DOT	US Department of Transportation
PHMSA	Pipelines and Hazardous Materials Safety Administration
OPS	Office of Pipeline Safety
	Southern Region

Principal Investigators	Gabriel Kotsis and Chris Taylor
Region Director	Wayne T. Lemoi
Date of Report	April 21, 2011
Subject	Failure Investigation Report – Southern Natural Gas Wrinkle Bend Failure

Operator, Location, & Consequences

Date of Failure	12/31/2009
Commodity Released	Natural Gas
City/County & State	Heflin/Cleburne County, Alabama
OpID & Operator Name	18516, Southern Natural Gas
Unit # & Unit Name	8142, AL-3
SMART Activity #	128232
Milepost / Location	399.642/In an open field east of Heflin County Road (CR) 488, south of CR 62
Type of Failure	Pipe ruptured due to a failed wrinkle in a four-wrinkle underbend configuration. The pipe's longitudinal seam was incorporated into the wrinkles during the fabrication of the bend.
Fatalities	0
Injuries	0
Description of area impacted	Class 2 Location, not an HCA.
Property Damage	There was minimal property damage. Escaping high pressure natural gas displaced soil and created a narrow hole on SNG's ROW.

Executive Summary

On December 31, 2009, at approximately 11:23 pm central standard time (CST), a rupture occurred on Southern Natural Gas' (SNG) 24-inch North Main Loop pipeline in Cleburne County, Alabama, approximately 9 miles east-southeast of the town of Heflin, Alabama. The rupture occurred on a pipeline segment near County Road 488 (CR 488) at Milepost (MP) 399.642 and was discovered by a nearby resident who reported a "jet engine sound" near his residence.

The resident called Cleburne County Emergency 911, who subsequently contacted SNG, Turkey Heaven Volunteer Fire Department as well as the Heflin City and Cleburne County law enforcement departments.

SNG responded to this event by isolating the rupture. That is, SNG closed the nearest upstream valve at Heflin Gate (MP 391.982) and the nearest downstream valve at Rome-Calhoun Gate (MP 400.244), isolating 8.26 miles of pipeline.

There were no fatalities or injuries, however, six residents whose homes were near the rupture site along CR 488 self evacuated as a precaution. The residents assembled at the Pine Grove Baptist Church (Appendix A) located north on County Road 62; approximately three-quarters of a mile from the rupture site. The Turkey Heaven Volunteer Fire Department established the emergency operations center (EOC), for staging and coordination of all emergency response for this event, at this same church.

SNG reported the incident to the National Response Center (NRC) via telephone on January 1, 2010, at 12:55 am CST (1:55 am Eastern Standard Time (EST) on the NRC report) (Appendix B).

The rupture occurred due to a failed wrinkle bend in the 24-inch pipe. The failed pipeline section had four wrinkles in an under bend (sag) configuration with the pipe's longitudinal seam near the center of the wrinkles. The pipeline right-of-way in the failure area consisted of rolling hills in both the upstream and downstream directions.

System Details

SNG's pipelines operate under the El Paso Pipeline Group (El Paso), which consists of several operating subsidiaries with approximately 42,000 miles of interstate natural gas transmission pipelines throughout the United States.

SNG's North Main Loop is part of SNG's North Main Pipeline System, which is comprised of three parallel lines at the failure location:

- 20-inch North Main Line
- 24-inch North Main Loop (failure occurred on this pipeline)
- 24-inch 2nd North Main Loop

The North Main Loop pipeline is approximately 455 miles long. It originates in Ouachita Parish, Louisiana, and traverses several parishes in Louisiana and several counties in Mississippi, Alabama, and Georgia. The pipeline terminates at Newman Gate, a natural gas delivery location in Douglas County, Georgia.

The failed 24-inch North Main Loop pipe had the following specifications:

- Manufacturer and Year: Republic Steel manufactured in 1948
- Wall thickness: 0.25-inch wall thickness
- Grade: X52
- Longitudinal seam: double submerged arc welded (DSAW)
- Coating: coal tar enamel

The operator established the maximum allowable operating pressure (MAOP) on this segment in accordance with 49 Code of Federal Regulation (CFR) §192.619(c), Maximum Allowable Operating Pressure-Steel or Plastic Pipelines, and was 500 psig at the time of the incident; the estimated pressure at the failure location was 462 psig.

Events Leading up to the Failure

To understand the events leading up to the incident, PHMSA investigators reviewed SNG's records, written procedures, and conducted interviews with SNG's staff to determine if any operations, maintenance, or procedural deficiency (or inadequacy) may have contributed to the incident. Only the records and procedures related to this failed pipeline segment were reviewed.

Interviews with SNG personnel found that anomaly repair activities took place in 2008 on the North Main Loop, approximately 100 feet upstream of the rupture location. These repair activities may have introduced additional external forces on the pipeline, which may have contributed to the wrinkle failure, as further explained in the "Investigation Findings and Contributing Factors" section of this report.

It should also be noted, that on January 26, 2008, SNG experienced an in-service wrinkle bend rupture on the same 24-inch North Main Loop pipeline at MP 401.210, approximately 2.5 miles downstream of the December 31, 2009, wrinkle bend failure. That rupture was in a Class 1 location. There were no fatalities or injuries, but two people were evacuated from a single family residence. The PHMSA Southern Region took no enforcement action against SNG with regards to the January 2008 rupture because, at that time, it appeared to be an isolated incident. PHMSA had no record of any previous wrinkle bend failures on SNG's pipelines. However, PHMSA did review and approve the pipe repair and system restart plans after the January 2008 failure.

Emergency Response

This incident did not require a substantial emergency response effort, because there were no fatalities or injuries; however, six residents, whose homes were near the rupture site along CR 488, self evacuated as a precaution. The residents assembled at the Pine Grove Baptist Church, located approximately one-third of a mile north of the rupture on CR 62. The Turkey Heaven Volunteer Fire Department established the Pine Grove Baptist Church as EOC for this event. All emergency response staging and coordination took place at this site until the emergency was over.

SNG responded to this event by isolating the rupture. That is, SNG closed the nearest upstream valve at Heflin Gate (MP 391.982) and the nearest downstream valve at Rome-Calhoun Gate (MP 400.244), isolating 8.26 miles of pipeline.

While the Turkey Heaven Volunteer Fire Department was in charge of this incident response, five other fire departments provided assistance, as needed, under mutual aid agreements.

SNG reported the incident to the National Response Center (NRC) via telephone on January 1, 2010, at 12:55 am CST (1:55 am Eastern Standard Time on the NRC report).

Summary of Restart Plan and Return-to-Service, Including Preliminary Safety Measures

Taking into account the 2008 wrinkle bend failure referenced above in the "Events Leading up to the Failure" section of this report, the age of the North Main Loop pipeline, the close proximity of this pipeline to areas of public access and roadways (including Interstate 20), and the hazardous nature of natural gas, PHMSA issued a Corrective Action Order (CAO)[1] to SNG on January 7, 2010.

With the exception of the instrumented aerial or instrumented ground leak survey SNG was required to conduct between the Tarrant Compressor Station (MP 321.9) and the Carrollton Gate (MP 421.3), the CAO applied to the North Main Loop, i.e. "the Affected Pipeline," from the DeArmanville Compressor Station at MP 380.600 to the Rome-Calhoun Gate at MP 400.244; a total of 19.6 pipeline miles. Below is a condensed description of significant CAO requirements. The CAO required SNG to

- Not operate the 8.26-mile isolated segment from Heflin Gate (MP 391.982) to the Rome-Calhoun Gate (MP 400.244) until authorized by the Southern Region Director (Director),
- Maintain a 20% pressure reduction in the operating pressure (i.e. do not exceed 369 psig) between the DeArmanville Compressor Station (MP 380.600) and the Rome-Calhoun Gate (MP 400.244) until it received written approval from the Director to remove the pressure restriction,
- Complete mechanical and metallurgical testing and failure site analysis of the failed pipe within 30 days of receiving the CAO,
- Develop and submit a return-to-service plan to the Director within 60 days of receiving the CAO,
- Perform either instrumented aerial or instrumented ground leak survey between Tarrant Compressor Station (MP 321.9) and Carrollton Gate (MP 421.3) within 30 days of receiving the CAO and submit survey documentation to the Director within 45 days; and,
- Perform a Root Cause Analysis of this incident within 60 days, specifically including a study and analysis of environmental and other factors that may have caused stresses on the pipeline and submit a report to the Director within 90 days.

While excavating the pipeline to expose and remove the failed wrinkle bend section, SNG crews discovered two additional overbend configurations, from the original construction, that used the wrinkle bend method to create the bend radii (Appendix A). SNG removed these bends as well as the failed bend for a total of 21 wrinkles removed.

SNG replaced the removed bends with 240 feet (six joints) of pre-tested and pre-bent pipe and used radiography (X-rays) to non-destructively inspect each of the girth welds connecting the six new pipe joints. PHMSA requested an additional 4-hour above the ditch hydrostatic pressure test to assure the integrity of the girth welds for the replacement pipe. On January 6, 2010, SNG successfully hydrotested the pipe; the tie-in welds and subsequent X-rays were completed the same day.

The replaced pipe had the following specifications:

[1] PHMSA Compliance Progress File (CPF) 2-2010-1001H

- Wall thickness: 0.343-inch wall thickness
- API 5L Grade X70
- Longitudinal seam: double submerged arc welded (DSAW)
- Coating: Fushion bonded epoxy (FBE)
- 6 joints of 24-inch diameter pre-tested pipe

The pipeline segment upstream of the rupture, between DeArmanville Compressor Station and Heflin Gate, remained in service immediately after the rupture, but operated at a 20% reduced pressure of 369 psig, as required by the CAO. On January 15, 2010, SNG submitted the return-to-service plan for the Heflin Gate to Rome-Calhoun Gate segment, to the Director for review and approval. On February 3, 2010, the Director approved the restart plan for the Heflin Gate to Rome-Calhoun Gate segment.

Investigation Findings & Contributing Factors

The investigation findings and contributing factors listed below were compiled from the operator's Root Cause Analysis (RCA), which was required by the CAO.

The PHMSA investigation, which began on site on January 2, 2010, revealed the following:

- During the field portion of this incident investigation, PHMSA investigators and SNG personnel observed a circumferential split along a wrinkle bend in the 24-inch North Main Loop pipe at the location of the failure. The split appeared to run from the 9 o'clock to 3 o'clock position around the pipe. The pipe's DSAW longitudinal seam (long seam) appeared to be near the center of the wrinkle bend.
- As SNG crews completed the initial cut to remove the failed pipe section, the failed section shifted (sprang) upward. The centerline of the pipe was offset by about 1½ inches from the centerline of the un-deflected pipe, indicating the pipeline had been subject to external forces that may have contributed to the failure (Appendix A).

The metallurgical and hydrogeological reports written subsequent to the failure, revealed additional, possible sources of these forces:

1) Stresses due to the wrinkle bend containing the pipe longitudinal seam.
   El Paso's Metallurgy Laboratory examined the failed pipe's longitudinal seam and determined the fracture started on (or near) the inner pipe diameter surface in the center of the long seam. The metallurgical testing determined the long seam welds were more brittle than the base metal and the yield strength was considerably higher (72,600 psig for long seam vs. 56,200 psig for base metal). El Paso also conducted micro-hardness evaluations on the base metal outside of any wrinkled areas as well as from the wrinkle bend decay to the fracture surface. The hardness values were highest in the wrinkle bends due to slight strain hardening that occurred during bending.
2) External stresses from probable shifting of the surrounding soil in the area of the failure.
   According to SNG's hydrogeological study, which was part of the RCA, both activities described in "a" and "b" below caused significant soil disturbance in close proximity to the failed pipe. The soil disturbance altered or decreased the support provided by the soil in the failure area.

a) *Pipe replacement in 1998.* The area along SNG's right-of-way at the failure location had a cross slope of approximately 25 degrees. There were three North Main Pipelines in this right-of-way, from north to south, the 20-inch North Main, the 24-inch North Main Loop (ruptured line), and the 24-inch 2nd North Main Loop. The 20-inch North Main Line, which was located the furthest down slope, was replaced in this area in 1998, disrupting the soil close to the ruptured pipe.

b) *Anomaly repairs in 2008.* In May 2007, the North Main Loop valve section from the Heflin Gate to the Rome-Calhoun Gate was inspected with a high-resolution magnetic flux leakage (MFL) in-line inspection (ILI) tool. By April 2008, SNG had identified all ILI features requiring remediation and had completed all the required pipeline repairs. The April 2008 repair included approximately 61 feet of the North Main Loop pipeline at MP 399.000, approximately 100 feet upstream of the rupture. This activity disrupted the soil close to the ruptured pipe. It should also be noted that the failed wrinkle bend was not identified as an anomaly requiring remediation during the ILI analysis.

3) Stresses from natural soil movement due to the geological characteristics of the area combined with the presence of water. The hydrogeologic evaluation conducted by SNG's contracted geologists noted the following: 1) the failure occurred in silty clay derived from weathered phyllite of the Lay Dam Formation, and 2) the failure was in a topographically low area that was a natural surface water drainage feature.

a) *Background*
Almost all of Cleburne County, Alabama, including the failure location is in the Northern Piedmont physiographic province. The Lay Dam Formation of the Talladega Group is a geological unit within the Northern Piedmont province. In Cleburne County the Lay Dam Formation consists primarily of phyllite as well as other irregularly bedded metamorphic rock. Rocks observed on land and in the excavation trench at MP 399.642 were consistent with those comprising the Lay Dam Formation.

In the Piedmont province, precipitation that seeps into the ground tends to move downward through the soil into weathered bedrock. If the bedrock is fractured, water will continue to move downward through the fractures and on to discharge points. If the bedrock is not fractured, ground water will move laterally along the top of the bedrock to a discharge point. As ground water travels to a discharge point along the top of the bedrock, its lubricating property can simultaneously facilitate soil movement.

b) *Discussion*
SNG's contract geologists visually observed relatively unfractured slightly weathered phyllite and undisturbed clay of low permeability, at the failure location. Moisture was observed in a zone above the slightly weathered phyllite indicating the phyllite probably served as a barrier to downward water migration.

Additionally, the geologists noted the actual rainfall totals for Cleburne County in calendar year 2009 exceeded the normal rainfall estimates by approximately 19%, however, the actual rainfalls in October and December 2009 exceeded the normal rainfall estimates by approximately 207% and 50%, respectively.

The geologists concluded the above-normal precipitation in 2009 was the water source in this area that provided for the subsurface soil movement in the pipeline right-of-way and caused soil movement near the pipe. This movement of subsurface materials along the slope resulted in redistribution of stresses on the pipe, which contributed to the pipe failure.

Appendices

A Map and Photographs

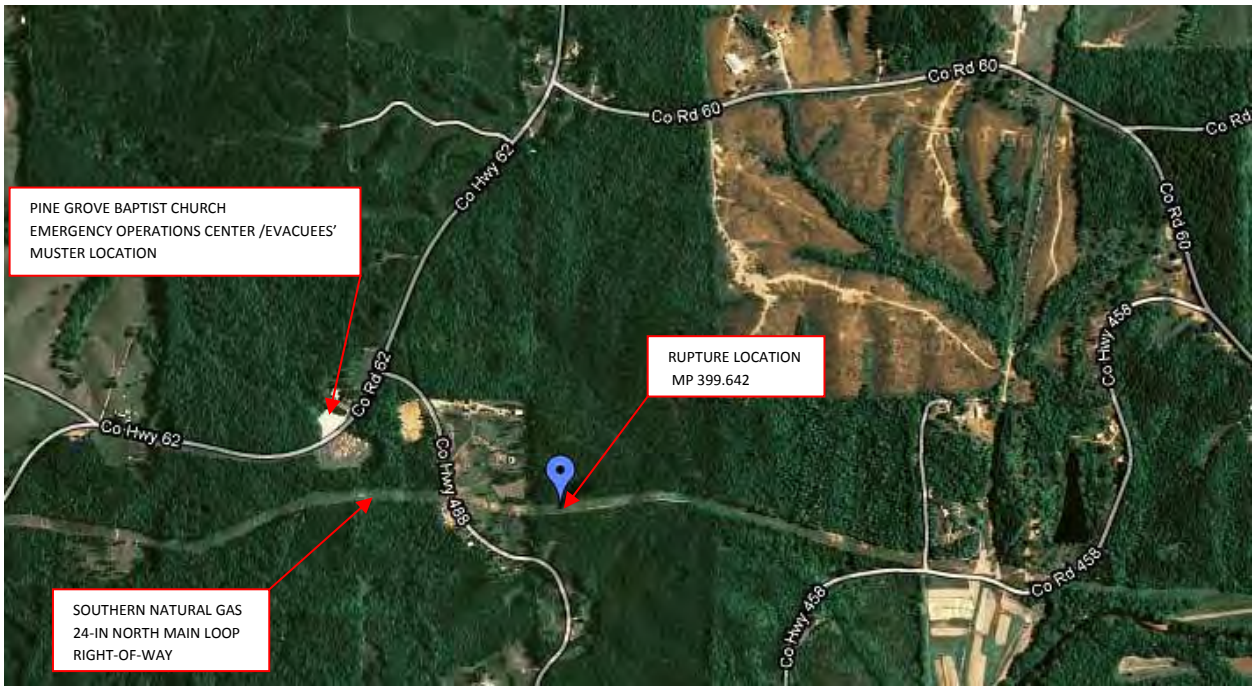
B NRC Report

C Southern Natural Gas Incident Report to PHMSA

D El Paso Metallurgical Analysis

E P.E. LaMoreaux & Associates, Inc. Hydrogeologic Evaluation of Area Near Pipeline Milepost 399.642

Aerial Map


PINE GROVE BAPTIST CHURCH
EMERGENCY OPERATIONS CENTER /EVACUEES' MUSTER LOCATION
RUPTURE LOCATION
MP 399.642
SOUTHERN NATURAL GAS
24-IN NORTH MAIN LOOP
RIGHT-OF-WAY
Co Rd 60
Co Hwy 62
Co Rd 62
Co Hwy 488
Co Hwy 458
Co Rd 458

24-in North Main Loop Failed Wrinkle, MP 399.642. One of four wrinkles in underbend configuration.

Pipe's DSAW longitudinal seam is perpendicular and roughly centered in failed wrinkle bend.

Additional wrinkles used to create the underbend configuration during original construction

Four-wrinkle underbend section with coating removed. The second downstream wrinkle is where the pipe rupture occurred (pipeline natural gas flow was from right to left).
Observe the cut and reference lines downstream of last wrinkle (importance next photo)

Cut pipe shifted off the reference line indicating external load(s) on pipe

Additional pipe bends uncovered, upstream and downstream of removed failed section

Replacement pipe hydrostatically pressure tested above the ditch as one unit

NATIONAL RESPONSE CENTER 1-800-424-8802
*** For Public Use ***
Information released to a third party shall comply with any
applicable federal and/or state Freedom of Information and Privacy Laws

Incident Report # 927518

INCIDENT DESCRIPTION

*Report taken at 01:55 on 01-JAN-10
Incident Type: PIPELINE
Incident Cause: EQUIPMENT FAILURE
Affected Area:
The incident occurred on 31-DEC-09 at 23:07 local time.
Affected Medium: AIR ATOMSPHERE

SUSPECTED RESPONSIBLE PARTY

Organization: SOUTHERN NATURAL GAS COMPANY
BIRMINGHAM, AL 35209

Type of Organization: PRIVATE ENTERPRISE

INCIDENT LOCATION

NEAREST ROAD IS CLEBURNE CTY RD 488 County: CLEBURNE
LAT 33.62998 N
LONG -85.46087 W
State: AL
Latitude: 33° 37' 48" N

Longitude: 085° 24' 25" W
RUPTURE SITE IS 5 MILES EAST OF HEFLIN, ALABAMA

RELEASED MATERIAL(S)

CHRIS Code: ONG Official Material Name: NATURAL GAS
Also Known As:
Qty Released: 0 UNKNOWN AMOUNT

DESCRIPTION OF INCIDENT

CALLER IS REPORTING A RELEASE OF NATURAL GAS FROM A PIPELINE DUE TO THE PIPELINE RUPTURING. THE CAUSE IS UNKNOWN AT THIS TIME.

INCIDENT DETAILS

Pipeline Type: TRANSMISSION
DOT Regulated: UNKNOWN
Pipeline Above/Below Ground: BELOW
Exposed or Under Water: NO
Pipeline Covered: UNKNOWN

DAMAGES

Fire Involved:	NO	Fire Extinguished:	UNKNOWN		
INJURIES:	NO	Hospitalized:		Empl/Crew:	Passenger:
FATALITIES:	NO	Empl/Crew:		Passenger:	Occupant:
EVACUATIONS:	YES	Who Evacuated:	PRIVATE CITIZENS	Radius/Area:	
Damages:	UNKNOWN				

Closure Type		Description of Closure	Length of Closure	Direction of Closure
Air:	N			
Road:	N			
Major Artery:	N			
Waterway:	N			
Track:	N			

Passengers Transferred: NO
Environmental Impact: NO

Media Interest: NONE Community Impact due to Material:

REMEDIAL ACTIONS

CALLER STATED THEY HAVE ISOLATED THE AREA AND THE PIPELINE IS BEING EVACUATED OF PRESSURE.
Release Secured: YES
Release Rate:
Estimated Release Duration:

WEATHER

Weather: PARTLY CLOUDY, 50°F

ADDITIONAL AGENCIES NOTIFIED

Federal: NONE
State/Local: CLEBURNE COUNTY EMA
State/Local On Scene: NONE
State Agency Number: NONE

NOTIFICATIONS BY NRC

ALABAMA DEPT OF ENV MGMT (MAIN OFFICE)
01-JAN-10 02:05
AL U.S. ATTORNEY'S OFFICE (COMMAND CENTER)
01-JAN-10 02:05
USCG ICC (ICC ONI)
01-JAN-10 02:05
DOT CRISIS MANAGEMENT CENTER (MAIN OFFICE)
01-JAN-10 02:05
EPA OEM (MAIN OFFICE)
01-JAN-10 02:08
EPA OEM (AFTER HOURS SECONDARY)
01-JAN-10 02:08
U.S. EPA IV (MAIN OFFICE)
01-JAN-10 02:08
FEDERAL EMERGENCY MANAGEMENT AGENCY (MAIN OFFICE)
01-JAN-10 02:05
USCG NATIONAL COMMAND CENTER (MAIN OFFICE)
01-JAN-10 02:09
JFO-LA (COMMAND CENTER)
01-JAN-10 02:05
NATIONAL INFRASTRUCTURE COORD CTR (MAIN OFFICE)
01-JAN-10 02:05
NOAA RPTS FOR AL (MAIN OFFICE)
01-JAN-10 02:05
NATIONAL RESPONSE CENTER HQ (MAIN OFFICE)
01-JAN-10 02:09
HOMELAND SEC COORDINATION CENTER (MAIN OFFICE)
01-JAN-10 02:05
PIPELINE & HAZMAT SAFETY ADMIN (OFFICE OF PIPELINE SAFETY (AUTO))
01-JAN-10 02:05
PIPELINE & HAZMAT SAFETY ADMIN (OFFICE OF PIPELINE SAFETY WEEKDAYS (VERBAL))
01-JAN-10 02:09
SECTOR MOBILE (COMMAND CENTER)
01-JAN-10 02:10
GEORGIA EMERGENCY MNGMT AGENCY (MAIN OFFICE)
01-JAN-10 02:05

ADDITIONAL INFORMATION

CALLER STATED THE PRIVATE CITIZENS EVACUATED THE AREA ON THEIR OWN.

***** END INCIDENT REPORT # 927518 *****

NOTICE: This report is required by 49 CFR Part 191. Failure to report can result in a civil penalty not to exceed $25,000 for each violation for each day that such violation persists except that the maximum civil penalty shall not exceed $500,000 as provided in 49 USC 1678. Form Approved OMB No. 2137-0522

U.S. Department of Transportation
Research and Special Programs
Administration

INCIDENT REPORT - GAS TRANSMISSION AND GATHERING SYSTEMS

Report Date Jan 21, 2010

No. 20090139 -- 8201
(DOT Use Only)

INSTRUCTIONS

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the Office Of Pipeline Safety Web Page at http://ops.dot.gov .*

PART A – GENERAL REPORT INFORMATION

Check one or more boxes as appropriate:
☐ Original Report ☒ Supplemental Report ☒ Final Report

Operator Name and Address

a. Operator's 5-digit Identification Number (when known) / 18516 /

b. If Operator does not own the pipeline, enter Owner's 5-digit Identification Number (when known) / /

c. Name of Operator SOUTHERN NATURAL GAS CO

d. Operator street address 569 BROOKWOOD VILLAGE, SUITE 501

e. Operator address BIRMINGHAM, JEFFERSON, AL, 35209
City, County or Parrish, State and Zip Code

2. Time and date of the incident

/ 2307 / hr. / 12 / month / 31 / day /2009/ year

3. Location of incident

a. CLEBURNE COUNTY ROAD 488
Nearest street or road

b. HEFLIN CLEBURNE
City and County or Parrish

c. AL 36264
State and Zip Code

d. Mile Post/Valve Station 399.631

e. Survey Station No. NORTH MAIN LOOP

f. Latitude: 33.62998 Longitude: -85.4608
(if not available, see instructions for how to provide specific location)

g. Class location description
Onshore: ○ Class 1 ● Class 2 ○ Class 3 ○ Class 4
Offshore: ○ Class 1 *(complete rest of this item)*
Area _____ Block # _____
State / / or Outer Continental Shelf ☐

h. Incident on Federal Land other than Outer Continental Shelf
○ Yes ● No

i. Is pipeline Interstate ● Yes ○ No

4. Type of leak or rupture
○ Leak: ○ Pinhole ○ Connection Failure *(complete sec. F5)*
○ Puncture, diameter *(inches)* _____
○ Rupture: ○ Circumferential – Separation
○ Longitudinal – Tear/Crack, length (inches) _____
Propagation Length, total, both sides (feet) _____
○ N/A
● Other: CIRCUMFERENTIAL PARTIAL SEPARATIO

5. Consequences *(check and complete all that apply)*
a. ☐ Fatality Total number of people: / 0 /
Employees: / 0 / *General Public:* / 0 /
Non-employee Contractors: / 0 /
b. ☐ Injury requiring inpatient hospitalization Total number of people: / 0 /
Employees: / 0 / *General Public:* / 0 /
Non-employee Contractors: / 0 /
c. ☒ Property damage/loss *(estimated)* Total $ 265000
Gas loss $ 40000 Operator damage $ 225000
Public/private property damage $ 0
d. ☐ Release Occurred in a 'High Consequence Area'
e. ☐ Gas ignited – No explosion f. ☐ Explosion
g. ☐ Evacuation *(general public only)* / 0 / people
Reason for Evacuation:
○ Emergency worker or public official ordered, precautionary
○ Threat to the public ○ Company policy

6. Elapsed time until area was made safe:
/ 1 / hr. / 38 / min.

7. Telephone Report
/ 927518 / NRC Report Number / 12 / month / 31 / day /2009/ year

8. a. Estimated pressure at point and time of incident:
462 *PSIG*
b. Max. allowable operating pressure *(MAOP):* 500 *PSIG*
c. MAOP established by 49 CFR section:
☐ 192.619 (a)(1) ☐ 192. 619 (a)(2) ☐ 192. 619 (a)(3)
☐ 192.619 (a)(4) ☒ 192. 619 (c)
d. Did an overpressurization occur relating to the incident? ○ Yes ● No

PART B – PREPARER AND AUTHORIZED SIGNATURE

KENNETH C. PETERS
(type or print) Preparer's Name and Title

(205) 325-7554
Area Code and Telephone Number

KEN.PETERS@ELPASO.COM
Preparer's E-mail Address

(205) 325-3729
Area Code and Facsimile Number

Authorized Signature (type or print) Name and Title

Date

Area Code and Telephone Number

PART C - ORIGIN OF THE INCIDENT

1. Incident occurred on
   - ● Transmission System
   - ○ Gathering System
   - ○ Transmission Line of Distribution System

2. Failure occurred on
   - ● Body of pipe ○ Pipe Seam
   - ○ Joint
   - ○ Component
   - ○ Other: _____

3. Material involved *(pipe, fitting, or other component)*
   - ● Steel
   - ○ Plastic (If plastic, complete all items that apply in a-c)
     Plastic failure was: ☐ a.ductile ☐ b.brittle ☐ c.joint failure
   - ○ Material other than plastic or steel: _____

4. Part of system involved in incident
   - ● Pipeline ○ Regulator/Metering System
   - ○ Compressor Station ○ Other: _____

5. Year the pipe or component which failed was installed: / 1948 /

PART D – MATERIAL SPECIFICATION (if applicable)

1. Nominal pipe size *(NPS)* / 24 / in.
2. Wall thickness / .25 / in.
3. Specification _____ SMYS / 52000 /
4. Seam type SAW
5. Valve type _____
6. Pipe or valve manufactured by REPUBLIC STEEL in year / 1948 /

PART E – ENVIRONMENT

1. Area of incident
   - ○ Under pavement ○ In open ditch
   - ● Under ground ○ Above ground
   - ○ Inside/under building ○ Under water
   - ○ Other: _____
2. Depth of cover: 71 inches

PART F – APPARENT CAUSE

Important: *There are 25 numbered causes in this section. Check the box to the left of the* ***primary*** *cause of the incident. Check one circle in each of the supplemental items to the right of or below the cause you indicate. See the instructions for this form for guidance.*

F1 – CORROSION

If either F1 (1) External Corrosion, or F1 (2) Internal Corrosion is checked, complete all subparts a – e.

1. ○ External Corrosion
2. ○ Internal Corrosion

a. Pipe Coating
- ○ Bare
- ○ Coated

b. Visual Examination
- ○ Localized Pitting
- ○ General Corrosion
- ○ Other: _____

c. Cause of Corrosion
- ○ Galvanic ○ Stray Current
- ○ Improper Cathodic Protection
- ○ Microbiological
- ○ Stress Corrosion Cracking
- ○ Other: _____

d. Was corroded part of pipeline considered to be under cathodic protection prior to discovering incident?
○ No ○ Yes, Year Protection Started: /_____/

e. Was pipe previously damaged in the area of corrosion?
○ No ○ Yes, How long prior to incident: /_____/ *years* /_____/ *months*

F2 – NATURAL FORCES

3. ○ Earth Movement => ○ Earthquake ○ Subsidence ○ Landslide ○ Other: _____
4. ○ Lightning
5. ○ Heavy Rains/Floods => ○ Washouts ○ Flotation ○ Mudslide ○ Scouring ○ Other: _____
6. ○ Temperature => ○ Thermal stress ○ Frost heave ○ Frozen components ○ Other: _____
7. ○ High Winds

F3 - EXCAVATION

8. ○ Operator Excavation Damage *(including their contractors)* / Not Third Party

9. ○ Third Party Excavation Damage *(complete a-d)*
   a. Excavator group
      ○ General Public ○ Government ○ Excavator other than Operator/subcontractor
   b. Type: ○ Road Work ○ Pipeline ○ Water ○ Electric ○ Sewer ○ Phone/Cable ○ Landowner ○ Railroad
      ○ Other: _____
   c. Did operator get prior notification of excavation activity?
      ○ No ○ Yes: Date received: /_____/ mo. /_____/ day /_____/ yr.
      Notification received from: ○ One Call System ○ Excavator ○ Contractor ○ Landowner
   d. Was pipeline marked?
      ○ No ○ Yes *(If Yes, check applicable items i – iv)*
      i. Temporary markings: ○ Flags ○ Stakes ○ Paint
      ii. Permanent markings: ○ Yes ○ No
      iii. Marks were *(check one)* ○ Accurate ○ Not Accurate
      iv. Were marks made within required time? ○ Yes ○ No

F4 – OTHER OUTSIDE FORCE DAMAGE

10. ○ Fire/Explosion as primary cause of failure => Fire/Explosion cause: ○ Man made ○ Natural
11. ○ Car, truck or other vehicle not relating to excavation activity damaging pipe
12. ○ Rupture of Previously Damaged Pipe
13. ○ Vandalism

F5 – MATERIAL AND WELDS

Material

14. ● Body of Pipe => ○ Dent ○ Gouge ● Wrinkle Bend ○ Arc Burn ○ Other: _____
15. ○ Component => ○ Valve ○ Fitting ○ Vessel ○ Extruded Outlet ○ Other: _____
16. ○ Joint => ○ Gasket ○ O-Ring ○ Threads ○ Other: _____

Weld

17. ○ Butt => ○ Pipe ○ Fabrication ○ Other: _____
18. ○ Fillet => ○ Branch ○ Hot Tap ○ Fitting ○ Repair Sleeve ○ Other: _____
19. ○ Pipe Seam => ○ LF ERW ○ DSAW ○ Seamless ○ Flash Weld
○ HF ERW ○ SAW ○ Spiral ○ Other: _____

*Complete a-g if you indicate **any** cause in part F5.*

a. Type of failure:

● Construction Defect => ○ Poor Workmanship ○ Procedure not followed ● Poor Construction Procedures

○ Material Defect

b. Was failure due to pipe damage sustained in transportation to the construction or fabrication site? ○ Yes ● No

c. Was part which leaked pressure tested before incident occurred? ● Yes, *complete d-g* ○ No

d. Date of test: / 7 / mo. / 14 / day / 1996 / yr.

e. Test medium: ● Water ○ Natural Gas ○ Inert Gas ○ Other: _____

f. Time held at test pressure: / 8 / hr.

g. Estimated test pressure at point of incident: 823 *PSIG*

F6 – EQUIPMENT AND OPERATIONS

20. ○ Malfunction of Control/Relief Equipment => ○ Valve ○ Instrumentation ○ Pressure Regulator ○ Other: _____
21. ○ Threads Stripped, Broken Pipe Coupling => ○ Nipples ○ Valve Threads ○ Mechanical Couplings ○ Other: _____
22. ○ Ruptured or Leaking Seal/Pump Packing

23. ○ Incorrect Operation

a. Type: ○ Inadequate Procedures ○ Inadequate Safety Practices ○ Failure to Follow Procedures ○ Other: _____

b. Number of employees involved who failed post-incident drug test: / _____ / Alcohol test: / _____ /

c. Were most senior employee(s) involved qualified? ○ Yes ○ No d. Hours on duty: / _____ /

F7 – OTHER

24. ○ Miscellaneous, *describe:* _____
25. ○ Unknown

○ Investigation Complete ○ Still Under Investigation *(submit a supplemental report when investigation is complete)*

PART G – NARRATIVE DESCRIPTION OF FACTORS CONTRIBUTING TO THE EVENT *(Attach additional sheets as necessary)*

CLEBURNE COUNTY (ALABAMA) EMA REPORTED A SUSPECTED NATURAL GAS RELEASE IN THE VICINITY OF SOUTHERN NATURAL GAS (SNG) COMPANY'S 24" NORTH MAIN LOOP PIPELINE ON DECEMBER 31, 2009. DISPATCHED SNG PERSONNEL CONFIRMED THE EXISTENCE OF THE GAS RELEASE AT APPROXIMATE PIPELINE MILEPOST 399.631, ABOUT 835 FEET EAST OF CLEBURNE COUNTY ROAD 488. THE 24-INCH NORTH MAIN LOOP LINE LEAKED DUE THE CUMULATIVE EFFECTS OF STRESSES (TENSILE AND TORSIONAL) ACTING ON A WRINKLE BEND CONTAINING A LONGITUDINAL WELD SEAM. THE FAILURE CONSISTED OF A 2™- 7.5fl LONG CIRCUMFERENTIAL CLEAVAGE FRACTURE ALONG THE APEX OF THE CONVOLUTION OF AN UNDER BEND. STRUCTURAL CAPACITY WAS EXCEEDED DUE TO THE FOLLOWING FACTORS: (A) NATURAL SOIL MOVEMENT DUE TO THE GEOLOGICAL CHARACTERISTICS COMBINED WITH THE PRESENCE OF WATER (B) GEOMETRICAL STRESSES INHERENT IN THE BENDING OF THE PIPE MATERIAL AND PROPERTIES OF THE LONGITUDINAL WELD METAL (C) NORMAL INTERNAL PRESSURES ASSOCIATED WITH THE OPERATION OF THE NATURAL GAS PIPELINE (D) EXCAVATIONS AND SOIL DISTURBANCES NEARBY THE PIPELINE™S RIGHT-OF-WAY. THE WRINKLE BEND WAS INSTALLED DURING THE PIPELINE'S ORIGINAL CONSTRUCTION AND WAS USED IN A SAG BEND WITH THE PIPE'S LONGITUDINAL SEAM HAVING BEEN PLACED IN THE INSIDE PORTION OF THE BEND. THE FAILURE SITE WAS REPAIRED BY REPLACEMENT WITH A NEW PIPELINE SEGMENT.

Appendix D El Paso Metallurgical Analysis

Report Date: 02/01/10

Request No: 5-2010-0014

This document is on file at PHMSA

P. E. LaMoreaux & Associates, Inc.
Hydrogeologists, Geologists, Archaeologists,
& Environmental Scientists

Via Email: *Raymond.Hayden@ElPaso.com*
Juan.McLane@ElPaso.com

March 2, 2010

Mr. Raymond Hayden
Principal Compliance Specialist
SE Division – DOT Field Compliance
El Paso Pipeline Group
P. O. Box 2563
Birmingham, AL 35202

RE: Hydrogeologic Evaluation of Area Near Pipeline Milepost 399.642
Southern Natural Gas North Main Loop Line, Cleburne County, Alabama
PELA Reference No. 128301

Dear Mr. Hayden:

In accordance with the authorization by Mr. Chris Bradberry on January 1, 2010, P.E. LaMoreaux & Associates, Inc. (PELA) has completed an evaluation of local hydrogeologic conditions near pipeline milepost 399.642 on the Southern Natural Gas North Main Loop Line in southern Cleburne County, Alabama. This letter report provides documentation of activities and findings.

INTRODUCTION

A 24-inch gas pipeline leaked at milepost 399.642 on the Southern Natural Gas North Main Loop Line in sec. 14, T. 16 S., R. 11 E., Cleburne County, Alabama (Figure 1), on December 31, 2009. To evaluate the possible influence of hydrogeologic conditions on the failure, an examination of local conditions was performed.

Specific objectives of this investigation were to confirm the geologic formation, lithology, topography, and local hydrologic influences at the site. Local surface water drainage patterns were observed and data necessary to establish the hydrogeologic setting in the vicinity of the pipeline failure were collected. This information also provides a basis for recommending strategies for future studies along the pipeline.

METHODOLOGY

Publications (maps and reports) on the geology and hydrogeology of the region were obtained and reviewed. After the regional setting was established, information at the local scale was reviewed. Topographic contour maps were studied to relate specific landforms in the area to the movement of ground water and surface water. A U.S.G.S. 7.5-minute quadrangle map was used as a base map for this effort (Figure 1).

Field reconnaissance began on January 4, 2010, with a visit to the site of the December 31, 2009, pipeline failure by PELA personnel. A PELA hydrogeologist and a geologist observed the excavation that had been made to remove the leaking section of pipe. PELA personnel were able to access the trench near the point where the pipe had failed, to make field observations of lithology and moisture content. Field samples of subsurface material were visually examined.

Subsequent visits to the site were made on January 6 and February 10, 2010. On January 6, 2010, the replacement section of pipe was being pressure tested and the ditch was still exposed for observation. On February 10, 2010, repairs had been completed and the right-of-way had been graded and erosion control measures had been implemented.

Precipitation data were obtained from the National Oceanographic and Atmospheric Administration's Southeast Regional Climate Center (SERCC), a division of the National Climatic Data Center. This information was used to identify recent trends in rainfall in the area.

OBSERVATIONS

The pipeline failure occurred on the north slope of a hill (Photograph 1), within a minor topographic low (Photograph 2) and change of slope. Examination on January 4, 2010, indicated the presence of a surface water drainage feature that extended northward from the pipeline right-of-way at the failure point. Surface water was directed from this area toward the north into a small stream that flowed eastward, downslope from a pond (Photograph 3). The pond was about 200 feet long by 100 feet wide, and approximately 300 feet northwest of the location of the pipeline failure.

During field reconnaissance, weathered phyllite, silty clay, and quartzite rubble were observed at land surface immediately upslope (west) of the failure. Repair crews had excavated the ditch to provide safe working conditions for replacement of a section of the pipe, and the complete soil profile was not available for examination. However, exposures of the lower portions of the walls of the ditch were accessible.

The majority of the ditch wall near the pipeline leak was composed of clay which had weathered from phyllite. The clay was moderate reddish-orange (10 R 6/6) to moderate reddish-brown (10 R 4/6), with minor dark yellowish-orange (10 YR 6/6) and dark yellowish-brown (10 YR 4/2). The clay was silty and slightly sandy (in part) with

very fine- to fine-grained, angular, poorly sorted quartz. The clay was saturated with water in the topographically low area, near the pipeline leak. This section, near the leak, appeared to have been wet more often than the surrounding area.

Relict bedding of weathered phyllite was common in the ditch walls. The phyllite was moderate reddish-orange (10 R 6/6) to dark yellowish-orange (10 YR 6/6) to grayish-orange (10 YR 7/4), weathered, silty in part, and micaceous with a weak phyllitic sheen. The phyllite broke easily along foliation planes that dipped 25° toward the east-southeast.

At the bottom of the ditch, in the area that was underneath the pipe before it was removed, more competent (less weathered) bedrock was visible. Phyllite in this area was pale olive (10 Y 6/2) to greenish-gray (5 GY 6/1) to light olive brown (5 Y 5/6), with a well-developed phyllitic sheen. This phyllite was only slightly weathered, firm, and also dipped about 25° east-southeastward (Photograph 4). This interval also included moderate reddish-orange (10 R 6/6) phyllite that was more competent than the phyllite in the walls of the ditch. This interval was hard, dry, and did not appear to readily transmit water.

DISCUSSION

HYDROGEOLOGIC SETTING

Almost all of Cleburne County, Alabama, is in the Northern Piedmont physiographic province. This region is a well-dissected upland developed on northeast-southwest trending bands of metamorphic rocks. Common rock types in the Piedmont include phyllite, metasiltstone, quartzite, schist, greenstone, and marble. In eastern Alabama, the Piedmont is bounded on the north and west by the Valley and Ridge physiographic province, and on the south by the East Gulf Coastal Plain physiographic province.

The Lay Dam Formation of the Talladega Group in Cleburne County (Figure 2) consists of irregularly bedded metamorphic rocks, including phyllite, metasiltstone, greywacke, and quartzite. Rocks observed at land surface and in the excavation at milepost 399.642 are consistent with those comprising the Lay Dam Formation.

In the Piedmont province, precipitation that seeps into the ground tends to move downward through the soil, then into the weathered bedrock (the saprolite). If the bedrock is fractured, water will continue to move downward into the fractures and on to discharge points. If the bedrock is not fractured, ground water will move laterally along the top of the bedrock to a discharge point.

Visual observations of the rock at the bottom of the ditch near milepost 399.642 on January 4 and 6, 2010, indicated a relatively unfractured, slightly weathered phyllite and undisturbed clay of low permeability (Photograph 4). The moisture observed in the dark, silty clay in the sides of the ditch on January 4, 2010, was in the zone above this slightly weathered phyllite, indicating that the phyllite at the bottom of the ditch probably

served as a barrier to downward migration of water.

PRECIPITATION

The nearest NOAA / National Climatic Data Center weather station is in Heflin, Alabama, about 8 miles west of the pipeline failure. The normal annual precipitation recorded at the Heflin station is 56.87 inches ("normal" is the official arithmetic mean of climatic values computed by the National Climatic Data Center for a particular area over three consecutive decades).

Precipitation in northeastern Alabama is typically lowest in September and October, increases in November and December, and is highest in January through April, during the winter and spring rains. For the last three years, precipitation totals in southern Cleburne County, Alabama, have ranged from exceptional drought conditions (National Drought Mitigation Center, 2010) recorded in late 2007 to above-normal rainfall recorded in 2009, immediately before the pipeline failure. Monthly precipitation totals from January 2007 through December 2009 are provided in Figure 3, and annual totals and departures from normal for 2007 through 2009 for this station are provided in Table 1.

YEAR	TOTAL RAINFALL (inches)	DEPARTURE FROM NORMAL (inches)
2007	27.23	– 29.64
2008	58.39	+ 1.52
2009	70.12	+ 13.25

Table 1. Local Precipitation (Heflin, Alabama, NOAA SERCC Station ID 013775).

OTHER INFORMATION

According to representatives of El Paso Pipeline Group, when the North Main Loop pipeline was cut to remove the damaged section, the ends shifted until the pipe on the western side of the cut was about 1.5 inches higher than the pipe on the eastern side of the cut. This indicates uneven loads or stresses placed on the pipeline by movement of water and silty clay in the zone around and immediately above the pipe in this area.

Also, according to El Paso Pipeline Group, two previous repairs in the area of the leak at milepost 399.642 required excavation and disturbance of the soil. The first was in 1998, when the adjacent 20-inch North Main Line was replaced. The North Main Line pipeline is about 20 feet north (downslope) of and parallel to the North Main Loop Line. The second repair was in 2008, on the North Main Loop Line. In this repair, a 60.7-foot section of pipe was removed and replaced, about 100 feet west (also downslope) of the failure point at milepost 399.642.

These disturbances of the subsurface material in the area of the leak, on the adjacent pipeline in 1998 and on the leaking pipeline in 2008, could have altered the ground-water flow and/or decreased the support provided by the soil in this topographically low area.

CONCLUSIONS

The December 31, 2009, pipeline failure on the Southern Natural Gas North Main Loop Line (milepost 399.642) in southern Cleburne County, Alabama, occurred in silty clay derived from weathered phyllite of the Lay Dam formation. The failure was in a topographically low area which was a natural surface water drainage feature. Observations made on January 4, 2010, in the trench indicated that lithology in the interval in which the pipeline failed was wet, silty clay, underlain by relatively dry partially weathered bedrock. The difference in color (darker) in the area near the pipeline failure suggested more water movement there than in the surrounding area. The underlying partially weathered bedrock served as a barrier to downward migration of water.

Water can serve as a lubricant in clay-rich material, such as the weathered phyllite at this site, and facilitate downslope movement. Above-normal precipitation in 2009 contributed water to the ground in the area of the topographic low in the pipeline right-of-way, and caused movement in the silty clay near the pipe. This movement of subsurface materials, in an interval in which the slope of the pipeline route varied, resulted in a redistribution of stresses on the pipe, which caused the pipe to leak at a weak point.

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U.S. Geological Survey, 1966 (photorevised 1980), Fruithurst quadrangle, Alabama, 7.5-minute series (topographic) map, U.S. Geological Survey, scale 1:24,000.

PELA appreciates this opportunity to work with El Paso on this project. Please let us know if you have any questions or comments.

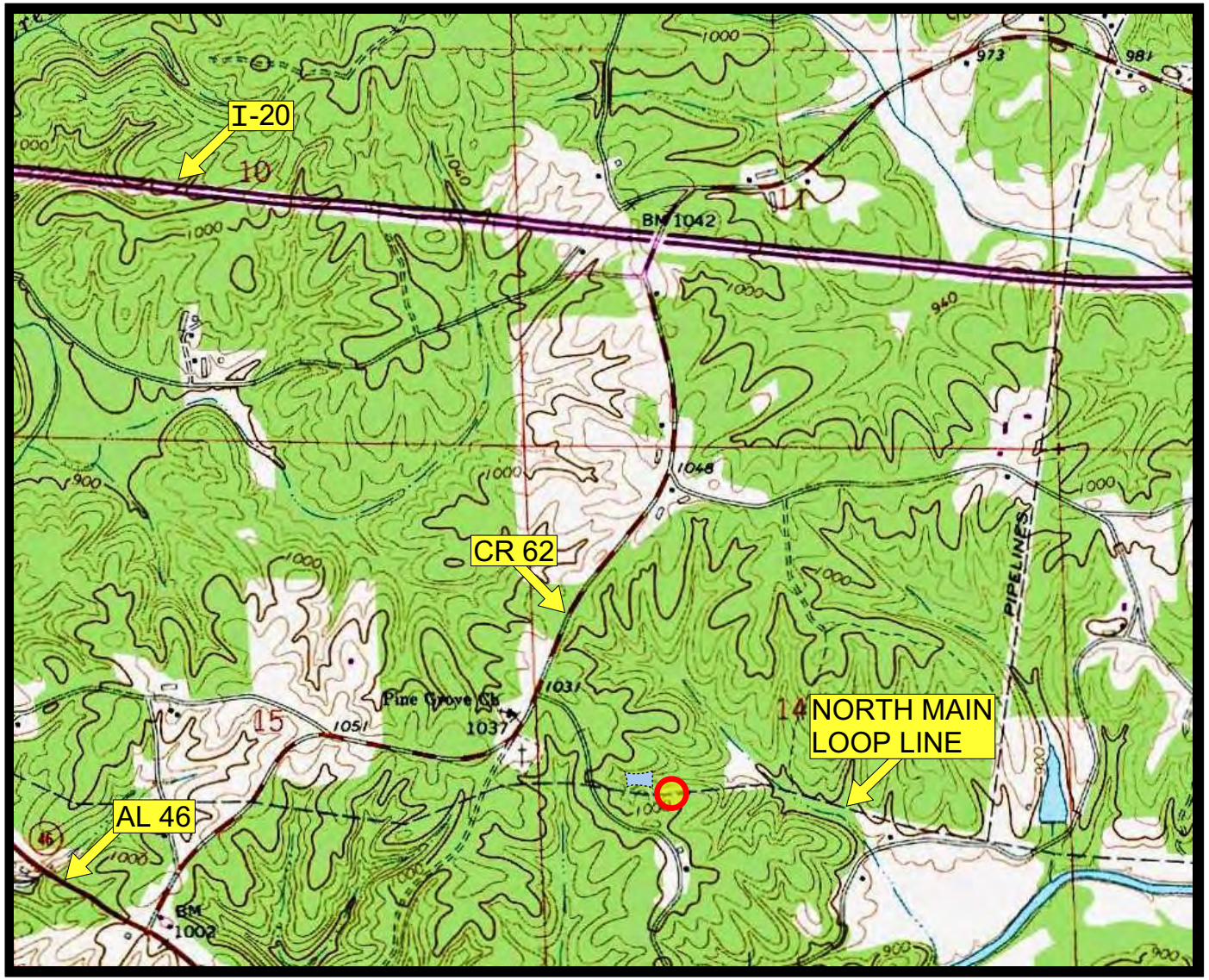
Sincerely,

Daniel S. Green
Project Manager
PG 540

Bashir A. Memon Ph.D.
Executive Vice President
PG 109

DSG\BAM\gfh
S:\1001\1283\128301\DOC\SITE399.642-D3.doc

Attachments: Figures 1 through 3
Photographs 1 through 4



EXPLANATION

PIPELINE MILEPOST 399.642

TALLAPOOSA RIVER

APPROXIMATE LOCATION OF POND

0 1000 2000 3000

SCALE IN FEET

SOURCE: USGS, 1980, FRUITHURST QUADRANGLE, ALABAMA, 7.5-MINUTE SERIES TOPOGRAPHIC MAP (SEC. 14, T. 16 S., R 11 E.)

N

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

FIGURE 1. TOPOGRAPHY NEAR MILEPOST 399.642

FILE: S:\1001\1283\128301\MAPS\FIGURE-1.dsf
DATE PREPARED: 02/15/10

EXPLANATION

- PIPELINE MILEPOST 399.642
- **Dtjc** JEMISON CHERT AND CHULAFINNE SCHIST
- **hgs** HILLABEE GREENSTONE
- **hp** HEFLIN PHYLLITE
- **ka** KETCHEPEDRAKEE AMPHIBOLITE
- **pbm** POE BRIDGE MOUNTAIN GROUP
- **tld** LAY DAM FORMATION
- **we** WEDOWEE GROUP

0 2 4 6
SCALE IN MILES

N

SOURCE: SZABO, M. W., AND COPELAND, C. W. JR., 1988, GEOLOGIC MAP OF ALABAMA: GEOLOGICAL SURVEY OF ALABAMA, NORTHEAST SHEET, SCALE 1:250,000

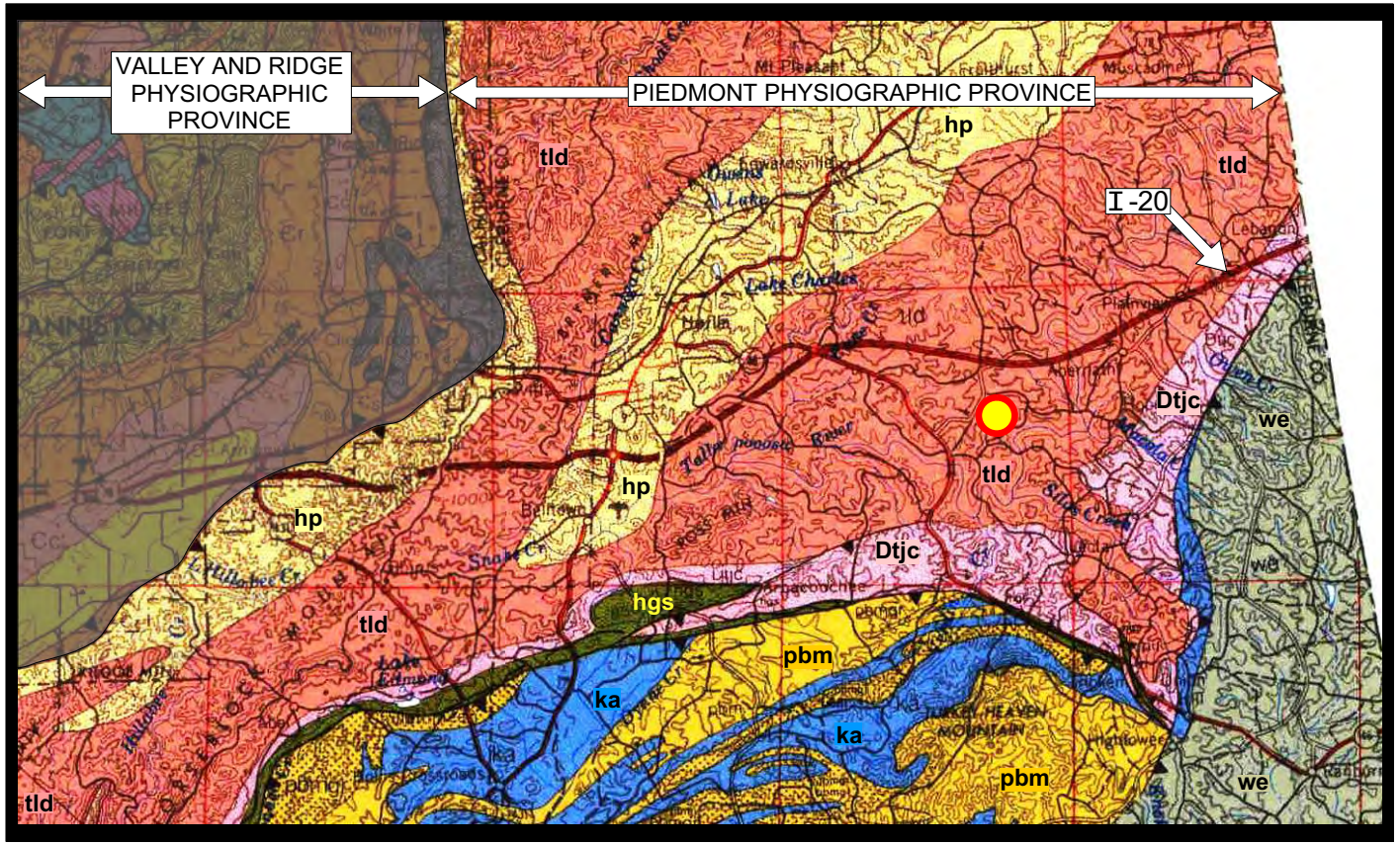
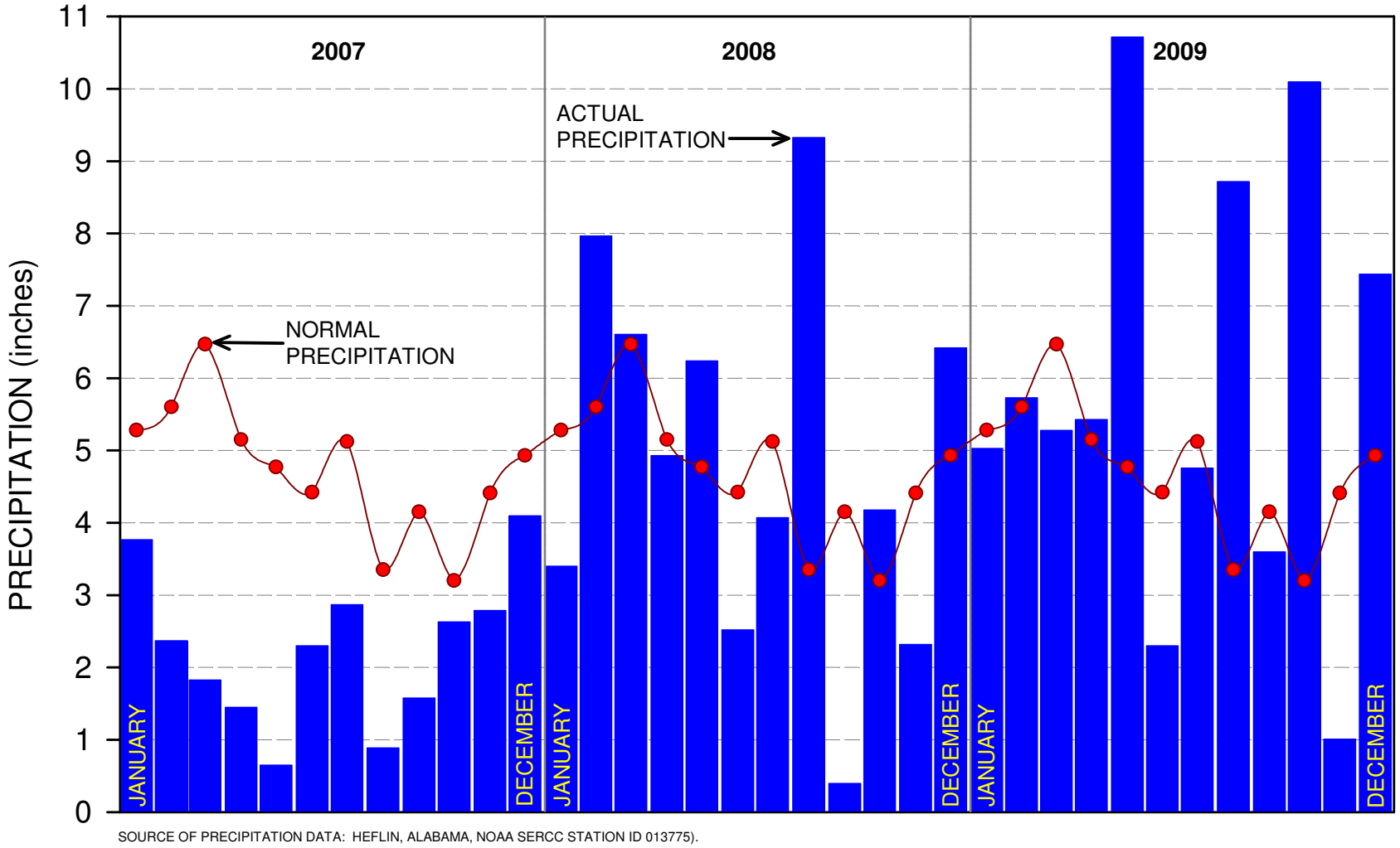


FIGURE 2. GEOLOGIC MAP

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

FILE: S:\1001\1283\128301\MAPS\FIGURE-2.dsf
DATE PREPARED: 02/15/10

FIGURE 3. MONTHLY PRECIPITATION AT HEFLIN, ALABAMA (JANUARY 2007 - DECEMBER 2009)



SOURCE OF PRECIPITATION DATA: HEFLIN, ALABAMA, NOAA SERCC STATION ID 013775).

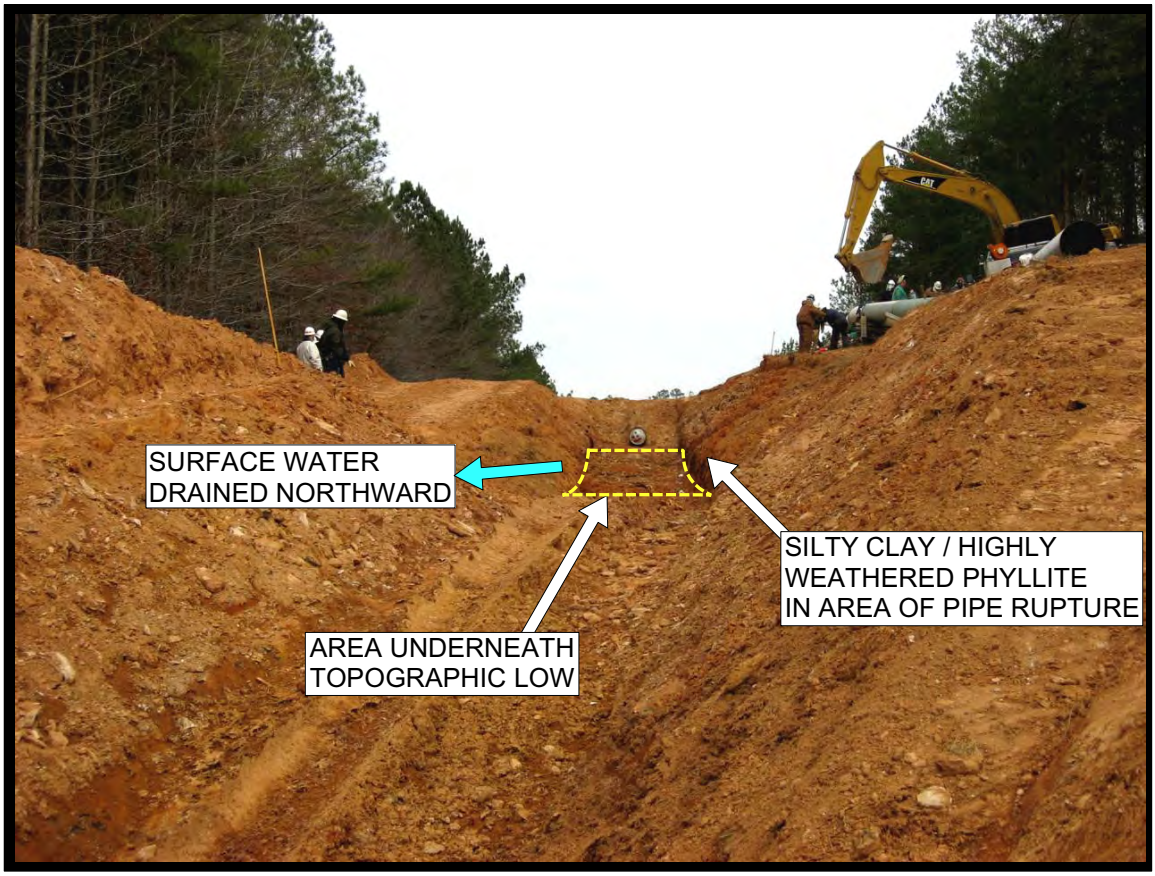
P.E. LaMoreaux & Associates, Inc.

SITE: SNG NORTH MAIN LOOP LINE (MP 399.642), CLEBURNE COUNTY, ALABAMA
FILE: S:\1001\1283\128201\FIGURE-3.jnb
PELA PROJECT NO: 129301 DATE: 02/16/10

PHOTOGRAPH 1. PIPELINE RIGHT-OF-WAY EAST OF RUPTURE (VIEW IS TOWARD EAST)

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

FILE: S:\1001\1283\128301\MAPS\PHOTO-1.dsf
PHOTOGRAPH TAKEN 01/04/10
DATE PREPARED: 02/26/10



PHOTOGRAPH 2. AREA OF PIPE FAILURE (VIEW IS TOWARD EAST)

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

FILE: S:\1001\1283\128301\MAPS\PHOTO-2.dsf
PHOTOGRAPH TAKEN 01/04/10
DATE PREPARED: 02/26/10

PHOTOGRAPH 3. PIPELINE RIGHT-OF-WAY (VIEW IS TOWARD EAST)

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

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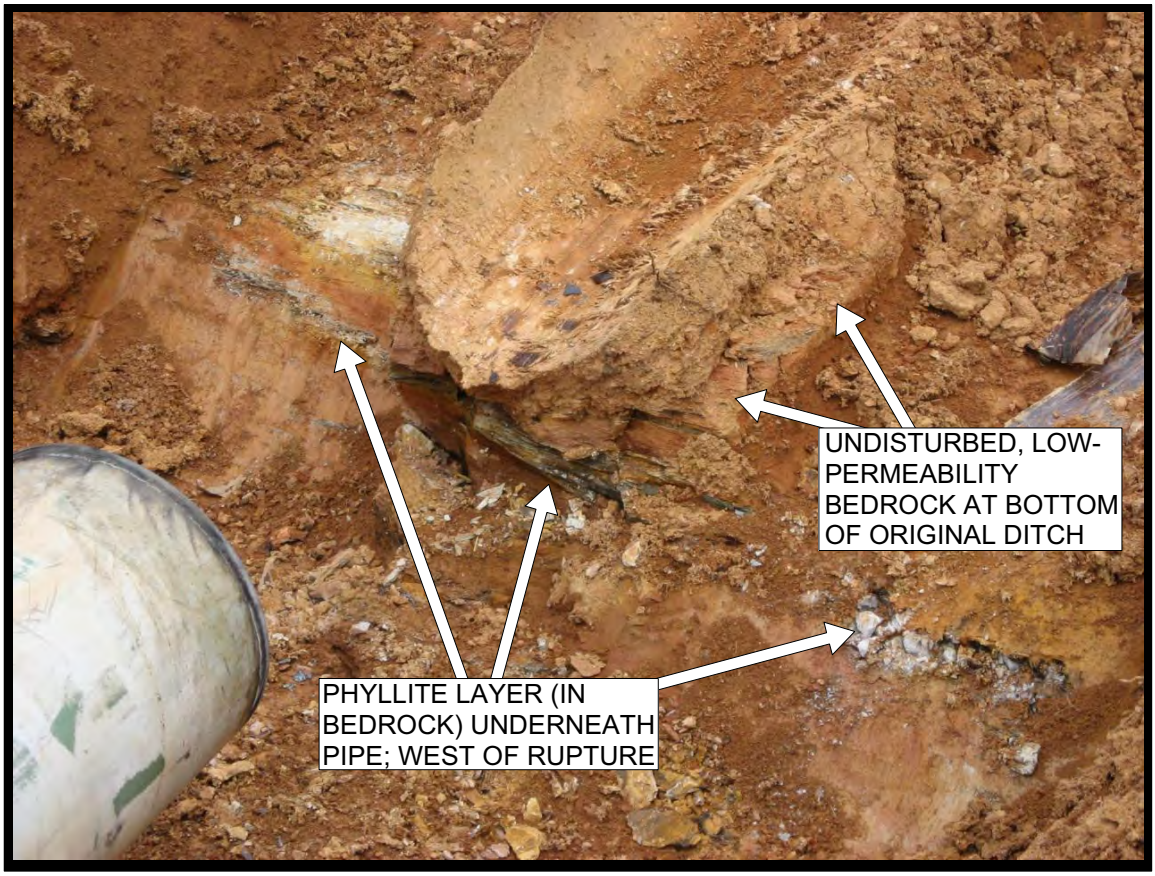
DATE PREPARED: 02/26/10



PHOTOGRAPH 4. BEDROCK UNDERNEATH PIPE (VIEW IS TOWARD NORTHEAST)

SITE: PIPELINE MILEPOST 399.642
SNG NORTH MAIN LOOP LINE
CLEBURNE COUNTY, ALABAMA
PELA NO: 128301

FILE: S:\1001\1283\128301\MAPS\PHOTO-4.dsf
PHOTOGRAPH TAKEN 01/04/10
DATE PREPARED: 02/26/10