Risk Matrix
- Case studies of abandoned wells in Calgary and Airdrie
- Headlines
- Conclusions/Recommendations

Introduction: Abandoned and suspended wells near municipalities

According to 16 x 9, there are 22 million meters of inactive well infrastructure buried in Alberta. How much of this infrastructure is leaking?

Image and data taken from: http://globalnews.ca/news/2301698/infographic-albertas-inactive-abandoned-oil-and-gas-well-problem/

— Graphic illustration by Kevin Salvatierra, Global News

Introduction: Abandoned and suspended wells near municipalities

- **Licensee of the well is responsible for the well indefinitely.**
- **CITY is liable for the approval and the developer is responsible for the risk assessment.**

Image and data taken from: http://globalnews.ca/news/2301698/infographic-albertas-inactive-abandoned-oil-and-gas-well-problem/

— Graphic illustration by Kevin Salvatierra, Global News

Problem:

Who is responsible?

Image modified from: Vintage Pointing hand clip art

Cross-section of a typical Alberta wellbore

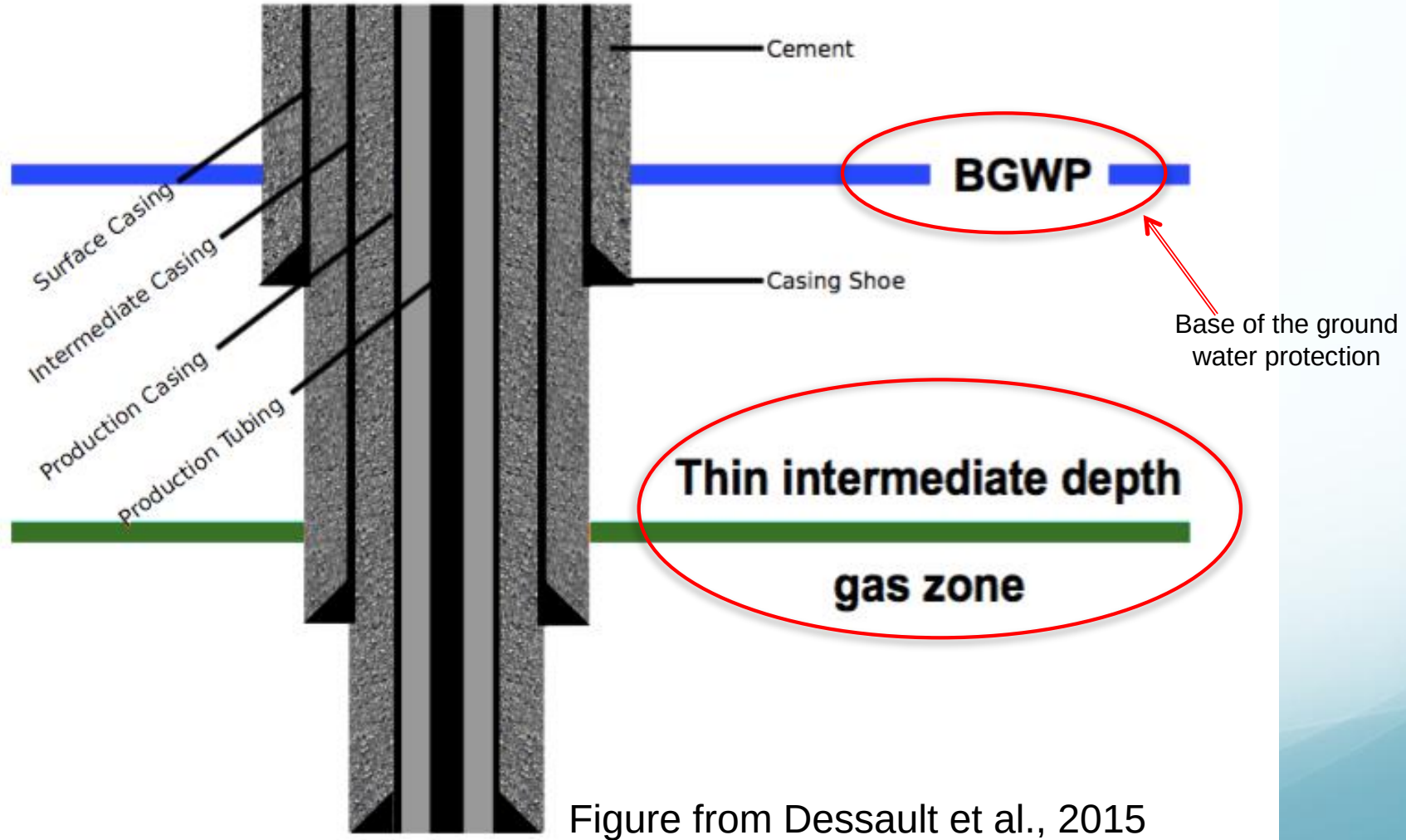


Figure from Dessault et al., 2015

AER Abandoned well decision tree

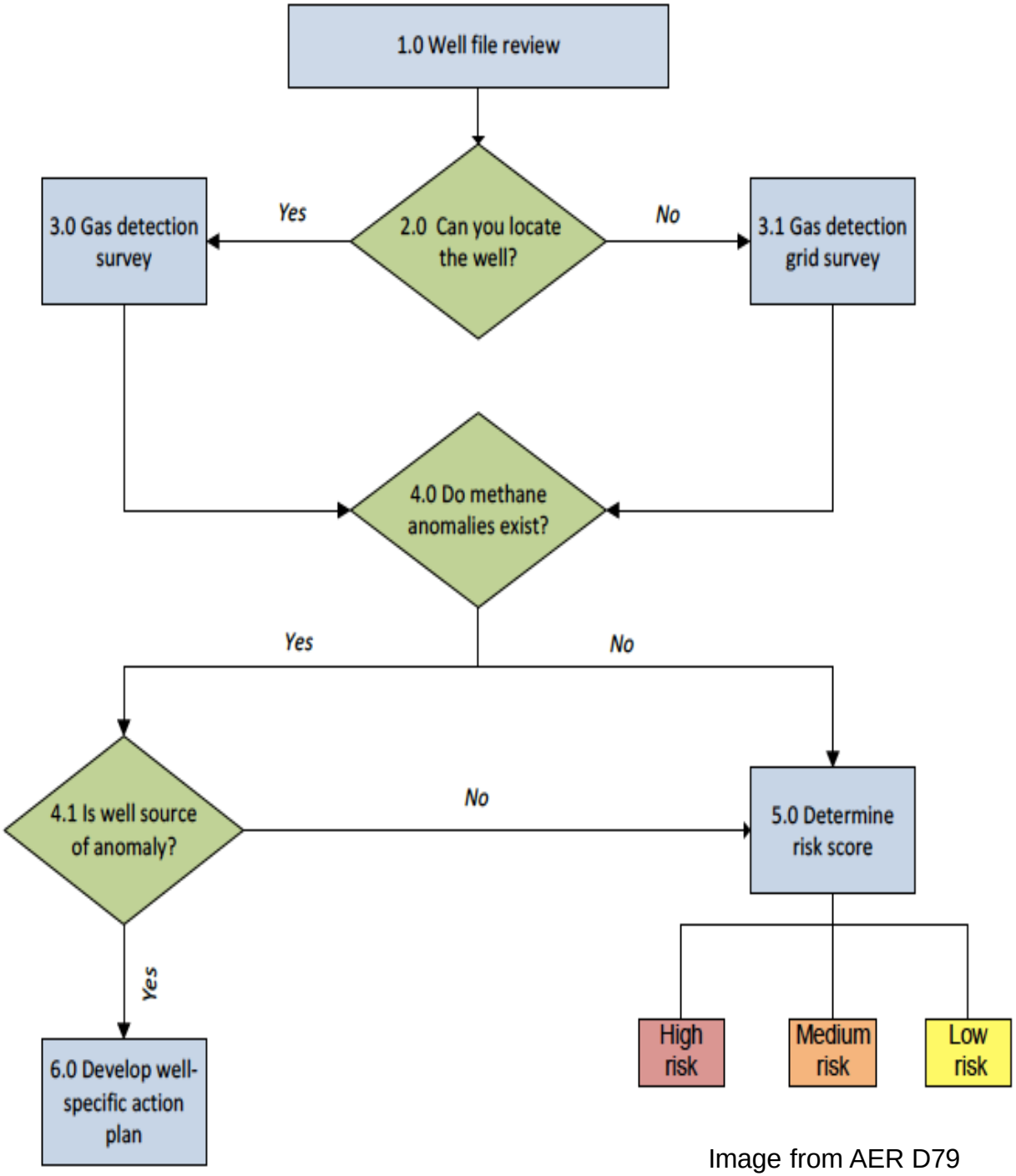


Image from AER D79

How many of those present today have seen this flowchart?

Risk Matrix

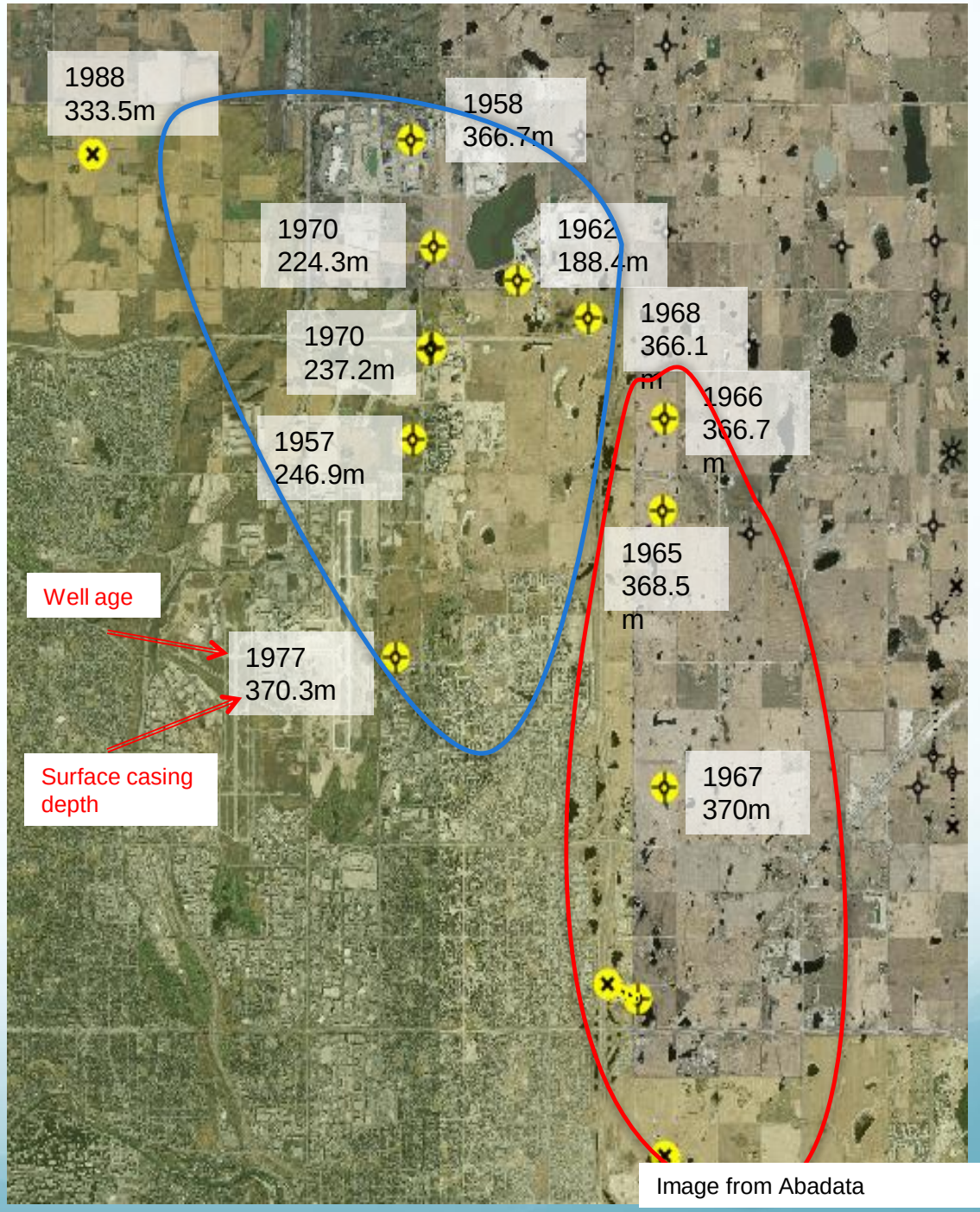
SCVF or GM History (4)	Well Deviation (3)	Cement Top (3)	TVD (mKB) (2)	Casing Failure History (3)	Well Age (3)	Inactive Well Status Date (4)	Well Operation type (3)	H_2S (4)	Land Use (5)	Protection of Useable Water Aquifers (3)	Proximity to Nearest drinking Water Well (4)	Well Accessibility (3)
Serious SCVF or GM	Unknown	Unknown	Unknown	Casing breakdown 50 % or greater	Unknown	Unknown / Non-Compliant	Not Reported	Unknown	Priority 1: Seniors or School, Hospital	Unknown	WSW ≤ 100m Drinking Water	Under Residential Sturcture
Non-Serious SCVF or GM	Directional	C.T. > 1000 mKB	≥ 3000 mKB or if OSA ≤300 mKB	Casing breakdown 30 %	Spud 1975-1985 faulty casing history	5-10 years Non Compliant	Class 2,3 and CO2 injectin/Disopo sal Wells	H2S > 25%	Priorty 2: Residential Areal Playgrounds	Useable Water, Aquifers not Protected	WSW ≤ 100 m Non-Drinking Water	Under Surface Structure
Not Tested	Slant	Below S.C. shoe and 600<CT<1000 mKB	2000-2999 mKB	Casing breakdown 10 %	Spud pre 1975	2 -5 years Non-Compliant	Flowing oil well	15% < H2S ≤ 25%	Priorty 3: Retail/Motel/Ho tel	Useable Water, Aquifers not Protected	100 m < WSW ≤ 500 m Drinking Water	Under Pavement
SCVF/GM Tested In Last 18 Months With Minimal Results	Deviated above 600m KB	Below S.C. shoe and C.T. <600 mKB	1000-1999 mKB	Casing acquired 1975-1985 faulty casing history	Spud 1975-1985 no faulty casing history	24 - 12 Months Non-Compliant	Medium Hazard Gas and non-flowing oil well with H2S >5%	5% < H2S ≤ 15%	Priority 4: Agriculture	Water Aquifers Protected - surface casing 12 years old	100 m < WSW ≤ 500m Non-Drinking Water	Not Under Surface Structure
SCVF/GM Tested In Last 18 Months With Negative Results	Deviated below 600 m KB	Above Surface Casing Shoe	<1000 mKB or if OSA >300 mKB	Historical Casing Failure	Spud 1986-1997	12 Months Non-Compliant	Low risk well inactive/suspe nded ≥10 yrs	1% < H2S ≤ 5%	Priority 5: Commercial	Water Aquifers Protected - surface casing 8 years old	500 m < WSW ≤ 1 km Drinking Water	Access clear 5m setback
SCVF/GM Tested In Last 6 Months With Minimal Results	Vertical no well logs	Above Surface Casing Shoe with GPS		No Historical Casing Failure	Spud 1997-2008	Compliant	all other wells types	H2S ≤ 1%	Priority 6: Light Industrial	BGWP Protected	500 m < WSW ≤ 1 km Non-Drinking Water	GPS and Monitoring Equipment installed
No Historical SCVF or GM	Verticle with well logs			New Casing	Spud After 2008	6 Months		No H2S	Priority 7: Heavy Industrial	All Useable Water Aquifers Protected	WSW > 1 km	GPS and Monitoring Equipment installed Access with 50m setback
										TOTAL SCORE		

Which wells are high risk?
In NORTH CALGARY:

The majority of old wells do NOT have surface casing that extends below the base of the ground water protection (BGWP).

Therefore OLD surface casing does not protect groundwater.

Wells circled in blue have less than 50,000 ppm H_2S; wells circled in red have greater than 200,000 ppm H_2S.



H_2S Concentrations and its Effects

Concentration (ppm)	Symptoms/Effects
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000	Nearly instant death

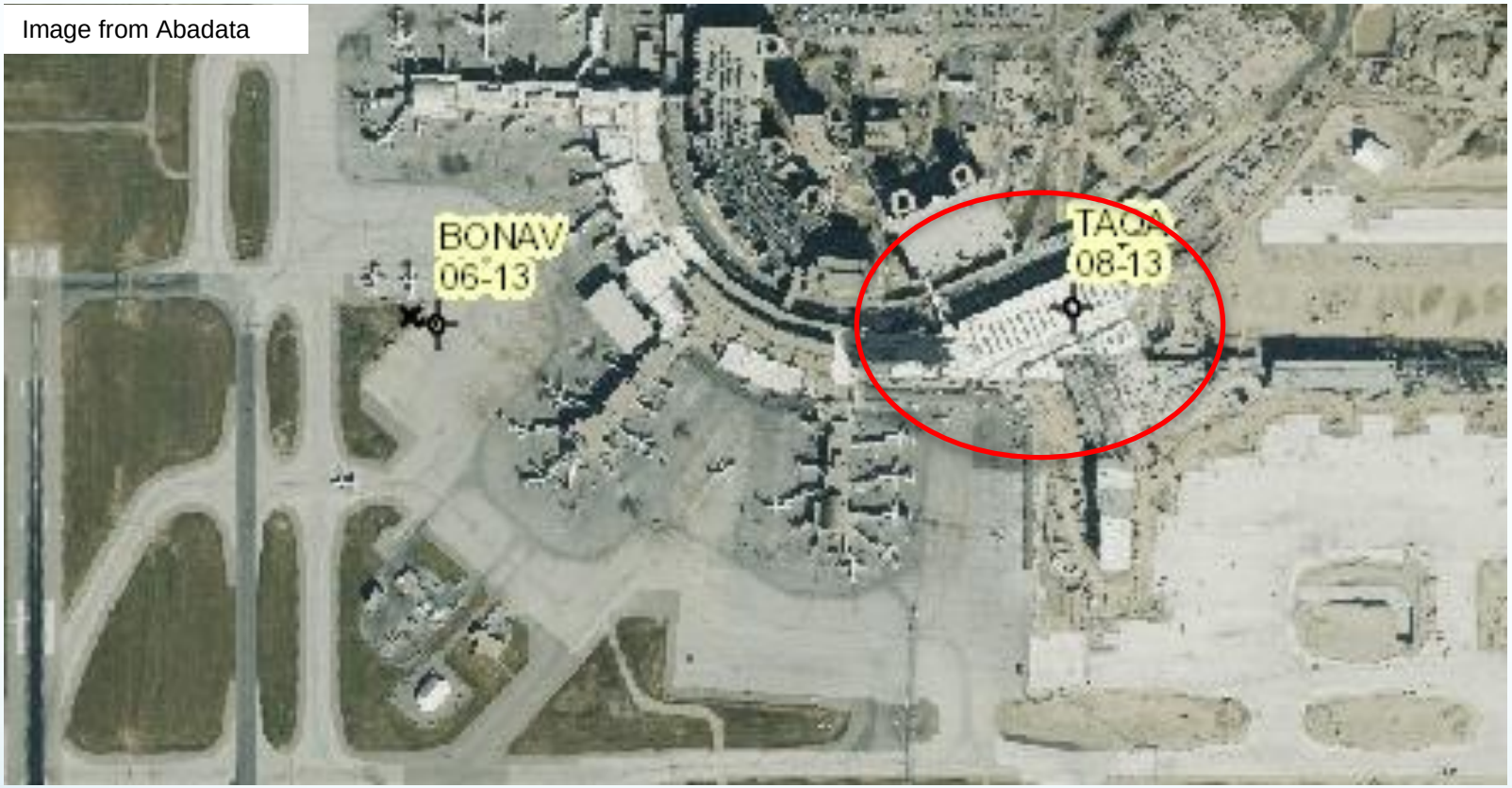
Table Source:https://www.osha.gov/SLTC/hydrogensulfide/hazards.html

Abandoned well case studies

Wells in Calgary and Airdrie, Medicine Hat and Lethbridge

Find the peanut....

In Calgary: risk level of well 8-13-25-1W5



Abandoned in 1961
Surface casing depth 191.7: there is NO OTHER casing in this well
There is no cementing, plug back OR abandonment data for this well
Lies UNDERNEATH airport building

In Calgary: risk level of well 8-13-25-1W5M

Image from Abadata

Risk Category												
SCVF or GM History	Well Deviation	Cement Top	TVD (mKB)	Casing Failure History	Well Age	Inactive Well Status	Well Operation	H_2S Content (%)	Land Use	Protection of Useable Water Aquifers	Proximity to nearest water wells	Well Accessibility
No Historical SCVF or GM	Vertical no well logs	Unknown	1000-1999 mKB	Casing breakdown 50 % or greater	Spud pre 1975	N/A	all other wells types	No H2S	Priorty 1: Seniors/School /Hospital	Useable Water, Aquifers not Protected	500m < WSW ≤ 1 km Non-Drinking Water	Under Surface Structure

Risk matrix total is 1640 out of 3080.
This is a low to medium risk well.

Well 14-35-025-01W5M AbaData View

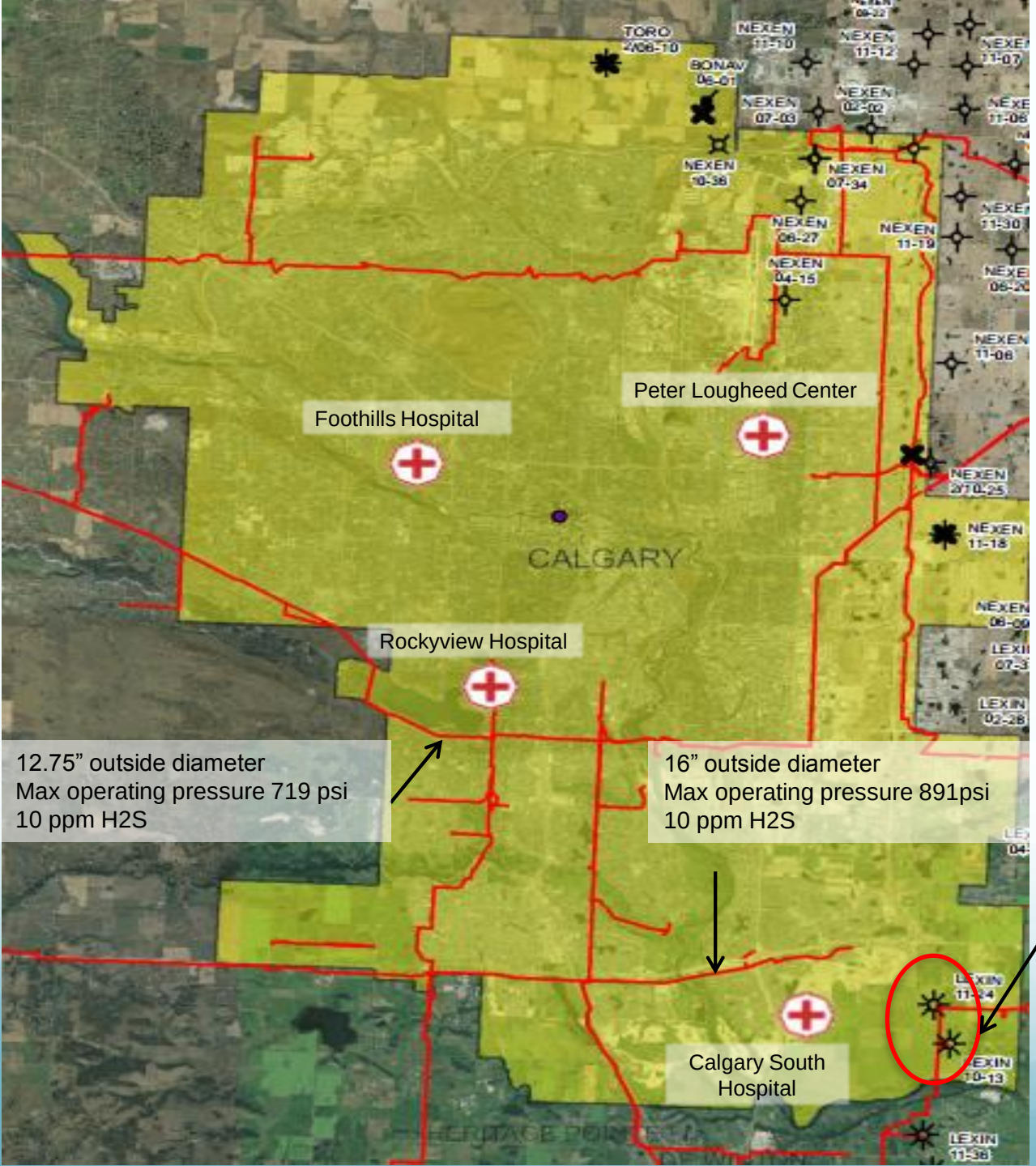
Location: Calgary, Alberta
Abandoned Date: April 24, 1962

Risk Assessment of Abandoned Well 14-35-025-01W5M

Risk Category													
SCVF or GM History	**Well Deviation**	**Cement Top**	**TVD (mKB)**	**Casing Failure History**	**Well Age**	**Inactive Well Status**	**Well Operation**	**H_2S Content (%)**	**Land Use**	**Protection of Useable Water Aquifers**	**Proximity to nearest water wells**	**Well Accessibility**	**SCORE**
No Historical SCVF or GM	Vertical with well logs	Unknown	1000-1999 mKB	Casing breakdown 50 % or greater	Spud pre 1975	Compliant	all other wells types	No H2S	Priority 4: Agriculture	Useable Water, Aquifers not Protected	100 m < WSW ≤ 500 m Non-Drinking Water	Not Under Surface Structure	1560

- Well Name: Canpet Sarcee Calgary 14-35-25-1.
- Current Licensee & Operator: TAQA North Ltd.
- Cement Top: Unknown. Also, it can be assumed that, as the well was drilled & completed before 1975, so the probability of presence of cement around the surface casing from below the BGWP to surface will be low or even if its present it will be degraded condtion, therefore, it can be concluded that groundwater is not protected from gas migration.
- Surface Casing Shoe Depth: 187.1 m & BGWP: 472.2 m
- Perforations: 1794.7 m to 1798.6 m.
- Bridge Plug Capped with Cement: At 1769.4 m.
- Risk Assessment Score: 1560 out of 3080.
- Therefore, it is a medium risk well.

Sour Gas Pipelines in Calgary



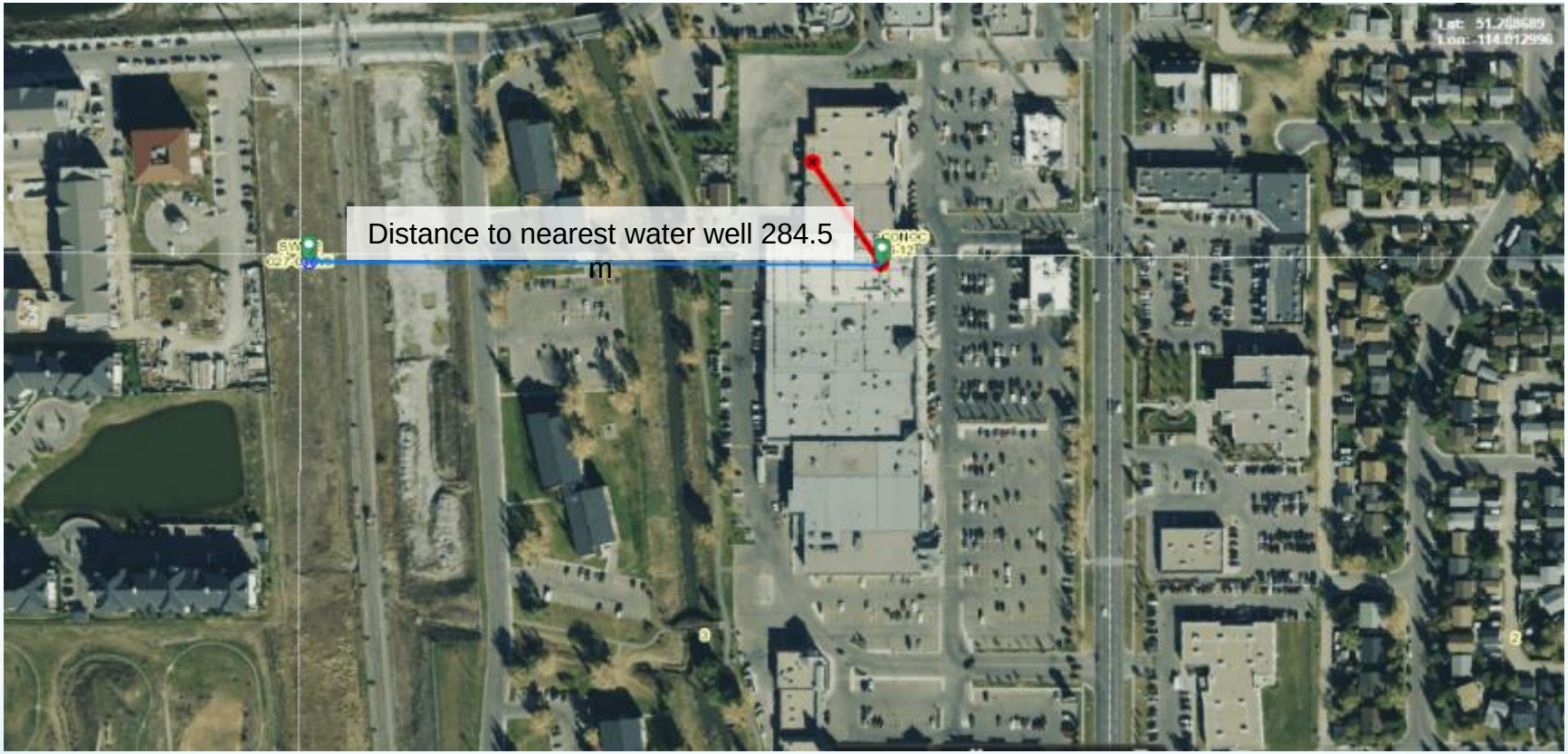
ALL pipelines are currently operating and have 10 ppm H2S.

At 10 ppm H2S, health effects include: painful eye, nose and throat irritation, headaches, fatigue, irritability, insomnia, gastrointestinal disturbance, loss of appetite, dizziness.

The two Lexin wells are operating at 41,990 & 37,490 ppm

The southern pipeline is operating at 400,000 ppm whereas the eastern one is operating at 20,000 ppm & the pipeline is 4.2 km away from Calgary South Hospital.

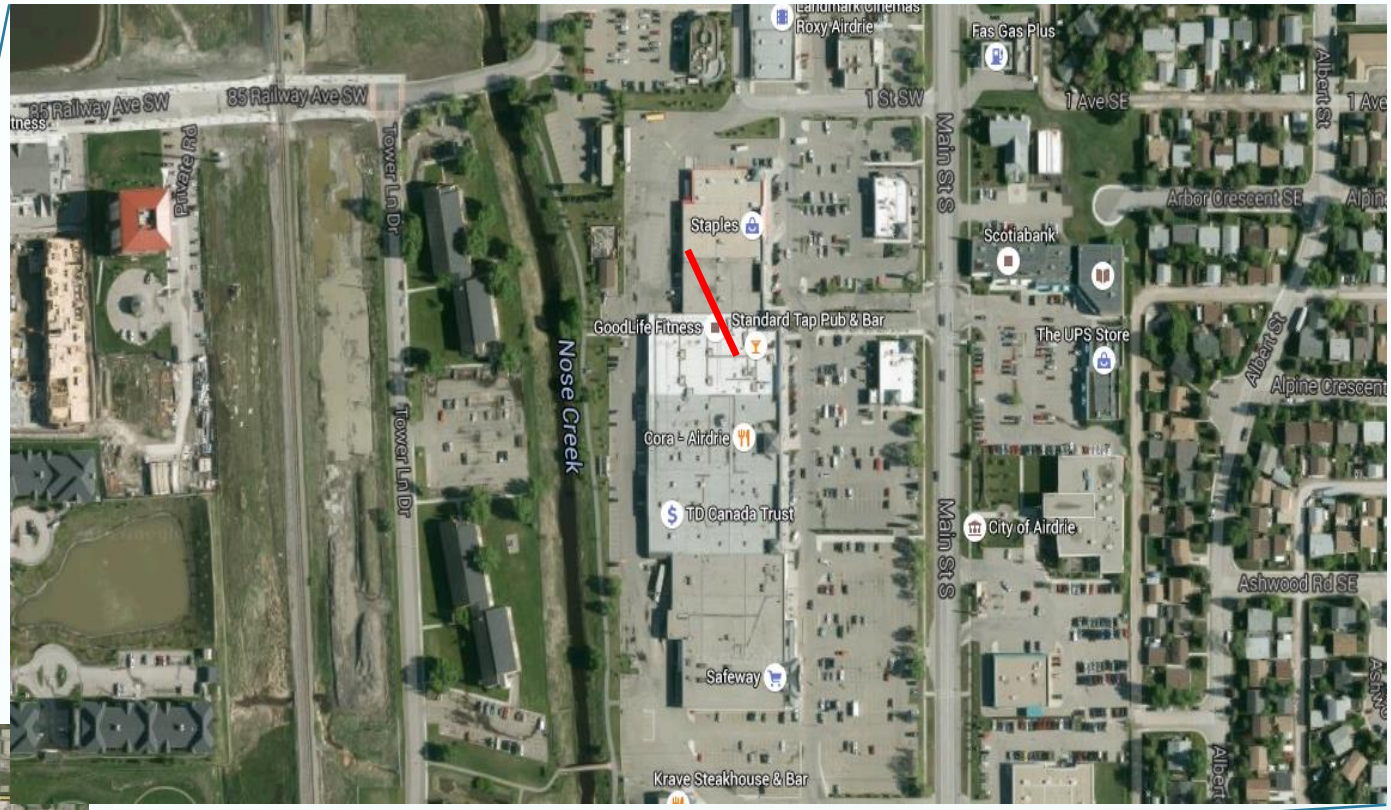
Well 06-12-027-01W5M AbaData View

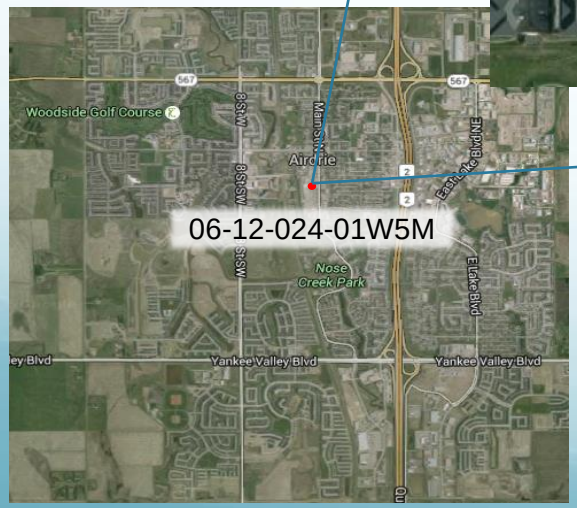


Location: Airdrie, Alberta

Abandoned Date: August 25, 1977

Well 06-12-027-01W5M Google Map View



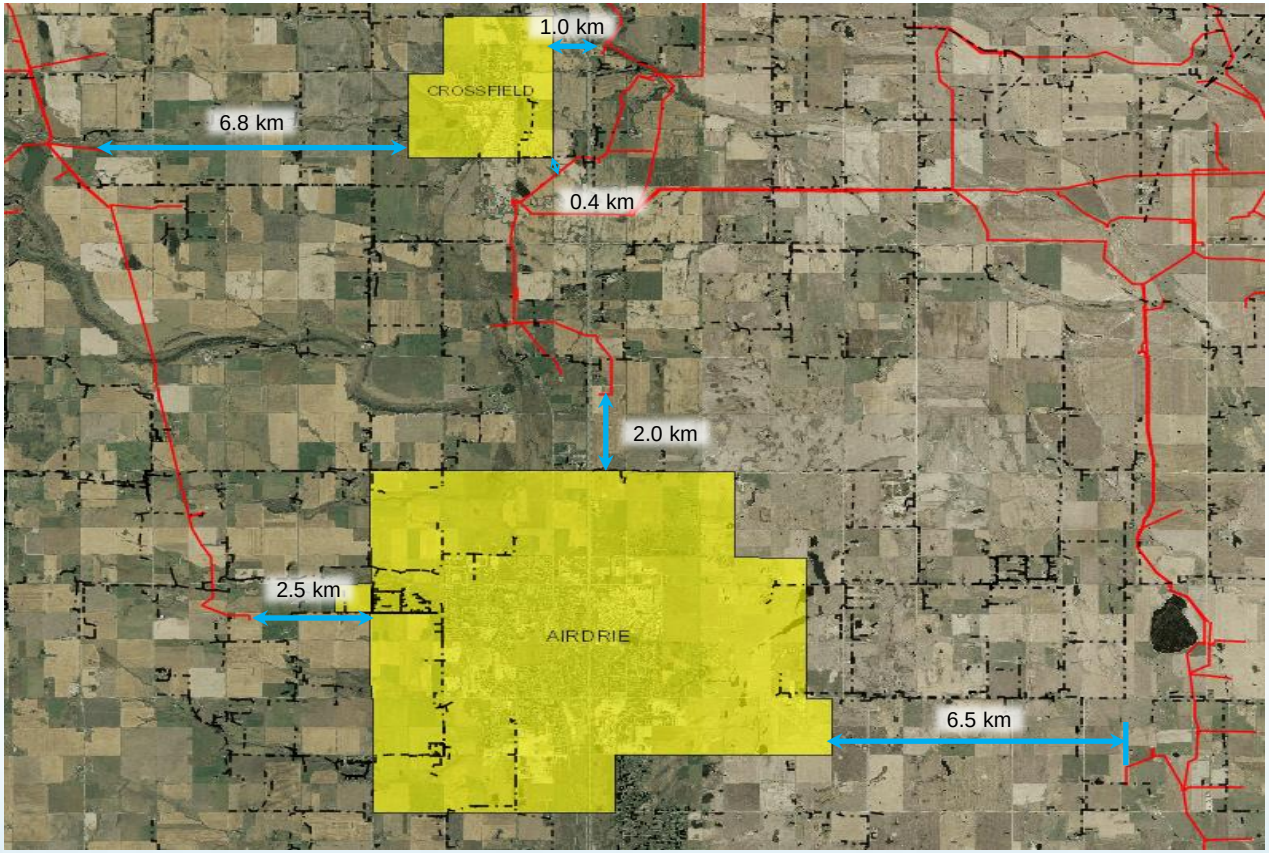


Risk Assessment of Abandoned Well 06-12-027-01W5M

Risk Category													
SCVF or GM History	Well Deviation	Cement Top	TVD (mKB)	Casing Failure History	Well Age	Inactive Well Status	Well Operation	H_2S Content (%)	Land Use	Protection of Useable Water Aquifers	Proximity to nearest water wells	Well Accessibility	SCORE
No Historical SCVF or GM	Deviated below 600 m KB	Unknown	2000-2999 mKB	Casing breakdown 50 % or greater	Spud pre 1975	Compliant	all other wells types	H2S > 25%	Priorty 3: Retail/Motel/Hotel	Useable Water, Aquifers not Protected	100 m < WSW ≤ 500 m Non-Drinking Water	Under Surface Structure	1950

- Well Name: Tipperary Et Al Crossfield 6-12-27-1.
- Current Licensee & Operator: ConocoPhillips Canada Resources Corporation.
- Cement Top: Unknown. Also, it can be assumed that the well was drilled & completed before 1975, so the probability of presence of cement around the surface casing from below the BGWP to surface will be low, therefore, it can be concluded that groundwater is not protected from gas migration.
- Surface Casing Shoe Depth: 371.2 m & BGWP: 542.4 m
- Perforations: 2705.1 m to 2714.9 m.
- Bridge Plug Capped with Cement: 2651.8 m to 2667.0 m.
- Risk Assessment Score: 1950 out of 3080.
- Therefore, it is a medium to high risk well.

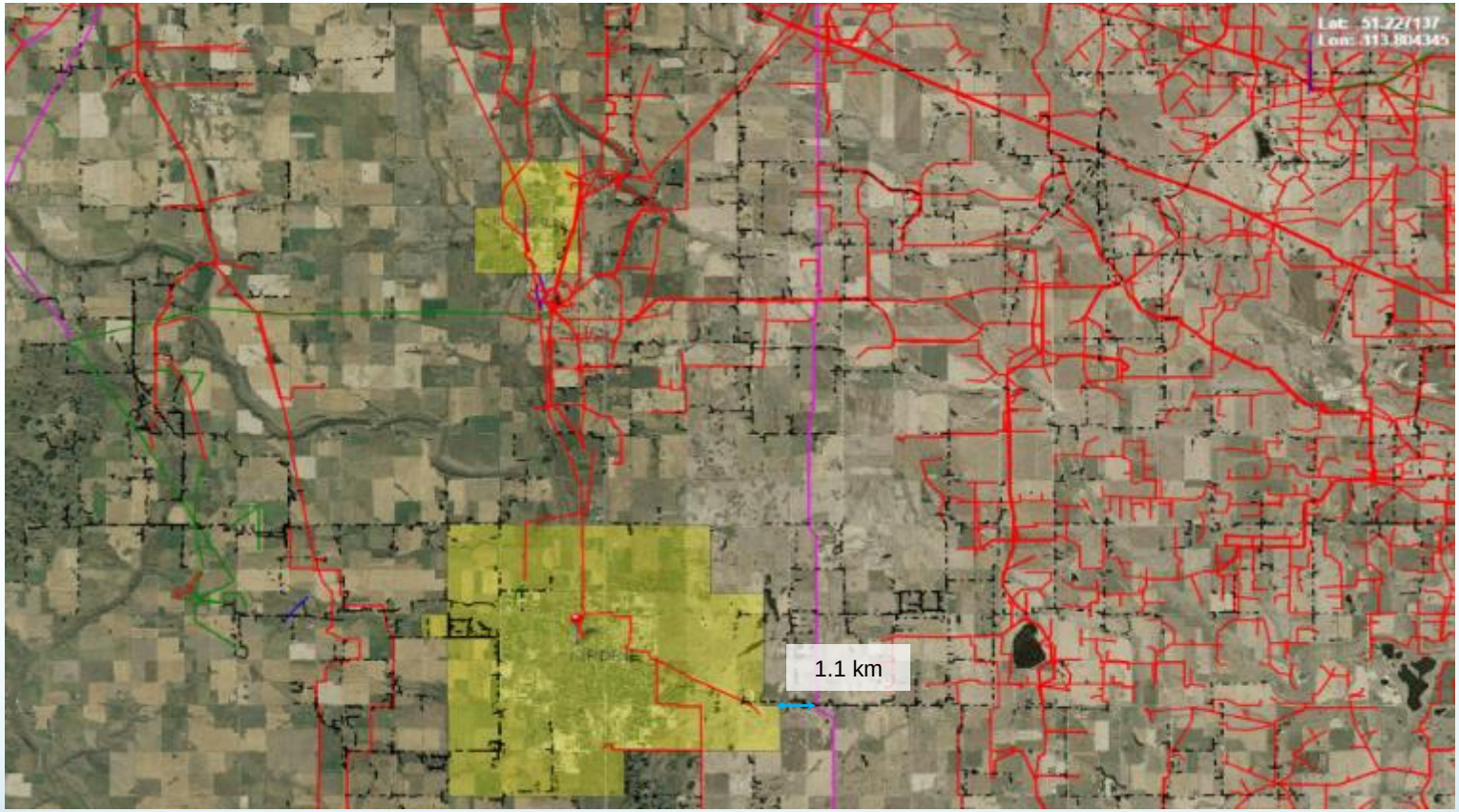
H_2S Gas Pipelines around Airdrie and Crossfield



- H_2S Content: Minimum of 10.1 mol/kmol (10,100 ppm) to 500 mol/kmol (500,000 ppm) [Approx. figures]

[Data & Image Source: AbaData]

Operating Pipelines around Airdrie and Crossfield



LEGEND:
Green: Crude Oil
Blue: Fresh Water
Purple: Alberta Products Pipe Line Ltd. (LVP like Condensate, Diesel Fuel, Heating Oil, etc.)
Red: Natural Gas, Fuel Gas, Sour Natural Gas, Misc. Gases, Oil Well Effluent, etc.

How can we be assured that monitoring equipment in pipelines under municipalities can detect small, pinhole leaks?

Nexen responds to suspension of 95 pipeline licences

SHEILA PRATT, EDMONTON JOURNAL 08.28.2015 |

Spilled oil rests on the dirt and grass near Nexen's Long Lake facility near Fort McMurray on Friday, July 17, 2015. The spill, which is enough to fill two Olympic-sized swimming pools, was discovered Wednesday afternoon. GARRETT BARRY / FORT MCMURRAY TODAY

http://www.edmontonjournal.com/Nexen+responds+suspesion+pipeline+licences/11327409/story.html

Calmar

100/01-36-49-27W4

A home is demolished in Calmar, Alta. in December 2010 after a gas well was discovered leaking in the neighbourhood in 2008. (CBC)

- Five homes were demolished in Calmar in 2010 for re-abandonment due to sweet gas leaking from an old abandoned well.
- Residents were asked to leave in 2013 and 2015 while Imperial Oil tried to fix the leak.
- Shockingly, the well is still leaking today.

Image from Abadata

Image from Abadata

Calmar

100/01-36-49-27W4

- Dozens of families were housed temporarily in hotels during the time of re-abandonment (approx. 3 weeks).

- Property values decreased for those houses bordering the well

A court case involving the town and the developers was started involving $400,000 in house compensation and $300,000 in additional damages (CBC News: 05/11/2011)

This is the municipality's liability!

Image from Abadata

Calmar

100/01-36-49-27W4

Risk Category												
SCVF or GM History	Well Deviation	Cement Top	TVD (mKB)	Casing Failure History	Well Age	Inactive Well Status	Well Operation	H_2S Content (%)	Land Use	Protection of Useable Water Aquifers	Proximity to nearest water wells	Well Accessibility
Serious SCVF or GM	Vertical no well logs	Unknown	1000-1999 mKB	Casing breakdown 50 % or greater	Spud pre 1975	Compliant	N/A	No H2S	Priorty 2: Residential Area playgrounds	Useable Water, Aquifers not Protected	WSW ≤ 100 m Non-Drinking Water	Under Residential Sturcture

Risk matrix total is 2040 out of 3080
This is a medium risk well that leaked.

Headlines…

CANADA November 23, 2014 11:27 am Updated: November 23, 2014 8:39 pm

UPDATE: Residents return to their homes, after sour gas leak southwest of Airdrie

By Alyssa Julie News Producer Global News

Comments 3 | Facebook 218 | Twitter | Email | Print | ...

Crews work to cap sour gas well southwest of Airdrie.

Global News

http://globalnews.ca/news/1687468/crews-work-to-cap-sour-gas-well-after-leak-southwest-of-airdrie/

In Hay River, orphaned sour gas well at risk of leaking

Aboriginal Affairs says this well is not currently a threat to people or the environment, but is showing signs of corrosion. (AANDC)

http://www.cbc.ca/news/canada/north/in-hay-river-orphaned-sour-gas-well-at-risk-of-leaking-1.2588465

Headlines…

Underground oil leak discovered in Southfield neighborhood

By: Ron Savage

April 24th 2016

Oil leaking from an abandoned well in a Southfield neighborhood is running into a culvert that drains into a creek that goes to the Rouge River

http://www.fox2detroit.com/news/local-news/131609033-story

Liability

Government of Alberta ■
Municipal Affairs

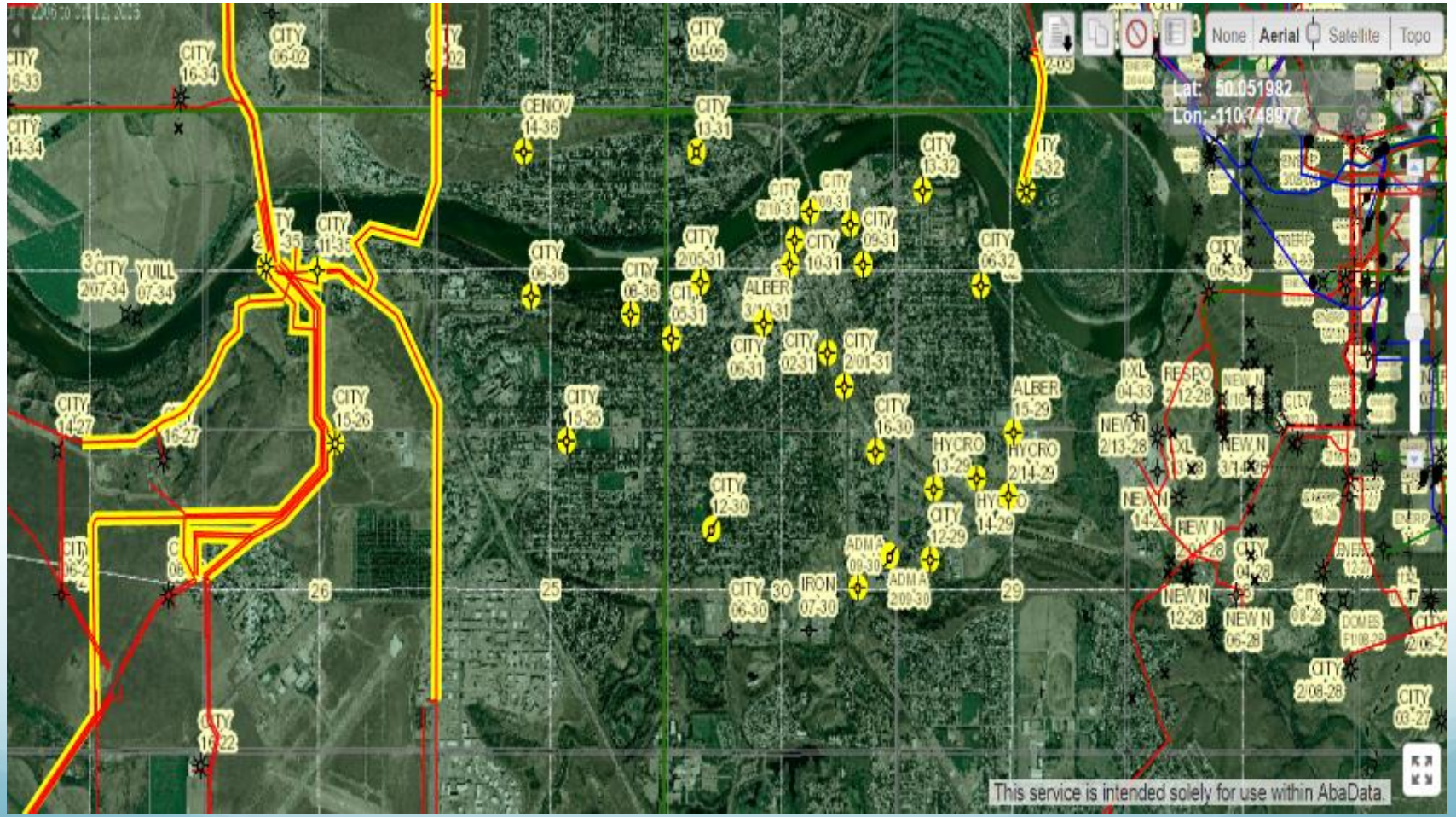
Information Bulletin

Number: 05/12 Date: Sept. 20, 2012

Advisory Land Use Planning Notes on New Regulatory Requirements for Surface Development in Proximity to Abandoned Wells

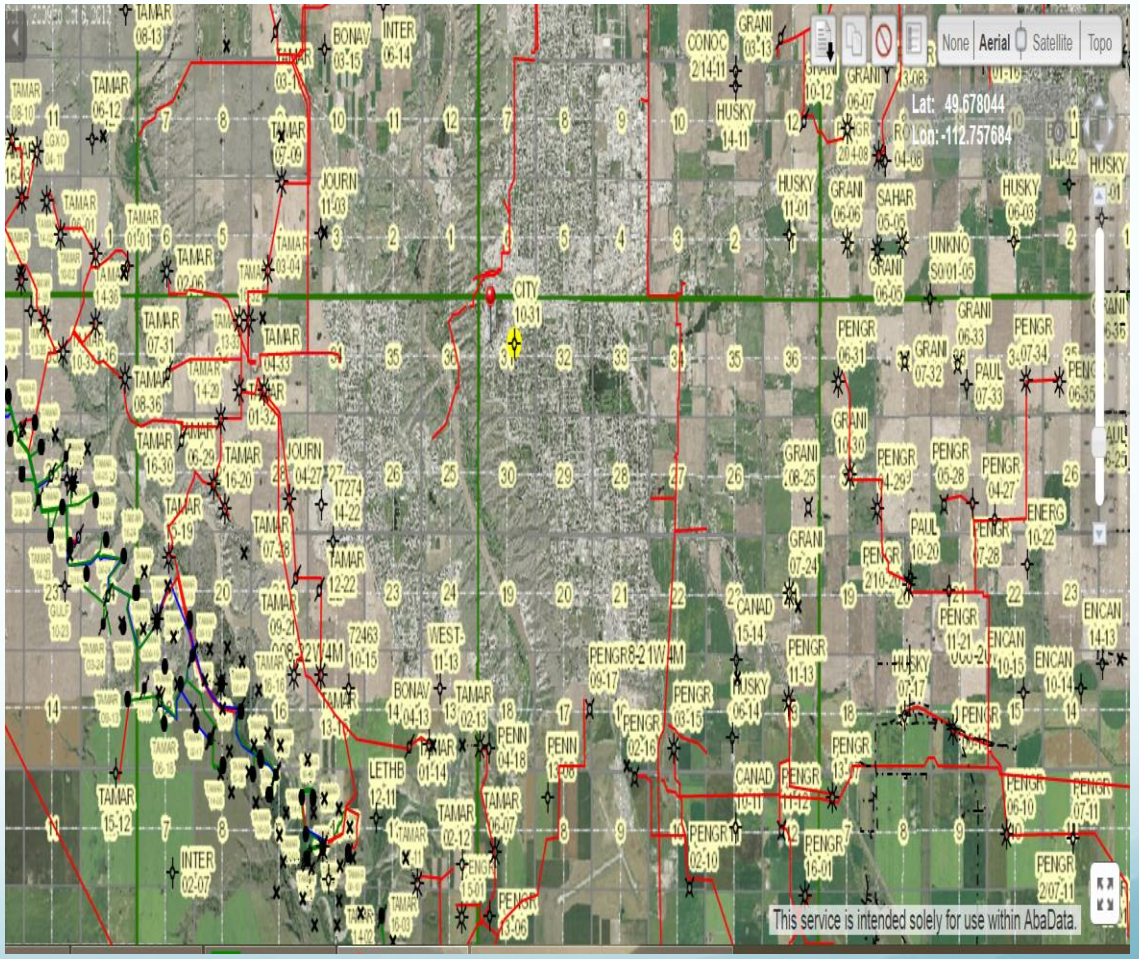
In summary, it is the responsibility of the developer or landowner (proponent) of the proposed subdivision and/or development to take measures to identify any abandoned wells within that property and to apply the required setback as set out in the ERCB directive. It is the responsibility of the municipality, as part of the subdivision and development application process, to ensure that the proponent of the subdivision or development has taken these measures and has applied the required setback. These efforts will ensure that abandoned wells are appropriately identified and suitable setbacks are incorporated in planning, development and construction decisions. The information that follows in this bulletin further explains these processes.

Medicine Hat



Lethbridge


CITY
10-31


None
Aerial
Satellite
Topo
Lat: 49.678044
Lon: -112.757684
CITY
10-31
This service is intended solely for use within AbaData.

Oilfield meets Municipal

Smallest intervention rig

Picture thanks to Greg Chapin of Wise Interventions

The SMALLEST coiled tubing unit that WISE Interventions has for well-site workovers is 3.3m wide by 12m long (pictured above).

Additionally, ~2-3 meters is required between the wellhead and the back of the unit.

The AER only requires a 5m setback from old abandoned wells: Obviously, as the Calmar example illustrates, 5m is simply not enough room to intervene and re-abandon a leaking gas well.

As well we need clear ACCESS to the wellbore.

Why are leaky wells risky?

Methane makes up the majority of natural gas leaks.
Methane is combustible, sinks in low lying areas that, if pooled in poorly ventilated buildings, can result in serious explosions.

March 1937 New London school in Texas
388 Children and teachers died
Accumulation of gas blamed for explosion

Image from:
http://www3.gendisasters.com/texas/2696/new-london-tx-school-explosion-mar-1937

Methane leaks above the Base of the Ground Water Protection can potentially contaminate groundwater.

Blow Out

Emergency Preparedness

- **Directive 071: Emergency Preparedness and Response Requirements for the Petroleum Industry**
- 5.2.4 Ignition Criteria 5.2.4.1 Sour Well Releases 8) The licensee must • include ignition procedures (e.g., ignition criteria flowchart) in its ERP, including a description of the equipment to be used in the event ignition criteria are met, and • acknowledge in its ERP that ignition authority will be assigned to a licensee representative on site.
- H2S become SO2 upon ignition, floating to aprx. The 5th floor height of a building.
- NOT ACCEPTABLE

Water vs Nitrogen

- The application of internal pressure to a closed system causes stress to be applied to individual components of the system. Those components may experience elastic deformation which, in turn, can result in leaks. Unfortunately, there is no current way of establishing the pressure integrity of a system without actually applying pressure.
- For this reason, oil and gas handling systems are pressure tested prior to being placed into operation.
- If a system is designed to operate with natural gas at high pressure, it is desirable to prove the system's integrity as closely as possible to its designed operating parameters. Should a leak develop or a component fail, it is preferable that this occurs with an inert gas rather than with a highly flammable material such as methane, with the consequent risk of explosion. The use of nitrogen as a pressure test medium allows a follow-up test under circumstances which simulate actual operating conditions.

Oilfield meets Municipal

- Ramping up for preparedness what does that look like?
- Liability – Risk
- Mutual Aide

Conclusions/ Recommendations

- Urban Development is encroaching on abandoned and suspend wells
- According to the Alberta Government Municipal affairs, liability for development lies with the municipality
- Use of the Risk Matrix will help assess the risk level of each individual well
- Municipalities should consider increasing the set-back distance from 5 m to at least 15m to allow a small service rig to intervene and re-abandon a leaky well.
- Municipalities need to make sure there is clear access to each wellhead.
- Once the wells are located and risk assessed, should we consider implementing technology that will provide continuous monitoring of the wellhead to immediately indicate if SCVF or GM begins in an abandoned well?
  - Should we implement technolgy that will detect SCVF/GM when it is at its initial stage right in the borehole without even waiting for it to come to surface? Is there a downhole monitoring tool which may be permanently installed and could provide continuous real-time monitoring?
- From the municipal land use bylaws, municipalities are required to, within the scope of their jurisdiction, utilize mitigative measures to minimize possible negative impacts. This takes us back to implementing continuous MONITORING in abandoned wells in municipalities.

Thank you

Acknowledgements:

Thanks to Deidre Macht
Lieu Le and Afia Natoma for help with developing the Risk Matrix
Greg Chapin from Wise Interventions for the photo of the intervention rig
Ed Davis from Abadata for letting us use their fantastic software

Questions?