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TECHNICAL COUNCIL ON LIFELINE EARTHQUAKE ENGINEERING AMERICAN SOCIETY OF CIVIL ENGINEERS TCLEE PIPELINE FAILURE DATABASE

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TECHNICAL COUNCIL ON LIFELINE EARTHQUAKE ENGINEERING
AMERICAN SOCIETY OF CIVIL ENGINEERS

TCLEE PIPELINE FAILURE DATABASE

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Precision Measurement Instruments, Los Altos Hills, CA, Co-Principal Investigator

National Science Foundation Project BCS-9011325

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

AMERICAN SOCIETY OF CIVIL ENGINEERS
TECHNICAL COUNCIL ON LIFELINE EARTHQUAKE ENGINEERING

TCLEE PIPELINE FAILURE DATABASE

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ABSTRACT

The American Society of Civil Engineers, Technical Council on Lifeline Earthquake Engineering was awarded a grant by the National Science Foundation (NSF BCS-9011325) to develop a computer-based database of pipeline damage and enter data collected from the Loma Prieta earthquake. The earthquake occurred near the San Francisco Bay area in California, USA, on October 17, 1989. The purpose of this project is to develop a computer-based database to preserve information on the location, pipe size, pipe material and type of pipeline damage for the engineering, geological, seismological, and seismic risk communities, and for lifeline researchers. The resulting database and methodology will be available in a public depository, in diskette format for use on personal computers, to the engineering and scientific community for the cost of duplication. It is the intent to add pipeline damage data from future earthquakes to this database as resources permit.

INTRODUCTION

LIFELINES

Lifelines are those services that are vital to the health and safety of the community and to the functioning of an urban and industrialized society. Lifelines are critical for emergency response and recovery of a community after a disaster such as an earthquake. Lifelines include power, communication, transportation, water, sewage, gas and liquid fuel systems.

Functional seismic performance of pipelines is necessary to facilitate emergency response and recovery of a community after an earthquake. Uninterrupted water supply is necessary for public health and safety purposes, including fire fighting, drinking, cooking and sanitary use. Functional sewer pipelines are necessary to carry waste away and to prevent pollution and the spread of illness or disease. Gas supplies are critical for heating and cooking in essential facilities such as hospitals. Also, gas and liquid fuels are essential for operation of emergency vehicles and equipment. Electric power generation is critical to support emergency services. In addition to public health and safety issues, lifeline operability can be critical to the economy of the effected region. In some cases, lifeline damage can reach far beyond the local economy, producing serious economic effects at the state and even national level.

LOMA PRIETA EARTHQUAKE

On Tuesday, October 17, 1989 at 5:04 p.m. (PDT), a magnitude Ms 7.1 earthquake occurred along the San Andreas Fault in the Santa Cruz Mountains of California. The epicenter was located 16 km (10 miles) northeast of Santa Cruz and 100 km (60 miles) south of San Francisco, California. This event killed 63 people, injured 3,757 people, destroyed 366 businesses, damaged 3,530 businesses and left more than 12,000 temporarily displaced. The strong shaking lasted less than 15 seconds, but is estimated to have caused more than $7 billion in damage, not including economic losses.

The Loma Prieta Earthquake affected the performance of almost every type of lifeline system in the San Francisco and Monterey Bay areas. The most significant were in transportation, especially the loss of the Cypress Street viaduct on US Interstate 880, and the collapse of a linking span on the San Francisco-Oakland Bay Bridge. Significant damage to pipelines occurred in the Marina and South of Market Street areas of San Francisco, areas along the San Francisco Bay in Oakland and Alameda, and areas along the San Lorenzo River in Santa Cruz. Underground pipelines were affected in unstable ground areas, especially those subjected to liquefaction. In a few cases the inability of the these pipelines to function affected emergency response and recovery activities.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Preliminary Earthquake Investigation of Lifelines

The Earthquake Investigation Committee, Technical Council on Lifeline Earthquake Engineering (TCLEE), American Society of Civil Engineers (ASCE) conducted a preliminary investigation of lifeline damage from the Loma Prieta Earthquake of October 17, 1989. This investigation evaluated the performance of transportation, power, gas, communications and water and sewage facilities, and subsequently prepared a report on lifeline performance. The report was published in the Earthquake Engineering Research Institute's professional journal, Earthquake Spectra (EERI, 1990).

NATIONAL SCIENCE FOUNDATION

ASCE-TCLEE, responding to a request for proposal (RFP), was awarded a grant (BCS-9011325) by the National Science Foundation (NSF) to develop a database of pipeline failures and insert data from the Loma Prieta earthquake. The resulting electronic database is to be made available in a number of public depositories for use by the engineering and scientific community for the cost of duplication. The database is stored in files on a single 5-1/4 in., 1.2 Mb diskette formatted for IBM-type personal computers.

OBJECTIVES

The objectives of this project are to develop a computer-based database and enter data collected from the Loma Prieta Earthquake. Information on the location, pipe size, pipe material and type of damage, for use by the engineering, geological, seismological, and seismic risk communities, and lifeline researchers is to be preserved. Also it is to encourage and facilitate the use of these data and methodology in future earthquakes, and ultimately to help improve the seismic performance of lifeline systems for the public welfare.

It should be noted that this is the first known attempt to document pipeline damage on a regionwide basis, and to establish a common methodology for collecting, storing, and disseminating pipeline damage data in an electronic format.

SCOPE OF PROJECT

1. Establish advisory group to review objectives of the project and to determine the type of data to be preserved.
2. Identify lifeline agencies operating pipelines that might have been affected by the earthquake. (A list of these agencies is provided in Appendix A.)
3. Collect the data on pipeline damage from agencies using a standard form. (The letter requesting information and the form used to collect it are presented in Appendix B.)
4. Determine longitude and latitude of pipeline damage.
5. For each location, add other data fields describing the damage.

6. Compile pipe break and leak data into electronic format, thereby creating computer database adaptable to existing commercially-available software for use on the personal computer.

7. Place methodology and computer data diskette in public depositories, available for use by researchers.

8. Publish and make oral presentations on the general methodology for collecting pipeline break and leak data to collect data from future earthquakes to develop a similar database.

ADVISORY GROUP

A project advisory group was established to assist the authors in identifying relevant damage and repair data. The advisory group consisted of experts in pipeline seismic performance, and included the following members:

Donald Ballantyne, Kennedy Jenks Consultants, Federal Way, WA

Ron Eguchi, EQE Engineering and Design, Costa Mesa, CA

Duane Ford, ConCeCo Engineering, Sacramento, CA

Thomas O'Rourke, Cornell University, Ithaca, NY

In a series of conversations and correspondence, the advisory group recommended specific types of information to be collected on pipeline damage. These are described in the next section.

DATA COLLECTION

The advisory group recommended collecting the following basic information on pipeline damage locations:

Lifeline conveyed:	Water, sewage, storm water, natural gas or liquid fuels
Size:	Pipe diameter and thickness
Material:	Steel, cast iron, ductile iron, plastic, copper, concrete (reinforced or unreinforced), concrete cylinder, etc.
Pipe or fitting:	Pipe, valve, elbow, tee, reducer, etc.)
Joint type:	Bell and spigot, welded (gas or electric arc), rubber gasket, bolted, mechanical coupling, butt strap, etc.
Age:	Year of installation.

Type of damage: Tension, compression, bending, corrosion, etc.

Leak or Break: Leak: lifeline continued to function with minim loss of service. Break: lifeline damaged with complete loss of function.

The advisory group also recommended collecting several other items, although with the knowledge that these data may not be as readily available as those listed above. These additional items are:

Method of Repair: Repair clamp, welding, coupling, replace pipe or fitting, etc.

Water Table: Elevation or depth to water from the ground surface.

Foundation Material: Description of bedding or trench material.

Coating and Lining: Cement mortar lining or coating, coal tar enamel lining or coating, multiwrap coating, etc.

Cathodically Protected: Yes or no.

The authors sent a letter requesting this information (an example is provided in Appendix B), to more than 65 water, sewer, drainage, and gas agencies. A list of agencies from whom data were solicited is provided in Appendix A. Telephone calls and personal visits were made to approximately 25 agencies in an effort to collect pipeline damage data. A printout of a sample response that was entered into the database is provided in Appendix B.

In the process of contacting these lifeline agencies, it has become evident that many, but not all of them have documented the location of damage to underground pipelines. Some identified the size, pipe material, type of damage and other features of the damage. In contrast, about one-half of agencies concentrated on restoring the lifeline service, and on documenting the cost of repair for use in preparing Agency's Damage Survey Reports, which are documents used for soliciting federal damage reimbursement from the Federal Emergency Management Agency (FEMA). Damage Survey Report forms were available from public utilities, as only public agencies are eligible for reimbursement from FEMA. (Private agencies may be eligible for low-interest loans from the federal government.) In summary, then, the availability and detail of pipeline damage data varied between agencies. Though most agencies did respond to our requests for damage data, some were unable to do so, even though their systems experienced damage. The database provided with this report contains 862 pipeline failure records from the Loma Prieta Earthquake. Indeed, since records were made only of reported repairs, much damage may have occurred has not yet been discovered, let alone documented.

Some agencies were fortunate and had no damage and only very few failed to respond. The project does not include data on service connections, meters and private lines. There were no reported breaks or leaks to pipelines transporting petroleum. Although substantial damage is known to have occurred to gas pipelines, the only damage data contained in the database is from Palo Alto.

DATA CONVERSION

COORDINATE CONVERSION

Contributing utilities generally provided street addresses of pipe repairs. These were converted to global latitude/longitude coordinates using EQEHAZARD, a proprietary program of EQE International. Global coordinates were chosen to provide the most-commonly accessible location context, although it is recognized that some areas have more sophisticated coordinate systems. The address database used by EQEHAZARD is drawn from the United States Census Bureau's most recent address files.

PIPE DAMAGE ELECTRONIC DATABASE

The database is composed of records, one record for each pipe failure. Each record consists of 51 data fields, which describe the earthquake and the pipe damage. The fields are defined in Table 1. Field names are shown on the left; explanatory text is provided opposite the field names. For example the first field in each database record is EARTHQUAKE, that is, the causative earthquake. Every record in this database refers to damage that occurred in the Loma Prieta earthquake, and therefore every record has the text "17 OCT 1989 Loma Prieta" entered in the first field. Field names are based on the entries in the pipeline damage check sheet, which contributing utilities filled out to supply pipe repair data. It should be noted that terminology used to describe pipeline material, construction, and repair varies between agencies. This fact is reflected in the data the agencies provided, and therefore is also reflected in the database. A glossary of relevant terms is provided in Appendix C.

The diskette provided with this report contains the following files:

TCLEE_DD.DBF: Pipeline damage database, compatible with dBase III database software.

TCLEE_DD.PRN:	Pipeline damage database in comma-and-quote delimited format, which is readable by virtually any database or spreadsheet program. These programs, such as dBase, FoxPro, and Lotus 1-2-3, have functions that enable the user to analyze, search, or print the data.
REPORT.DOC:	This report, in Microsoft Word for DOS, version 5.5 format.
REPORT3.STY:	Microsoft Word 5.5 stylesheet associated with REPORT.DOC.

PROJECT PRODUCTS

1. Project report describing methodology used to collect data, computer data file, and a sample application for use in future research.
2. Methodology and format for collecting similar data from future earthquakes.
3. Diskette in pocket with database files TCLEE_DD.DBF and TCLEE_DD.PRN, whose formats are discussed above.
4. Figure 1, showing pipeline breaks and leaks in the Loma Prieta earthquake area of impact
5. Figure 2, showing close-up view of pipeline breaks and leaks in the San Francisco Marina District.
6. Figure 3, showing pipeline breaks and leaks in the San Francisco Marina District, along with soil classification (using the UBC soil profile system).

PROBLEMS

There are significant differences in the amount of damage information available from different agencies. Not all agencies kept detailed records of the type of damage and method of repair. Most public agencies kept records on the cost of repair for possible reimbursement by FEMA. This reimbursement was not available to private agencies, although they may be eligible for low interest loans if the earthquake impact area is declared a "disaster area" by a state and federal governments.

Some agencies lack extensive information on the systems they operate. Many reasons explain this. In some cases a utility acquired an old system for which detailed records were never kept. Some utilities were created through the merger of a group of smaller agencies, and therefore lack common records. Some small agencies lack any technical staff. The quality and detail of data provided by these agencies may therefore be lower than that provided by larger, older utilities.

After the Loma Prieta earthquake, a flyer with a check sheet (similar to that shown in Appendix B) was distributed by the TCLEE Earthquake Investigation Committee (EIC) to a number of lifeline agencies, requesting they collect the information described above. The agencies were informed that a TCLEE EIC representative would contact them in about 30 days to collect damage information for inclusion in a report on the performance of lifelines in the earthquake. When TCLEE EIC personnel called or visited the agencies, it was found that only a very few respondents followed these suggestions. The information they provided was the basis for the 1990 EERI Spectra Loma Prieta Preliminary Reconnaissance report on water and sewage facilities.

The methodology used in this project is the first known attempt to collect and digitize pipeline damage on a regionwide basis. Like all first attempts, it is subject to improvement in future events. In future earthquakes in the United States, the flyer and check sheet, with a format similar to that shown in Appendix B, should be distributed. The format should be modified if appropriate; however, the value of the database may be degraded by inconsistencies between events. It should be recognized that there may be varying degrees of compliance.

APPLICATIONS

One purpose of this study is to supply researchers with a single, consistent database of pipe damage in a format usable to all database and spreadsheet programs. The object of future investigations that use this data is, of course, up to the researchers themselves. However, for purposes of illustrating the utility of this database, we have supplied results from a sample application: soils data for each pipeline repair record. Two soil classifications are provided for each pipe repair location: one according to the United States Geological Survey (USGS), and one according to the Uniform Building Code. The former system, by Evernden and others of the USGS (1981), describes soil type in terms of *ground condition units* A through J, as defined in Table 2. The latter system classifies a *soil profile* as S1 through S4, for the purpose of characterizing seismic frequency response content at the ground surface. Table 3 is extracted from the Uniform Building Code (ICBO, 1991), and defines the S1 through S4 soil profiles.

One possible use for these data would be to correlate pipe damage with soil type. It is known that pipe damage in earthquakes is frequently concentrated in zones of liquefaction. Liquefaction typically occurs where loosely-consolidated saturated alluvium is subjected to strong ground motion. Therefore, the tendency for pipe breakage to occur in saturated alluvial soils may be evaluated by overlaying the data provided in this sample application with peak ground acceleration or other appropriate measure of seismic intensity.

Soil data presented in the sample application are based primarily on high resolution geological maps digitized by EQE. These electronic maps cover the urbanized San Francisco Bay area, and are based on 1:24,000 and 1:62,500-scale geological maps published by such agencies as USGS and the California Division of Mines and Geology (CDMG). Slightly over half of the San Francisco Bay area was digitized using the higher-resolution maps. In addition, Santa Cruz has been digitized using a 1:24,000 scale geological map. The small scale provides for an accuracy of between 75 and 300 feet in the location of soil type boundaries.

Except for Santa Cruz, soil data for regions outside the urbanized San Francisco Bay area are based on 1/2-minute geological maps provided by Evernden and Thompson of the United States Geological Survey. The USGS 1/2-minute maps present average soil types in rectangles whose dimensions are approximately 2,400 feet (east-west) by 3,000 feet (north-south); accuracy of soil data drawn from this source is therefore limited.

DISSEMINATION

The computer diskette and report are to be distributed for permanent storage in a number of public depositories, including: the National Information Service for Earthquake Engineering and Bechtel Engineering Library at University of California, Berkeley; National Center for Earthquake Engineering Research at State University of New York, Buffalo; Terman Engineering Library at Stanford University; Southern California Earthquake Center, at University of Southern California; Library of Congress; California Institute of Technology; University of California, Davis; University of California, Los Angeles; University of California, Irvine; California State University, San Jose; and available to any researcher for nominal cost. Also oral presentations and publication in professional journals.

CONCLUSIONS

The data provided with this report may be used by geotechnical researchers to determine damage as related to different geological conditions or seismicity. Seismic risk researchers may employ the information to analyze lifeline systems, to understand better the performance of lifeline systems in earthquakes, and to identify regions where soil or geological conditions would affect seismic risk or damage. The ultimate goal for these data is to improve the performance of lifeline systems.

The methodology presented herein may be used in future earthquakes for the collection of pipeline damage data. As future earthquakes occur, new data may be collected in the same manner and compiled into the same database, so that accumulated data can be placed in a data bank representing different magnitudes, geological and topographical conditions.

RECOMMENDATIONS

1. The collection of pipeline data is different than other post-earthquake investigation activities in that it is often several months before most of the damage is discovered and repaired. Thus, the data collection of pipeline damage cannot meet the needs for most reconnaissance activities, which are typically to be completed within 2 months after the earthquake. Thus, there is a need for a mechanism to support the detailed effort needed to document pipeline damage.

2. There is a need for better coordination in the collection of pipeline damage data. After significant earthquakes, many geotechnical teams go into the field to collect data, including pipeline damage data. As a result, water and other agencies get several requests for damage information.

3. Obtaining a reasonable description of the system at the time of the earthquake would greatly enhance the value of the data in the database. It would be desirable at least to get aggregate length of various types and sizes for each agency reporting damage.

4. It is recommended that this methodology be used in future earthquakes to ensure that critical data is collected and that it is compatible with the database.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to NSF for supporting this project. The authors also thank the representatives of the many lifeline agencies who took the time to provide damage data. Marie McGuinness of ASCE, and the members of the advisory group provided invaluable assistance. Charles Scawthorn, Mahmoud Khater, Keith Porter, and Mahadevan Subramani of

EQE Engineering and Design, San Francisco, compiled the database into an electronic format, digitized pipeline damage and soils data, and published this report. Their participation is greatly appreciated.

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Earthquake Engineering Research Institute, Loma Prieta Earthquake Reconnaissance Report, Earthquake Spectra, Supplement to Volume 6, May 1990, El Cerrito, CA. pp. 239 - 338.

Evernden, J.F., Kohler, W.M., and Clow, C.D., 1981. Seismic Intensities of Earthquakes of Conterminous United States -- Their Prediction and Interpretation. Geological Survey Professional Paper 1223. 55 pp.

International Conference of Building Officials (ICBO), 1991. Uniform Building Code. p. 184.

Personal communications with lifeline agency representatives by Le Val Lund.

Field no.	Field name	Explanation
1	EARTHQUAKE	Name and date of causative earthquake
2	AGENCY	Name of responding agency
3	MEDIUM	Medium carried by pipeline (e.g., water)
4	CONTACT	Name of person providing data
5	PHONE	Telephone number of person providing data
6	LOCATION	Approximate address of pipeline damage
7	CITY	City of same address
8	ZIP	5-digit zip code of same address
9	LAT	Location of damage, degrees latitude (+N, -S)
10	LONG	Location of damage, degrees longitude (+E, -W)
11	SOIL_USGS	Soil type: USGS ground condition unit
12	SOIL_UBC	Soil type: UBC soil profile classification
13	SIZE	Pipe nominal diameter, inches
14	THICKNESS	Pipe wall thickness, inches
15	MATERIAL	Pipe material
16	LINING	Pipe lining, applied to inside of pipe
17	COATING	Pipe coating, applied to outside of pipe
18	YEAR_INST	Year of installation
19	JOINT_TYPE	Type of joint
20	BUR_DEPTH	Depth of pipe invert below ground surface, feet
21	BEDDING	Material on which pipe rests
22	BACKFILL	Material in which pipe is buried
23	GW_PRESENT	Groundwater present when excavating pipe
24	GW_DEPTH	Depth to groundwater below ground surface, feet
25	BREAK	Flow disrupted, loss of function
26	LEAK	Damage caused leak, but pipeline function continued
27	ROUND	Circumferential pipe crack
28	BLOWOUT	Blowout-type damage
29	SPLIT	Longitudinal pipe crack
30	CORROSION	Corrosion evident at damage
31	PIPE_OTHER	Pipe damage caused by other phenomenon (described)
32	CRACK	Joint failure caused by crack
33	PULL	Joint pulled apart
34	COMPRESSION	Joint failure caused by compression
35	GASKET	Joint gasket failure
36	JT_OTHER	Other type of joint failure (described)
37	ELBOW	Failure at elbow fitting
38	TEE	Failure at tee fitting
39	CROSS	Failure at cross fitting
40	OFFSET	Failure at offset fitting
41	FLANGE	Failure at flange fitting
42	HYDRANT	Failure at fire hydrant
43	FITG_OTHER	Failure at other type of fitting (described)
44	CLAMP	Damage repaired with repair clamp
45	STRAP	Damage repaired with butt strap
46	WELD	Damage repaired with weld
47	REPLACE	Damage repaired by replacing pipe or fitting
48	REP_OTHER	Damage repaired with other method (described)
49	COMMENTS1	Comments, 1st line
50	COMMENTS2	Comments, 2nd line
51	COMMENTS3	Comments, 3rd line

Table 1: Database format

Geologic map units	Ground-condition unit
Granitic and metamorphic rocks (Kjfv, gr, bi, ub, JT_m, m, mV, PpV, PmV, Cv, Dv, pS, pSv, pCc, pCgr, pC, epC, Tl)	A
Paleozoic sedimentary rocks (Ms, PP, Pm, C, CP, CM, D, S, pSs, O, E)	B
Early Mesozoic sedimentary rocks (Jk, Ju, JmE, Tr, Kjf)	C
Cretaceous through Eocene sedimentary rocks (Ec, E, Epc, Ep, K, Ku, KE)	D
Undivided Tertiary sedimentary rocks (QTc, Tc, TE, Tm)	E
Oligocene through middle Pliocene sedimentary rocks (PmEc, PmE, Mc, Muc, Mu, Mmc, Mm, ME, Φe, Φ)	F
"Plio-Pleistocene" sedimentary rocks (Qc, OP, Pc, Puc, Pu)	G
Tertiary volcanic rocks (Pv, Mv, Olv, Ev, QTv, Tv)	H
Quaternary volcanic rocks (Qrv, Qpv)	I
Quaternary sedimentary deposits (Qs, QaE, Qsc, Qf, Qb, Qst, QE, Qq, Qt, Qm)	J

Table 2: Explanation of USGS ground condition units
From Evernden et al., 1981

TYPE	DESCRIPTION
S_1	A soil profile with either: (a) A rock-like material characterized by a shear-wave velocity greater than 2,500 feet per second or by other suitable means of classification, or (b) Stiff or dense soil condition where the soil depth is less than 200 feet.
S_2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 200 feet.
S_3	A soil profile 70 feet or more in depth and containing more than 20 feet of soft to medium stiff clay but not more than 40 feet of soft clay.
S_4	A soil profile containing more than 40 feet of soft clay characterized by a shear wave velocity less than 500 feet per second.

Table 3: Explanation of UBC site soil profile classifications
From 1991 Uniform Building Code

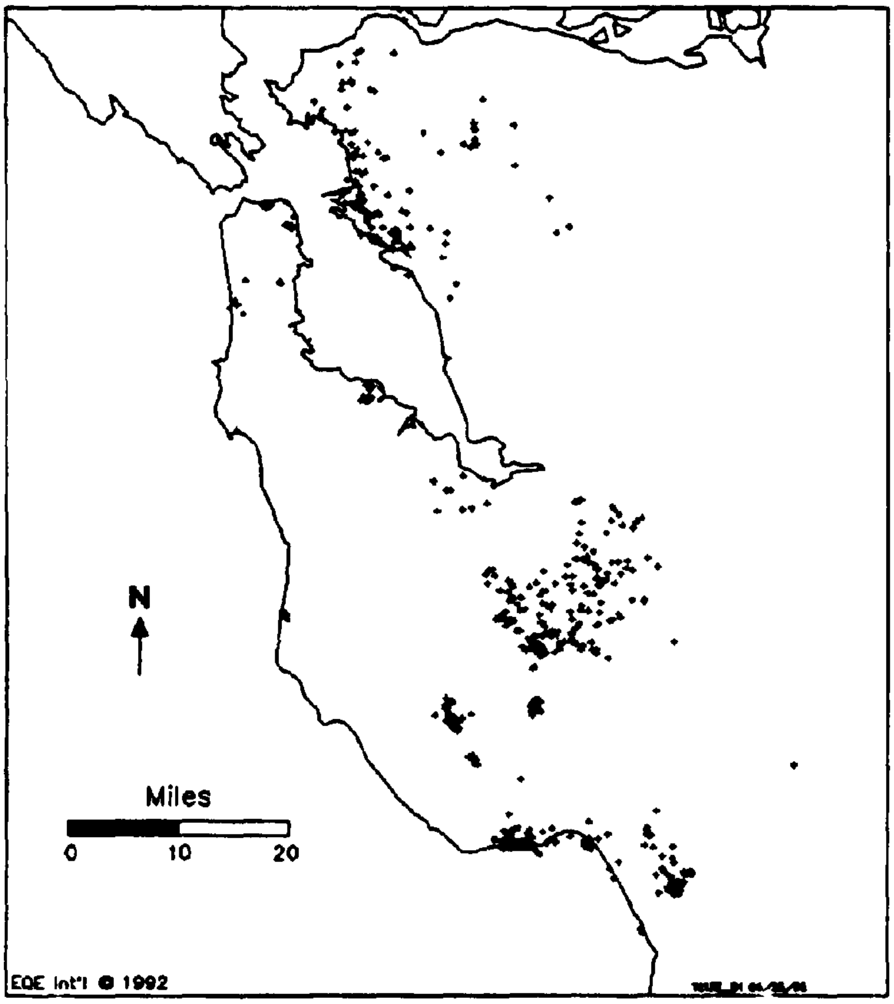

Figure 1: Pipeline breaks and leaks in the Loma Prieta Earthquake

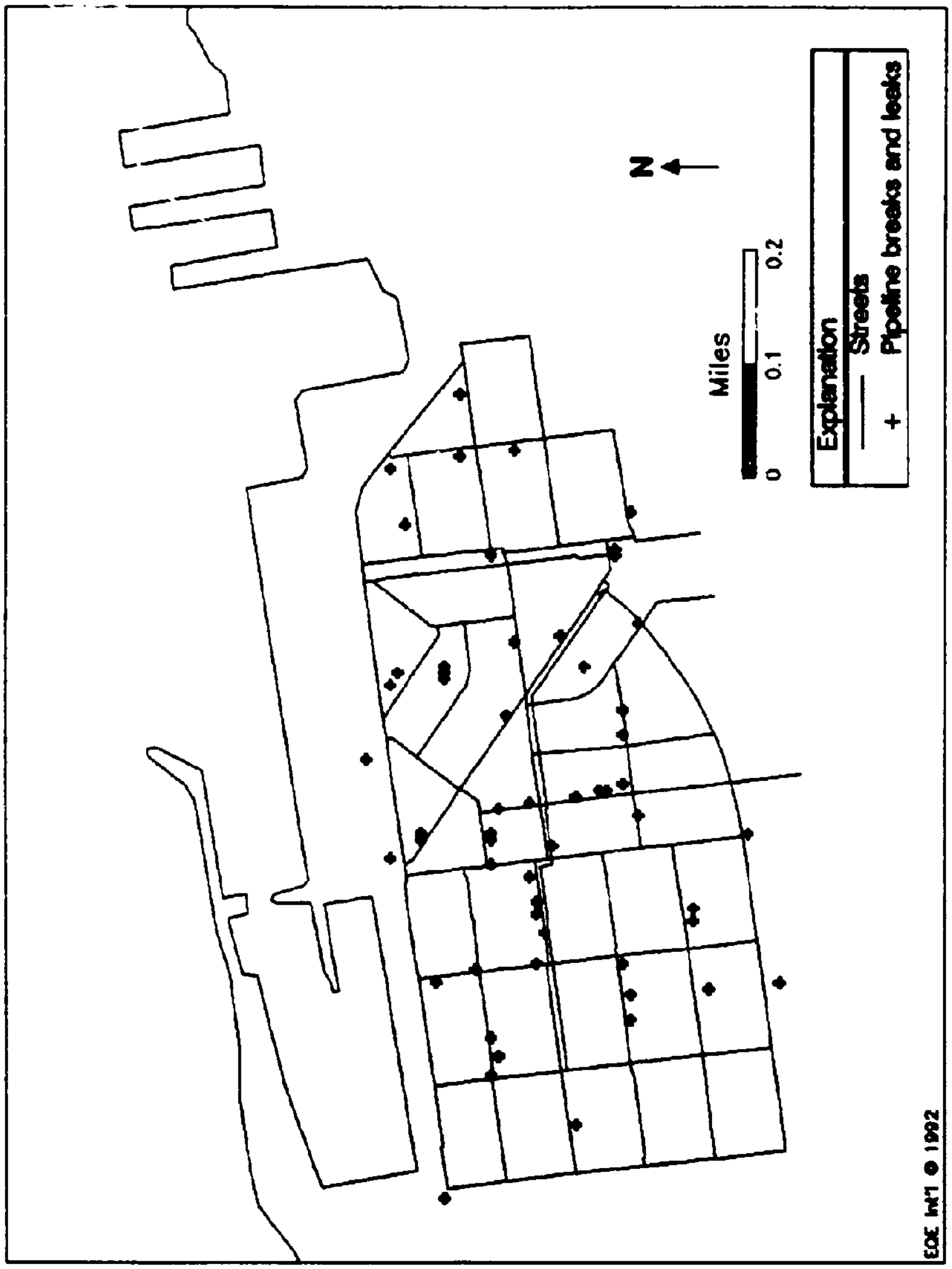

Figure 2: Pipeline breaks and leaks in the San Francisco Marina District

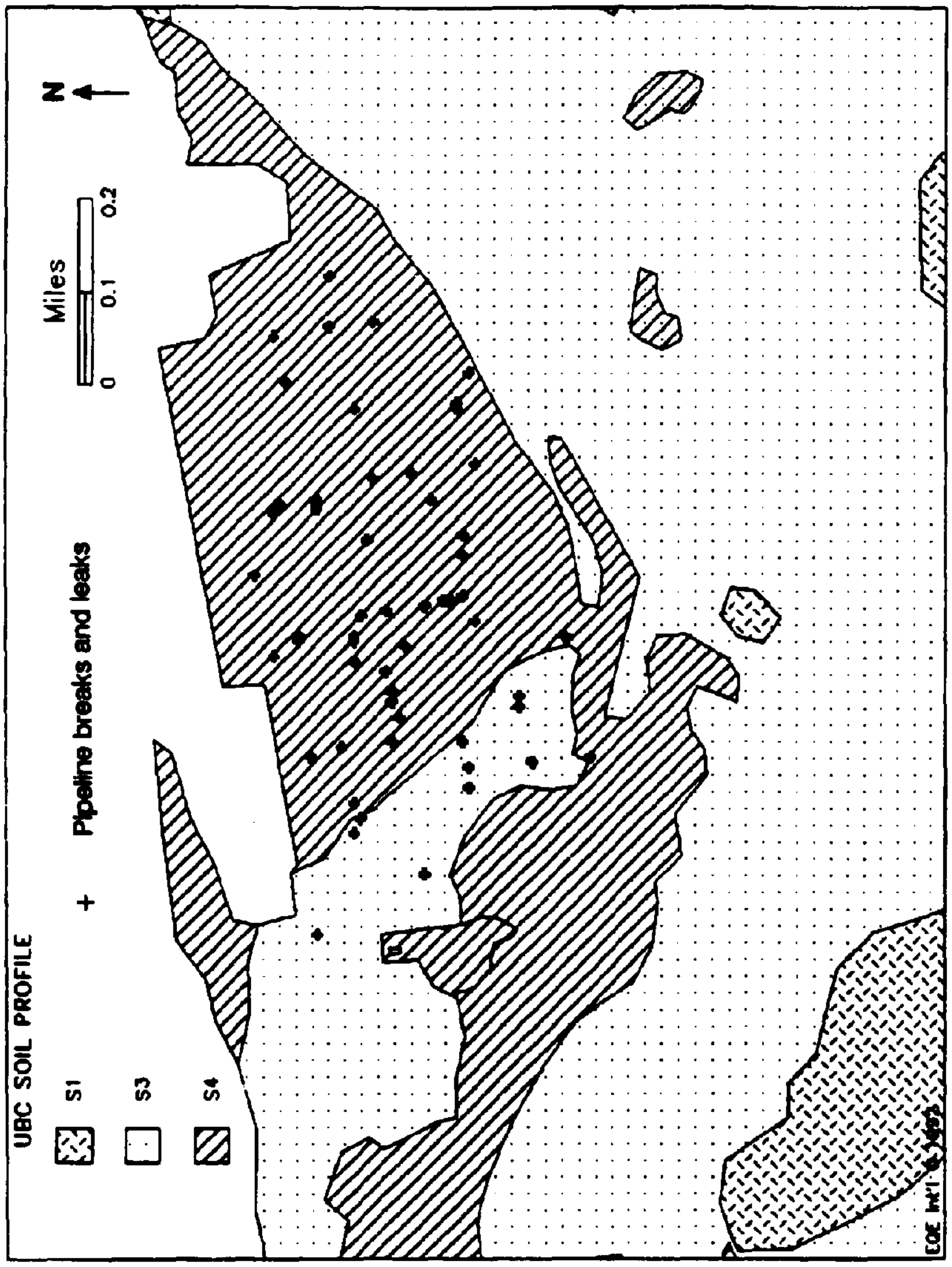

Figure 3: Pipeline breaks and leaks in the San Francisco Marina District, with UBC soil type

APPENDIX A
LIST OF AGENCIES SOLICITED FOR PIPELINE DAMAGE DATA

SAN FRANCISCO BAY AREA WATER USERS ASSOCIATION

Jim Beard
Alameda County Water District
43885 S. Grimmer Blvd, P.O. Box 5110
Fremont, CA 94537
(510) 659-1970

Warren J. Mitchell
Belmont County Water District
1513 Folger Drive, P. O. Box 129
Belmont, CA 94002
(415) 591-8941

Roger A. Kilil
Water Department
44 Visitacion Avenue
Brisbane, CA 94005
(415) 467-1515

Ralph E. Kirkup
501 Primrose Lane
Burlingame, CA 94010
(415) 342- 8132

Ralph J. Steiber
California Water Service Company
1720 North First Street
San Jose, CA 95108-4598
(408) 453-8414

Robert R. Rathborne and Dave Mier
Coastside County Water District
766 Main Street
Half Moon Bay, CA 94019
(415) 726-4405

Mario Wijtman
Cordilleras Mutual Water Association
1827 Cordilleras Road
Redwood City, CA 94063
(415) 572-1919

R. George Zinckgraf
East Palo Alto Water District
805 Veterans Blvd, Suite 301
Redwood City, CA 94063
(415) 363-4102

R. George Zinckgraf
Palomar County Water District No. 3
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Redwood City, CA 94063
(415) 363-4102

Michael D. Abramson and Mike Cooney
Water Department
153 Lake Merced Blvd.
Daly City, CA 94015
(415) 755-6557

Charles F. Loucks and David Valkenns
Estero Municipal Improvement District
610 Foster City Blvd.
Foster City, CA 94404
(415) 349-1200

Roger Kalil
Guadalupe Valley Municipal Improvement District
44 Visitacion Avenue
Brisbane, CA 94005
(415) 467-1515

James Lundgren and Mike Higares
Water System
22300 Foothill Blvd.
Hayward, CA 94541
(510) 581-2345, X 5211

Terrance Leong
Town of Hillsborough
1600 Floribunda Avenue
Hillsborough, CA 94010
(415)343-2735

Stanley R. Gage
Los Trancos County Water District
455 Old Spanish Trail
Portola Valley, CA 94025
(408) 435-6115

Lauren E. Mercer
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701 Laurel Street
Menlo Park, CA 94025
(415) 858-3420

Wayne Bush
Director of Public Works
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Millbrae, CA 94030
(415) 259-2339

Wesley D. Smith
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(408) 942-2361

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Pete Nelson
North Coast County Water District
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Pacifica, CA 94044
(415) 355-3462

Douglas M. Short
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Palo Alto, CA 94301
(415) 329-2523

William D. McCann
Purissima Hills Water District
26375 West Fremont Avenue
Los Altos Hills, CA 94022
(415) 948-1217

Curtis M. Luck
City of Redwood City
P. O. Box 391
Redwood City, CA 94064
(415) 780-7377

Lee R. Ritzman
City of San Bruno
567 El Camino Real
San Bruno, CA 94066
(415) 877-8865

Dennis Futamase
City of San Jose
801 North First Street
San Jose, CA 95110
(408) 277-4218

Richard H. Hathorn
City of Santa Clara
1500 Warburton Avenue
Santa Clara, CA 95050
(408) 984-3183

Richard Henwood
Skyline County Water District
13885 Skyline Blvd.
Woodside, CA 94062
(415) 851-0529

Cheryl Jensen
Stanford University
315 Bonair Siding
Stanford, CA 94305
(415) 725-1813

William Weisend
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Robert Yee
Westborough County Water District
2263 Westborough Blvd.
South San Francisco, CA 94080
(415) 589-1435

SANTA CLARA VALLEY WATER USERS

San Jose Water Company
San Jose Municipal Water
City of Sunnyvale Water
City of Santa Clara Water
City of Cupertino Water
California Water Service Company

WATER AND SEWAGE AGENCIES

Water

Ted Way,
Tom Linville, Manager of Maintenance, and
Jack Jacobs, Manager of Operations
EBMUD
Box 24055
Oakland, CA 94623-1055
415-835-3000

Jim Beard
Alameda County Water District
P. O. Box 5110
Fremont, CA 94537-5110
415-659-1970

Jack LaPorte
Hollister Water and Sewer
375 Fifth Street
Hollister, CA 95023
408-637-8247, -8221

Joe Rosa
Pajaro Community Services District
Sunny Mesa Water District
305 Salinas Road
Box 1543
Watsonville, CA 95077
408-722-1389

William McCann
Purissima Hills Water District
26375 Fremont Road
Los Altos Hills, CA 94022

Robert Howard
Santa Clara Valley Water District (SCVWD)
400 More Avenue
Los Gatos, CA 95030
408-395-8121

Roger James, Mgr. of Water Operations and Water Quality
5750 Almaden Expressway
San Jose, CA 95118
408-265-2600

Robert Gazzetta
California Water Service Company
1720 North First Street
San Jose, CA 95112
408-453-8414

Bill Kocher and Gregg Tom
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809 Center Street
Santa Cruz, CA 95060
408-429-3674

Martin Lieberman
Water Department
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San Francisco, CA 94124
415-550-4902

Paul Schreiber
San Jose Water Company
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San Jose, CA 95196
408-279-7801

John Capebianco
San Lorenzo Valley Water District
13060 Central Avenue
Boulder Creek, CA 95006
408-338-2153

Jon Sansing
Scotts Valley Water District
Box 660006
Scotts Valley, CA 95066-0006
408-438-2363

Robert Johnson
Soquel Creek Water District
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Soquel, CA 95073
408-475-8500

Bryan Yamaoka
Sunnyslope County Water District
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Hollister, CA 95023-9702
408-637-4670

John Nichols and Charles Wales
Watsonville Water
Box 430
Watsonville, CA 95077
408-728-6045

John Jones
Tracy Water
6649 South Tracy Boulevard
Tracy, CA 95376
209-836-2550

Riva Ridge Mutual Water Company

Wester Sweet
Mountain Charlie Water Company
338 East Julian Street
San Jose, CA 95112
408-292-2759

Don McKenzie
Bruce Franks, Owner/operator
Villa Del Monte Mutual Water Company
Idlywild Water Co.
Chemeketa Park Water Co.
Aldercroft Valley Water Co.
20915 Old Santa Cruz Highway
Holy City, CA
408-353-1343

Redwood Estates Mutual Water Co.
Redwood Estates, CA 95044

James Davis
Cupertino Water Utility
10555 Mary Avenue
Cupertino, CA 95014-3255
(408) 253-5757

<u>Sewer</u>

John Ballard
Palo Alto Water Pollution Control Facility
2501 Embarcadero Way
Box 10250
Palo Alto, CA 94303
415-329-2120

Todd Cockburn (Pronounced Coeburn) and Henry Anderson
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San Francisco, CA 94124
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45 Hyde Street
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Watsonville Sewer
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Scotts Valley Wastewater
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Lee Doty
Union Sanitary District
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East Bay Municipal Utility District-Wastewater
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Martin Gonzalez
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Tim Clayton
West Bay Sanitary District
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Menlo Park, CA
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Bill Mcbee
Cupertino Sanitary District
20065 Stevens Creek Blvd., Bldg. C
Cupertino, CA 95014
408-253-7071

Gary Valladao
Mid-Coast Sewer Authority
P. O. Box 3100
Half Moon Bay, CA
415-726-0124

Fred Cebalt
San Mateo Wastewater Treatment Plant

Gas

James Clark
Pacific Gas and Electric Company
123 Mission Street H-1013
San Francisco, CA 94106

Roger Jensen
Water, Sewer and Gas
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301
(415) 469-6932

APPENDIX B

REQUEST FOR PIPELINE DAMAGE INFORMATION; SAMPLE PIPELINE DAMAGE CHECK SHEET; SAMPLE DATABASE RECORD

AMERICAN SOCIETY OF CIVIL ENGINEERS
Technical Council on Lifeline Earthquake Engineering
Loma Prieta Earthquake Pipeline Failure Documentation
NSF Contract No. BCS-9011325

9 August 1990

Mr John Ballard
Palo Alto Water Pollution Control Facility
P.O. Box 10250
Palo Alto CA 94303

Dear John

The American Society of Civil Engineers, Technical Council on Lifeline Earthquake Engineering has been awarded a grant by the National Science Foundation (NSF) to develop a data base of pipeline failures from the Loma Prieta Earthquake, 17 October 1989. The purpose of the project is to preserve information on pipeline failures for the engineering and scientific communities. The resulting data base will be available, in disk format for personal computers at the cost of duplication. No reference to specific agencies will be made be made in the final report.

I would like to come to your agency during the month of September to obtained a map of your system and a map showing the location of pipeline failures. The map will be used to tie pipeline failures into a coordinate system of latitude and longitude.

Also, I would be interested in the total length of pipe in your system, the percentage of pipe by different materials, mode of failures and method of repairs. A damage information sheet is attached for your convenience.

The primary purpose of the visit is to determine the location of pipe failures, and any other information on pipe failures would be appreciated. I will call to schedule a meeting with your agency.

Sincerely yours,

Le Val Lund, P.E., M. ASCE
Principal Investigator

3245 Lowry Road
Los Angeles, CA 90027
(213) 664-4432

Attachment
LL 8-8-90

American Society of Civil Engineers
Technical Council on Lifeline Earthquake Engineering

Pipeline Damage Check Sheet

Location of Damage ____

Pipe Description

Size ____, Thickness ____, Material ___________, Lining ____,
Coating ____, Date of Installation _____

Type of Joints ___________, Burial Depth ____,
Bedding Material ___________,Type of Backfill ________________

Ground Water Present ___, Depth to Water Surface ___

Damage

Impact on Flow: Break (flow disrupted) ____
or Leak (flow continued) _____

Pipe Failure: Circumferential (round crack) ____,
Change in Pressure (blowout) ____, Longitudinal (split) ____,
Corrosion ____, Other (describe)____

Joint Failure: Cracked ___ Pulled __, Compression __, Gasket __,
Other (describe) ______________

Fitting Failure: Elbow __,Tee __, Cross __,Offset __,Flange __, Flange __,
Hydrant __, Other (describe) _______________

Repair Method: Repair Clamp __, Butt Strap __, Welded __, Replaced pipe or fitting __, Other (describe) _______________

Supervisor __________________ Date _________

Comments ____

____

____

LL 8-8-90

American Society of Civil Engineers
Technical Council on Lifeline Earthquake Engineering

Pipeline Damage Check Sheet

Earthquake: 17 OCT 1989 LOMA PRIETA

Agency: SAN FRANCISCO WATER DEPARTMENT Medium: WATER
Contact person: MARTIN LIEBERMAN Phone: 415-550-4902

Location of damage: 3642 WEBSTER ST
SAN FRANCISCO, CA 94123

Latitude: 37.8043 Longitude: -122.4342
Soil (USGS): J Soil (UBC): S4

PIPE DESCRIPTION

Size (in): 8.00 Thickness: 0.00 Material:
Lining: Coating: Year installed: 0

Joint type: Burial depth (ft): 0.00
Bedding material: Type of backfill:

Ground water present: At depth (ft): 0.0

DAMAGE

Impact on flow: break (flow disrupted): X
or leak (flow continued):

Pipe failure: circumferential (round crack): X
Change in pressure (blowout): Longitudinal (split):
Corrosion:
Other (describe):

Joint failure: Crack: Pull:
Compression: Gasket:
Other (describe):

Fitting failure: Elbow: Tee: Cross:
Offset: Flange: Hydrant:
Other (describe):

Repair method: Repair clamp: X Butt strap:
Weld: Replace pipe or fitting:
Other (describe): 8" FULL CIRCLE

Comments:

APPENDIX C

GLOSSARY OF TERMS USED IN PIPELINE DAMAGE DATABASE

Term	Explanation
ABS	Acrylonitrile butadiene styrene, a black plastic pipe used for sewer and low pressure gas
AC	Asbestos cement
ACP	Asbestos cement pipe
AV	Air valve
B&S	Bell and spigot
CI	Cast iron
CI HP	Cast iron high-pressure pipe
CCCL	Cement-coated, cement-lined welded steel
CONC	Concrete
COP	Copper
DICL	Ductile iron, cement-lined
FKCL	Kraft-wrapped, cement-lined steel
FLEX COUPL	Flexible coupling, also called Dresser coupling or mechanical coupling. A 2-3 ft in-line segment of pipe with unrestrained, gasketed sleeve joints at each end. Space is left between the pipe segment and adjacent pipe to permit contraction of the coupling. Gaskets are clamped into the sleeve
FLEX FITG	A U-shaped offset fitting 1-2 feet in each dimension
FS	Fire service
GALV	Galvanized (steel, typically)
GG	Grovie/grip, a thin-walled steel pipe with victaulic-like joints, of 1940's vintage
HSL	House line, service pipe on the consumer's side of the meter
ML&C	Mortar-lined and coated steel
PLAS	Plastic
POLY	Polyvinyl chloride
PVC	Polyvinyl chloride
RCP	Reinforced concrete pipe
RGJ	Rubber gasket joint
RPP	Reduce pressure principle, a backflow device
S	Steel
SI	Sheet iron, riveted or gas-welded
SM	Steel main
SMB	Steel main with bitchmastic (tar) lining
SMM	Modified prestressed concrete
SOMCL	Somastic-coated, cement-lined steel
SRV	Service
SS	Standard screw steel
STL	Steel
SVC	Service
TRANSITE	Trade name for asbestos cement
VCP	Vitreous clay pipe
WS	Welded steel
WSCL	Welded steel, cement-lined