

PG&E Redacted Release

**Investigation Status Update 12/13/2013**


Redacted

**Exponent**<sup>®</sup>  
*Failure Analysis Associates*<sup>®</sup>

# BACKGROUND

# Leak Location

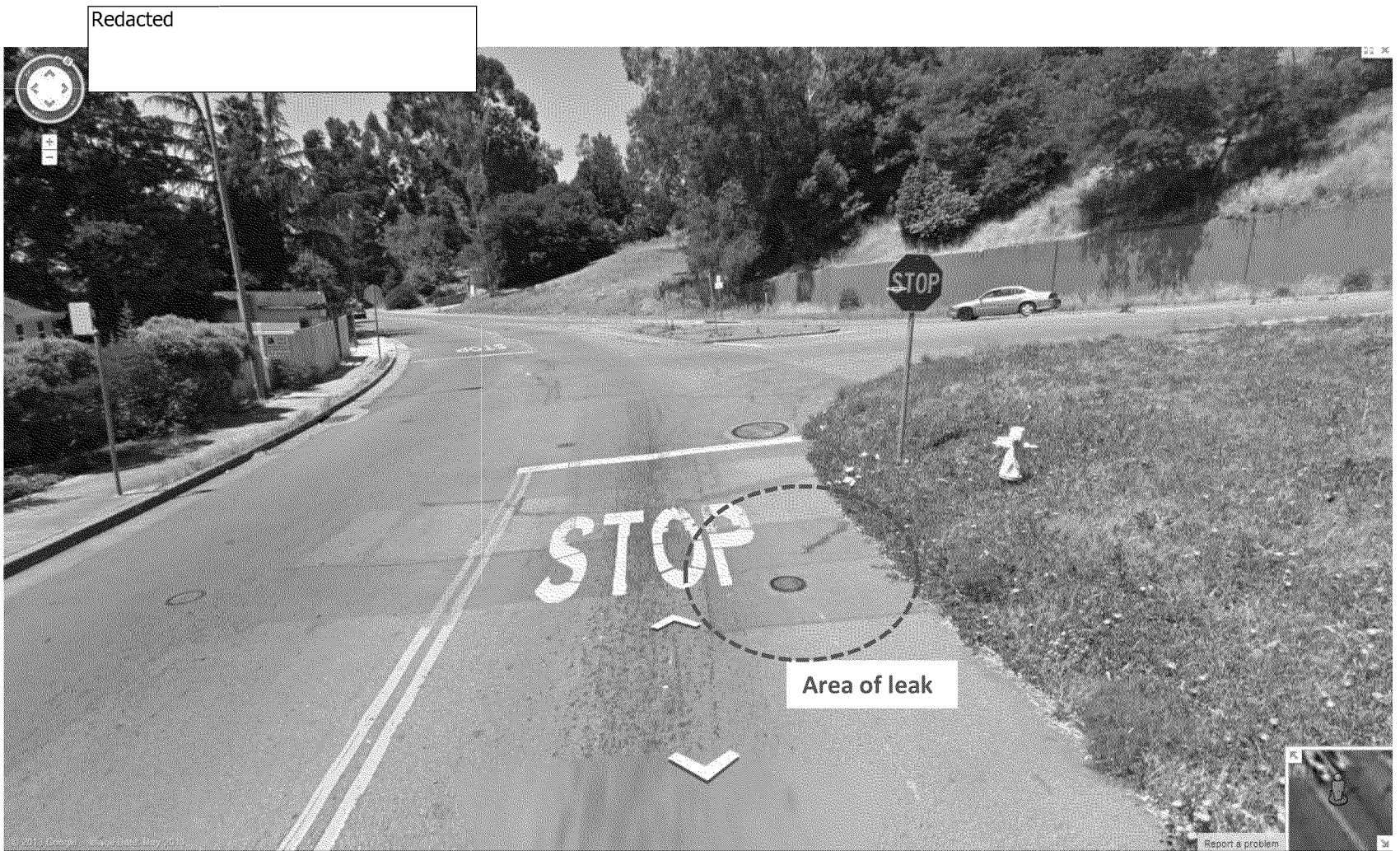
Redacted



Satellite image from Google Maps

3

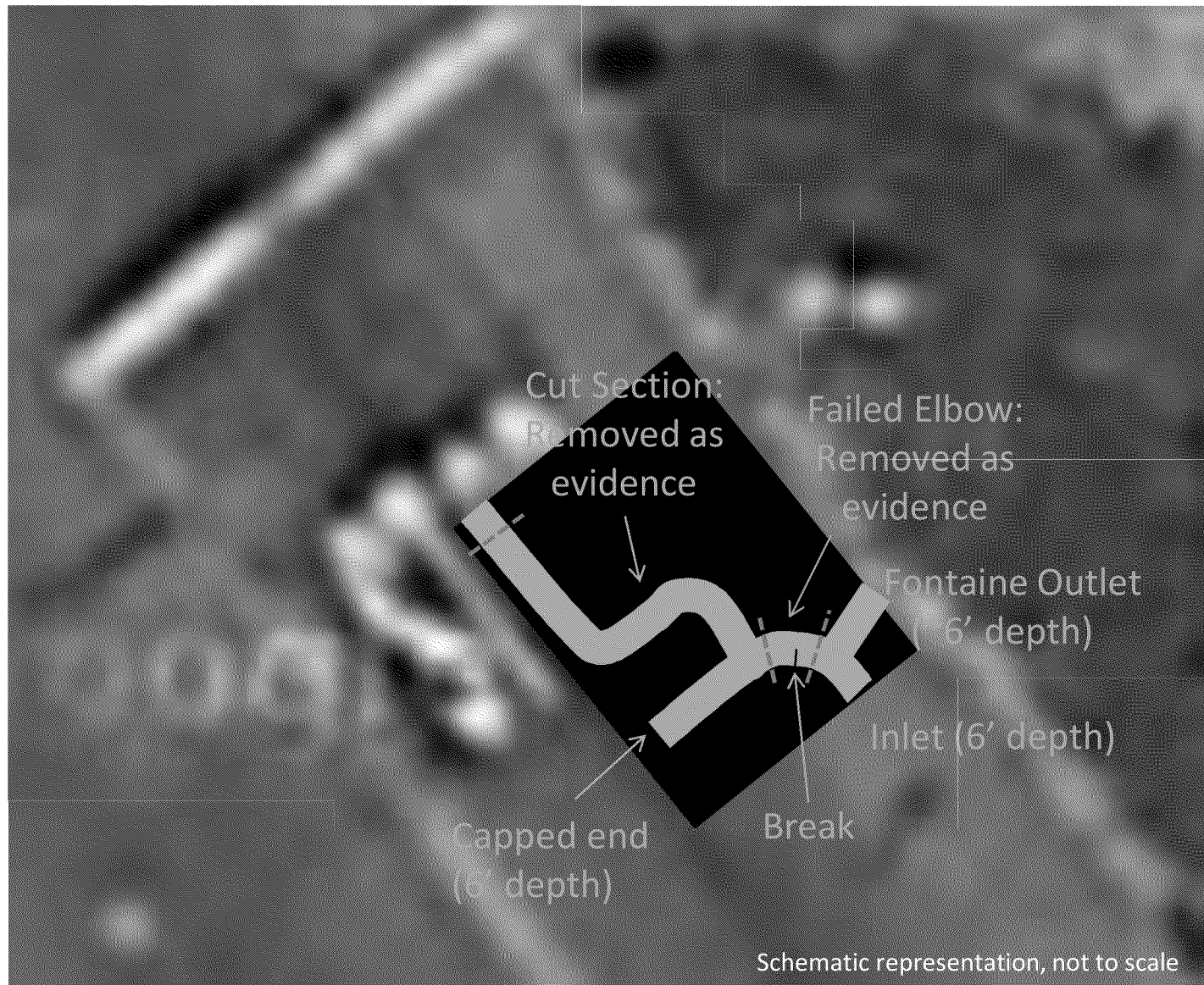
# Leak Location



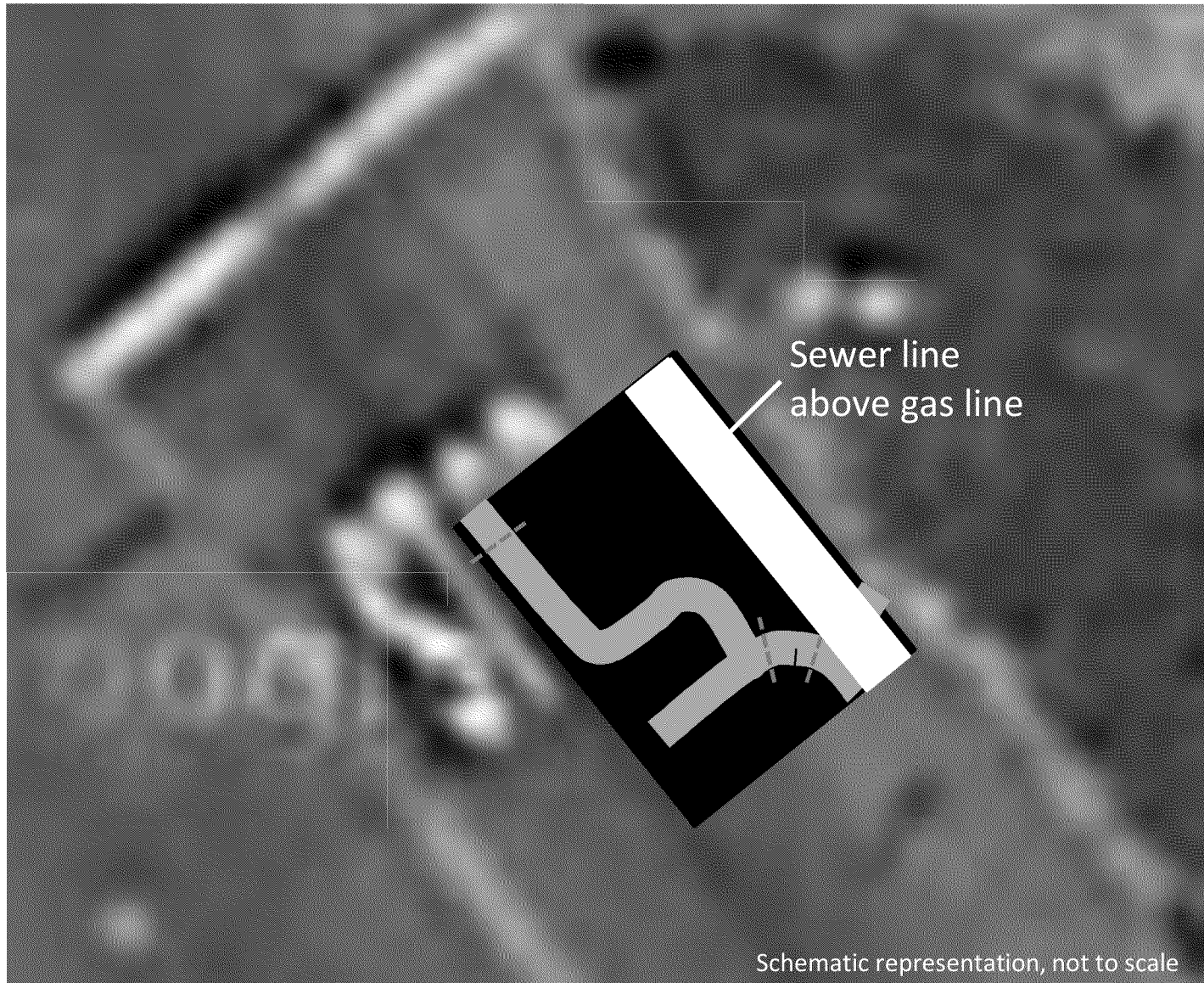
Redacted

2011 Image from Google Street View

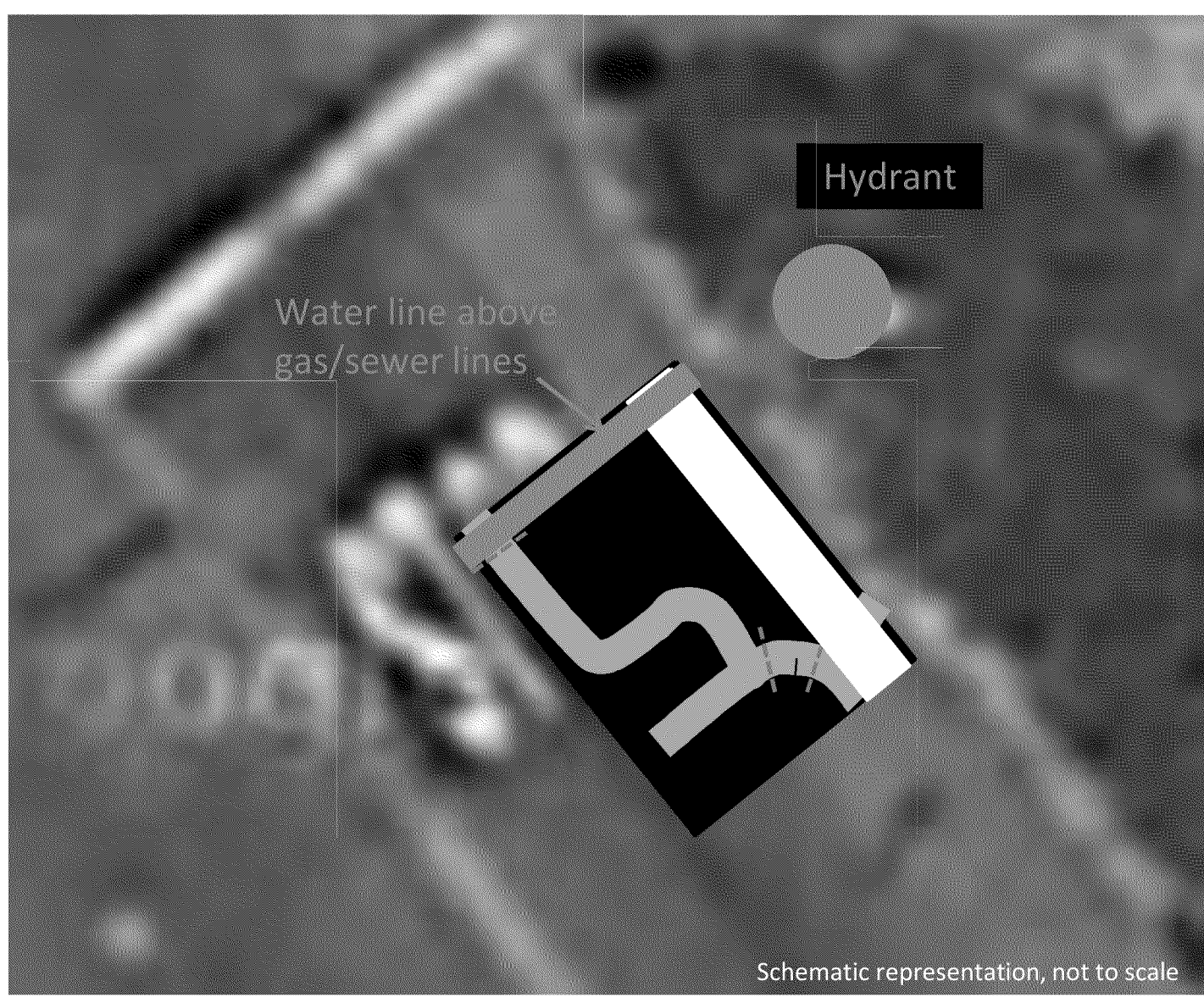
# Gas Pipe Location:



# Sewer Line Location:



# Water Line Location:

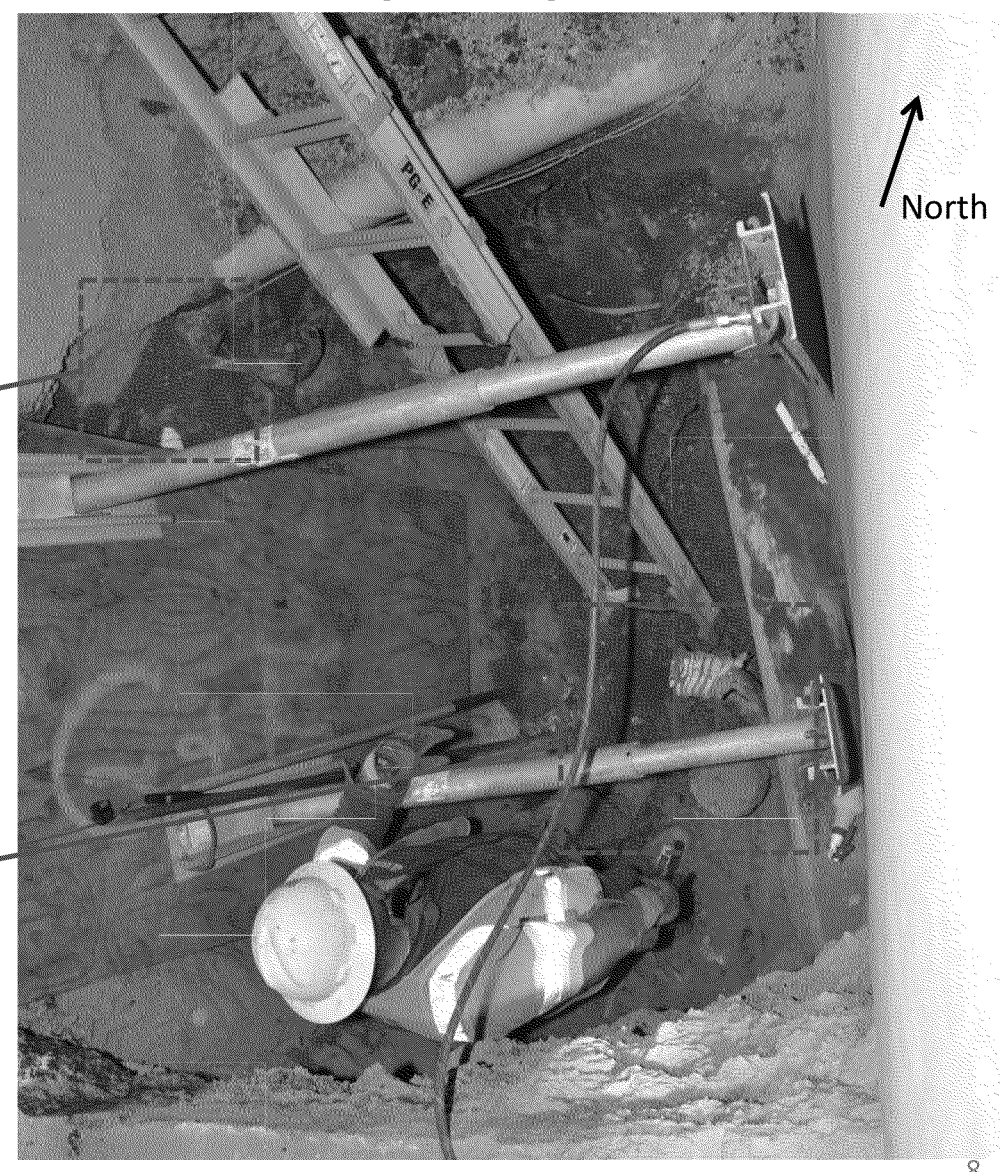


# Site Inspection on 12/10/13

4" gas main and water line



3" and 4" gas mains and sewer line

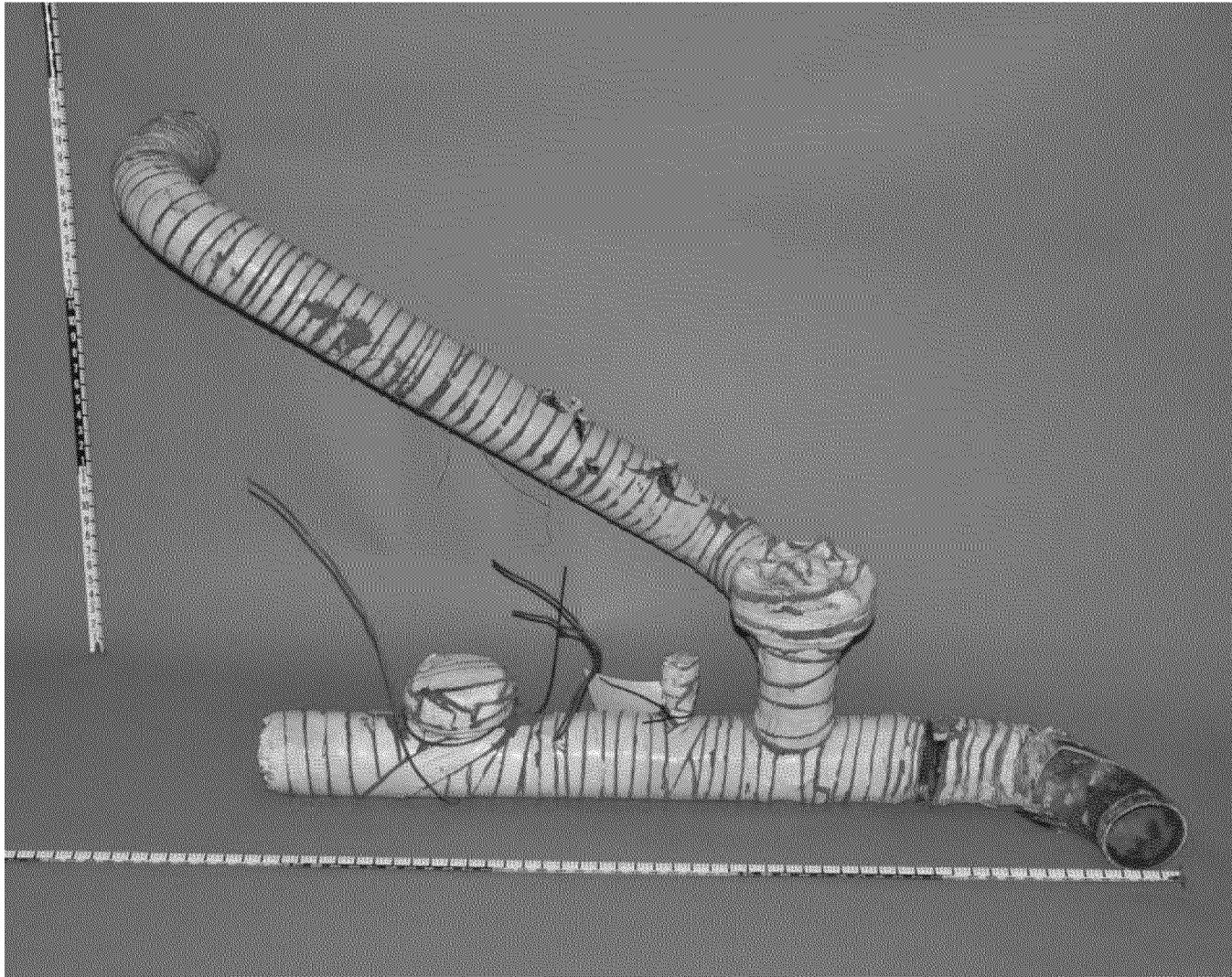




# Failed Elbow Before Removal



# Evidence at Exponent

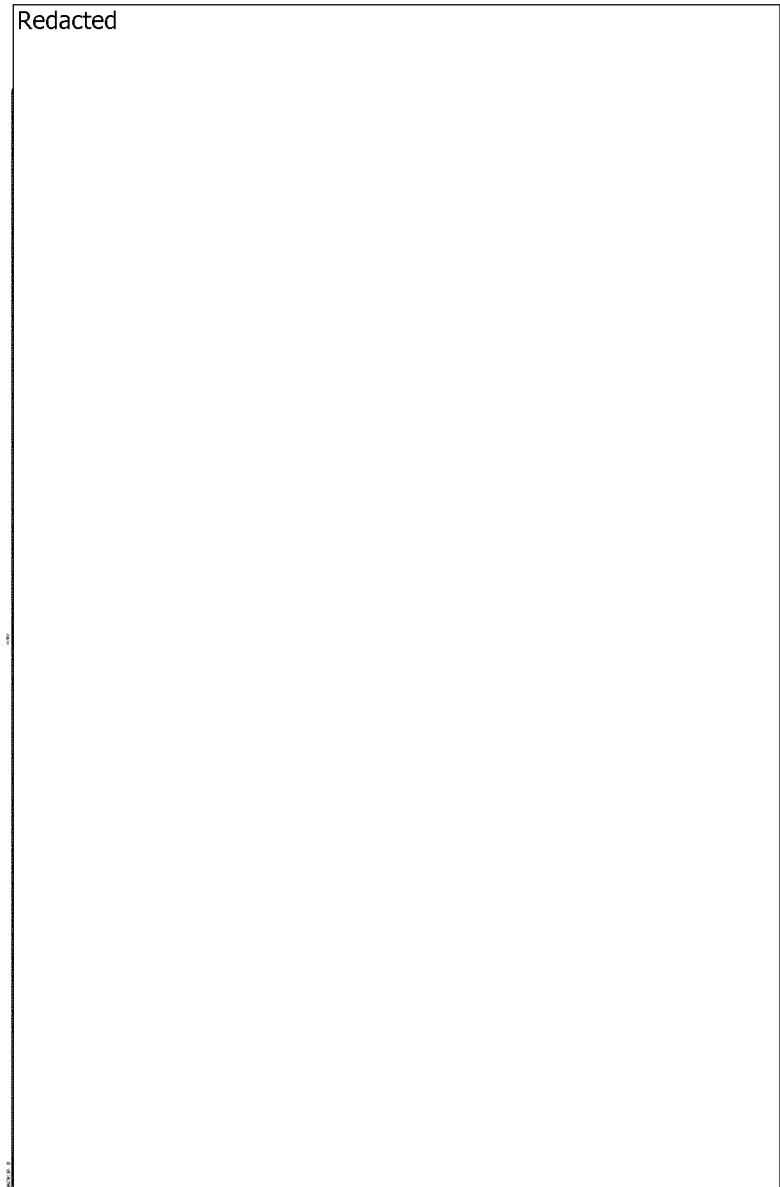


# **CONSTRUCTION DOCUMENTS AND MATERIAL SPECIFICATIONS**

# Distribution Plat

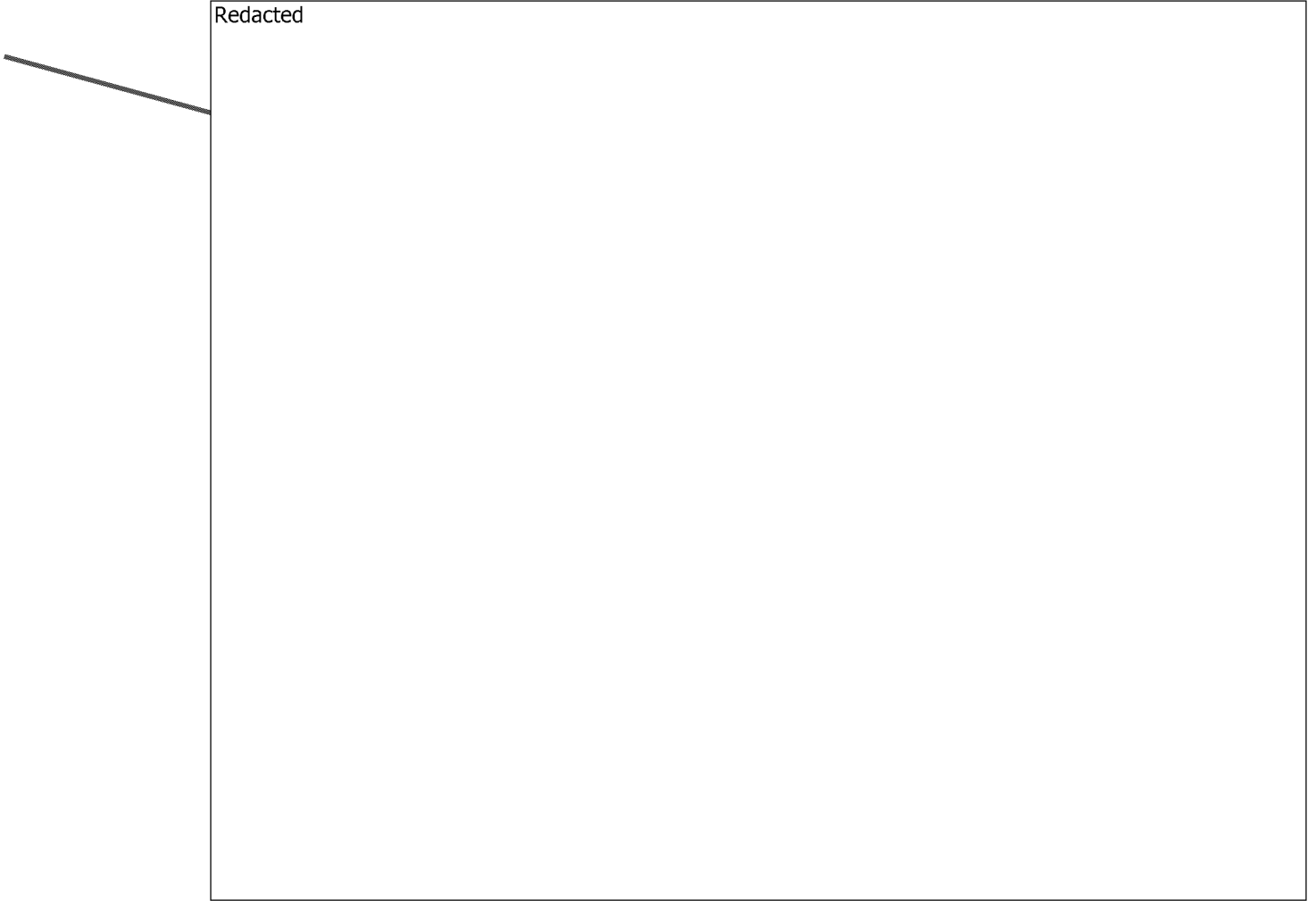
- D-Plat 10B-03 shows area of leak
- Indicates three jobs installed mains in the immediate area of the leak

Redacted



# Distribution Plat

Area of leak



# Relevant Construction Jobs

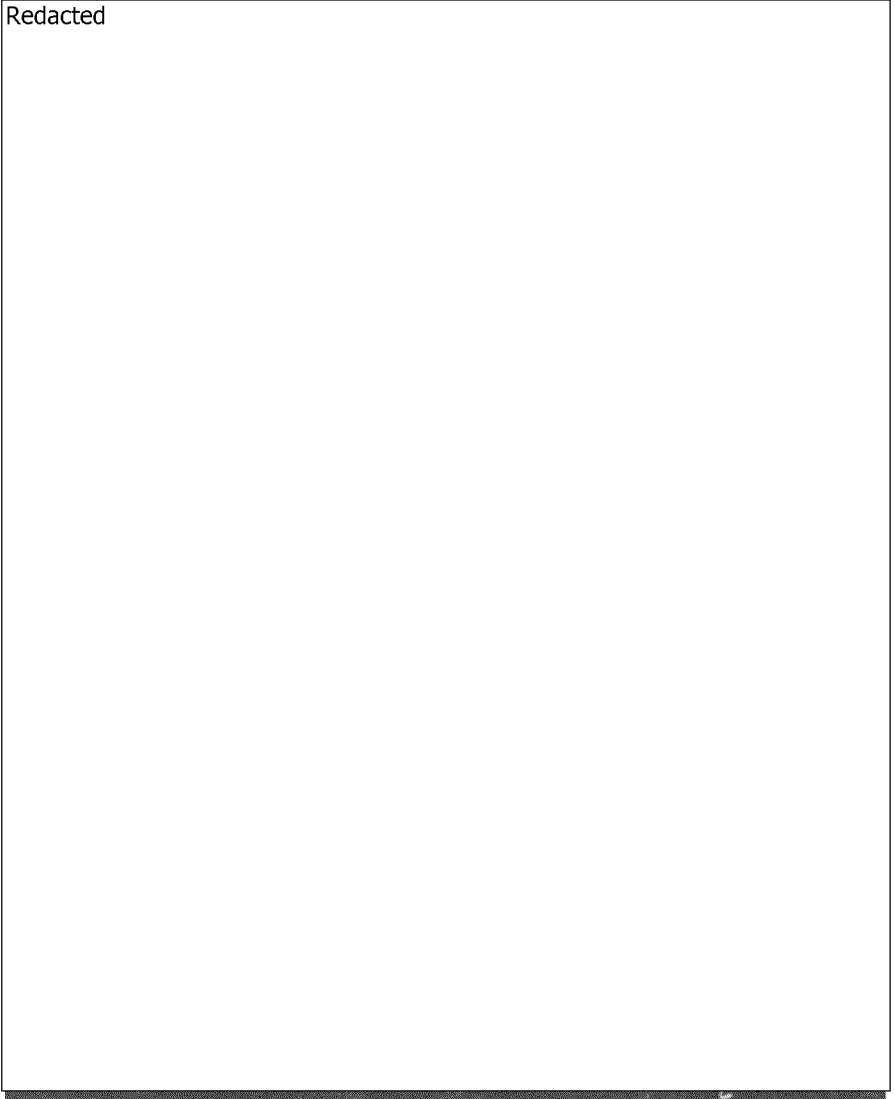
Construction drawings indicate:

- G.M.G. 82435 (1946)
  - Installed a 4” steel distribution main and two 4” weld elbows
  - The distribution main extends along [Redacted]
- W.O. 4747 (1965)
  - Installed a 3” steel distribution main along [Redacted]
  - Tapped into the 4” steel main at [Redacted] with a 3” flange tee
- G.M. 4564829 (1987)
  - Installed a 4” plastic distribution main along [Redacted]
  - The distribution main connects to the 4” steel main at [Redacted] with a 3” flange tee and ~4’ of steel pipe
  - Capped the existing 4” steel main and installed a line stopper fitting

# G.M.G. 82435 (1946)

- The 1946 construction drawing shows the installation of 4" 90° elbows and a steel distribution line
- Detail A is consistent with the intersection of Redacted and Redacted
- The location of the 4" 90° elbows is consistent with "existing" features shown in later construction drawings

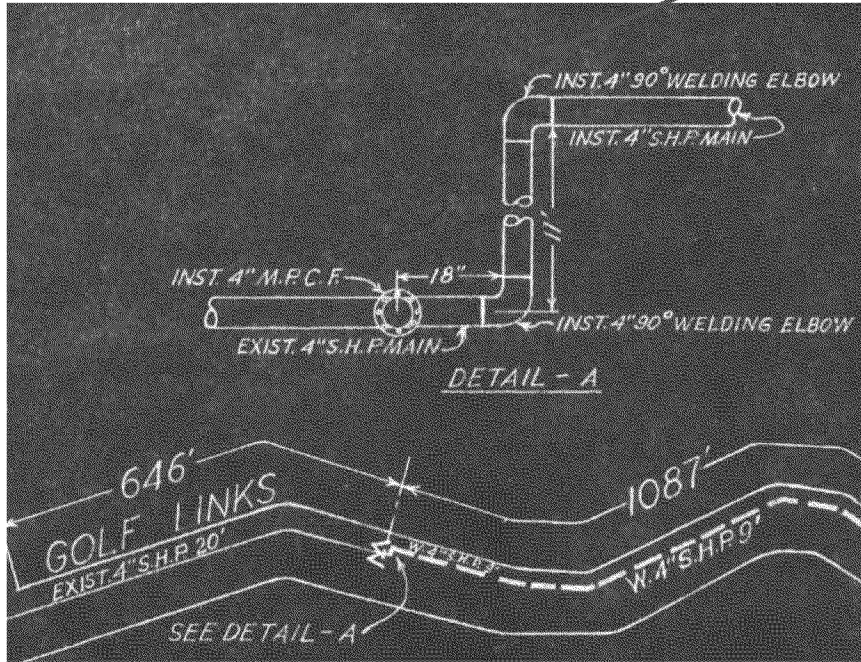
Redacted



Construction drawing for G.M.G 82435 (1965) 15

# G.M.G. 82435 (1946)


Installed 4" elbow and 4" main (1946)





# W.O. 4747 (1965)

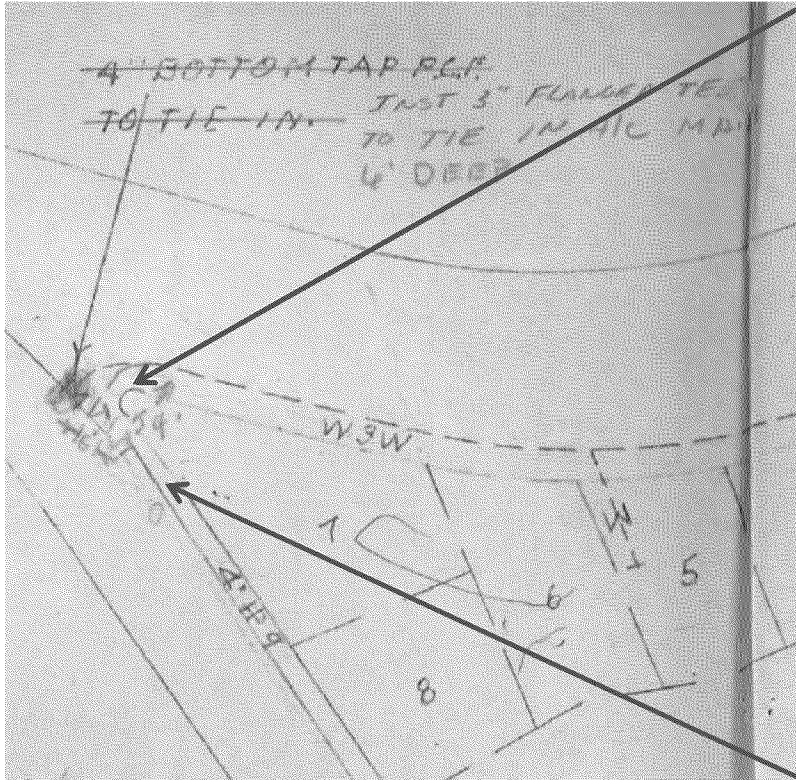
Redacted



Construction drawing for W.O. 4747 (1965)

# W.O. 4747 (1965)


Installed 3" flanged tee and 3" main (1965)



Existing 4" main (1946)

# G.M. 4564826 (1987)

Redacted

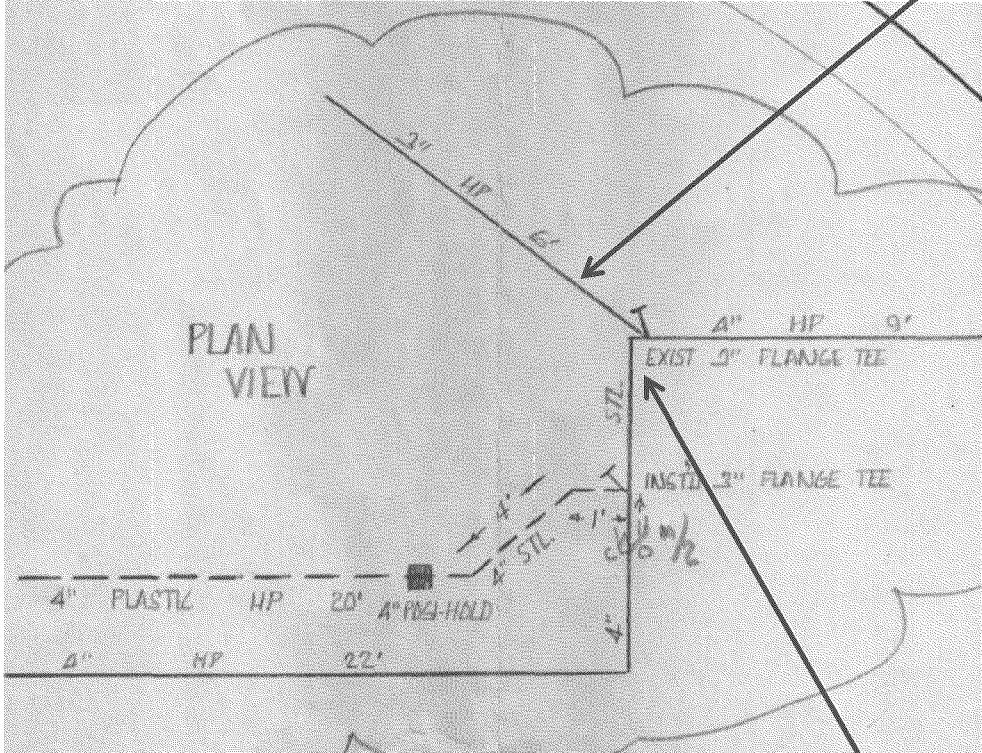


As-built construction drawing for GM 4564829 (1987)

# G.M. 4564826 (1987)

Existing 3" line and flanged tee (1965)

As-built construction drawing from GM 4564829 (1987)



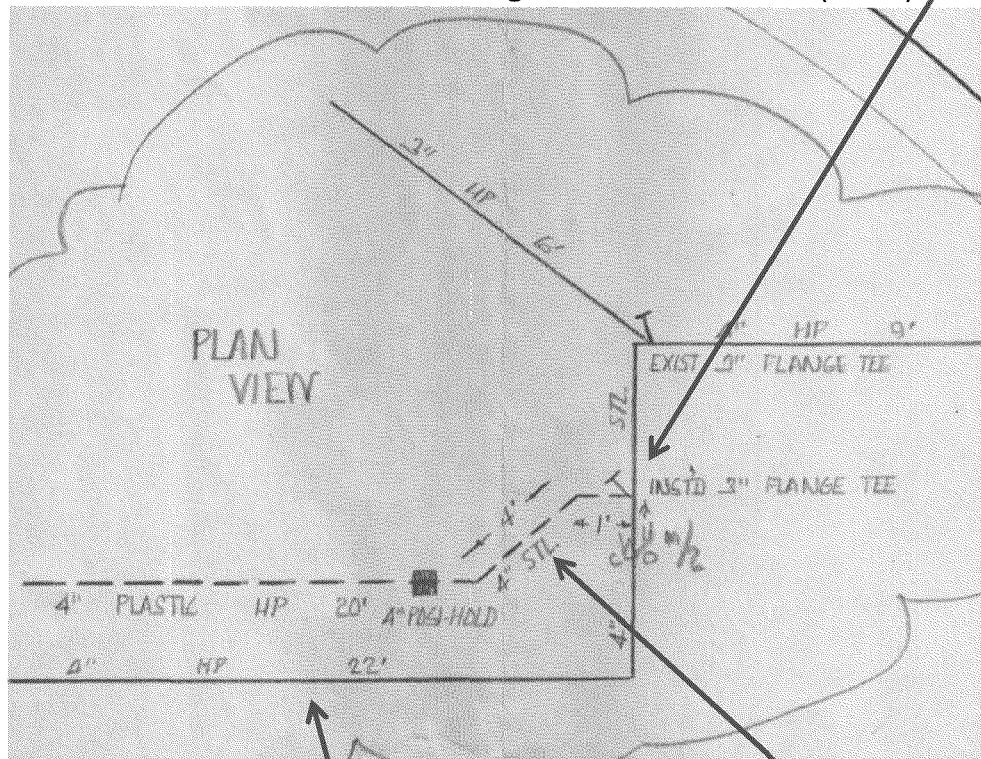
Inspection photo 12/11/13



Existing 4" line and elbow (1946)

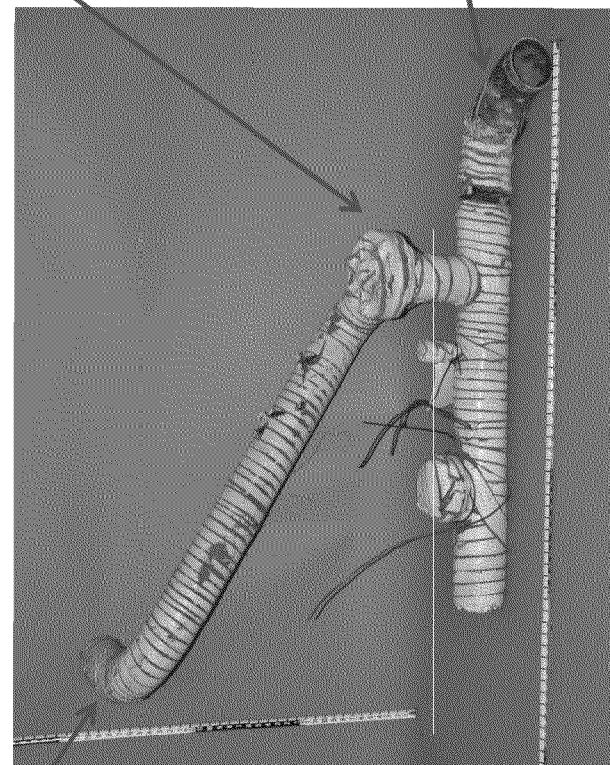
# G.M. 4564826 (1987)

As-built construction drawing from GM 4564829 (1987)



Installed flanged tee (1987)

Existing elbow (1946)

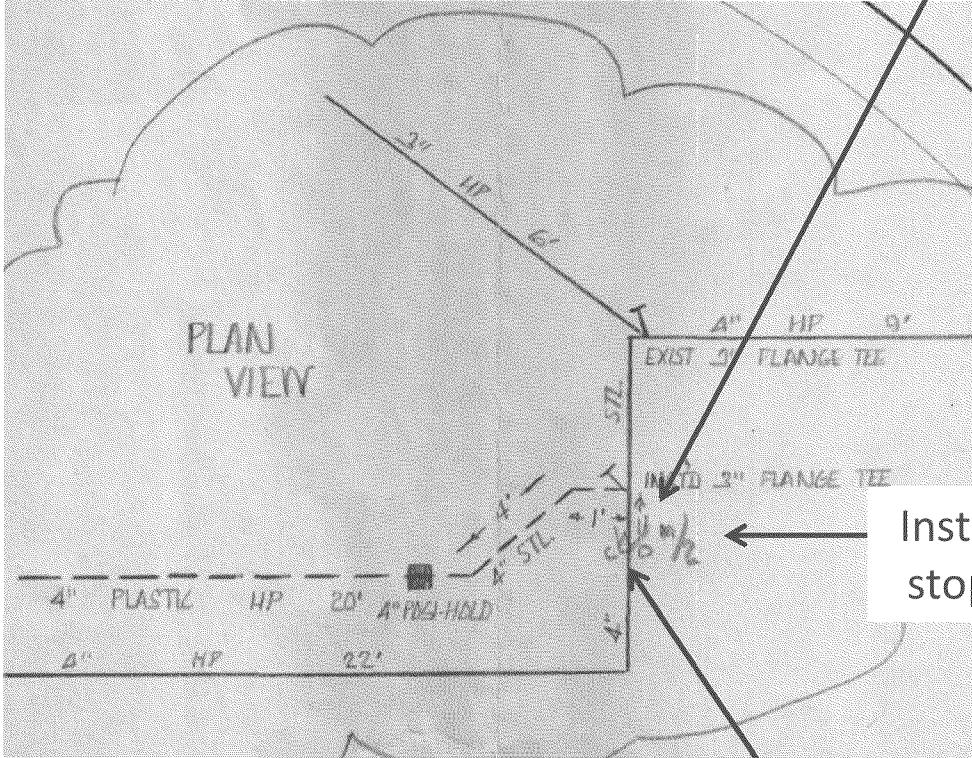


Existing 4" line deactivated in 1987

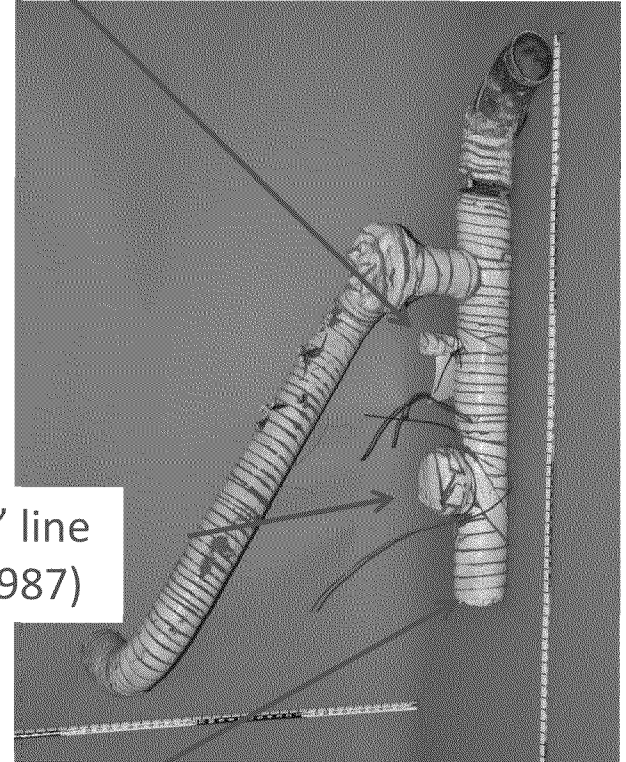
Installed 4" line and elbows (1987)

# G.M. 4564826 (1987)

As built construction drawing from GM 4564829 (1987)



Installed sav-a-valve (1987)



Installed 4\" line stopper (1987)

Installed 4\" cap (1987)

# Construction Documents Conclusions

- The component that failed is a 4” diameter, 90 degree manufactured steel elbow that was installed in 1946.
- Immediately upstream the failed elbow, a 3” diameter tee was installed in 1965 that fed the Fontaine Street main.
- Downstream of the failed elbow, the 4” line was cut and capped in 1987 and an upward transition was added to feed a plastic line that continued down Golf Links Road.
- The construction documents from 1946 and 1987 accurately reflect the as-installed conditions.

# Material Specifications

1946 elbow documentation:

Ordered two 4" 90 deg steel weld elbows with material code 02-2039

From PG&E dwg #281992 "Long Radius Welding Elbows" dated 10/8/52, material code 02-2039 corresponds to

- Std. weld elbow
- Wall thickness – 0.237"
- Unknown grade, likely Grade A or Grade B

Installed on GMG 82435

**PACIFIC GAS AND ELECTRIC CO.**  
**GENERAL CONSTRUCTION DEPT.**  
**CONSTRUCTION JOURNAL VOUCHER**

NOTE: ONE ORIGINAL AND AS MANY COPIES AS ACCOUNTS INDICATED ON DEBIT AND CREDIT SIDES ARE REQUIRED TO BE FORWARDED TO ACCOUNTANT, GENERAL CONSTRUCTION DEPARTMENT.  
**CHECK COPY FOR EACH ACCOUNT WITH RED PENCIL.**

ITEM NO. OR	DESCRIPTION GIVE FULL DETAILS OF ALL CHARGES	ITEM NO. OR	QUANTITY	AMOUNT
	<i>Typesetting - 1/2 lb.</i>			
<i>02-2039</i>	<i>02 2039, 4" 90° st. Welding</i>		<i>2</i>	<i>9.74</i>
<i>✓</i>	<i>157026, Electric, To Portland #5 lbs.</i>		<i>2</i>	<i>18</i>
<i>✓</i>	<i>157027, "No. 1" #5 lbs</i>		<i>4</i>	<i>30</i>
<i>02-3</i>	<i>157027, Red, 3/4" O.D. 9" L.R. Welding</i>		<i>15</i>	<i>1.57</i>
<i>✓</i>	<i>470022, Acetylene</i>	<i>gas</i>	<i>300</i>	<i>8.34</i>
<i>✓</i>	<i>470024, Oxygen</i>	<i>✓</i>	<i>1000</i>	<i>3.76</i>
<i>02-2</i>	<i>134112, Primer Paper 3772</i>	<i>Prm</i>	<i>2</i>	<i>31</i>
<i>02-4</i>	<i>ditto</i>	<i>✓</i>	<i>4</i>	<i>63</i>
<i>1014</i>	<i>Stars Expense</i>			<i>2.00</i>
I CERTIFY THAT THE MATERIAL ON THIS DOCUMENT HAS BEEN RECEIVED AND USED ON G. M. 82435 ITEM .....				
<i>W. J. Moore</i> <i>W. J. Moore</i> SUPERVISOR      FOREMAN				
<i>inspected</i>				TOTAL <i>27.03</i>
MONTH OF <i>November</i> 194 <i>6</i>				
DEBIT THE FOLLOWING ACCOUNTS IN THE AMOUNT SHOWN		CREDIT THE FOLLOWING ACCOUNTS IN THE AMOUNT SHOWN		
<i>GMG 82435</i>	<i>27.03</i>	<i>MS Moore Materials</i>	<i>27.03</i>	

Redacted

MAOP25369015.jpg



# Material Specifications

1946 pipe documentation:

Ordered 1116' of 4" gas line pipe with material code 01-1026

No information has been located on material code 01-1026

Installed on GMG 82435

419044

PACIFIC GAS AND ELECTRIC COMPANY  
Requisition on Storekeeper

Date 5/15 1946

Redacted

PLEASE DELIVER TO BEARER THE UNDERNOTED ARTICLES

CHKD. BY	MATERIAL NUMBER	ARTICLES	QUANTITY	PRICE	AMOUNT	PLANT LOCATION OR FILE NO.	ACCT. NO.
	01 1026	GAS LINE PIPE 4" S.W. <del>1116'</del>	23 pcs.	1116	.5625	62775	903-1
						6278	1014
					TOTAL	69053	

(DESCRIBE FULLY WORK ON WHICH MATERIAL IS USED)  
*install 4" gas main*

Redacted

G. M. NO. PREFIX NUMBER SUFFIX  
*GM 82435*

GENERAL CONSTRUCTION DEPARTMENT No. 3

DATE MATERIAL RECEIVED 5/15/46

RECEIVED ABOVE MATERIAL

1 2 3 4 5 6 7 8 9 10 11 12  
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

No. 126678

MAOP25369015.jpg

# Material Specification Conclusions

A construction journal voucher from GM 82435 (1946) indicates that the failed elbow:

- Is a standard weld elbow with a wall thickness of 0.237" and a material code of 02-2039
- Elbow material grade is specified to be Grade A unless: "if greater working pressure is wanted specify Grade B" (Grade A = 30ksi yield, 48ksi UTS; Grade B = 35ksi yield, 60ksi UTS; Grade C = 40ksi yield, 70ksi UTS\*)

A material requisition from GM 82435 (1946) indicates that the pipe in the vicinity of the failed elbow is:

- 4" gas line pipe with a material code of 01-1026 (material specifications for the pipe have not been located)

\*ASTM A 106, 1967 version

# **METALLURGICAL ANALYSIS**

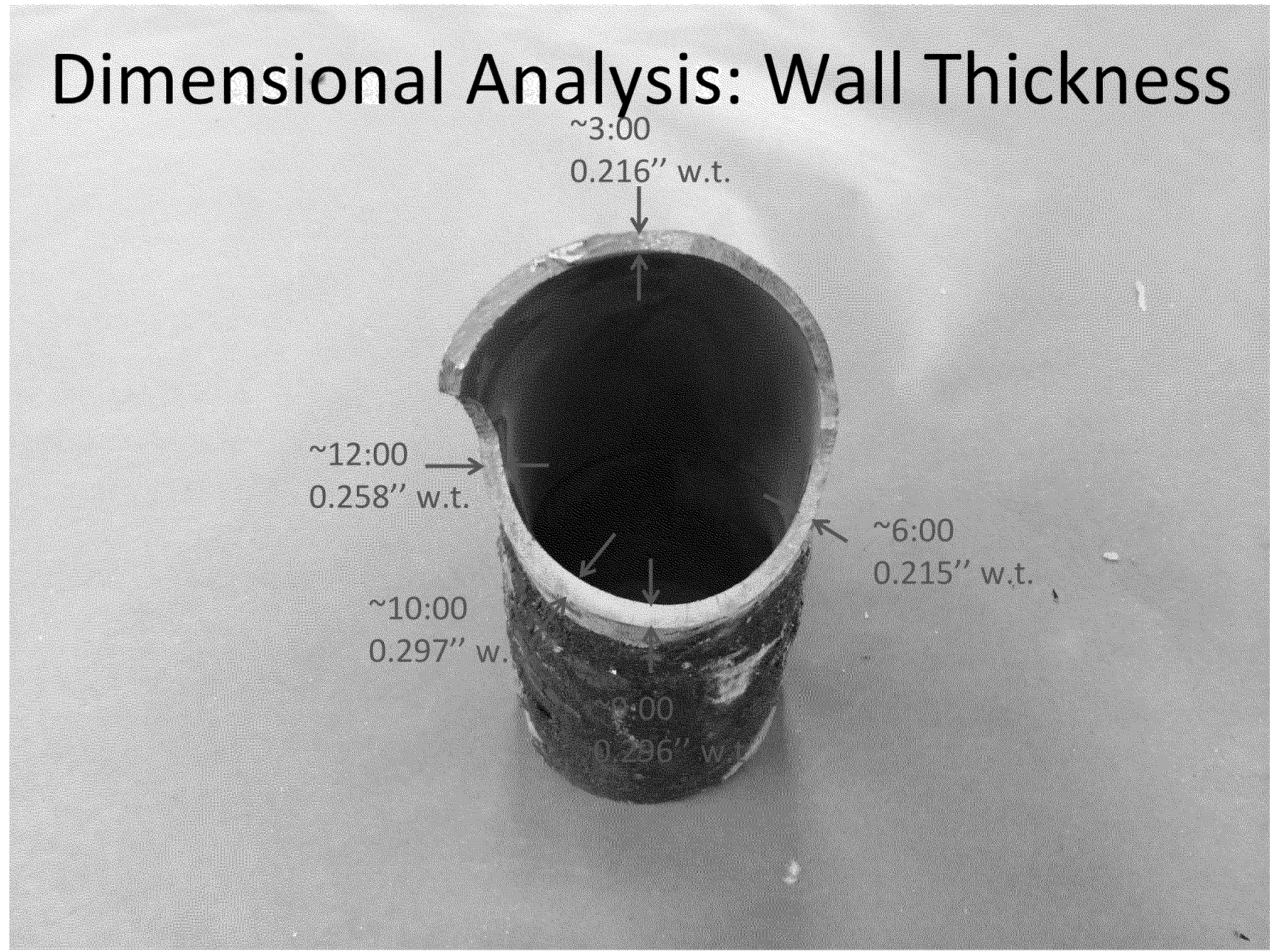
# Metallurgical Analysis

- Visual Inspection
- Optical Microscopy
- Scanning Electron Microscopy
- Energy Dispersive Spectroscopy
- Metallographic Analysis
- Hardness Testing

# Visual Inspection



# Dimensional Analysis: Wall Thickness



# Dimensional Analysis: Corrosion

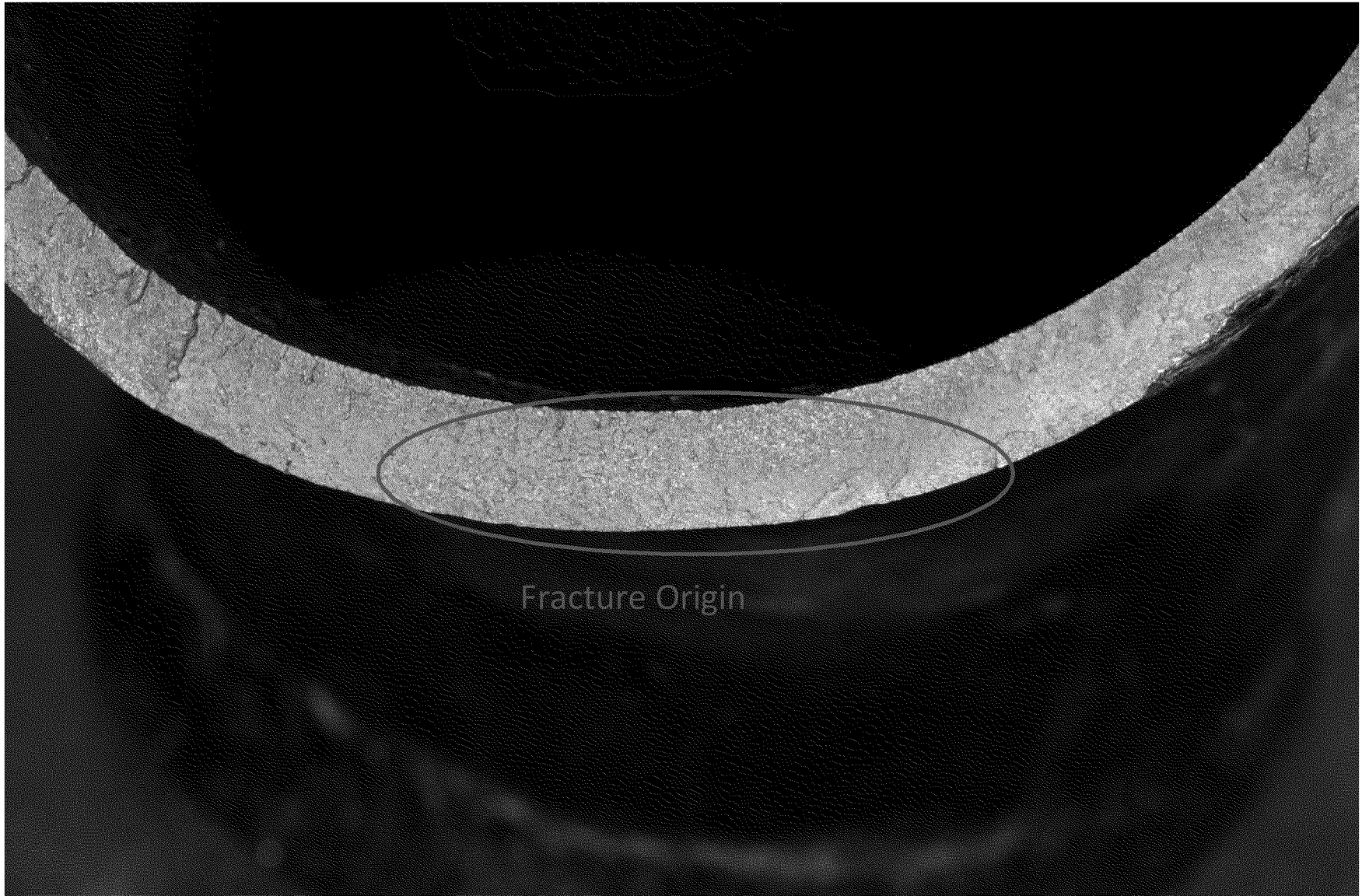


# Dimensional Analysis



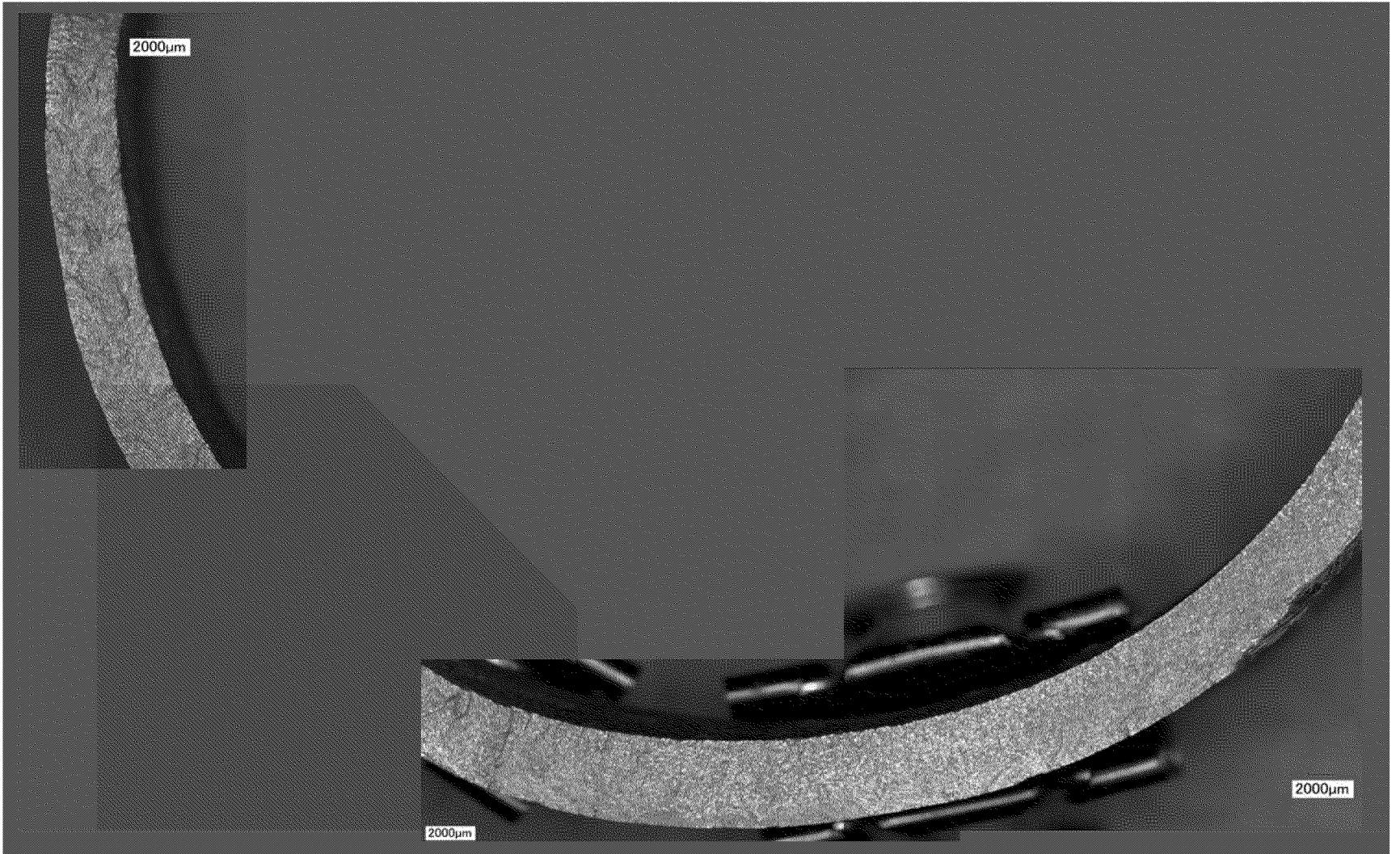


# Visual Inspection

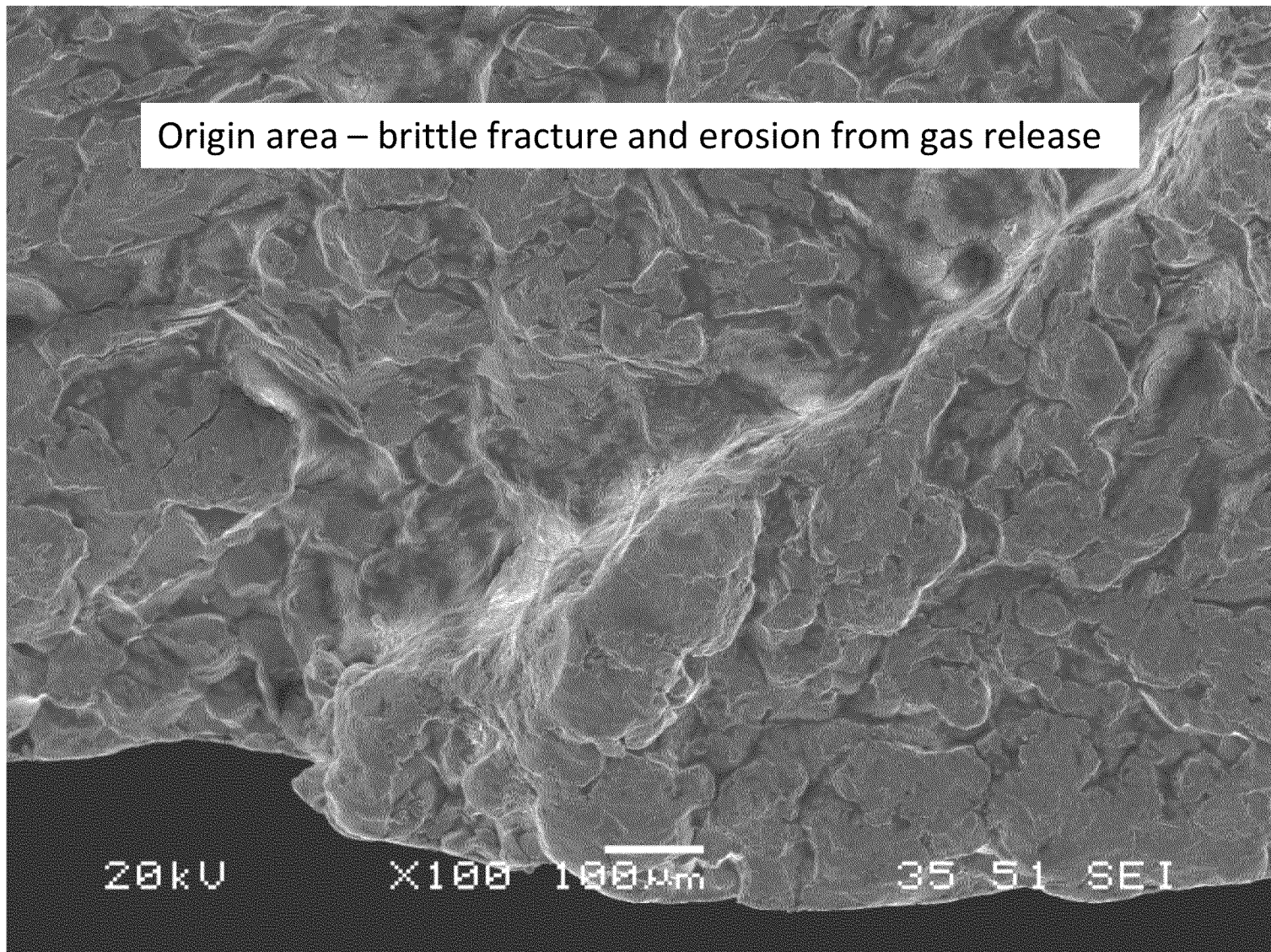


Fracture Origin

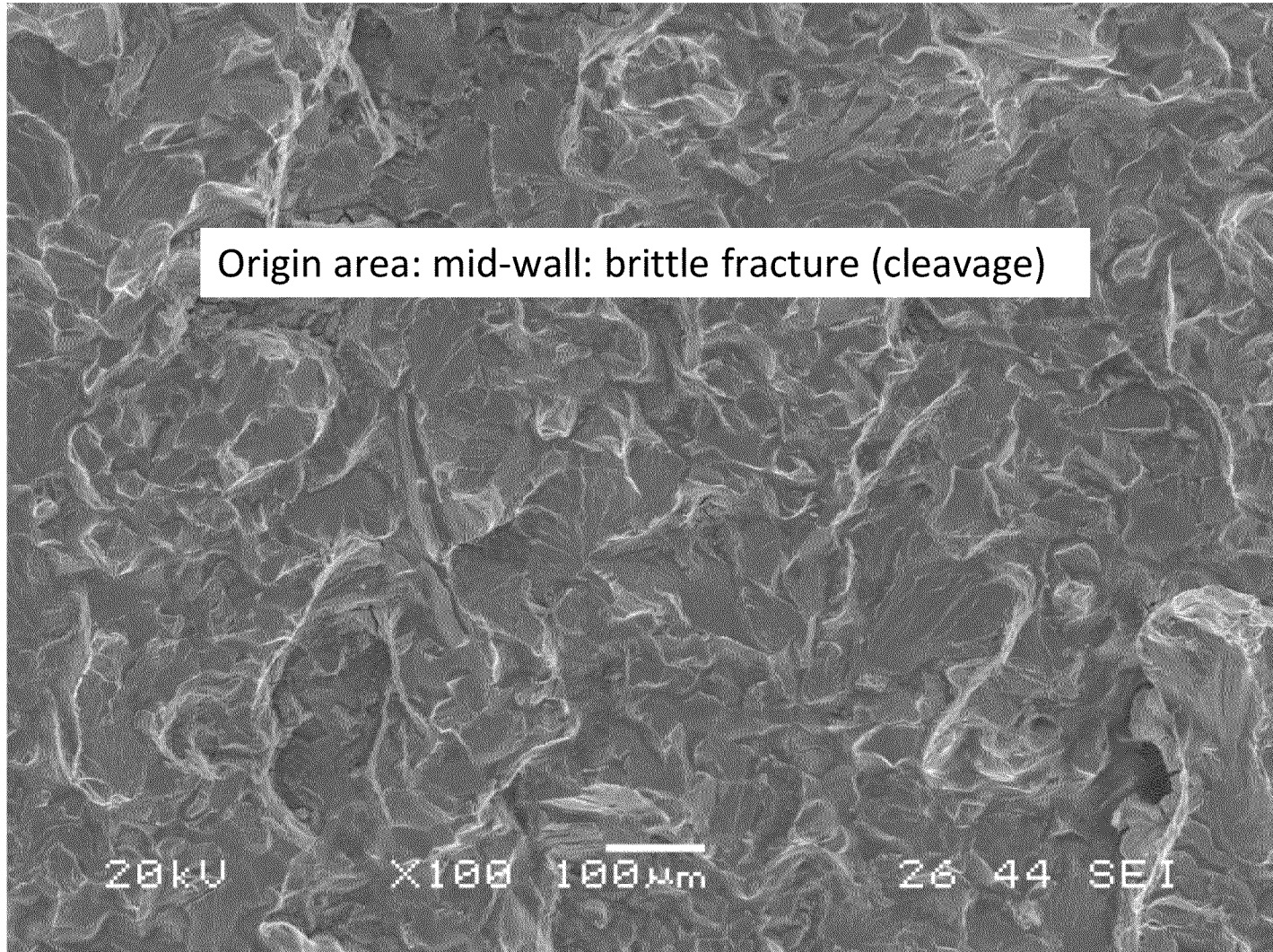
# Optical Microscopy



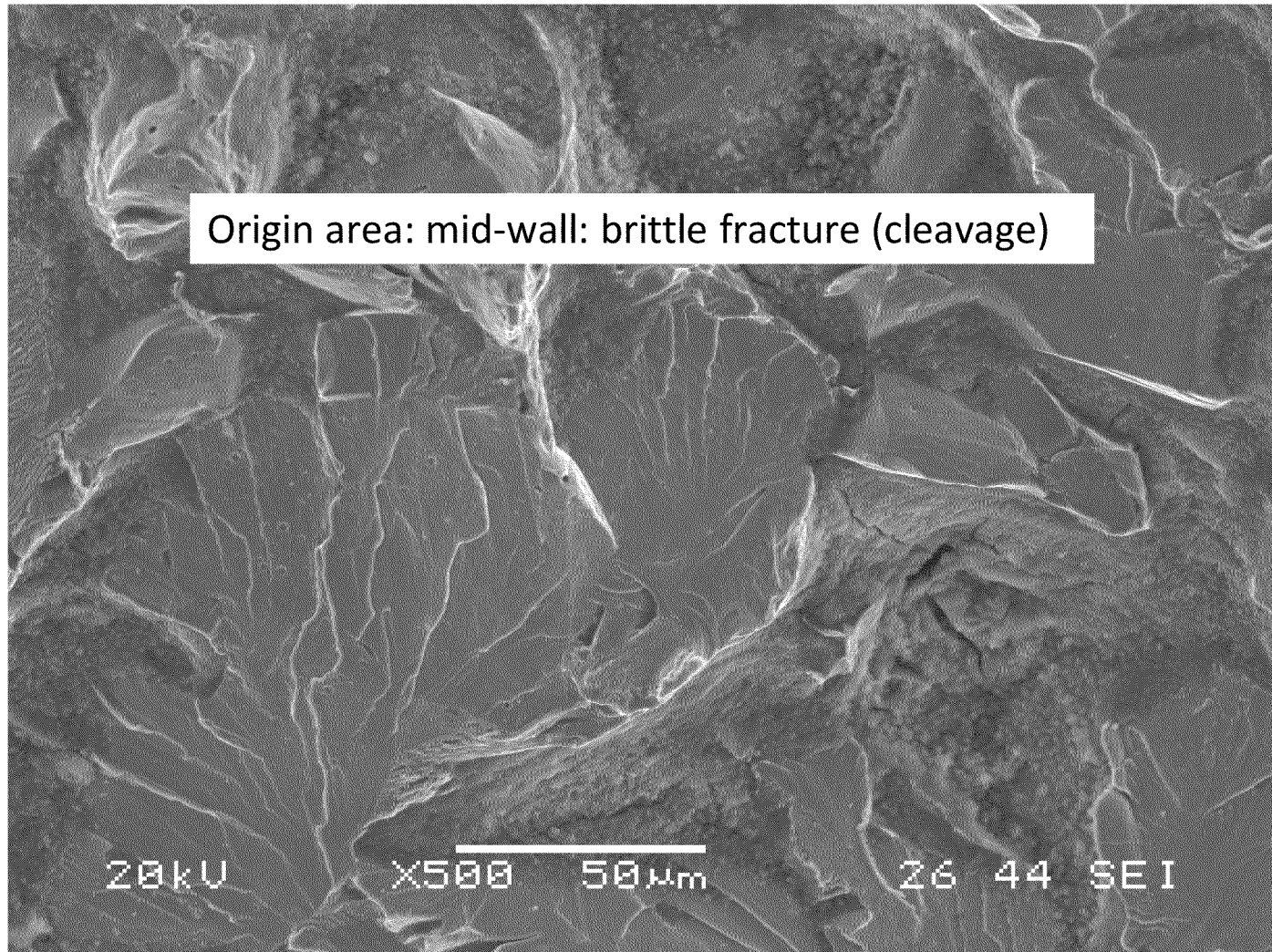
# Scanning Electron Microscopy



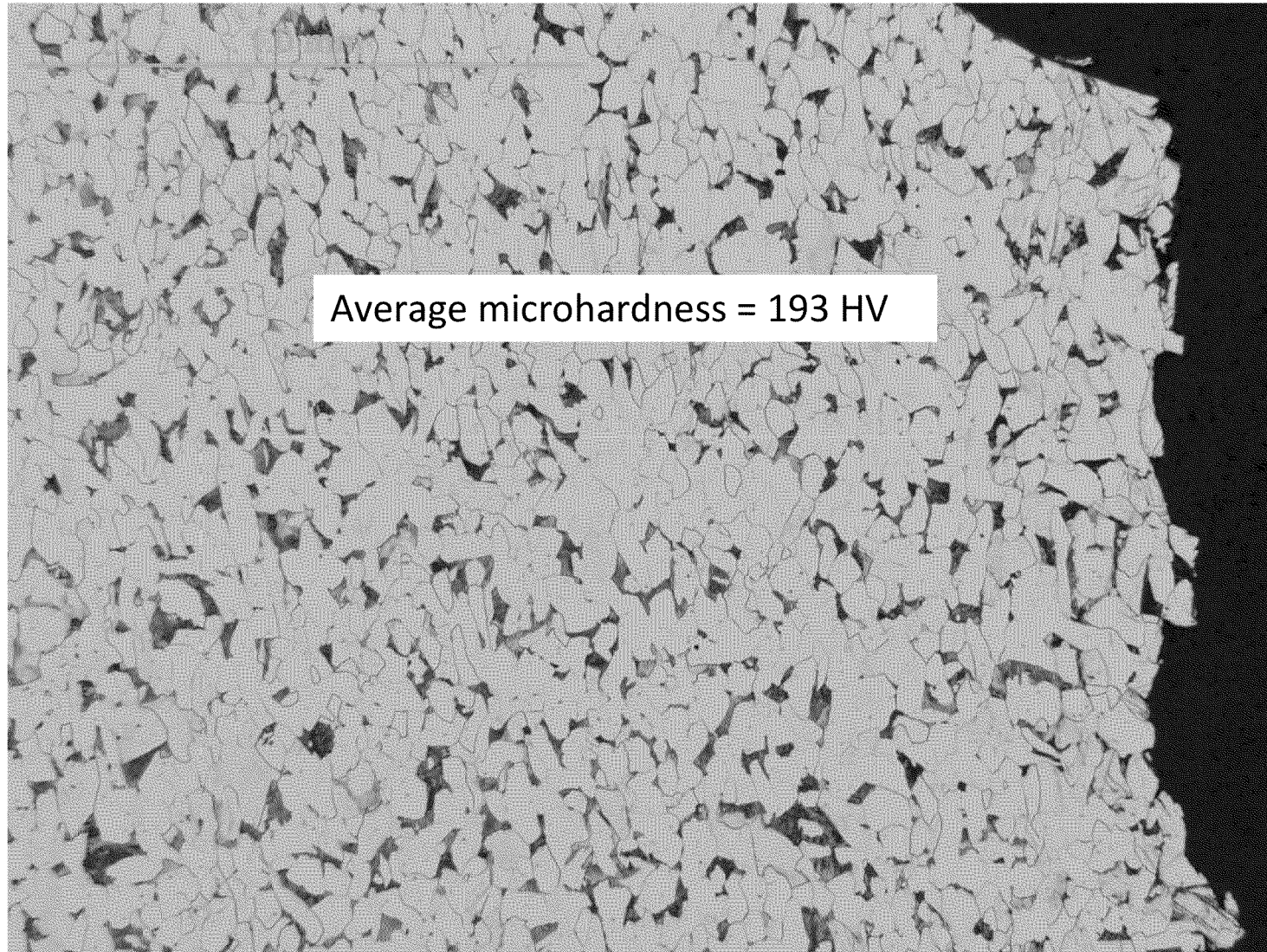
# Scanning Electron Microscopy



# Scanning Electron Microscopy



# Metallography



# Conclusions

- The subject elbow fracture was caused by a single, overload event
- Brittle (cleavage) fracture morphology was observed
- No evidence of progressive fracture (such as fatigue or stress corrosion cracking) was observed
- The fracture was not associated with a mechanical, corrosion-induced, or metallurgical defect
- The elbow exhibited the expected “ferrite-pearlite” microstructure
- The elbow hardness was measured to be 193 HV, roughly equivalent to a UTS of 92 ksi

# Limitations

At the request of PG&E, Exponent performed an analysis of the [Redacted] natural gas release that occurred on Tuesday December 10, 2013 in [Redacted]. Exponent's analysis is based on data and information provided by PG&E, the accuracy and validity of which has not been independently verified by Exponent. The scope of services performed during this investigation may not adequately address the needs of other users of this presentation, and any re-use of this presentation or its findings, conclusions, or recommendations is at the sole risk of the user. Opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed component or condition is expressed or implied.

The findings presented herein are made to a reasonable degree of engineering certainty. We have made every effort to accurately and completely investigate areas of concern identified during our investigation. If new data becomes available or there are perceived omissions or misstatements in this report, we ask that they be brought to our attention as soon as possible so that we may have the opportunity to fully address them.