National Transportation Safety Board
Washington, D.C. 20594

Office of Railroad, Pipeline and Hazardous Materials Investigations

Operations / Integrity Management

Group Chairman's Factual Report of the Investigation

Operations and Integrity Management Report

Atmos Energy

Natural Gas Pipeline Release

Dallas, Texas

February 23, 2018

NTSB Investigation No.:

PLD18FR002

Report Date: July 22, 2020

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B. Accident Summary

For a summary of the accident, refer to the *Accident Summary* report within this docket.

C. Accident Site

1. Location of the Accident

The accident occurred in the Walnut Hill Estates subdivision in Dallas, Texas, which was constructed in the late 1940s.[2] The house involved in the accident was built in 1947 and located at 3534 Espanola Drive, Dallas, Texas, a Class 3 location.[3] The houses involved in the two incidents[4] which occurred on February 21, 2018 and February 22, 2018 were built in 1948 and located at 3527 Durango Drive, Dallas, Texas and 3515 Durango Drive, Dallas, Texas, respectively. All three of these houses were built with a frame construction, pier and beam foundation and no basement.[5] The three houses shared an unpaved alley which contained the sanitary sewer main and natural gas main that served the houses (Figure 2).[2,6]

The sanitary sewer main had been originally installed in the 1940s and was replaced by the City of Dallas in 1995. The sewer main and lateral replacement project was performed under a contract between the City of Dallas and Atkins Bros. Equipment Co., Inc. A City of Dallas Water Department Sanitary Sewer Construction Inspector oversaw the contractors' work. The sanitary sewer main was specified to be 8-inch diameter PVC at a depth which varied between about 4-7 feet in the alley and with a Class "B-1" embedment (Figure 3). The contractor was required to replace the sewer laterals that extended between the sewer main and the property line of each home in the alley. The PVC sewer lateral pipes for homes on the south side of the unpaved alley extended over the natural gas main. The sewer laterals were specified in accordance with *Dallas Water Utilities Standard Drawings, Details, & Appurtenances for Water and Sanitary Sewer Construction Methods – March, 1991*.[6]

[2] Original Main Installation for Fontana-Larga-Marsh-Almazan 1947
[3] A gas pipeline's class location broadly indicates the level of potential consequences for a pipeline release based upon population density along the pipeline. According to 49 CFR §192.5(a), class locations are specified by using a "sliding mile" that extends 220 yards on both sides of the centerline of a pipeline.
[4] The term "incident" is used throughout this report in reference to the events at 3527 Durango Drive and 3515 Durango Drive. Use of this term does not indicate that these events meet the Pipeline and Hazardous Materials Safety Administration's definition of incident as promulgated in 49 CFR §192.3.
[5] http://www.dallascad.org/DataProducts.aspx, accessed 06April2020
[6] Sanitary Sewer References from the City of Dallas

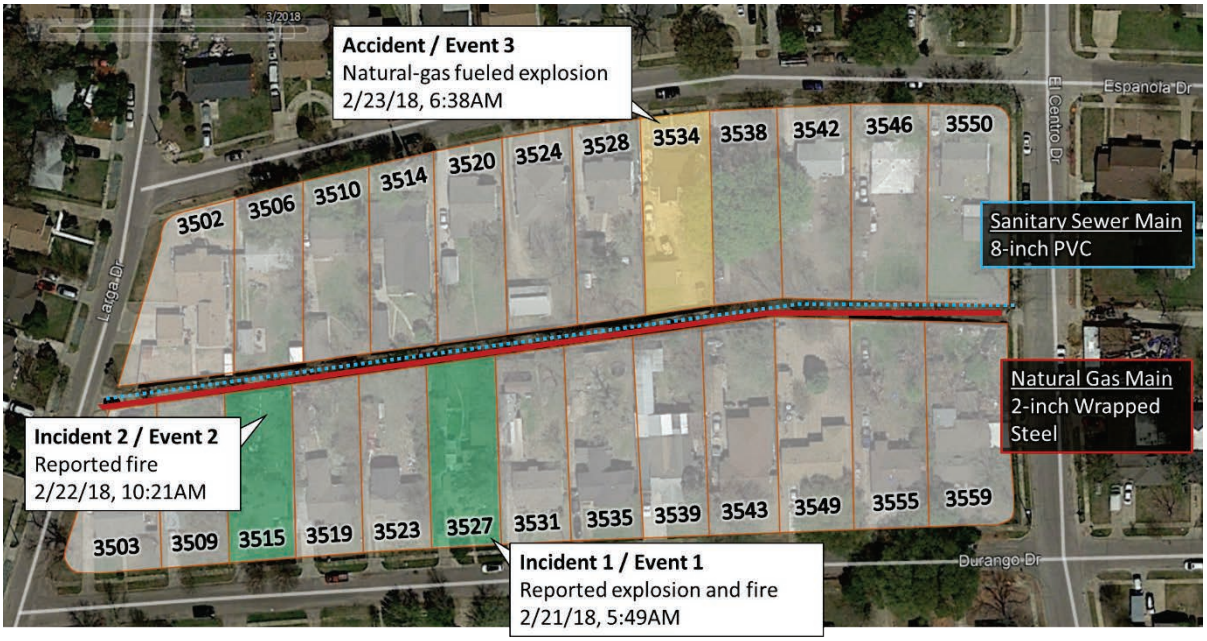

Figure 1. Approximate Location of Accident, Preceding Incidents, and Utilities in Shared Alley[2,6]

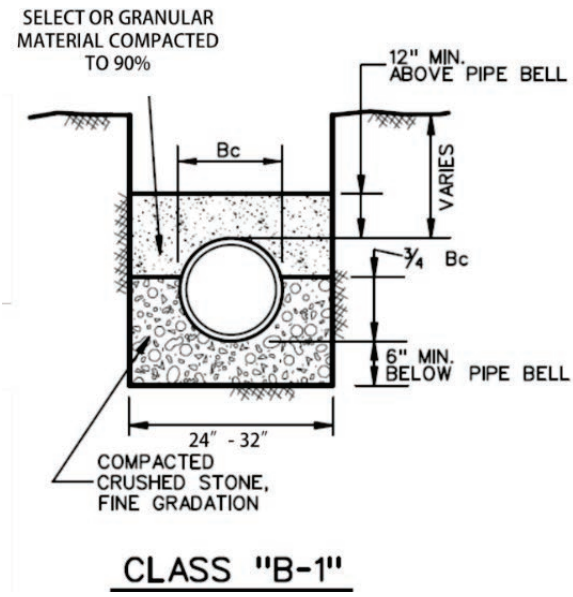

Figure 2. Example Class B-1 Embedment for 8-inch Diameter Wastewater Piping[7]

[7] Simplified from "Standard Drawings for Water & Wastewater Construction," Dallas Water Utilities, City of Dallas, October 2016.

2. Weather

The National Transportation Safety Board's Senior Meteorologist gathered relevant weather data for the accident location.[8] Liquid-equivalent precipitation data for Dallas Love Field Airport (DAL) in Dallas, Texas, which was located about 1 mile south of the accident site at an elevation of about 485 feet, was obtained from the National Weather Service (NWS) and from the Applied Climate Information System (ACIS).[9] A graph of the cumulative precipitation totals for DAL for the time period December 1, 2017 through February 23, 2018 is shown below in Figure 4. Temperature observations at DAL between February 20, 2018 and February 23, 2018 are shown in Figure 5.

The NTSB Weather Study identified notable liquid-equivalent maximum precipitation records[10] set for DAL between December 1, 2017 and February 23, 2018, including:

- 3.21 inches was the record daily[11] total for December 19, 2017
- 3.83 inches was the record daily total for February 20, 2018
- 1.66 inches was the record daily total for February 21, 2018
- 6.14 inches, recorded between February 20-22, 2018, was the record three-day total for the month of February
- 7.14 inches, recorded between February 1, 2018, and February 22, 2018, was the record month-to-date total

The NTSB's Senior Meteorologist clarified that in the 10 years prior to February 23, 2018, higher three-day total liquid-equivalent precipitation had been observed at DAL in late October and late November 2015.

[8] NTSB Weather Study WX-PLD18FR002

[9] ACIS is a system architecture developed, maintained, and operated by the National Oceanic and Atmospheric Administration Regional Climate Centers. Further information on ACIS can be found at http://www.rcc-acis.org/index.html.

[10] For determining records, the time period for consideration was August 1, 1939, through April 23, 2018.

[11] Daily precipitation totals are calculated between 0000 and 2359 local time.

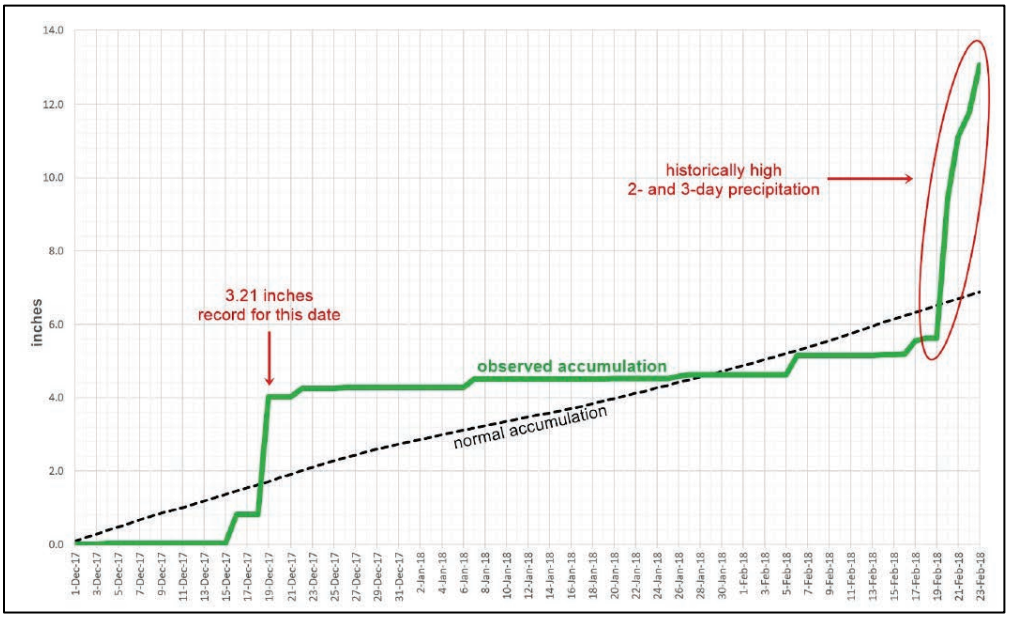

Figure 3 -- Liquid equivalent precipitation accumulation (inches) at DAL for December 1, 2017 through February 23, 2018 along with normal accumulations for this calendar period

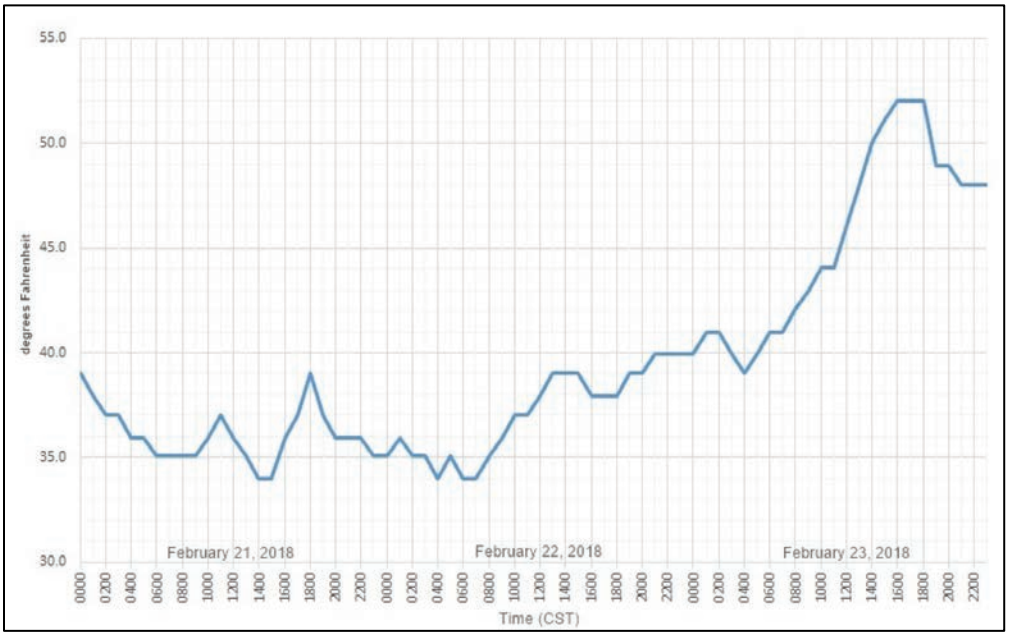

Figure 4. Temperature observations (rounded to nearest whole °F) at DAL between 2353 CST on February 20, 2018, and 2253 CST on February 23, 2018. Times of observations have been rounded to the nearest whole hour.

D. Description of the Operator[12]

Atmos Energy Corporation (Atmos Energy), headquartered in Dallas, TX, is an independent, publicly held natural gas distribution company. As of March 2018, Atmos Energy served more than 3 million distribution customers in over 1,400 communities across eight states. Atmos Energy also managed company-owned natural gas pipeline and storage assets. Atmos Energy employed approximately 4,600 people.

As of March 2018, Atmos Energy's distribution operations were divided into six divisions serving eight states, encompassing approximately 69,000 miles of distribution pipeline: Colorado-Kansas, Kentucky/Mid-States, Louisiana, West Texas, Mississippi, and Mid-Tex.

Atmos Energy's Mid-Tex Division was formed when Atmos Energy acquired distribution and transmission assets from TXU Gas Company in 2004. As of March 2018, Mid-Tex distribution operations served approximately 550 communities and 1.6 million customer meters in the North-Central Texas region, including the Dallas-Fort Worth metroplex. The Mid-Tex distribution assets included approximately 31,850 miles of distribution pipelines and approximately 310 miles of transmission pipelines. As of March 2018, approximately 1,700 people were employed by the Mid-Tex Division.

The organizational structure of Atmos Energy Shared Services and Mid-Tex Division as of March 2018 are shown in Figure 6, Figure 7, and Figure 8. This accident occurred on assets within Atmos Energy's Mid-Tex division (Figure 9).

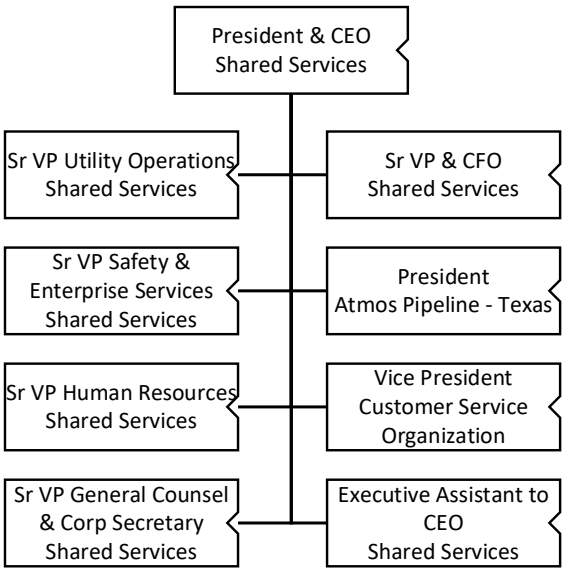

Figure 5. Atmos Energy Shared Services Organizational Structure

[12] Atmos Corporate Overview

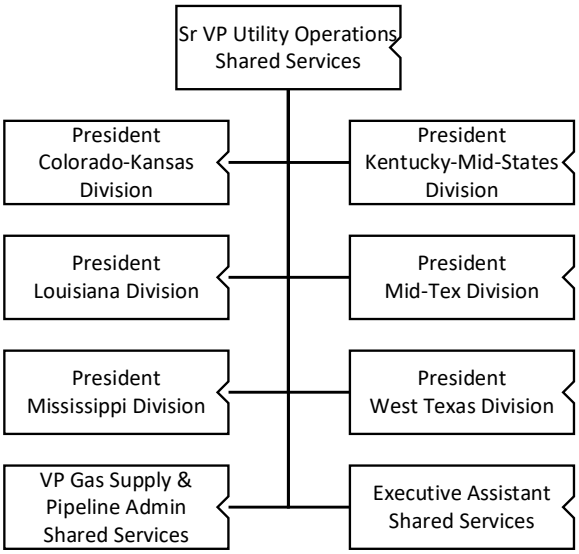

Figure 6. Atmos Energy Utility Operations Organizational Structure

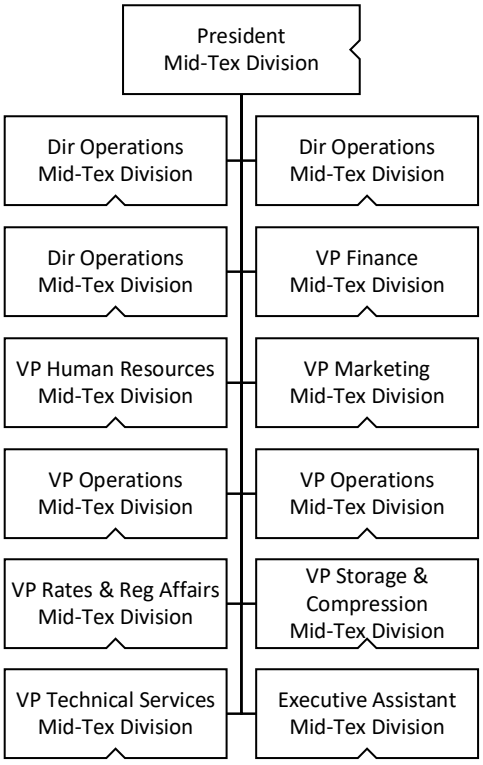

Figure 7. Atmos Energy Mid-Tex Division Organizational Structure

Figure 8 -- The Atmos Energy Mid-Tex Division Map

E. The Impacted Gas Distribution System

1. General Description

Natural gas service was provided to the Walnut Hills subdivision during its original construction. The 2-inch diameter steel main (the natural gas main) that served the three houses where natural gas related events occurred was installed in 1946. The exterior of the natural gas main was spiral wrapped with coal tar enamel coating.[2,13] Atmos Energy did not have records of the manufactured date of the gas main or name of the company that manufactured the pipe.

The natural gas main was located in the alley that extended behind the affected houses. Service lines were connected to the natural gas main to provide natural gas to each residence along the alley where the accident occurred. Each service line extended underground to the location of the service regulator and meter. In this area, the service regulators and meters were typically located on the customer's property near the rear property line. The service lines transitioned aboveground at about the operating pressure of the natural gas main until it reached the service regulator. The pressure was then reduced to about 0.25 psig prior to reaching the meter. The service line and Atmos-owned[14] portion of the system ended at the outlet of the meter. All piping downstream of the outlet of the service meter was the responsibility of the customer (Figure 10).

The customer-owned piping included the portion that transitioned below ground downstream of the meter, extended across the yard to the residence, transitioned above ground near the residence, and entered the residence, as well as all natural gas piping contained within the home itself. All the customer-owned piping operated at about 0.25 psig based on the service regulator set point.[15]

The natural gas main had a maximum allowable operating pressure (MAOP) of 55 psig. NTSB investigators reviewed the operating pressure data for the gas main for the period between 2016 through the time of the accident in 2018; all pressure measurements reviewed were below the MAOP. Figure 11 shows pressure indications around the time of the accident, including post-accident pressure measurements that were taken during the gas odorization tests (see Section I.2).

The natural gas main was cathodically protected.[16] Atmos Energy provided documentation of cathodic protection related work performed within this particular cathodic

[13] NTSB Materials Laboratory Factual Report No. 18-067 and 19-028

[14] All portions of the gas distribution system described in this report to be "Atmos-owned" are regulated by the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) and the Texas Railroad Commission (TX-RRC).

[15] The service regulators were tested post-accident (see Section H.3)

[16] Cathodic protection (CP) is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. A simple method of protection connects the metal to be protected to a more easily corroded "sacrificial metal" to act as the anode. The sacrificial metal then corrodes instead of the protected metal. For structures such as long pipelines, where passive galvanic cathodic protection is not adequate, an external DC electrical power source is used to provide sufficient current.

protection zone since 1976. [17] There were two test stations in this zone: station #1 showed readings beginning in 1976 and is identified as 3655 Durango Drive, and test station #2 showed readings beginning in 1984 and is identified as 3502 Espanola/3515 Durango. The data indicates a negative voltage of at least 0.85 volts over the last 10 years. [18]

Documentation of gas sample analysis was provided by Atmos Energy for the six months prior to the accident. [19] Atmos Energy indicated that all measurements were within a range that was acceptable.

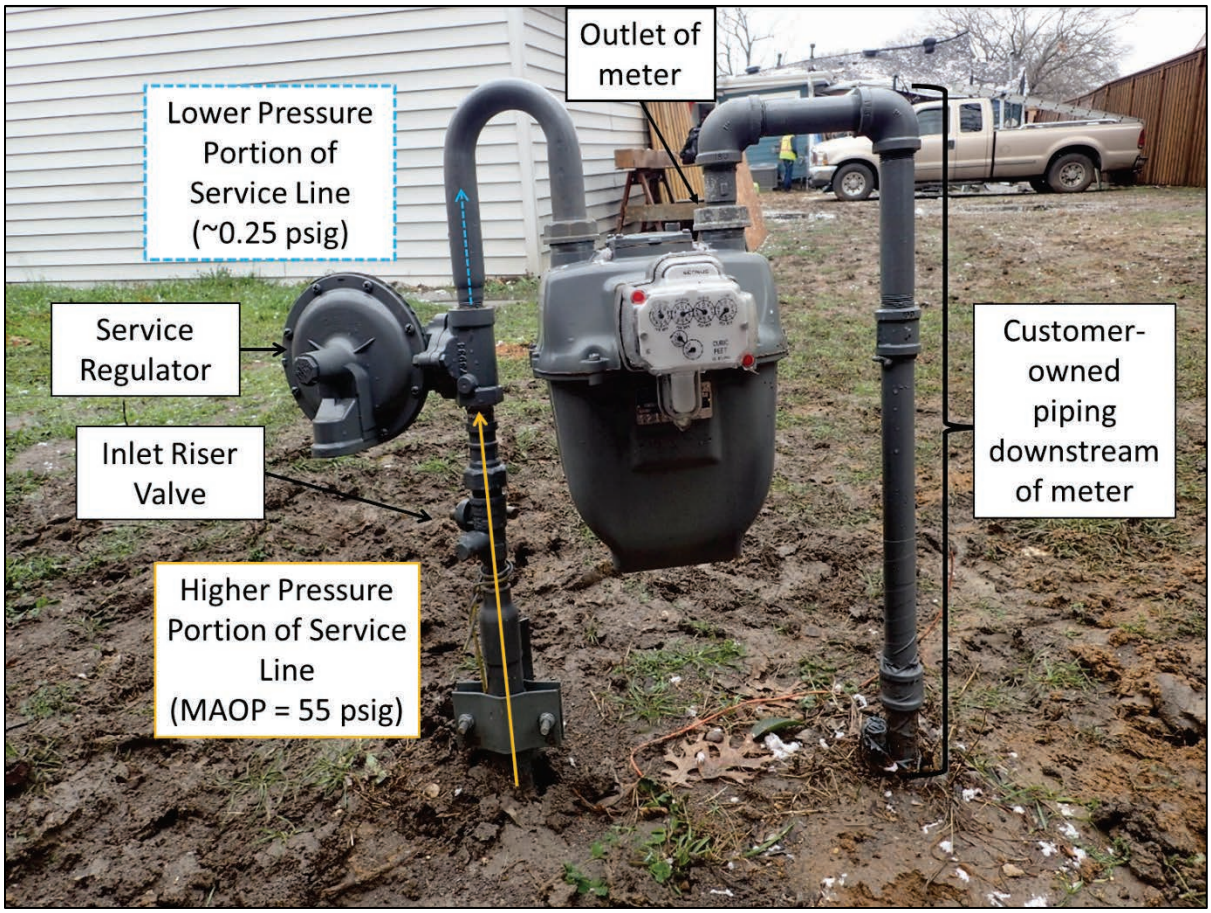

Figure 9. Example service regulator and meter (Photo taken at 3534 Espanola Drive post-accident on 2/23/18 by BakerRisk for Atmos Energy)

[17] Multiyear Cathodic Protection Readings
[18] 49 CFR Part 192, Appendix D, "Criteria for Cathodic Protection and Determination of Measurements," requires, in part, that cathodically protected steel structures have a negative voltage of at least 0.85 V.
[19] Atmos Gas Sample Analysis

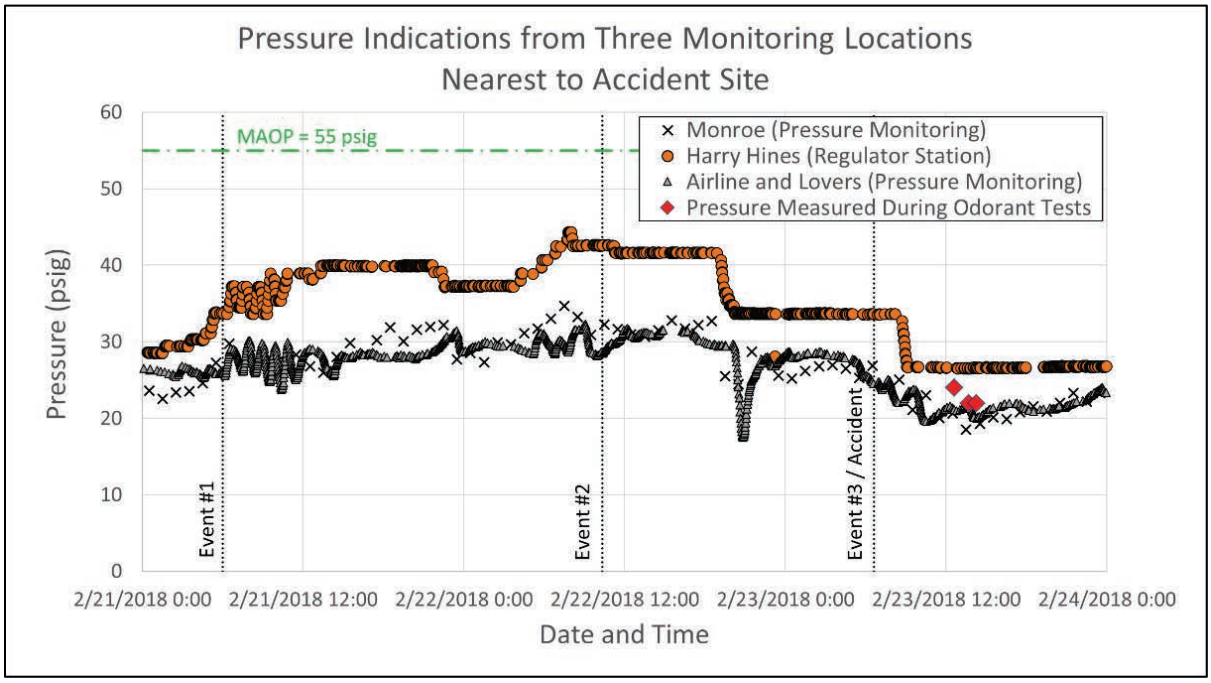

Figure 10. Pressure Measurements Taken Near the Accident Location Before and After the Accident

2. Regulatory Oversight of the Pipeline System

PHMSA is responsible for ensuring adequate protection against risks to life and property posed by pipeline transportation of natural gas.[20,21] The federal government establishes minimum pipeline safety standards under the U.S. Code of Federal Regulations (CFR), Title 49, "Transportation." Through certification by PHMSA Office of Pipeline Safety (OPS), the Pipeline Safety Department of the Texas Railroad Commission (TX-RRC) inspects and enforces the pipeline safety regulations for intrastate gas distribution pipeline operators in Texas. TX-RRC requirements for intrastate gas distribution systems are codified in Texas Administrative Code, Title 16, "Economic Regulation," Part 1, "Railroad Commission of Texas," Chapters 8, "Pipeline Safety Regulations" (16 TAC Chapter 8).

The Atmos-owned portion of the pipeline system serving the Walnut Hills neighborhood includes the main and service lines. Per 49 CFR §192.3, the service line ends at the outlet of the customer meter.

The piping downstream of the customer meter outlet is not subject to federal regulations. It is constructed under permit from the local jurisdiction and is maintained by the customer. In residential areas with single family homes, this piping is typically referred to as "customer piping," as it is owned by the homeowner. Gas appliances and the lines supplying them are a

[20] Norman Y. Mineta Research and Special Programs Improvement Act
[21] Title 49 United States Code (USC) Subtitle VIII—Pipelines, Chapter 601—Safety

part of each homeowner's piping system. It is also common to refer to the piping extending from the meter to the home as the "house line."

TX-RRC requirements adopt PHMSA requirements by reference, including:

- 49 CFR Part 191, *Transportation of Natural and Other Gas Pipeline; Annual Reports, Incident Reports, and Safety-Related Condition Reports*
- 49 CFR Part 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*
- 49 CFR Part 199, *Drug and Alcohol Testing*, and 49 CFR Part 40, *Procedures for Transportation Workplace Drug and Alcohol Testing Programs*

TX-RRC imposes additional requirements for intrastate gas distribution operators operating in the state of Texas. Some of these more restrictive requirements are applicable to the gas distribution system in the Walnut Hills neighborhood, including:

- 16 TAC §8.205, "Written Procedure for Handling Gas Leak Complaints," which requires, in part, that each gas company have written procedures which include:
    - procedures for locating the source of a leak and determining the degree of hazard involves,
    - a chain of command for service personnel to follow if assistance is required in determining the degree of hazard,
    - instructions to be issued by service personnel to customers or the public or both, as necessary, after a leak is located and the degree of hazard determined, and
    - a requirement that supervisory review of leak complaints must be completed and documented by 10:00 am of the next business day for calls received by midnight on the previous day.
- 16 TAC §8.206, "Risk-Based Leak Survey Program," which requires, in part, that each operator has either a prescriptive or risk-based program for leak surveys. As of the time of the accident, the piping in the area around the accident was leak surveyed under Atmos Energy's prescriptive program. The prescriptive program requires the operator conduct leak surveys no less frequently than every three calendar years at intervals not exceeding 39 months for the natural gas distribution system in the Walnut Hills neighborhood.

- 16 TAC §8.207, "Leak Grading and Repair"
- 16 TAC §8.209, "Distribution Facilities Replacements"
- 16 TAC §8.210, "Reports"
- 16 TAC §8.215, "Odorization of Gas"

<u>49 CFR Part 191</u>

This part "prescribes requirements for the reporting of incidents, safety-related conditions, annual pipeline summary data."

Immediate notice and 48-hour revision or confirmation to the National Response Center is required for each incident meeting the criteria specified in this part. A natural gas distribution incident includes any of the following events:

- An event that involves a release of gas from a pipeline that results in one or more of the following consequences:
    - A death, or personal injury necessitating in-patient hospitalization
    - Estimated property damage of $50,000 or more, including a loss to the operator and others, or both, but excluding the cost of gas lost; or
    - Unintentional estimated gas loss of three million cubic feet or more.
- An event that is significant in the judgment of the operator

Additionally, an incident report is required to be submitted using DOT Form RSPA F 7100.1 as soon as practicable but not more than 30 days after detection of an incident which was required to be submitted to the National Response Center. The operator is required to make supplemental reports as deemed necessary when additional relevant information is obtained.

Additional reports pertaining to the natural gas distribution system in the Walnut Hills neighborhood required under this part include:

- Annual report submitted using DOT Form PHMSA F 7100.1-1 (annual)
- Mechanical Fitting Failure Reports using Form PHMSA F-7100.1-2 (annual)
- Safety-related conditions must be filed not later than 10 working days after the day a representative of the operator discovers the condition[22] (e.g., unintended movement or abnormal loading by environmental causes, a leak in a pipeline that constitutes an emergency) unless the safety-related condition:
    - Exists on a customer-owner service line
    - Is an incident or results in an incident before the deadline for filing the safety-related condition report
    - Is corrected by repair or replacement in accordance with applicable safety standards before the deadline for filing the safety-related condition report

49 CFR Part 192

This part prescribes minimum safety requirements for pipeline facilities and the transportation of gas.

49 CFR §192.16, *Customer notification,* applies to each operator of a service line who does not maintain the customer's buried piping up to entry of the first building downstream.

49 CFR Part 192 Subpart H, *Customer Meters, Service Regulators, and Service Lines,* prescribes minimum requirements for installing customer meters, service regulators, service line valves, and service line connections to mains.

[22] Atmos Energy submitted Safety-related condition report 19-148170 to PHMSA on March 7, 2018, which indicated that unintended movement or abnormal loading was discovered on 2/28/2018.

49 CFR Part 192 Subpart I, *Requirements for Corrosion Control*, prescribes minimum requirements for the protection of metallic pipelines from external, internal, and atmospheric corrosion.

49 CFR Part 192 Subpart J, *Test Requirements*, prescribes minimum leak-test and strength-test requirements for new, relocated, or replaced pipelines.

49 CFR Part 192 Subpart L, *Operations*, prescribes minimum requirements for the operation of pipeline facilities.

49 CFR §192.613, *Continuing surveillance*, requires, in part, that each operator have a procedure for continuing surveillance of its facilities to determine and take appropriate action concerning changes in class location, failures, leakage history, corrosion, substantial changes in cathodic protection requirements, and other unusual operating and maintenance conditions.

49 CFR §192.614, *Damage prevention program*, requires, in part, that each operator of a buried pipeline carry out a written program to prevent damage to that pipeline from excavation activities.

49 CFR §192.616, *Public Awareness*, requires, in part, that each operator develop and implement a written continuing public education program that follows the guidance provided in the American Petroleum Institute's (API) Recommended Practice (RP) 1162.

49 CFR §192.617, *Investigation of failures*, requires each operator establish procedures for analyzing accidents and failures.

49 CFR §192.625, *Odorization of gas*, requires a distribution line contain a natural odorant or be odorized so that the gas is readily detectable by a person with a normal sense of smell at a concentration in air of one-fifth of the lower explosive limit.

49 CFR Part 192 Subpart M, *Maintenance*, prescribes minimum requirements for maintenance of pipeline facilities.

49 CFR §192.721, *Distribution systems: Patrolling*, requires the frequency of patrolling mains be determine by the severity of the conditions which could cause failure or leakage, and the consequent hazards to public safety.

49 CFR §192.723, *Distribution systems: Leakage surveys*, requires each operator conduct periodic leakage surveys with leak detector equipment as frequently as necessary, but at least once every 5 calendar years at intervals not exceeding 63 months.

49 CFR Part 192 Subpart N, *Qualification of Pipeline Personnel*, prescribes minimum requirements for operator qualification of individuals performing covered tasks on a pipeline facility. A covered task is an activity that:

- Is performed on a pipeline facility
- Is an operations or maintenance task
- Is performed as a requirement of this part, and
- Affects the operation or integrity of the pipeline

49 CFR Part 192 Subpart P, *Gas Distribution Pipeline Integrity Management (IM)*, prescribes minimum requirements for an IM program.

49 CFR §192.1007, specifies the required elements of an integrity management plan: knowledge; identify threats; evaluate and rank risk; identify and implement measures to address risks; measure performance, monitor results, and evaluate effectiveness; periodic evaluation and improvement; report results.

49 CFR Part 199

This part requires operators of pipeline facilities to test covered employees for the presence of prohibited drugs and alcohol. The following drug test are required when applicable: pre-employment testing, post-accident testing ("accident" includes incidents reportable under 49 CFR Part 191), random testing, based on reasonable cause, return-to-duty, and follow-up testing. The following alcohol tests are required when applicable: post-accident, reasonable suspicion testing, return-to-duty testing, follow-up testing, and retesting.

The Railroad Commission of Texas[23]

Texas has the largest pipeline infrastructure in the nation, with 469,737 miles of pipeline representing about 1/6 of the total pipeline mileage of the entire United States. Texas' pipelines are divided into the categories of natural gas and LP-gas distribution lines (156,459 miles), hazardous liquid and natural gas transmission lines (72,370 miles), hazardous liquid and natural gas regulated gathering lines (6,654 miles), intrastate production and gathering lines leaving a lease (181,687 miles), and interstate lines (57,567 miles). The Railroad Commission of Texas has safety responsibility over the first four categories.

The TX-RRC Pipeline Safety department works to enforce compliance with federal and state laws and regulations by pipeline operators. These regulatory responsibilities extend to 1,387 operators of intrastate gathering, transmission, distribution, and master-metered systems.

The Commission also promotes and enforces an underground pipeline damage prevention program for Texas. The Pipeline Safety department is responsible for the enforcement of damage prevention regulations involving the movement of earth (excavation) surrounding pipeline facilities.

The TX-RRC indicates that the goal of the Pipeline Safety department is to encourage an efficient, economical, and safe pipeline industry; they oversee pipeline activities to ensure compliance with state and federal safety regulations and promote public safety and awareness.

[23] *See* https://www.rrc.state.tx.us/pipeline-safety/ (Accessed June 25, 2019)

3. Procedures

Atmos Energy employs a variety of policies, procedures, specifications and practices in the operation of their distribution systems. Atmos Energy provided excerpts from several of the associated documents that were in effect at the time of the accident for review by NTSB investigators as part of this investigation. Pertinent documents are summarized below.

- Customer Notification of Responsibility to Maintain Buried Piping (49 CFR §192.16): Atmos Energy's O&M Manual indicated that notification of customer's responsibility for maintenance of customer-owned facilities are specified in their Pipeline Safety Public Awareness Program. Atmos Energy's Pipeline Safety Public Awareness Program indicated that Atmos Energy will notify each customer once in writing and that the notification will be consistent with 49 CFR §192.16 requirements.
- Continuous Surveillance (49 CFR §192.613): Atmos Energy's O&M Manual indicated that it is management's responsibility to periodically review the work done by their employees through field observations, documentation review and review of program results. The minimum annual review requirements stated were: leak call response, classification of leaks, cathodic protection surveys, patrols, valve maintenance program, and regulator station inspection and testing. Atmos Energy's O&M Manual further stated that the local manager or supervisor is responsible for periodic review and analysis of records for patrols, leak surveys, valve inspections, vault inspections, regulator station inspections, corrosion control inspections and facility failure investigations. This manual stated that all employees are expected to visually monitor the company's facilities on an ongoing basis and report any concerns that are identified by documenting the results or reporting it to their immediate supervisor. Atmos Energy's O&M Manual stated that anytime a pipeline is found to be damaged or deteriorated to the point that a section of pipe becomes unsafe, immediate measures should be employed through Atmos Energy H.E.L.P. procedures. Atmos Energy H.E.L.P. procedures identified emergency responder action steps to determine the hazard, the extent of hazard, protect life, and protect property.
- Damage Prevention Program (49 CFR §192.614): Atmos Energy's O&M Manual described the Damage Prevention Program, indicating that it is designed to prevent damage to underground facilities caused by excavating activities, blasting, boring, tunneling, backfilling, and the removal of aboveground structures. This program, as described in Atmos Energy's O&M Manual, included: identifying persons who normally engage in excavation activities, notifying excavators and the public about their program, receiving location requests, contacting excavators, and marking the pipeline. Atmos Energy's Construction Procedures Manual described procedures for pipeline locating and marking, as well as trenchless excavation.
- Public Awareness (49 CFR §192.616): Atmos Energy's Pipeline Safety Public Awareness Program indicated it is intended to better educate and inform relevant stakeholders (e.g., affected public, excavators, contractors, first responders) about the presence of their natural gas pipelines; how to recognize and respond to a natural gas release or emergency; steps to prevent damage to their pipelines; and the role pipelines play in energy delivery.

- Odorization of Gas (49 CFR §192.625): Atmos Energy's Measurement Procedure Manual/Utility Operations Handbook described the guidelines for the specification, selection, installation, injection rates, inspection, maintenance, retirement and documentation of odorization equipment. Atmos Energy's Operations and Maintenance Manual further detailed Atmos Energy's gas odorization procedures.
- Patrolling (49 CFR §192.721): Atmos Energy's O&M Manual indicated that the frequency of observational patrolling must be determined by the severity of conditions which could cause failure or leakage, with consequent hazards to public safety. Atmos Energy patrolled the distribution lines in the Walnut Hills neighborhood in conjunction with operational activities, including leak surveying and operation and maintenance activities.
- Gas Leak Surveys (49 CFR §192.723): Atmos Energy's procedures for gas leak surveys are discussed in Section E.4.
- Qualification of Pipeline Personnel (49 CFR Part 192 Subpart N): Atmos Energy's Distribution Risk and Integrity Management Plan (IM Plan) indicated that their Operator Qualification Program ensures that their employees and contractors have the necessary skills and knowledge to properly perform their assigned covered tasks related to their distribution system. Atmos Energy provided training and qualification records for several employees that were onsite for review by NTSB investigators.
- Gas Distribution Pipeline Integrity Management (49 CFR Part 192 Subpart P): Atmos Energy's Mid-Tex Division Gas Distribution Pipeline Integrity Management Program (DIMP) is discussed in Section E.5.

4. Gas Leak Surveys

Atmos Energy's Operations and Maintenance Manual indicated that for leak surveys conducted in accordance with 49 CFR §192.723 for regulatory compliance purposes all mains and service lines be surveyed as frequently as necessary, but at least once every 5 calendar years at intervals not exceeding 63 months.[24] At the time of the accident, Atmos Energy Mid-Tex was surveying the alley where the accident occurred every 36 months. Acceptable survey methods included: flame ionization equipment, optical methane detector, remote methane leak detector (RMLD), and other approved methods.[24]

The Operations and Maintenance Manual indicated that:

- all leakage surveys were conducted using calibrated leak-detection equipment per the respective manufacturer's Operator Manual over the route of the gas pipeline
- indication of underground leakage shall be confirmed by use of the sub surface gas survey using a CGI
- all possible indications of natural gas are to be investigated and evaluated in an appropriate timeframe
- leaks are classified into one of three grade categories (Grade 1, Grade 2, or Grade 3) based on criteria summarized in Table 1

[24] Atmos Procedure Excerpts

The two leak surveys performed prior to February 23, 2018 were performed in 2014 and 2017. In both leak surveys, the technicians used a vehicle mounted Detecto Pak-Infrared (DP-IR)[25] technology and a hand-held RMLD, both manufactured by Heath. When necessary, a SENSIT® GOLD combustible gas indicator (CGI) was used to pinpoint leaks, often in combination with a bar hole test[26] when the leak was suspected to be below surface.[27,28]

The Operations and Maintenance Manual also provided specific guidance related to leak survey weather conditions when conducting surveys for regulatory compliance purposes in accordance with 192.723. For example, when survey conditions had high moisture content, the O&M Manual indicated that the Survey Technician may go to a known leak to validate that conditions are conducive for a quality surface gas detection survey. The O&M Manual further noted that if the Survey Technician was of the opinion that environmental conditions were not favorable to perform a quality leak survey, then the survey should not be conducted. Severely saturated soils were provided as an example of unfavorable conditions. Similarly, the O&M Manual specifically stated that "water-saturated soil may prevent the use of a CGI," but noted that the Survey Technician should visually inspect for the presence of gas which may be observed by water bubbles or vapors if weather conditions or water saturated soil prevented the use of survey equipment or the CGI.[29]

The O&M Manual indicated that a subsurface gas detection investigation shall be utilized to pinpoint the extent of a suspected leak. The subsurface survey was to be performed by testing with a combustible gas indicator (CGI) by punching a number of probe holes in the soil near the gas line, including over service tees, main line valves and couplings. The manual calls for probe holes to be placed in all directions and gas readings noted until 0% gas readings are reached to "pinpoint the leak and determine the migration pattern." An outside leak investigation includes "the perimeter of the structure and adjacent structures on the property, service lines, and mains in all directions and on both sides of the street, alley, or easement at the reported location until 0% gas is reached using a CGI." The manual stated if gas is detected, the Survey Technician must also use a CGI to bar hole test at the "service riser, tap, main(s) in all directions… water meter and both sides of the driveway along with the perimeter of the structure and the adjacent structures on the property… accessible sewer vents on and around the structure… storm sewer outlets… accessible storm drains, manholes, and sanitary sewer outlets in the area."

[25] The Heath DP-IR uses an infrared optical gas detection system to detect methane.
[26] The term *bar hole test* describes a gas measurement technique in which a subsurface probe hole is made in the ground, a bar hole probe (or probe rod) is inserted into the probe hole, and a gas measurement is made (typically for 45 seconds).
[27] Emails Between NTSB IIC and Atmos Energy
[28] SENSIT GOLD Combustible Gas Indicator (CGI) Instruction Manual
[29] In addition to the periodic leak surveys conducted in accordance with 49 CFR §192.723 and described in Atmos Energy's O&M Manual, Atmos Energy also employs "special" leak surveys. These special leak surveys are not intended for compliance purposes, and are used as a tool for operational purposes such as supplementing leak investigations. Accordingly, Atmos Energy permits a special leak survey to be used under conditions (such as wet weather) that would not be chosen for a compliance leak survey. These special leak surveys are to be conducted in general accordance with Atmos Energy's O&M Manual.

The Heath RMLD User's Manual described the equipment as being "capable of detecting methane leaks from a remote distance… because it uses laser technology known as Tunable Diode Laser Absorption Spectroscopy…" which "makes it possible to detect leaks along the sight line…" The User's Manual states that the "RMLD operates under a variety of environmental conditions including cold or hot weather and light rain." The RMLD System Specifications indicate a nominal detection distance of 100 feet, an operating temperature of 0 to 122 degrees F, and humidity of 5 – 95% relative humidity, non-condensing. The User's Manual further indicates that several conditions may occur that will cause the algorithm to give a detection indication, including overly strong returns due to strong reflectors, such as "water droplets."

Table 1. Classification of Leaks per Atmos Energy Operations and Maintenance Manual

Grade 1	
A leak that represents an existing or probable hazard to persons or property that requires immediate repair or continuous action until the conditions are no longer hazardous. Immediate corrective action shall be taken on all Grade 1 leaks.	Examples: • An immediate hazard in the judgment of an on-scene operator. • Escaping gas has ignited. • Indication of gas which has migrated into or under a building. • Any reading at the outside wall of a building or where gas would likely migrate to an outside wall of a building. • Any reading of 80% LEL or greater in a confined space or small substructure. • Any leak that can be seen, heard, or felt and in a location that may endanger the general public or property. • Any above-ground leak that results in a hazardous concentration of gas at a building wall, or structural overhang.
Grade 2	
A leak that is recognized as being nonhazardous at the time of detection, but justifies scheduled repair based on probable future hazard. Repair required within 6 months of detection; some require repair within 5 or 30 days.	Examples: • Any leak, which under frozen or other adverse soil conditions would be likely to migrate to the outside wall of a building. • Any reading of 40% LEL or greater under a sidewalk in a wall-to-wall paved area, or 100% LEL or greater under a street in a wall-to-wall paved area. • Any reading less than 80% LEL in small substructures from which gas would likely migrate creating a probable future hazard, or 20-80% LEL in a confined space. • Any above-ground leak located under a structural overhang. • Any leak which, in the judgment of operating personnel at the scene, is of sufficient magnitude to justify scheduled repair.
Grade 3	
A leak that is non-hazardous at the time of detection and can be reasonable expected to remain non-hazardous. Repair required within 36 months of detection.	Examples: • Any reading of less than 80% LEL in small gas associated substructures. • Any reading under a street in areas without wall-to-wall paving where it is unlikely the gas could migrate to the outside wall of a building. • Any reading of less than 20% LEL in a confined space. • Above-ground leak located in remote area and where it is unlikely the gas could accumulate to a hazardous concentration.

5. Gas Distribution Pipeline Integrity Management Program (DIMP)

NTSB investigators reviewed Atmos Energy's Distribution Risk and Integrity Management Plan (IM Plan) which provided a written explanation of the mechanisms and procedures that Atmos Energy used to implement its integrity management program and ensure compliance with 49 CFR Part 192 Subpart P, *Gas Distribution Pipeline Integrity Management (IM)* and 16 TAC 8.206, *Risk Based Leak Survey Program.* This review included interviews with Atmos Energy risk management professionals within the department that manages their IM Plan. The TX-RRC had conducted a DIMP review of Atmos Energy's Mid-Tex Division in 2012. Atmos Energy responded in 2013 and documented the actions taken.[30]

The scope of Atmos Energy's IM Plan included mains, service lines, and related facilities (e.g., service regulators, company owned meters). Atmos Energy developed a statistical risk evaluation methodology for its distribution systems that was built through an iterative process based on leakage history. Atmos Energy's IM Plan is intended to address those elements required by 49 CFR §192.1007: knowledge; identify threats; evaluate and rank risks; identify and implement measures to address risks; measure performance, monitor results, and evaluate effectiveness; periodic evaluation and improvement; report results.

Knowledge: Atmos Energy gathered information about the distribution infrastructure from existing records of design, construction, O&M activities, and SME input. They also collected data to support their IM Plan in conjunction with normal construction and O&M activities.

Identify Threats: Atmos Energy's risk model considered the following categories of threats to each gas distribution pipeline: corrosion, natural forces, excavation damage, other outside force damage, material or welds, equipment failure, operations, and other concerns that could threaten the integrity of its pipeline. The natural force damage threat considered that ground movement could result in a leak for all pipe material types.

Evaluate and Rank Risk: Atmos Energy used a commercially available software-based risk assessment tool, Optimain, to support risk analysis. Segments of mains were risk-ranked every year based on a score which took into consideration factors that were used to estimate the likelihood (e.g., the number of leaks, coating condition) and consequence (e.g., line pressure, population density) of failure. The risk model did not specifically consider the age of the segments but grouped pipeline segments into failure families based on similar attributes (e.g., material, coating) and specifically considered degradation due to corrosion.[31] Atmos Energy determined that the impact of some environmental factors (i.e., earthquakes, freeze/thaw cycles, snow loading) were minimal in the geographic region where the accident occurred. Atmos Energy also noted in its DIMP that information should be gathered to "identify environmental factors that could increase the potential for leakage or cause leaking gas to migrate to an area where it could create a hazard." As of February 2018, this risk assessment did not consider the risk contribution of service lines. According to Atmos

[30] Letter from TX-RRC to Atmos Energy, dated December 13, 2012 and January 10, 2013 response
[31] Interview - Atmos Manager of Engineering Services 04.25.2018 with Errata

Energy, service lines were considered through a parallel modeling effort which was used to identify higher risk service lines.[31]

Identify and Implement Measures to Address Risk: Atmos Energy credited programs and policies that they indicated were in-place to meet federal and state pipeline safety regulations to reduce the risk to threats across their system, and took additional and accelerated actions to address relative high risks identified through DIMP. Existing programs and policies that were credited included: leak management program; damage prevention program; operator qualification program; public awareness program; excess flow and curb valve installation; alcohol misuse and drug abuse policy; continuing surveillance program; pipeline patrolling program; welding program; plastic pipe joining program; corrosion control program; technical training programs; odorization program; risk based leak survey program; distribution facility replacement program; and cross bore mitigation program.

Relative high-risk segments were defined based on risk scores that were two standard deviations above the statistical mean or that had been identified by an SME as having high risk. At the time of the accident, segments of main with a risk score of 89 and above were considered relative high-risk. According to Atmos Energy, the segment of main which included the 2-inch steel main in the alley of the 3500 block of Espanola Drive and Durango Drive had a risk score of 7.9; it was not considered relative high risk and was not subject to accelerated action (i.e., increased leak survey frequency or scheduled replacement).

Measure Performance, Monitor Results, and Evaluate Effectiveness: Atmos Energy's IM Plan indicated that performance would be measured on an annual basis relative to baseline figures established using historical data. The performance measures included several that were required by PHMSA Form 7100.1-1 annual report and an additional measure related to the number of hazardous leaks either eliminated or repaired, categorized by material.[32]

Periodic Evaluation and Improvement: Atmos Energy's IM Plan indicated that the IM Program would be reviewed annually to determine its overall effectiveness in mitigating distribution system risks.

Report Results: Atmos Energy's IM Plan indicated that those performance measures that were required by PHMSA Form 7100.1-1 annual report would be reported to PHMSA annually.

[32] Atmos Energy Distribution Integrity Management Metrics Combined

6. Maintenance History

Odorant

Natural gas provided to the Walnut Hills neighborhood was odorized. Atmos Energy provided documentation of odorant tests in the five years prior to the accident, which indicated that the gas was "readily detectable" at a concentration less than one-fifth of the LEL.[33]

Leak Surveys

Prior to the accident, Atmos Energy had most recently completed leak surveys in the area of the accident on March 7, 2017 and March 21, 2014.[34] Atmos Energy organized leak surveys based on map sheets. The map sheet where the accident occurred was identified as number 2374 as shown in Figure 12. Three leaks graded as Grade 2.030 were identified in map sheet 2374 during the 2017 leak survey; no leaks were identified in this area in 2014.[34]

The three leaks graded as Grade 2.030 were identified at 3546 Espanola Drive, 3641 Durango Drive, and 3651 Durango Drive. Atmos Energy replaced the service lines at these addresses as well as the service lines at 3640 Espanola Drive and 3650 Espanola Drive on March 29-30, 2017.[34]

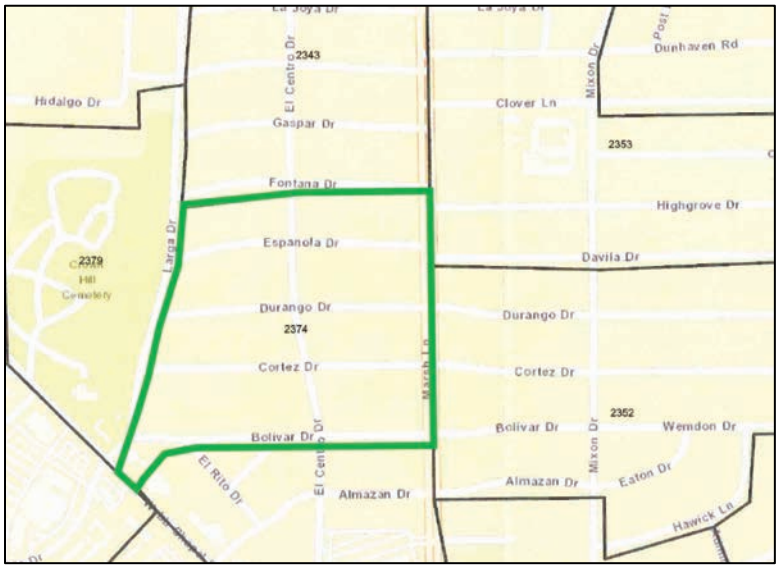

Figure 11. Leak Survey Map Sheet Location (Green Outline Added by NTSB to highlight map sheet 2374)[34]

[33] Natural Gas Odorant Test Locations Map and Associated Readings
[34] Last Two Historical Leak Surveys and Historical Survey Map 2374

Leak History[35]

Atmos Energy leak data for the impacted area indicated that the 2-inch main in the 3500 block of the alley between Durango and Espanola Drives had no history of leaks in the 10 years prior to this accident. Atmos Energy identified one leak on this main in the last 25 years, according to historical records. That leak was graded as a Grade 2.180 and was permanently repaired in 1997.[36] There were several leaks on the service lines that tied-in to the 2-inch main during the past decade.

The 25 service lines connected to the natural gas main on the 3500 block of Espanola Drive and Durango Drive were originally installed with wrapped steel between 1947 and 1950. Thirteen of these original service lines had been replaced with plastic service lines between 1994 and 2018. Two of the replaced service lines had been replaced again with plastic service lines between 2017 and 2018. The service lines at 3534 Espanola Drive and 3527 Durango Drive had been replaced and had excess flow valves installed; the service line at 3515 Durango Drive was original (1948) and did not have an excess flow valve installed.

In addition to the three leaks that were identified through Atmos Energy's 2017 leak survey, two leaks that occurred on the 3500 block of Durango Drive and Espanola Drive were identified in the year prior to the first event at 3527 Durango Drive. These leaks occurred at 3514 Espanola Drive and 3527 Durango Drive.

The leak at 3514 Espanola Drive was reported by a customer on September 17, 2017. The technician investigated the leak, noting that bar hole tests were performed at the sewer, the company facility, and the customer facility. The technician indicated that gas was found underground migrating towards the house and that the customer piping was pressure tested and passed. In response, Atmos Energy classified this leak as Grade 1, addressed leaks on the meter and service regulator, and replaced the service line on September 17, 2017. The technician noted that gas odorant was detected.

The leak at 3527 Durango Drive was identified through customer notification on January 1, 2018. The customer indicated they smelled gas at the meter. The responding Atmos Energy technician found an above ground leak on the service regulator and a below ground leak near the service riser. The technician noted that bar hole tests were performed at the sewer, the company facility (i.e., service line), and the customer facility (i.e., customer-owned piping). The only indication of gas from these bar hole tests was near the service riser. The customer-owned natural gas line was also pressure tested and passed. Atmos Energy responded by replacing the service regulator on January 1, 2018 and replacing the service line on January 29, 2018. The responding technician noted that the water heater was "not connected right" and was red tagged.

Excluding leaks that occurred as a result of third party damage, the table below indicates the total repaired leaks, based on Atmos Energy determined leak grade for a two-mile area surrounding the accident site between 2013 and 2018 (Table 2). This represents a total of 443 repaired leaks over approximately 155 miles of main (i.e., 2.86 repaired leaks per mile of main). For context, the approximate mileage of mains for the City of Dallas is 3,245 and

[35] Leak History - Service Orders, Leak Reports, Summaries
[36] 1997 Main Segment Leak Report

there were 9,256 repaired leaks also excluding third party damage for the same time period (i.e., 2.85 repaired leaks per mile of main).

Table 2. Natural Gas Leak History for 2-Mile Area Surrounding Accident Site, Excluding Leaks Attributed to Third Party Damage (January 1, 2013 - February 22, 2018)

Repair Year	Grade 1	Grade 2.005	Grade 2.030	Grade 2.180	Grade 3	Total
2013	20	13	12	7	10	62
2014	29	11	27	10	5	82
2015	43	22	33	5	5	108
2016	23	9	18	26	5	81
2017	23	7	17	18	17	82
2018[37]	9	6	11	2	0	28
Total	**147**	**68**	**118**	**68**	**42**	**443**

[37] Partial year data: January 1, 2018 - February 22, 2018

F. Events Leading Up to the Accident

In the days before this accident at 3534 Espanola Drive, two gas-related incidents occurred at houses on the same block that were served by the same natural gas main (Figure 13). The first incident occurred on February 21, 2018, at 5:49 a.m. and resulted in one injury involving second-degree burns and significant structural damage to 3527 Durango Drive. The second incident occurred on February 22, 2018, at 10:21 a.m., when a kitchen fire resulted in one injury involving second-degree burns and significant structural damage to 3515 Durango Drive.

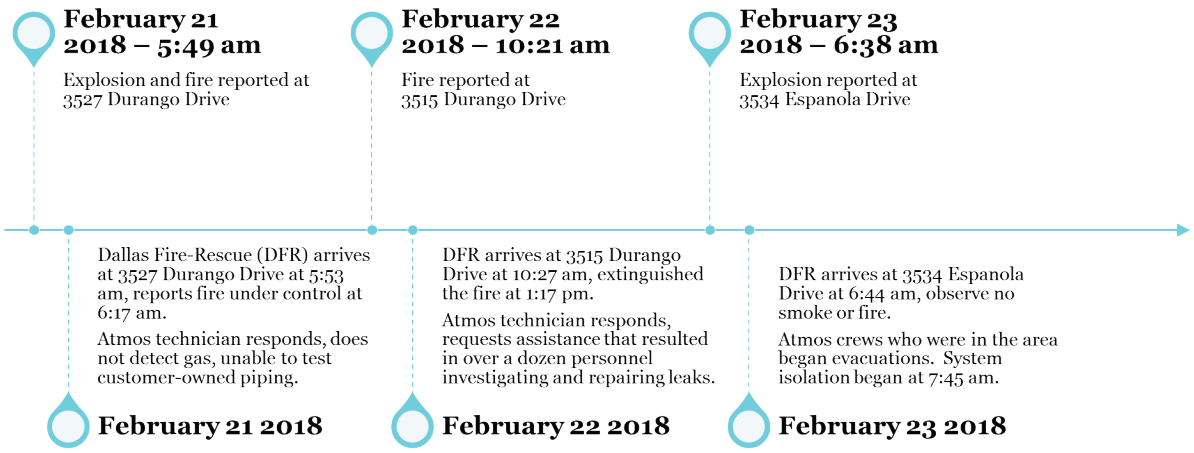

Figure 12. High-level Timeline Associated with Accident at 3534 Espanola Drive

1. February 21, 2018

Dallas Fire-Rescue (DFR) Arrives at 3527 Durango Drive[38]

On February 21, at 5:49 a.m., the Dallas Fire-Rescue (DFR) dispatch received multiple emergency calls for a structure fire at 3527 Durango Drive. The 9-1-1 calls from neighbors reported that a house "exploded" and they observed smoke coming out. The first engine arrived at 5:53 a.m. and the firefighter on that engine told NTSB investigators that the fire was coming from the back of the house. He observed that the roof was not involved in the fire and had blown off. He said that normally, during house fire events, the roof falls into the house. He noticed that glass was broken outside of the house and sheetrock had been knocked down from the interior of the house onto the floors, as well as outside the exterior of the house. Upon this realization, the firefighter turned off the gas supply at the meter behind the house and requested for gas and electric utilities to respond at 5:59 a.m. Two other firefighters, the safety officer and the IC, told NTSB investigators that the post fire structural

[38] This summary is based on the NTSB Emergency Response Factual Report, which contains additional information regarding DFR's response to the event.

conditions of the house could have resulted from an explosion or from the kind of construction that was used to build the exterior walls. d. The DFR IC did note the bulging of the house walls.

The fire was reported under control by 6:17 a.m. Arson investigators initially classified this accident as “Accidental.” However, the classification was later changed to “Undetermined.”

Figure 13. Photo of 3527 Durango Drive Post-Incident by DFR.

Figure 14. Photo of 3527 Durango Drive Post-Incident by NTSB.

Atmos Energy Senior Service Technician Arrives at 3527 Durango Drive

An Atmos Energy Service technician arrived on scene soon after the fire was extinguished at 3527 Durango Drive. He told NTSB investigators that it was not raining when he arrived, but "started raining afterwards."[39] He said that he checked in with the firefighters and learned they had already turned off the gas. He indicated that his Atmos Energy issued SENSIT® GOLD combustible gas indicator (CGI) was on as he proceeded to the meter located at the rear of property. He did not recall looking at the CGI during this time but indicated that it would have started beeping if it picked up gas and it never beeped. When he reached the meter, he confirmed that the gas was off, inspected the meter, and observed no damage. He pressure-tested the meter to determine if an overpressurization had occurred at the regulator. He observed a reading of four ounces [per square inch],[40] which is the correct pressure setting (see Section H.3). The service technician placed a lock on the meter to ensure that only Atmos Energy employees would have access to turn it back on.

The service technician said that he was unable to pressure test the house line during his visit because the fire department was in the house and it would not have been safe. He did not indicate plans to return and conduct a pressure test when it was safe to do so.[41] The service

[39] Interview - Atmos Senior Service Technician 02.28.2018 with Errata

[40] Low pressure measurements are often made in ounces per square inch (oz/in^2); 4 oz/in^2 equals 0.25 psi.

[41] Atmos Energy's Fire Response Procedure (Atmos Procedure Excerpts) indicates that a full leak investigation should be completed when access to the premises is allowed and when practical. According to Atmos Energy, the technician was following procedures and was not required to return to this location to conduct a pressure test.

technician indicated that he did not go inside homes to obtain gas readings for "safety reasons."

The service technician told NTSB investigators that he needed to check to make sure there was no leak on the line. To do so, he proceeded to investigate with his CGI, which had most recently been calibrated on February 5, 2018. Using his CGI, he performed one bar hole test near the riser at the meter and detected no gas. He recalled that he did not want to place his CGI into the probe hole because the ground was already saturated with water. Inserting the CGI in the water would damage it. Further, if the "soil is too wet, you can't really use your bar hole, because it's going to draw water in the hole."

Though the service technician was able to perform one bar hole test near the meter without placing his CGI all the way down into the probe hole, he recalled that in other areas around the property, he was not able to perform additional bar hole tests because of the soil was too saturated with water. The technician indicated that if the soil had been dry, he would have performed multiple bar hole tests. The photo in Figure 16 depicts the rear of the property at 3527 Durango Drive three days after the event.

The service technician said that he did not perform any bar hole testing on the customer side. He said that the property between the house and the meter was saturated with water due to the fire department's extinguishing the fire. Moreover, the service technician indicated that the alley behind the house was muddy and largely saturated with water. Due to the wet conditions the technician put his CGI in "survey" mode, which allowed him to survey above the top of the soil including along the 2" main in the alley. While surveying, he was also looking for bubbles emerging from the water, which are indicative of gas. He said that he neither saw bubbles, nor obtained any positive gas readings with his CGI.

The service technician told NTSB investigators that the arson investigators indicated that the fire was gas-related and that it "probably came from inside the house," likely originating from the back part of the house where heavy damage was observed. When NTSB investigators asked the Atmos Energy service technician if he agreed with the assessment of the arson investigator, he said "he really couldn't say" because he "couldn't run a test on the house line."

The technician said that he then returned to his truck and completed his paperwork. He documented that the gas leak was on the house line per the fire investigator and that the bar hole test was negative.[42] When asked about what is done with the service order and what follow-on actions are taken, the technician indicated that he was not sure where it goes.[43]

The Atmos Energy technician said that he had received formal training from Atmos Energy on numerous topics and had electronic access to written procedures for reference. He estimated that he was at the scene for about 25-30 minutes. The service technician also told investigators that he did not smell gas at any time while at the property.

[42] Leak Investigation and Repair Documentation - Prior to Accident

[43] Additional information on how Atmos Energy used this information is provided in the NTSB Human Performance Factual Report.

Figure 15. Photo of 3527 Durango Drive Taken by Atmos Energy on 2/24/2018. Image is taken from rear facing the back of the house. Standing water is shown in backyard.

2. February 22, 2018 and February 23, 2018 (Prior to the Accident)

Dallas Fire-Rescue (DFR) Arrives at 3515 Durango Drive[44]

On February 22 at 10:21 a.m., the homeowner at 3515 Durango Drive reported a fire in his kitchen. Responding firefighters arrived at 10:27 a.m. Upon arrival, the incident commander observed large amounts of smoke that came from the south and west sides of the residence. He saw a significant fire on the north and west side of the structure. It took about three hours to extinguish the fire and the incident ended at 1:17 p.m.

The fire investigation report stated that the fire originated in the kitchen on or adjacent to the stove. The fire traveled vertically to the attic, igniting nearby combustible cabinets and surrounding structural members, causing significant fire and smoke damage resulting in a total loss. DFR requested a response from the electric and gas utility at 10:38 a.m. and 11:40 a.m., respectively.

[44] This summary is based on the NTSB Emergency Response Factual Report, which contains additional information regarding DFR's response to the event.

Figure 16. Front of 3515 Durango Drive. Photo by DFR.

Figure 17. Back of 3515 Durango Drive. Photo by DFR.

Atmos Energy Employees Arrive at 3515 Durango Drive

An Atmos Energy Service Technician 2 was the first Atmos Energy employee to respond to the fire at 3515 Durango Drive. He told NTSB investigators that he arrived around noon, where he remained until early the next morning (around midnight).[45] His first task was to examine the meter and verify that the gas was off. He confirmed that DFR had already turned off the gas at the meter.

DFR incident commander told the Service Technician 2 that the fire started in the kitchen at the range. DFR incident commander also told him that on the previous day (February 21), a gas-related event had occurred on the same street, three houses to the east (3527 Durango Drive). According to the Service Technician 2, he was asked "to get in contact with someone to come out here to investigate what was going on." He then contacted his supervisor who sent additional Atmos Energy employees to the site.

Two operations supervisors and a distribution operator traveled to the property. This was the beginning of a response from Atmos Energy which included over a dozen people, including a director of operations, an operations manager, survey specialists, and construction crews.

Atmos Energy employees were continuously working in the area surrounding the two Durango Drive residences from the afternoon of February 22 through the morning of February 23, 2018. During this time, Atmos Energy identified four leaks graded as Grade 1 and nine leaks graded as Grade 2 in an approximately 8 block area around the 3500 block of Espanola Drive. Of these, Atmos Energy had completed repairing all four Grade 1 leaks and two of the Grade 2 leaks before the accident occurred on the morning of February 23. All six repairs were made on coated steel (with five of those repairs being made on service lines); four were attributed to a thread leak and two were attributed to ground movement. These leaks and repairs are geospatially depicted in Figure 19. On the 3500 block of the alley between Durango and Espanola Drives, two leaks were identified, both classified as Grade 2.

Throughout the afternoon and evening, when a hazardous leak was discovered, Atmos Energy personnel worked to eliminate conditions they determined to be hazardous. While Atmos Energy employees were working in the area, they were approached by a customer who reported that she had smelled gas and seen bubbles near her sidewalk at 9583 Larga Drive. After investigating this complaint, Atmos Energy identified one of the Grade 1 leaks at this location and resolved the leak. In addition, a leak survey technician found a hazardous condition near the structure located at 3655 Durango and evacuated the resident until the hazard was eliminated.

Atmos Energy's leak detection efforts that day began around 3515 Durango Drive. The Service Technician 2 told investigators that he did not test the regulator.[46] He also said the customer's "piping wasn't testable because of fire." He stated that "the whole house had caught fire and the firemen were in there." The Service Technician 2 said that he conducted

[45] Interview - Atmos Service Technician 2 02.28.2018 & 06.06.2018 with Errata
[46] The regulator was later tested at a laboratory as part of the NTSB's investigation (See Section H.3).

bar hole testing around the house, which did not reveal the presence of gas. However, he said that the soil conditions were "really wet," and "we were able to punch some bar holes and get some readings in, but a lot of holes were filling in with water." He said that to mitigate this issue, "We just usually test it above ground. We put our detector as close to the hole as we can without getting it wet," a technique likened to surveying.

The Service Technician 2 told investigators that they could not bar hole test the riser because there was "Too much water. There was a puddle of water there." Atmos Energy service technicians are trained to look for bubbles in wet conditions as an indication of gas presence, which the Service Technician 2 did. He said that there were "visible bubbles at the riser." However, the Service Technician 2 indicated that CGI surveying over the top of the water near the riser did not result in any positive gas readings. He also indicated that he "did bar holes on both sides, both directions of where the meter at 3515 was." The results of the Atmos Energy employee bar hole testing and surveying are shown below in Figure 20. The figure has two notes at 3515 Durango; the word "Bubbles" is written at the location of the riser, and the words "Standing Water" are written with an arrow pointing to a sketch of water around the northwest side of the house. These notes were transcribed from Atmos Energy employee handwritten notes.

Additional bar hole tests were also performed at 3527 Durango Drive. These tests, which included a perimeter around the foundation of the house, did not indicate the presence of natural gas. Atmos Energy employees also conducted bar hole testing throughout the alley. Measurement locations were spaced approximately 5-feet apart from Larga Drive to the east until and including the area behind 3539 Durango Drive (Figure 18). However, muddy, wet soil conditions were described by the employees as making the task difficult. The Service Technician 2 told investigators that some of the probe holes they created filled up with water. He described their work process as "kind of bar holing, kind of surveying."

The Service Technician 2 told investigators that they "worked together as a group and we all checked the sewer boxes that were visible in that alley" (referencing the alley bordered by Durango Drive, Espanola Drive, Larga Drive, and El Centro Drive). This sewer testing near 3515 Durango Drive indicated the presence of gas at first, but the measurements were not sustained.

Of the nine leaks classified as Grade 2 Atmos Energy employees identified that day, two were discovered in the alley bordered by Espanola Drive, Durango Drive, El Centro Drive and Larga Drive. Near the residence 3519 Durango Drive, a 52% gas reading is indicated in an Atmos Energy leak report, with the "Probable Source" recorded as "Service."[42] This leak was repaired that same evening.

The second leak classified as Grade 2 was discovered near the residence of 3531 Durango Drive. The leak report indicated multiple positive gas readings.[42] The leak report indicated that the "Probable Source" was "Service." Repair work was ongoing at 3531 Durango Drive at the time of the explosion at 3534 Espanola Drive. One operations supervisor described the

repair work generally as “pretty rough on us” because there was “just so much rain.” [47] He said that it was challenging to dig in the alley because the probe holes “would get full of water.” He said that it was not possible to bring a truck with a pump into the alley because it would have gotten stuck. He said that the workers had to try to “scoop water out” with a bucket and that they were “trying… against all odds.” During this time, Atmos Energy personnel continued to monitor the area, checking sewer clean outs, and bar hole testing and surveying with their CGIs.

In addition, the leak report for 3531 Durango Drive indicated a leak (31% natural gas in air) on the customer-owned house line (the portion of the system that is not regulated by PHMSA or TX-RRC). “Tech Completion Notes” for an “Update Service Order” for the residence, dated February 22, 2018 indicated that gas was detected in the backyard.[42] Further, notes indicated that even after isolating all appliances, the customer’s house line still failed, and therefore a red tag was issued (gas was shut off to the property). The homeowner was advised to contract a professional to repair the line.

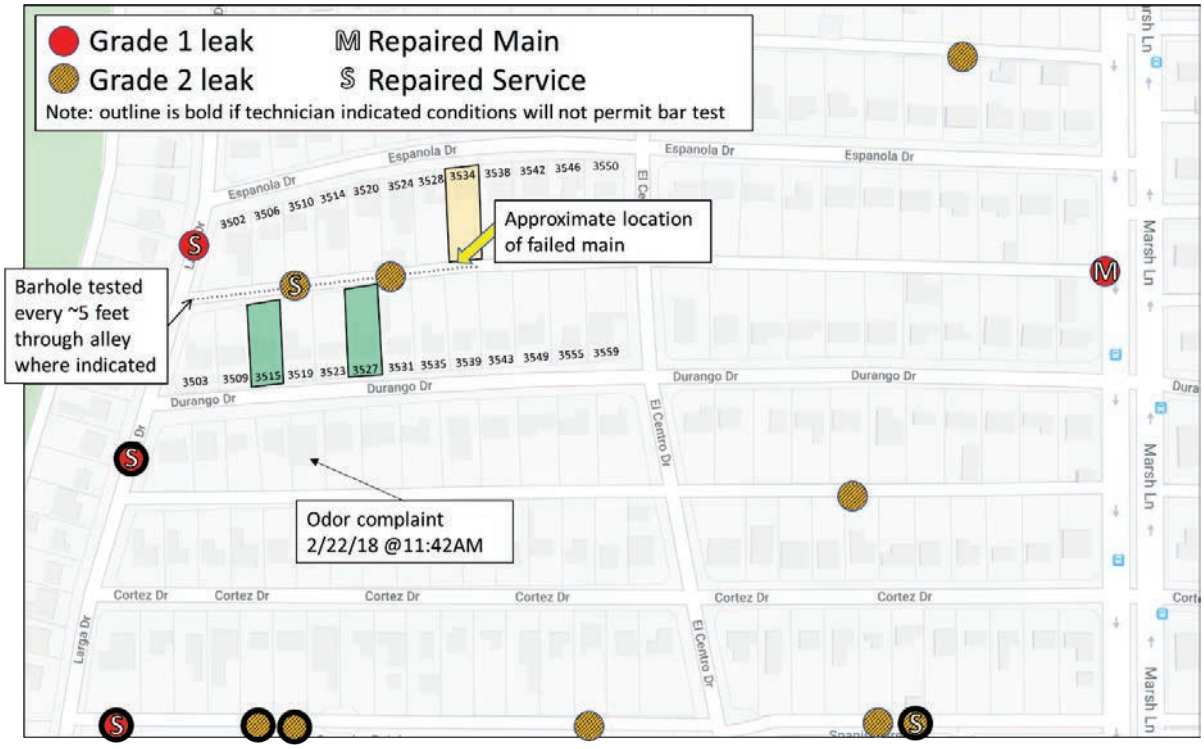

Figure 18. Leaks Identified by Atmos Energy Staff Following Event 2, Prior to the Accident on February 23, 2018. Repairs made prior to the accident are indicated by an "M" or "S" for repairs on the main and service lines, respectively. [42]

[47] Interview - Atmos Operations Supervisor 'B' 03.05.2018 & 03.08.2018 with Errata

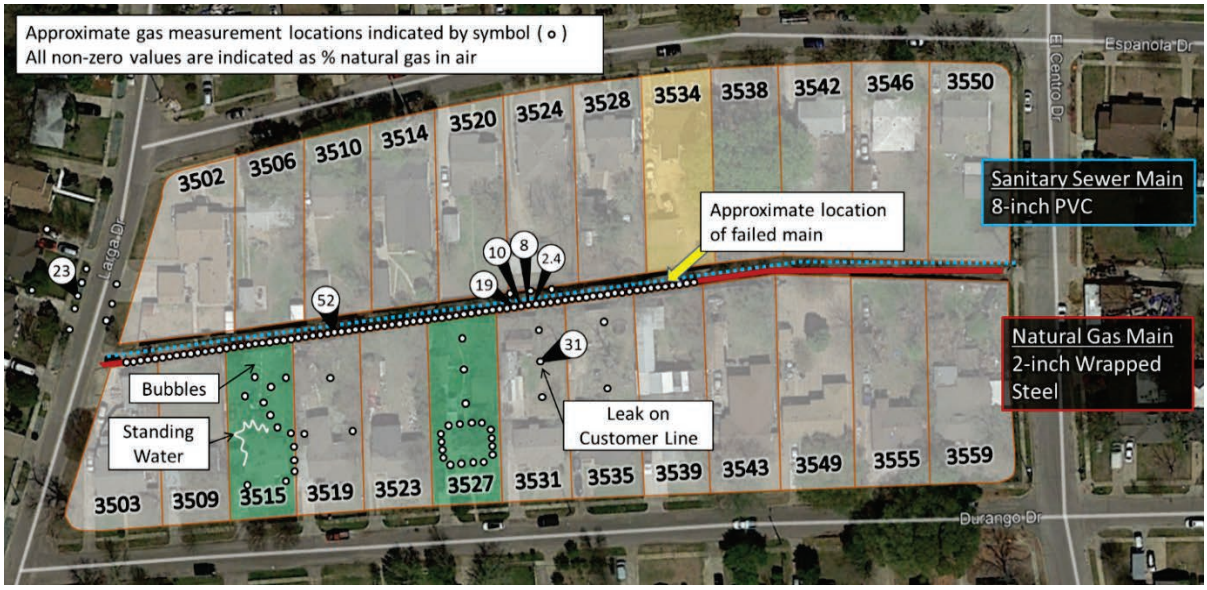

Figure 19. Bar hole testing results around the 3500 block of Durango Drive and Espanola Drive on Thursday, February 22, 2018.

Atmos Energy Survey Specialists

As part of Atmos Energy's response, two Atmos Energy survey specialists were directed to conduct a leak survey. The leaks they discovered are included above in Figure 18. For disambiguation, these two employees will be referred to as Survey Specialist A and Survey Specialist B.[48] Survey Specialist A told NTSB investigators that he was on his way home when he received a call around 3:00 - 3:30 p.m. requesting that he perform a special leak survey,[49] and that he arrived at the scene around 4:00 p.m.[50] Survey Specialist B was called around the same time – about 3:15 or 3:30 p.m. and arrived at the scene around 4:30 – 5:00 p.m.[51] The two coordinated their survey plans, but largely operated independently of each other.

Survey Specialist A

Survey specialist A said that he was equipped with a [Heath] Remote Methane Leak Detector (RMLD). He said the RMLD can provide a general idea of where gas is. He said, "The RMLD does not go subsurface." He said that it was necessary to conduct follow up testing with a combustible gas indicator (CGI) to identify the precise location of a leak. He described the instruments as "totally opposite," stating that RMLDs are "used to just find methane, it's not used to pinpoint." He said the CGI is needed to see "the percentage of gas

[48] Above a "service technician 2" is identified, wherein the "2" signifies the specific type of position within the company. By contrast, using the "A" and "B" designation is to uniquely identify two employees who hold the same position within the company.
[49] Special leak surveys (like the one conducted on 2/22) are not intended for compliance purposes, and are used as a tool for operational purposes such as supplementing leak investigations. Accordingly, a special leak survey may be used under conditions (such as wet weather) that would not be chosen for a compliance leak survey.
[50] Interview - Atmos Survey Specialist 'A' 03.04.2018 & 06.06.2018 with Errata
[51] Interview - Atmos Survey Specialist 'B' 03.04.2018 & 06.06.2018 with Errata

that you get or how much gas is there in that one location." Survey specialist A said that both pieces of equipment are crucial in finding leaks.

Investigators spoke with the survey specialists about limitations of the RMLD and CGI. Regarding the RMLD, Survey Specialist A said: "As far as wind, I believe the manual states up to 15 miles per hour. And not recommended for wet weather. None of our equipment is." However, survey specialist A indicated that it was possible to use a CGI when it was raining. He said that "it will work as long as you have a dry… place to put a bar hole and to stick it in a dry hole." He said that in the alleys they were surveying "certain spots" were "under water," but "we were able to get enough holes to get some CGI readings." Regarding the potential to use different equipment, given the weather, Survey Specialist A said, "there was no way you could use a DP-IR. DP-IR has a pump that sucks up, and it would have immediately been full of water." Survey Specialist A indicated "the Picarro unit" may be suited to wet weather conditions.[52] Atmos Energy owned one vehicle-mounted Picarro unit at the time of the accident and indicated that it could not have been used in the unpaved alleys on February 22.

Survey Specialist A indicated that it was raining "Pretty much the whole time" he was working. He indicated that there was a significant amount of standing water in the area. He said that he was wearing waterproof shoes and a rain suit. He said, "I could not see my shoe, in the mud or the water." Survey specialist A said that he asked his supervisor how he was supposed to survey in "pouring down rain." He said that his supervisor told him to "Use your RMLD and do the best job you can." He told NTSB investigators that "It's not protocol to survey in the rain…" and the RMLD was the "…only piece of equipment that I had that could survey in the rain." He also stated that "If I had a choice to which tool to use in the rain, it would be the RMLD."

Survey Specialist A discussed his findings as he proceeded with his leak survey in the alley bordered by Durango Drive, Espanola Drive, Larga Drive and El Centro Drive; he described multiple gas indications. He said that using his RMLD he "got one solid indication all the way down." He said that he reported his findings to two operations supervisors. One of the operations supervisors indicated to NTSB investigators that at the time, he interpreted Survey Specialist A's positive RMLD readings as false positives.[53] The operations supervisor therefore decided not to order additional bar hole testing as a result of the positive RMLD gas readings. He also said that other technicians had already performed bar hole testing in the area in question and did not detect gas. The alley is shown in Figure 21.

At one point while working on Espanola Drive, Survey Specialist A said that he "could not get my CGI in the ground because it was so wet." A Service Technician 2 was deployed to assist him and they used his CGI because according to Survey Specialist A, his "didn't have a water trap or anything to catch the water so I couldn't use mine, so that's why we used his." He further clarified that when he "first tried to use" his CGI that day, "it filled up with water, and I didn't have another one."

[52] The manufacturer of Picarro indicated that the mobile natural gas leak detection system collects "methane, wind, atmospheric and GPS data which is later processed to detect and localize leaks and calculate methane emission rates" and that gas is measured with a parts-per-billion sensitivity (Picarro Technology Brief).
[53] Interview - Atmos Operations Supervisor 'A' 02.28.2018 & 06.06.2018 with Errata

Survey Specialist A indicated that it was not uncommon to find gas readings as high as 50%, 60%, or even 90% while surveying over main and service lines. He did not have any concerns about the integrity of the main line at any point in the evening nor the number of leaks he detected. Survey Specialist A said that he completed his task, delivered his notes to an operations supervisor, and departed around 11:00 p.m.

Figure 20. Alley Behind 3534 Espanola Drive Prior to Excavation. Wet muddy soil and puddles of standing water are shown. Photograph by Atmos Energy, 3/01/18.

Survey Specialist B

Survey Specialist B said "It wasn't raining, but it… we had had just tremendous amounts of rain that entire week. I mean, there was water everywhere." He determined that it would not be possible to survey in his vehicle and he would have to walk. He said that he "surveyed the perimeter, the main, and the services along those mains." He said that he used an [Heath] RMLD. He indicated that the RMLD is not recommended for use in wet conditions, but if a survey needs to be done in these conditions he's going to lean on his RMLD the most. He added that the RMLD was the only tool that he could use on that day to survey.

Survey Specialist B indicated that he did an initial perimeter sweep of the area with an RMLD, then conducted follow up CGI bar hole testing with a distribution operator. His statements describe his experience collecting bar hole test data in a "flooded" alley:

"We were trying to find -- on the banks, there were some spots where you could punch some holes and drill some holes. But almost immediately after drilling them

out, they would backfill and get water right in them. So it made it very challenging. We did the best we could under those circumstances. We were able to get some reads in some holes. Some holes we just couldn't; there was just too much water."

Survey Specialist B also indicated that it was dark, and "staying on your feet was challenge." He said that they were using maps to navigate. He indicated that the conditions made it "a lot more difficult" to investigate the leaks. Regarding one of the leaks, which he graded as a 2.030, he said that they had "some difficulty with barring it out." That is, the conditions made it difficult to pinpoint the exact location of the subsurface gas. He described trying to establish migration patterns under such conditions (i.e., "water everywhere") as "very challenging." He said that there was "some uncertainty" in the process, but he was doing the best job that he could.

Survey specialist B was asked if he considered his leak survey activities that day to be routine in nature. He responded "…there was nothing routine about that night. It was more than I -- we had 10 leaks. That was a lot of leaks. I've never investigated that many leaks in one day." He had been with Atmos Energy for about 12 years at the time. He also indicated that it was not common to conduct leak surveys under these conditions. He said "These are not normal operating conditions. I've never surveyed in these kinds of -- I don't think anybody has." Survey Specialist B said that his supervisor was aware of the challenging conditions, which is why his supervisor sent a distribution operator to help him. However, Survey Specialist B indicated that he had not been concerned about the integrity of the main line. He said that he completed his survey and departed early in the morning of February 23 (around 12:30 – 1:30 a.m.), and that it was a "long night." In his interview, Survey Specialist B noted that he was able to smell gas coming from a leak he identified that night in the alley behind 3502 Cortez Drive.

G. Post-Accident Activities

The natural gas explosion at 3534 Espanola Drive caused structural damage to the residence (Figure 22). All five family members who were in the house at the time of the accident were injured in the explosion; one 12-year-old resident's injuries were fatal. Atmos Energy crews, who were already in the area repairing leaks, heard the explosion and began evacuating the neighborhood.

Figure 21. Northwest corner of 3534 Espanola Drive, Photo Taken Post-Accident on 2/23/18 by DFR

1. System Isolation and Pipe Segment Replacement

Atmos Energy isolated the gas distribution system in the nine-block area through a series of staged system isolations. System isolation began at about 7:45 am on February 23, 2018 and was completed that evening. At about 7:45 am, Atmos Energy crews started working to isolate the main in the alley between Espanola and Durango Drives from Marsh Lane to Larga Drive; this isolation was completed at about 8:30 am. At about 8:00 am, Atmos Energy crews decided to isolate the mains: in the alley between Durango Drive and Cortez

Drive; in the alley between Cortez Drive and Bolivar Drive, in the alley between Espanola Drive and Fontana Drive, and on Larga Drive. The Operations Manager reported "most valves operated just fine…" but there were three instances where "short stops"[54] were used to isolate main lines either because existing valves were too difficult to operate, or because an existing valve could not be closed without affecting a larger area.[51,55] By the evening of February 23, 2018, Atmos Energy had disconnected gas service to this area.[56] On the afternoon of February 23, 2018, Atmos Energy decided to replace all mains and service lines in this isolation area.[57]

Atmos Energy continued performing special leak surveys on the evening of February 23, 2018 and for the next several days, surveying over an expanded area. Atmos Energy's Vice President of Technical Services indicated that, "at some point during Friday [February 23, 2018] we – when we started seeing the leaks and the number of leaks that was going on and when we went through an area and then went back over the same area, we would find new leaks, different leaks, and so it was something we hadn't seen before. And so out of, out of caution because we didn't know the – what caused the explosion, we were seeing these other leaks, so we went ahead and based upon the material types, and we looked at the pipe that was installed at the same time period or under the same what we call expenditure requisition, we chose to isolate that section, which was the 300, about a nine block area." [58]

Between February 22, 2018 and March 18, 2018, Atmos Energy found nine leaks they classified as Grade 1 and 17 leaks they classified as Grade 2 in the area around the accident site (Figure 23). Of these 26 leaks, 11 were not excavated to determine the cause (the system was replaced); six were attributed to stripped threads; two were attributed to corrosion; two were attributed to ground movement; and one was attributed to each of the following causes: gasket/O-ring, excessive strain, weld (steel), third party damage, and other.[59]

On the afternoon of February 24, 2018, Atmos Energy released a public statement,[60] announcing they had "coordinated with Dallas-Fire Rescue in lifting evacuations in Northwest Dallas" following the accident at 3534 Espanola Drive. Atmos Energy reported completing "exhaustive leak testing in the west Dallas neighborhood bounded by Gaspar Drive to the north, Larga Drive to the west, Almazan Drive to the south and Marsh Lane to the east" (which generally corresponds to the area of the evacuation). However, to "ensure the safety of residents, natural gas service to this area" had been disconnected. Atmos Energy announced that they had approximately 40 contract crews replacing 2.5 miles of pipe throughout the area. Atmos Energy indicated that natural gas services would be restored following the completion of the "installation of the new main and services."

[54] The term *short stop* is used to describe a process by which a fitting is welded to the natural gas main, a hole is cut in the main, and a stopper is inserted to stop the flow of gas.
[55] Interview - Atmos Operations Manager 03.03.2018 & 03.07.2018 with Errata
[56] Evacuations that were performed following the accident are discussed in the NTSB Emergency Response Factual Report.
[57] Atmos Energy Timeline as of April 4, 2018
[58] Interview - Atmos Vice President of Technical Services 04.25.2018 with Errata
[59] Atmos Energy Leak Report Form PS-95 Data Withheld Pursuant to 49 CFR 831.1(c) with Transmittal Letter and Filing Requirements
[60] Atmos Energy Statements Regarding Evacuations and Replacements

Between February 23, 2018 and March 1, 2018, Atmos Energy continued performing special leak surveys over an expanded area and worked with DFR to evacuate additional areas in Northwest Dallas. Atmos Energy's Vice President of Technical Services indicated that while performing special leak surveys, "basically you'd survey one time. We'd say get a crew out there and take care of that leak and you go back over that area again and there was new leaks. So it was something that was unexplained. I've never seen it in my 25 years of working for the gas company." Atmos Energy's Vice President of Technical Services explained that they decided to get a soil expert because it was very wet and there was something going on that they couldn't explain. He indicated that at some point, they brought in their innovative leak detection (ILD), including one Picarro unit and one ABB/LGR unit where such units could be used based on conditions in the alleys.

On March 1, 2018, Atmos Energy provided a letter to their customers that were to be impacted in the northwest Dallas region and released a public statement.[60] The letter stated that Atmos Energy would be conducting a planned outage, temporarily disconnecting natural gas service to approximately 2,800 homes in northwest Dallas. The outage area included the areas bound by Walnut Hill to the north, Web Chapel to the east, near Northwest Highway to the south, and Lakemont Drive to the north (a larger area than indicated in the February 24, 2018 public statement). The public statement indicated that the outage was "necessary to replace Atmos Energy's natural gas distribution system after recent extraordinary rains and unique geological conditions in the area have caused unprecedented system performance."[60] Atmos Energy indicated that more than 120 crews were being deployed to complete this work but also that the action was "not being taken because of any imminent emergency or danger."

In a July 2, 2018 letter to the Railroad Commission of Texas, Atmos Energy indicated that the March 1 Outage was "in direct response" to the leak activity in Northwest Dallas."[60] Moreover, in a summary provided to the NTSB, Atmos Energy stated that "The extraordinary measure was taken after a period of intensive leak surveying and monitoring of system performance."[60] According to Atmos Energy:

> Atmos Energy engaged a geoengineering firm to understand the potential cause for the sudden and unexplained leaks and assist in developing a response. The preliminary findings of the geoengineering firm indicate that the area in question contains dissimilar geological formations in close proximity which were impacted by the historic rain fall. The different characteristics of these formations – and resulting movement of one formation relative to the other, together with many other contributing factors – likely caused longitudinal forces to be added to the system that could not have been readily detected, predicted, anticipated, or foreseen.

In a July 12, 2018 letter to the TX-RRC, Atmos Energy attributed the increase in the number of leaks reported by their Mid-Tex Division for that six-month period to "abnormal, sudden, and unexplained leak activity within a defined geographic area in Northwest Dallas." On July 25, 2018, Atmos Energy issued a public statement, indicating that their leak investigations "revealed that in less than a week's time, our system experienced multiple times the number of leaks experienced in each of the previous three years over this area" and summarizing their resulting pipeline replacement project.

Atmos Energy has communicated to the NTSB that they have continued to coordinate with BCI in the development of a new geological risk factor that was incorporated into their 2019 risk model for their Mid-Tex operating system.[27] Atmos Energy is continuing to work with geotechnical engineering and climatological consultants to evaluate if a similar geological risk factor should be incorporated into their risk assessment models in other states where they operate.

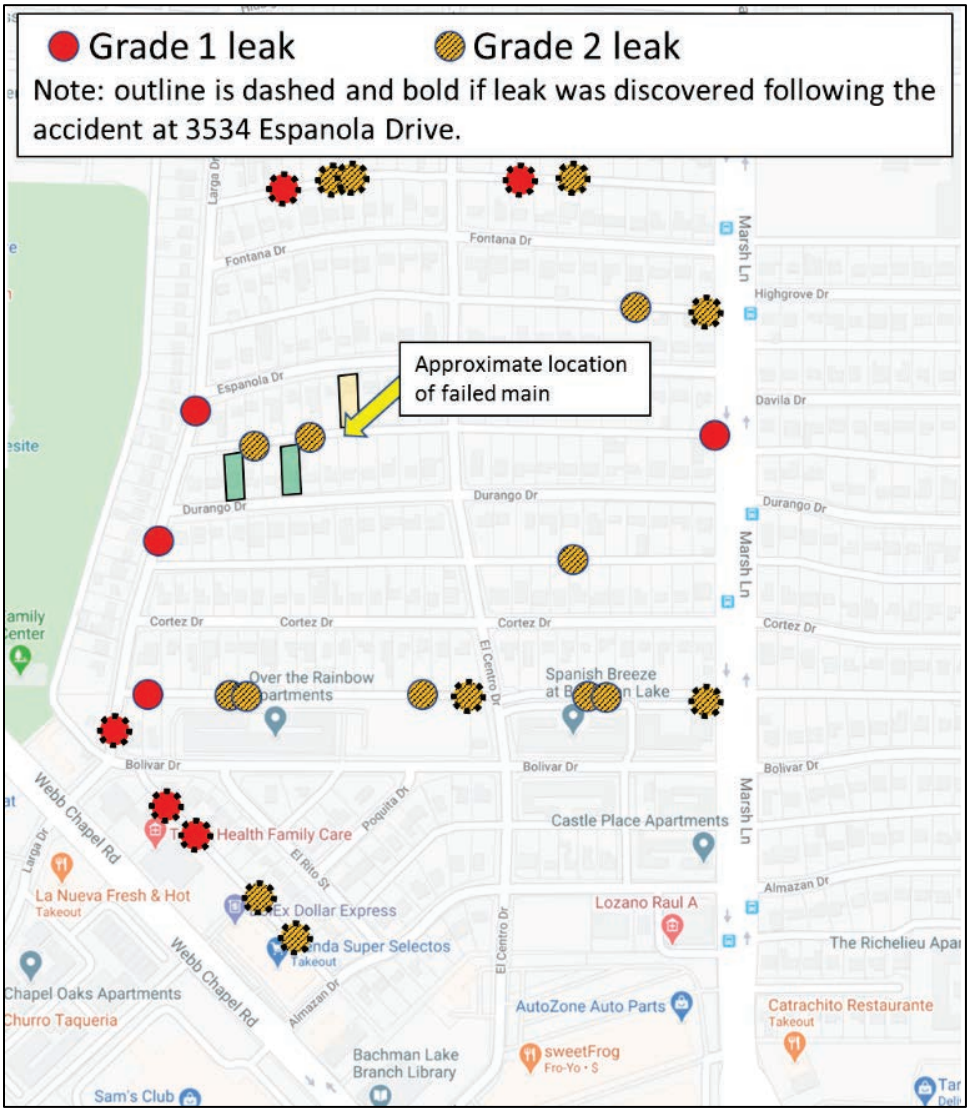

Figure 22. Grade 1 and Grade 2 Leaks Discovered Between February 22 and March 18, 2018

2. Drug and Alcohol Testing

PHMSA regulations under 49 CFR §199.105(b) require that an operator must drug test all "surviving, covered employees whose performance of a covered function either contributed

to the accident or cannot be completely discounted as a contributing factor to the accident." This test must be administered no later than 32 hours after an accident. The operator must report on their PHMSA Incident Report form the completion of the test and how many employees, as well as contract employees, were tested and how many tests had failed.

Atmos Energy reported on their PHMSA incident report for the February 23, 2018 gas incident that they tested 31 employees and 12 contract employees, and no tests failed. NTSB reviewed the drug tests for the employees and found no positive test results for opioids, amphetamines, cocaine, tetrahydrocannabinol, or alcohol.

3. Integrity Tests

On February 23, 2018, Atmos Energy performed a pressure test of the customer-owned piping at 3534 Espanola Drive from the outlet of the meter to the riser near the house. The customer-owned natural gas piping was found to be disconnected near the riser to the house post-accident. The customer-owned piping was pressurized with air at 4 oz per square inch and held for 10 minutes, passing the pressure test.[61]

On February 24, 2018, Atmos Energy began preparations to pressure test the main and service lines that supplied the impacted homes with natural gas (Figure 24). All service lines were disconnected and isolated just upstream of the service regulator between Durango Drive and Espanola Drive from Larga Drive to El Centro Drive (Figure 25). The pressure test was performed with air in various phases to locate the point of failure, as described below. The pressure test was planned to be performed at a pressure of 25 psig.

The full test segment extended from behind 3503 Durango Drive (Excavation #1) to behind 3559 Durango Drive (Excavation #2).[62] Excavations #1 and #2 were completed and the main was cut and capped in order to perform the pressure test. When the main and service lines failed to hold pressure, Atmos Energy soap tested all riser plugs and found one leak where a brass plug was cross threaded on the steel riser. After addressing the leak, the line was pressure tested again to 12 psig and failed to hold pressure. Pressure was then increased to 25 psig and the line was walked to search for bubbles in the standing water in the alley; no bubbles were found. Probe holes were then made in the alley, above the main approximately every five feet from Larga Drive to El Centro Drive to see if bubbles could be found. No bubbles were found.

On February 26, 2018, NTSB investigators developed a leak testing procedure which included the following steps:

1. Confirm integrity of main from Larga Drive (Excavation #1) to El Centro Drive (Excavation #2) is undisturbed from prior test. This includes, but not limited to, a review of the valves, stopple fittings, and bell holes on both ends.

[61] Post-Accident Pressure Tests by Atmos Energy Prior to NTSB Investigation
[62] Excavation Site Maps and Material Inventory

2. Within alley, expose pipe of existing bell holes (2 or 3 locations) via hand digging. Locations will be determined on site. Perform a visual inspection of the condition of pipe and any associated service connections.
3. Check calibration record of recording device. Attach chart recording device (pressure).
4. Connect the air compressor to the 1-inch thread-o-let installed on the 2 in main in Excavation #1 and pressure the main to 25 psig. Maintain the stabilized 25 psig test pressure for 30 minutes or test duration determined on site. Monitor the pressure at both the riser furthest from the compressor, and at the compressor site. Pressure should not exceed 28 psig.
5. Monitor each exposed bell hole for leaks.
6. If test fails, all parties will agree while on site on an agreed upon location to segment the pipe for additional leak testing.
7. Once location is agreed to, pipe to be exposed no closer than approximately 15 feet from any service tap. Excavation near pipe facility should be via hand digging. Perform a visual inspection of the condition of pipe and any associated service connections.
8. Upon satisfactory examination of pipe, cold cut pipe to remove an approximate 2-3 foot section of the main, and install a 1-inch thread-o-let on the section of main.
9. Connect the air compressor to the 1-inch thread-o-let installed on the 2-inch main and pressure the main to 25 psig. Maintain the stabilized 25 psig test pressure for 30 minutes or test duration determined on site. Monitor the pressure at both the riser furthest from the compressor, and at the compressor site. Pressure should not exceed 28 psig.
10. Repeat steps #6 through #9 as agreed to in field by all parties.
11. All removed pipe and associated facilities will be documented, preserved, and securely stored.

The NTSB investigators exposed the service tees and a portion of the main behind 3531 Durango Drive (Excavation #3) and 3519 Durango Drive (Excavation #5). The depth of cover was 58-inches and 44-inches at Excavation #3 and Excavation #5, respectively. The backfill around the sewer line at Excavation #3 and Excavation #5 was tested with a CGI and both locations indicated readings of about 1% natural gas in air. The full test segment was then pressurized to approximately 12 psig. While air was being added to the line, leak detection fluid was placed on the exposed service tees and main. No leaks were identified at either location. Excavation #3 was then extended to expose the service tee and main behind 3524 Espanola Drive. The full test segment was again pressurized with air, and leak detection fluid applied. A leak on the threads of the service tee and of the threads of the service tee cap behind 3524 Espanola Drive was identified (Figure 26). NTSB investigators continued to look for additional leaks which might explain the failed pressure test.

An excavation began behind 3523 Durango Drive (Excavation #4) but was determined to be the wrong location. The area was excavated about 18-inches before the wrong address was confirmed and digging ceased.

On February 27, 2018, a portion of the 3524 Espanola Drive and 3531 Durango Drive service lines (tap to service riser) were extracted and removed as evidence. The service to 3524 Espanola Drive was cut in half to ease removal and transport. The main was then capped in both directions at Excavation #3. The main and service lines between Excavation #1 and Excavation #3 (Pressure Test Section #1 in Figure 24) were pressure tested at 25 psig for 30 minutes and passed.[63]

The main and service lines between Excavation #2 and Excavation #3 were pressurized to 12 psig and did not hold pressure. The main just west of the service tee to 3542 Durango Drive (Excavation #6) was excavated, cut, and capped on both ends. This created two new segments which were each pretested at 12 psig. The segment of main between Excavation #6 and Excavation #2 passed the pretest; the segment of main between Excavation #3 and Excavation #6 did not hold pressure.

On February 28, 2018, no excavation field work was completed due to rain.

On March 1, 2018, the segment of main between Excavation #6 and Excavation #2 (Pressure Test Section #2 in Figure 24) was pressure tested. Initially, issues with the pressure recording device and a leaking inlet riser valve was identified. Once these issues were addressed, Pressure Test Section #2 was pressure tested at 25 psig for 35 minutes and passed.[63]

The main was partially excavated from the 3534 Espanola Drive service tee to the east past the original and replacement service tees (Excavation #7). The original service line was a 1-inch steel line that had been disconnected and abandoned in place and the original tap had been removed and replaced with a tornado plug and wrapped. A new polyethylene ¾ inch service line had been installed in November 2017 (Figure 27). The depth of cover to the new service tee measured 49 inches. The sewer lateral was excavated from the 3534 Espanola Drive fence line to the sewer main tee (Figure 27). Gas readings were taken in the sand padding of the sewer lateral to 3534 Espanola Drive; peak readings as high as 35% gas in air were recorded on the east side of the sewer lateral in the embedment. The segment of main between (Excavation #3 and Excavation #6) was tested again at 8 psig and leak detection fluid was applied. No leaks were observed in the exposed area. This section failed the pressure test.

On March 2, 2018, CGI readings were taken in Excavation #7 on the east side of the 3534 Espanola Drive sewer lateral, west side of the sewer lateral, and directly above the sewer lateral towards the fence, all in the embedment of the lateral. Percent natural gas in air readings were 16% east of the lateral, 0% west of the lateral, and 19% north of the lateral.

Excavation #7 was extended further east of the abandoned 3534 Espanola Drive service tee. An unidentified collar/fitting was found about 56.5 inches east of the tornado plug. This collar/fitting was included in the segment with the 3534 Espanola Drive service tee. The

[63] Pressure Test Sections 1-5 and 3534 Espanola Drive House Line

NTSB investigators then removed a 43.375-inch section of 2-inch main and welded a cap on both sides of the remaining pipe; a cap with a test tap was used on the west side. The removed section was retained as evidence. The segment from Excavation #7 to Excavation #6 passed an initial pressure test at 12 psig; the segment from Excavation #3 to Excavation #7 failed.

Excavation activity was also completed on the west side of the 3534 Espanola Drive service tee. During this excavation, a peak CGI reading of 1.5% gas in air was observed near the main about 3.5-feet to the west of the 3534 Espanola Drive service tee.

A pressure test of the customer-owned natural gas piping at 3534 Espanola Drive (House Line in Figure 24) was performed by Atmos Energy and supervised by TX-RRC. This pressure test was performed from the outlet of the meter to the house riser using a hand pump. The pressure test passed. The test was held for at least 30 minutes at 4 ounces per square inch after an initial 30 minutes of 0 pressure to establish a baseline. [63]

On March 3, 2018, the main and service lines between Excavation #7 and Excavation #6 (Pressure Test Section #3 in Figure 24) was pressure tested and passed.[63]

Excavation #8 began west of the 3539 Durango Drive service tee. NTSB investigators noticed a change in soil color and a sulfur smell emitting from this excavation site. The soil characteristics changed at a depth of approximately 1-2 feet. The gas main was partially exposed at a depth of 43-inches below ground level. Investigators leveled the ditch bed at an approximate depth of 40-inches.

On March 5, 2018, field operations resumed after a delay due to weather conditions on March 4, 2018. An existing concrete section west of 3539 Durango Drive was removed. The depth of cover at Excavation #8 was measured at 4.5 feet. NTSB investigators noticed a strong sulfur smell. Contact between gas impacted soil and clean clay was observed on western half of the excavation. The odor became stronger and the discoloration more apparent with continued excavation to the east. Localized pockets of sand, similar to the sewer lateral sand, were occasionally observed. Two individual pipe coating damages (later determined to be areas covered by a hard deposit as discussed in the Materials Laboratory Factual Reports 18-067 and 19-028) were noted when the gas main was exposed. The observed pipe coating damages included a split in the coating near the center of the excavation and a larger more irregular coating loss feature. The coating damages were soap tested under pressure and exhibited no signs of leak. A section of main, approximately 3-feet in length, was removed from Excavation #8; the remaining main was cut and capped. The cutout section included the split coating damage.

The section of main and service lines between Excavation #3 and Excavation #8 (Pressure Test Section #4 in Figure 24) was pre-tested at 12 psig and passed. Pressure Test Section #4 was then tested at 25 psig and passed.[63]

The section of main and service lines between Excavation #8 and Excavation #7 were pre-tested at 8 psig and failed with no visible leaks.

The portion of the main just west of the 3534 Espanola Drive service tee in Excavation #7 was removed and the remaining main capped on both ends, creating Pressure Test Section #5 (Figure 24). Pressure Test Section #5 was pretested at 12 psig and passed.

On March 6, 2018, NTSB investigators performed pressure tests throughout the day on Pressure Test Section #5. Due to multiple gauge, connection, and charting errors, an accurate charted pressure test was not obtained until the following day.

NTSB investigators began Excavation #9. To accommodate the excavation in this area, Excavation #8 had to be backfilled. A profile view of the gas main and sewer lateral and then the remaining length of main in this excavation (about 24-feet) was exposed (Figure 29). No soil discoloration or sulfur smell was observed around the main east of the 3539 Durango Drive sewer lateral. The sewer lateral was estimated to have a clearance from the top of the gas main to the bottom of the sewer lateral of approximately 0.5-inches.

Unlike soil in other excavations, which consisted of continuous, clean clay, in Excavation #9, non-continuous sand pockets contained within pebbly clay were observed. The CGI registered 0% gas at a depth of 37-inches. Bar hole testing was completed along the southern wall of the excavation, with gas in air readings decreasing from east to west (highest readings of 44.2% gas at the eastern most portion of Excavation #9). The approximate depth of cover at the gas main and sewer lateral crossing were taken: 32-inches to top of sewer lateral sand; 42-inches to top of sewer lateral; 48-inches to bottom of sewer lateral; 49-inches to top of gas main (Figure 28 and Figure 29).

The 2-inch main exposed in Excavation #9 was soap tested; NTSB investigators observed an audible air release and visible soap bubbles on the main at the 3539 Durango Drive lateral crossing (Figure 30). After cleaning, a dent and circumferential crack were identified on top of the pipe directly under the western section of the sewer lateral. Substantial coating damage and an adherent concrete-like substance were found on the location of the pipe.

On March 7, 2018, Pressure Test Section #5 was pressurized to 25 psig for one hour and passed.[63] The 3534 Espanola Drive main and service line was removed and retained as evidence.

The 2” main directly beneath the sewer lateral was exposed. The circumferential crack that had been identified on the previous day was observed towards the top of the pipe. The extent of coating damage appeared across about 25-inches of pipe, mostly concentrated on the top of the pipe in the area directly beneath and to both sides of the sewer lateral. From the east property line of 3539 Durango Drive, the path of the gas main took a downward dip to the west, just west of the sewer lateral to 3539 Durango Drive; there appeared to be slight over-bend in the pipe.

The damage main near the lateral to 3539 Durango Drive was removed as evidence. The remaining section was cap welded on west end and a preliminary pressure test at 25 psig for 30 minutes resulted in a pressure drop of 5 psig. A small leak was identified on the service tap to 3539 Durango Drive (Figure 31). The 3539 Durango Drive sewer lateral connection to sewer main was exposed; the sewer main had a depth of cover of approximately 75-inches (Figure 32). A plastic soft drink bottle (Coke) removed from the excavation above the sewer lateral to 3539 Durango Drive indicated a “1995 sweepstakes date.”

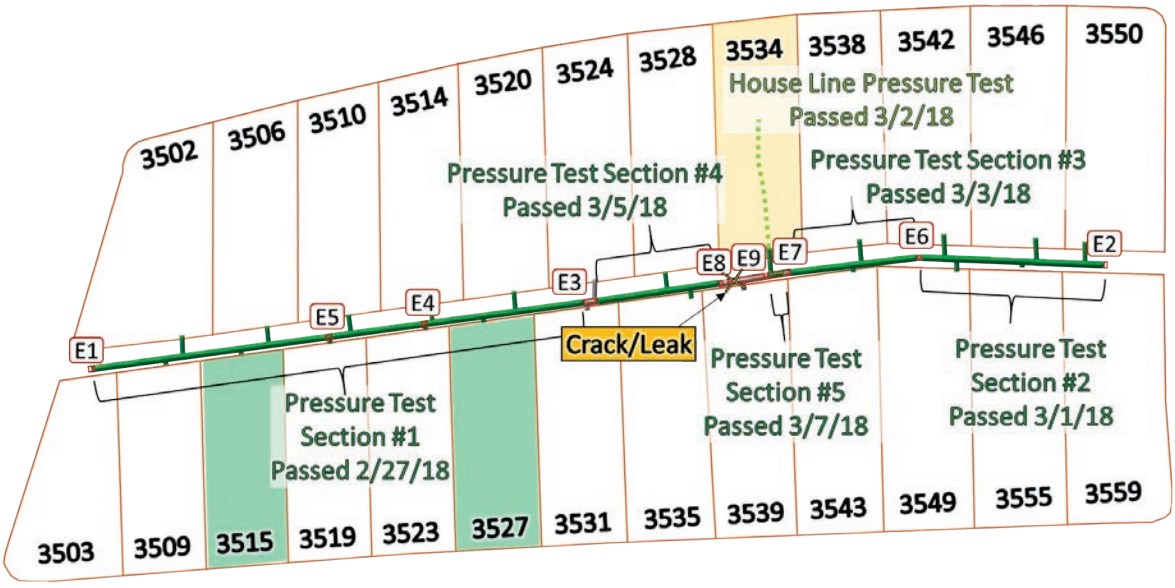

Figure 23. Overview of Main Integrity Tests Performed Following the Accident. Approximate excavation locations are indicated by a red rectangle with identification above the symbol (e.g., "E1" is Excavation #1).[62]

Figure 24. Example Service Line Preparation for Pressure Test. Meter-Regulator Set Shown is from 3515 Durango Drive. Photo by Baker-Risk on Behalf of Atmos Energy: 2/24/18 at 2:49PM.

Figure 25. Photograph of Leak on Threads of 3524 Espanola Drive Service Tee and Service Tee Cap (Photograph by Atmos Energy, 2/28/19)

Figure 26. Sewer Lateral from 3534 Espanola Drive at Excavation #7 facing west (Photograph by PHMSA, 3/1/18)

Figure 27. Sewer Lateral from 3539 Espanola Drive at Excavation #8 Facing East (Photograph by TX-RRC, 3/6/18)

Figure 28. View from Excavation #7 Facing West Towards 3539 Espanola Drive Sewer Lateral (Photograph by Atmos Energy, 3/6/18)

Figure 29. Soap Bubbles from 2-inch gas main at 3539 Durango Drive sewer lateral crossing (Photograph by Atmos Energy, 3/6/18)

Figure 30. Photograph of Leak on 3539 Durango Drive Service Tap (Photograph by Atmos Energy, 3/7/18)

Figure 31. Sewer lateral from 3539 Durango Drive Connection to Sanitary Sewer Main, Facing East (Photograph by Atmos Energy, 3/7/18)

4. Gas Measurements

Several gas measurements were taken following the accident using a SENSIT® GOLD CGI. Figure 33 and Figure 34 depict a compilation of the results of the gas measurements that were taken following the accident. The numbers within the white circles identify the gas concentration readings in percent natural gas in air as indicated in Atmos Energy records[64] or measured during the NTSB investigation. Locations where the gas measurement indicated that no natural gas was present are shown, but there is no accompanying measurement value. The graphic also identifies (by an orange "X") the location of the crack that was discovered in the 2-inch main.

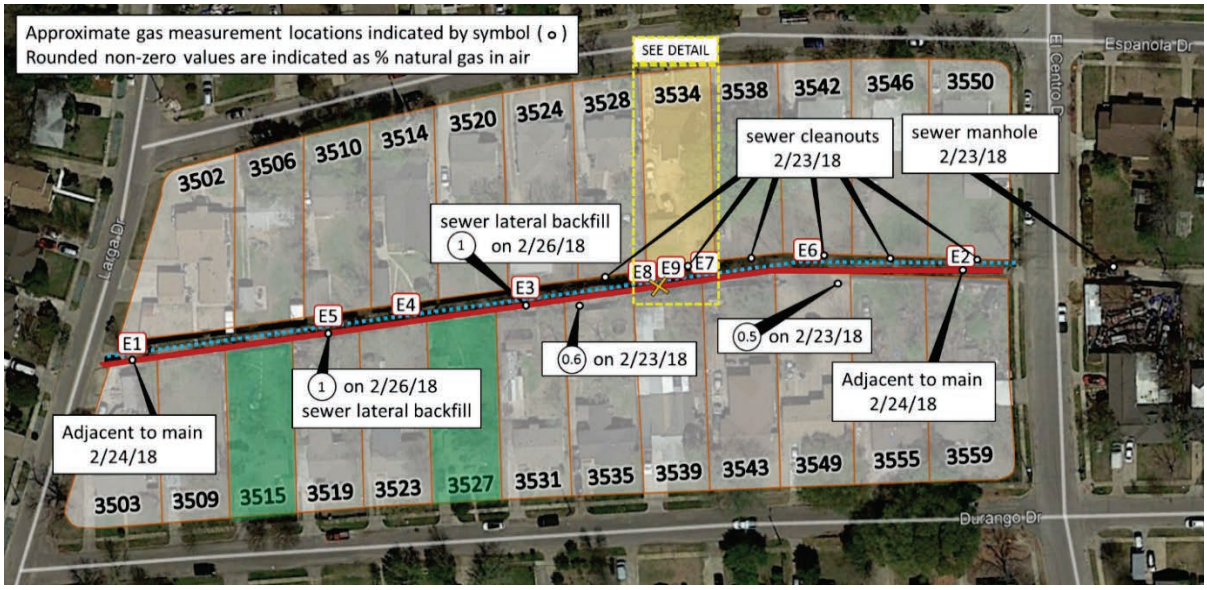

Figure 32. Post-Accident Gas Measurements (Detail Near 3534 Espanola Drive Provided in Subsequent Figure)[65]

[64] Post-Accident Gas Measurements by Atmos Energy Prior to NTSB Investigation
[65] Peak measurements were higher at some measurement locations.

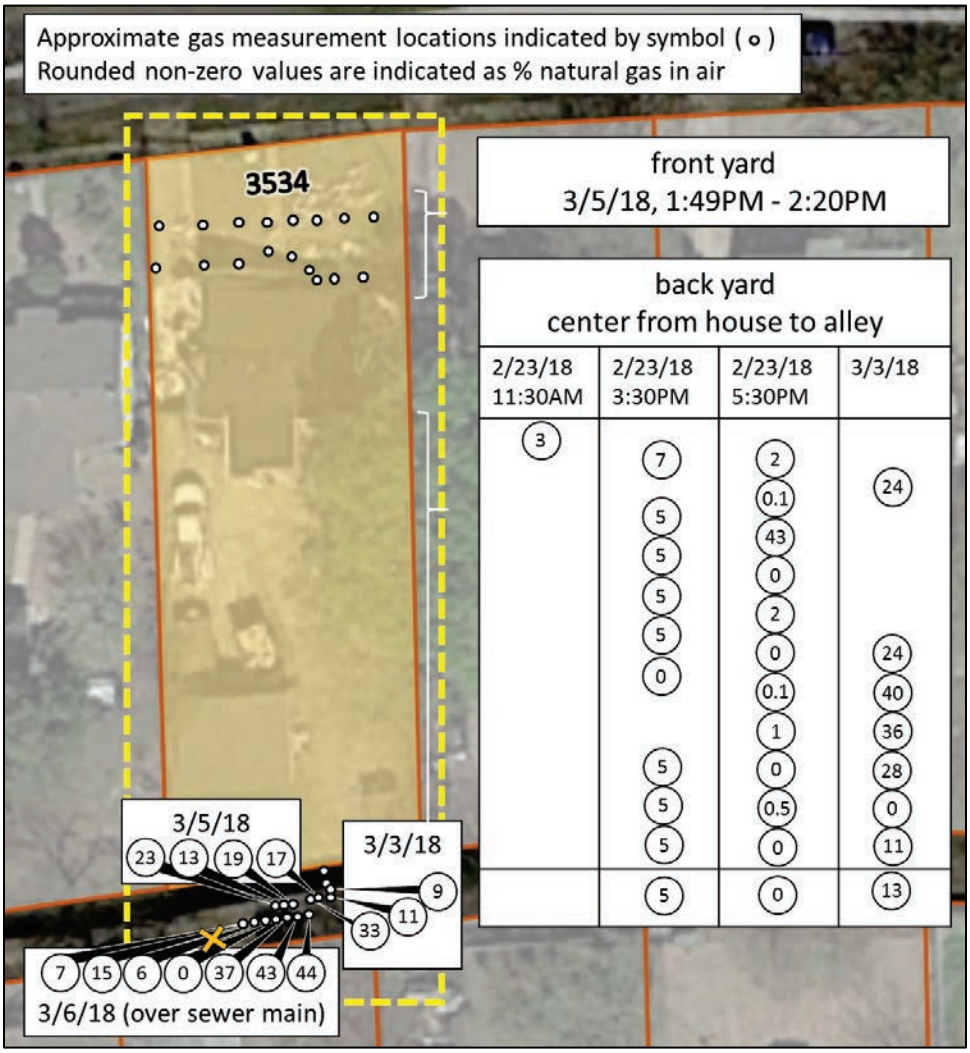

Figure 33. Post-Accident Measurements (Detail Near 3534 Espanola Drive).[66] *Measurement locations in the back yard are not shown; they were taken between the house and alley near the centerline of the property.*

H. Post-Accident Examinations

At the completion of the excavation and testing process, NTSB investigators collected and classified evidence some of which was forwarded to the NTSB headquarters in Washington, DC. The bulk of the evidence was shipped to a storage facility in the Dallas metro area. The evidence that was removed includes: 3534 Espanola Service Line; 3534 Espanola Segment E3; 3534 Espanola Segment W4; 3534 Espanola Segment W5; 3534 Espanola Riser; 3534 Espanola ABN Service South; 3534 Espanola ABN Service North; 3539 Durango Segment 1 (failed piping); 3539 Durango Segment 2; 3539 Durango Segment 3; 3539 Durango Segment 4.[62]

[66] Peak measurements were higher at some measurement locations.

1. Testing of Atmos Energy Gas Detection Equipment

NTSB investigators shipped CGIs that Atmos Energy used to detect the presence of natural gas in the impacted area to the manufacturer, Sensit Technologies, to determine if the devices had been compromised by excessive moisture as the testing for the presence of gas was done in wet conditions and during periods of rain. The results of the testing found that the gas detectors were functioning in accordance with the manufacturer's specifications.[67]

2. Gas Odorization Test

The Texas Railroad Commission conducted a gas odorization test on February 23, 2018 and found the natural gas odorant to be "readily detectable." The odorant test was performed at four test points using two Heath Odorators.[68]

3. Gas Regulator Testing[69]

Atmos Energy shipped the gas regulators from the three affected homes and an exemplar regulator to an independent test laboratory, Rothfuss Engineering Company, for non-destructive testing. NTSB investigators approved the testing protocol prior to the commencement of the testing. The testing was witnessed by Atmos Energy's Director of Engineering & Compliance.

Honeywell American Meter manufactured two of the regulators, which were model numbers 1813c (homes at 3527 Durango Drive and 3534 Espanola Drive). Lancaster National Meter manufactured the third regulator, which was a Model 61 Type R (home at 3515 Durango Drive).

In accordance with the testing protocol, each regulator was tested at inlet pressures of 14, 25, and 52 psig with a flow rate of 50 standard cubic feet per hour (SCFH) to determine the downstream set point. Prior to recording the downstream, regulated pressure, it was verified that each regulator could maintain the downstream pressure set point for a minimum of 30 seconds. Once the downstream pressure was recorded, the flow rate was reduced to zero SCFH to verify that the regulator would lockup and to determine the downstream lockup pressure. The downstream lockup pressure was recorded. Following the downstream set point verification and the lockup verification, the regulators were tested to verify that the regulator's internal pressure relief functioned properly.

The testing laboratory reported that all three regulators functioned properly as their downstream set points were in the expected range for a residential natural gas regulator. The testing laboratory indicated that all three regulators properly locked up when the flow was shut off and they all also relieved when the downstream pressure exceeded the internal relief

[67] NTSB Materials Laboratory Factual Report No. 18-096
[68] Post-Accident Odorization Test (TX-RRC Odorization Form PS-28)
[69] Regulator Functionality Testing by Rothfuss Engineering Company

set points. The testing laboratory determined that all internal relief set point were within the normal expected range except for Regulator No. 1 (3534 Espanola Drive) which had a "slight deviation above the factory specification" which was considered by the testing laboratory to be "insignificant."

4. NTSB Research and Engineering Testing

The steel gas main that was installed behind the dwelling at 3539 Durango Drive and a portion of the same gas main with a tee assembly that was installed behind the dwelling at 3524 Espanola Drive were examined by the NTSB Materials Laboratory (See Figure 35, Figure 36, Figure 37, and Figure 38).[70]

During the examination, NTSB investigators observed:

- The 2" main was coated with a black tar enamel spiral wrap coating. This coating was damaged in four areas (on the top side of the main) and covered in a hard, compacted, adherent deposit.
- The hard deposit was not present on any other portion of the pipeline.
- When the hard deposits were removed, each of the four areas contained at least one major gouge in the metal.
- The pipe had a slight downward bow with the greatest vertical deformation in the area where the pipe was cracked.
- The crack extended approximately halfway around the circumference of the pipe and intersected a significant dent.
- There was a 20% reduction in wall thickness at the point of the dent.

A 10-foot segment of the main with the circumferential crack was pressure tested (Figure 37). The cut end was plugged by the NTSB with a mechanical pipe plug that contained a pass-through port that allowed pressurized air to enter the main. The other end contained a weld plug, as indicated earlier.

NTSB investigators attempted to pressurize the pipe to 55 psig, the MAOP of the pipe, but this was not possible because air flowing out of the crack exceeded the capacity of the air compressor to provide the desired pressure. The pressure test was terminated at 33 psig.

A 3-foot segment of the steel main with a steel tee assembly and polyethylene service pipe located behind the dwelling at 3524 Espanola Drive was also examined. Pressure testing was conducted on the portion of the service pipe that contained the riser, and separately on the portion of the service pipe that contained the tee assembly and main, since the service pipe was severed to facilitate transportation.

The cut end of the as-received service pipe was attached to a mechanical plug containing a pass-through port that allowed pressurized air to enter the service pipe. The upper end of

[70] NTSB Materials Laboratory Factual Report No. 18-067

the meter riser contained a plug that was installed on-site. The service pipe was subjected to 56 psig and showed zero air flow. A soap solution was sprayed on various parts of the service pipe and meter riser. Areas that show evidence of bubbles are a positive indication of a leak. The service pipe and meter riser showed no evidence of bubbles, indication of no evidence of a leak.

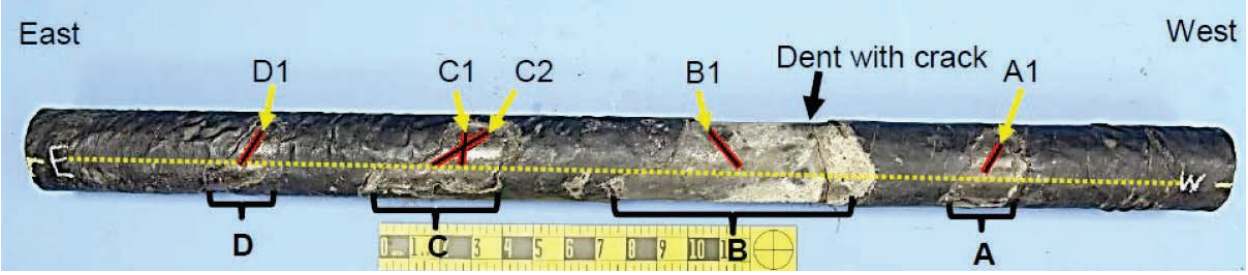

Figure 34 -- Top surface of the main showing location of five major gouges, "A1", "B1", "C1", "C2", and "D1", indicated by black and red outlines (black and red outlines are not to scale). Top of main line is indicated by a yellow dashed line.

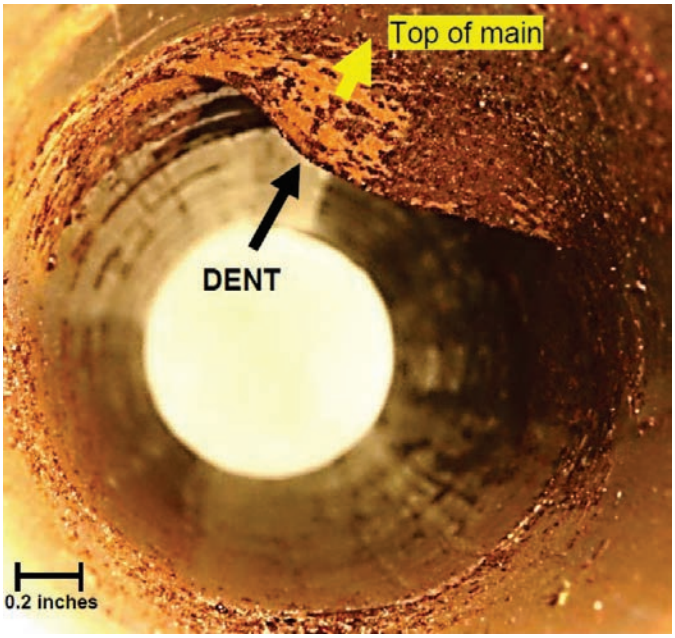

Figure 35 – View of the inner surface of the main looking east showing a dent that intersected the circumferential crack. Arrow also points to the approximate top of the main.

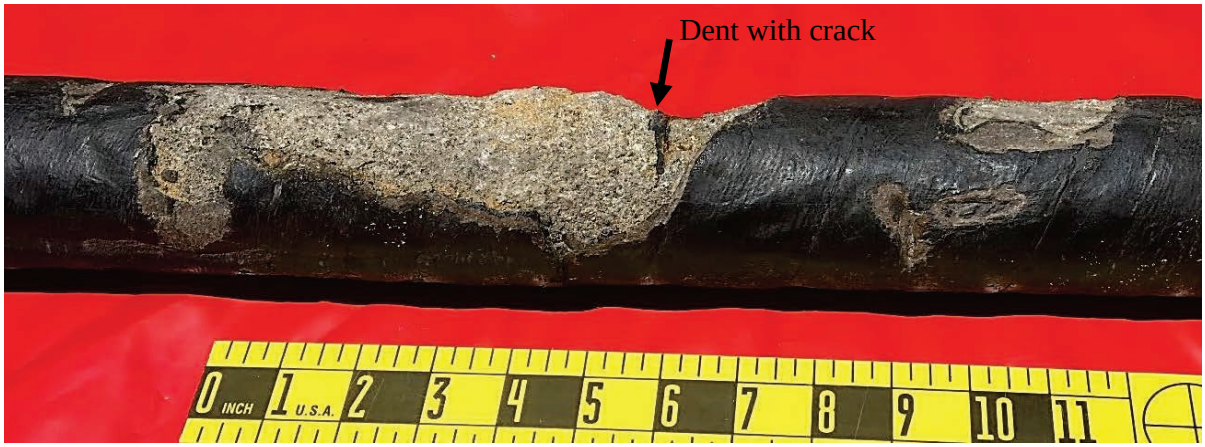

Figure 36 -- Side view of the as-received main showing the dent with a crack

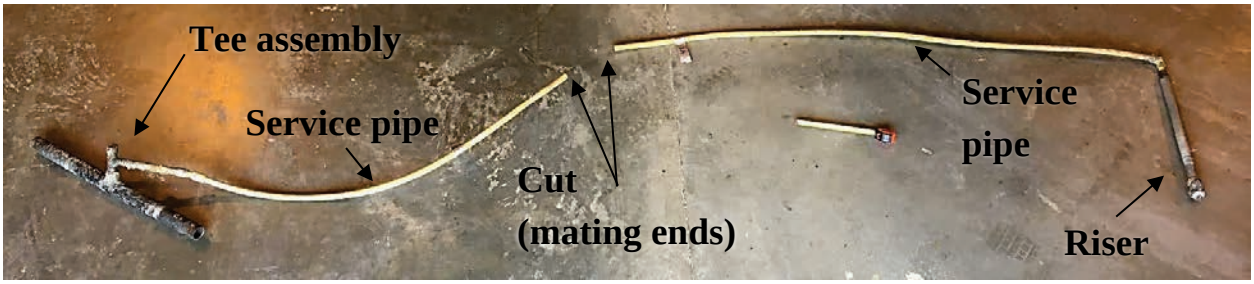

Figure 37 -- As received riser and service pipe for dwelling 3524 Espanola Drive that connects to the tee assembly and main

5. Soil Testing

Geotechnical reports were prepared by two organizations following the accident. Atmos Energy retained a geotechnical engineering firm, Bryant Consultants, Incorporated (BCI). Atmos Energy indicated that BCI was retained to assist in determining a potential cause of the sudden and unexplained leaks in a defined area in NW Dallas in the days leading up to Atmos Energy's planned system outage on March 1, 2018 and assist in developing a response. A separate evaluation was prepared at the request of the NTSB. A Government Geotechnical Report was completed by the U.S. Army Corps of Engineers (USACE) to evaluate the technical accuracy of the preliminary geotechnical assessment report provided by BCI.[71]

[71] Government Geotechnical Report for the NTSB (CESWF-EC-G) by the U.S. Army Corps of Engineers

Bryant Consulting Soil Study

Atmos Energy hired a geotechnical engineering firm, Bryant Consultants, Incorporated (BCI), who completed a "Preliminary Assessment Report," which contained a "theoretical model."[72] BCI's Preliminary Assessment Report contends that there are two different geologic formations, the Eagle Ford and Austin Chalk, underlying a defined area in NW Dallas. The report states that the close proximity of these two formations creates a geological "hingepoint" where the land generally to the west of Marsh Lane may move more relative to the land to the east of Marsh Lane where more uniform and stable soil and moisture conditions are generally encountered. The report further suggests that the recent extended period of rain had "likely exacerbated this movement," and that these forces "caused unanticipated external loadings" on Atmos Energy's piping system. According to Atmos Energy, following the release of the Preliminary Assessment Report, BCI obtained data that corroborated this theory.[27] Specifically, in the following months, BCI performed an in-depth analysis of this area in Northwest Dallas which Atmos Energy stated corroborated the Preliminary Assessment. According to Atmos Energy, as a part of this work, dozens of core samples were collected, and subsurface geological testing was conducted throughout the area that refined existing geological maps of the area. BCI presented a project summary of this work[27] but did not produce another written report (other than the Preliminary Assessment Report).

According to Atmos Energy, BCI was not engaged to investigate, or draw conclusions, regarding the events of February 21-23, 2018, and did not perform any testing within the 3500 block of Durango and Espanola Drives. According to Atmos Energy, the company has never claimed that the damaged main behind 3534 Espanola Drive cracked due to heavy rains and soil composition. According to Atmos Energy, they instructed BCI not to obtain core samples or conduct geological subsurface testing in the 3500 block of the alley between Durango and Espanola Drives.

U.S. Corps of Engineers Soil Study

A separate evaluation was prepared at the request of the NTSB. A Government Geotechnical Report was completed by the U.S. Army Corps of Engineers (USACE) to evaluate the technical accuracy of the preliminary geotechnical assessment report provided by BCI.[71] The USACE report contains a written analytical narrative supported by boring locations and logs, laboratory testing data, and plots. The USACE reported that based on the site-specific borings, drilled as part of the subsurface investigation, there is only one geologic formation, the Eagle Ford Shale, underlying the accident site. Moreover, based on the lab test results described in their report, USACE concluded that the plasticity characteristics and swell potential (relative change in volume to be expected with changes in moisture content) of the subsurface materials within the accident block are highly uniform.

Though uniform, USACE observed that the subsurface soils in the accident block are high plasticity clays, the swell potential of which significantly increases as subgrade moisture content increases. That is, the clay swells when saturated with water and shrinks on drying, and the associated movement with this tends to distress the structures constructed on top or

[72] Preliminary Assessment Report – Bryant Consultants, Incorporated (BCI)

within (i.e., buried piping) these formations. The magnitude of force exerted on piping systems is proportional to the plasticity of the soil and the variability of the moisture content within the soil.

6. Customer-Owned Piping at 3527 and 3515 Durango Drive

Although the NTSB investigation focused on the accident at 3534 Espanola Drive, the NTSB investigators also gathered available information related to the incidents at 3527 Durango Drive and 3515 Durango Drive as described below.

Atmos Energy provided an update to the NTSB stating that additional testing of the customer-owned piping at 3527 Durango Drive was conducted in connection with litigation. Atmos Energy provided a summary of the testing, "Pressure tests were conducted on this home but there were no leaks on the system or on any of the appliances."[73] Atmos Energy also noted that a "poorly-constructed addition" to the home, char pattern of the tile floor of the addition and in the space between the addition and the home, and a disconnected toilet was observed during the testing.

Atmos Energy provided an update to the NTSB stating that additional testing of the customer-owned piping at 3515 Durango Drive was also conducted in connection with litigation. Atmos Energy provided a summary of the testing. The test conducted on 3/15/18 resulted in a documented pressure drop from 7.56 inches water column[74] (0.27 psig) to 5.97 inches water column (0.22 psig) over approximately 7 minutes.[73,75]

In April 2020, the NTSB IIC contacted the plumbing company that performed the testing of the customer-owned piping at 3515 Durango Drive. The NTSB obtained a video which had been recorded during the testing on 03/15/2018 and a written statement from the plumber responsible for performing this work. The plumber indicated that he was a licensed Master Plumber with 39 years of experience which included designing, installing, repairing and testing commercial and residential low pressure and medium pressure gas piping systems. He indicated that he first visited the property on March 14, 2018 to evaluate the job site and had performed testing on March 15, 2018 and March 20, 2018. The Responsible Master Plumber indicated that there were three gas appliances in the home (gas range, water heater and furnace) and that the only damage to the gas piping that he recalled was that the flex connector to the stove was disconnected from the stove. He indicated that the system was tested with normal operating pressure and that there were no indications that any of the gas piping system was leaking or malfunctioning.[76] In the video, the Responsible Master Plumber indicated that a very minute leak will drop the pressure measuring gauge to zero and

[73] Post-Incident Testing at 3527 and 3515 Durango Drive – Observations by Atmos Energy
[74] Inches of water column ("in H_2O," "in wc," or "wc") is defined as the pressure exerted by a 1-inch high column of water under specific conditions. 1 in H_2O is equal to 0.036 psi.
[75] Atmos Service Technician 2 indicated customer piping is usually tested for 1 minute (Interview - Atmos Service Technician 2 02.28.2018 & 06.06.2018 with Errata)
[76] Post-Incident Testing at 3515 Durango Drive by Mesquite Plumbing

that the leak that was indicated by the digital manometer would probably not be found by a soap test nor be flammable.[77]

Additional information regarding the incidents at 3527 Durango Drive and 3515 Durango Drive will be documented in the Materials Laboratory Fire Factual Report (Report No. 20-031).

[77] Transcript of Video from Post-Accident Pressure Test at 3515 Durango Drive on March 15, 2018

I. Post-Accident Regulatory Actions

Following the accident, the following two bills were enacted by the Texas legislature: [78]

- HB 864 (2019): H.B. 864 details information operators must provide to the TX-RRC after an incident. H.B. 864 also requires operators to notify the railroad commission of any incident within one hour of incident discovery, and for the railroad commission to keep incident investigation records perpetually. H.B. 864 was signed by the Governor of Texas on June 14, 2019.
- HB 866 (2019): H.B. 866 requires natural gas operators to replace all cast iron pipelines by December 31, 2021. In addition, operators would be prohibited from installing new lines made from cast iron, wrought iron, or bare steel. H.B. 866 also requires pipeline operators to replace eight percent of their highest risk pipelines every year. H.B. 866 was signed by the Governor of Texas on June 2, 2019.

TX-RRC has amended their regulations, accordingly, as described below:

- TAC 8.209(h) was revised to require operators to replace 8% of their highest risk pipe identified in their integrity management plan annually. It previously required operators to replace 5% of their highest risk pipe.
- TAC8.210(f) was added, requiring the RRC to retain state records regarding a pipeline incident perpetually.
- TAC8.210 (a)(1) was revised to require telephonic incident reporting no later than one hour following confirmed discovery.
- TAC8.210 (a)(2) was added and specifies information that must be provided following an incident when the information is known by the operator.

As of April 2020, no local, state, or federal enforcement actions have been taken related to the accident at 3534 Espanola Drive or the two events at 3527 Durango Drive and 3515 Durango Drive.

[78] https://capitol.texas.gov/BillLookup/BillNumber.aspx (Accessed June 29, 2020)

J. Post-Accident Actions Implemented by Atmos Energy[79]

Following the accident, Atmos Energy indicated that a number of initiatives across ten categories have either been completed or are underway. A summary of these initiatives, as described by Atmos Energy, is included below.

Damage Prevention

To further reduce the risk of third-party excavation damage, Atmos Energy indicated that they:

- Audited more of its 3rd party line locating services to determine what actions can be taken to further reduce third party excavation damage.
- Strengthened its 'Watch and Care' program to require additional follow-up with excavators who have called in a line locate ticket.
- Started flagging and/or marking the location of newly installed pipe and associated facilities to bring immediate visibility to their location while Atmos facilities map records are updated.
- Added new reporting metrics to better evaluate the performance of its damage prevention program.
- Implemented a Damage Prevention Ambassador Program that encourages employees to proactively stop by excavation sites to provide damage prevention materials to excavators and ensure proper 811 notification.
- Are working to complete the roll out of LocusView so that by the end of 2020 all distribution construction crews can capture and transmit detailed data on new pipe installation through a mobile app. To date, over 700 construction crews (internal and contractors) are using LocusView. This includes as-built maps, tracking and traceability of materials, joints and associated information. LocusView's high accuracy GPS creates as-built maps that are integrated directly into Atmos Energy's GIS.
- Developed safety mascots and ambassadors Gus the Gopher and Rosie the Skunk to engage customers and the public in remembering to call 811 before you dig and using your senses to detect natural gas.

Pipeline Safety Management System

Atmos Energy indicated that they have:

- Participated in industry workshops and discussion groups to learn more about PSMS after its issuance by API in 2015.
- Engaged an industry third-party expert in 2016 to examine its practices in light of RP1173, and also conducted a self-assessment for one of its operating divisions.
- Continued to participate in industry discussion groups and workshops to gain expertise and better understand how to develop and implement PSMS across its entire organization.
- After February 23, 2018, accelerated the implementation of PSMS by updating its initial self-assessment and engaging its industry third-party expert to perform an enterprise wide PSMS assessment and gap analysis.

[79] Atmos Safety Initiatives

- Developed a roadmap and draft PSMS program documents to allow it to reach significant and widespread maturity across all elements of a PSMS.
- Added a Director level resource to support this accelerated implementation effort.

Procedures

Atmos Energy indicated that they:

- Regularly review and revise their procedures as they continue to learn from their own experiences and those of others in the industry, with participation of internal subject matter experts (SMEs).
- Updated their leak survey and leak investigation procedures to include mandatory 911 notification and the establishment of a Safety Perimeter when a hazardous condition is discovered.

Training

To enhance their training curriculum, Atmos Energy indicated that they:

- Developed and delivered an online leak survey refresher training for all employees with specified leak survey Operator Qualification (OQ) requirements.
- Developed and delivered a one-week leak survey refresher training class in the first half of 2019 to all employees whose primary job responsibilities are leak surveying. The training consisted of classroom instruction, a review of procedures, hands-on training by equipment vendors, discussion of weather-related conditions, and industry case studies.
- Implemented an Operations Supervisor Boot Camp at our Charles K. Vaughan training facility that allows operations supervisors to gain a better understanding of our technical training courses, processes and equipment through a one-week hands-on experience class. Every operations supervisor at Atmos Energy has now completed the training, and all new supervisors will be required to attend future classes.

Leak Survey

To enhance their leak survey program, Atmos Energy indicated that they:

- Created a dedicated work group within the Mid-Tex division to support and monitor leak survey activity.
- Continue to closely monitor their system in the Dallas-Fort Worth area through more frequent leak surveys and employed third-party resources to support these efforts.
- Are conducting additional leak surveys across a broad area of the Mid-Tex system at more frequent intervals than required by federal and state regulations.
- Have purchased additional advanced mobile leak detection units within their Texas operations. These units are equipped with sensors that are 1,000 times more sensitive than traditional technologies. They plan to add additional units over time.
- Continue to implement GPS tracking functionality on leak survey equipment.

Risk Factors

To better address geological and climatological threats, Atmos Energy indicated that they have:

- Developed and implemented a geological risk factor that was included in their 2019 Mid-Tex division risk analysis.
- Developed a geological risk factor across the state of Texas.
- Initiated and ongoing review of geological and climatological threats across all states where they operate.

Research and Development

Atmos Energy specifically noted their efforts through partnership with the Gas Technology Institute's Operations Technology Development (OTD) collaborative related to residential methane detectors, leak survey/investigation sensors and technology, and damage prevention tools and practices.

System Modernization

Atmos Energy indicated that they have invested $10 billion company-wide to modernize their pipeline infrastructure, over 80% of which was allocated to safety. They also indicated that they have committed to replacing approximately 5,000 – 6,000 miles of distribution and transmission pipe in the next five years and replacing all remaining cast iron by the end of 2021.

Quality Management

Atmos Energy indicated that they have:

- Deployed an electronic inspection application to their internal and third-party inspectors to drive consistency in inspection and quality management processes.
- Implemented an automated interface between their OQ program and their work management system.

Data Analysis

Atmos Energy indicated that they have:

- Implemented advanced data analytics tools that provide faster and more precise results than manual processes.
- Implemented visualization technology tools that can provide near real-time graphical representation of data to assist operations and compliance leaders in their decision making.

/s/ Date: July 22, 2020

Sara Lyons

Pipeline Investigator

Operations and Integrity Management Group Chairman