Incident Summary #II-1326616-2022 (FINAL)

SUPPORTING INFORMATION	Incident Date		February 9, 2022
	Location		Fernie
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	2
		Injury description	Two individuals received minor cuts and bruises.
		Injury rating	Minor
	Impact – Damage	Damage description	Explosion and fire damage to a residential home, including blown out walls and collapsed roof. Damage to neighbouring homes from explosion concussion and flying debris.
		Damage rating	Severe
	Incident rating		Severe
	Incident overview		Escaping gas from a damaged gas line migrated into a home through building openings and contacted a source of ignition which resulted in a large explosion and subsequent fire. The exposed underground gas line was struck by an excavator while digging for a new water line for a new planned detached building on the property. The excavator strike caused the gas line to sever underground next to the home 50 feet away from where the excavation was taking place.
INVESTIGATION CONCLUSIONS	Site, system and components		The home on the property was approximately six hundred square feet and was originally built over 100 years ago. The home had a masonry crawl space under a portion of the building. The remainder of the home was constructed on blocks over natural dirt ground. The crawl space contained a natural gas fired hot water tank and heating furnace. The natural gas service to the home was at the rear of the property and consisted of a 3/4” underground steel gas line which transitioned to a 1/2” plastic polyethylene gas line approximately 6 feet away from the home. The gas line had a 90-degree elbow off the end of the transition fitting and continued approximately 10 feet to the gas meter on the corner of the home (Image 1). Gas supply pressure in the line to the meter was approximately 60 pounds per square inch (psi). The medium density polyethylene underground gas line and the exterior coating of the underground steel gas line found on the site are manufactured yellow which provides increased visibility while exposed and identifies it as containing a flammable product. Excavation work in the vicinity of a gas installation is subject to section 39 of the *Gas Safety Regulation*, requiring persons performing excavating work to: - Request gas service locations from the gas company prior to beginning excavation work,

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	- Consider a gas installation to lie within a one-meter zone on either side of the location indicated by the gas company, - Confirm gas line locations by hand digging to expose their exact locations, - Not excavate in a manner that is damaging or *dangerous* to a gas installation. Manners of excavation that are considered *dangerous* are not defined in the Regulation. The CSA Z662 Canadian Standard for Oil and Gas Pipeline Systems states that operating companies (Gas utility) shall communicate company-specific safe work practices and conditions to those who propose ground disturbance. The BC Common Ground Alliance best practices, identify a "*Tolerance zone*", based on the *Gas Safety Regulation*, within one meter on either side of an underground facility, such as a gas line. The guidance from the best practice document is for the ground disturber to "*exercise the necessary care*" within this zone. There is discretion given to the ground disturber who "may wish to consider using" lower risk methods such as hand digging, hydro-excavation, or pneumatic hand tools in the tolerance zone. WorkSafeBC produced a guideline document titled "Prevention of Damage to Buried Facilities in BC" that recommends "*The hand exposure zone is a distance 1m either side of the located marks within which an excavation with mechanical equipment must not take place, until the buried facility has been hand exposed and is clearly visible."* This recommendation is included in the standard for training programs produced by the BC Common Ground Alliance for ground disturbance. The gas utilities' guideline for excavation safety around natural gas states that when exposing gas lines, no mechanical equipment can be used within one meter of an identified buried gas line, until such time that the gas line has been exposed by hand. Once a gas line has been exposed, the guideline does not contain any rules or guidance addressing the protection of an exposed gas line or limits for distances away for mechanical excavation. Combustible gases have a specific range of fuel-to-air ratios in which ignition can occur called the flammable range. For natural gas, the flammable range is commonly identified as between 5-15% of a gas-air mixture. The 5% is the lower flammable limit (LFL) and the 15% is the upper flammable limit (UFL). These terms are also referred to as the lower explosive limit (LEL) and upper explosive limit (UEL) when detecting gas concentrations in an enclosed space. Natural gas concentrations outside of this range are typically not ignitable. For a natural gas explosion of a structure to take place, the released gas needs to mix with a volume of air to between its LEL and UEL then contact an ignition source. The expansion of gases during combustion will be contained by the structure causing a rapid increase in pressure inside that will force the structure outward. Natural gas is naturally odourless. Trace amounts of a chemical odorant called mercaptan are added to natural gas so it can be identified by smell if there is a leak. Mercaptan is derived from naturally occurring compounds like hydrogen sulphide, which has a strong smell even in very low concentrations.
Failure scenario(s)	Over 20 years prior to the incident, the gas utility company relocated the gas meter to the corner of the home from its original location to make it less susceptible to

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damage from snow and ice falling from the roof. This was done by cutting back the original steel underground gas line next to the home, where the original gas meter was located, and transitioning from 3/4” steel to 1/2” plastic polyethylene gas pipe using a manufactured transition fitting and 90-degree elbow that was routed to the new meter location at the corner of the home.

Approximately two months prior to the incident, the homeowner, who is a homebuilder by trade, began work to add a detached building at the rear of the property next to a laneway. A BC One Call ticket was obtained prior to this work being started which identified the location of the gas line service for the property. Work had begun to dig a trench for a new water line from the existing home to the new building location. A section of the polyethylene gas line was located and exposed where it crossed the new trench by the contracting company that was hired to trench for the water line. The gas line was exposed up to the transition fitting at the older steel gas service. A trench was dug part way from the foundation of the home to the location for the new building (Image 3). A waterline was installed in the trench from the crawlspace of the home through a drilled hole in the foundation. The trench was only partially dug to the new building location and the remainder of the waterline was left coiled in the trench, covered with plywood, and backfilled and marked with a wooden 2x4 to identify its location. When the trench was backfilled, the area around the gas line from the transition fitting up to the home foundation was backfilled with 3/4” clear crushed rock.

The location of the existing underground steel gas line needed to be relocated to accommodate the foundation of the new building. On the day of the incident, the gas utility was scheduled to disconnect the existing gas service and install a new one, relocated away from the new building location. The homeowner hired an excavator and planned on trenching for the new gas line, for the gas company, to reduce the cost of installation. The morning of the incident, the gas company crew did not arrive at the site as scheduled. While waiting for the gas company crew to arrive later in the afternoon, the homeowner and excavator operator began trenching to expose the buried coiled water line to extend it out to the new building location. The steel gas line was exposed and ran parallel to the new water line trench and was visible to the excavator operator from the machine.

No actions were taken prior to the excavation work commencing to anticipate for an accidental gas release or to identify risk factors such as, possible gas migration into the building, building occupancy at the time of the work or potential ignition sources in the area.

While digging the trench, the excavator contacted the steel gas line approximately fifty feet away from the home, pulling it upwards, causing it to bend, and damaging its protective outer coating (Image 5). The operator shut down the machine and the operator and homeowner thoroughly inspected the gas line. No sign of a gas leak was found at the location where the excavator struck the line. The gas utility was notified immediately that the line had been struck and a gas company technician was dispatched to investigate but did not arrive prior to the explosion.

The excavator pulling up on the steel line caused the buried polyethylene gas line to sever at a 90-degree elbow at the steel to plastic transition fitting, 6 feet away from the home (Image 7). The escaping gas traveled underground through the void spaces in the clear crush backfill up to the home and migrated inside.

The homeowner noticed a very faint gas odour near the home after the line was struck and went into the crawlspace and shut off the gas hot water heater and the

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	electrical switch to the gas furnace. Unknown to the owner there was a tenant in the home at the time. While the owner was exiting the crawl space and standing in the exterior doorway, the gas that had migrated into the home contacted a source of ignition resulting in an explosion which blew out the walls and partially collapsed the roof (Image 8).
Facts and evidence	Interviews were conducted with the excavator operator and the homeowner responsible for the excavation work. Excavator operator statements • He has been operating machinery as a general contractor for over 35 years and has worked as an independent excavator operator for the gas utility for over 25 years. • He had a map with measurements from the gas utility showing the approximate location of the underground gas line. • When he had dug the hole to find the water line, the gas line was exposed and visible. • The bucket of the machine was working within one inch next to the exposed gas line when the bucket or a rock in the bucket caught on the gas line and pulled it up. • He knew the gas line was there and could see it from the seat of the machine and was being cautious to avoid hitting it. • He saw the gas line when it was struck and stopped the machine and checked the gas line where it was hit. • The homeowner was in the trench and acting as the spotter but did not witness the gas line being hit by the machine. • When digging around underground gas lines, he always stays three feet away from the location of a suspected underground gas line and has the line exposed by hand. Once it is exposed by hand, he will work cautiously around the line to within an inch if the line is visible or there is a spotter. • He is unaware of the Gas Safety Regulation for excavating near underground gas lines. Homeowner statements • He is a registered contractor and home builder who was doing the work to build a new detached carriage home at the back of the property. • He had made a BC One Call and received drawings showing the approximate location of the underground gas line. • The gas utility was scheduled to be onsite in the morning to decommission the gas line before they started digging then to install a new gas service in the new trench above the water service and away from the foundation of the new purposed carriage home. • The gas utility crew went to another location and would not be onsite until the early afternoon. • When the gas utility contacted the homeowner that morning to inform that the crew would not be there until the afternoon, he felt frustrated and pressure to do excavation work to try to make progress while they were there and there was an ongoing financial cost for the equipment and operator being on site. He decided to proceed with the digging to get the water line out of the hole while waiting for the gas utility crew to arrive to shut off and disconnect the gas line. • After exposing the gas line no further actions were taken to protect it from accidental damage.

- He was in the trench when the gas line was hit by the excavator, but he did not see it happen. After the line was hit, the operator shut off the machine and told him that the gas line had been struck. He could see that the steel line had been bent up where it was hit. They both inspected the line where it was hit and could not see, hear, or smell any gas leaks.
- He informed the gas company immediately that the gas line had been struck but they did not suspect a gas leak.
- After the line was struck, he was standing next to the gas meter location at the home and detected a faint smell of gas. He went inside the home to shut the furnace and hot water tank off but did not smell gas in the home.
- The new water line went through a 1" hole in the foundation that was not sealed, the remaining portion of the home was built on concrete pads with wood posts holding it up, over a dirt crawl space.
- He was unaware of the Gas Safety Regulation and had never read it.

Summary

The excavator operator and homeowners' statements indicate they did not perceive that they were working in a manner that was dangerous. They did not state an awareness of explosion risks or hazards when asked. They indicated a limited understanding of gas flammability and explosion mechanics.

Odorant test report from the gas utility

- Multiple gas samples were taken by the gas utility and sent for odorant analysis at their laboratory. For odorant concentrations to be deemed acceptable, gas samples need to contain between 8-24 mg/m3 of odorant. The testing measured the amount of odorant found in the samples to be between 12.5-15.5 mg/m3. This concluded that the natural gas in the distribution grid contained an adequate amount of odorant.

Testing and analysis

Analysis of the damaged sections of piping was conducted by an independent laboratory (Appendix A). The analysis concluded that the material of the pipe fittings examined was consistent with the requirements for underground gas lines and there were no signs of manufacturing defects. Analysis found that the pipe suffered a catastrophic ductile fracture due to overload conditions introduced to the pipe. The damage to the pipe indicates the piping and elbow were fully restrained or loaded at a high strain rate at the elbow location. The gas line at the location of the damage was buried in the earth which fully restrained it. The excavator applying force to the gas line provided a high strain rate causing the gas line to sever from the elbow.

Engineering analysis

An independent engineering analysis was conducted to examine the components, design, and installation of the gas service line to the home (Appendix B). The findings of the analysis found that all materials specified and used by the gas utility in the design and installation of the gas service line were compliant as required. Compliance was confirmed through a thorough review of the material specifications, CSA B137.4 material property requirements, and laboratory test results which confirm the material properties of the polyethylene pipe involved.

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	The independent engineering report also stated that, in general, when subject to the same force, elbows can increase the stress on a pipe when compared to a long radius bend, increasing the chances of the failure occurring near the elbow.
Causes and contributing factors	The gas line in the vicinity of the excavation work had been located, identified, and exposed. The cause of the explosion was the ignition of an uncontrolled release of gas from the disconnected/broken gas line after it was struck and dislodged by the nearby excavating work. The emphasis of the regulation and guidelines are focused on prevention of damage through identification and exposure of underground gas lines and has not been found to directly consider explosion risks prior to an accidental gas release. Contributing factors that could be considered dangerous manners of excavation work include: • Working in close proximity to an exposed and unprotected gas line with a mechanical excavator. • Working in close proximity to an unprotected gas line without a spotter. • Misunderstanding of explosion risks when working near live gas lines. • Not moderating excavation practices when increased risk of explosion hazards are present such as occupied buildings, and ignition sources.

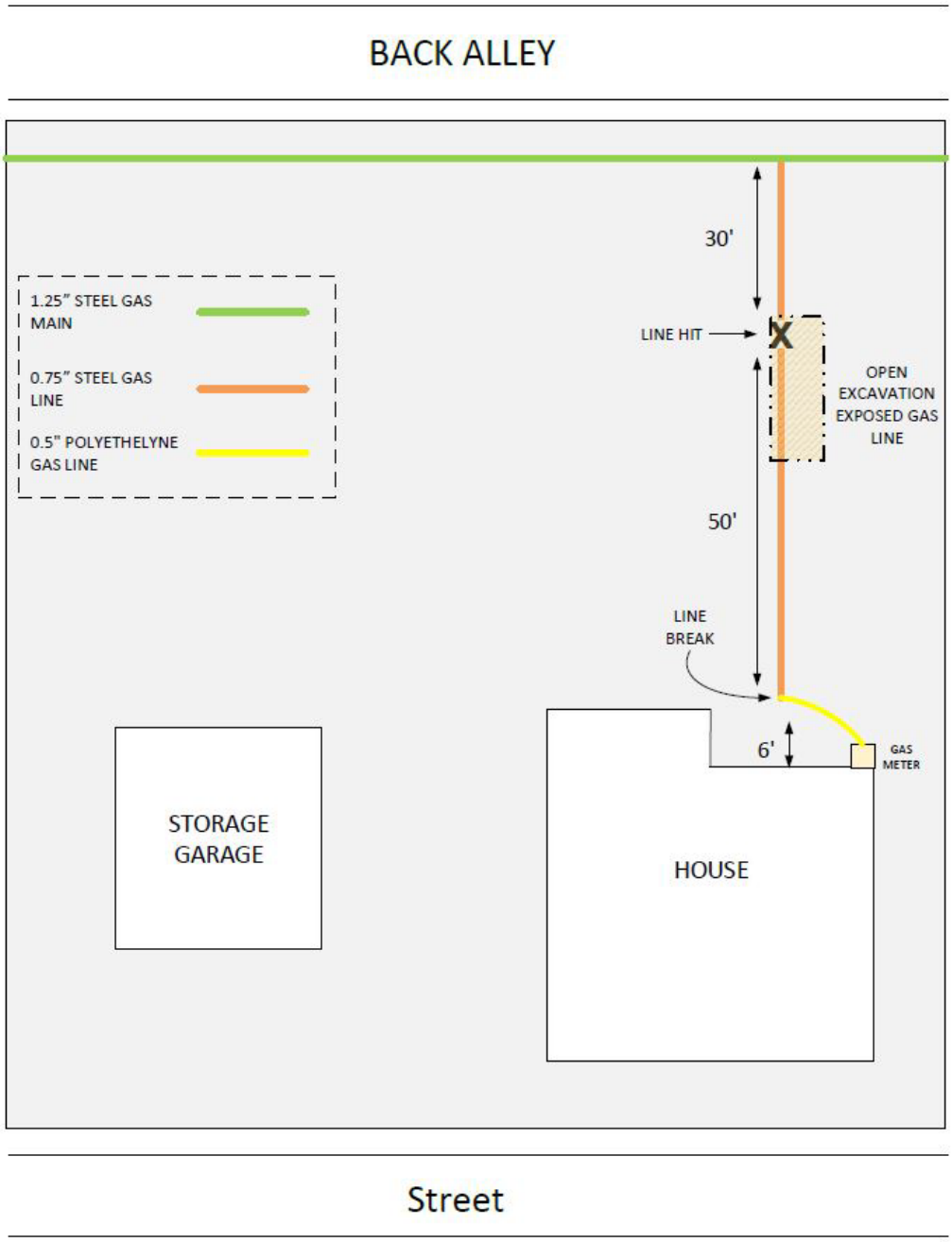

Image 1 – Diagram of site showing locations of buried gas lines, line hit and line break.

Image 2 – The home before and after the explosion and fire.

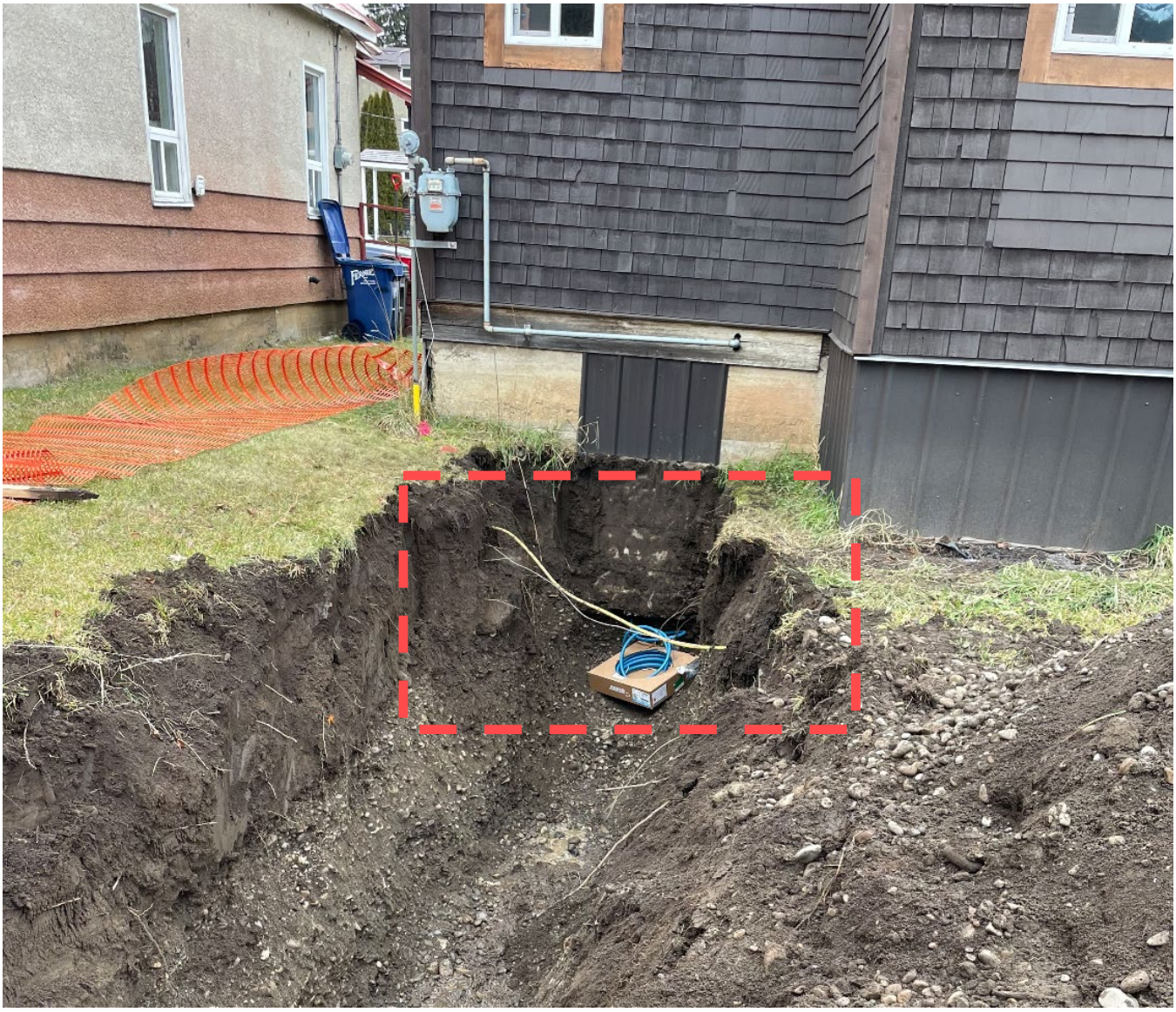

Image 3 – Red box showing exposed gas line (yellow) during previous excavation for new water line (blue). Area was later backfilled with ¾” crush rock.

Image 4 – Red box showing area of excavation work and exposed gas line on day of incident. Excavation filled with water after the incident.

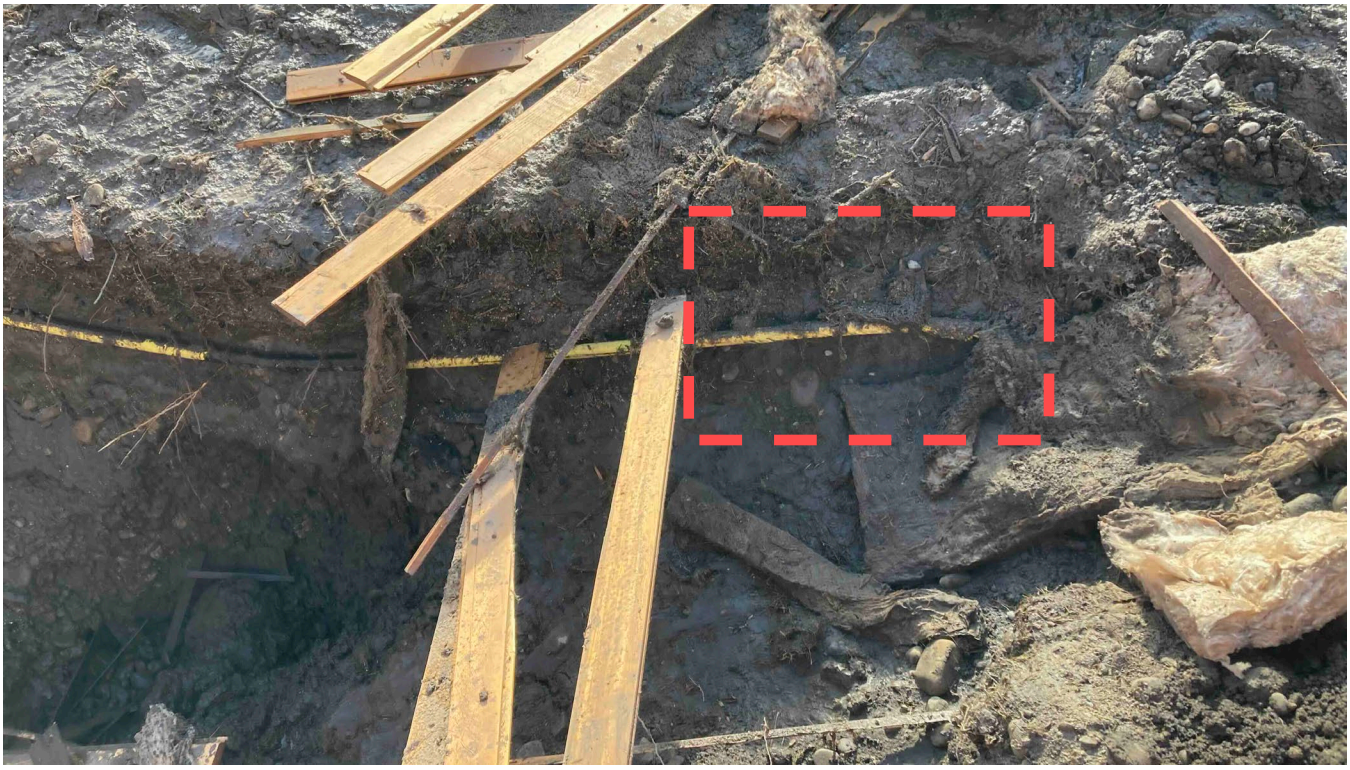

Image 5 – Excavation showing exposed yellow 3/4” steel gas line. Red box showing area gas line was struck and pulled upward by excavating machine.

Image 6 – Red box showing area exposed by hand after the incident detecting the separated gas line. 3/4” clear crush backfill was observed surrounding 1/2” plastic gas line.

Image 7 – Close up of separated gas line that was uncovered after the incident.

Image 8 – Home collapsed from explosion with fire fueled by leaking gas.

Image 9 - Front of home collapsed from explosion.

Image 10 – Home with rear exterior wall removed.