PHASE I GEOLOGIC FAULT ASSESSMENT
60-INCH WATER LINE ALONG MONROE AND ROCKHILL
FROM AIRPORT BOULEVARD TO GLEN VALLEY DRIVE
WBS NO: S-000900-0129-3
HOUSTON, HARRIS COUNTY, TEXAS

PREPARED FOR:
KUO & ASSOCIATES, INC.
10700 RICHMOND AVENUE, SUITE 113
HOUSTON, TEXAS 77042

PREPARED BY
HVJ ASSOCIATES, INC.
HOUSTON, TEXAS
MAY 15, 2015

REPORT NO. HE1416540
KEY MAP 535Y & 575C

HVJ ASSOCIATES

Houston
Austin
Dallas
San Antonio

6120 S. Dairy Ashford Rd.
Houston, TX 77072-1010
281.933.7388 Ph
281.933.7293 Fax
www.hvj.com

May 15, 2015

Mr. Shaheen Chowdhury, PE, RPLS
Kuo & Associates, Inc.
10700 Richmond Avenue, Suite 113
Houston, Texas 77042

Re: Geologic Fault Assessment
60-Inch Water Line along Monroe and Rockhill
From Airport Blvd to Glen Valley Drive
WBS No: S-000900-0129-3
Owner: City of Houston
HVJ Project No. HE1416540

Dear Mr. Chowdhury:

Presented herein is our Phase I Geologic Fault Assessment final report for the above captioned project. The study was performed in general accordance with our proposal number HE1416540 dated October 29, 2014.

This report presents HVJ Associates' understanding of the project's scope, the methodology we employed in executing the work, and the conclusions we reached.

It has been a pleasure to work with you on this project, and we appreciate the opportunity to be of service. Please notify us if there are questions or comments or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.
Texas Firm Registration No. F-000646

STATE OF TEXAS
EDWARD F. HAWKINSON
Geology
45
LICENSED
PROFESSIONAL GEOSCIENTIST

Edward F. Hawkinson, PG
Project Manager

EH/MH/sv/nl

Copies Submitted: 4 final & 1 electronic

The following lists the pages which complete this report:

- Main Text - 15 pages
- Plates - 9 pages
- Appendix A – 9 pages
- Appendix B – 8 pages
- Appendix C – 3 pages

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1. INTRODUCTION 1
   1.1 Project Objective 1
   1.2 Project Scope 1
   1.3 Basis of Report 1

2. PROJECT DESCRIPTION 2

3. BACKGROUND 2
   3.1 Geologic Setting 2
   3.2 Nature of Faulting 3
   3.3 Indications of Faulting 4
   3.4 Literature Review 4

4. FAULT ASSESSMENT 4
   4.1 Review of Aerial Photographs 4
   4.2 Review of Topographic Maps 5

5. RECONNAISSANCE 5
   5.1 Objectives 5
   5.2 Field Reconnaissance 5

6. SUMMARY OF FINDINGS/CONCLUSIONS 5
   6.1 Findings 5
   6.2 Conclusions 6

7. RECOMMENDATIONS 6

8. LIMITATIONS 8

9. REFERENCES 8

PLATES

Plate

SITE VICINITY MAP 1A

PROJECT LOCATION MAP 1B

PRINCIPAL ACTIVE FAULTS IN THE HOUSTON AREA 2

AREA FAULT PATTERN MAP 3

PROJECT ALIGNMENT FAULT MAP 4

LOCATION OF FAULT 8 ..... 5A & 5B

LOCATION OF FAULT 9 6

APPENDICES

AERIAL PHOTOGRAPHS ..... A

TOPOGRAPHIC MAPS ..... B

SITE PHOTOGRAPHS C

EXECUTIVE SUMMARY

HVJ Associates, Inc. has completed a Phase I Geologic Fault Assessment prior to the anticipated construction of water lines along Monroe Road and Rockhill Road from Airport Blvd. to Glen Valley Drive in Houston, Texas.

Our services included a review of available published and unpublished literature on faulting in the area, ground profile survey and site reconnaissance. The project alignment is mostly developed mixed residential and commercial area of Houston. Access to the project alignment was not limited. The available information for this project and the on-site reconnaissance conducted during November 2014 are summarized below:

- The subject project alignment appears to be in southeast of Houston with well documented fault systems with surface expressions. Two faults have been identified in the geologic literature near the project alignment on Monroe Road and over ten faults are located within one mile of the project. A northeast to southwest trending down to the southeast Fault No. 8 has been identified by the United States Geological Survey (USGS) as crossing Wynlea Street near the intersection of Monroe Road and terminating at or near Monroe Road. This fault is dashed on the USGS map at both its northeastern terminus on Wynlea Street near Monroe Road and its southwestern terminus near Airport Blvd. indicating that its exact position is uncertain due to modification of the landscape. A short northeast to southwest trending down to the southeast Fault No. 9 has been identified by the USGS as trending parallel to Monroe Road for a short distance near the intersection of Airport Blvd. This fault is not mapped crossing Airport Blvd.

- Analysis of a 1944 vertical aerial photograph revealed a linear feature or lineament near the project alignments which might be indicative of some faulting in the project alignment but not coincident with the mapped traces of Faults 8 and 9. Development in the project alignment makes resolution of these features difficult. Later photos showed no linear features that might be indicative of faulting.

- Examination of the 1915 historical topographic map revealed a topographic feature that could be related to some faulting in the area but not coincident with the mapped traces of Faults 8 and 9. Later topographic showed no features which could be interpreted as fault related.

- Cracked paving along the fault alignment was observed on Wynlea Street adjacent to Monroe Road. No obvious building damage indicating recent fault movement was observed.

Based on the information obtained in this study, the potential for surface faulting in the project alignment should be considered high. Fault 8 terminates near the intersection of Wynlea Street and Monroe Road near the project alignment and dips below the project alignment at an angle of 75° (from the horizontal). Since the location of this fault is fully documented in the geologic literature and documented by field reconnaissance we conclude that no additional investigation(s) to determine the extent of potential faulting in this part of the project alignment is needed. Fault 9 which is mapped near the intersection of Monroe Road and Airport Blvd. was not observed in the field or on aerial photographs; however, due to its proximity to the project alignment, we conclude that further assessment at this location is needed. No faults other than Faults 8 and 9 were observed and/or documented in the literature on or near the project alignment.

Faults are not always associated with lineaments. Thus in the absence of definitely recognizable fault scarps or fault-related damage, they may not be identifiable by visual inspection alone. Additionally, vegetative cover and uneven topography can obscure the presence of a fault, especially if it is slow moving or currently inactive. Predicting future fault activity cannot be done with certainty due to the number of variables involved. Dormant or very slow moving faults can be, respectively, reactivated or accelerated due to a number of reasons, including groundwater withdrawals and petroleum production.

Based on availbale information we cannot rule out fault activity at either fault location. We recommend that fault protective measures be designed based on a 50 year Design Criteria Movement of 11 inches vertically within a hazard band extending 100 feet from either side of each fault. The portions of the project potentially affected are from about Station 3+40 to 7+60 at fault 9 and Station 17+30 to 20+30 at fault 8. These hazard bands might be reduced or eliminated if Phase II subsurface fault investigations are conducted.

Two design approaches can be taken for design of buried utilities crossing a fault line. Limited measures to protect the utility can be taken and the utility can be designed to be easily serviced when a break occurs. This approach may be suitable for the 16-inch water line given the uncertainty in whether the faults actually cross the alignment and the lower level of impact of a future break. As an alternative, the section of the utility that is located within the fault zone can be designed to accommodate the projected fault movement without damage. We recommend this approach for at least the 60-inch line due to the higher impact of a break, unless Phase II fault studies are performed along the alignment to confirm that the faults are not present.

One approach to solving the deflection issues is to use jointed pipe within the fault zone that is capable of sustaining the rotation and extension that may occur. We recommend that valves be installed in the pipe near but outside the fault zone in order that the portion of the line within the fault zone can be easily isolated for repair in the event of a break.

This executive summary does not fully summarize our findings and opinions. Those findings and opinions are related through the full report only.

1. INTRODUCTION

1.1 Project Objective

HVJ Associates, Inc. was contracted by Kuo & Associates, Inc. to perform a Phase I Geologic Fault Assessment in support of proposed construction activities for the 60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive in Houston, Texas. The project alignment includes Rockhill from Glen Valley Drive to Monroe Road and Monroe Road from Rockhill to Airport Blvd. Access to the project alignment was not limited. The objective of this study was to identify active faulting in the study area (if any) based on available data, a site reconnaissance and to determine if faulting hazards exist that could affect planned development.

1.2 Project Scope

The following tasks were performed:

1. A search was conducted of available published and unpublished literature on geologic faulting to point out areas of known fault activity and assist in locating direct site-specific evidence. Literature reviewed included publications of the U.S. Geological Survey, Texas Bureau of Economic Geology, Gulf Coast Association of Geological Societies, and the Houston Geological Society.

2. A review of the results of previous fault studies, performed by HVJ Associates, in adjacent areas was conducted and relevant information from those studies was considered for this study.

3. A review of a series of black and white and colored vertical aerial photographs and both recent and historic U.S.G.S. topographic maps was conducted to identify features that may indicate the presence of faulting.

4. A physical site and area reconnaissance was performed to identify and locate features that indicate the presence of faulting. All evidence derived from the literature, photo and map reviews was evaluated in the field and used to locate the position of the ground profiles.

5. This report was prepared summarizing our findings, conclusions and recommendations. The investigation was conducted in accordance with current guidelines for Geologic Fault Studies contained in the March 1985 Houston Geological Society (HGS) Bulletin.

1.3 Basis of Report

Although this study has been a reasonably thorough attempt to identify faulting in the vicinity of and on the subject property, there is a possibility that existing faults may have escaped detection due to the inherent limitations of this or similar studies or the inaccuracy of published and unpublished data. If faults are present, the surface evidence may not be well developed or may be obscured by erosion, soil and vegetation cover, and/or new construction.

HVJ Associates reserves the right to alter our conclusions and recommendations based on our review of any information obtained after the date of this report. The data obtained during the course of this investigation and this report is for the sole and exclusive use of Kuo & Associates, Inc. Unless permission is granted for other uses by Kuo & Associates, Inc., HVJ Associates will hold all data, papers, correspondences, and reports pertaining to this study confidential to the extent allowed by law.

Our professional services have been performed using that degree of care and skill ordinarily exercised, under similar conditions, by geotechnical consultants practicing in this or similar localities. No warranty, express or implied, is made as to the professional information included in this report.

2. PROJECT DESCRIPTION

The project alignment extends along Monroe Road north of Airport Blvd. to Rockhill Street and along Rockhill Street west of Monroe Road to Glen Valley Drive in a primarily residential area. Airport Boulevard adjoins the project alignments to the south. The Hobby Airport main terminal adjoins the project alignment to the southwest (see Plates 1A and 1B for the project location). This project alignment was originally developed in the 1960's.

3. BACKGROUND

3.1 Geologic Setting

A review of the Bureau of Economic Geology 1982 Geologic Atlas of Texas, Houston Sheet indicates that the geologic formations underlying the project alignment are the Pleistocene Beaumont and Lissie Formations. The Beaumont Formation is a relatively younger formation generally found to the southeast of the Lissie Formation. The Beaumont formation dips southeastward and extends beneath beach sand and waters of the Gulf of Mexico as far as the continental shelf. The project site is located in the Beaumont Formation.

The Beaumont Formation was deposited on land near sea level in flat river deltas and in inter-delta regions. Soil deposition occurred in fresh water streams and in flood plains (as backwater marsh and natural levees). The courses of major streams and deltaic tributaries changed frequently during the period of deposition, generating within the Beaumont clay a complex stratification of sand, silt and clay deposits. Frequently, stream courses were diverted significant distances from a given point in a backwater marsh, and the water overlying the soil would evaporate since it was cut off from a drainage path. Such water, which would be highly alkaline, would precipitate large nodules of calcium carbonate (calcareous nodules) throughout the surface of evaporation. With the coming of the Second Wisconsin Ice Age, the nearby sea withdrew, leaving the formation several hundred feet above sea level and permitting the soil to desiccate. The process of desiccation compressed the clays in the formation such that they became significantly overconsolidated to a large depth. In addition to pre-consolidating the soil, the process of desiccation, together with the later rewetting, produced a network of fissures and slickensides that are now closed but which represent potential planes of weakness in the soil.

The Beaumont Formation is considered upper Pleistocene in age and typically consists of clays, silts, sands deposited in stream channels, point-bars, natural levees, backswamp and coastal marsh environments. Iron oxide concretions (generally pebble size) are found in the zone between 1 and 3 feet, and are locally known as "iron ore." The formation weathers to a fairly flat and featureless surface except for numerous rounded shallow depressions and pimple mounds.

In their "Map Showing Surface Faults in the Southeast Houston Metropolitan Area, Texas" (1978) prepared in conjunction with NASA, E.R. Verbeek and U.S. Clanton show two faults designated Faults 8 and 9 extending for relatively short distances on and near the Subject Project Alignments. Northeast to southwest trending down to the southeast Fault No. 8 has been identified as crossing Wynlea Street near the intersection of Monroe Road and terminating at or near Monroe Road. This fault is dashed on the USGS map at both its northeastern terminus on Wynlea Street near Monroe Road and its southwestern terminus near Airport Blvd. indicating that its exact position is uncertain due to modification of the landscape. A short northeast to southwest trending down to the southeast Fault No. 9 has been identified by the USGS as trending parallel to Monroe Road for a short distance near the intersection of Airport Blvd. This fault is not mapped crossing Airport Blvd.

Both of these faults are classic radial fault associated with the South Houston Oil Field salt dome to the northeast and the Mykawa Field salt dome to the southwest and is one of many in the Houston metropolitan area (see Plates 2 and 3). Antithetic (complementary) faults may also occur in conjunction with very active, larger growth faults. These antithetic faults tend to dip toward the active growth fault and terminate into it. Antithetic faults tend to be much shorter in length, and have smaller displacements. No antithetic faults were observed in the vicinity of the Faults 8 and 9.

3.2 Nature of Faulting

In the Gulf Coast region of Texas over 200 faults are known or suspected to be active with an aggregate length of approximately 370 miles. Many of these faults are located in the Greater Houston-Galveston area subsidence bowl. Although the existence of most of these faults have been reported in the literature, only 100, with an aggregate length of approximately 140 miles have been mapped at scales suitable for general use. These faults extend offshore several hundred miles and inland north of the Conroe area. Evidence of fault activity includes laterally persistent abrupt changes in the elevation of the ground surface (scarps) where the slope of the land on either side of the fault scarp is similar. Fault scarps can produce linear features (lineaments) on aerial photographs and topographic maps, linear patterns of vegetation that are primarily due to the ponding of water on the downthrown side of the fault, and damage to pavement and other structures. Evidence of active faulting in undeveloped areas may be obscured due to dense vegetation cover such as woods and underbrush.

Many faults are classified as growth (down-to-the-coast) faults wherein the dip angle of the fault near the ground surface is very high, averaging 75 degrees. These faults may have been active for a long period of time. As their name implies, growth faults are active during sedimentation, and consequently, subsurface features include increased thickness of geologic units on the downthrown side and increased displacement of these units with depth adjacent to the fault. Another type of fault found along the Gulf Coast is often associated with growth faults. These faults generally parallel growth faults and have a fault-plane dip that is up-to-the coast. Because of their opposite dip and close association with growth faults, these faults are known as antithetic faults. Growth faults and their antithetic faults have a strike or orientation that generally parallels the coast. Movement rates of growth and antithetic faults are slow and generally range from 0.1 in. to slightly more than 1.0 inches/year. Horizontal movements are extensional and depend upon the dip of the fault, generally being about one-fourth to one-half the vertical movement. These surface movements generally occur in a band of significant width which is likely to be different for each fault and to vary along the length of a particular fault. Band widths of 30 to 50 ft. are common, but wider or narrower bands are also found. In general, fault movement rates may be episodic for a specific fault and an extended period of time may pass between movement periods. Fault movement and fault reactivation has been attributed to fluid withdrawals from pumping of groundwater and oil and gas production, however the predominant affect of this fluid pumping has been local and regional ground subsidence. Fault movement and subsidence rates are documented in Houston where older structures or roadways can display damage.

Other types of faults found along the Gulf Coast are those associated with salt domes. Faults immediate to or overlying salt domes may have surface expressions that tend to be shorter in length and may form either an irregular radial or offset pattern around the salt dome. Away from the dome tangential faults may be present. Unlike growth faults, the orientation of dome-related faults does not follow a general orientation, that is, they can have strikes that are randomly oriented. In the general study area two salt domes are present. The South Houston Oil Field salt dome is located northeast of the study area and the Mykawa Field and salt dome is located southwest of the study area. These domes have associated faults, most of which have been identified by subsurface methods used by oil companies. Many faults mapped in the subsurface are inactive and do not extend to the surface.

3.3 Indications of Faulting

Evidence of faulting at the surface is not always readily identifiable and can also be falsely inferred. Topographic features such as escarpments associated with river terraces may resemble a fault scarp. However, in many cases these features cannot be traced laterally for any substantial distance, or the relative direction of movement observed might change significantly which would indicate the feature is not related to active faulting. Normal deterioration on existing buildings and other structures may produce damage that may resemble damage associated with active faulting. Other sources of linears that can erroneously suggest faulting include clearings made for seismic surveys during oil exploration, fence lines, stratigraphic contacts, or drainage patterns. In most cases, the observed linears on aerial photographs are related to changes in vegetation, while on topographic maps they are related to changes in slope and/or drainage patterns.

Though the existence of river terraces and other linear natural topographic features does not necessarily indicate the presence of a fault, there are times wherein fault scarps are coincident with and are the progenitors of these features. Additionally, there are instances where the fault may be offset from such a topographic feature yet nevertheless is the cause of its existence and the control on its orientation.

In undeveloped terrains covered by dense forest and underbrush and possessing varied topographic relief, the visual, onsite identification of fault scarps can be difficult. Lineaments that could be associated with faulting are likely to be masked by the heavy overgrowth. In such environments, several lines of boreholes across the study area may be needed to supplement the aerial photograph/topographic map analysis and field reconnaissance. Electric log data obtained from these boreholes can provide an idea of subsurface conditions and the likelihood of fault existence.

3.4 Literature Review

We reviewed published literature on faults in the Hobby Airport area. According to the United States Geological Survey (USGS) publication "Faults in Parts of North-Central and Western Houston Metropolitan Area, Texas" (Verbeek, Ratzlaff and Clanton, 1979) containing a figure modified after Verbeek and Clanton (1978) the northeast to southwest trending Fault 8 system extends to near the intersection of Monroe Road and Wynlea Street and is part of a regional fault system that extend from South Houston Oil Field northeast of the project alignment to Mykawa Oil Field southwest of the project alignment. A copy of this map is provided as Plate 4. This fault has caused documented damage to street curbs and paving. No data for movement rates across Faults 8 and 9 are available. Movement data, based on profiles across two nearby faults along Airport Blvd. are available (Elsbury, 1980). The profiles were taken in 1966 and 1974. When compared to the 1936 design elevation of Airport Blvd., a maximum vertical movement of about 0.66 feet (7.92 inches) was observed for 38 years, or about 0.21 inches per year. Projecting this movement over 50 years, a total movement of about 10.4 inches is estimated.

4. FAULT ASSESSMENT

4.1 Review of Aerial Photographs

HVJ Associates reviewed a series of aerial photograph for the general project alignment (see Appendix A). Due to extensive commercial and residential modifications of the landscape no obvious fault(s) were observed on photos later than 1944. The 1944 aerial photograph shows a northeast to southwest trending linear feature that may be associated with some of the faulting in the general project alignment but not Faults 8 and 9.

In viewing aerial photographs, features that may indicate the presence of a fault, include tonal variations in vegetation, areas of standing water and lineations associated with drainage patterns. These features by themselves do not prove that a fault is present, but allow for more effective topographic map review and field reconnaissance.

4.2 Review of Topographic Maps

HVJ Associates reviewed 1915 and later topographic maps for the Park Place and Pearland Quadrangles, Texas (see Appendix B). Because of a terrain with relatively low relief and five-foot contour intervals, no obvious lineaments were observed on maps later than 1915. The 1915 map with its one-foot contour intervals provided more definition to the topography in the study area. A narrowing of some contours (that coincided with a significant change in slope) within the project alignment suggests fault influence and may be indicative of some faults in the area but not Faults 8 or 9 (a northeast to southwest trending ridge is shown where Hobby Airport is now present). The contours coincide with the strike of the family of faults located on and immediately east of the Hobby Airport area.

5. RECONNAISSANCE

5.1 Objectives

A reconnaissance was performed during November 2014 on foot and by automobile to observe the project alignment and areas identified through literature research and on topographic maps for evidence of faulting.

5.2 Field Reconnaissance

During the course of the field reconnaissance, paved roads adjacent to the project alignment were examined for road surface flexures and/or cracks that would be indicative of faulting. Cracked paving related to Fault 8 was observed near the project alignment near the intersection of Wynlea and Monroe Road. No obvious building damage indicating recent fault movement was observed (a series of site photos showing this location is provided in Appendix C). Plate 4 shows the trend of this fault based on this information and our literature review. Plate 5 shows the trend of this fault based on this our field reconnaissance.

It should be noted that a common complication in many fault studies is that much of the evidence normally used to map surface traces of faults in the Gulf Coast have been destroyed in developed areas. Only the most active and damaging faults or faults whose scarps are of substantial height are likely to be noticed during mapping of developed areas. Mapping of faults is most difficult in areas of recent construction. In older developed area faulting can be located quite accurately at many points where it has damaged buildings, road and other manmade structures. The Fault 8 trace is evident near the project alignment but obscured by landscape modifications to the northeast near Monroe Road and the southwest near Airport Blvd. Fault 9 was not observed near the southeast corner of the project alignment because of landscape modifications.

6. SUMMARY OF FINDINGS/CONCLUSIONS

Based on our site reconnaissance and review of available information obtained for this project, our findings and conclusions are summarized below:

6.1 Findings

The subject project alignment appears to be in an area of Houston with well documented fault systems with surface expressions. One main active surface fault is present in the project alignment. The main fault in the project alignment is northeast to southwest trending Fault 8 which was found to terminate near the intersection of Wynlea Street and Monroe Road. Its approximate location is depicted on Plates 3, 4, 5A and 5B. During site reconnaissance an obvious expression of Fault 8 was observed at one location on Wynlea Street near the intersection of Monroe Road. This fault does not appear to cross Monroe Road. Fault 9 which is mapped near the intersection of Monroe Road and Airport Blvd. was not observed in the field or on aerial photographs.

Analysis of a 1944 vertical aerial photograph revealed a linear feature or lineament near the project alignment which might be indicative of faulting. Development in the project alignment makes resolution of these features difficult. Later photos showed no linear features that might be indicative of faulting. Examination of the 1915 historical topographic map revealed a topographic feature that could be related to faulting. Later topographic showed no features which could be interpreted as fault related. Cracked paving indicative of faulting was observed at one location on Wynlea Street. No obvious building damage indicating recent fault movement was observed.

6.2 Conclusions

Based on the information obtained in this study, the potential for surface faulting in the project alignment should be considered high. Fault 8 terminates near the intersection of Wynlea Street and Monroe Road near the project alignment and dips below the project alignment at an angle of 75° (from the horizontal). Since the location of this fault is fully documented in the geologic literature and documented by field reconnaissance we conclude that no additional investigation(s) to determine the extent of potential faulting in this part of the project alignment is needed. Fault 9 which is mapped near the intersection of Monroe Road and Airport Blvd. was not observed in the field or on aerial photographs however, due to its proximity to the project alignment, we conclude that further assessment at this location is needed. No faults other than Faults 8 and 9 were observed and/or documented in the literature on or near the project alignment.

Faults are not always associated with lineaments. Thus in the absence of definitely recognizable fault scarps or fault-related damage, they may not be identifiable by visual inspection alone. Additionally, vegetative cover and uneven topography can obscure the presence of a fault, especially if it is slow moving or currently inactive. Predicting future fault activity cannot be done with certainty due to the number of variables involved. Dormant or very slow moving faults can be, respectively, reactivated or accelerated due to a number of reasons, including groundwater withdrawals and petroleum production.

7. RECOMMENDATIONS

Fault 8 is well documented in the geologic literature and terminates near the project alignment near the intersection of Wynlea Street and Monroe Road. This fault location was confirmed in the field and is expressed by obvious cracked pavement at one location. Due to the lack of evidence of additional fault indicators unrelated to Fault 8 such as scarps or linear features in this part of the project alignment, additional faulting is probably not present on or near this part of the Subject Project Alignment and further assessment(s) are not recommended at this location. Fault 9 which is mapped near the intersection of Monroe Road and Airport Blvd. was not observed in the field or on aerial photographs however, due to its mapped proximity to the project alignment, we recommend further assessment at this location.

Planned construction consists of 16-inch and 60-inch diameter water lines. The lines will be installed using open-cut techniques in the vicinity of faults 8 and 9 with the exception of the tunneled crossing of Airport Boulevard along Monroe which is located south of fault 9. The fault protective measures required for a buried utility are determined based on the size of the utility, the method of installation, and the fault activity. While there is some uncertainty of whether faults 8 or 9 actually cross the alignment, we recommend that the 60-inch line in particular be designed with protective measures unless additional study is done to confirm that faulting is not present. We recommend that fault protective measures be designed based on a 50 year Design Criteria Movement of 11 inches vertically within a hazard band extending 100 feet from either side of each fault. The portions of the project potentially affected are from about Station 3+40 to 7+60 at fault 9 and Station 17+30 to 20+30 at fault 8.

Two design approaches can be taken for design of buried utilities crossing a fault line. Limited measures to protect the utility can be taken and the utility can be designed to be easily serviced when a break occurs. This approach may be suitable for the 16-inch water line given the uncertainty in whether the faults actually cross the alignment and the lower level of impact of a future break. As an alternative, the section of the utility that is located within the fault zone can be designed to accommodate the projected fault movement without damage. We recommend this approach for at least the 60-inch line due to the higher impact of a break, unless Phase II fault studies are performed along the alignment to confirm that the fault is not present.

The utility design at the fault crossing needs to address the following fault-related design issues in addition to the normal utility design issues:

1. Vertical loads due to the fault displacement,
2. Lateral loads due to the fault offset,
3. Loss of support beneath a portion of the culvert due to fault displacement,
4. Tension stress in the culvert due to fault extension, and
5. Rotation and extension at the culvert pipe joints due to fault displacement.

One approach to solving the deflection issues is to use jointed pipe within the fault zone that is capable of sustaining the rotation and extension that may occur. These design issues and our related recommendations are discussed in the following paragraphs. We recommend that valves be installed in the pipe near but outside the fault zone in order that the portion of the line within the fault zone can be easily isolated for repair in the event of a break.

Vertical Load. The fault is projected to produce up to about 11 inches of vertical offset over a fifty-year period. This vertical loading will deform the pipe and needs to be accommodated without damage to the pipe.

Lateral Load. The fault is projected to produce up to about four inches of lateral movement over a fifty-year period. To the extent that the pipe centerline does not cross perpendicular to the fault lateral loads can be generated. These lateral loads will deform the pipe and need to be accommodated without damage to the pipe.

Loss of Support. The pipe will tend to "bridge" and lose contact with the underlying soil for some distance on the downthrown side of the fault. The pipe must be designed to accommodate this loss of support without damage.

Tension Stress. The fault is projected to produce about 4 inches of horizontal extension along the alignment over a fifty-year period. The soil structure friction will produce tension stresses in the pipe because of the extension which need to be resisted by the pipe without damage. This tension may also have a tendency to disengage joints between pipe sections located within the fault area.

Backfill and Bedding. Rigid backfill and bedding materials, such as cement stabilized sand, should not be used within the fault hazard zones identified in this report. Rigid materials can cause stress concentrations leading to highly localized failure of the pipe, and they may make access to the pipe for repair more difficult. Crushed rock with sand backfill is preferred.

Within the hazard zones we recommend that the trench be lined with a geotextile filter installed per the manufacturer's recommendations. This lining will serve to prevent infiltration of natural soil into the backfill and will prevent sediment inflow into the culvert in case of breakage or joint distress.

Alignment. We recommend that no sensitive structures be installed within the hazard zones. Sensitive structures include manholes, valves, access manways and similar facilities.

8. LIMITATIONS

The conditions and recommendations contained in this report are based on our review of available documents and field geologic mapping techniques. Shallow soil conditions, cultural activities, new construction, slow movement rates, and repair of existing fault damage may obscure fault-related features.

This report is an instrument of service of HVJ Associates, Inc. The report was prepared for and is intended for the exclusive use of Kuo & Associates, Inc. The report's contents may not be relied upon by any other party without the express written permission of HVJ Associates and Kuo & Associates, Inc.

The report's findings are based on conditions that existed on the dates of HVJ Associates site visit(s) and should not be relied upon to precisely represent conditions at any other time. All conclusions are qualified by the fact that no excavations or borings were made and no geophysical surveys or logging was conducted. Conclusions about site conditions under no circumstances comprise a warranty that conditions in all areas within the site and study area (and below existing grade) are of the same quality that HVJ Associates has inferred from observable site conditions.

HVJ Associates' findings and conclusions must be considered probabilities based on professional judgment applied to the limited data HVJ Associates was able to gather during the course of this fault study.

9. REFERENCES

The following references were used to compile this report:

- A Study of Active Fault Movement, Houston, Texas and Vicinity. Unpublished M.S. Thesis, University of Houston. J.J. Mastroianni, December 1991.

- Approximate Land-Surface Subsidence in the Houston-Galveston Region, Texas, 1906-78, 1943-78, and 1973-78, Open File Report 80-338, US Geological Survey, March 1980.

- Park Place and Pearland Quadrangles, Texas Topographic Map, US Geological Survey, 1915 and later.

- Elsbury, B.R. et. al., September 1980. Engineering Aspects of the Houston Fault Problem. ASCE Texas and New Mexico Sections Fall Meeting.

- Faulting and Land Subsidence from Ground-Water and Hydrocarbon Production, Houston-Galveston, Texas. C.W. Kreitler, Bureau of Economic Geology, Univ. of Texas at Austin, Research Note 8, 1978.

- Geologic Atlas of Texas, Houston Sheet, Bureau of Economic Geology, Univ. of Texas at Austin, 1968, revised 1992.

- Verbeek, Ratzlaff and Clanton, U.S. Geological Survey, 1979, Miscellaneous Field Studies, Map MF-1136, Faults, Houston Metropolitan Area, Texas.

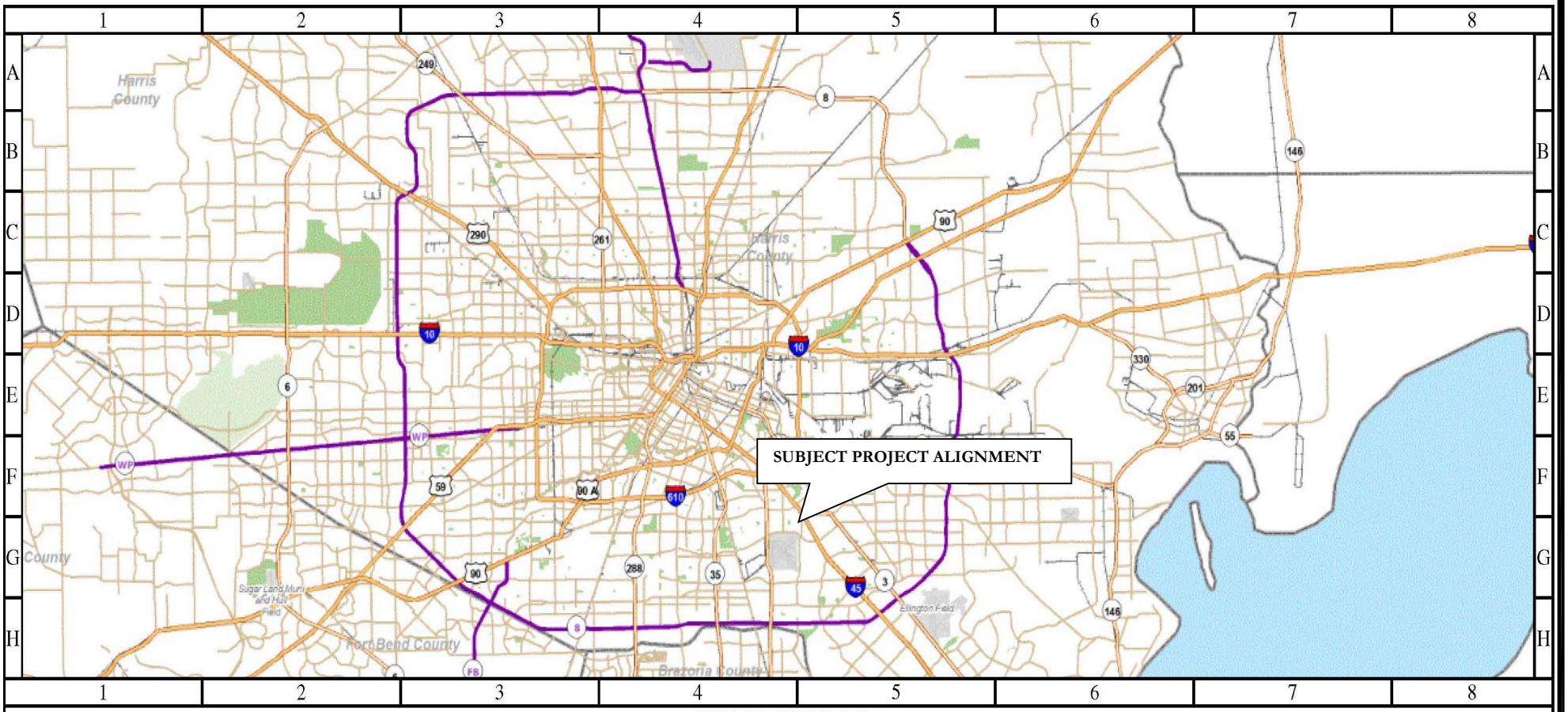
- Historically Active Faults in the Houston Metropolitan Area, Texas, in Houston Area Environmental Geology: Surface Faulting, Ground Subsidence, Hazard Liability, Verbeek E.R. and Clanton, U.S., Houston Geological Society, 1981.

- Soil Survey of Harris County Texas, Soil Conservation Service, US Department of Agriculture, 1972.

- Clanton. U.S. and Amsbury, D. L., 1976, Active Faults in Southeast Harris County, Texas: Environmental Geology, v. 1, no. 3.

- Kreitler, C.W., 1976, Lineations and Faults in the Texas Coastal Zone, Report of Investigations No. 85, Bureau of Economic Geology, the University of Texas.

PLATES



CITY OF HOUSTON

Department of Public Works and Engineering

Geographic Information & Management System (GIMS)

1 inch = 29465 feet

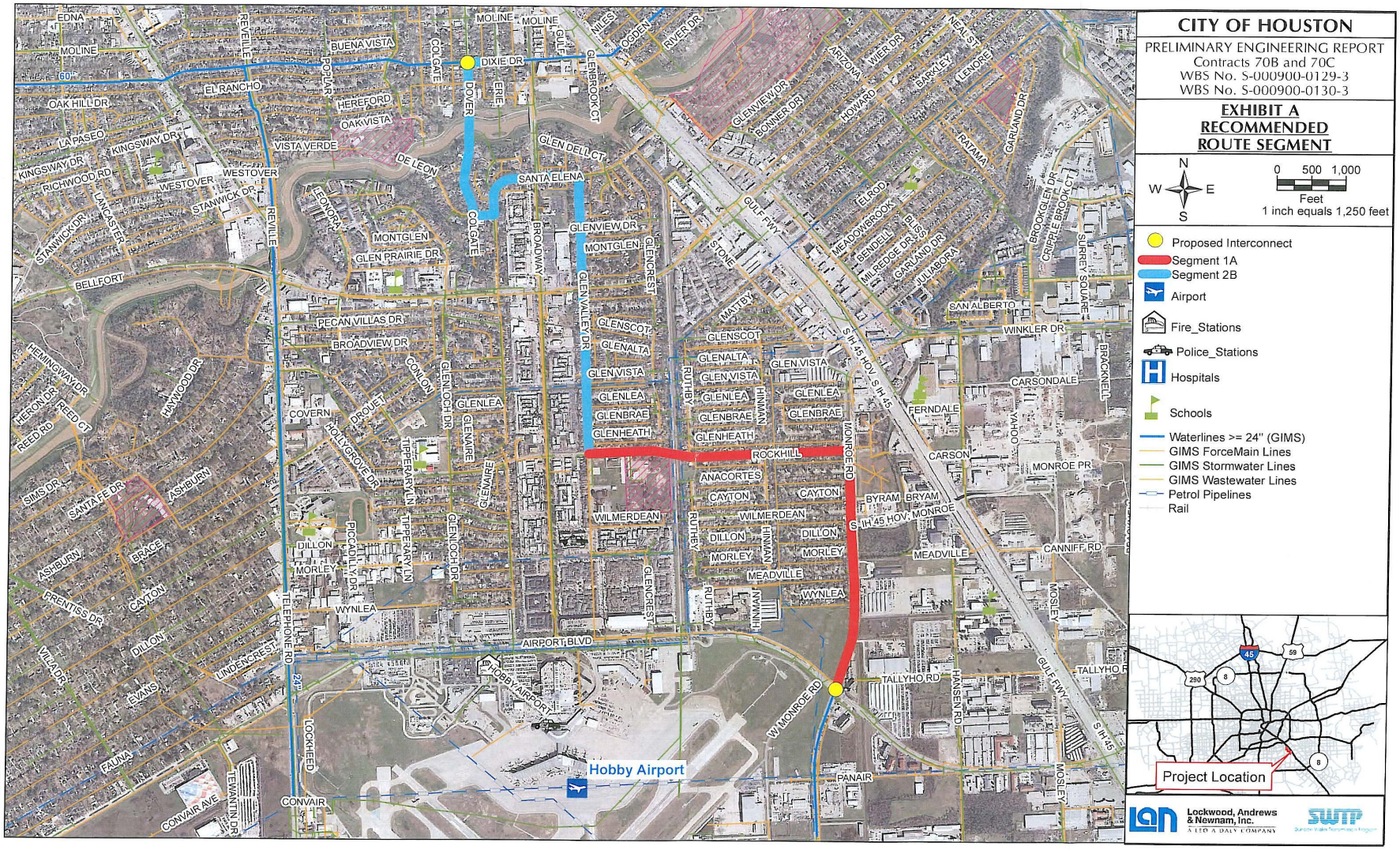
DISCLAIMER: THIS MAP REPRESENTS THE BEST INFORMATION AVAILABLE TO THE CITY.
THE CITY DOES NOT WARRANT ITS ACCURACY OR COMPLETENESS.
FIELD VERIFICATIONS SHOULD BE DONE AS NECESSARY.

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

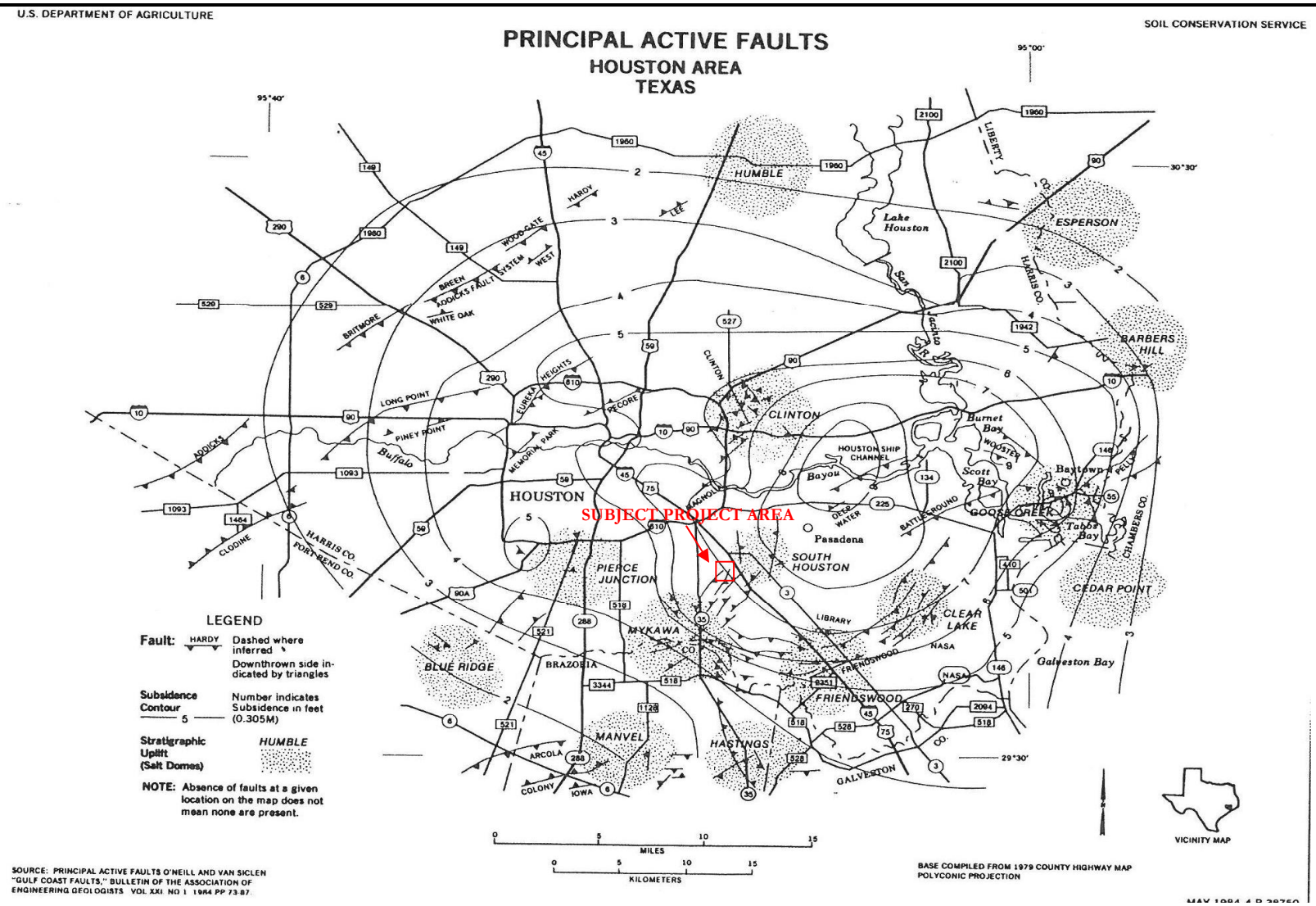
DATE: 4/27/2015	APPROVED BY: MM	PREPARED BY: EH

SITE VICINITY MAP
60-Inch Water Line along Monroe and Rockhill
From Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3

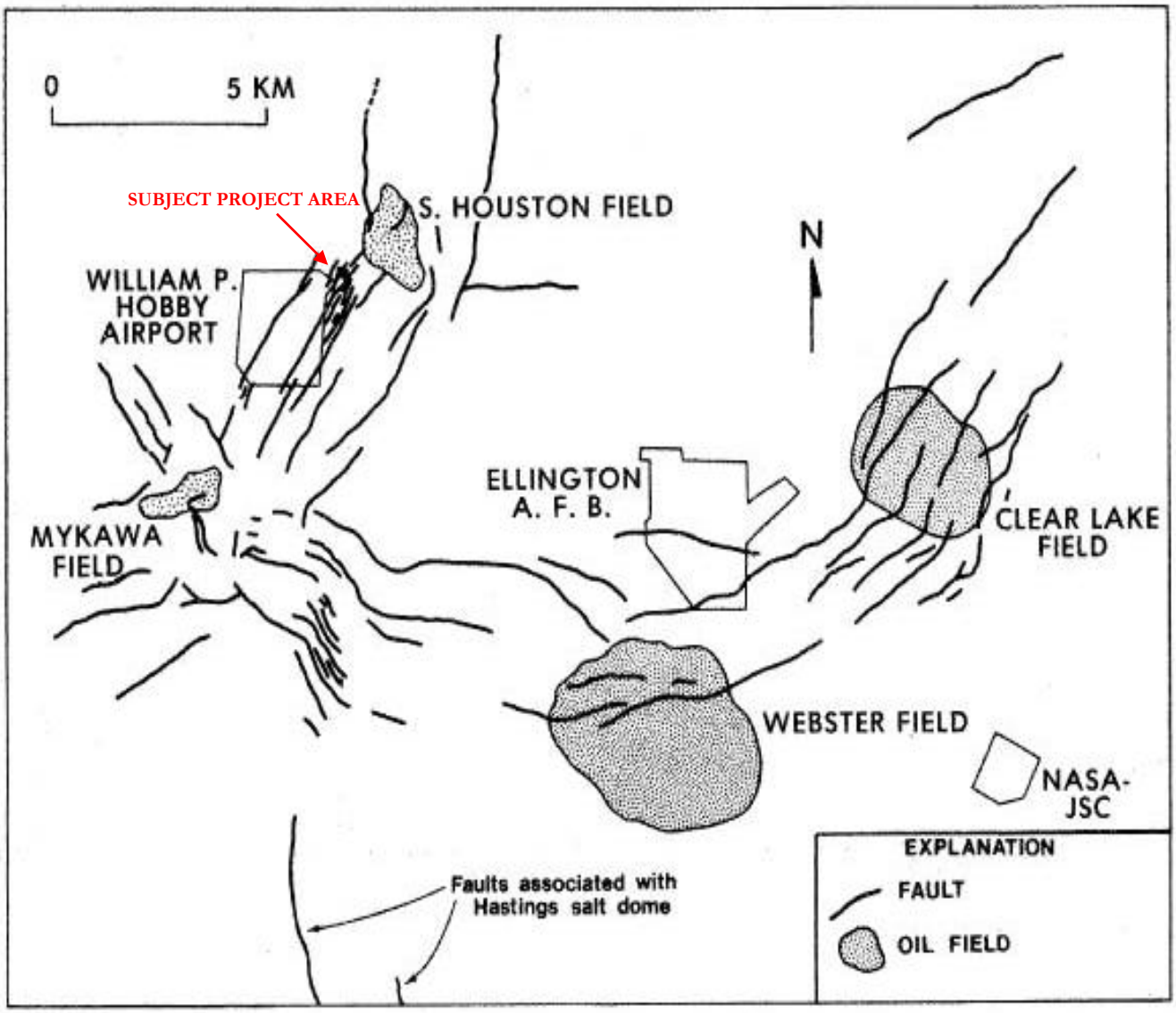
PROJECT NO.: HE1416540	DRAWING NO.: PLATE 1A



HVJ ASSOCIATES	Drawn:	NL	**Plate 1B** **Geologic Fault Assessment** **Project Location Map** **60-Inch Water Line Along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
	Checked:	EH	
	Date:	April 2015	
Project No. HE1416540	Scale	NTS	

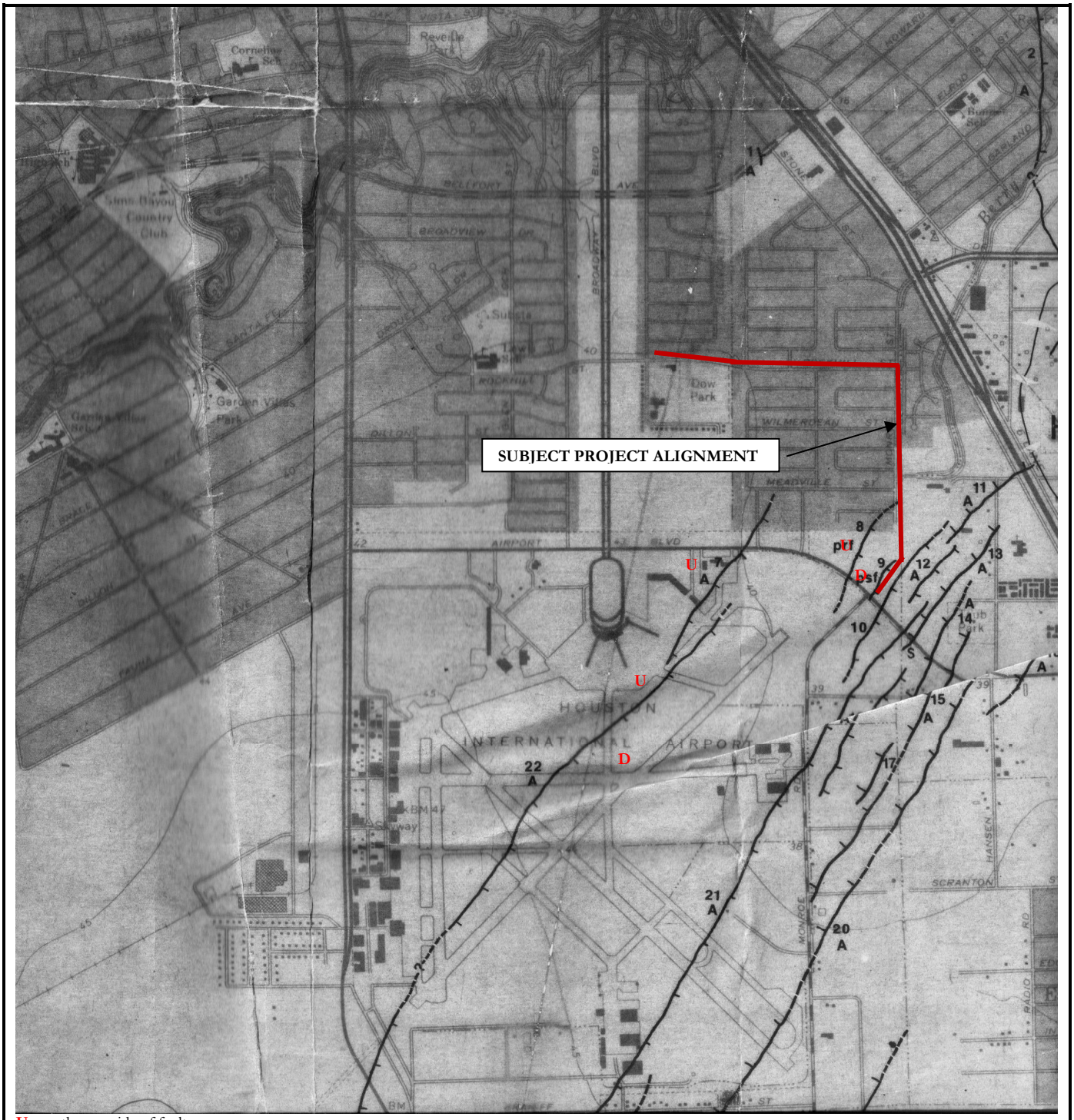


HVJ ASSOCIATES	Drawn:	NL	**Plate 2** **Principal Active Faults in the Houston Area** **60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
	Checked:	MH	
	Date:	April 2015	
Report No. HE1416540	Scale:	NTS	



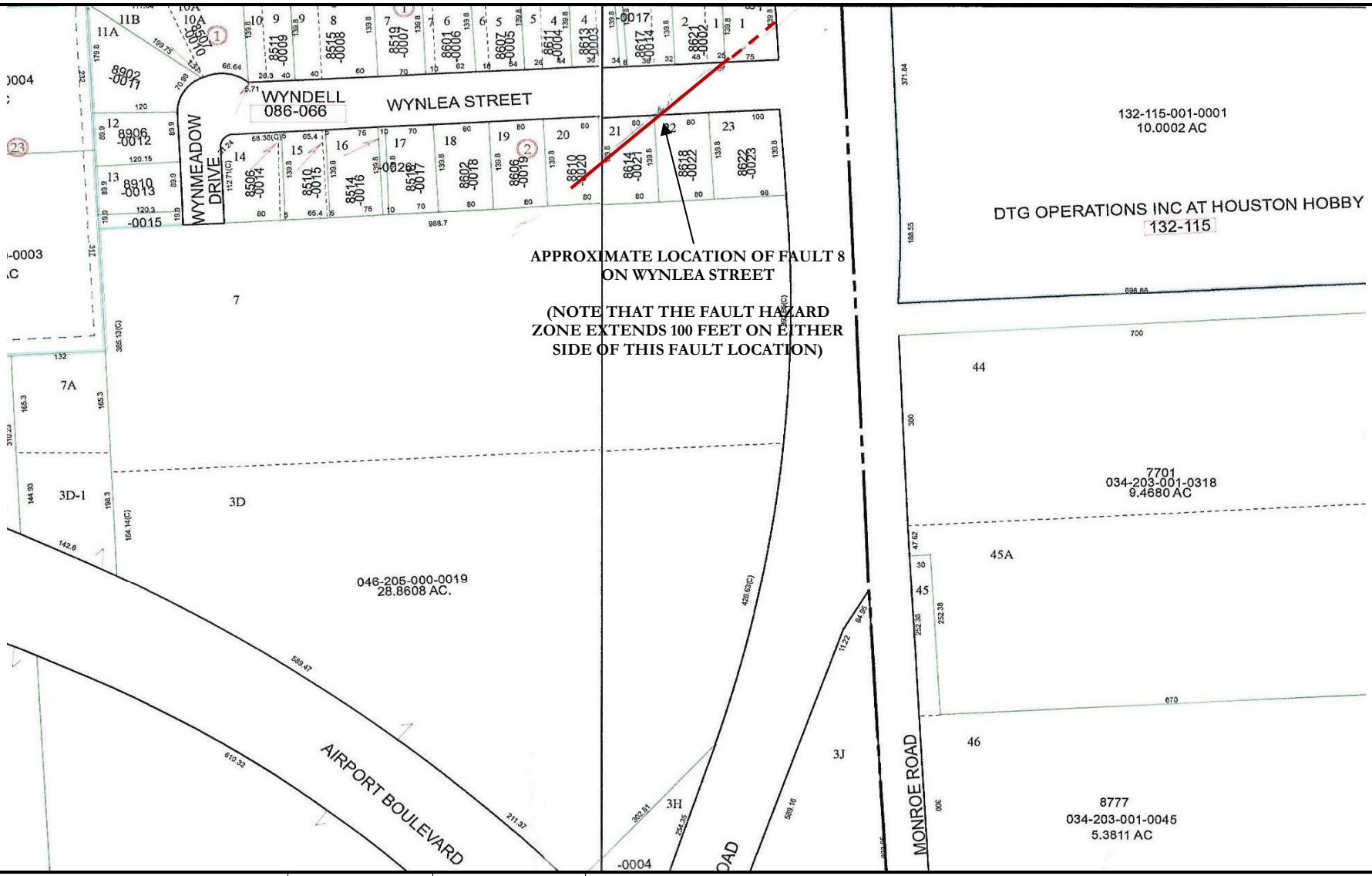
Note: Modified after Verbeek and Clanton (1978)

HVJ ASSOCIATES		Drawn:	NL	**Plate 3** **Project Area Fault Pattern Map** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**	N
		Checked:	EH		
		Date:	April 2015		
Report No.	HE1416540	Scale:	NTS		

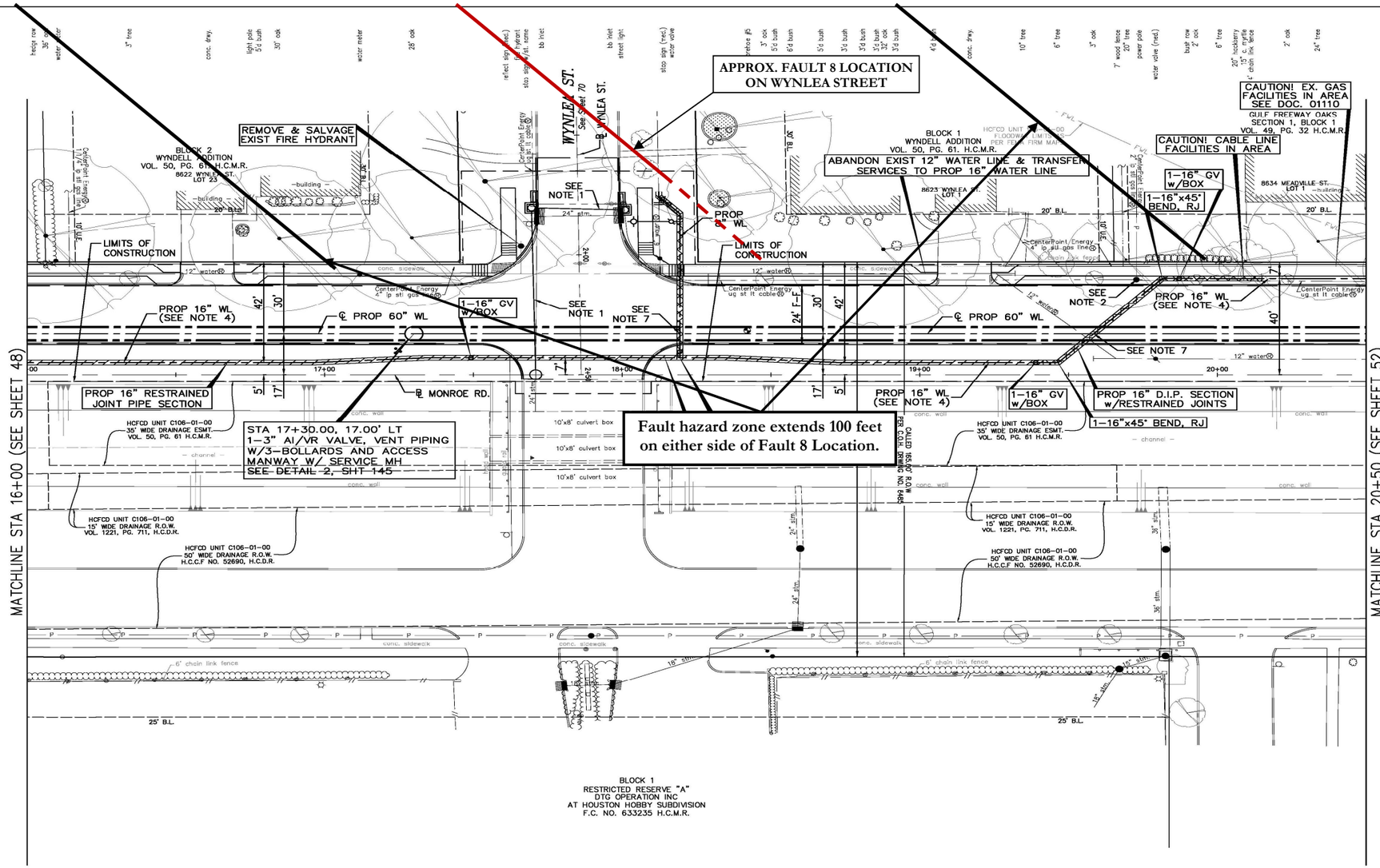


U – upthrown side of fault
D – downthrown side of fault
Note: solid line where position is certain based on field and other evidence. Dashed where exact position is uncertain due to modification of the landscape.
Source: Verbeek, Ratzlaff and Clanton, U.S. Geological Survey, 1979, Miscellaneous Field Studies, Map MF-1136, Faults, Houston Metropolitan Area, Texas.

HVJ ASSOCIATES		Drawn:	NL	**Plate 4** **Project Area Fault Location Map** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



HVJ ASSOCIATES	Drawn:	NL	**Plate 5A** **Location of Fault 8 on Wynlea Street** **60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
	Checked:	EH	
	Date:	April 2015	
Report No. HE1416540	Scale:	NTS	



SEE SHEET 51 FOR PROFILE

SCALE: 1" = 20'-0"

BENCHMARK:
CITY OF HOUSTON MONUMENT 5653-0812, A BRASS DISK IN CONCRETE. LOCATED AT SOUTH OF THE INTERSECTION OF ROCKHILL STREET AND RUTHBY STREET.

ELEV. 33.336 FEET NAVD 1988 (CORS96)*

* OBSERVED BY GPS SURVEYING AND PROCESSED IN REFERENCE TO THE CORS DATED FEBRUARY 27, 2014 & GEOID '12A.

NOTE: BEARINGS AND COORDINATES SHOWN HEREON ARE REFERENCED TO THE TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE, NAD 83 (CORS 96) (EPOCH: 2002.0000)

T.B.M.
T.B.M. # 15:
SET "X" CUT ON CONC., APPROX. CENTER OF MONROE RD. AT WYNLEA ST.
ELEV.=32.72 FEET (℄ STA. 17+69.63 OFFSET: 34.99' RT)

NOTE:
1) SEE SHEETS 76 TO 109, REGARDING PROPOSED PAVEMENT AND STORM SEWER, FOR MORE INFORMATION.
2) SEE SHEETS 135 TO 136, REGARDING STREET LIGHTING PLAN, FOR MORE INFORMATION.
3) ADJUST EXISTING WATER VALVE/METER BOXES TO NEW GRADE. REPLACE ALL MISSING OR DAMAGED WATER VALVE/METER BOXES AND COVERS.
4) THE PROPOSED 16" AND SMALLER WATER LINES SHALL BE BUILT BY MEANS OF TRENCHLESS CONSTRUCTION. CONTRACTOR TO DETERMINE THE LOCATIONS OF PITS IN FIELD, SUBJECT TO THE CITY ENGINEER'S APPROVAL.
5) REFER TO CONSTRUCTION PHASING AND SEQUENCING, AND TRAFFIC CONTROL PLANS SHEETS 194 TO 236, FOR MORE INFORMATION.
6) TREES ARE LOCATED IN THE VICINITY OF PROPOSED ALIGNMENT OF WATER LINE AND ITS APPURTENANCES. REFER TO THE TREE PROTECTION PLANS SHEETS 237 TO 244, FOR APPROPRIATE PROTECTION MEASURES.
7) REMOVE AND REPLACE ONE FULL JOINT OF NEWLY CONSTRUCTED 16"/8" WATER LINE IF NECESSARY FOR CONSTRUCTION OF PROPOSED 60" WATER LINE.

SWTP
Surface Water Transmission Program

TO ARRANGE FOR LINES TO BE TURNED OFF OR MOVED, CALL CENTERPOINT ENERGY AT 713-207-2222
NOTICE:
FOR YOUR SAFETY, YOU ARE REQUIRED BY TEXAS LAW TO CALL 811 AT LEAST TWO WORKING DAYS BEFORE YOU DIG, DRILL OR BLASTING. THIS VERIFICATION DOES NOT FULFILL YOUR OBLIGATION TO CALL 811.

VERIFICATION OF PRIVATE UTILITY LINES

Date:
CENTERPOINT ENERGY/UNDERGROUND ELECTRICAL FACILITIES VERIFICATION ONLY.
(THE SIGNATURE VARIFIES EXISTING UNDERGROUND FACILITIES - NOT TO BE USED FOR CONFLICT VERIFICATION.) SIGNATURE VALIED FOR SIX MONTHS.

Date:
CENTERPOINT ENERGY/NATURAL GAS FACILITIES VERIFICATION ONLY.
(THIS SIGNATURE VERIFIES THAT YOU HAVE SHOWN CNP NATURAL GAS LINES CORRECTLY. NOT TO BE USED FOR CONFLICT VERIFICATION.) (GAS SERVICE LINES ARE NOT SHOWN.) SIGNATURE VALID FOR SIX MONTHS.

Date:
Approved for AT&T Texas/SWBT underground conduit facilities only.
SIGNATURE VALID FOR ONE YEAR

KUO & associates, Inc.
Consulting Engineers & Surveyors
10700 Richmond Ave., Ste 113, Houston, Texas 77042
Tel: 713-975-0765, Fax: 713-975-0520
www.kuoassociates.com
Texas Firm Registration No. F-4578
TBPLS Firm Registration No. 10075600

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF
SUDHEER GOUD SANGAM, P.E.
TEXAS REG. NO.: 111684
ON 12/12/2014
IT IS NOT TO BE USED FOR PERMIT, BIDDING OR CONSTRUCTION PURPOSES

SURVEYED BY:
KUO & ASSOCIATES, Inc.
C.O.H. Field Book P-5887

KUO & ASSOCIATES, INC.
TEXAS FIRM NO. F-4578

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SWTP CONTRACT 70B

WATER LINE
MONROE ROAD
PLAN
STA 16+00 TO STA 20+50

SHEET 7 OF 16

WBS NO. S-000900-0129-4	
DRAWING SCALE	
HORIZ: 1"=20',VERT: 1"=2'	
CITY OF HOUSTON PM	
ARTHUR MORRIS, P.E.	
SHEET NO. 50 OF 246	

No.	Date	Revisions	App.

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

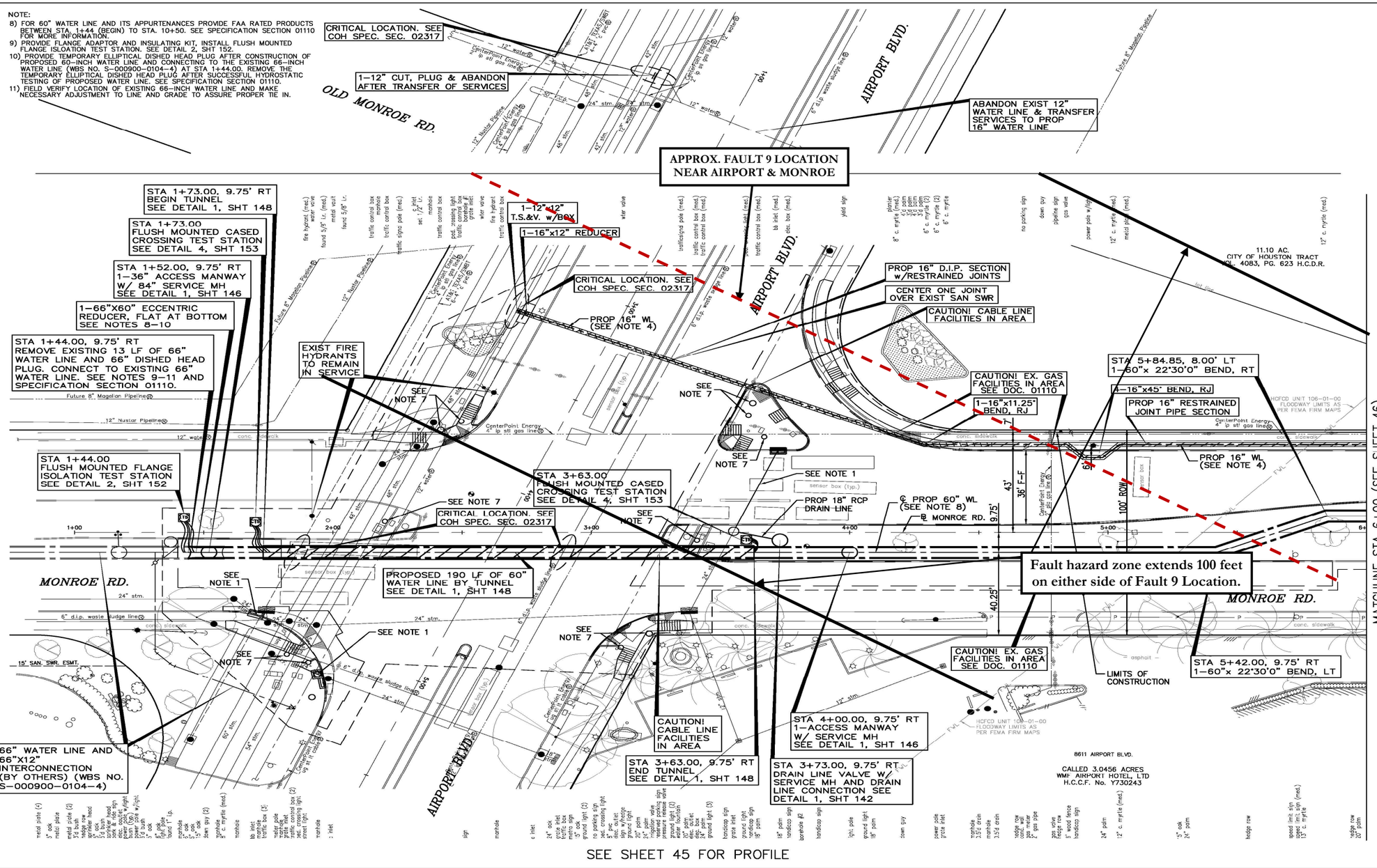
DATE: 4/28/2015	APPROVED BY: EH	PREPARED BY: NL

60-Inch Water Line along Monroe and Rockhill
From Airport Blvd. to Glen Valley Drive
Fault 8 Location near Monroe & Wynlea

PROJECT NO.: HE1416540	DRAWING NO.: PLATE 5B

NOTE:

8) FOR 60" WATER LINE AND ITS APPURTENANCES PROVIDE FAA RATED PRODUCTS BETWEEN STA. 1+44 (BEGIN) TO STA. 10+50. SEE SPECIFICATION SECTION 01110 FOR MORE INFORMATION.
9) PROVIDE FLANGE ADAPTOR AND INSULATING KIT, INSTALL FLUSH MOUNTED FLANGE ISLOATION TEST STATION. SEE DETAIL 2, SHT 152.
10) PROVIDE TEMPORARY ELLIPTICAL DISHED HEAD PLUG AFTER CONSTRUCTION OF PROPOSED 60-INCH WATER LINE AND CONNECTING TO THE EXISTING 66-INCH WATER LINE (WBS NO. S-000900-0104-4) AT STA 1+44.00. REMOVE THE TEMPORARY ELLIPTICAL DISHED HEAD PLUG AFTER SUCCESSFUL HYDROSTATIC TESTING OF PROPOSED WATER LINE. SEE SPECIFICATION SECTION 01110.
11) FIELD VERIFY LOCATION OF EXISTING 66-INCH WATER LINE AND MAKE NECESSARY ADJUSTMENT TO LINE AND GRADE TO ASSURE PROPER TIE IN.



SCALE: 1" = 20'-0"

BENCHMARK:
CITY OF HOUSTON MONUMENT 5653-0812, A BRASS DISK IN CONCRETE, LOCATED AT SOUTH OF THE INTERSECTION OF ROCKHILL STREET AND RUTHBY STREET.

ELEV. 33.336 FEET NAVD 1988 (CORS96)*

* OBSERVED BY GPS SURVEYING AND PROCESSED IN REFERENCE TO THE CORS DATED FEBRUARY 27, 2014 & GEOID '12A.

NOTE: BEARINGS AND COORDINATES SHOWN HEREON ARE REFERENCED TO THE TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE, NAD 83 (CORS 96) (EPOCH: 2002.0000)

T.B.M.
T.B.M. # 11:
SET 1/2" I.R. W/CAP AT SOUTHWEST CORNER OF AIRPORT BLVD. AND MONROE RD. INTERSECTION.
ELEV.=32.02 FEET (℄ STA. 2+33.27 OFFSET: 50.45' LT)

NOTE:
1) SEE SHEETS 76 TO 109, REGARDING PROPOSED PAVEMENT AND STORM SEWER, FOR MORE INFORMATION.
2) SEE SHEETS 135 TO 136, REGARDING STREET LIGHTING PLAN, FOR MORE INFORMATION.
3) ADJUST EXISTING WATER VALVE/METER BOXES TO NEW GRADE. REPLACE ALL MISSING OR DAMAGED WATER VALVE/METER BOXES AND COVERS.
4) THE PROPOSED 16" AND SMALLER WATER LINES SHALL BE BUILT BY MEANS OF TRENCHLESS CONSTRUCTION. CONTRACTOR TO DETERMINE THE LOCATIONS OF PITS IN FIELD, SUBJECT TO THE CITY ENGINEER'S APPROVAL.
5) REFER TO CONSTRUCTION PHASING AND SEQUENCING, AND TRAFFIC CONTROL PLANS SHEETS 194 TO 236, FOR MORE INFORMATION.
6) TREES ARE LOCATED IN THE VICINITY OF PROPOSED ALIGNMENT OF WATER LINE AND ITS APPURTENANCES. REFER TO THE TREE PROTECTION PLANS SHEETS 237 TO 244, FOR APPROPRIATE PROTECTION MEASURES.
7) SEE SHEETS 177 TO 182, REGARDING PROPOSED TRAFFIC SIGNALS, FOR MORE INFORMATION.

SWTP LQN
Surface Water Transmission Program

TO ARRANGE FOR LINES TO BE TURNED OFF OR MOVED, CALL CENTERPOINT ENERGY AT 713-207-2222
NOTICE:
FOR YOUR SAFETY, YOU ARE REQUIRED BY TEXAS LAW TO CALL 811 AT LEAST 48 HOURS BEFORE YOU DIG, BORE, OR EXCAVATE TO HAVE UTILITIES MARKED. THIS VERIFICATION DOES NOT FULFILL YOUR OBLIGATION TO CALL 811.

VERIFICATION OF PRIVATE UTILITY LINES

Date:
CENTERPOINT ENERGY/UNDERGROUND ELECTRICAL FACILITIES VERIFICATION ONLY.
(THE SIGNATURE VARIFIES EXISTING UNDERGROUND FACILITIES - NOT TO BE USED FOR CONFLICT VERIFICATION.) SIGNATURE VALID FOR SIX MONTHS.

Date:
CENTERPOINT ENERGY/NATURAL GAS FACILITIES VERIFICATION ONLY.
(THIS SIGNATURE VERIFIES THAT YOU HAVE SHOWN CNP NATURAL GAS LINES CORRECTLY - NOT TO BE USED FOR CONFLICT VERIFICATION.) (GAS SERVICE LINES ARE NOT SHOWN.) SIGNATURE VALID FOR SIX MONTHS.

Date:
Approved for AT&T Texas/SWBT underground conduit facilities only.
SIGNATURE VALID FOR ONE YEAR

KUO & associates, Inc.
Consulting Engineers & Surveyors
10700 Richmond Ave., Ste 113, Houston, Texas 77042
Tel: 713-975-8769, Fax: 713-975-0920
www.kuoassociates.com
Texas Firm Registration No. F-4578
TBPLS Firm Registration No. 10075500

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF
SUDHEER GOUD SANGAM, P.E.
TEXAS REG. NO.: 111684
ON 12/12/2014
IT IS NOT TO BE USED FOR PERMIT, BIDDING OR CONSTRUCTION PURPOSES

SURVEYED BY:
KUO & ASSOCIATES, Inc.
C.O.H. Field Book P-5887

KUO & ASSOCIATES, INC.
TEXAS FIRM NO. F-4578

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SWTP CONTRACT 70B

WATER LINE
MONROE ROAD
PLAN
BEGIN TO STA 6+00

SHEET 1 OF 16

WBS NO. S-000900-0129-4	
DRAWING SCALE	
HORIZ: 1"=20',VERT: 1"=2'	
CITY OF HOUSTON PM	
ARTHUR MORRIS, P.E.	
SHEET NO. 44 OF 246	

No.	Date	Revisions	Apr.

NOTES:

The exact position of Fault 9 is uncertain due to modification of landscape.

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 4/28/2015	APPROVED BY: EH	PREPARED BY: NL

60-Inch Water Line along Monroe and Rockhill
From Airport Blvd. to Glen Valley Drive
Fault 9 Location near Airport Blvd. & Monroe

PROJECT NO.: HE1416540	DRAWING NO.: PLATE 6

APPENDIX A

AERIAL PHOTOGRAPHS

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
2012 AERIAL PHOTO
SCALE: 1" = 700'

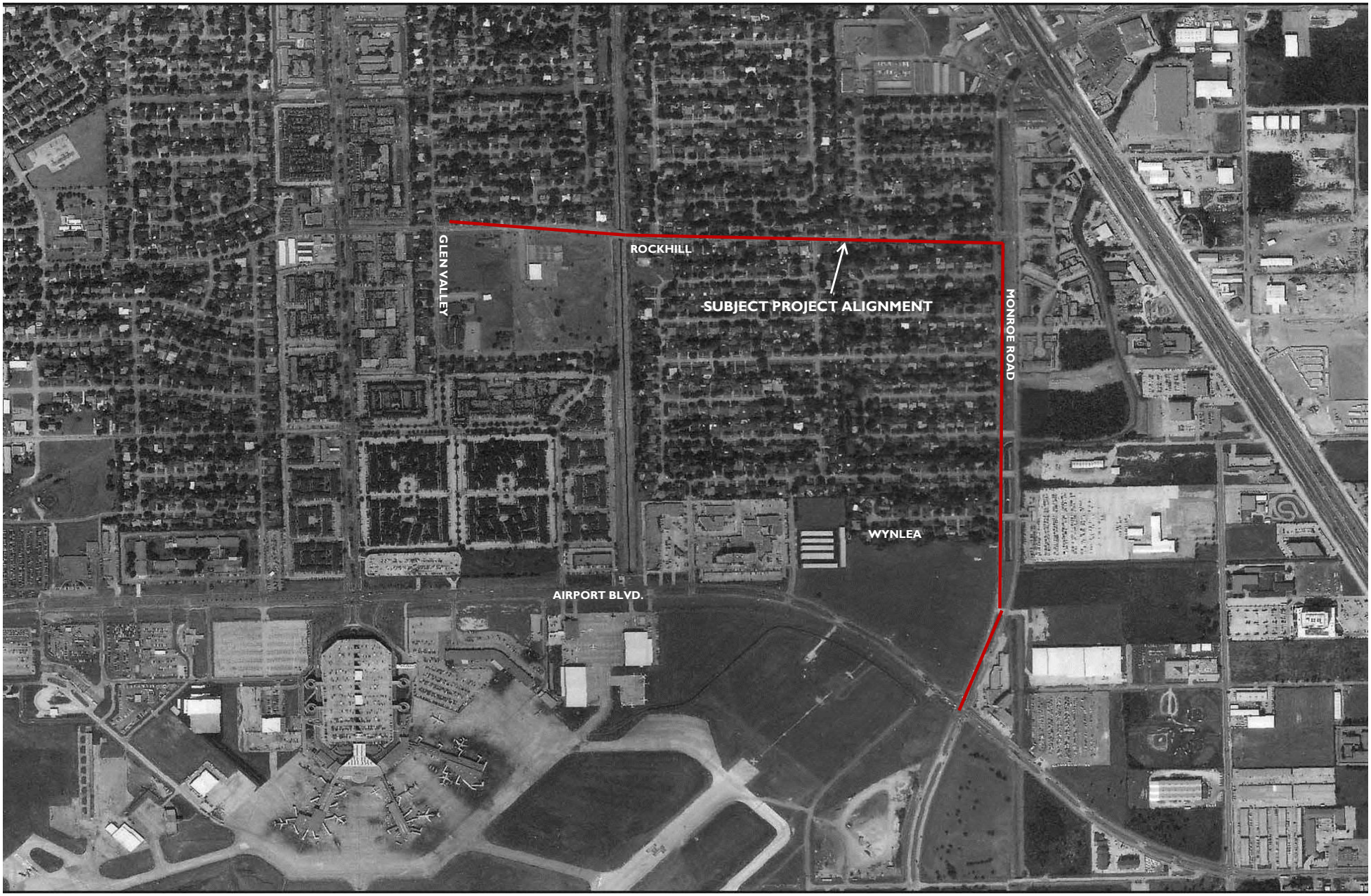
N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
2004 AERIAL PHOTO
SCALE: 1" = 700'

N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1996 AERIAL PHOTO
SCALE: 1" = 700'

N



PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1989 AERIAL PHOTO
SCALE: 1" = 700'

N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1979 AERIAL PHOTO
SCALE: 1" = 700'

N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1969 AERIAL PHOTO
SCALE: 1" = 700'

N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1953 AERIAL PHOTO
SCALE: 1" = 700'

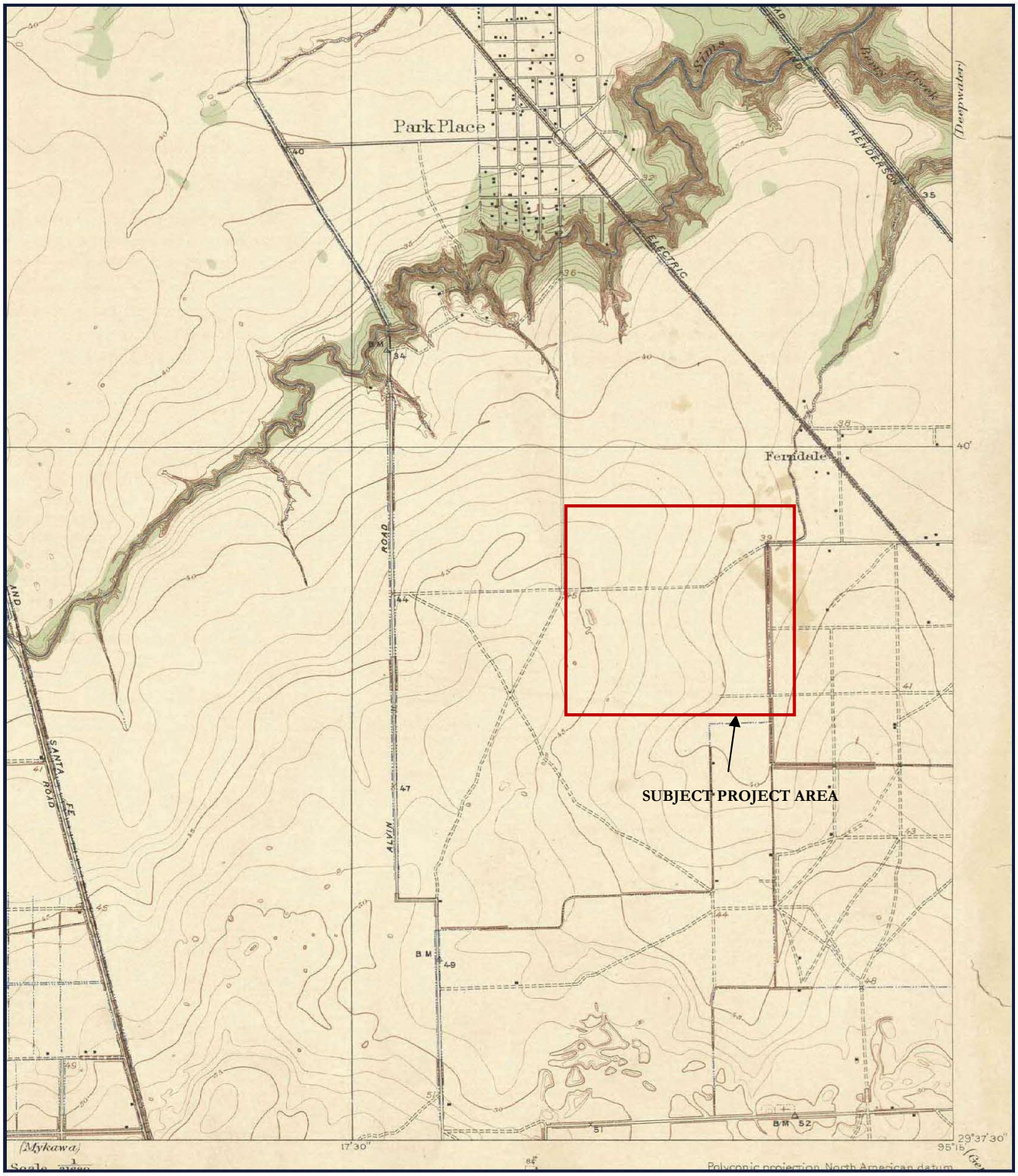
N

PHASE I GEOLOGIC FAULT ASSESSMENT
60-Inch Water Line along Monroe and Rockhill from Airport Blvd. to Glen Valley Drive
WBS No: S-000900-0129-3
1944 AERIAL PHOTO
SCALE: 1" = 700'

N

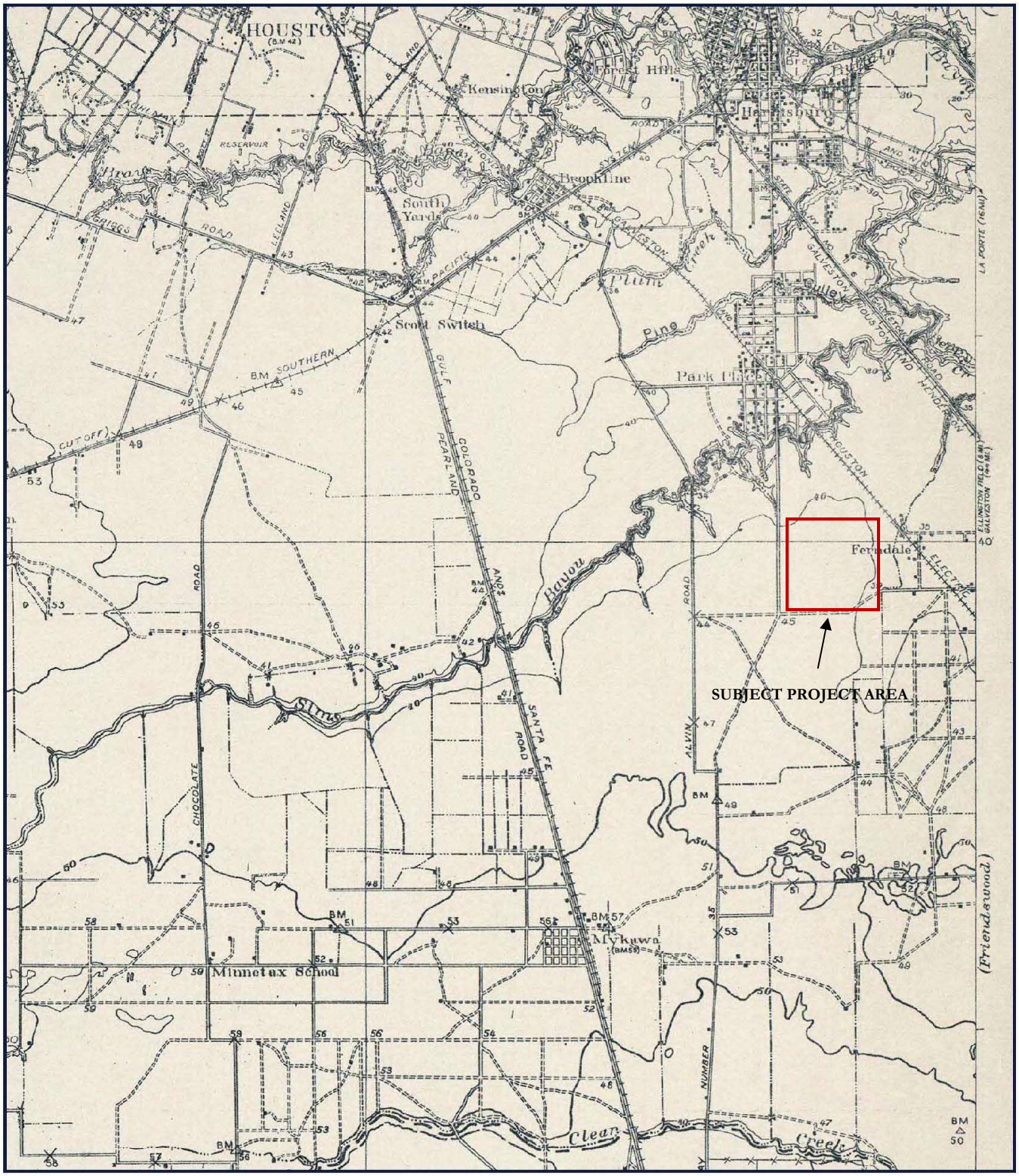
APPENDIX B

TOPOGRAPHIC MAPS



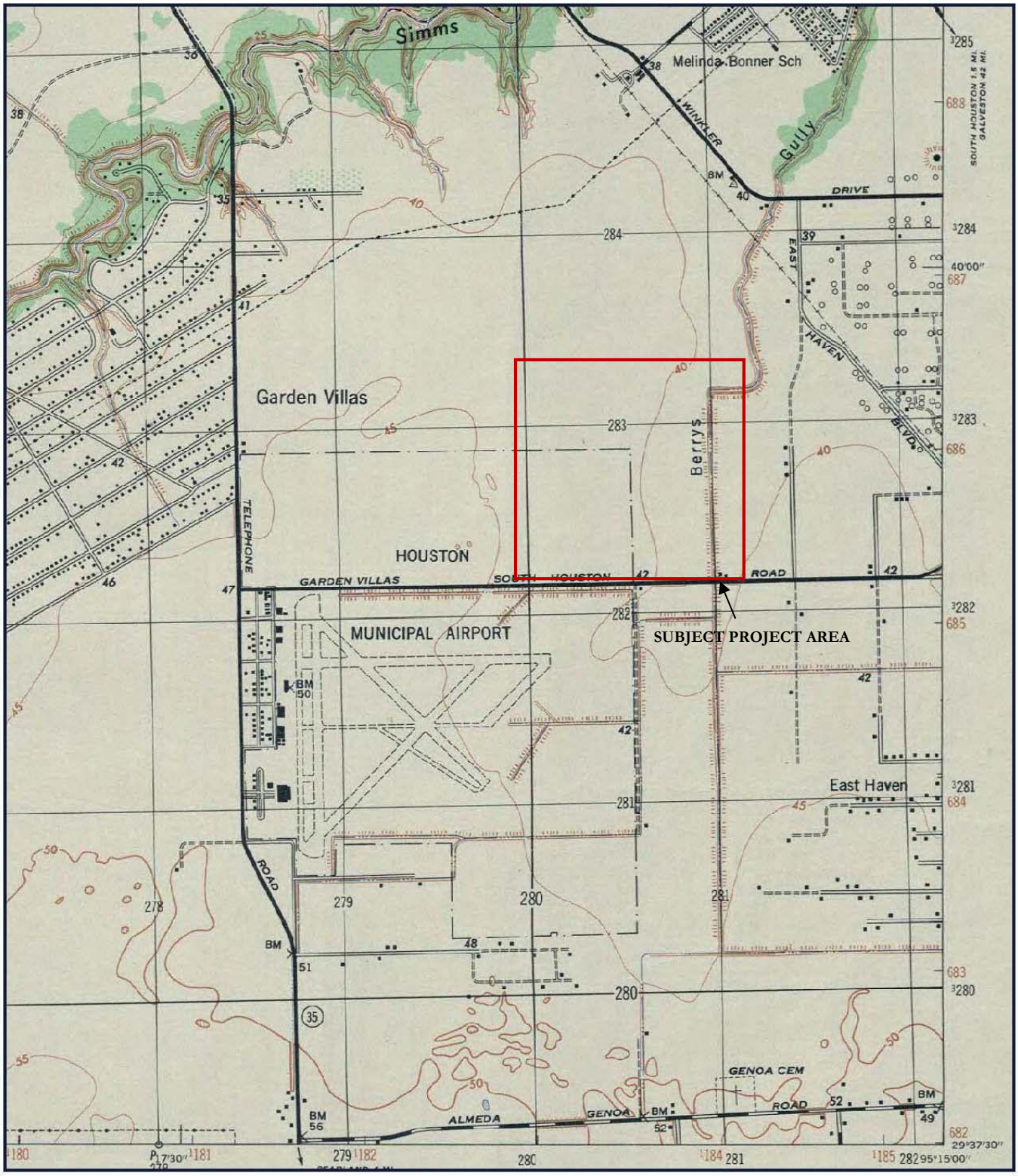
Source: 1915 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1915 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



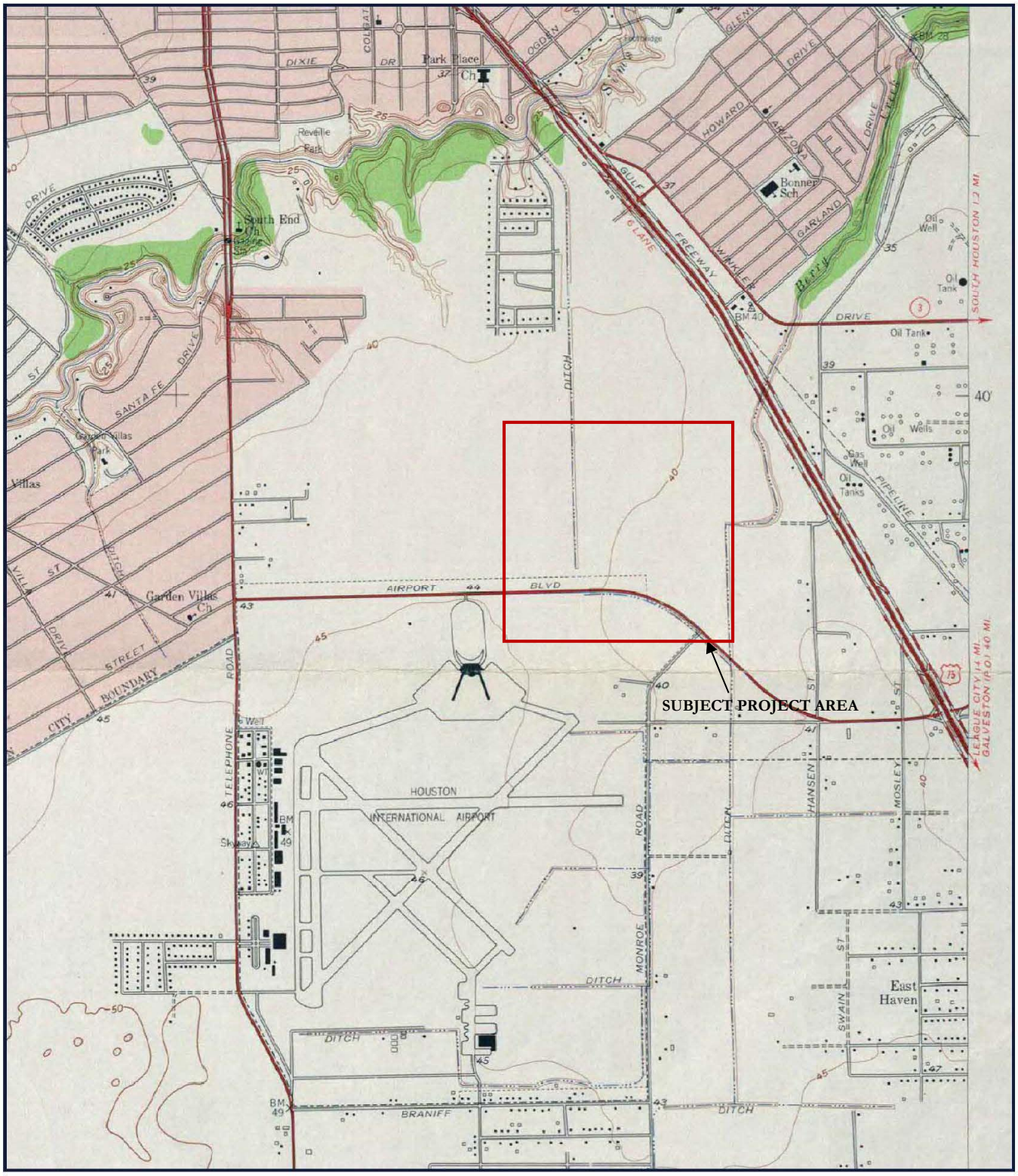
Source: 1929 Pearland, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1929 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



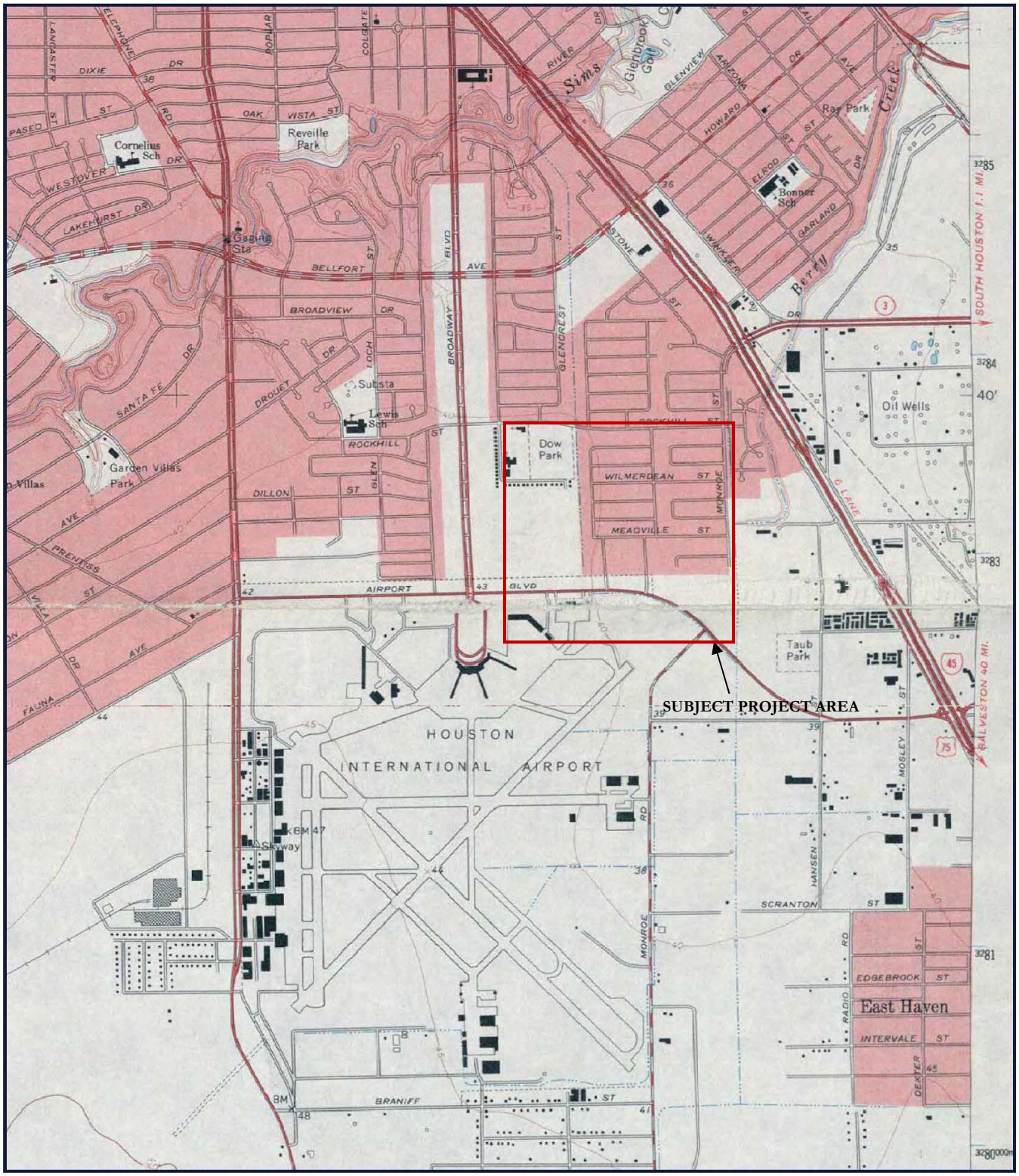
Source: 1947 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1947 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



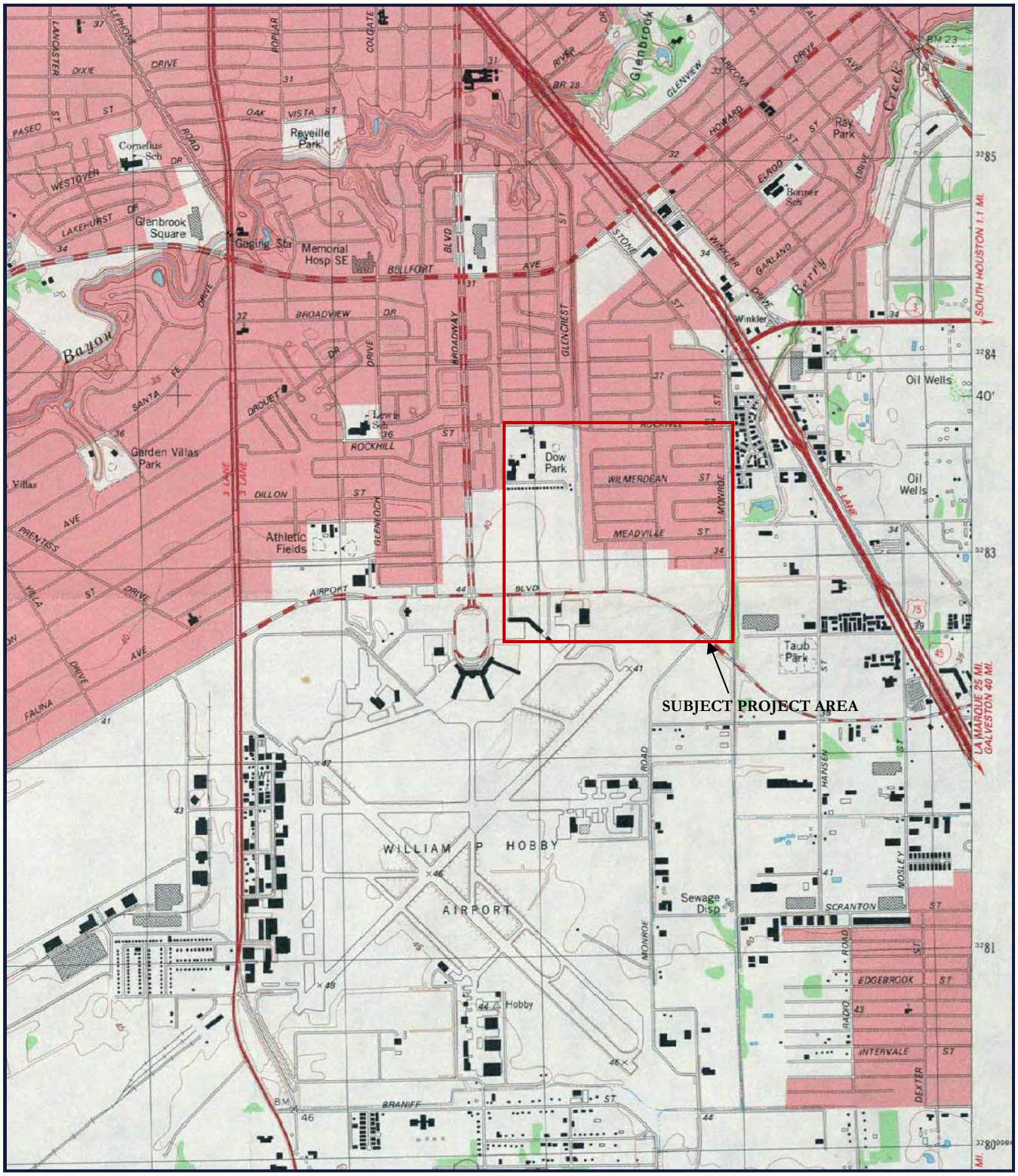
Source: 1955 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1955 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



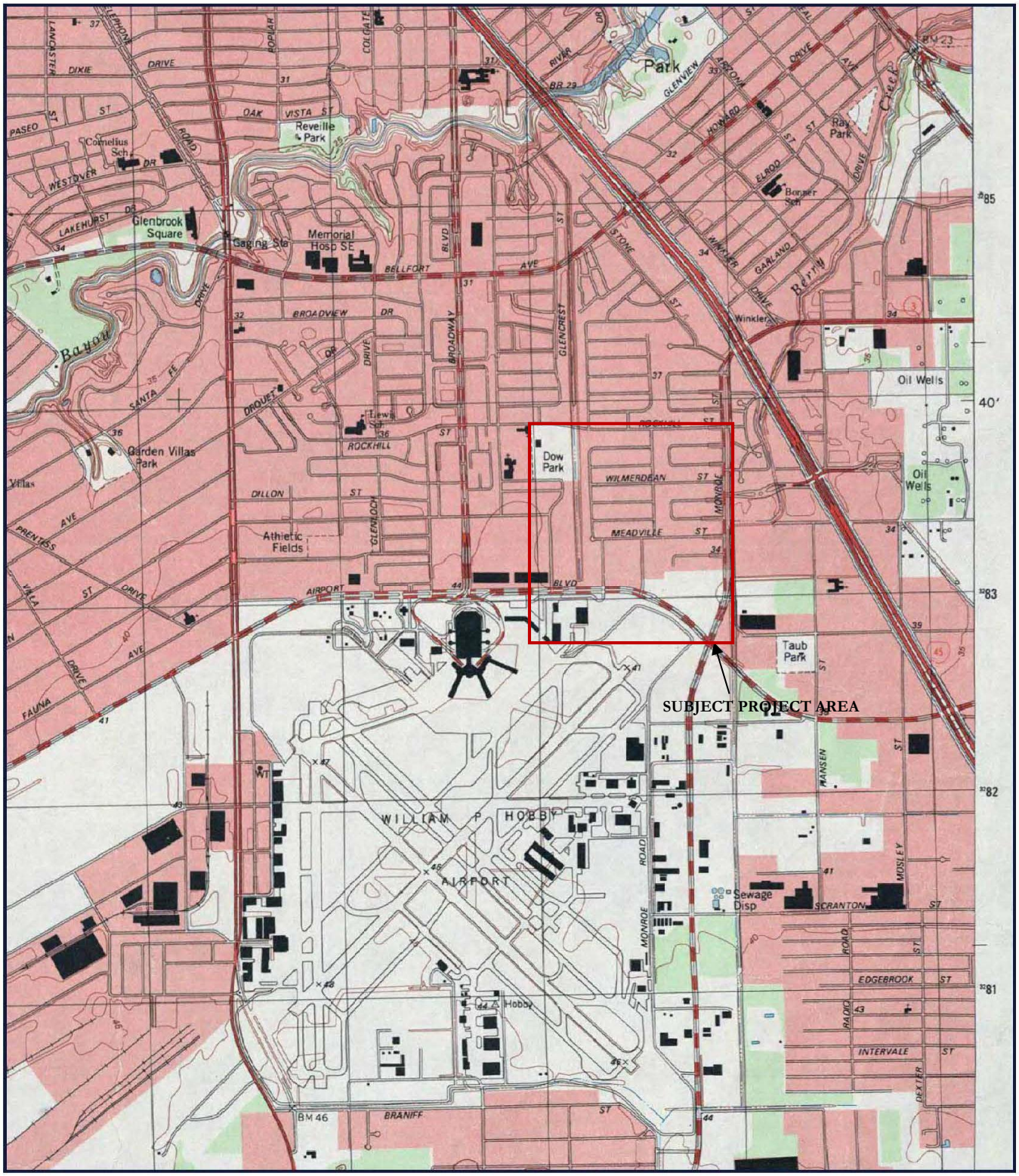
Source: 1967 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1967 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



Source: 1982 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1982 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	



Source: 1995 Park Place, TX Topographic Map

HVJ ASSOCIATES		Drawn:	NL	**1995 Historical Topographic Map** **Geologic Fault Assessment** **60-Inch Water Line along Monroe and Rockhill** **From Airport Blvd. to Glen Valley Drive** **WBS No: S-000900-0129-3** **Houston, Harris County, Texas**
		Checked:	EH	
		Date:	April 2015	
Report No.	HE1416540	Scale:	NTS	

APPENDIX C

SITE PHOTOGRAPHS

Photo 1. View looking east along Wynlea Street toward Monroe Road showing Fault 8 associated pavement cracking.

Photo 2. View looking west along Wynlea Street showing Fault 8 associated pavement cracking.

Photo 3. View looking south of possible fault related curb damage and pavement cracking along Wynlea Street.

Photo 4. View of northeast end of Fault 8 at the intersection of Wynlea Street and Monroe Road. Fault 8 is not seen crossing Monroe Road.