NATIONAL TRANSPORTATION SAFETY BOARD
Office of Railroad, Pipeline, and Hazardous Materials Investigations
Washington, D.C. 20594

Operations / Pipeline Integrity

Group Chairman's Factual Report of the Investigation

Operations and Integrity Management Factual Report

NiSource / Columbia Gas

Natural Gas Release

Merrimack Valley, Massachusetts

September 13, 2018

NTSB Investigation No.:
PLD18MR003

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Contents

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B. Accident Summary

On September 13, 2018, about 4:00 p.m.[1] eastern daylight time, explosions and fires occurred after high-pressure natural gas was released into a low-pressure gas[2] distribution system in the northeast region of the Merrimack Valley, Massachusetts. The distribution system was owned and operated by Columbia Gas of Massachusetts (CMA) [3], a subsidiary of NiSource, Inc. The overpressure event damaged 131 structures, including at least 5 homes that were destroyed in the city of Lawrence and the towns of Andover and North Andover. Most of the damage was a result of structure fires ignited by gas-fueled appliances. Several homes were destroyed by natural gas explosions. One person was killed and 22 individuals, including two firefighters, were transported to the hospital. Seven other firefighters received minor injuries. The home where the fatality occurred is shown in Figure 1.

Figure 1-- Damaged home where fatality occurred

The cast-iron, low-pressure natural gas distribution system was installed in the early 1900s and had been partially improved with both steel and polyethylene pipe (PE) upgrades since the 1950s. The low-pressure distribution system in the affected area relied on 14 regulator stations to deliver natural gas at the required pressure into structures serviced by the system. Each of the regulator stations reduced the natural gas pressure from about 75-pounds per

[1] All times stated within this report are Eastern Daylight Time

[2] A distribution system in which the gas pressure in the main is substantially the same as the pressure provided to the customer.

[3] NiSource recognizes Columbia Gas of Massachusetts with the acronym CMA (Columbia Massachusetts) and does not use the acronym CGM (Columbia Gas Massachusetts).

square inch, gauge (psig) to about 0.5 psig, or, equivalently, about 12-inches of water column (w.c.), for delivery to customers.[4]

Beginning in 2015, CMA designed a pipeline replacement project to replace 7,595 feet of low-pressure, existing cast-iron, and PE natural gas main with 4,845 feet of low-pressure and high-pressure PE gas main on South Union Street and neighboring streets.

On September 13, prior to the overpressure event, a CMA-contracted work crew, overseen by a CMA construction coordinator, executed one of the CMA-designed and approved tie-ins at the intersection of South Union Street and Salem Street in South Lawrence. This tie-in was part of the project to install a PE distribution main and abandon in place an 8-inch cast-iron distribution main on South Union Street. The distribution main that was abandoned still had the regulator sensing. Regulator-sensing lines were used to detect pressure in the low-pressure distribution system and provide input to the regulators to control the system pressure. On the day of the accident, completion of the Salem Street tie-in disconnected the 8-inch cast iron main from the distribution system. The 8-inch cast iron main still had the sensing lines connected to it.

As the pressure in the abandoned distribution main dropped to by about 0.25 inches of w.c., the regulators at the district regulator station at South Union Street and Winthrop Ave. (the Winthrop regulator station) responded by opening further, increasing pressure in the distribution system. The regulators at the Winthrop regulator station opened completely when they no longer sensed system pressure, allowing the full flow of high-pressure gas to release into the affected distribution system. As a result, natural gas was delivered to customers at a pressure well above the maximum-allowable operating pressure which led to the ignition of fires and explosions in homes.

Minutes before the fires and explosions occurred, the NiSource Gas Systems Control monitoring center in Columbus, Ohio, received two high-pressure alarms for the South Lawrence gas pressure system: one at 4:04 p.m. and the other at 4:05 p.m. Consistent with applicable regulations, the monitoring center had no control capability to close or open valves remotely on the affected distribution system; its only capability was to monitor pressures on the distribution system and advise field technicians accordingly. Following company protocol, at 4:06 p.m., the CMA controller reported these alarms to the Measurement and Regulation group in Lawrence. A local resident made the first 9-1-1 call to Lawrence Emergency Services at 4:11 p.m.

Once Gas Systems Control notified M&R of the alarms, three technicians dispersed to perform field checks on the affected distribution system's 14 regulator stations. CMA shut down the regulator station at issue by about 4:30 p.m. - within 25 minutes of being notified - which had the effect of stopping the flow of high-pressure gas into the affected distribution system. The critical valves of the distribution system were closed by 7:17 p.m. Shortly after the alarms, CMA technicians began going to homes and businesses within the affected distribution system to shut off their meters, thereby cutting off their gas supply. Beginning about midnight, crews consisting of two CMA technicians escorted by two emergency response personnel worked through the night to ensure customers' meters in the affected system were shut off. The impacted system consisted of approximately 70 miles of main comprised of cast iron, steel and PE (Figure 2).

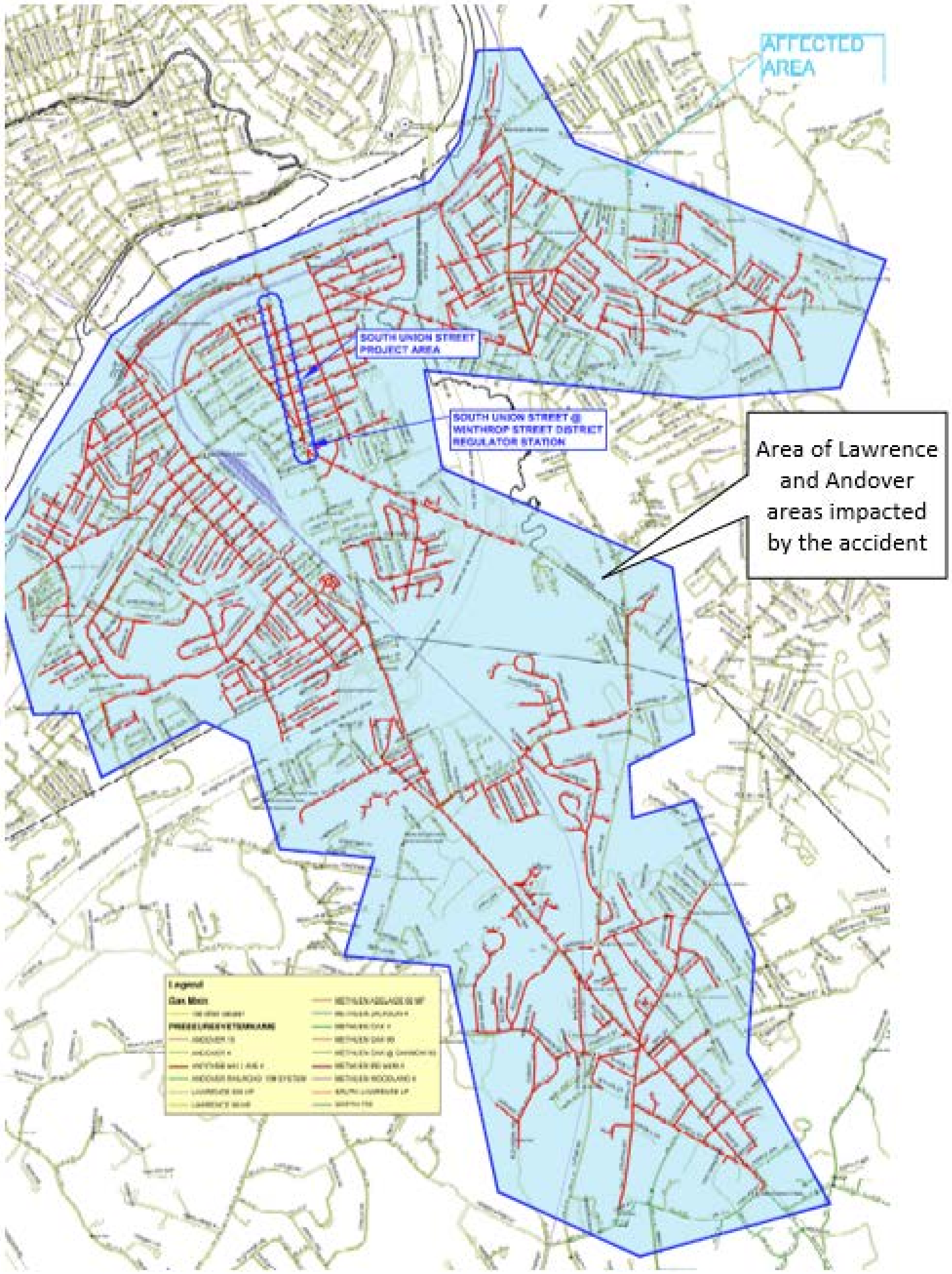

Figure 2 -- Area impacted by accident with clouded gas main depicted

Over a period of approximately 4 hours, CMA personnel relieved excess system pressure and verified that the pressure within the system was at 0 inches w.c. by approximately 7:55 pm.

C. Description of the Operator

NiSource Inc. is an energy holding company whose subsidiaries are fully regulated natural gas and electric utility companies serving approximately 3.9 million customers in seven states. Based in Merrillville, Indiana, NiSource has approximately 8,000 employees across its service area. NiSource is the successor to an Indiana corporation organized in 1987 under the name of NIPSCO Industries, Inc., which changed its name to NiSource on April 14, 1999.

NiSource is one of the nation's largest natural gas distribution companies, as measured by number of customers. NiSource's principal subsidiaries include NiSource Gas Distribution Group, Inc., a natural gas distribution holding company, and Northern Indiana Public Service Company (NIPSCO), a gas and electric company. NIPSCO generates, transmits and distributes electricity to approximately 469,000 customers in Indiana.

NiSource's natural gas distribution operations serve approximately 3.5 million customers in seven states and operate approximately 60,000 miles of pipeline located in its service areas. Within these seven states, NiSource currently has 732 low-pressure gas distribution systems.[4] Through its wholly-owned subsidiary NiSource Gas Distribution Group, Inc., NiSource owns six gas distribution subsidiaries that provide natural gas under the local Columbia Gas brand to approximately 2.6 million residential, commercial and industrial customers in Kentucky, Maryland, Massachusetts, Ohio, Pennsylvania and Virginia. Additionally, NiSource also distributes natural gas to approximately 830,000 customers in northern Indiana through its wholly-owned subsidiary NIPSCO.

CMA delivers natural gas to over 320,000 natural gas customers in southeastern Massachusetts, the greater Springfield area and the Merrimack Valley. Headquartered in Westborough, Massachusetts, CMA is the largest gas-only provider in the state.[5]

D. The Impacted Gas Distribution System

The impacted system operated at low pressure with a nominal operating pressure range of 7-inches w.c. to 12-inches w.c., and the maximum allowable working pressure (MAOP) was 14-inches w.c. The low-pressure system was supplied gas from the NiSource 99 psig distribution system via 14 low-pressure regulator stations. The low-pressure regulator stations reduced the line pressure in the 99 psig system to low pressure as previously described located at various locations throughout the low-pressure system.[6]

The distribution piping in the low-pressure system (Figure 2) was comprised of PE, steel, cast iron, and wrought iron ranging in size from less than 1-inch in diameter to 12-inch in diameter. Table 1 below shows the estimated distribution of pipe by material, size and length for the low-pressure system that existed on September 13, 2018. The impacted low-pressure system described here served approximately 8,450 residential and commercial customers.

[4] See NiSource Party Coordinator to NTSB IIC email of May23, 2019

[5] See NiSource Party Coordinator to NTSB IIC email of October 31, 2018 – NiSource Company Bio

[6] See NiSource Party Coordinator to NTSB IIC email of March 28, 2019

Pipe Diameter (inches)	Steel	Cast Iron	Wrought Iron	PE	Other	Total
Less than 1”	2	11			25	38
1”		6		93		99
1.25”	37				36	73
1.5”	2				8	10
2”	3439	1575	989	4009	129	10140
3”	980	4459	36		5	5479
4”	19867	114203	2	47147	59	181278
6”	25088	49131	271	36103	8	110601
8”	5272	21997	341	16015	3	43628
10”	31	5867	4			5901
12”		518				518
Total	**54716**	**197767**	**1643**	**103365**	**273**	**357776**

Table 1-- The estimated distribution of pipe by material, size and length for the low-pressure system

E. Gas Distribution System -- Regulatory

1. Regulatory Requirements

Areas within both the PHMSA regulations and ASME guidelines that encompass the requirements and guidelines for low pressure systems and the specifics for overpressurization are as follows:

a. Pipeline and Hazardous Materials Safety Administration (PHMSA)

Regulations within Part 192 *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards* include:

§ 192.195 Protection against accidental overpressurization

Within section § 192.195 protection against accidental overpressurization is covered. Excerpts from the regulations that address this are provided below:

Each pipeline that is connected to a gas source so that the maximum allowable operating pressure could be exceeded as the result of pressure control failure or of some other type of failure, must have pressure relieving or pressure limiting devices that meet the requirements of §§192.199 and 192.201.

§192.201 Required capacity of pressure relieving and limiting stations.

Each pressure relief station or pressure limiting station or group of those stations installed to protect a pipeline must have enough capacity, and must be set to operate, to insure that in in a low-pressure distribution system, the pressure may not cause the unsafe operation of any connected and properly adjusted gas utilization equipment.

§ 192.605 Procedural manual for operations, maintenance, and emergencies.

Each operator shall prepare and follow for each pipeline, a manual of written procedures for conducting operations and maintenance activities and for emergency response. Specifically, § 192.605(b)(3) states:

> *Making construction records, maps, and operating history available to appropriate operating personnel.*

> **§** *192.203 Instrument, control, and sampling pipe components*

> *Each operator is required to use materials for pipe and components that are designed to meet the particular conditions of service. Specifically,* **§***192.203(9) states that:*

> *Each control line must be protected from anticipated causes of damage and must be designed and installed to prevent damage to any one control line from making both the regulator and the over-pressure protective device inoperative.*

b. American Society of Mechanical Engineers -- B31.8: Gas Transmission and Distribution Piping Systems

The Code[7] sets forth engineering guidelines for the safe design and construction of gas distribution systems and includes requirements for district regulator vaults, regulators and control lines.

> **845.36**

> (a) When a monitoring regulator, series regulator, system relief, or system shutoff is installed at a district regulator station to protect a piping system from overpressuring, the installation shall be designed and installed to prevent any single incident, such as an explosion in a vault or damage by a vehicle, from affecting the operation of both the overpressure protective device and the district regulator. (See paras. 846 and 847.)

> (b) Special attention shall be given to control lines. All control lines shall be protected from falling objects, excavations by others, or other foreseeable causes of damage and shall be designed and installed to

[7] https://www.asme.org/Products/Codes-Standards/B318-2018-Gas-Transmission-Distribution-Piping

prevent damage to anyone control line from making both the district regulator and the overpressure protective device inoperative.[8]

The redundant pressure control provided by the Winthrop regulator station's two regulators (worker and monitor) and their respective sensing lines satisfied all federal and state requirements for overpressurization protections. CMA did not have additional overpressurization protections in place for their low-pressure system in the affected distribution system areas, beyond those required by federal or state authorities.

F. Massachusetts Public Utility Commission

The Department of Public Utilities (DPU) is an adjudicatory agency overseen by a three-member Commission. It is responsible for oversight of investor-owned electric power, natural gas, and water utilities in the Commonwealth. In addition, the DPU is charged with developing alternatives to traditional regulation, monitoring service quality, regulating safety in the transportation and gas pipeline areas, and the siting of energy facilities. The mission of the DPU is to ensure that utility consumers are provided with the most reliable service at the lowest possible cost, along with the protecting the public safety from transportation and gas pipeline-related accidents, overseeing the energy facilities siting process, and ensuring that residential ratepayers' rights are protected.[9]

1. Pipe Safety Division Enforcement

The Pipeline Safety Division acts as the enforcement arm of the Department of Public Utilities, ensuring that operators of natural gas distribution companies, municipal gas departments, steam distribution companies, and other intrastate operators are following state and federal regulations governing safety. The Pipeline Division serves the public by investigating gas incidents and determining their cause. This helps improve safety and prevent similar incidents in the future. Incident investigations have resulted in new safety regulations for abandoned service lines, cast iron pipe, and liquefied natural gas plants.

The Division regulates pipeline safety solely within the state of Massachusetts (intrastate). Pipelines that cross state lines (interstate) are regulated by the Pipeline and Hazardous Materials Safety Administration within the United States Department of Transportation.

The Division also tests all gas meters in the state for accuracy and leaks. After passing the test, each meter is marked with a stamp, showing that it is approved for use.[10]

The Massachusetts code *220 CMR 69.00, Procedures for the Determination and Enforcement of Violation of Safety Codes pertaining to Pipeline Facilities, Transportation of Natural Gas, and Liquified Natural Gas Facilities* is the guiding document for the DPU and their enforcement actions.[11]

[8] See Exhibit -- Regulatory of April 22, 2019

[9] See Department of Public Utilities (DPU) is an adjudicatory agency; Accessed March 19, 2019

[10] See https://www.mass.gov/pipeline-safety-information; Accessed March 19, 2019

[11] See https://www.mass.gov/info-details/220-cmr-department-of-public-utilities; Accessed March 19, 2019

2. History of DPU Enforcement Actions for CMA

NiSource stated to NTSB that there were no DPU enforcement actions involving the affected distribution system dating back several years preceding the accident. [12] A list of DPU enforcement actions for CMA outside the affected distribution system for violations occurring previous to the accident is provided in chronological order in the Table 2 below.

[12] Email of NiSource Party Coordinator to NTSB IIC March 28, 2019

	Violation Date	Code Sections	Fine	Location	Description
12-PL-03	3/7/2012	192.13(c) 192.227 192.455 192.461 192.605	$7,500.00	55 Arthur's Place Bridgewater	Buried steel portion of transition fitting on 2" plastic main had no cathodic protection; records did not indicate transition fitting or name of welder
12-PL-05	7/26/2012	192.13(c) 192.361(a) 192.375	$15,000.00	100 Union St Attleboro	Shallow cover on service and outlet piping; transition fitting used as service riser, and exposed transition fitting
12-PL-07	6/24/2012	192.13(c) 192.605(a), 192.615(a)(2), 192.615(b)(2) 192.805(h), 192.727(a), (b)	$20,000.00	390 Fall River Avenue Seekonk	First Repsonder did not make immediate contact with incident commander, CMA did not seal ends of the service at the customer end, did not abandon service according to gas standard.
12-PL-11	11/23/2012	192.13(c) 192.605(a), 192.615(a)3,5,7 192.615(b)(2), (3) 192.805(b),(d),(e),(h), 199.101 199.105(b) 199.202 199.225(a) 199.107(a) 40.277	$170,000.00	453 Worthington Street Springfield (leak)	CMA tech failed to follow proper procedures during leak investigation; during abnormal operating condition, CMA did not check other buildings in area per procedures; CMA did not properly evaluate tech's conduct; call center response to caller was inadequate, did not follow script; CMA did not follow its anti-drug and alcohol plans for testing
12-PL-12	11/23/2012	192.13(c) 192.481(a) 192.491(c) 192.605(a) 192.723(a), (b)(1) 192.805(h)	$150,000.00	453 Worthington Street Springfield (ignition)	CMA failed to show that it monitored service lines for atmospheric corrosion; provided insufficient evidence that it performed atmospheric corrosion inspections per procedures; insufficient evidence re leak surveys in business district; insufficiently calibrated leak detection equipment; personnel not properly requalified for leak investigation and surveys
12-PL-13	5/1/2012	192.13(c) 192.605(a), 192.615(a), (b) 192.727(a), (b) 220 CMR 107.04	$125,000.00	36 Maple Avenue Seekonk	improper abandonment of service; failed to report leak and fire to Division; CMA integration center personnel failed to act after reports of fire from four employees; insufficient procedures; inadequate communications with Fire Dept; insufficient public awareness plan;
12-PL-14	11/17/2012	192.13(c) 192.605(a), 192.615(a)(5), (7), (b)(2), (3) 192.703(a), (b), (c) 192.805(b), (e), (h) 220 CMR 101.06(21)(e)	$100,000.00	189 Washington Street Canton	CMA personnel failed to classify leak pursuant to CMA's gas standard; supervisor did not have current OQ necessary to classify leaks; CMA did not check building foundations in area;
16-PL-02	2/4/2015	192.13(c) 192.605(a), 192.805(b), (h) 192.807(a), (b)	$35,000.00	335 Washington Street Taunton	(service outage) unqualified employee attempted to install Trident Seal on leak; no mention of Trident Seal in procedures;
18-PL-03	2/15/2016	192.201(a)(2)(i) 192.739(a) 192.195(b)(2) 192.603(b) 192.13(c) 192.605(b)(1)	$75,000.00	West Water Street Taunton	overpressurization; MAOP exceeded; distribution system not designed to prevent accidental overpressuring; CMA failed to protect regulators from dirt and debris; failed to maintain records re testing, maintenance, inspection;

Table 2 -- Massachusetts Department of Public work - Enforcement Actions

The DPU is audited annually by PHMSA and given a proficiency score based on compliance to PHMSA requirements; the score received is used to determine the amount of funding that will be received by PHMSA.

G. NiSource Safety Management System

Investigators spoke with the Director of Pipeline Safety for NiSource Corporate Services about NiSource's efforts to develop a safety management system (SMS). He said that both he and the NiSource Board of Directors were excited about the deployment of SMS, and that initial efforts first started in 2015 in Virginia. After the incident, he indicated that he had another opportunity to discuss the SMS with the Board, at which point SMS efforts were "very much encouraged to move even faster" and NiSource has now accelerated implementation of SMS in all of its companies. The Director of Pipeline Safety for NiSource Corporate Services stated that NiSource was still early in the process. When investigators asked about the maturity of the SMS, he indicated that the maturity measures had not "been defined," though there was "certainly a lot of discussion" taking place on the topic, additional resources have been added to accelerate SMS implementation, and there is not an "endpoint" because SMS involves a process of continual improvement. NiSource provided investigators with a timeline of their SMS progress, which is shown in Appendix C: NiSource SMS Plan.

Investigators asked the Director of Pipeline Safety for NiSource Corporate Services about how NiSource would provide oversight of its subsidiary organizations, including Columbia Gas of Massachusetts. He said that NiSource, as well as third parties, would be involved in safety oversight. He indicated that there would be checks and balances and stated that the "governance piece is really good." However, he also indicated that "the auditing process is yet to be defined." He said that NiSource is trying to get the primary elements of SMS in place by the end of 2019.

The Director of Pipeline Safety for NiSource Corporate Services discussed the organization's efforts to enhance their risk management processes through SMS. He indicated that a key development was a risk register that aggregated information from different sources, for example, the integrity management program, the transmission integrity management program, and the underground storage integrity management program. He said that "SMS is going to allow us to have one risk register." Regarding the progress of this effort, he said that it was "in scope for what we want to look at and accomplish."

Investigators also spoke with NiSource's Senior Vice President of Safety, Environmental and Training about the implementation of SMS. Direct reports to this Senior Vice President include the Vice President of Safety, the Vice President of Training, and the Vice President of Environmental.

He indicated that the initial plans for SMS prior to the accident were a "sequential deployment" on a state by state basis. He said that he believed that a "generic gap analysis kind of at the gas segment level" had been performed. The Senior Vice President stated that NiSource was in the process of:

> *"really deploying and building safety management systems around the recommended practice [API] 1173*[13]*"*

He also indicated that gap analyses had been performed for Virginia and Indiana, and that NiSource is undertaking them in other States, including Massachusetts.

The Senior Vice President of Safety, Environmental and Training indicated that many gaps had been improved upon, if not closed. When they began their effort, they performed a gap analysis based on the ten elements[14] within the API-1173 standard and determined that their Virginia based safety programs were about 58% in agreement with the ten elements. Relating to API-1173 implementation, Virginia was intended to be the pilot state for implementation; hence, at the time of the accident, API-1173 had yet to be implemented in Massachusetts. NiSource was also one of 12 utilities[15] within the United States that participated in the American Gas Association's SMS pilot project two years prior to the accident.

Further, he said that he believed that "the majority" of their processes, supporting software and tools would be in place within the year. When asked about the specific areas of improvement, he indicated that NiSource was "enhancing system knowledge in and around assets." Moreover, he indicated that NiSource was working to improve their processes pertaining to management of change and configuration control. Finally, he indicated that NiSource was working to improve their risk management by "developing more sophisticated models and more predictive models around what could occur and what the potential consequence could be."

The President and CEO of NiSource has identified several SMS-related projects that NiSource has accelerated since the accident.[16] For example, as part of SMS development, NiSource has launched asset review and probabilistic risk assessment teams focused on improving risk analysis, as well as identification and mitigation efforts across the organization.

NiSource has also developed and deployed Management of Change (MOC) procedures to its construction employees and contractors that detail steps needed to enhance safety on a project during a change in personnel, as well as new enhanced tapping and tie-in procedures that outline

[13] The Pipeline Safety Management System (SMS) industry recommended practice standard ANSI/API RP 1173 was published in July 2015 and developed by API with input from NTSB, PHMSA, states, and industry representatives, following the 2010 oil pipeline accident in Marshall, Michigan. The standard's purpose is to help pipeline operators create a framework for developing a comprehensive, process-oriented approach to safety, emphasizing continual assessment and improvement.

[14] The API-1173 ten elements include: Leadership and Management Commitment; Stakeholder Engagement; Risk Management; Operational Controls; Incident Investigation, Evaluation, and Lessons Learned; Safety Assurance; Management Review and Continuous Improvement; Competence, Awareness, and Training; and Documentation and Record Keeping.

[15] American Gas Association – Pipeline Safety Management Systems March 1-2, 2016 PowerPoint presentation on *Enhancing Safety: A Joint Effort*

[16] See Letter from Joe Hamrock to Hon. Robert Sumwalt, Chairman of the National Transportation Safety Board, dated March 15, 2019.

stakeholder engagement, risk identification, roles and responsibilities, and MOC principles.

And NiSource has created a Quality Review Board, which will provide independent review and oversight over the Company's implementation of SMS.[17] In addition, NiSource implemented additional safety enhancements, including:

- NiSource conducted a field survey of its low-pressure systems to enhance its mapping of sensing lines on its low-pressure systems by verifying sensing line locations and including that information in its electronic mapping system.
- NiSource now requires a professional engineer to review and certify complex low-pressure system project designs. In coordination with professional engineers, NiSource is in the process of developing a review process for standard designs for routine projects
- NiSource is also in the process of installing automatic pressure control equipment on low-pressure systems across its seven-state operating area. These devices provide another level of control and protection, in that when they sense operating pressure that is too high or too low, they immediately shut down gas to the system.
- As an additional layer of protection, NiSource is in the process of installing remote monitoring devices on low-pressure systems so that its gas control center will see an alarm should the monitoring device indicate a high- or low- pressure alarm.

[17] See NiSource Press Release, "Secretary Ray LaHood Named Chair of NiSource's Quality Review Board, Providing External Governance for Safety Management System (SMS) Implementation" (March 14, 2019), https://www.nisource.com/news/article/secretary-ray-lahood-named-chair-of-nisource's-quality-review-board-providing-external-governance-for-safety-management-system-(sms)-implementation-20190314.

H. Supervisory Control and Data Acquisition (SCADA)

The SCADA center (Gas Systems Control) for the NiSource natural gas network is located in Columbus, Ohio. The controllers work 12 hours shifts with shift change on the day of the accident occurring at 5:30 p.m. The SCADA capability for the South Lawrence System, the affected area, complies with all applicable regulatory requirements. It is limited to the monitoring of pressure; no actions such as opening or closing valves, adjusting flow, adjusting pressures, etc., can be accomplished from the SCADA center. In addition, the SCADA system has no software or tools to support leak detection.[18]

On the day of the event, the first alarm within the SCADA center occurred at 4:04 p.m. at pressure 15.02 inches w.c. (Figure 3). The second alarm occurred at 4:05 p.m. at pressure 16.94 inches w.c. The required response time for controllers to respond to these alarms is ten minutes. At 4:06 p.m., Gas System Control notified the Lawrence on-call technician for Measurement and Regulation alaabout the alarms. The Lawrence technician then immediately notified all Lawrence Measurement and Regulation technicians who then immediately moved to perform field checks on the affected distribution system's 14 regulator stations to identify and shutdown any station that was continuing to feed the system.

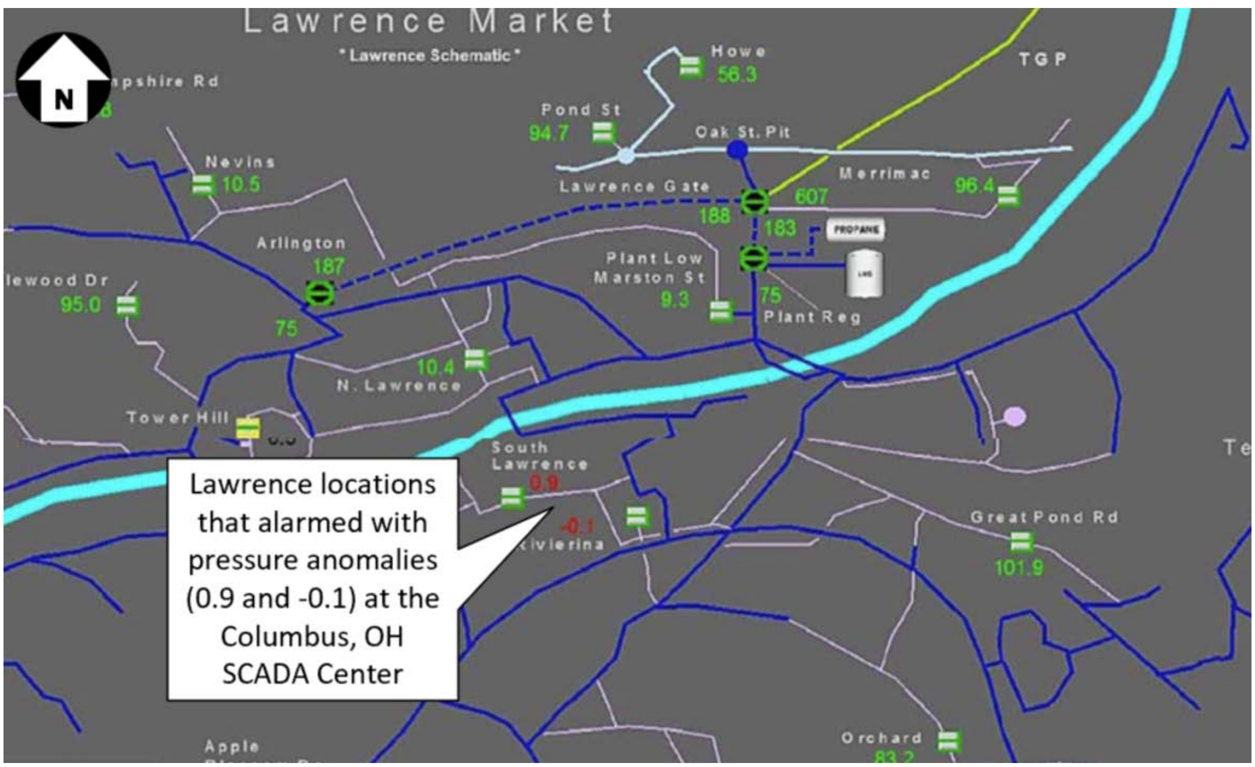

Figure 3 -- Lawrence locations that alarmed at the Columbus, OH SCADA Center

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[18] Interview of SCADA operators on September 17, 2018

I. Overview of Gas Sensing Lines

1. Regulator Sensing Lines

Natural gas delivered to the affected low-pressure distribution system, originated at the 75 psig gas main (MAOP 99). As gas flowed through the system, regulators controlled the flow from higher pressure at the main to the lower pressure at the low pressure main. The system operates on the premise that as the gas demand changes, the regulators within the system sense that the pressure has dropped below an established set-point. The regulator then opens accordingly to allow more gas to flow. Conversely, when pressure rises above a set-point, the regulator will close to adjust the pressure.

To meet the demands of gas pressure control for the affected distribution system, the CMA gas system was configured with 14 individual regulator vaults identified as district regulator stations. Typically, the vaults are below grade and are protected with metal lockable accessways (vaults). The Winthrop regulator station, the regulator station associated with the overpressurized low pressure main on the day of the accident, is shown in Figure 4. Each of the regulator stations had two sensing lines: one sensing line from the worker regulator[19] to the main, and one sensing line from the monitor regulator[20] to the main. The sensing lines from both the worker regulator and the monitor regulator at the Winthrop regulator station were both attached to the 8-inch cast iron main on South Union Street that was disconnected from the distribution system on the day of the accident. In Figure 4 below, the mains are shown along with the sensing lines from the regulator to the gas mains.

[19] The worker regulator is the primary regulator that regulates the gas pressure on the low-pressure gas main.

[20] The monitor regulator is the backup regulator that is only used when the worker regulator fails. The port on this regulator is open.

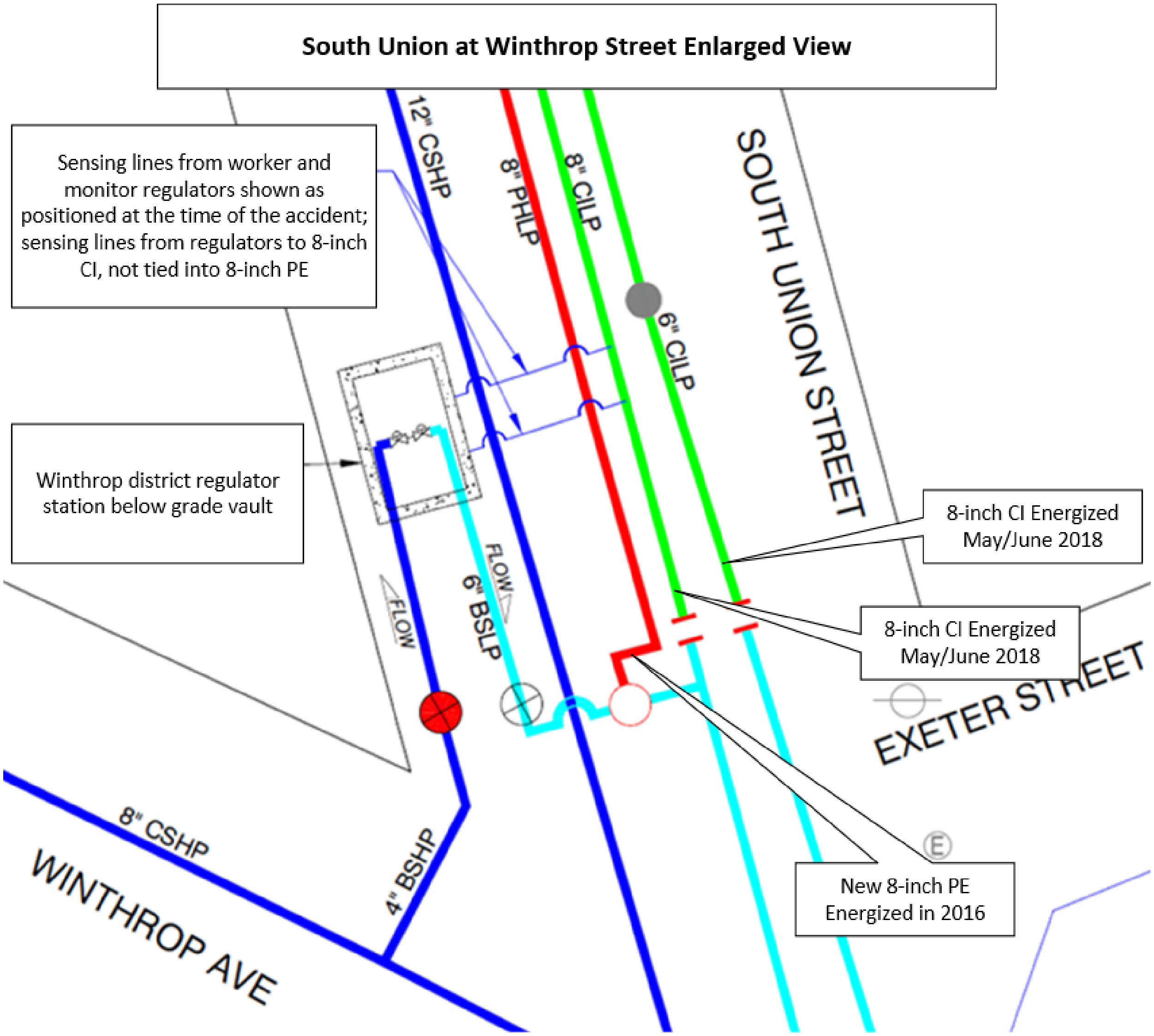

Figure 4-- Sensing lines from the regulator station

2. Documentation Related to Sensing Lines

The project work scope being performed on the day of the accident made no mention or reference to sensing, static, or control lines. The crew and the CMA Construction Coordinator who were present during the execution of the work did not discuss sensing lines on the day of the accident. Furthermore, the NTSB requested to see any work orders for the period September 1, 2015 through December 31, 2018 related to the modification or relocation of the sensing lines that were impacted by the work package performed by the Feeney Brothers crew on the day of the accident. CMA provided a work order for sensing line work for the Winthrop monitor regulator that is dated September 15, 2015. The work encompassed installing a new monitor sensing line that was connected to the 8-inch low-pressure main.

In addition, documentary evidence confirmed that the engineer that prepared the work package was aware of sensing lines when the South Union Project work package was prepared.

NiSource provided the field engineer with training about sensing lines. Also, portions of the field engineer's notes were obtained, which indicated he had a note to himself to talk to M & R about "outlet of regulation, pipe material and sense line distances". There is evidence that the engineer consulted with the Systems Operations Supervisor in Lawrence – who had oversight of Measurement and Regulation in Lawrence to determine whether the South Union Street design would affect the sensing lines. Documentation of this consultation was not required, and the result of the consultation was not ascertained.

The table below Table 3 details the sources of sensing line location information and select documents housed at the regulator stations.

Sources of Sensing Line Information and Select Regulator Station Documentation				
Document or Source of Information	**Location**	**Description**	**Update Interval**	**Responsible for Updating**
Critical Valve Book **(contains sensing line information)**	Lawrence Operations Center	Identifies the location of critical valves in relation to other system components, including regulator stations and sensing lines where applicable.	As needed	Engineering
Work Done Files **(contains sensing line information)**	Lawrence Operations Center	Compilation by town and street of records and as-built sketches of work done on system, including sensing line installations, replacements, and relocations.	As work is done	Distribution, Construction, Operations
Historical Maps **(contains sensing line information)**	Lawrence Operations Center	System maps pre-dating implementation of GIS. Certain historical maps include sensing line locations.	Historical	N/A
Capital Close Out Files **(contains sensing line information)**	Lawrence Operations Center	As-built drawings and other project documentation from inspector work order packets for capital projects, including as-built drawings of project sensing line installations, replacements, relocations.	As projects are closed out	Construction, Capital Close Out
WMS Docs **(contains sensing line information)**	WMS Docs Database	Electronic version of Capital Close Out files, including as-built drawings of project sensing line installations, replacements, relocations.	As projects are closed out	Capital Close Out
Measurement & Regulation Regulator Books **(contains sensing line information)**	Measurement & Regulation Technician Vehicles	Books maintained for reference by M&R in the field. The Books contain diagrams depicting the piping configuration around regulator stations, including the location of sensing lines.	As needed	M&R
Regulator Station Inspection Record	Regulator Station	Record of station inspections.	Upon inspection	M&R
Regulator Station Inventory Record	Regulator Station	Record of station attributes, major components, station shut off valve.	As inventory changes	M&R
Station Isometric Drawing	Regulator Station	Depicts direction of flow through regulator station and sequence of major station components.	As needed	Engineering
GIS Map Printout	Regulator Station	Geographic Information System ("GIS") record identifying location of regulator station's critical valve in relation to regulator station, station's inlet and outlet piping, and gas mains in the vicinity of station.	As needed	Capital Close Out

Table 3 – Sources of Sensing Line Information and Select Regulator Station Documentation

Investigators spoke with the current Leader of Measurement and Regulation at CMA who, in spring/summer 2018, succeeded the Lawrence Systems Operations Supervisor in overseeing Measurement and Regulation in Lawrence. The following is excerpted from a portion of that conversation about the identification and documentation of control (i.e., 'sensing') lines.

> ***Question:*** *Can you also talk about, when we were out there, we talked about the measurements to the control lines and identification of the control lines. Can you talk about --*

Answer: *The measurements of the control lines?*

Question: *In identification of them, where that information is contained or lack thereof.*

Answer: *Okay. Where we keep the information where the control lines are?*

Question: *Um-hum.*

Answer: *Except for the newest stations, there's no, there is no, there is no drawings of control lines. We frequently get asked to come out and help, you know, locators mark control lines. We can't really help them because we don't know where they are. Well, I mean a lot of the stations go back to the '50s and '60s. The new stations, we have the field engineers come out and draw them for us.*

Investigators also learned from the CMA's Leader of Measurement and Regulation that, when he was a field technician, employees sometimes used Measurement and Regulation Regulator Station Books to supplement Engineering's isometric drawings at regulator stations, which were primarily designed to document the direction of flow through regulator stations and the sequence of the major station components. The isometric drawings therefore did not contain all the information that Measurement and Regulation's Regulator Station books contained. Figure 5 is the isometric drawing for the Winthrop regulator station.

He described Measurement and Regulation's Regulator Station Books as "the old books," stating that "we call them our bibles." He said that even though he thinks employees "weren't supposed to have them anymore because they may not be current," during his tenure in his prior position in the field, he found them to sometimes be "more current than Engineering's isometric drawings."[21]

The Regulator Station Book maintained by Measurement and Regulation in Lawrence identifies locations of sensing lines for the regulator stations in the affected area, including the Winthrop regulator station. M&R also had extensive institutional knowledge about sensing line locations. M&R technicians would also work with locators to physically locate sensing lines in the field.[22]

This sensing line information was not included in the NiSource GIS system. Following the accident, NiSource added the geometry of over 2,000 sensing lines to the GIS systems for the seven states serviced by their company. Engineers and technicians can now view the sensing line geometry from several electronic platforms; a capability that was unavailable at the time of the accident. Figure 5 is an example of a current-day isometric containing sensing lines.

[21] See interview of Leader of M&R, page 41.

[22] NiSource Party Coordinator email of April 19, 2019 in response to NTSB document request of April 11, 2019

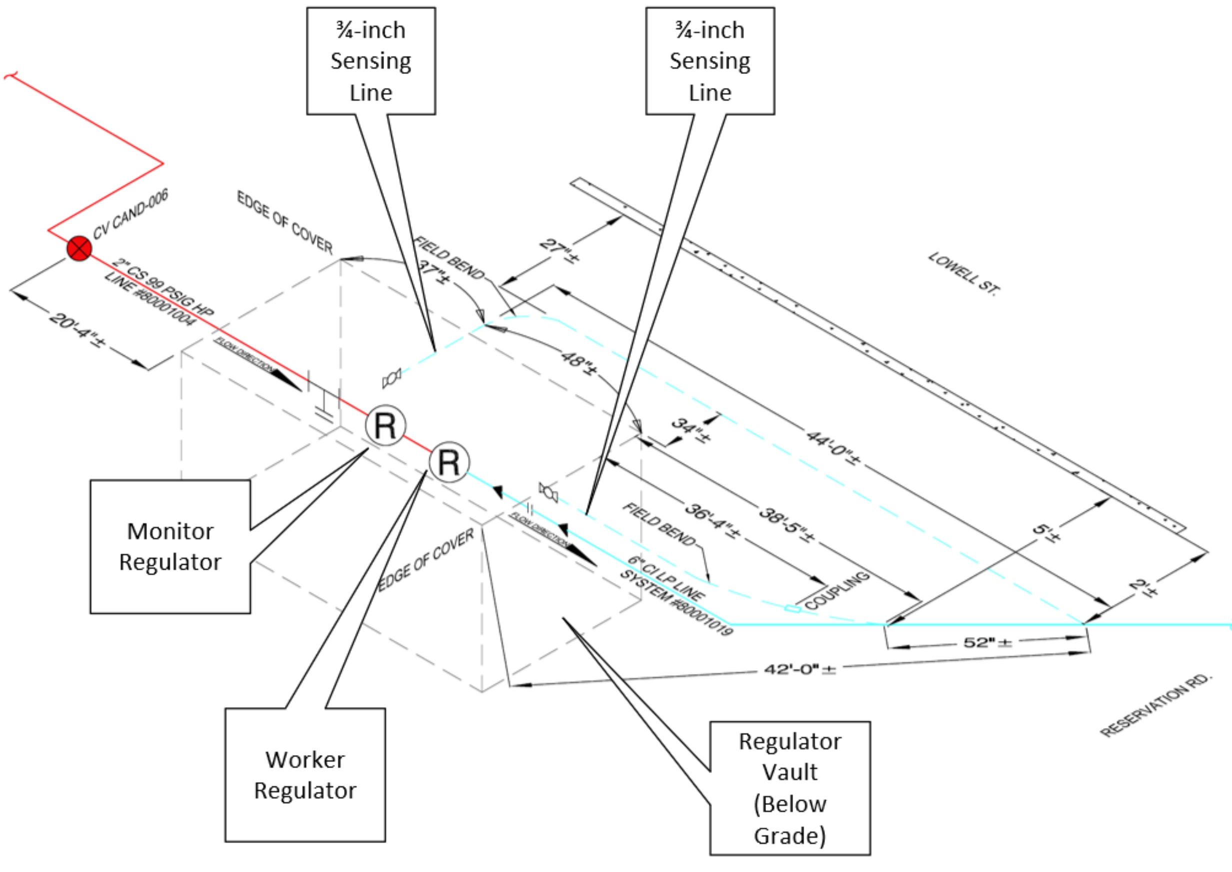

Figure 5 – Isometric Drawing Containing Sensing Lines

3. Sensing Line Training for CMA Engineers

CMA provides training coursework related to regulators and sensing lines for its engineers that prepare project work packages such as the South Union project. This coursework includes courses entitled, *Performing Basic Maintenance Operations on Self Operated Regulator Installations* and *Operating Characteristics of Pilot Operated Regulators.* It covers topics including regulator upstream and downstream piping, regulator sensing pressures, regulator vent lines, and regulator pressure ratings. These courses include a basic overview of low-pressure systems, the importance of pressure regulation, the way sensing lines regulate pressure, and the hazards of inoperable regulators/sensing lines. The coursework entails three full days of classroom hands-on training. For successful completion and understanding of the material, each student is required to pass a test.

According to NiSource, CMA also notifies its employees of changes to gas standards related to regulators and sensing lines. Prior to this accident, the engineer that authored the South Union work package most recently acknowledged his receipt and review of a revised gas standard training related to regulators and sensing lines in April 2018.[23]

J. Overpressure Detection

NiSource described the following ways it would detect an overpressurization event. The detection methods, both passive and active, include:

- Gas Control (for stations or gauge points with electronic monitoring) - high-high alarm
- Chart, ERX (microprocessor-based, data recorder that measures gas pressure) and EFC (electronic flow corrector) at a station
- A temporary gauge at a station to read pressure
- A customer call due to indicators at the home (LP or venting service regulator)
- Annual maintenance at a station
- Odor of gas call and/or leakage
- Gauge installed on the system (for new service installations, tie-in/bypass procedures, or winter operations monitoring locations)

K. The Regulator Risk Model[24]

1. Risk Model Overview

To assure the proper functionality of the gas regulators within 14 vaults that control the flow and pressure of the gas to its customers in the affected system, CMA uses a process by which subject matter experts prepare the Regulator Risk Model. The model is a subject matter expert (SME) based process that allows CMA to assess, rank and manage the risk profile associated with regulator stations. This includes all district regulator

[23] See NiSource Party Coordinator email to NTSB IIC of March 20, 2019

[24] See NiSource Party Coordinator email to NTSB IIC of October 16, 2019

stations and points-of-delivery, including the sensing lines for those stations. It specifically enables Field Engineering and Systems Operations to evaluate the overall risk, across multiple variables, of each station on an annual basis and formulate repair vs. replacement strategies if any action is required at all. The model is used to facilitate regulator threat assessment and remediation within CMA's Distribution Integrity Management Plan (DIMP). The model is updated annually and reviewed every year by the DIMP Steering Committee.

The model is used to aggregate point scores for inputs regarding factors such as station capacity, physical labor for operations, environmental, health and safety considerations, design, leakage, corrosion, security, and station component failures to name a few. In total, there are 40 factors evaluated annually that make up the total risk score. Further explanation of these factors can be found in CMA's DIMP Plan along with the Definitions and Tables tabs within the model itself.[25]

2. Risk Review

As part of the regulator risk evaluation and DIMP processes, subject matter expert groups review the individual factors that drive the total regulator station score and make remedial actions to either lower the risk or eliminate the risk altogether. The priority focus on station evaluation and remedial actions is made on regulator stations with "High" risk scores, with expectations to reduce or eliminate the risk within a risk-reduction regimen scheme established within the DIMP program. The risk-reduction scheme within DIMP allows technicians to work toward medium and low risk scoring ratings. Remedial actions can range from specific incidental improvements within a station as well as targeting specific activities to improve the total risk score. If the desired risk reduction cannot be achieved, full replacement of the regulator may occur. Remedial actions are also determined by factors beyond risk reduction. Other activities to impact risk reduction include items such as infrastructure replacement, system reliability projects, and operation and maintenance activities. The results of the most recent assessments indicated that none of the 14 stations had a risk ranking of higher than *Medium*. For this accident, the functionality of the worker and monitor regulators at the Winthrop regulator station operated as designed and performed according to manufacturer's specifications.

L. Distribution Integrity Management System (DIMP)

PHMSA gas distribution integrity management regulations, specifically §49 CFR Part 192, Subpart P, which was promulgated in December 2009, requires operators to write and implement distribution integrity management (IM) procedures for gas distribution pipeline systems. The regulation requires owner/operators to:

- Understand system design and material characteristics, operating conditions and environment, and maintenance and operating history
- Identify existing & potential threats

[25] See NiSource Distribution Integrity Management Plan doc

- Evaluate and rank risks
- Identify and implement measures to address risks
- Measure IM program performance, monitor results, and evaluate effectiveness
- Periodically assess and improve the IM program
- Report performance results to PHMSA and, where applicable, also to States.[26]

Even though the regulations only require operators to undertake this assessment every five years, each of the NiSource subsidiaries, including CMA, does so annually.

1. Overview of the CMA DIMP program as it Relates to Overpressurization

A review of the 160-page DIMP plan was conducted to ascertain any relevance that sections of the program may have with regard to the accident. Section 6.1.7 addresses Incorrect Operations and includes *inadvertent overpressurization*. Incorrect Operation leaks result from inadequate procedures or safety practices, or failure to follow correct procedures, or other operator errors. It includes leaks due to improper valve selection or operation, inadvertent overpressurization, or improper selection or installation of equipment. To date, this accident represents the fifth overpressurization event on a low-pressure natural gas system since March of 2004; however, none of the previous incidents were of a serious nature[27]. Within section 8.2.6.5 Regulator Station Inspections, the program states:[28]

> *The Company has in place a program to inspect and test each pressure limiting station, relief device, and pressure regulating station and its equipment to determine that it is in good mechanical condition, adequate from the standpoint of capacity and reliability of operation for the service in which it is employed, properly installed and protected from dirt, liquid, or other conditions that might prevent proper operation.*

Also, related to overpressure protection the program states:

> *Each overpressure protection device, except for rupture discs, is tested to determine if the device is set to operate at the correct pressure. Prompt action is taken to correct deficiencies found during the inspection.*

The CMA DIMP Plan makes no explicit mention of control lines, static lines, or sensing lines, but these features of the distribution system are treated as component parts of the regulator stations for purposes of the DIMP analysis. The risks associated with them – including the risks of buried control lines – are factored into the CMA DIMP Plan.

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[26] https://www.phmsa.dot.gov/pipeline/gas-distribution-integrity-management/gas-distribution-integrity-management-program-dimp (Accessed April 3, 2019)

[27] NiSource Party Coordinator to NTSB IIC email of March 25, 2019 - NiSource previous incidents on low-pressure systems.

[28] CMA Distribution Integrity Plan – Effective May 4, 2017; Regulator Station Inspections

M. Engineering Project Management

1. Engineering Management / Design Systems in Place

The Capital Allocations and Controls department within NiSource administers and manages the Optimain DS[29] mains risk model. Optimain, a software program, is used to evaluate risk factors such as leak history, break history, corrosion history, age, class of area, and material type. The original implementation of Optimain DS in Massachusetts was in February 2013. Production patches and enhancement release R 16.14 was the active release on the day of the accident. The Optimain risk model cannot be used to evaluate the likelihood or consequence of events such as line ruptures or overpressurization events.

Data from the NiSource GIS (Geographic Information System), CIS (customer information system) and the NiSource Work Management System (WMS) leakage information is loaded into Optimain nightly. The engineering department uses Optimain scores as part of the capital priority main replacement project prioritization planning process. The data is collected to assess risk. That data, together with several other factors, informs NiSource's 5-year priority main replacement plan, which is submitted to management for review and approval.

Documentation from the work order packages is placed into the on-line WMS Docs System. WMS Docs is the document management system for project packages as well as the management system for the project approval process. The system allows reviewers of the work packages access to all documentation contained within a given project package.

The current WMS was placed into service in 2012. Prior to WMS, CMA used custom built "Work Order Management System" (WOMS) built on the "Progress" programming language platform. WOMS consisted of four separate applications that included:

Security Access & New Business Project Planning,

Work Order Creating and Completions - WOMS,

A Preventive Maintenance Tracking system - PMTS, and

A Compliance Management System – CMS.

Synergi Gas is the software tool that is used by engineering to simulate natural gas gathering, transmission, and local distribution systems for hydraulic modelling. In addition to pressure and flow calculations, Synergi Gas also has extensive gas component, gas property, and thermal tracing features. The hydraulic modelling software identifies, predicts and helps address operational challenges, enabling day-to-day efficiency of gas distribution and transmission networks. Based on emails that

[29] Optimain DS the decision support (DS) product, is risk-based asset management software tool that follows ISO 55000 risk management principles for pipeline safety management, integrity management, and excavation damage prevention. The software includes a customizable system interface to permit two-way integration with the CMA enterprise geographic information system (GIS). (See https://www.opvantek.com; accessed April 4, 2019)

were exchanged by CMA engineers who worked on the South Union project, the reference calculations mentioned in those email exchanges were performed using the Synergi Gas software.[30]

2. Staffing and Scope of Responsibilities

The Field Engineering Department is managed by the Manager of Field Engineering. Directly below the Manager of Field Engineering, are two Leaders of Field Engineering – one for CMA's Brockton Operations Center and the other for CMA's Springfield and Lawrence Operations Centers. The Leader of Field Engineering for the Lawrence Operations Center began working for Bay State Gas Company (which is now doing business as Columbia Gas of Massachusetts) as a co-op student on January 3, 1984. He was hired full time as an associate engineer in 1987 and worked within the engineering capacity until 2001. He then left the company and went into private consulting for five years. He came back to CMA in April 2007. He was promoted from field engineer to leader of field engineering in December 2013. In that capacity, his responsibilities included overseeing engineering projects in areas covering Springfield and Lawrence, MA. He had six full-time engineers who reported directly to him from the Springfield division, and three engineers in the Lawrence operations center. The work package associated with the accident was prepared by one of the engineers in the Lawrence Operations Center.[31]

The Leader of Field Engineering received his Bachelor of Science in mechanical engineering, and a Master of Science in engineering management. He is licensed as a Professional Engineer (PE).[32]

Primarily, the field engineering group provides engineering support that includes design of replacement projects, estimating, cost tracking, creation of tie-ins, and project management. For calendar year 2018, management established a goal to replace 58 miles of what was categorized as priority pipe. The section of cast iron pipe related to the accident was part of this 58-mile scope.[33]

Selection of piping runs to be replaced is based on the output of the pipeline risk program, Optimain, together with consideration of several other factors, such as maintenance history and municipal projects.

During the interview, the Leader of Field Engineering described the project initiation:

> *"Once a year, we submit a 5-year plan to the Department of Public Utilities. It's part of what we call a GSEP [Gas System Enhancement Program]. A GSEP program focuses on replacing what we call priority pipe. That is pipe that is leak-*

[30] See https://www.dnvgl.com/services/hydraulic-modeling-and-simulation-software-synergi-gas-3894 . Accessed on April 20, 2019; Emails exchanged between gas system planning engineer and field engineer on March 15, 2018.

[31] See Leader of Field Engineering interview of September 16, 2018

[32] See Director of Engineering interview of March 7, 2019 and Leader of Field Engineering NiSource personnel file

[33] See Leader of Field Engineering interview of September 16, 2018

prone pipe, pipe we should be concerned about; older, aging infrastructure that fell into one of the categories I was just talking about.

So that's the identification of projects. There'll be one of those -- something triggers us to decide to focus on a section of pipe that we're going to replace. So, one of the responsibilities of my team and myself is to identify the best projects based on risk, based off of public improvement projects, based off all those scenarios. Once we do that, we will actually develop a preliminary design. Field engineering will develop a preliminary design to try to best address any priority pipe that's located within an area, whether it would be a high-risk concentration or whether it will be a public improvement project, to determine the scope of a project. We do an initial estimate. We do an initial design. Once we go through that design process, we will meet with construction and do what we call a constructability review. So we'll meet with either leadership of our construction team. If it's an operations-driven project, something, say, Mr. Nelson here, they voiced concern about a piece of pipe, priority pipe, that they have concerns about, that may also trigger replacement. We will sit down with that team and go over the scope of the project and look for feedback from that team as well. Okay. Now once that is done, we finalize the, we finalize the project plans that make -- when we project -- when we finalize a plan, we make sure that we take a look at all of the material that's going to be installed and abandoned. We develop tie-in procedures, pressure testing procedures. We make sure environmental concerns are addressed. And we actually have a checklist to go down to make sure that the protocol has been followed as far as constructability reviews, reviews of crews in the field -- I mean, constructability reviews for the construction people so they understand the scope of the project. And we will -- on the bigger projects, we will actually walk projects with the construction people. When I say the contractor, as well as company personnel, so everybody has a thorough understanding of what the project is going to be, the proposed project."[34]

The engineering review may include sign-off by the Leader of Field Engineering, Manager of Engineering, and the Director of Engineering; all of which were interviewed. During the interviews, all three of these engineers stated that their review did not include an evaluation of each step in the work package. Although part of his job description, the Leader of Field Engineering stated during the NTSB interview the following:

"I do not go through and actually – on every single project look at every single step of the process."

Investigators also spoke with NiSource's Director of Engineering about several aspects of the design and review processes.

The Director of Engineering indicated that when engineers were in the process of gathering information on a project, they looked at the documentation on the facilities that are in the scope of the work. He said that, after the incident, NiSource recognized that, with respect to GIS itself,

[34] See Leader of Field Engineering interview of September 16, 2018

"we were short on readily available information around the sensing lines, the control lines."

He said that post-incident, NiSource engaged in extensive efforts to confirm the location of existing sensing lines throughout their system and incorporate that information into its GIS.

He stated that through this process, they confirmed that there was a higher incidence of remote sensing lines in Massachusetts than in other parts of the NiSource footprint, where most regulator stations are above ground, and the sensing lines are contained within the footprint of the vault, fence, or building of the regulator station. He said that the company's extensive follow up actions post-incident reinforced the need to make sure that documentation was readily available in GIS for anybody doing work around regulator stations with more remote sensing lines.

Regarding the review process, the Director of Engineering indicated that he was responsible for approving projects with costs over a million dollars. He said that below a million, the individual Managers of Engineering (his direct reports) could approve them. He said that his reviews typically were at a higher level, and he did not carefully review each step of work packages, particularly those that were routine in nature - as was the case with the work being done on the day of the incident. Moreover, he suggested that he would expect the Managers of Engineering to perform similar high-level reviews.

The Director of Engineering indicated that he would expect the field engineers and their direct supervisors (Leaders of Field Engineering) to work together to ensure that work packages were safely designed. One of the essential responsibilities of the Leader of Field Engineering is to review engineering designs to ensure they comply with all policies, procedures, standards, federal, state and local codes, and long-term system plans. The Director of Engineering indicated that it was up to the Leader of Field Engineering to assess the level of mastery of each field engineer and provide the appropriate level of oversight.

The Director of Engineering indicated that peer reviews, in which field engineers evaluated each other's work, were often used as well. However, he said that such reviews were informal and unstructured.[35]

In addition to WMS Docs, users can view how the project work will impact existing and approved projects not yet installed through a review via the geographic information system (GIS). Access to the GIS system, available from a wide range of platforms (laptops, service trucks, desktops, etc.), allows users to see the approved projects and the as-installed gas main in Lawrence. At the time of the accident, GIS did not include the geometry of the Lawrence pipeline sensing lines. Consequently, GIS did not provide project reviewers/approvers with sensing line location information. An overview of WMS and WMS Docs (Figure 6 and Figure 7) is shown in the following slides:[36]

[35] See Director of Engineering interview of March 7, 2019

[36] See email NiSource Party Coordinator to NTSB IIC of April 12, 2019

Overview of Work Management and WMSDocs

- **WMS Scope**
  - Asset Management
  - Repetitive Tasks for compliance and preventative maintenance
  - Field Maintenance and Operations Orders
  - Customer Service Orders
  - Capital orders for installation and replacement of assets
  - Scheduling
  - Reporting
- **WMSDocs Scope**
  - Document management related to WMS orders, projects and assets (see appendix for document class examples)
  - Workflows to process reviews and approvals (see appendix for workflow types)

- **Basic work management process map**

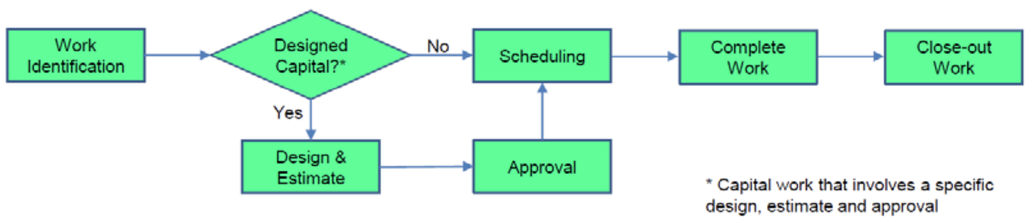

Figure 6 -- Overview of the NiSource Work Management System WMS and WMSDocs. Courtesy NiSource

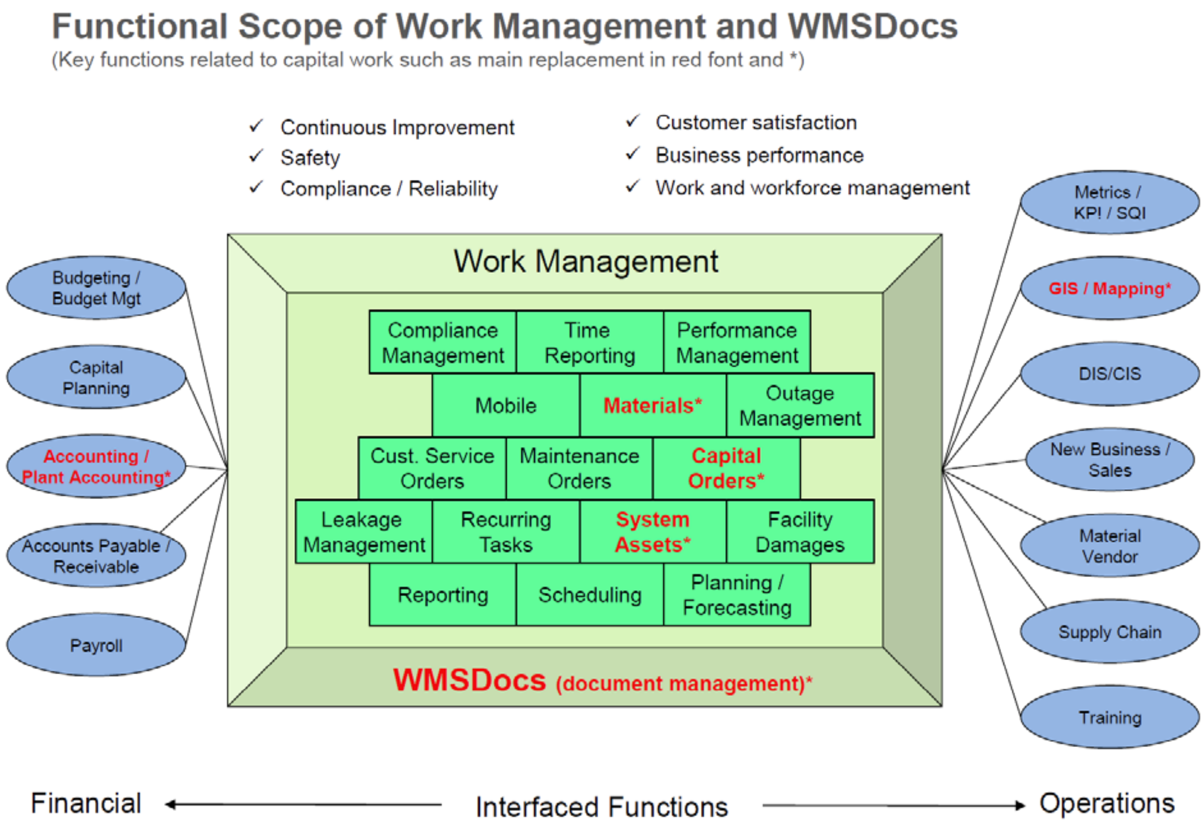

Figure 7-- Key functionality within the Work Management System. Courtesy NiSource

N. Project Work Package Management / Workflow

Project workflow for CMA is closely tied to the capital execution process. The capital work process consists of the following steps:[37]

- Capital budget and allocation,
- Capital Work Plan,
- Capital Project Design and Approval,
- Tactical Capital Plan,
- Scheduling and assigning,
- Field Construction and Execution,
- Field Construction Documentation and,
- Capital Closeout Process.

Capital project design and approval is based on the capital budget funding requirements. Since the South Union Project was valued at more than one million dollars, approval was required at the Director of Engineering level.

[37] NiSource Party Coordinator to NTSB IIC email; NTSB – South Union St Project Work Flow Data Request

CMA uses various documents to control the workflow of a project: They include:

- Capital Design Job Order Checklist,
- Constructability/Safety Review and,
- Capital Project Execution Workflow

The four-page *Capital Design Job Order Checklist* details the individual steps and activities, accountabilities, and approvals performed and obtained by the field engineer during the project design and approval process. The two-page *Constructability /Safety Review* documents a collaborative discussion between the project engineer and the construction leader to ensure there is a clear understanding of the construction expectations, ensure project construction is aligned with design, and close any gaps that exist between engineering design and construction. The constructability review is the last step before the project is submitted to the Engineering chain for approval.

There were three constructability reviews related to the South Union project one signed on March 1, 2016, and others signed on January 6, 2017, and December 14, 2017. The Constructability Review form has a required signature line for Engineering and Construction, and a signature line for M&R that is designated as optional. The constructability reviews related to the South Union project did not include the signature(s) for representatives from the M&R department. [38]

Prior to September13th, M&R's participation in the Constructability Review itself varied case by case.[39] A variety of circumstances could lead to M&R's participation in a Constructability Review itself. For example generally speaking, if the project itself involved the installation of a new regulator station or replacement of a regulator station directly – e.g., the project contemplated changing the design or location of regulator station — then M&R would likely be involved in the Constructability Review and/or there would be a meeting in the field involving relevant personnel, including M&R.

On the South Union project an email was discovered between a construction representative and M&R dated October 17, 2016. The email specifically stated that that both Engineering and Construction communicated with M&R about the project, and about its sensing lines in particular, both before and after the project construction began.

The three-page *Capital Project Execution Work Flow* provides the activity detail, handoffs, accountability and approval that occurs throughout the construction process from the time a project is released until it is completed and submitted to the GIS Capital Closeout team for project closeout and mapping. None of CMA's workflow documents within the construction packages mentioned above refer to control, sensing, or static lines for regulator control. The 2018 Constructability Review document references pressure monitoring and states that:

> *"if pressure rises/falls beyond these points, contact M&R"*

[38] See docs: NTSB_South Union 2016_Constructability Review & NTSB; 2018 South Union -- Constructability Review

[39] NiSource Party Coordinator to NTSB IIC email.

1. Professional Engineer Stamp Not Required

At the time of the accident, a Massachusetts Professional Engineer's stamp was not required on any utility system construction, operations or maintenance projects as local gas distribution companies in the state had a utility exemption from requiring a PE's stamp. However, in response to the NTSB recommendation that was generated shortly after the accident, the Massachusetts Senate passed an act on December 31, 2018, ensuring the safety and soundness of the commonwealth's natural gas infrastructure, previously passed by the House, and signed into law by the Governor as Chapter 339 of the Acts of 2018. This new law included an emergency preamble and took effect immediately. It requires that all natural gas work that might pose a material risk to the public be reviewed and approved by a certified professional engineer.[40]

2. Overview of Process – South Union Project

Following the identification of a scope of work, engineers that report to the Leader of Field Engineering assemble the required information to begin the preparation of the work package. This would include the detailed design of the layout, the bill of material needed to fabricate and install the package, the budget request, engineering checklist, construction checklist, the tie-in information to accommodate the addition/deletion of pipeline components, and the finished work package.

Construction work on the South Union Project began in 2016. The job order for the PE pipe installation work in 2016 was 15-0845564-00, and the job order for the cast iron main abandonment scheduled for 2016 was 15-0845565-00; the project ID was 15-19388. The project was estimated to last approximately 96 days with two crews. The project included work on 93 service lines—65 service line replacements, and 28 service line tie-overs. The estimated cost for the project was approximately $1.49 million. The project was scheduled for completion in 2016.

In October 2016, a Lawrence city official ordered CMA to stop all work, including work on the South Union Project.[41] After discussions with the City, CMA was allowed to resume limited work on pending projects. Work restrictions impeded CMA from completing the South Union Project in 2016. As a safety precaution, CMA gassed the 8-inch PE main in November 2016 so that if it incurred any damage before CMA was permitted to resume work on the project, that damage would be detected more readily. The work moratorium on the South Union Project lasted until Spring 2018. The job order for the continued installation of PE pipe in 2018 was 16-0849062-00, and the job order for the abandonment of the cast iron main was 16-0849063-00; the project ID remained 15-19388. Both job orders originated on December 13, 2016, after the 2016 work on the project ended and with the expectation that work would resume in 2017. The job orders were then revised on January 19, 2018, before the 2018 construction work began. When work resumed in 2018, the project was scheduled for completion that same year.

[40] See https://www.acecma.org/about/news/massachusetts-passes-law-requiring-professional-engineers-on-natural-gas-projects-2340; accessed April 4, 2019

[41] NiSource provided the NTSB with an internal email, as well as field notes from a contractor, stating that the South Union Project was shut down by the city.

3. Role of CMA Construction Coordinator[42]

The construction crew performing the final tie-in on the day of the accident were being guided in the execution of their work scope by a CMA construction coordinator. The construction coordinator's role is to coordinate construction activities associated with construction replacement projects. This includes any coordination between customers, contractors, communications, vendors, construction leadership, welders, engineering, field operations and the CMA integration center to ensure customer focused safe and cost-effective construction. The construction coordinator responsibilities include:

- Observe contractor adherence to construction plan related to customer notification, permit changes, documented tie-in plans and documented test records and uprate plans
- Notifies governmental agencies, other utilities and customers of construction schedule
- Works across geographic boundaries whenever necessary
- Records construction practices used during installation (i.e. directional boring logs, sewer lateral inspections, customer service installation method, x-ray records, etc.)
- Monitors and orders, when necessary, materials needed and used on the job. Coordinates weekly job site deliveries from 3rd party vendor to contractor. Communicates delivery issues and monitors lost, damaged and excess materials
- Coordinates need for welder, tapping crew, directional bore crew, service technicians, etc. with the Integration Center
- Partners with engineers and engineering technicians to develop capital job order scope changes and cost estimate revisions. Assists in capital job order completion reports
- Effectively uses technology, tools and planning techniques to track and communicate project status
- Creates and maintains valued relationships with government entities, industry associates, company affiliates and contractors
- Promotes and assures a safe working environment and public safety
- Communicates concerns about contractor qualifications and certifications and ensures proper documentation

The construction coordinator position requires prior experience in natural gas construction operations, prior experience working on construction sites, experience maintaining field records, WMS experience, and prior experience overseeing working with pipeline contractors. The construction coordinator on scene had 22 years with CMA and over six years as a coordinator and had worked with Feeney Brothers for several years performing similar work scopes such as cast-iron replacements and gas tie-ins[43] There was no evidence that any prior accidents occurred on work that he supervised during his six years as a CMA

[42] Reference NiSource Party Coordinator to NTSB IIC email of April 8, 2019, the terms contractor inspector and construction coordinator are often used interchangeably. The current title is Construction Coordinator.

[43] • Construction Coordinator background and years, NiSource Party Coordinator email to NTSB IIC received 05 April2019

construction coordinator before this accident. Based on the Feeney Brothers interviews, the construction coordinator was with the crew and on-scene at all times on the day of the accident.

O. Contractor Training and Crew Assignments

The Operator Qualification rule was adopted into the Code of Federal Regulations under Subpart N in 49 CFR Part 192 and Subpart G in 49 CFR Part 195. Under the rule, each pipeline operator is responsible for developing an OQ program, following their written OQ plan, establishing a covered task list applicable to their system, and defining the training and qualification requirements for personnel performing covered tasks on their pipeline facility. It is the operator's responsibility to ensure their contractors and vendors comply with their program requirements.[44]

The Feeney Brothers crew had four contractors on scene on the day of the accident. The crew consisted of a foreman, two laborers, and a truck driver. The foreman had 22 years of gas pipeline experience; eight of these years were spent at Feeney with the majority of the eight years spent working with CMA, While on CMA projects, the foreman had never received a stop work order nor had there been any infractions against his or his crew's performance. At the time of the accident, the foreman was up to date with his Operator Qualification (OQ) requirements.[45]

Crew member ONE, with about two years of gas pipeline experience, said that he had his OQ training, however, when asked if he had OQ training in reference to gauges he replied:

> *"I am not sure I did any OQ specifically for gauges."*

Crew member ONE was working in the excavated area and supplied the tools, plugs, wrenches, etc., to Crew member number TWO.[46]

Crew member TWO, with two seasons of gas pipeline experience, said that he had his OQ training but had trouble identifying any specific OQ topics he had been trained to other than

> *"dealing with specialized equipment, AOCs"*[47]

Crew member THREE, a truck driver with five years of experience with Feeney Brothers, did not make reference to OQ training, however, did mention that he had a commercial driver's license (CDL). He also stated that:

> *"I just have the basic training. That's why I don't do any of that stuff. It's, I don't even know what they're called but, more safety precautions, I would say, for abnormal operating, recognizing that I would say."*[48]

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[44] See https://www.phmsa.dot.gov/pipeline/operator-qualifications/operator-qualification-overview; accessed on April 5, 2019

[45] See Foreman interview of September 16, 2018

[46] See Crew Member ONE interview of September 16, 2018

[47] See Crew Member TWO interview of September 16, 2018

[48] See Crew Member THREE interview of September 16, 2018

P. Events Prior to the Accident

1. The Work Order Package

The work order package was prepared by a degreed Field Engineer. The Field Engineer received his bachelor's degree in mechanical engineering on May 18, 2014. He was issued an Engineer Intern Certification (EIT) by Office of Professional Regulation, Board of Professional Engineering on April 28, 2014. He began working for NiSource on July 14, 2014 as a "Field Engineer 1". He was hired as a full-time employee with standard work hours of 40 hours per week. He was promoted to an Associate "Field Engineer 2" effective December 25, 2016.

He told investigators that his duties included: operations support and maintenance of existing distribution pipelines in the pipeline system, as well as main replacement projects and designing those in order to replace old infrastructure. Additionally, he designed new business services for new customers that needed to be added to the gas distribution system.[49]

The tie-in procedure, prepared by the aforementioned engineer, that was being executed on September 13, 2018, was one of 15 tie-in procedures contained within a 38-page packet of tie-in procedures. The packet of tie-in procedures was identified with the job order number (15-0845564-00) for the work scheduled to be performed in 2016. That job order number was later crossed out and replaced with the job order number (16-0849062-00) for the work to be completed in 2018.

The project design began in 2015 and was finalized in 2016. It was later modified because, after the city-imposed work moratorium in 2016, the city paved streets within the project scope, thereby precluding execution of the original project design. The project was modified to its 2018 design to work around the construction restrictions resulting from the paving. The project consisted of the replacement of an 8-inch cast iron main that had been selected for replacement due to municipal factors, such as anticipated public works projects, encroachment concerns/risks, and city paving schedules. The work being addressed on the day of the accident was at the intersection of South Union and Salem Streets in Lawrence. South Union Street generally runs in a North/South direction. Salem Street runs East/West (Figure 8). The regulator station that serviced the 8-inch main was located at South Union at Winthrop.

According to NiSource, the company has very little cast iron except in Massachusetts. CMA's Gas System Enhancement Program (GSEP) to replace first generation pipe, including cast iron and bare steel mains and service lines, was approved by the MA DPU in 2015 as a twenty-year plan. According to NiSource, CMA plans to replace an average of 59 miles/year of cast iron and bare steel main over the next five years and complete the replacement of all 623 miles of cast iron and bare steel mains by about 2030.

[49] NiSource provided personnel file of the Field Engineer & interview of Field Engineer of September 16, 2018

The replacement project required mains on cross streets to be tie-in to the 8-inch PE main on South Union Street to support the gas distribution for those customers serviced by those mains.

The project included tie-ins for:

Salem at Union Street (location of work at the time of the accident)

Springfield at Union Street

Bailey at Union Street

Abbott at Union Street

Farnham at Union Street

Andover at Union Street

Boxford at Union Street

Cambridge at Union Street

Foster at Salem at Union streets

Market at Union Street

Winthrop at South Union

Exeter at South Union

In addition to the above, the original project design included drawings and details for disconnecting the 8-inch cast iron main and the tie-in of the new 8-inch PE main to the outlet pipe for the Winthrop regulator station at South Union Street and Winthrop Avenue.

The new 8-inch PE main, approximately 3,900 feet in length, ran parallel the existing 8-inch cast iron main. The 8-inch PE main was installed by late 2016; as-built drawings for the installation are dated no later than October 15, 2016.

Sensing lines were discussed in 2016 but were not addressed in the project documents.[50] Sensing lines were not relocated to the 8-inch PE main in 2016. They remained attached to the 8-inch CI main, which itself remained connected to the outlet pipe for the Winthrop regulator station.

That sensing line relocation would ordinarily be performed after some service lines had been tied into the 8-inch PE main and before the 8-inch CI main was disconnected from the distribution system. In 2016, the South Union Project's construction crew, construction foreman, construction lead, and construction coordinator all knew that the sensing lines on the 8-inch cast iron main needed to be relocated before the 8-inch cast iron main was abandoned. CMA's Construction Leader also emailed Measurement and Regulation in 2016 regarding the planned relocation of the sensing lines. Sensing line work was to be executed under the 2016 job order for the South Union Street project after

[50] See affidavit of contract-inspector in CMA's Lawrence Operations Center during CMA's annual construction season.

some service lines had been tied in to the 8-inch PE main and before the 8-inch cast iron main was disconnected from the distribution system. When the City of Lawrence suspended work on the project in 2016, no service lines had been tied in to the 8-inch PE main.

On the day of the accident, the tie-in at Salem and South Union represented the last tie-in to complete the South Union Project.

2. Tie-in Disconnecting 8-inch Cast Iron

On Thursday September 13, 2018 around 7:00 a.m., Feeney Brothers, a local pipeline services firm, arrived at the intersection of Salem Street and South Union Street in Lawrence, Massachusetts to tie-in the Salem Street main to the 8-inch PE main on South Union Street. That tie-in would result in disconnecting the 8-inch cast iron main on South Union Street from the distribution system. The Feeney Brothers crew consisted of 4 employees.

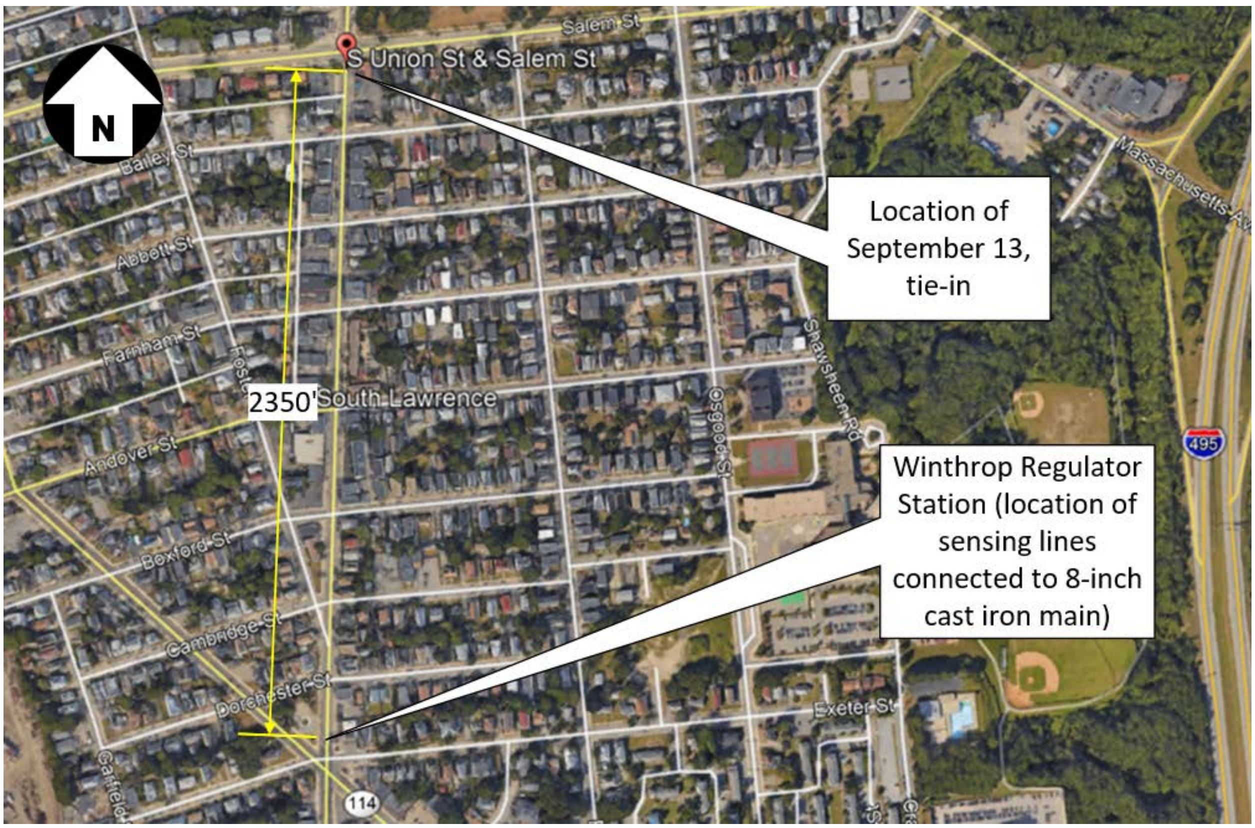


Figure 8 -- Relative location of Feeney Brothers crew to regulator vault location

In addition to the Feeney Brothers crew, CMA had a Construction Coordinator[51] on the scene. The CMA Construction Coordinator, also referred to as the inspector, had worked

[51] Reference NiSource Party Coordinator to NTSB IIC email of April 8, 2019, the terms contractor inspector and construction coordinator are often used interchangeably. The current title is Construction Coordinator.

with Feeney Brothers crew a number of years previous to the accident and acted as liaison between the crew and the CMA gas operations personnel.

The tie-in associated with Job Order Number: 16-084-9062-00; designation for low pressure gas distribution System number 80001016, began with a tailgate safety meeting. Traffic control was initiated with local police present. The work area for the tie-in was excavated a day or two day prior to tie-in (See Figure 7).

The tie-in began by drilling, tapping and plugging the main for installations required for the tie-in task. The pressure gauges on the 6-inch cast iron were installed first. The pressure read 9.5-inch w.c. The by-pass piping was next on the work order. This consisted of installing two tees into the servi-seals (reinforced taps) with valves and a section of 2-inch PE piping. Sealing bags were installed in the order of the work plan, with hold points[52] between the bags for pressure gauge readings.

The bags were installed to seal the cast iron main while the section of cast iron was to be removed for the tie-in. After the bags were installed, areas between each pair of bags were purged to assure the bags were preventing flow. After assuring the bags were holding and the by-pass valves confirmed open, the 6-inch cast iron section between points 9 and 11 (See Figure 9 and Figure 10) was removed from the system. The end at section (point 9) was capped and torqued. Bags 3 and 1 were removed.

[52] Hold points require that the next step in the process cannot proceed; in this instance, the crew was required to check the line pressures to assure that the sealing bags were holding pressure.

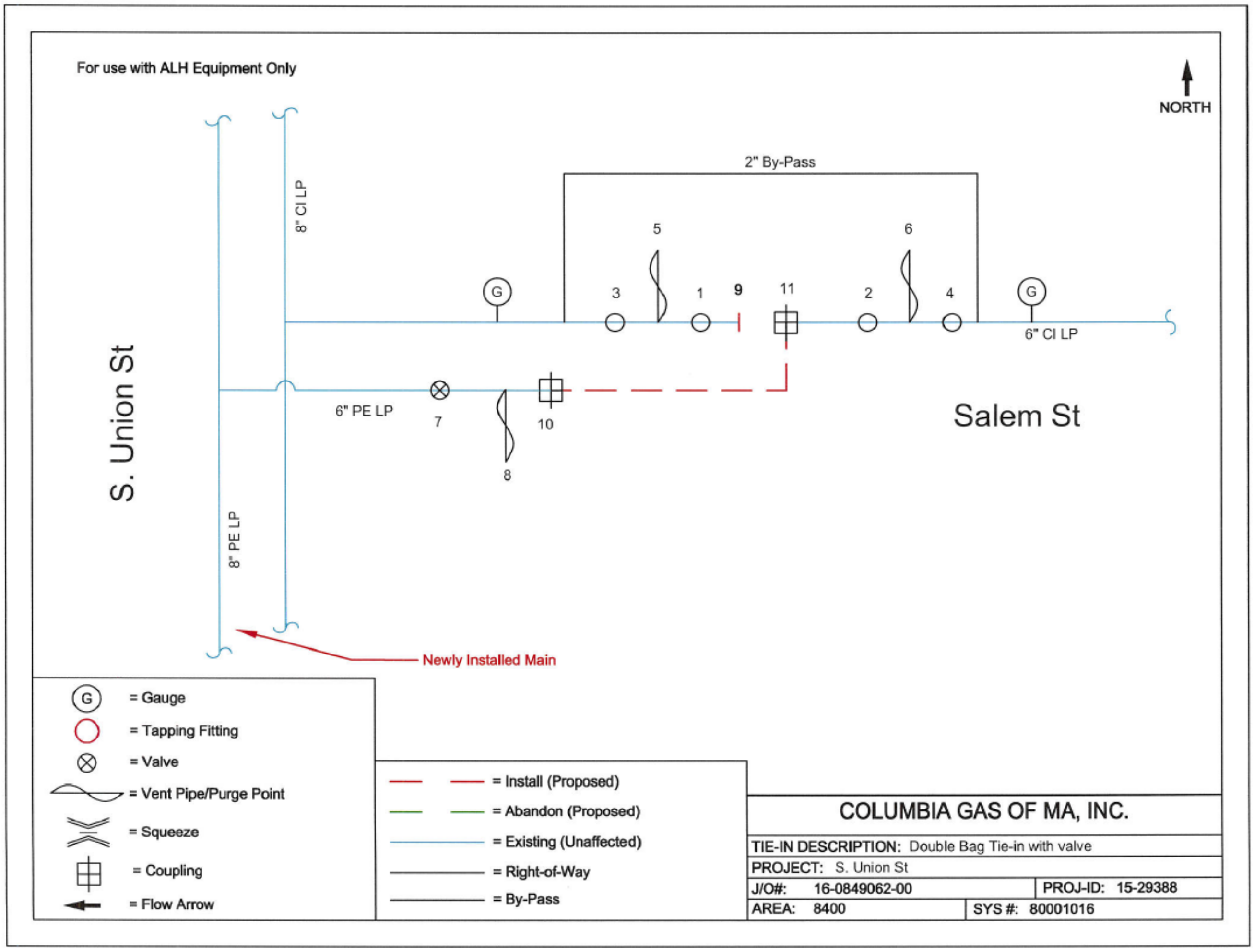


Figure 9 -- Tie-in Procedure for Tie-in of Low Pressure Main on Salem Street East of the Intersection of Salem Street and South Union Street

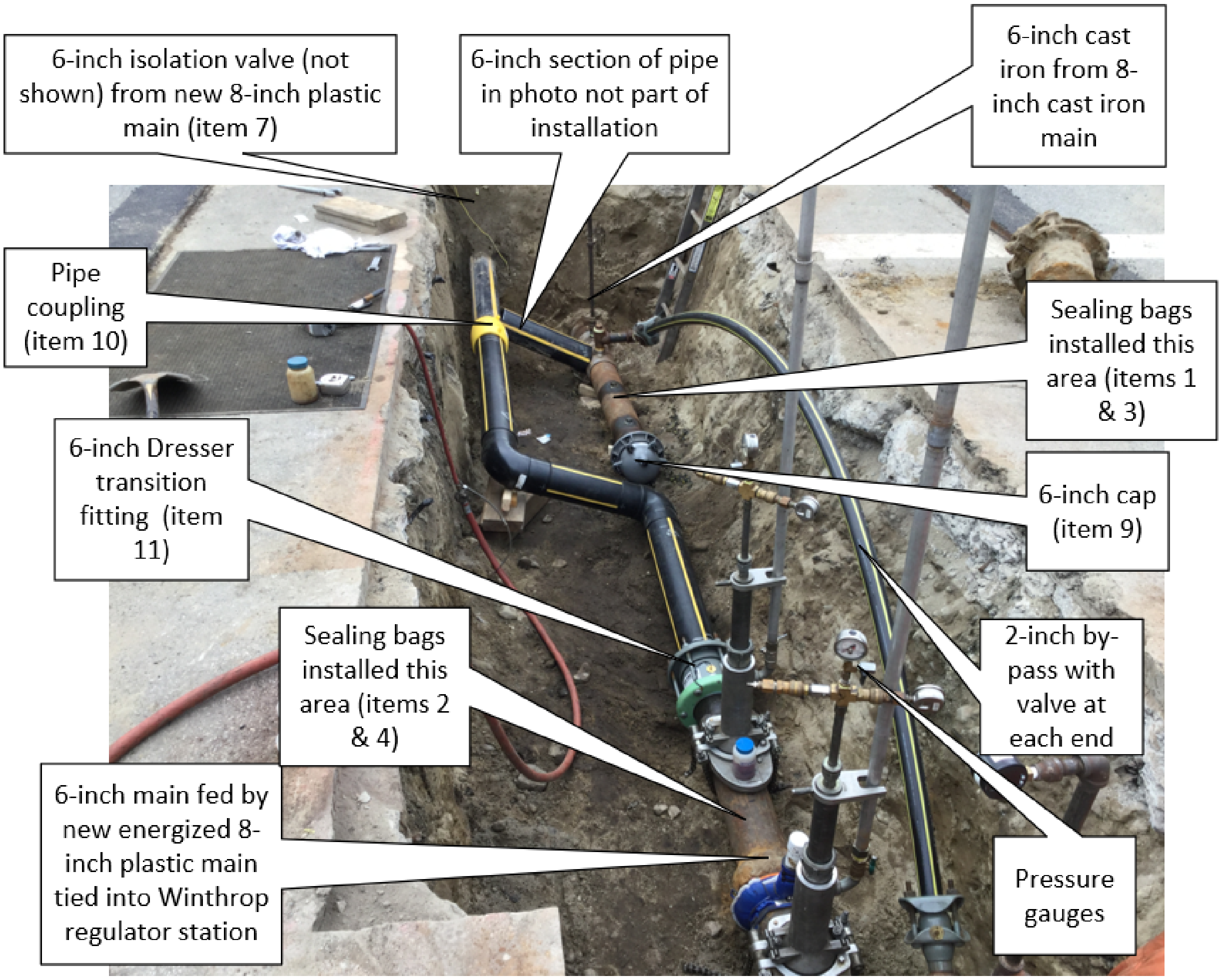


Figure 10 -- Annotated photo of South Union Project tie-in referenced to South Union Job Order (Courtesy The Feeney Brothers)

The by-pass was still open at this point and the main pressure was still communicating as the sensing lines remained intact connecting the 8-inch cast iron main to the regulators at the Winthrop regulator station. The new 6-inch PE tie-in was dry fitted to assure a successful lineup when fused. After dry-fitting, the PE pipe (the new section of the PE main) was fused and allowed to cool.

Next, the PE pipe was aligned to point 11 were a Dresser transition coupling was installed and torqued onto the cast iron. The bag at point 2 was then deflated. The dresser coupling passed a soap leak test. Gas was introduced by opening the valve at point 7 and purged through bag 4 vent. After the line was purged of air with gas, the remaining bag, bag 4 was deflated. Bags 2 and 4 were then removed.

At this juncture, the tie-in was complete allowing the removal of the equipment. The first step of this process began with closing the by-pass valves. The closing of the by-pass valves would isolate the section of cast iron to which the Winthrop regulator station sensing lines were connected from the relevant distribution system. Once the by-pass valves were closed, the Winthrop regulators were no longer able to sense pressure in the relevant distribution system.

3. Crew Unaware of Sensing Line Situation

Unknown to the crew and the construction coordinator in 2018 was the fact that the sensing lines, although intact, were not connected to the new 8-inch PE main: The sensing lines were attached to the 8-inch cast iron main that was no longer connected to the distribution system.

As the by-pass removal work progressed, the disconnected cast iron line began to lose pressure. In keeping with standard procedure, this section of line had not yet been vented or purged, and the 9.5 inches of w.c. remained for a period of time. The regulators at the Winthrop station (Figure 11) began to operate (open) after about a .25-inch w.c. drop in pressure in the main.

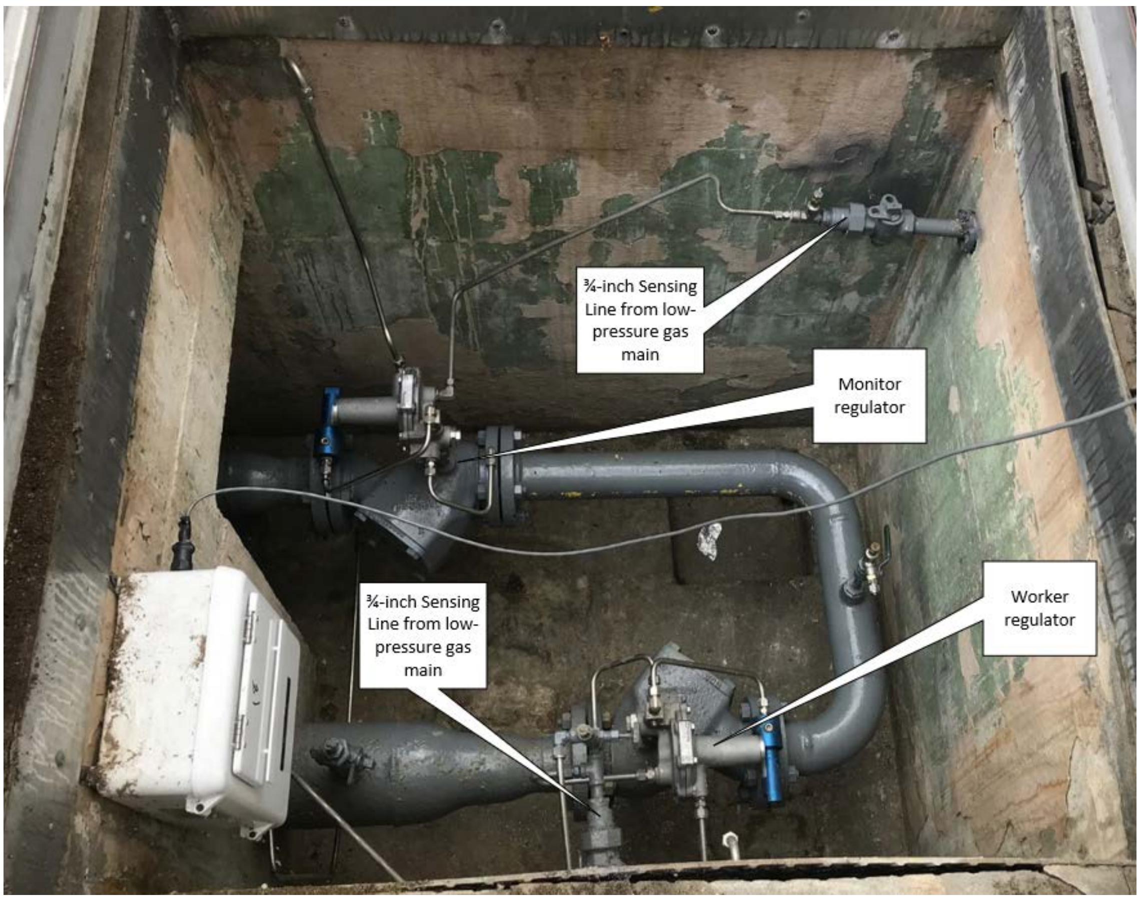


Figure 11-- The Worker and Monitor regulators with sensing line connections at the Winthrop station

The next step in the project instructions was to remove the by-pass. This was done by cutting the 2” plastic line that was used for the by-pass line from the tapping tees located on the cast iron. The pressure gauges read 9.5-inch w.c. on both sides of the by-pass. The pressure gauge to the right of bag 4 (see Figure 10) was removed first. The next step was to remove the by-pass tapping tee on that same side of the tie-in. This was done around 5 to 10 minutes after the pressure gauge was removed.

4. High Pressure on a Low-Pressure System

When the tapping tee was removed, the pressure that had built up over the 5-10 minutes was high enough to blow the fitting out of the Feeney Brothers contractor's hand.[53] The contractor grabbed the fitting and tried to reinstall the tap; however, due to the pressure of the blowing gas, the contractor was unable to install the tap. The contractor then placed his foot over the tapped hole to stop the blowing gas while a special fitting was found to plug the hole. Through the NTSB interviews, Feeney Brothers contractors stated that sirens were heard at the excavation site with a range of fifteen minutes prior to the incident to as many as fifteen minutes after the accident. Feeney Brothers contractors also described that they observed residents leaving their homes. They also heard residents complaining of gas odors within their neighborhood.

5. Releasing Gas Plugged--System Blowdown Completed

The by-pass tap hole in the pipeline was plugged with a fitting and the blowing gas was stopped about 5 minutes after the tapping tee was removed. Within an hour the Lawrence Operations Center Manager and a CMA Field Operations Leader for Distribution arrived on scene. The latter was designated Incident Commander.

The Operations Center Manager had a pressure gauge and blowdown stack installed. Before the blowdown began, the gauge had reached 2.5 psig. The blow-down continued for about 45 minutes and the pressure at the tie-in eventually read 2 psig. Shortly after, the gauge read inches of w.c. and the blowdown was removed and the main plugged. According to the SCADA data from the South Lawrence and Riverina telemetering stations, the pressure rose again for about 30 minutes. The data shows no additional gas was introduced into the distribution system during that time. According to the Columbia Gas Pressure Chart Extrapolation Analysis developed by NiSource at the IIC's request, the SCADA data is indicative of pressure relieving activities.[54]

Around 6:14 p.m., the Winthrop station's critical valve was closed: the pressure had dropped to 9.5-inches of w.c. At 7:17 p.m., the critical valves for the 14 regulator stations in the affected distribution system had been closed. By 7:33 p.m., the pressure was reduced to 1-inch w.c. Early the next day, a valve was found bleeding. This was repaired, and the pressure was now zero.

[53] The Feeney Brothers contractor (Crew Member ONE interview; pages 21 and 22).
[54] See document - Gas Pressure Chart Extrapolation Analysis developed by NiSource.

Q. Measurement and Regulation Department

1. Roles and Responsibilities / Winthrop Regulator Work Scope

The Measurement and Regulation department is responsible for maintaining the regulator stations in the CMA gas distribution system. On September 13th, it consisted of 11 full time M&R technicians across Massachusetts, with two technicians in the Lawrence area who had more than 45 years of experience between them. The M&R department is responsible for the regulator vaults, the physical regulators, and the sensing lines (small diameter pipes, typically .75-inch diameter that connect from the mains to the regulators.

NiSource expects M & R department to initiate work for existing sensing line maintenance. On capital projects, NiSource expects Engineering to work in coordination with M&R and Construction when sensing line work is needed.

The NTSB was provided an affidavit from the field engineer in which he stated that he discussed sensing line configurations in general with a member of the construction department during the design phase of the South Union Street project, and during the constructability review that took place on March 1, 2016. The field engineer also said that he contacted the M&R department to discuss sensing lines, though he no longer recalled "all the specifics of that conversation."

NiSource provided a list from the field engineer that had a note to contact M&R, which was crossed off, consistent with his affidavit. The field engineer said that he concluded his discussion with the M&R department with the understanding that the engineering department did not need to do anything further regarding sensing lines on the South Union Street project.

The affidavit did not reveal a plan to relocate the sensing lines. NiSource did not have a requirement to document conversations between the engineering and measurement and regulation departments regarding sensing lines.

The only sensing line work order NiSource provided for the 8-inch cast iron main was the 2014 work order to install a sensing line on the main, that started September of 2015. Although relocating the sensing lines from the 8-inch cast iron main to the 8-inch PE main was within the scope of the South Union Project, NiSource did not document a plan for that work. On the day of the accident, the 8-inch PE main did not have the sensing lines from the Winthrop regulator attached.

2. M&R Department Regulator Station Monitoring During Gas Distribution Modifications

In 2015, NiSource issued a company-wide Operational Notice requiring that Measurement and Regulation personnel be consulted on all future excavation work that was done within 25 feet of a regulator station with sensing lines, other communications and/or electric lines critical to the operation of the station, or buried odorant lines. The Operational Notice provided that Measurement and Regulation personnel stand by the regulator station throughout the excavation if there was a risk that the excavation could damage any such line. The purpose of ON 15-05 is to prevent direct strikes during excavation. The South Union Project excavation work being performed on the day of the accident occurred over 2,000 feet away from the Winthrop Regulator Station, and thus was beyond the 25 feet requirement in ON 15-05. The basis of the 25 feet in ON 15-05 is the assumption of a safe distance that encompasses the equipment associated with a regulator station including sensing lines.

In the NTSB's Safety Recommendation Report: Natural Gas Distribution System Project Development and Review (Urgent) (Report PSR1802 issued November 14, 2018), the NTSB referenced a purported past policy or practice that NiSource allegedly phased out, whereby Measurement and Regulation personnel stood by a regulator station when construction took place on its gas mains. No documentation was found to support that such a policy or practice existed, except as outlined by ON 15-05. NiSource stated that no such policy or practice existed and therefore none was phased out or discontinued.[55]

During interviews with a NiSource employee, and a former employee, investigators were told that there were times in the past (at least five years earlier) when M&R personnel provided assistance during distribution system piping modifications. This practice was performed at the discretion of the M&R Leader to minimize the risks associated with overpressurizations at gas mains.

[55] NiSource informed the NTSB that it had investigated this issue thoroughly, speaking with18 field and supervisory employees from Construction and M&R at each of CMA's operations centers—including the employee interviewed by the NTSB. NiSource also provided the NTSB with sworn affidavits from each of those employees regarding this issue.

R. Previous Incidents

1. Overpressurization Incidents

A search of previous overpressurization incidents within the seven State NiSource network revealed the following incidents on low pressure natural gas systems.[56]

Date	Location	Description
March 1, 2004	McKinney Avenue, Lynchburg, VA	A system with an inlet pressure of 50 psig and an outlet pressure of 13-inches w.c. MAOP overpressurized to 4.5 psig when debris was lodged at the seat of the bypass valve. When found, the regulator was in 100% lock-up mode. At the time of the incident, the former CDC Excursion Team recommended to install a pressure recorder and 1" non-primary relief valve on the system.
February 28, 2012	Multiple streets in Wellston, OH	Operator error during an M&R station inspection resulted in accidental overpressurization; 314 customers impacted for 14 hours without service. The operator qualifications of the employee responsible were suspended.
March 21, 2013	Kerns Avenue, Pittsburg, PA	A segment of pipe with a MAOP of 1 psig was operating at over 2 psig. Crew under the direction of Columbia Gas was making a tie-in and failed to monitor the pressure and flow of the existing low-pressure system during the tie-in process. The pressure on the old main cycled from 12-inches w.c. up to 2 psig three times. Pennsylvania Public Utility Commission required for future tie-ins a written tie in plan to include personnel that would be able to monitor and control pressure at regulator stations during a tie-in that has a regulator station feeding gas to the system, and train all inspectors and engineers responsible for tie-in plans on what personnel should be used to monitor and control the flow of gas from a regulator station.
January 13, 2018	Longmeadow, MA	Upon investigation of a service complaint, 2 psig was discovered on a 14-inch w.c. system. The cause was associated with debris accumulation on both the control and monitor regulator seats at a regulator station. Debris removed and pressure returned to normal.

Table 4 -- Previous overpressurization incidents

2. Sensing Line – Near Miss

On August 11, 2014 a Columbia Gas of Kentucky crew in Frankfort, Kentucky was excavating to repair a Grade 1 leak located on the outside of a regulator station building. The crew uncovered and narrowly missed hitting one of the two 1-inch sensing lines and tap located on the 8-inch outlet pipeline. The crew called local M&R to confirm what

[56] NiSource Party Coordinator to NTSB IIC email of March 25, 2019, and May 17, 2019 – NiSource previous incidents on low pressure systems

they had uncovered. The M&R personnel advised the crew of the purpose of sensing lines and what would have happened if the line had been broken.

Because the system at issue had both a worker and monitor regulator, each of which had a sensing line that sensed gas pressure in the system, the gas system would have continued to operate unimpeded had one of those two sensing lines been broken. The other sensing line would have continued to sense system pressure.

a. NiSource corporate actions following the Kentucky near-miss:

- Issued to NiSource Distribution Operations personnel the operational notice *Below Grade Regulator Control Lines: Caution When Excavating Near Regulator Stations or Regulator Buildings* No. ON 15-05 dated September 2, 2015
- State law excavation practices to be followed
- Pre-excavation meeting with crew and M&R personnel
- As-built drawing reviewed prior to execution of work
- Line/electrical locates conducted prior to execution of work
- Company excavations within the footprint of a City Gate/Town Border/Point of Delivery Station or a District Plant Regulator Station and/or within 25 feet of a station building or fence shall only proceed with M&R personnel standing by throughout the excavation unless all control lines, other communications and electric lines critical to the operations of the station, and odorant lines, are verified to be located completely above ground.
- For customer M&R stations Any Company excavations within 25 feet of a Customer M&R Station with control line(s), other communications and/or electric lines(s) critical to the operations of the station, or buried odorant lines, shall only proceed after a consultation with M&R personnel. The M&R personnel shall stand by throughout the excavation if there is a risk of damaging a control line, other communications or electric lines critical to the operation of the station.
- NiSource Leadership to determine the feasibility of other Damage Prevention opportunities to identify situations where 3rd party excavators are digging within 25 feet of a City Gate/Town Border/POD Station or District Plant Regulator Station, so that excavations planned near these Company facilities require consultations and/or on-site monitoring.

S. Weather on the Day of the Accident

Information was retrieved[57] from the Automated Surface Observing System (ASOS) located at Lawrence Municipal Airport (LWM) in Lawrence, Massachusetts. LWM was located about 2 statute miles north-northeast of the address “35 Chickering Road, Lawrence, Massachusetts” at an elevation of about 150 feet. The reports from LWM give the best information on current weather conditions for the area.

[57] Reported by NTSB Senior Meteorologist

At 1954Z (1554 EDT) on 13 September 2018, the LWM ASOS reported a temperature of 24°C (75°F), a dew point temperature of 17°C (63°F), a two-minute average wind magnitude of 5 knots (6 mph) from 120° true, a station pressure of 1020.86 millibars (calculated from altimeter setting of 30.31 inches HG and a station elevation of 150 feet), cloudy conditions and unlimited surface visibility.

It appears as though the area recently received some rainfall. Between 1754 EDT on 10 September 2018 and 0454 EDT on 11 September 2018, LWM registered 1.19 inches of rainfall. There was only 0.02 inches reported on the day of the accident (early morning). A National Weather Service report around the time of the accident applicable to the greater region notes the "recent soaking rainfall."

Appendix A: CONSTRUCTION PROJECT - PROCESS FLOW

The CMA Constructability / Safety Review Process

The 20 Steps within the process[58]

1. Field Engineer and Construction Leader/ Specialist
    a. Pre-project design review - review project scope
2. Field Engineer
    a. Submits permit and permit maps to town/city DPW for review and approval process
3. Field Engineer and Construction Leader/Specialist
    a. Constructability review
        i. Review and sign off on the following items:
            1. Project scope
            2. Traffic plans
            3. Safety
            4. Duration
            5. Materials estimated
            6. Tie in plans
            7. Environmental and State Road work, if applicable
            8. Permit status
            9. Service counts
            10. Misc. items - school zones, state roads, digging conditions, etc.
4. Field Engineer
    a. Receives approved permit and releases project packet to Construction and Scheduling
5. Scheduler
    a. Orders materials in WMS
6. Construction Leader/Specialist
    a. Reviews project packet with Inspector
7. Construction Leader/Specialist
    a. Walks project with local DPW inspector, Police and Contractor Supervisor to confirm/mark main locations and discuss traffic plan

[58] See the Constructability / Safety Review Process contained within the CMA Capital Project Workflow

8. Scheduler/Construction Leader
    a. Assigns contractor crew to project
9. Construction Specialist
    a. Pre-marks the project and calls in Dig Safe
10. Construction Specialist
    a. Project packet is split up into the following smaller packets:
        i. Contract locator packets
            1. Project scope map
            2. Customer service list
            3. Copies of service cards
        ii. Contract Foreman/Supervisor
            1. Project scope map
            2. Customer service list
            3. Copy of tie in/abandonment plans
            4. Copy of Dig Safe numbers
        iii. Pipefitter (both Company and Contractor)
            1. Project scope map
            2. Customer service list
        iv. Sewer Locate
            1. Project scope map
            2. Customer service list
        v. Inspector
    1. Project scope map
    2. Customer service list
    3. Copy of tie in/abandonment plans
    4. Copy of Dig Safe numbers
    5. Copy of approved road opening permit
    6. Copy of approved environmental permit, if applicable
    7. VaIve sheets
    8. Job order print outs
    9. ECP form
    10. Corrosion form

11. Copy of DPls, if applicable
12. Construction checklist
13. Odorization form, if applicable
14. Sewer locate form

11. Contractor - Contract Locators

    a. Mark out mains and services within the scope of the project

12. Construction Leader/Specialist

    a. Requests road opening permit from city/town

13. Contractor

    a. If environmental is applicable, contractor sets up environmental protection based on conservation's requirements and it must be inspected before a project starts and after it ends

14. Construction Specialist

    a. Coordinate with sewer locate company

    b. Sewer locate calls and schedules police details to scope sewer mains, drains and laterals

    within the scope of the project

15. Contractor/Company Pipefitter (depends who is assigned to the project)

    a. Pipefitters begin to walk and knock to schedule pre-pipes

16. Contractor

    a. Calls for police details

    b. Provides town notifications daily (Andover, North Andover and Methuen; Engineering updates Lawrence weekly)

17. Scheduler/Construction Leader/Specialist and Contractor

    a. Once notification is made to the towns and Dig Safe is good, construction begins

18. Construction Leader/Specialist

    a. Weekly updates with Inspectors regarding project status/needs

19. Inspector

    a. Once project is complete, Inspector needs to ensure the following items are completed and in packet for Capital Close Out and completed in WMS:

        i. Conversations #1, #2, #4, #5, #6, #7 (if applicable), and #11 in WMS are complete

ii. Final map has all new main installation drawn in RED, existing main in BLUE and

retired main in GREEN; all necessary swing ties, measurements off

houses/structures, marker ball locations, corrosion control features such as test

stations, insulators, rectifiers, and anodes. Signed, dated and the word

"COMPLETED" on final map/sketches with a north arrow

iii. Valve sheets with sketch and swing ties to newly installed valves; control of flow

and location

iv. Signed tie in plans (signed by Inspector and Foreman)

v. Signed job order print outs

vi. Signed corrosion forms

vii. Test station forms with wire drawings, if applicable

viii. Completed DP ls both in written form and in conversation #7 of WMS, if

applicable

ix. Signed and dated construction checklist

x. Pressure test charts with the back data complete (i.e., date, time, footage, pipe

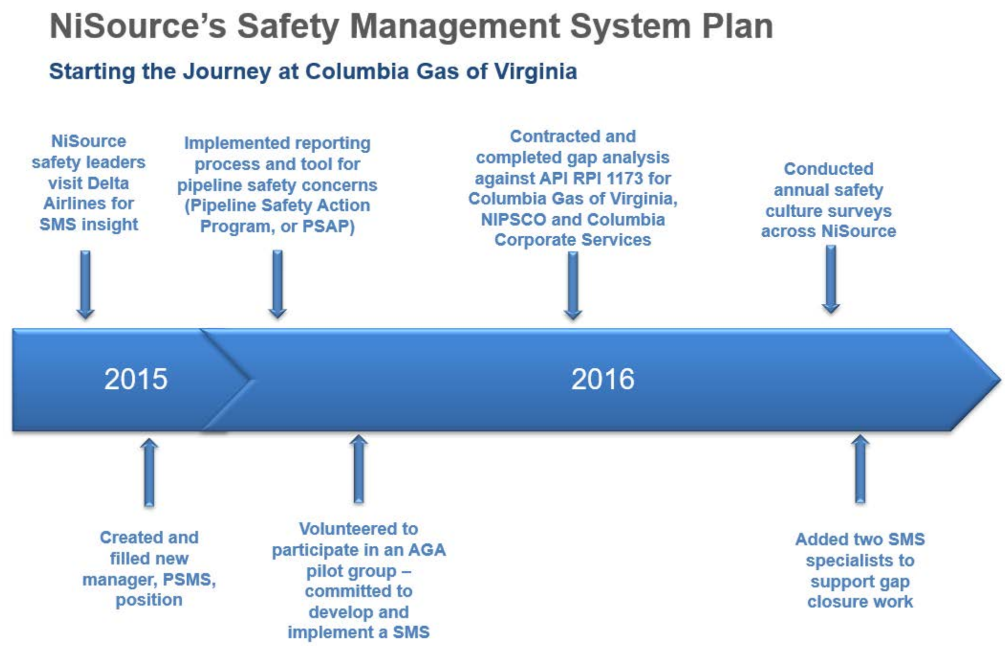
size, etc.)

xi. Complete soap test form - for any fittings

20. Construction Specialist

a. Does final check through of completed Capital Close Out packet submitted by Inspector, scans all documentation and uploads and updates metadata and status to "COMPLETE" in WMS Docs; submits final package electronically to Capital Close Out and drops off physical packet to Capital Close Out

Appendix B: NiSource SMS Plan



SMS Plan

Appendix C: Interviews Conducted

The following individuals were interviewed by the Pipeline Operations/Integrity Management Party

Interviews Conducted:

Feeney Brothers:

William De Roache -- Foreman

Anthony Moschella -- Laborer

Jose Madera -- Laborer

Matthew Mendes – Truck Driver/Materials and Parts

NiSource:

Rob Mooney – VP Engineering and Safety Management Systems

Dave Mueller – Manager of Engineering

Dave Monte – VP of Safety

Dana Argo – Operations Center Manager

Kevin Swiger – Director of Engineering Policies /Procedures and Training

Jim Roberts – Director of Pipeline Safety

Mark Chepke – VP of Training

Erich Schlitt – Systems Support Specialist Leader

Adam Roorda -- SCADA Senior Controller

Kevin Earl Mayes – SCADA Senior Controller

Steve McGinnity – M&R Technician

Martin Kulig – Leader of Field Engineering

Louie De Roxas – Associate Field Engineer

Jeffrey Croke – Manager of M&R

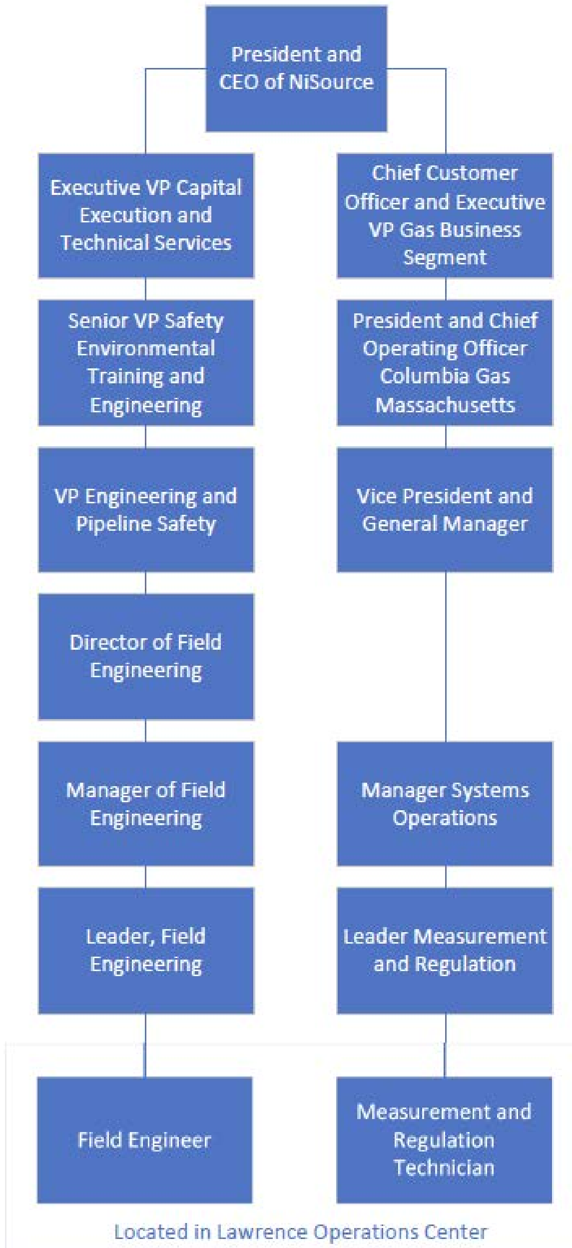
David Rhoads -- SCADA Senior Controller

Retired Columbia Gas Employee

Bart Maderios – Former Manager of M&R

Appendix D: NiSource Organizational Chart

Measurement and Regulation and Engineering – Reporting structure at the time of the accident.


President and CEO of NiSource
Executive VP Capital Execution and Technical Services
Chief Customer Officer and Executive VP Gas Business Segment
Senior VP Safety Environmental Training and Engineering
President and Chief Operating Officer Columbia Gas Massachusetts
VP Engineering and Pipeline Safety
Vice President and General Manager
Director of Field Engineering
Manager of Field Engineering
Manager Systems Operations
Leader, Field Engineering
Leader Measurement and Regulation
Field Engineer
Measurement and Regulation Technician
Located in Lawrence Operations Center

Roger D. Evans
Investigator In Charge

National Transportation Safety Board
Accident Investigator
Operations / Integrity Management Group Chairman

______//s//____________________Date: September 12, 2019

Robert Mooney
Party Coordinator

NiSource (Columbia Gas)
Vice President Gas Engineering/Pipeline Safety

______//s//____________________Date: September 12, 2019

Richard Wallace
Party Member

Massachusetts Department of Public Utilities
Director of Pipeline Safety

______Acknowledged ____________________Date: September 12, 2019

Darren Lemmerman
Party Member

Piping and Hazardous Materials Safety Administration
National Pipeline Incident Coordinator
Manager Region 6 Oversight & Safety
Division of Office of Pipeline Safety
US Department of Transportation

_______ Acknowledged ___________________Date: September 12, 2019