GUIDELINES FOR EVALUATING FOUNDATION PERFORMANCE BY MONITORING

Document no: FPA-SC-12

Developed by: FPA Structural Committee

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Presented by: Nicole Wylie, E.I.T., Forensic Engineers Inc.

Presented to : Foundation Performance Association

Presented on: 11 January 2006

FOUNDATION MONITORING

1. Why was it written?
2. Who needs it?
3. What are the benefits?
4. How is it organized?

FOUNDATION PERFORMANCE ASSOCIATION

Guidelines for Evaluating Foundation Performance by Monitoring

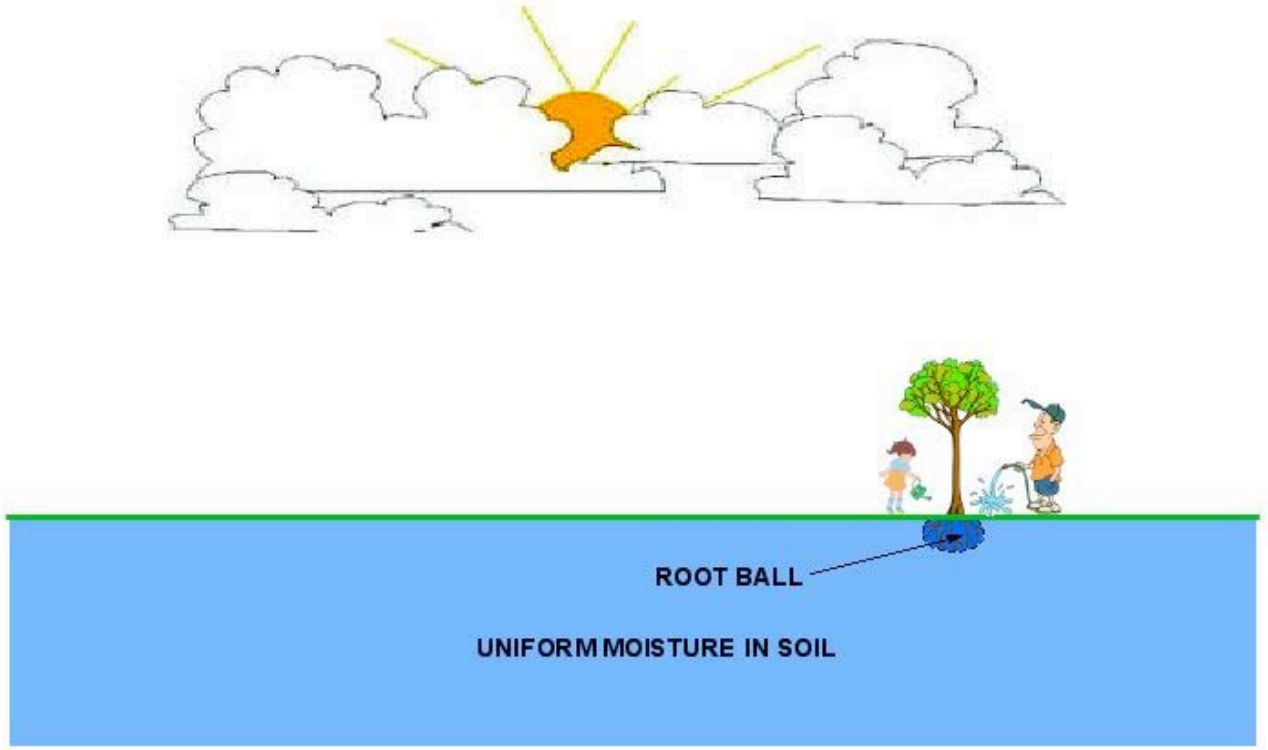
Table of Contents

WHAT'S THE DEAL WITH EXPANSIVE SOIL?

It causes:

- ***Heave***
- Subsidence / Shrinkage
- Non-cyclical and Cyclical Movement
- Distress Phenomena

How Heave Happens:



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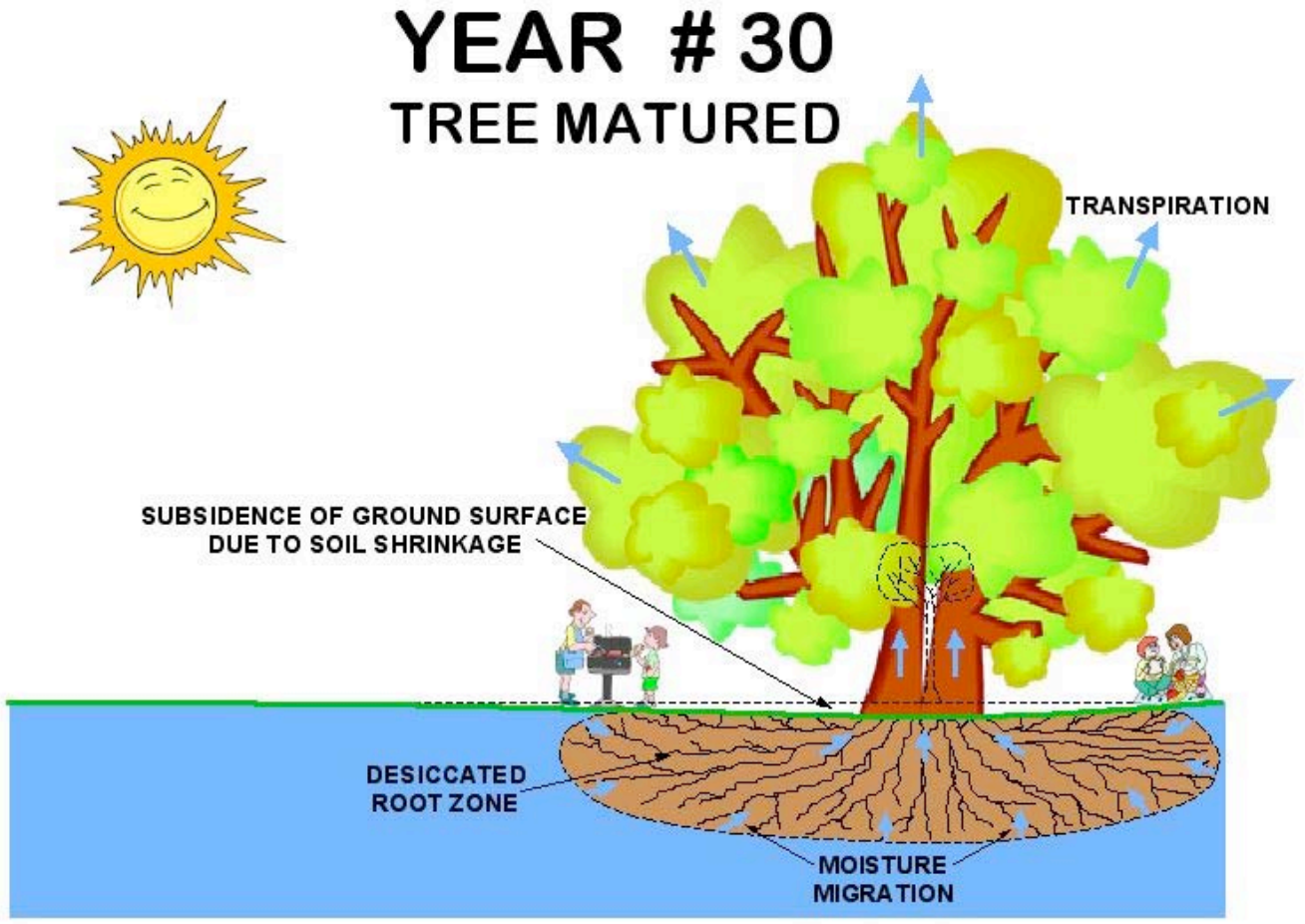

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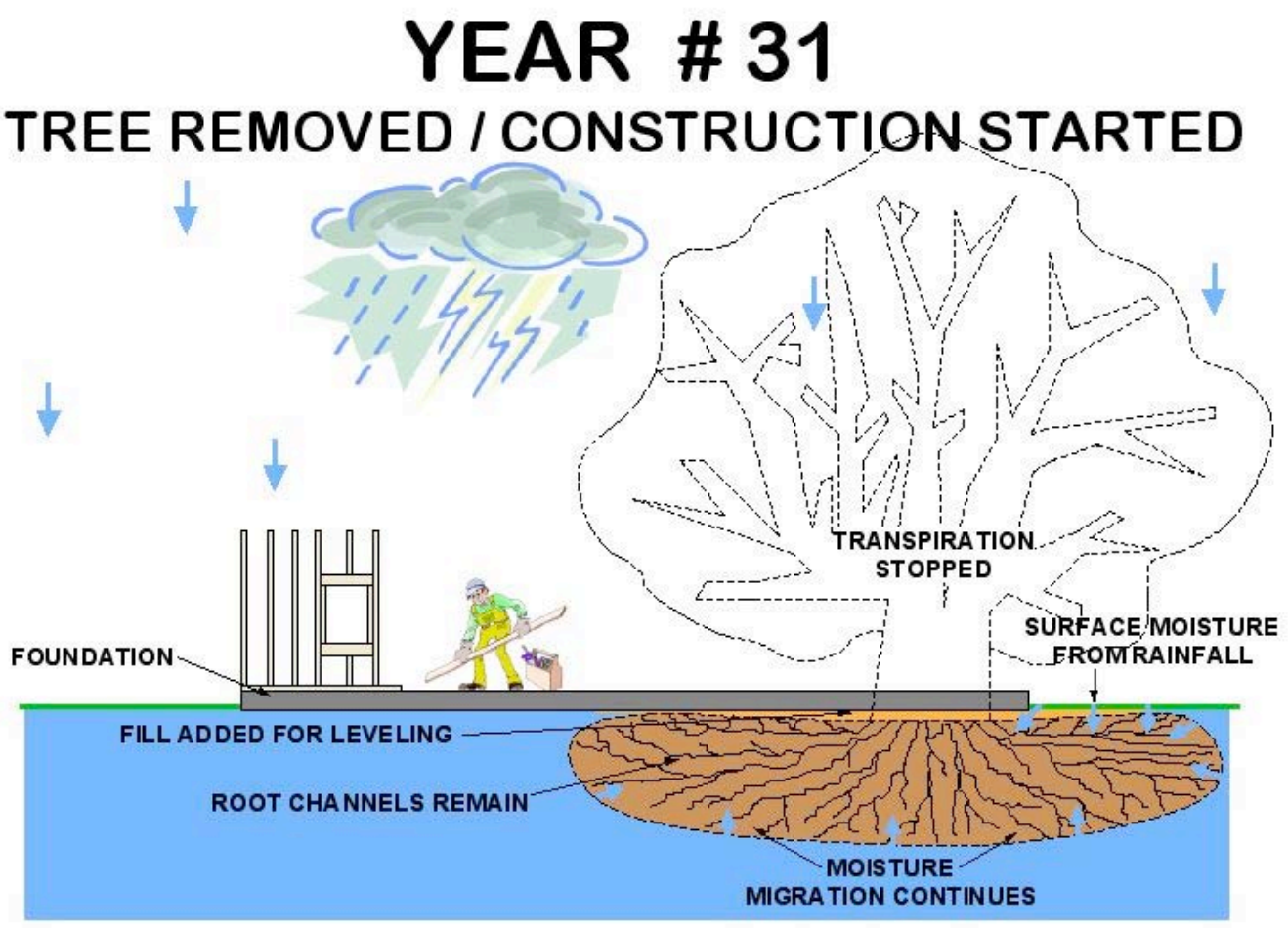

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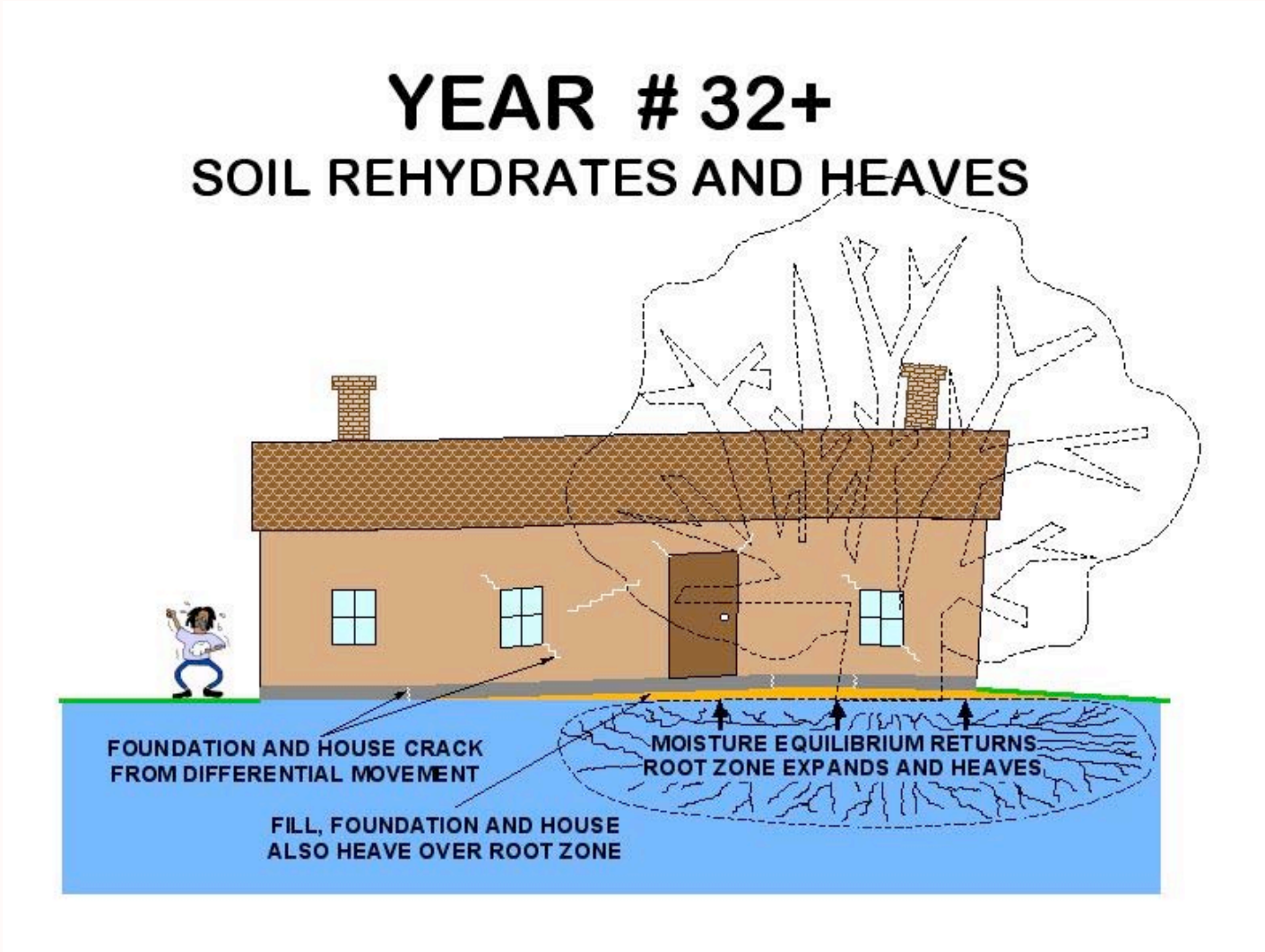

WHAT'S THE DEAL WITH EXPANSIVE SOIL?

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- ***Subsidence / Shrinkage***
- Non-cyclical and Cyclical Movement
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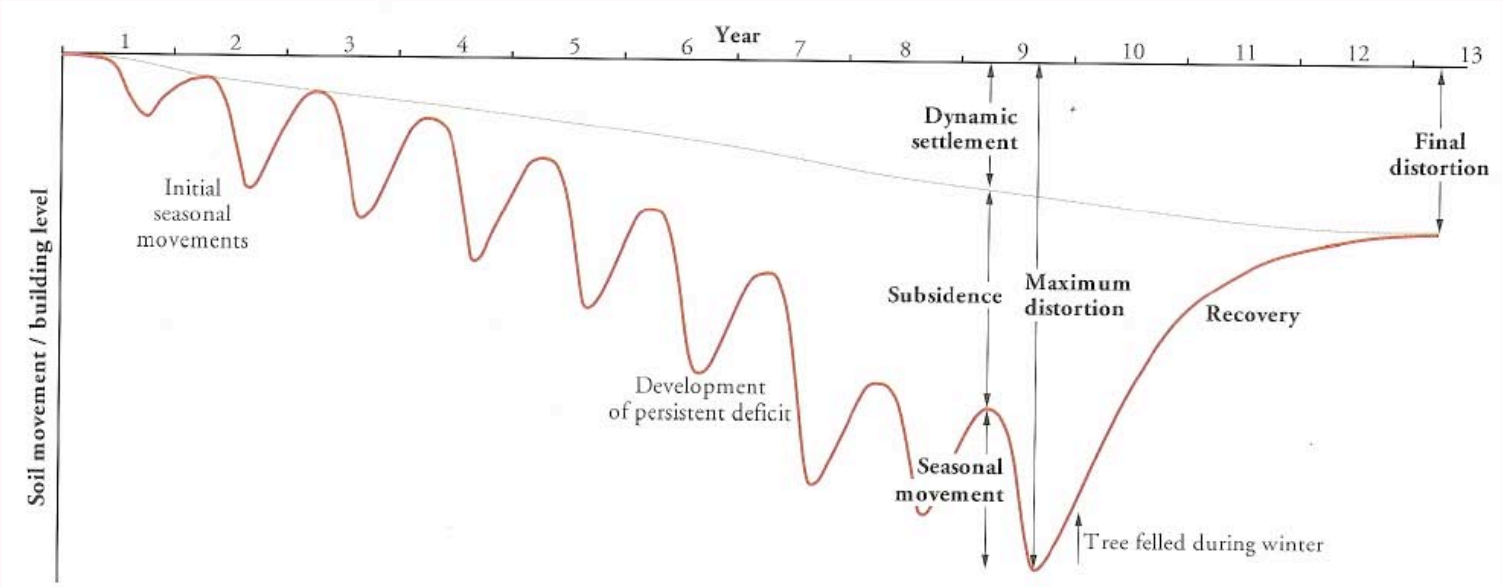
TREES AND SHRINKAGE



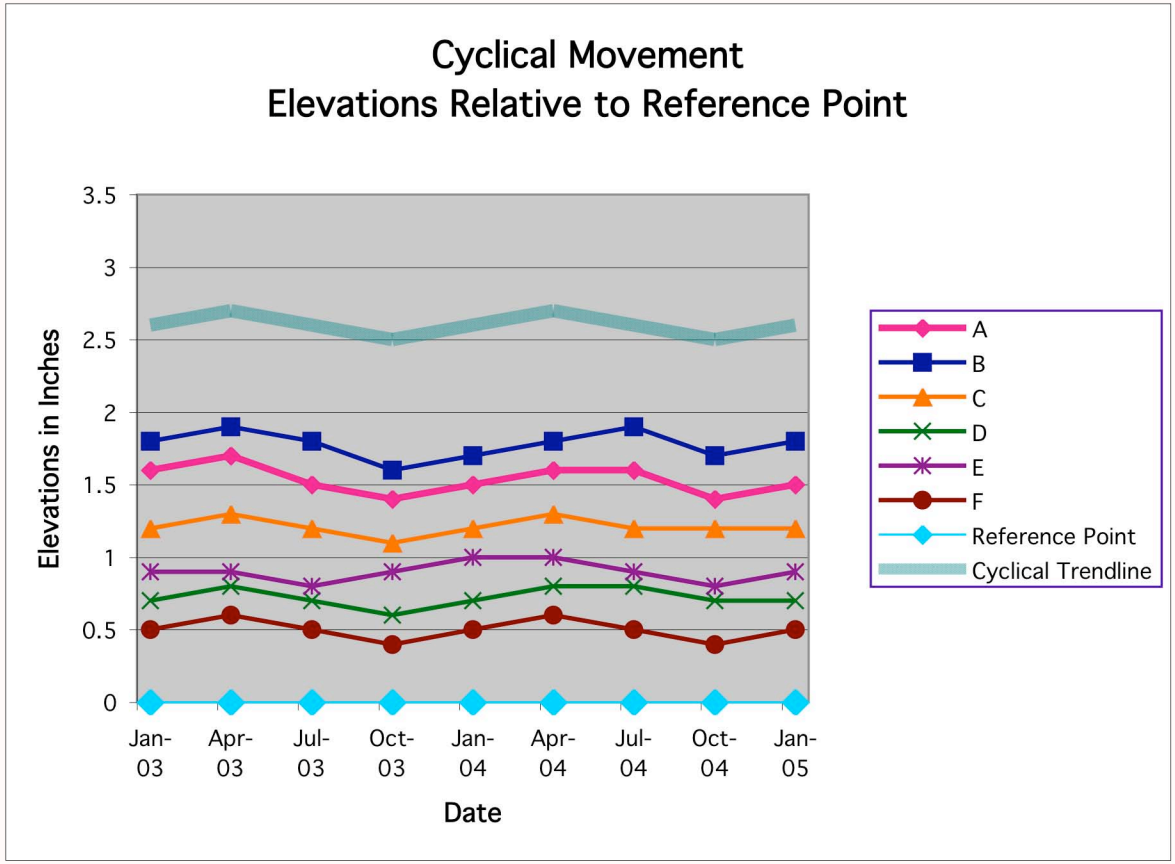
Plot from "Tree Root Damage To Buildings," Vol. 1, by P.G. Biddle
ISBN 0953308618

WHAT'S THE DEAL WITH EXPANSIVE SOIL?

It causes:

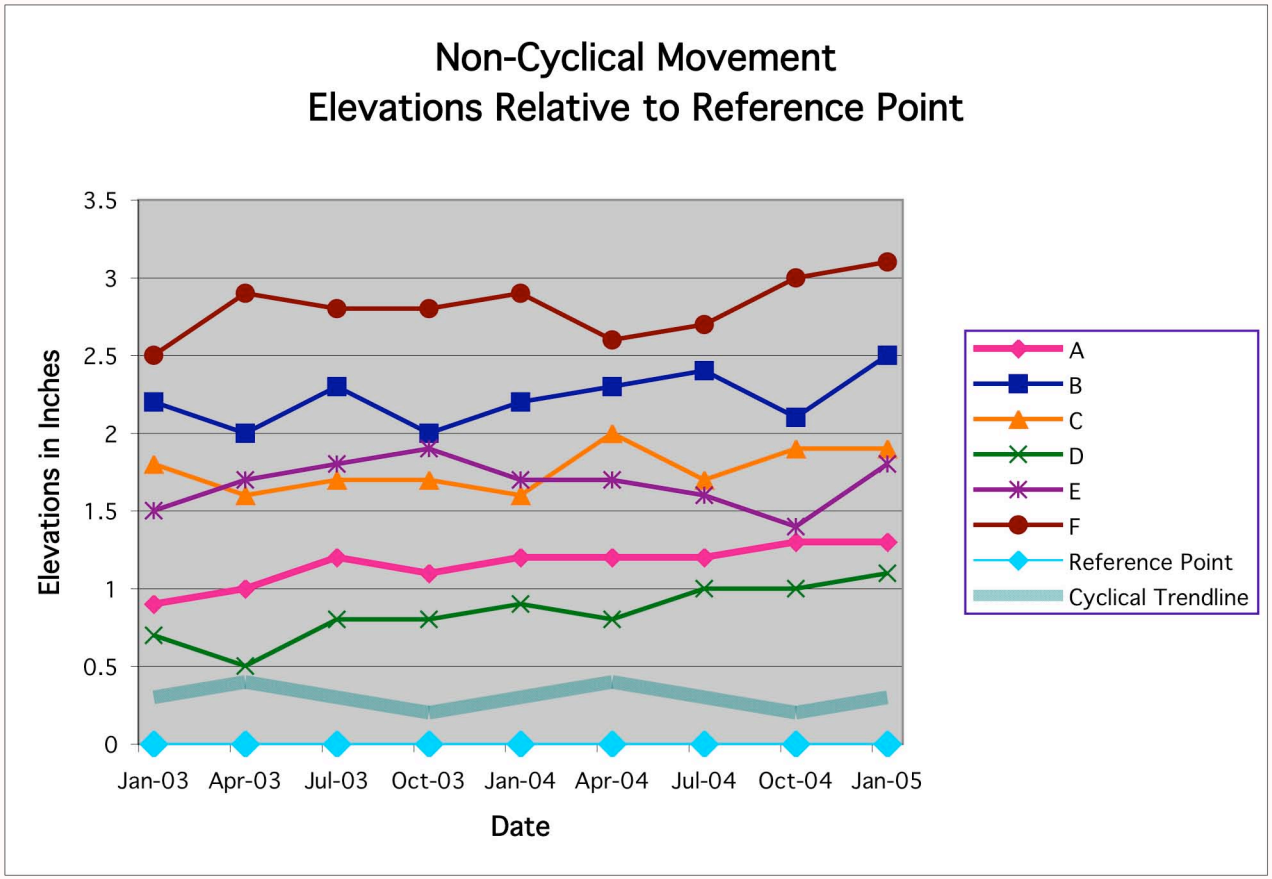
- Heave
- Subsidence / Shrinkage
- ***Non-cyclical and Cyclical Movement***
- Distress Phenomena

GRAPH OF PLOT POINTS VS. TIME:



CYCLICAL MOVEMENT

GRAPH OF PLOT POINTS VS. TIME:



NON-CYCLICAL MOVEMENT

WHAT'S THE DEAL WITH EXPANSIVE SOIL?

It causes:

- Heave
- Subsidence / Shrinkage
- Non-cyclical and Cyclical Movement
- ***Distress Phenomena***

3 TYPES OF PHENOMENA

Architectural

Functional

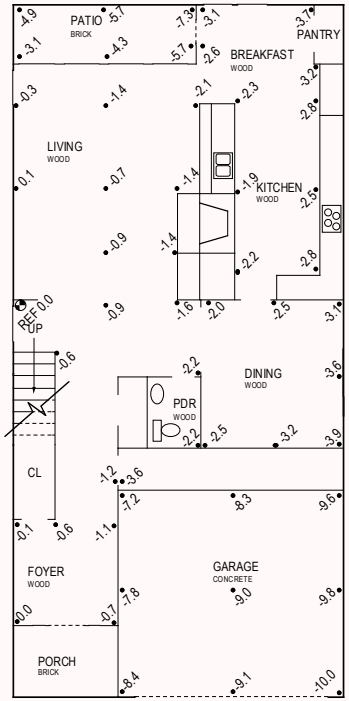
Bowed Roof Support

Structural

TESTING TO ASSIST IN THE MONITORING PROCESS:

ELEVATION SURVEYS

Digital Leveling Systems
Electronic Water Level

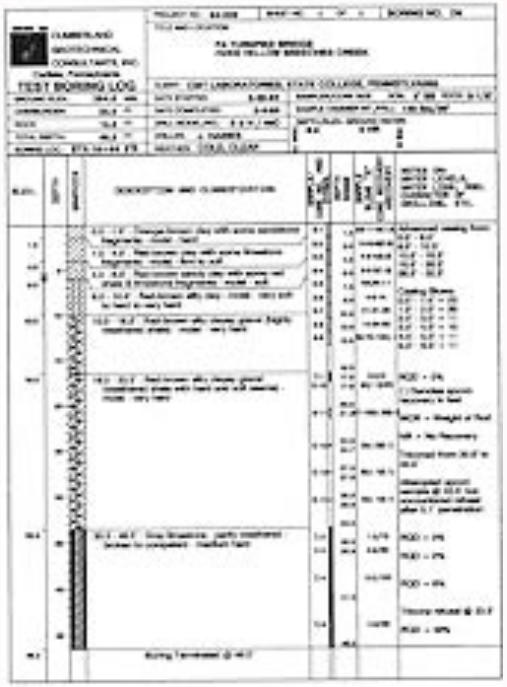


Zip Level

TESTING TO ASSIST IN THE MONITORING PROCESS:

GEOTECHNICAL TESTS

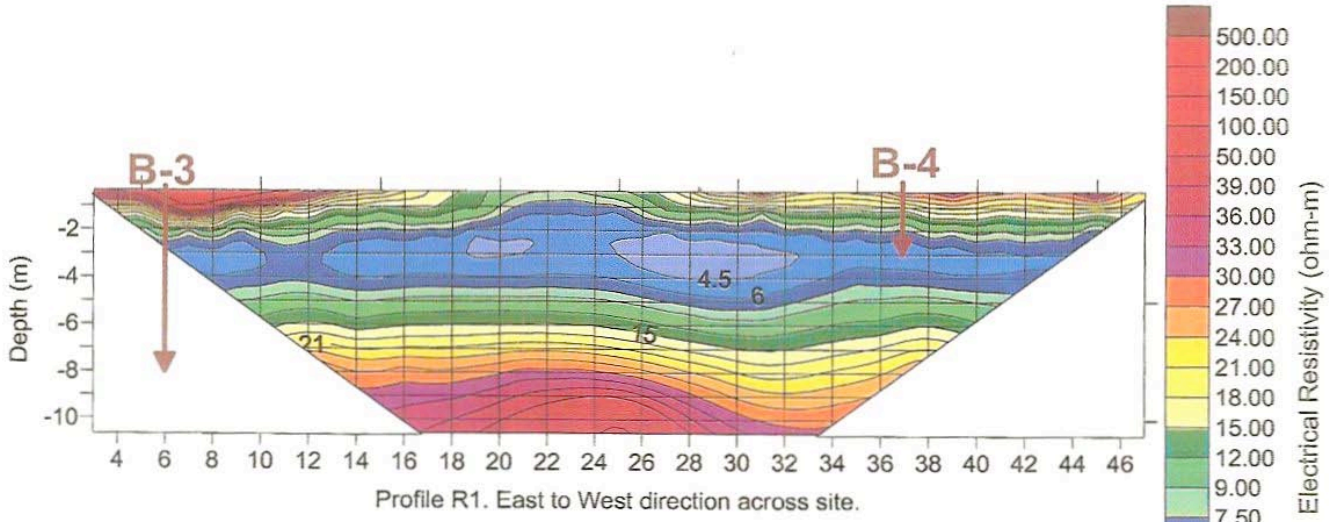
Portable Drill Rig



Truck Mounted Drill Rig

TESTING TO ASSIST IN THE MONITORING PROCESS:

GEOPHYSICAL TESTING



Electrical Resistivity Plot
Blue=Wet Red=Dry

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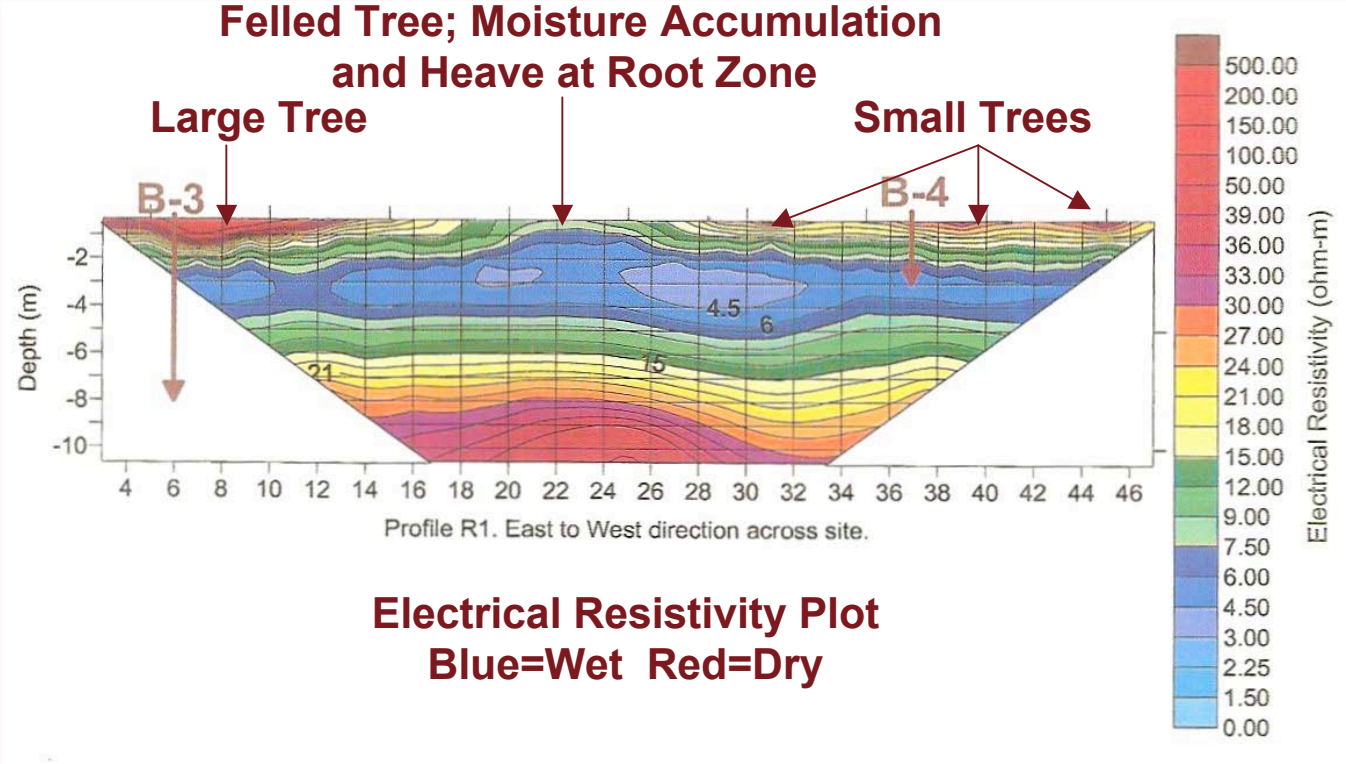
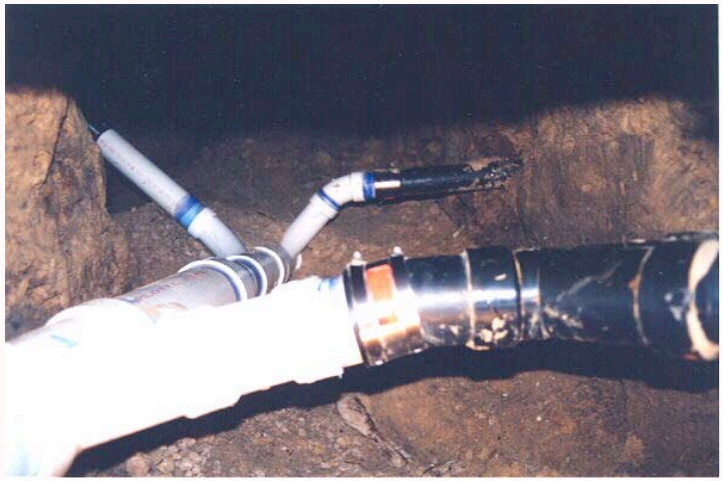
GEOPHYSICAL TESTING



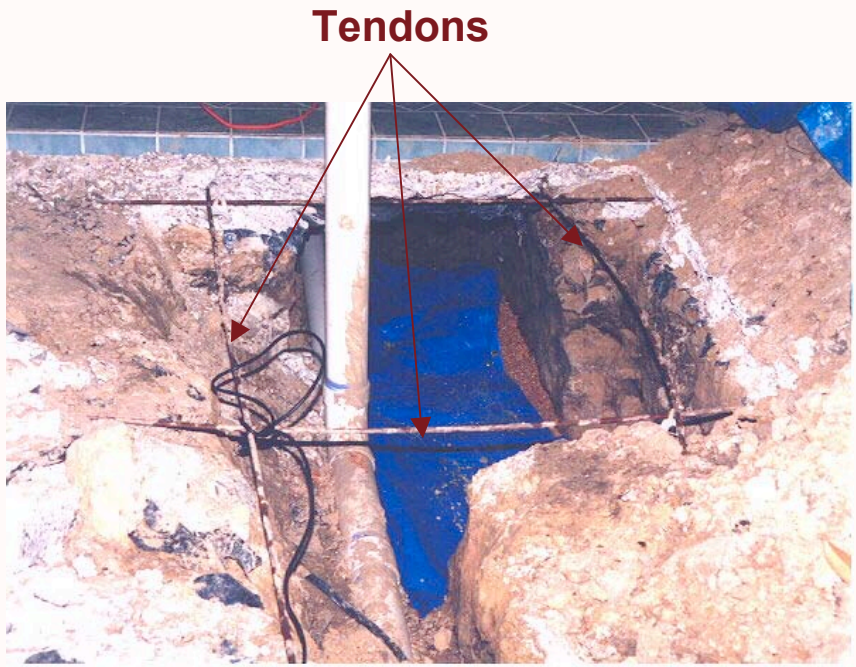
Electrical Resistivity Plot
Blue=Wet Red=Dry

TESTING TO ASSIST IN THE MONITORING PROCESS:

PLUMBING LEAK DETECTION TESTING



Tunneling under slab for leak repair



Slab break-out for leak repair

TESTING TO ASSIST IN THE MONITORING PROCESS:

GROUNDWATER MONITORING

Submerged water meter

Water ponding at grade beam / pier

TESTING TO ASSIST IN THE MONITORING PROCESS:

SITE RECONNAISSANCE

- ***Aerial Photos***
- Topographic Maps
- Foundation Excavation
- Drainage
- Landscaping
- Rainfall Data

Aerial Overlay
Mid-Development

Aerial Overlay
Pre-Development

TESTING TO ASSIST IN THE MONITORING PROCESS:

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- Aerial Photos
- ***Topographic Maps***
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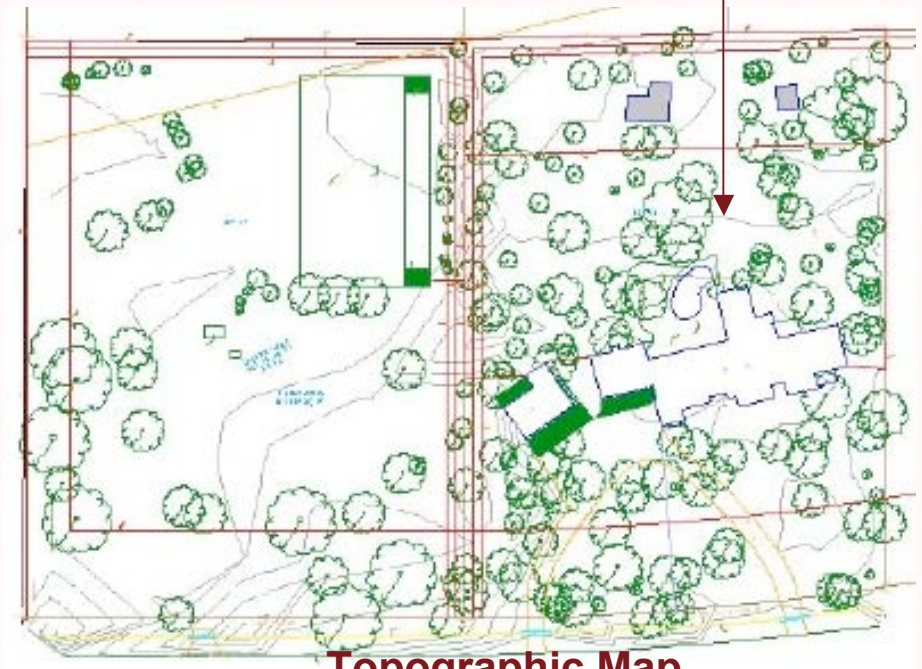

Topographic Map

TESTING TO ASSIST IN THE MONITORING PROCESS:

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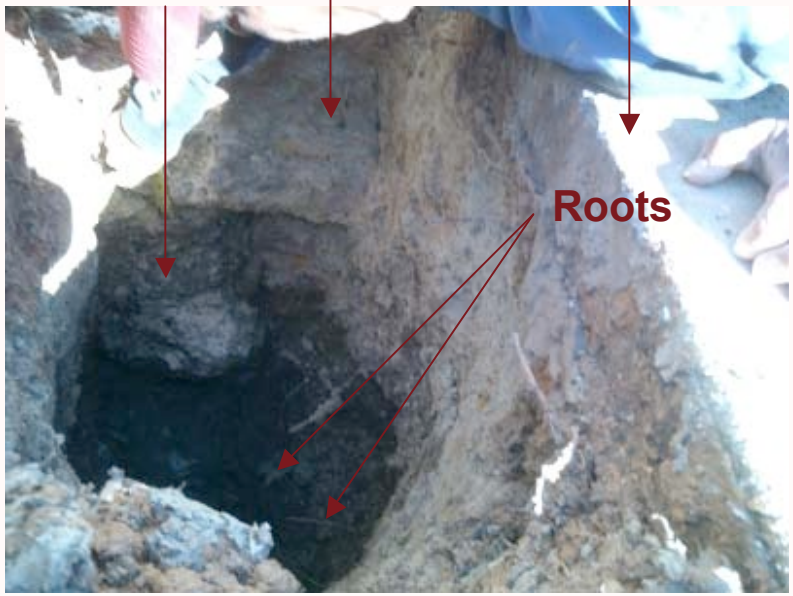
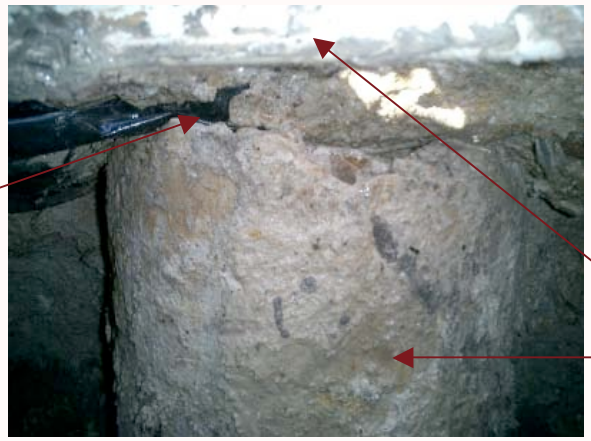


Excavation Pit



Excavation Pit

TESTING TO ASSIST IN THE MONITORING PROCESS:

SITE RECONNAISSANCE

- Aerial Photos
- Topographic Maps
- Foundation Excavation
- ***Drainage***
- Landscaping
- Rainfall Data

Drains Towards Residence

Standing Water

Poor Drainage

Submerged / Slimy Water Meter

TESTING TO ASSIST IN THE MONITORING PROCESS:

SITE RECONNAISSANCE

- Aerial Photos
- Topographic Maps
- Foundation Excavation
- Drainage
- ***Landscaping***
- Rainfall Data

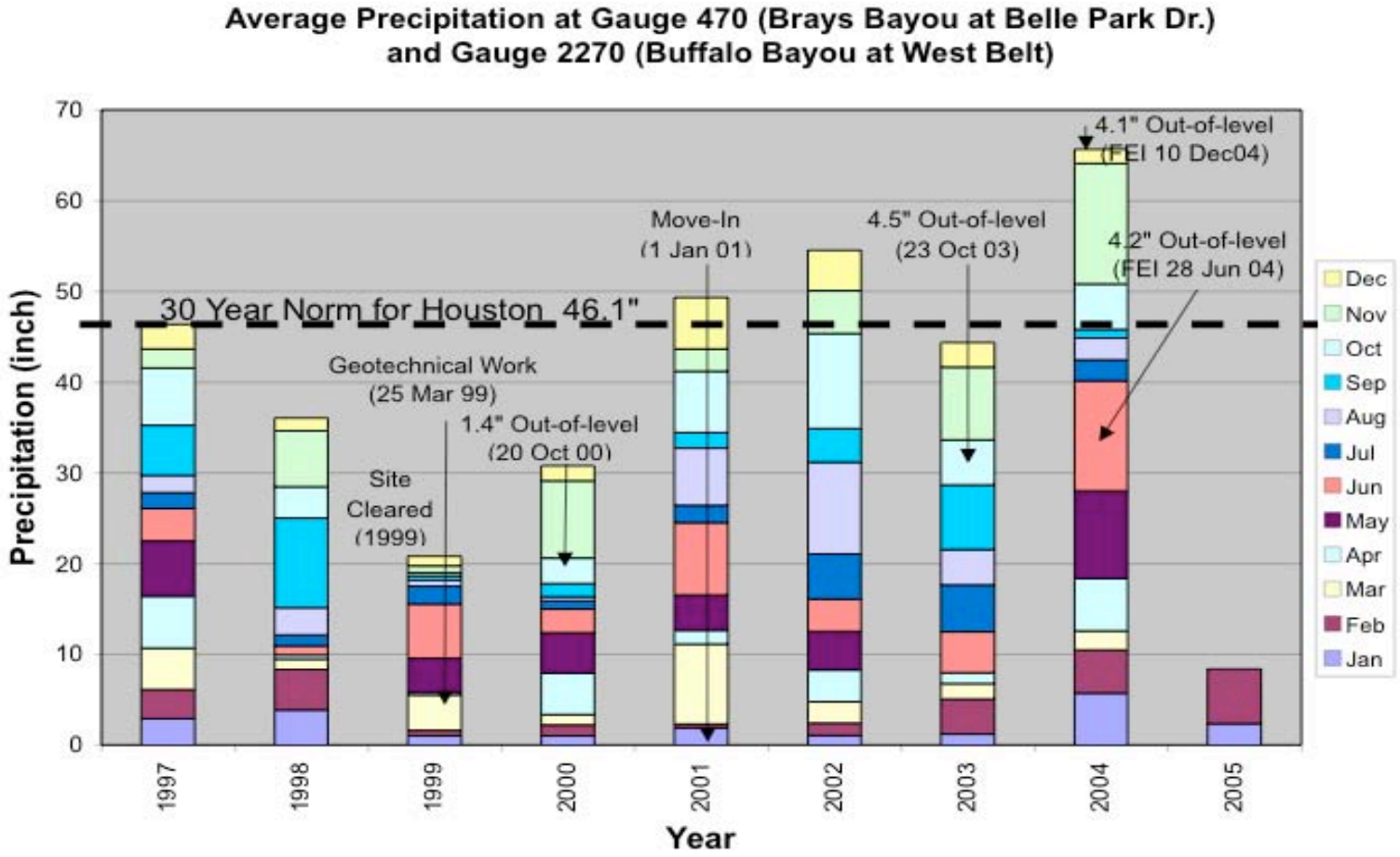
TESTING TO ASSIST IN THE MONITORING PROCESS:

SITE RECONNAISSANCE

- Aerial Photos
- Topographic Maps
- Foundation Excavation
- Drainage
- Landscaping
- ***Rainfall Data***...

Rainfall Data

Check out: www.hcoem.org



Monthly Rainfall Plot

Case Study 1:

Problem: Foundation movement and distress phenomena in new home

Work: Monitoring March 2003 to present

Outcome: Movement cessation predicted within next 12 months

Case Study 1:

1999: Site cleared, canal filled

Feb 00: Geo report showed PI=41, soil wetter than plastic limit

Aug 00: Foundation complete

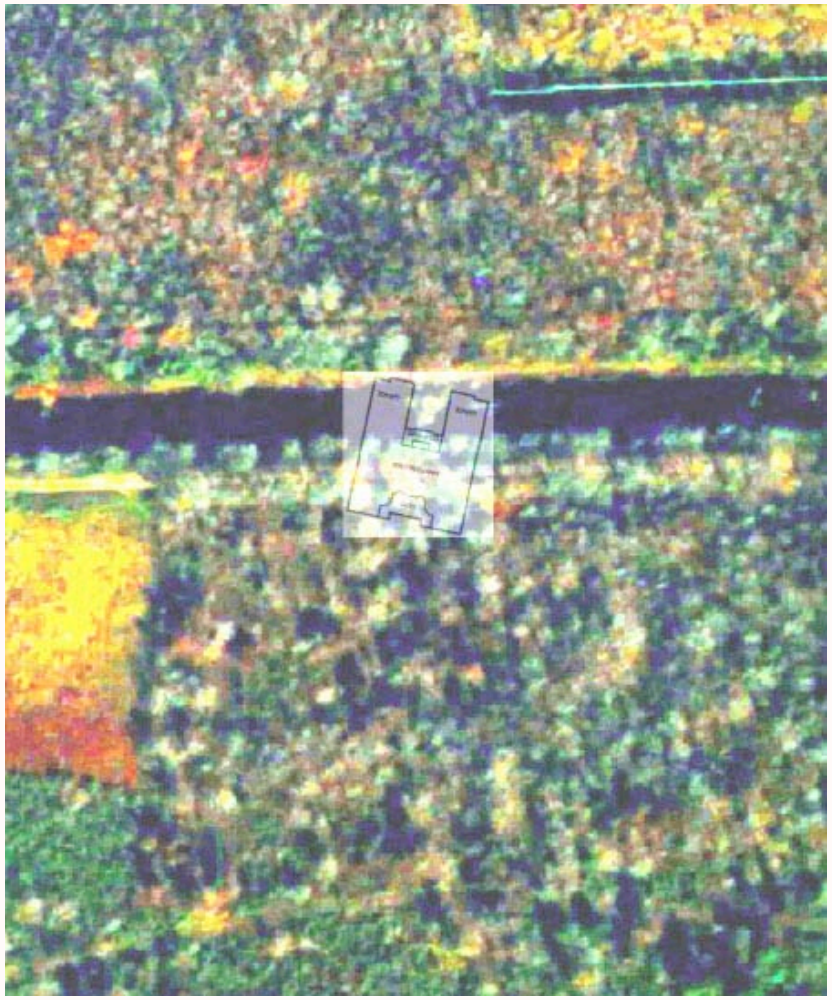
May 01: Closing & Move-In

Jun 01: Owner observed first distress phenomenon

Mar 02: Engineer of record observes overly wet yard, suspects heave, east-west slab crack is epoxy injected

Oct 02: Engineer returns and finds new slab crack parallel to repair; requests further testing

Mar 03: Forensic Engineers Inc (FEI) were hired



Aerial overlay with north end of house over canal

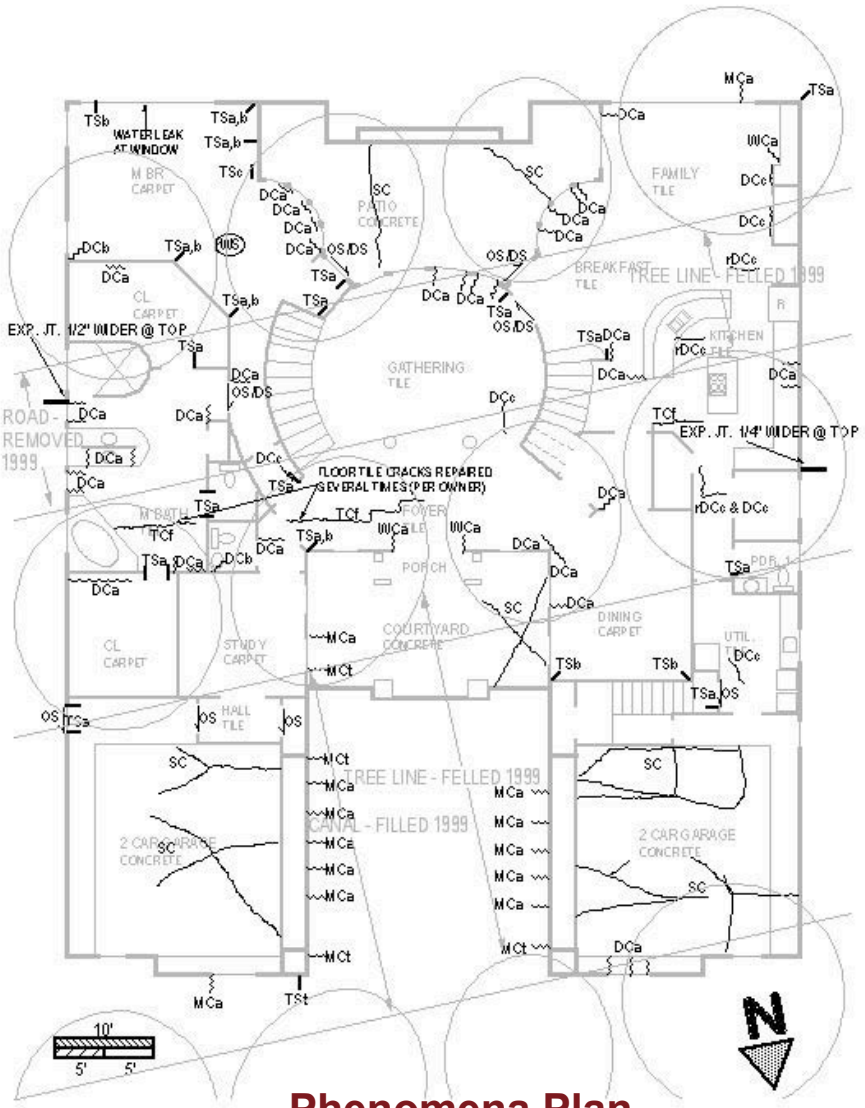
Case Study 1:

Mar 03:

FEI used aerial photo overlays to find that house was sited across a canal, a road and mature trees.

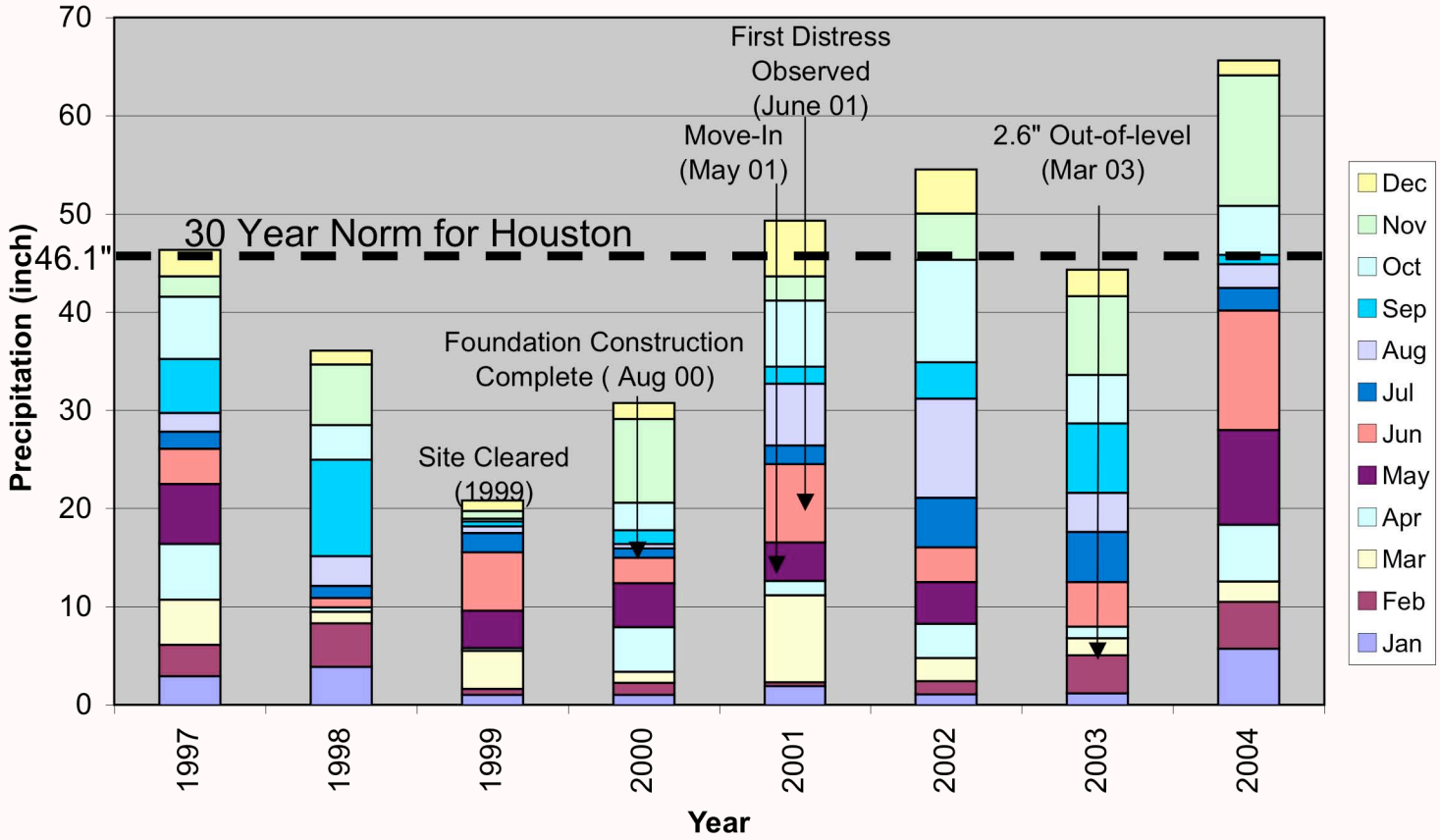
185 phenomena observed, some shown at right

Leak test was negative



Phenomena Plan
31 Mar 03

Case Study 1:



- Mature trees + drought = Site desiccated when cleared
- Site still very dry during construction
- First phenomena observed as site began to wet-up in 2001

Case Study 1:

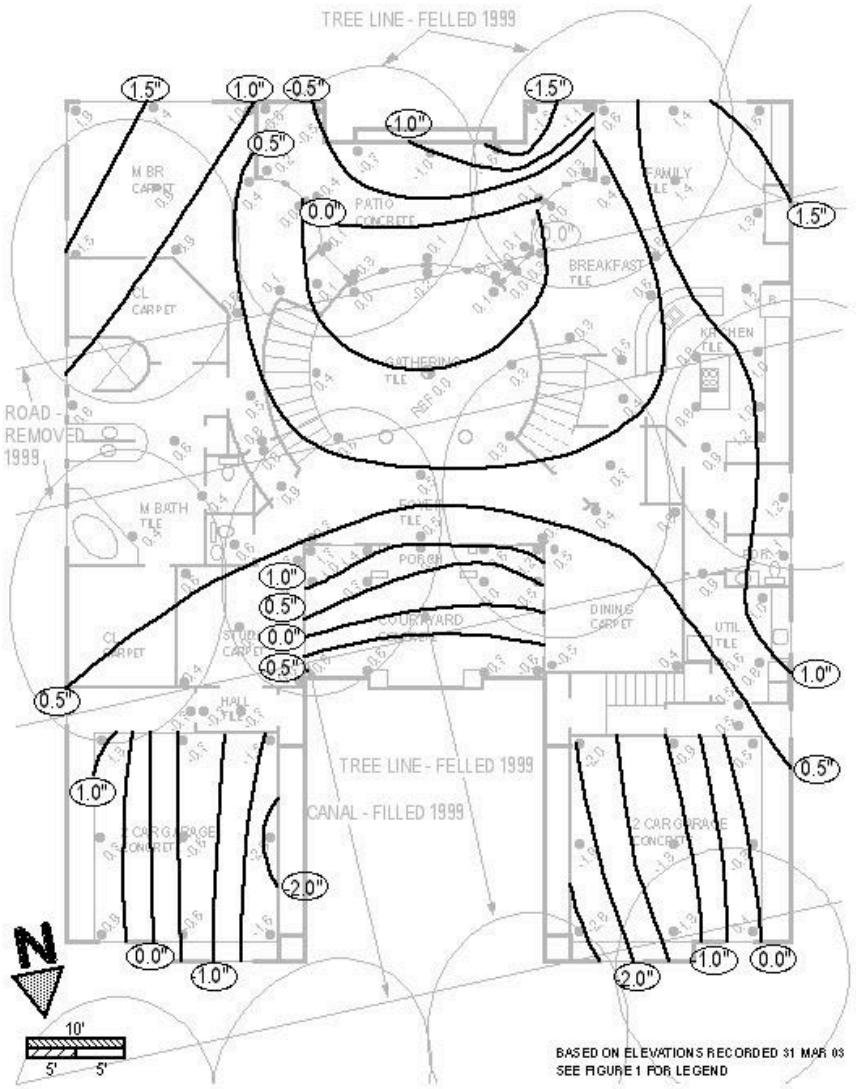
Mar 03:

FEI Elevation survey shows Maximum Differential Elevation of 2.6”

Contours follow an east-west direction following the rows of felled trees along the canal and road.

FEI confirmed that heave had occurred and recommended monitoring to determine when repairs may be safely made with little risk of reoccurrence.

FEI recommended homeowner start following maintenance procedure outlined in FPA-SC-07.



Adjusted Elevations 31 Mar 03

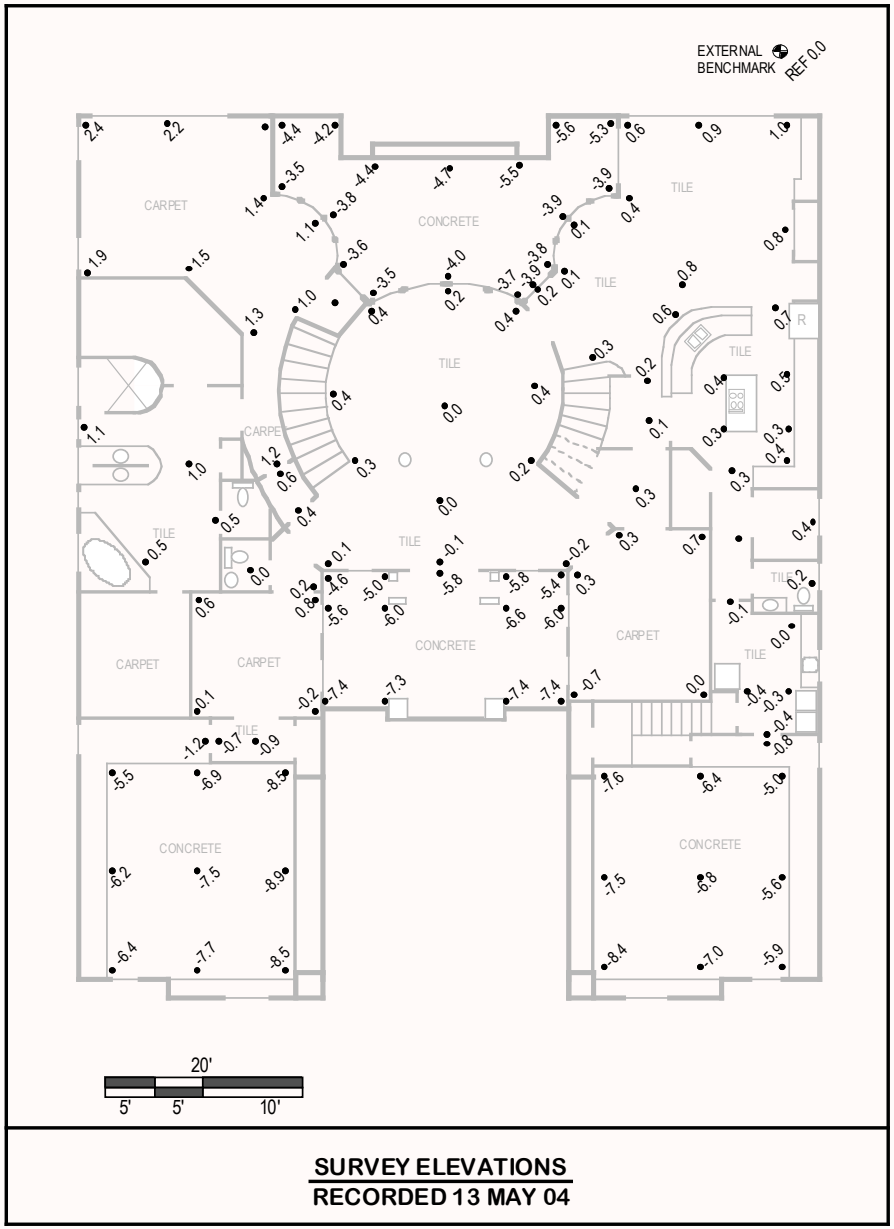
Case Study 1:

May 04

Example Survey Elevation Plan at right.

Full Elevation survey conducted every 12 months (figure at right). Note benchmark in backyard.

Limited survey conducted every 3 months with fewer data points (next figure).



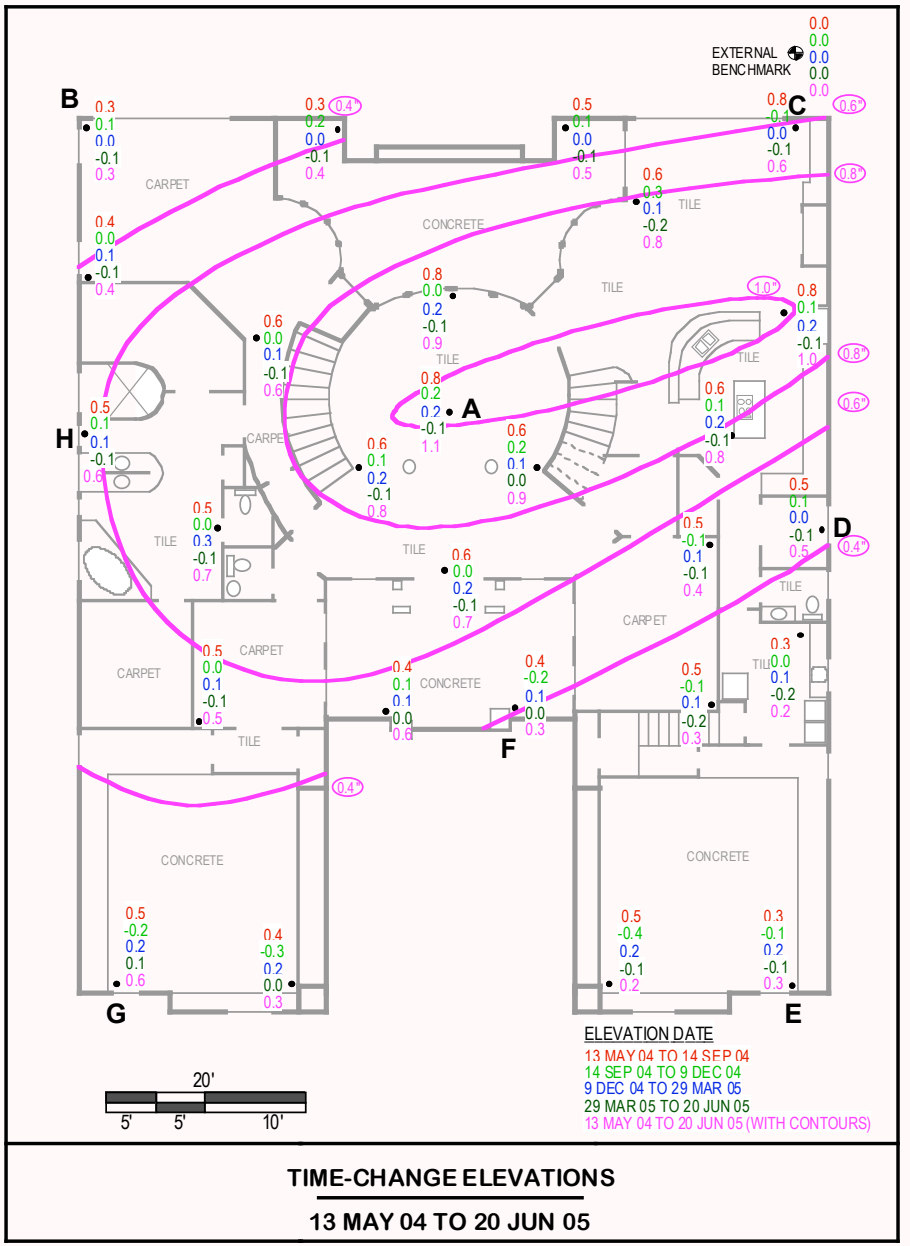
SURVEY ELEVATIONS
RECORDED 13 MAY 04

Case Study 1:

Mar 03 - Jun 05:

Time-change Elevations calculated as noted in the figure's legend.

Comparing the contours for the Time-change Elevation Plots showed the high point moving to the right over time.

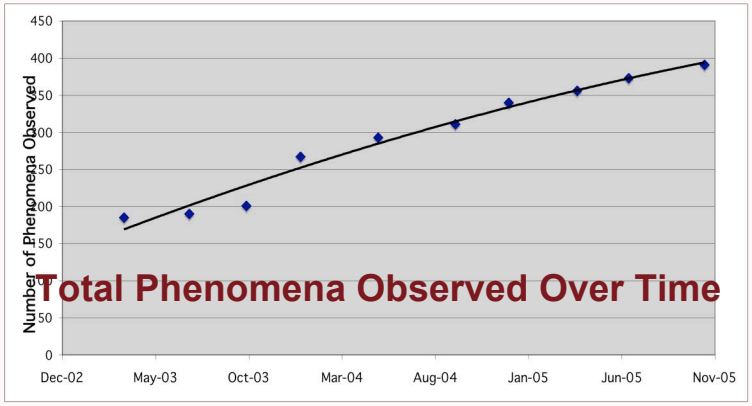


Case Study 1:

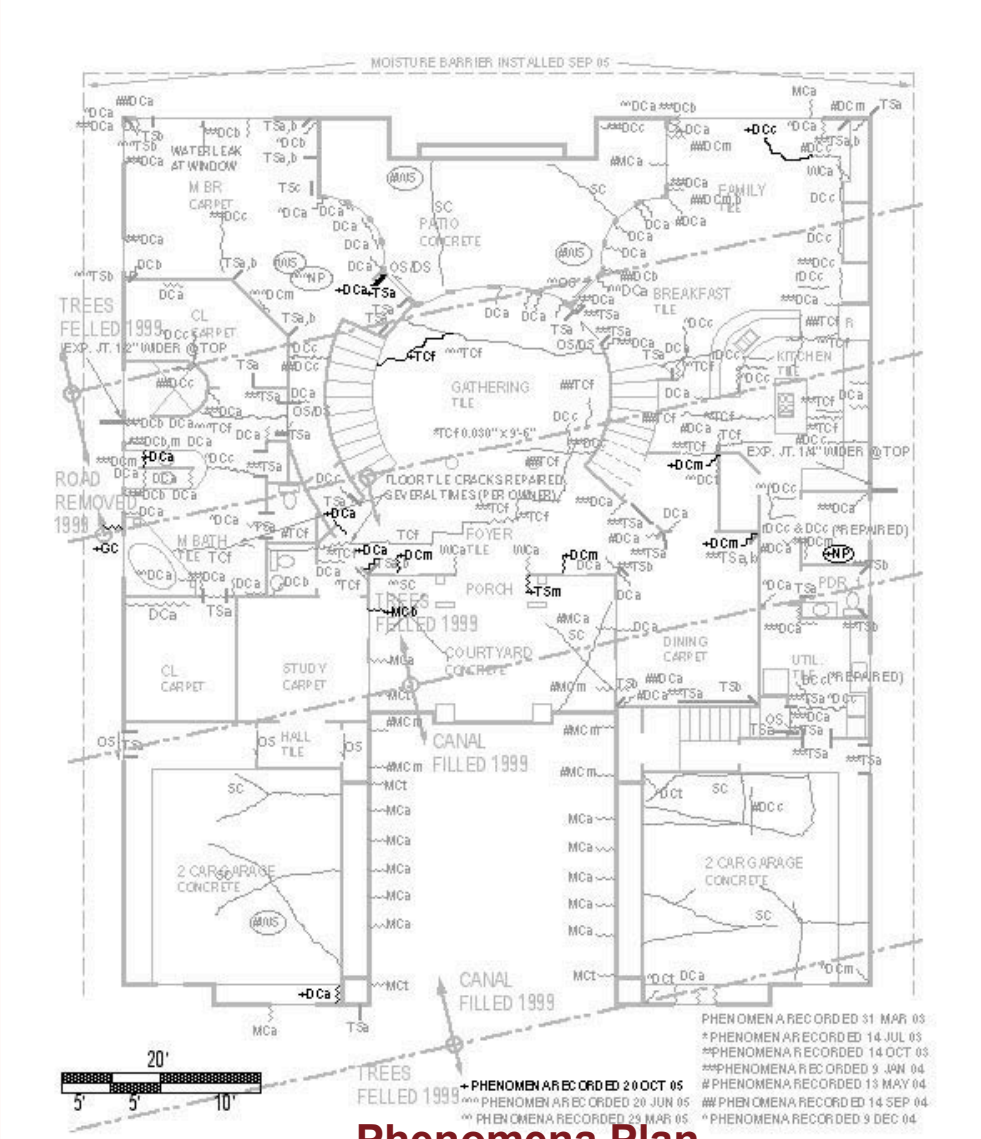
Mar 03 - Oct 05:

Movement continues, moisture barrier installed

Date	Period (Days)	# New Phenomena	Days / Phenomena
25 May 01	-	Assumed Zero	-
31 Mar 03	673	185	3.6
14 Jul 03	105	5	21.0
14 Oct 03	92	11	7.5
9 Jan 04	87	66	1.3
13 May 04	125	26	4.8
14 Sep 04	123	18	6.8
9 Dec 04	86	29	3.0
29 Mar 05	110	16	6.9
20 Jun 05	83	17	4.8
20 Oct 05	122	18	6.8
TOTALS	**1606**	**391**	**4.1**



Total Phenomena Observed Over Time



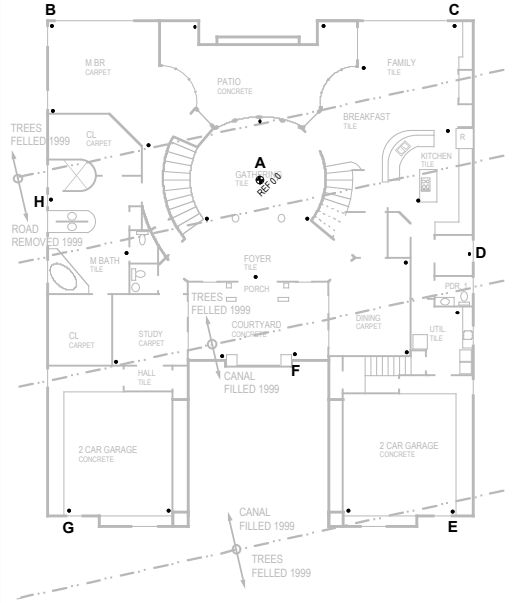
Phenomena Plan
31 Mar 03 to 20 Oct 05

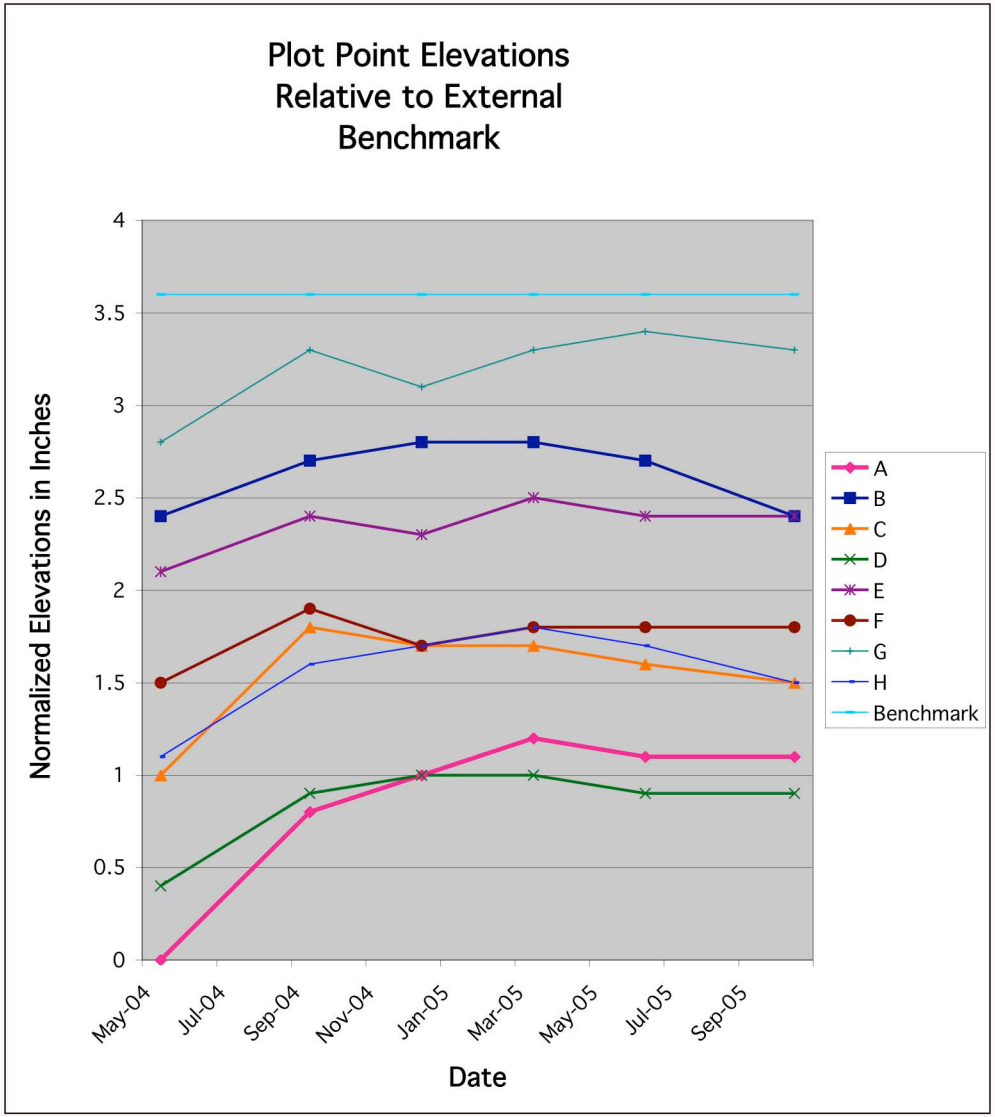
Case Study 1:

May 04 - Oct 05
Plot Point Elevations:

General upward trend with some cyclical movement.

Although A, D, E and F remained level Jul-Oct 05, the weather was extremely dry and a "normal" foundation would have moved down.





Case Study 1 Conclusion:

Monitoring helped us:

- Understand the type of movement
- Quantify movement and distress phenomena
- Explain the cause and remedy to the owner
- Take appropriate corrective action (moisture barriers)
- Predict movement's end

Case Study 2:

Problem: Foundation movement and distress phenomena in 1960s home

Work: Diagnosis in June 2003, monitoring began April 2005

Outcome: Foundation has rebounded, slight movement continues

Case Study 2:

4 bedroom house, built 1963

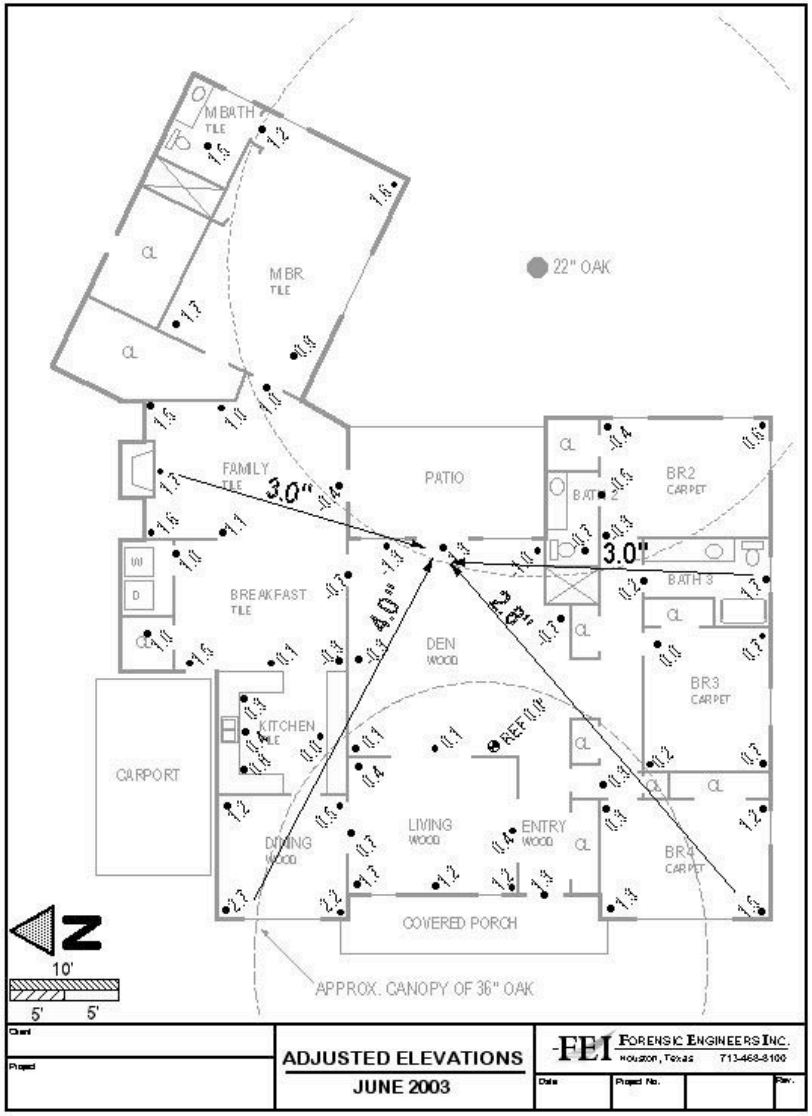
Piers installed along front left side prior to purchase in late 90s

PI=60-70% (USDA)

Hump running N-S through Den

Extensive distress phenomena

Forensic Engineers Inc's Adjusted Elevation Survey showed 4.0" out-of-level in June 2003, low at Den/Patio.



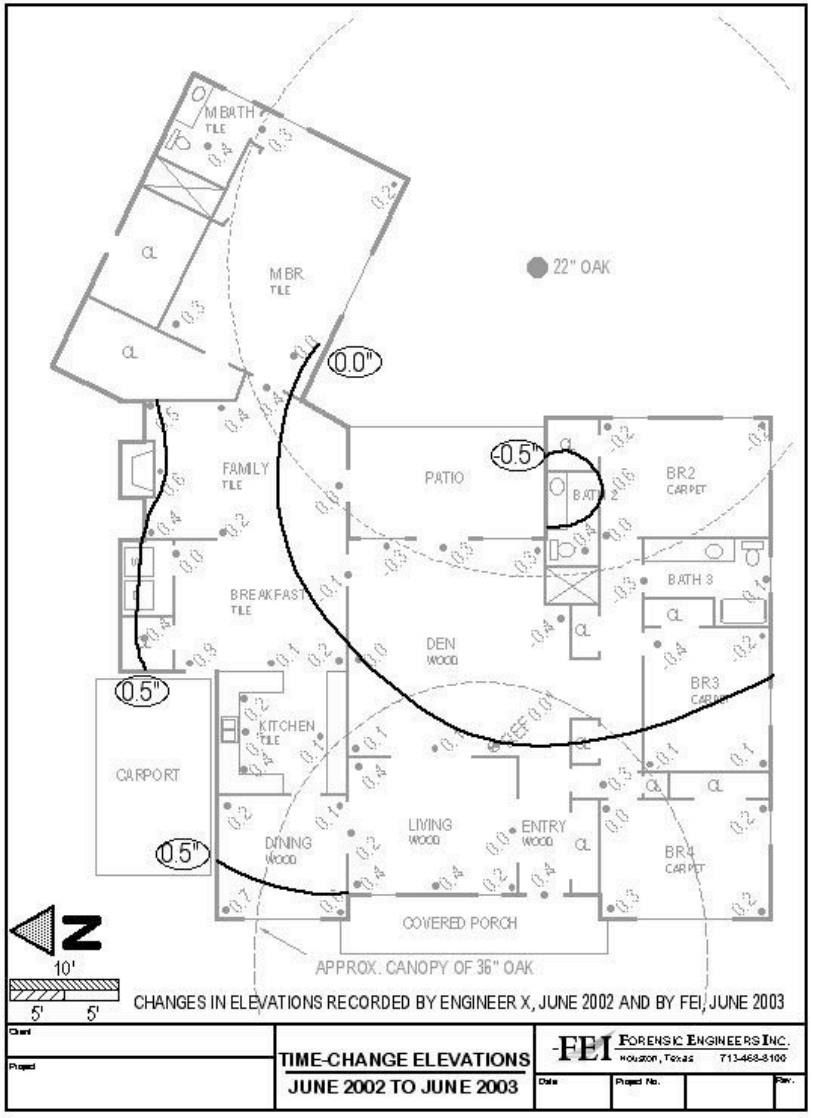
Adjusted Elevations Recorded June 2003

Case Study 2:

Comparing FEI's June 2003 survey to a June 2002 survey showed the Patio/Den/Bedroom 2 area had dropped relative to the rest of the residence, and overall change of 1.5" in one year.

22" oak in backyard was blamed; FEI diagnosed subsidence/shrinkage and recommended heavy pruning or removal of 22" oak.

FEI also recommended homeowner correct drainage issues and start following maintenance procedure outlined in FPA-SC-07.



Time-change Elevations June 2002 to June 2003

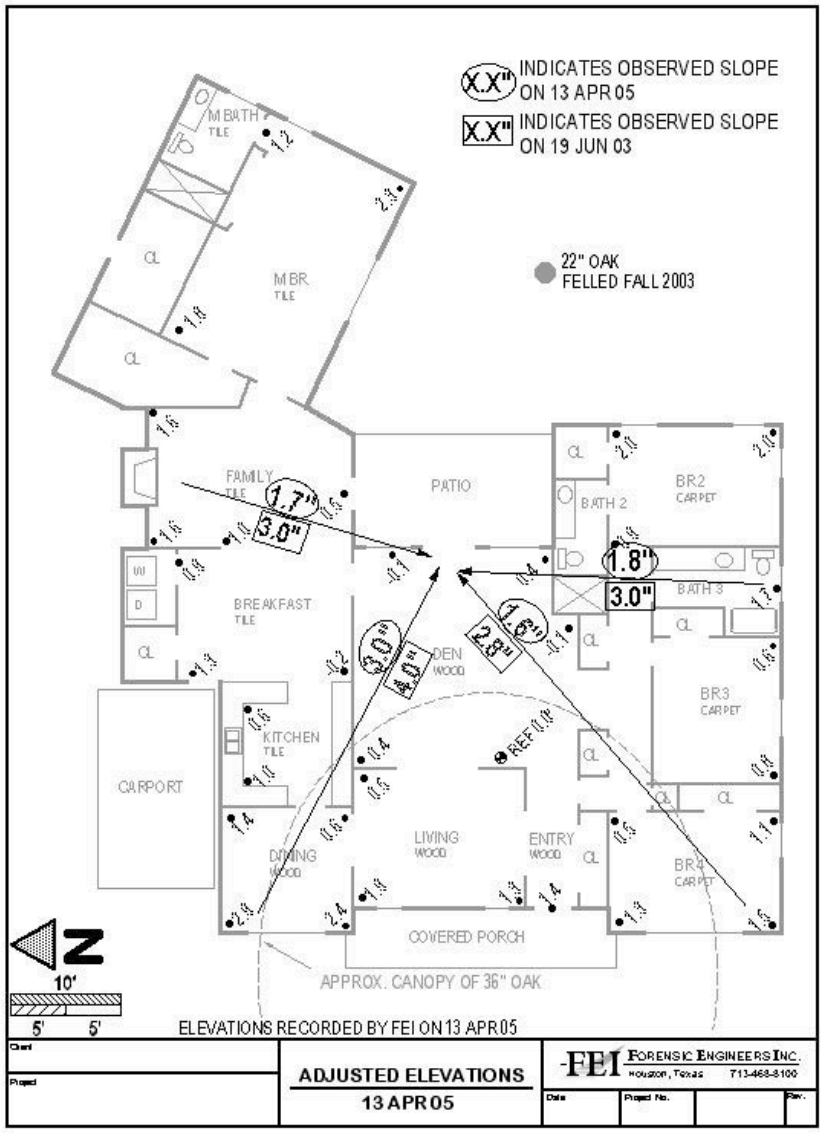
Case Study 2:

22” oak felled Fall 2003

Owner called FEI out in 2005 to access whether the foundation had “rebounded”.

Remarkable change - Patio/Den/Bedroom 2 area lifted significantly after felling the tree 18 months prior.

FEI could not ascertain that movement was complete, and monitoring was necessary.



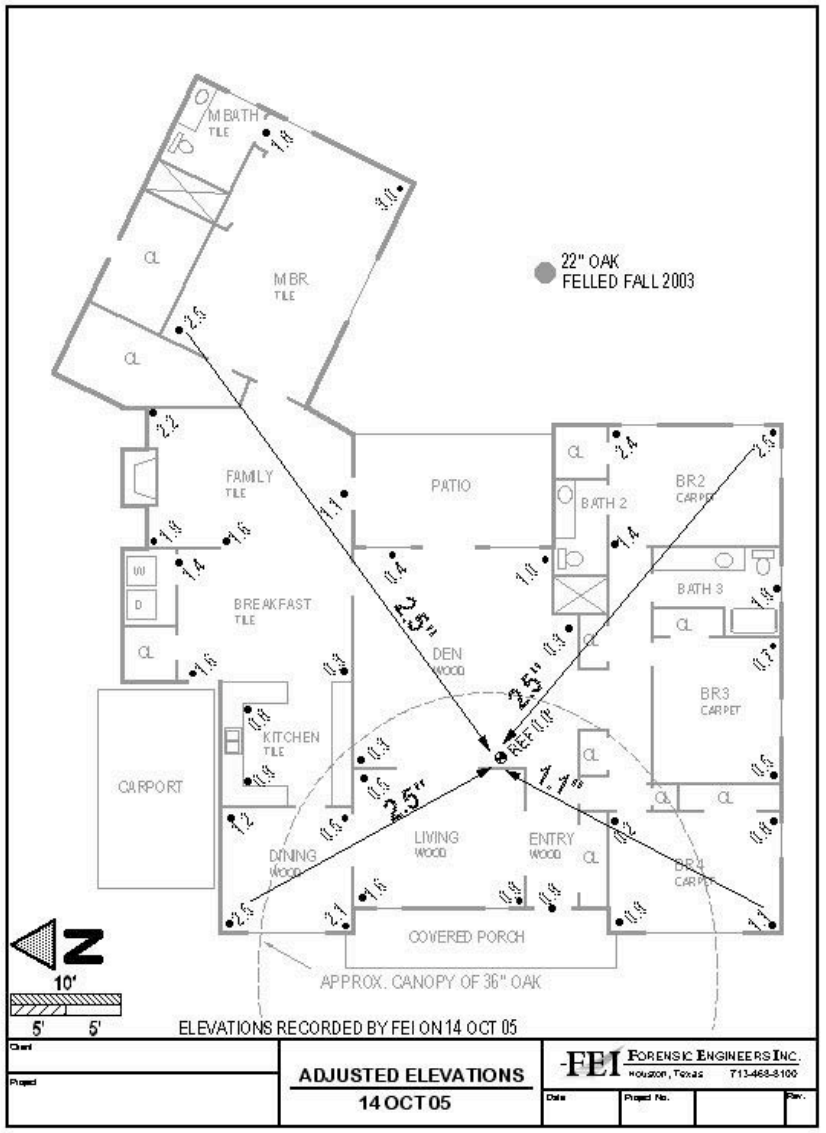
Adjusted Elevations Recorded 14 Apr 05

Case Study 2:

14 Oct 05 Adjusted Elevation Survey showed 3.0” out-of-level; Compare to 4.0” prior to felling oak tree.

Low point moved from Den/Patio interface to Den/Living Room interface, ~20’.

Recommended further monitoring and heavy pruning of front yard oak.



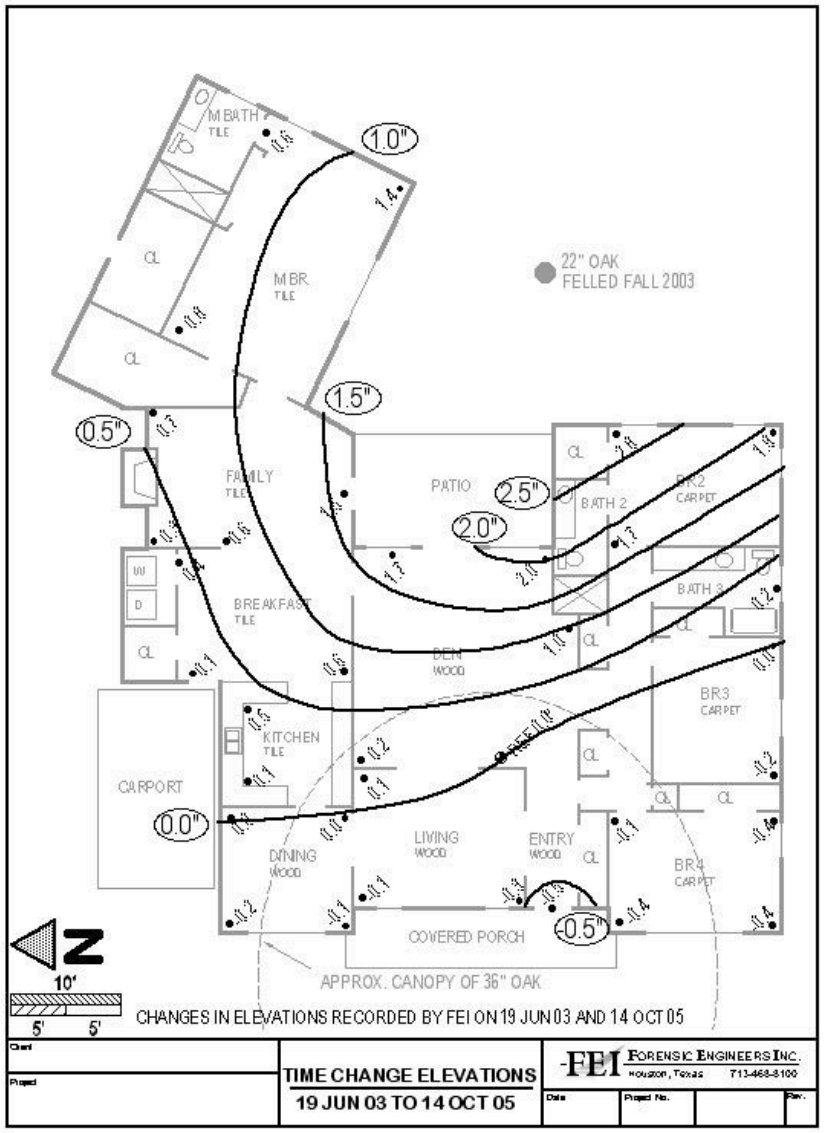
Adjusted Elevations Recorded 14 Oct 05

Case Study 2:

Contours on Time-change Elevation Survey tell the story.

Leveling may not be necessary if trend continues.

Too much movement over six-month period to advise repair. Owner requests continued monitoring.



Time-change Elevations
19 Jun 03 to 14 Oct 05

Case Study 2 Conclusion:

Monitoring helped us:

- Ascertain that tree removal was correct repair
- Take further corrective action (heavy pruning of front trees) to prevent additional distress
- Understand the direction of movement
- Document the quantity of movement
- Predict movement's end

FOUNDATION PERFORMANCE ASSOCIATION

QUESTIONS?

Download “Guidelines for Evaluating Foundation Movement by Monitoring” at:
http://www.foundationperformance.org/committee_papers.cfm