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**Visual Structural Engineering Foundation Performance Evaluation For  
Client: Michelle Sample**

relation of client to property: owner

property located at

**4927 Valkeith**

**Houston, Texas**

There is an **Executive Summary** on page 4. The **Executive Summary** provides a summary of the engineering evaluation of the visually apparent foundation performance.

The space to the right contains a computer-generated Professional Engineering Seal. The seal was authorized by R. Michael Gray, P.E. (72949) on Tuesday, February 02, 2010. It is a violation of law to copy or alter this seal in any manner.



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**Project Description**

Some of the information listed below is from the owner. The report and the engineering judgments expressed in the report rely, in part, on the information in the table below:

Building Type: single family home	Approximate Age of House: 50-years
Number of Stories: 1	Was Client Present?: yes
Was Building Occupied?: yes	Was the Owner Present? yes; the owner is the client

This real estate inspection was performed and the report prepared pursuant to the **PROFESSIONAL ENGINEERING CONSULTING AGREEMENT** (hereafter referred to as the “agreement”) between the Client and R. Michael Gray.

**METHODOLOGY OF PROFESSIONAL ENGINEERING FOUNDATION PERFORMANCE EVALUATION:**

This inspection and report is a Level A evaluation as defined in the Texas Section of the American Society of Civil Engineers publication *Guidelines for the Evaluation and Repair of Residential Foundations*. The methodology of a Level A engineering performance evaluation inspection is visual. The engineering evaluation of the visually apparent foundation performance will be based on visual observations using generally accepted engineering standards.

The inspection methodology is visual in that the inspection consists of observing the visible condition of building surfaces and/or components that are open to view. Observations are limited to only those areas open to view without moving any item which is blocking the view. No wall or floor coverings are removed, no soil is excavated and no furnishings are moved. The inspection and engineering evaluation does not involve a definitive, formal engineering inspection/analysis; the inspection is limited in the scope and the amount of time spent at the site; therefore, no special testing or diagnostic inspections will be performed. I will not employ any instruments to aid in the inspection, employ any destructive testing, or make any formal engineering calculations. It is expressly pointed out that the Level A foundation performance evaluation will be preliminary in scope and restricted to the use of the inspector's visual ability to make observations. For these reasons, the inspection process is not diagnostically and/or technically exhaustive.

**SCOPE OF OFFERED PROFESSIONAL ENGINEERING FOUNDATION PERFORMANCE EVALUATION:**

The foundation performance evaluation I provide is intended to provide you with unbiased, subjective opinions regarding the overall performance of the building foundation for your exclusive use so that you can better evaluate the overall performance of the foundation of the building. The report will be based on our observations of the visible and apparent performance of the foundation on the date of the inspection. In the conduct of the inspection, we do not perform any action that, in our judgment, could damage the property or endanger the safety of the inspector or any other person. Although care is taken in the performance of the inspection, R. Michael Gray makes no representations regarding any latent, concealed or obstructed defects that may exist. The foundation performance evaluation report is not fully exhaustive nor does it imply that every component was inspected or that every possible defect was discovered and reported.

The opinions formulated by the inspector will be based on perceived conditions as compared to the inspector's personal knowledge and/or experience and will, therefore, be subjective and not based upon any Code requirements,

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manufacturer requirements and/or performance standards and/or compliance with any Federal, State or local codes, lender requirements and/or other legal requirements. The content of the report should be considered as a first impression opinion of apparent foundation performance; therefore, the observations of the structure and foundation by a different professional can result in differing opinions and/or conclusions.

Judgments concerning the performance of the foundation will be based on the visible condition of the exposed area of the foundation, the levelness of surfaces that would normally be expected to be level (such as countertops and sills) as well as distress patterns in wall coverings that are normally associated with foundation movement such as diagonal cracks in drywall, stair-step or diagonal cracking in brick veneer, diagonal cracking in stucco and sticking doors. We will make an unbiased recommendation to underpin or not to underpin the foundation based on the apparent performance of the foundation as well as our estimate of the degree to which the performance of the foundation is likely to be improved by underpinning. We will also provide an unbiased, subjective opinion concerning the structural performance of the foundation as compared to our inspection experience with houses of similar construction, age and general location.

**Items Excluded from an Engineering Foundation Performance Evaluation:** The foundation performance evaluation does not include any item or component not listed above. The following are specifically excluded from a normal home inspection:

**No Structural Pest Inspection:** According to the Texas Structural Pest Control Act only persons who possess a valid Structural Pest Control Business License may inspect or make reports with respect to structural pest infestations including any wood destroying organisms including insects such as termite and fungus such as rot. We do not possess a Structural Pest Control Business License and thus cannot legally inspect or make reports with respect to structural pest infestations including any wood destroying organisms. We strongly recommend that you engage the services of a Structural Pest Control Business Licensee.

**No Hazardous Materials or Environmental Inspection:** There are many hazardous materials or environmental conditions that may be present in a building. This inspection and report does not address any environmental conditions (such as mold or radon) or hazardous materials (such as lead or asbestos).

**No Engineered Repair Plan:** While we do normally provide general descriptions of needed repairs, the report is not intended to be used as an engineering design document for the repair of the foundation.

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**EXECUTIVE SUMMARY**

This section is an executive summary of the report. The executive summary includes a summary of the engineering performance evaluation of the foundation. Also included is a summary of the observed defects from the subsection, Recommended Repairs, Observed Defects and Comments for all the sections other than the foundation. For complete information about the condition of the components included in this inspection, please refer to the appropriate sections of the report.

**FOUNDATION SUMMARY:**

**VISUAL FOUNDATION INSPECTION AND VISUAL ENGINEERING PERFORMANCE EVALUATION SUMMARY**

Issues	summary comments
1. Does the house show damage that is probably due to foundation movement?	Based on my observations of the house, it is my engineering judgment that the house does exhibit visible damage due to foundation movement.
2. What kinds of damage does the house exhibit due to foundation movement?	In the judgment of this engineer, the visible damage to the house resulting from foundation movement is cosmetic.
3. Engineer’s opinion of the visually apparent foundation performance.	In the judgment of this engineer, the foundation is performing in a serviceability sense within what I consider to be an acceptable range of structural performance given the apparent age, construction and location of the structure.
4. Is the foundation performance adequate in terms of usability and serviceability of the house?	It is my judgment that the foundation is performing in a way that does not impair the usability and serviceability of the house.
5. Is the foundation performance adequate in terms of structural damage to the house?	It is my judgment that the foundation is performing in a way that is not significantly impairing the ability of the structural frame of the house structure to carry normal imposed loads in a safe manner.
6. Is the apparent geometry of the foundation surface as indicated by Finish Floor Elevation Profiles consistent with normal foundation performance?	The Finish Floor Elevation Profiles, in this engineer’s opinion, are consistent with normal foundation surface geometry taking into consideration published ACI construction tolerances and expected foundation surface distortion for foundations in this area and age.
7. Is foundation underpinning structurally necessary?	It is my judgment that this question should be answered in the affirmative only if foundation movement is clearly causing significant structural damage to the house or if the foundation movement is resulting in structural safety issues that cannot be addressed without underpinning the foundation. It is my judgment that foundation underpinning is not structurally necessary for this house.

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Issues	summary comments
8. Is foundation underpinning recommended?	Foundation underpinning is an option if you find the performance of the foundation inadequate. It is my judgment that this question should be answered in the affirmative only if foundation is clearly distorting to a degree that foundation underpinning is likely to make a significant improvement to the future performance of the foundation. It is my judgment that foundation underpinning is not recommended for this house; it is my judgment that any improvement in the future performance of the foundation is outweighed by the risk of damage to both the house and the foundation that could result as an unintended consequence of the foundation underpinning process. I recommend that the two trees that are close to the house at the left side be removed. The bare soil should be covered with a ground cover or mulched. Proper drainage should be created and the air conditioning condensate made to discharge on the ground at least 5-feet away from the foundation. If after 6-months the situation has improved or at least stabilized, foundation underpinning should not be considered. If, after 6 months, the situation is continuing to deteriorate, foundation underpinning the left side of the foundation should be considered.
9. What options are available for repairing the visible foundation distress?	In my opinion, the distress evident in this house (brick veneer cracks, sheetrock cracks and minor door issues) cannot be repaired by making adjustments to the foundation. There is no clear evidence, in my opinion, that the foundation movement has been excessive. There are only 2 reasonable options, in my view. Since there were no structural safety issues observed, it is acceptable to simply live with it if that is acceptable to you. A second option is to repair the objectionable distress using normal carpentry and masonry repair techniques..
10. Are any concrete repairs recommended?	During the visual inspection I did not see anything that indicated to me that any concrete repairs are necessary at this time.
11. Comments concerning previous reports.	There were no previous reports available.

**ENGINEERING FOUNDATION PERFORMANCE EVALUATION**

**Description of Foundation Performance**

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It is important for the client to understand what is meant by “foundation performance”. Engineers view the adequacy of a structure from two different perspectives. These are usually referred to as “strength” and “serviceability”.

Broadly speaking, the strength of a structure may be thought of as the load a structure can carry before it collapses. You have probably seen signs near the entrance of some bridges, for instance, that prohibit the passage of trucks that weigh more than some specified amount. This is because the bridge structure could be damaged or even collapse if trucks that weighed too much were allowed to travel over the bridge. The strength of a structure is the load required to break the structure. In the case of a bridge, the strength is the load that would cause the bridge to collapse.

The other way to view a structure is from a “serviceability” perspective. Serviceability normally addresses the flexibility of a structure. A structure may be adequate from a strength perspective but could be excessively flexible from a serviceability perspective. An example might be a bridge that was in no danger of collapse but which sagged so much when vehicles traveled over it that the public refuses to use it.

Slab-on-ground foundations are ground-supported structures (as opposed to elevated structures like bridges) and, as such, are not in danger of collapse. They are normally evaluated from a serviceability perspective and not from a strength perspective. The evaluation described in this report is not a strength evaluation; it is a serviceability evaluation. Foundation performance is normally judged in terms of the damage caused to the supported structure by foundation movement.<sup>1</sup> We judge the performance of a slab-on-ground foundation in terms of damage to the supported structure in the following terms:

- Maximum and cumulative crack widths in the brick veneer, stone veneer and/or stucco exterior walls.
- The number of cracks in the interior drywall.
- The number of doors that stick or bind.
- The degree of rotation of the fireplace chimney away from the house structure.
- Significant structural damage to the load-carrying capacity of the wood frame structure.
- Levelness of normally level surfaces, specifically sills and countertops.

**COMPONENTS INSPECTED:**

*The components of the **Foundation Performance** listed below were inspected unless otherwise noted under **ADDITIONAL INFORMATION**.*

<b>Type of Foundation:</b>	slab-on-ground foundation; for an explanation of the performance implications of the foundation type, see the Additional Information section
<b>Visible Foundation Surfaces</b>	visible fractures
<b>Interior Walls Surfaces</b>	diagonal drywall fractures
<b>Exterior Wall Surfaces</b>	stair-step brick veneer/stone veneer cracks and diagonal stucco cracks
	separations between adjacent materials
<b>Levelness of Normally Level Surfaces</b>	countertops sills

<sup>1</sup> **International Building Code, 2000 edition**, section 1805.8.1; I am referencing this code because the quoted performance standard is widely accepted, even by governmental authorities, not because this inspection is a code inspection; this inspection is not a code inspection

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<b>Door Frame Distortion</b>	binding and sticking doors nonfunctional doors doors that do not latch

**Performance Implications Related to the Type of Foundation**

Slab-on-ground foundations are the most common type of foundation in the Greater Houston Area for residential foundations. When supported by active or expansive soils, this type of foundation will frequently deflect enough to result in cosmetic damage (usually sheetrock, brick veneer cracking and floor tile cracking) and possibly some minor functional problems such as sticking doors. Any owner of a building founded on a slab-on-grade foundation should be prepared to accept a degree of cosmetic distress and minor functional problems due to foundation movement.

**Description of Performance**

From a structural perspective, a foundation on expansive soils acts as a buffer that reduces the distortion of the supported structure from the differential deformations of the soil below the foundation. One accepted standard<sup>2</sup> requires that foundations on expansive soils be designed and constructed so that 1) "deflection and racking of the supported structure shall be limited to that which will not interfere with the usability of and serviceability of the structure" and 2) foundation movement does not result in "structural damage to the supported structure".

Item number two is clear enough, but item number one requires some interpretation. It can be interpreted to mean that expansive soil induced foundation distortion shall be limited so that the supported structure shows no distress that impairs the functioning of the supported structure, such as doors that will not work due to binding. In my interpretation, structural damage to the structural frame of the supported structure is prohibited as is damage to the supported structure such as binding doors that impairs the functioning of the supported structure. From the perspective of this accepted standard, a foundation that deflects to the extent that there is structural damage to the structural frame of the supported structure or that results in damage to the supported structure that impairs the usability of the supported structure is performing in an inadequate manner.

It should be noted that, given this interpretation of the performance standard quoted above, many houses founded on expansive soils will not perform in an adequate manner during their normal service life.

Foundation performance is best understood in terms of degrees of performance. To quote Donald P. Coduto, P.E. "A common misconception, even among some engineers, is that foundations are either perfectly rigid and unyielding, or they completely incapable of supporting the necessary loads and fail catastrophically. This 'it's either black or white' perspective is easy to comprehend, but it is not correct. All...foundations have varying degrees of performance that we might think of as various shades of gray." (**Foundation Design - Principles and Practices**, by Donald P. Coduto, P.E., page 10).

To evaluate the performance of the foundation we do the following:

- Identify the visible distress (likely, in my engineering judgment, to be foundation induced) in terms of 1)structurally significant cracks in the slab, 2)cracks in the sheetrock, 3)doors that are sticking, not latching

<sup>2</sup> **International Building Code, 2000 edition**, section 1805.8.1

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or not functional as a result of foundation movement, 4)the foundation-movement induced strain-displacement in the exterior brick veneer, stone veneer and/or stucco walls, and 5)visible evidence of damage to the structural frame of the supported structure that significantly reduces the ability of the structural frame to carry normally imposed loads.

- Render an unbiased engineering judgment as to whether the visible distress that is, in my engineering judgment, likely to be to be foundation induced is structural, functional and/or cosmetic. Structural distress is defined as distress that significantly reduces the ability of the structural frame to carry normally imposed loads in a safe manner.
- Render an unbiased engineering judgment, based on the visually apparent foundation performance and my engineering judgment, as to whether the deflection and racking of the supported structure has interfered with the usability of and serviceability of the structure in the form of binding, sticking or non-functional doors
- Render an unbiased engineering judgment, based on the visually apparent foundation performance and my engineering judgment, as to whether foundation movement has resulted in significantly degrading the ability of the structural frame to safely carry and transmit normally imposed loads
- Render an unbiased engineering judgment, based on the visually apparent foundation performance and my engineering judgment, as to whether it is structurally necessary to underpin the foundation.
- Render an unbiased engineering judgment, based on the visually apparent foundation performance and my engineering judgment, as to whether it would be prudent to underpin the foundation.

**Comments Concerning the Visually Apparent Foundation Serviceability Performance**

Foundations should also remain stable under the imposed loads so that any damage (usually cosmetic or functional issues such as sloping floors, sticking doors, etc.) to the building is tolerable to the owner or buyer. The type, extent and severity of damage that is tolerable is subjective and will vary from person to person. It is the responsibility of the client to decide if the presence and amount of foundation induced damage is acceptable.

**Damage Based Foundation Performance Evaluation**

Reported Past Distress History and Other Information	
1. Previous Underpinning of the Foundation?: no	5 Masonry Fireplace Chimney Rotation: not applicable
2. Brick Veneer, Stone Veneer and/or Stucco Cracking: yes	6. Were Site-Specific Soils Reports Available?: no
3. Drywall Cracking: yes	7. Were Previous Engineering/Inspection Reports Available?: no
4. Door Sticking, Door Binding and Door Latching: yes	

1. Foundation Cracking and Levelness	
number of distinct cracks	no structurally significant cracks were observed; as is

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	normally the case, most of the foundation surface was concealed from view; see the comment below concerning cracks in concrete
<b>width of largest crack</b>	not applicable
<b>floor tile cracking</b>	none due to foundation movement
<b>levelness</b>	based on walking the first floor, the slab surface appeared to not have been severely distorted by foundation movement

comment: wedge cracks and hairline or very tight cracks are not structurally significant in this context and are not reported; cracks covered by floor coverings are not visible and are not reported; should floor coverings be removed and it is desired for this engineer to evaluate these cracks, this can be done for an additional fee

comment: ceramic and other brittle floor tiles will crack even with very minor foundation movement; to a significant extent floor tile cracking can be avoided by using a separation membrane such as you can find at <http://www.schluter.com>; be forewarned that the use of a separation membrane is not standard construction in the Greater Houston Area

comment: how level a foundation floor surface should be is a matter of personal taste; if the levelness of the floor surfaces is important to you, make sure you walk all the floors to make sure the floor levelness is acceptable to you; when the normally level surfaces (such as sills and countertops) are level, any unlevelness of the floor surface, in my opinion, can be largely attributed to original construction and not to foundation movement.

<b>2. Drywall cracks and cabinet/wall separation</b>	
<b>number of distinct cracks and/or cabinet/wall separations</b>	11
<b>width of largest wall crack or cabinet/wall separation</b>	3/16 <sup>th</sup> inch
comment: whether cracks of this nature are related to foundation movement is largely a matter of judgment; I do not report cracks that, in my judgment, are clearly not related to foundation movement. I also do not report cracks that are less than 6-inches in length.	
comment: vertical and horizontal sheetrock cracks, in my experience, are usually caused by something other than expansive soil foundation movement; more likely causes include poor drywall fastening, poor drywall finishing, concentrated load paths in the framing, normal shrinkage of wood framing and normal construction errors in the framing	
comment: sheetrock cracks in ceilings, in my engineering judgment, are frequently not related to expansive soil foundation movement; they are usually related to framing details and sheetrock application	

<b>3. Doors</b>	
<b>number of doors sticking or not latching properly</b>	none due to foundation movement

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<b>inoperable doors</b>	none due to foundation movement
<b>visible first story door frame distortion</b>	minor only
comment: door distress that is not related to foundation movement such as hardware defects or moisture problems is not reported	
comment: door frame distortion can indicate foundation movement but may not be indicative of excessive foundation movement	
comment: in my engineering judgment, door frame distortion upstairs in a multistory house is usually not related to expansive soil foundation movement	

**4. Cracks and Separations in Exterior Walls**

wall	number of cracks and separations	largest crack or separation (inches)	cumulative crack/separation width (inches)	estimated deflection ratio
front	0	0	0	0.00/360
right	1	1/8	1/8	0.13/360
left	4	1/4	15/32	0.47/360
rear	0	0	0	0.00/360

comment: cracks and other openings that appear to be caused by thermal stresses or other non-foundation related causes are not reported

comment: I would not normally consider foundation underpinning as a viable option unless one or more of the estimated deflection ratios exceeded 1/360

comment: the estimated deflection ratios are based on brick veneer cracks/separations that are visible; it does not take into account repaired brick veneer cracks/separations

<b>5. Masonry Fireplace Chimney Rotation</b>	not applicable
<b>gap between house and fireplace chimney</b>	not applicable
<b>height above foundation at which gap was measured</b>	not applicable

<b>6. Visible Evidence of Structural Damage to the Structural Frame</b>	none
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Based on my observations of the house, it is my engineering judgment that the house does exhibit visible damage due to foundation movement.

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It should be noted that the distress and damage reported in this section is not intended to be a complete list of all the foundation movement related distress and damage in the house.

It should also be understood that it is not unusual for a homeowner to make repairs to the house including repairs to damage that is caused by foundation movement. There is nothing wrong with a homeowner making repairs to the house, but I make no warranty that I can detect such repairs. In addition, the owner's disclosure statement does not require the owner to disclose such repairs. When the owner is at the inspection, we ask about repaired drywall cracks, repaired brick veneer cracks and repaired door issues. If the owner is not present we have to go by what we can see.

### **Engineer's Judgment Concerning the Types of Foundation Induced Damage**

Foundation induced damage to a building can be categorized in three different categories as listed below:

- **Structural Damage** - this refers to a situation where foundation movement has resulted in a load-carrying member being broken or otherwise damaged to the point where it can no longer carry or transmit the magnitude of loads or forces that it would normally be intended to carry.
- **Functional Damage** - this refers to a situation where foundation movement has distorted the frame structure to the extent that parts of the structure do not work right. A typical example is a door that is sticking due to foundation movement..
- **Cosmetic Damage** - this is damage that does not result in structural damage or functional damage; it only affects the way the building looks. Some common examples of cosmetic damage include sheetrock cracks, brick veneer cracks, floor tile cracks, tight cracks in the slab, separating fascia trim, etc. Cosmetic damage does not impair the load carrying capacity of the structure.

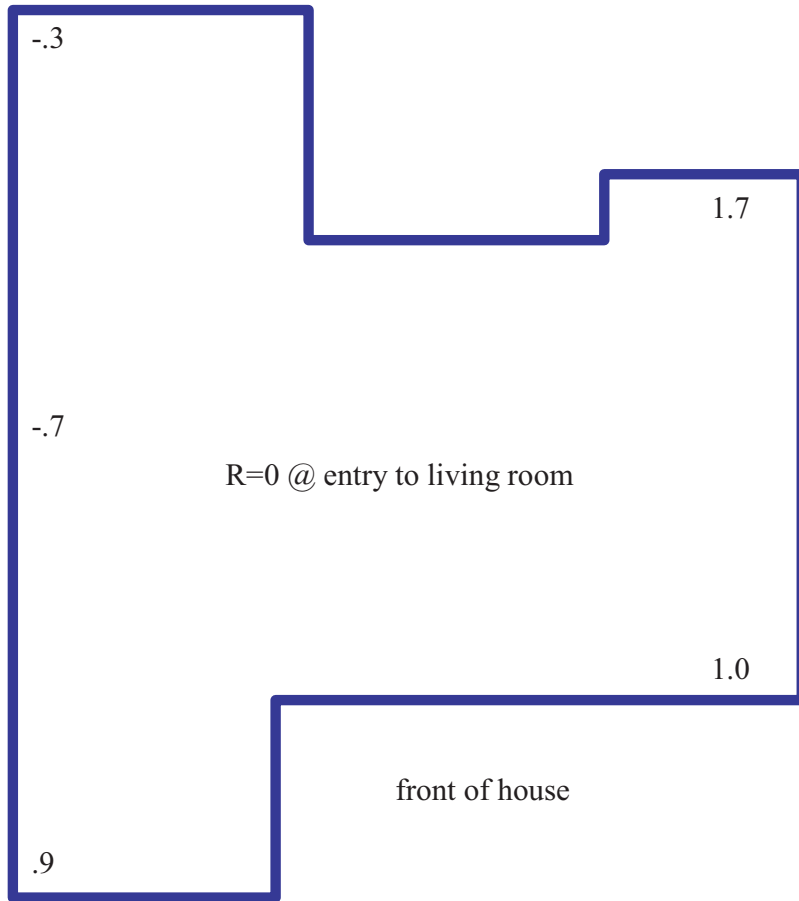
In the judgment of this engineer, the visible damage to the house resulting from foundation movement is cosmetic.

### **Foundation Tilt/Deflection Analysis Using Finish Floor Elevation Profiles**

I made some finish floor elevation measurements and used these to create longitudinal (side to side) and transverse (front to rear) Finish Floor Elevation Profiles as shown below. These profiles can be analyzed to make engineering judgments concerning the apparent deflection and tilt of the foundation across specific profiles of interest.

The first step is to create an approximate model of the foundation that, in our judgment, allows us to identify the approximate design rectangles for the foundation. The approximate model of the foundation is shown below. The model shown below can be viewed as an approximation of the foundation footprint. The red lines with an arrow head on each end shows the approximate location of the profiles. The profiles I use are based mainly on the shape of the foundation, the visible damage judged to be due to foundation distortion, sloping of the first floor as perceived by me and my engineering judgment.

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### Elevation Measurements (in inches) Showing Shape of Foundation

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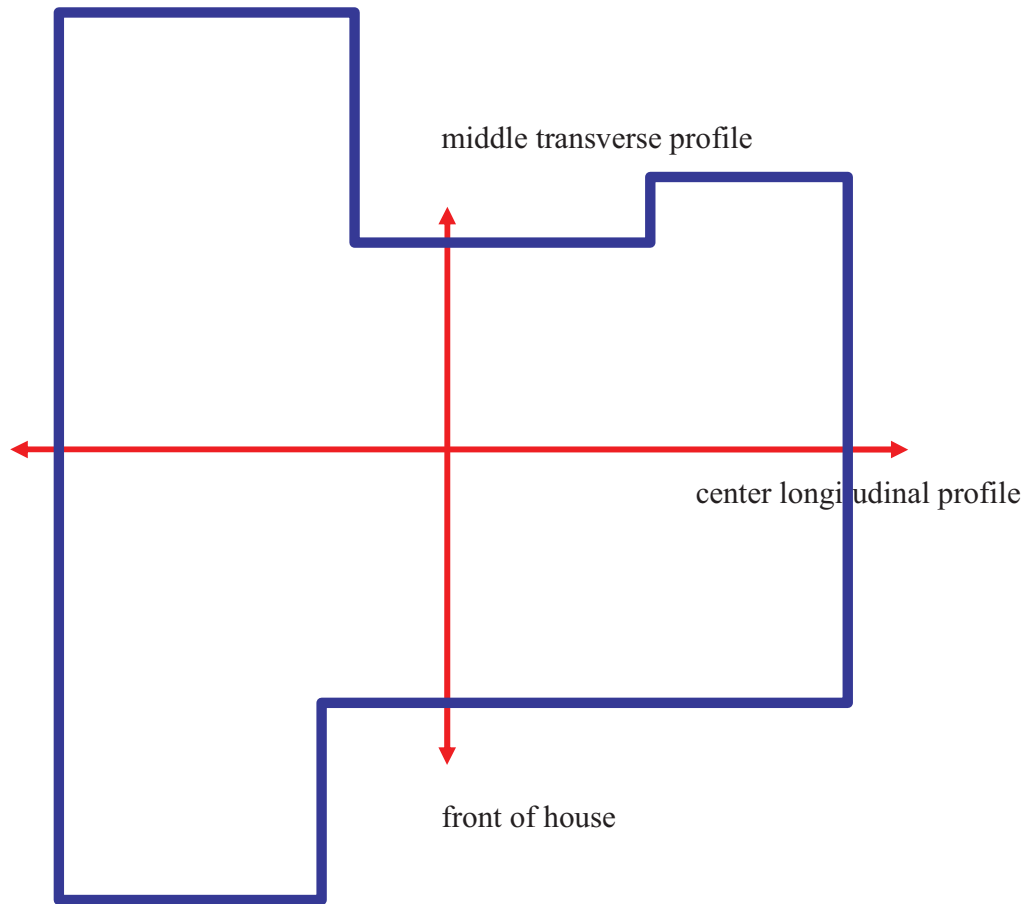
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**Approximate Profile Locations**

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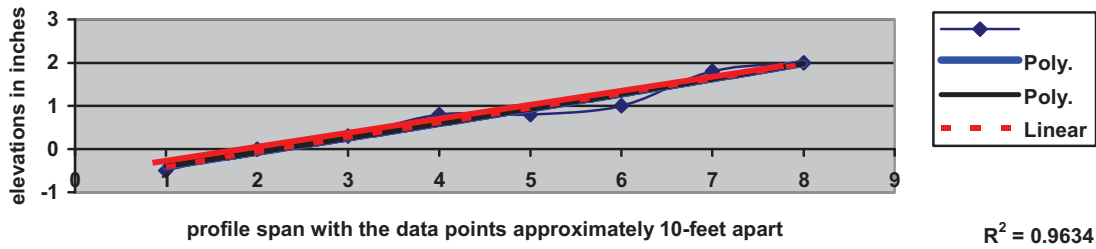
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**Center Longitudinal (side to side) Finish Floor Elevation Profile Data (inches)**

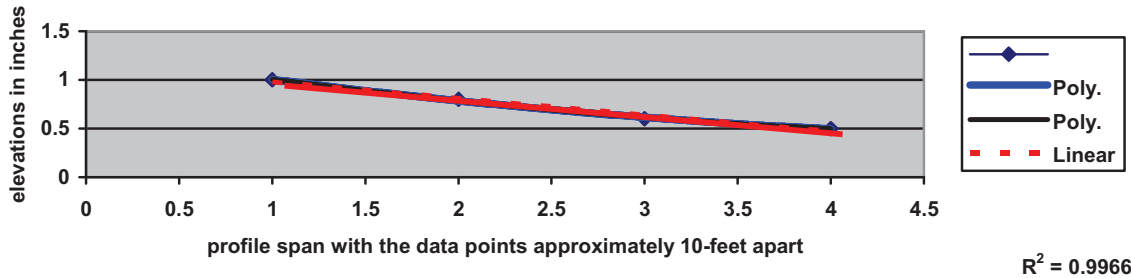
**Finish Floor Elevation Profile for Deflection/Tilt Estimation**



profile span (feet)	profile deflection (inches)	estimated profile deflection ratio
51	.1	0.06/360

**Middle Transverse (front to rear) Finish Floor Elevation Profile Data (inches)**

**Finish Floor Elevation Profile for Deflection/Tilt Estimation**



profile span (feet)	profile deflection (inches)	estimated profile deflection ratio
24	.1	0.13/360

In the above finish floor elevation profiles, the following should be kept in mind:

- The curved black line that runs through the data points is an approximation of the distortion of the foundation across the subject profile based on the raw data.

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- The curved dark blue line (on the profiles for deflection/tilt estimation) is an approximation of the deflection curve caused by expansive soil foundation movement by the subject profile based on a mathematical engineering analysis of the raw data using a technique called regression analysis.
- The straight red line that connects the end points of the curved dark blue line (on the profiles for deflection/tilt estimation) is a graphical representation of the tilt exhibited by the foundation across the subject profile.
- The variation between the curved dark blue line and the curved black line (on the profiles for deflection/tilt estimation) can be interpreted as due to a combination of as-constructed out-of-levelness and settlement.
- The dashed red line allows us to tell of the profile data indicate a foundation constructed outside accepted construction tolerances.
- The  $R^2$  number (on the profiles for deflection/tilt estimation) is a measure of how well the well regression analysis conforms to the raw data.
- The estimated profile deflection ratios are approximations only. The reliability of the deflection ratios can be questioned. These estimates can be affected by several factors including the type or types of floor covering, releveling due to foundation repair, non-random as constructed out-of-levelness and the application of floor leveling compounds.

The Finish Floor Elevation Profiles, in this engineer's opinion, are consistent with normal foundation surface geometry taking into consideration published ACI construction tolerances and expected foundation surface distortion for foundations in this area and age.

### **Engineer's Judgment Concerning the Adequacy of Foundation Performance**

The previously discussed performance standard requires that foundations on expansive soils be designed and constructed so that 1) "deflection and racking of the supported structure shall be limited to that which will not interfere with the usability of and serviceability of the structure" and 2) foundation movement does not result in "structural damage to the supported structure". Our engineering judgments concerning the performance of this foundation using this standard is given below:

- **Usability and Serviceability of the Supported Structure:** It is my judgment that the foundation is performing in a way that does not impair the usability and serviceability of the house.
- **Structural Damage to the Structural Frame of the Supported Structure:** It is my judgment that the foundation is performing in a way that is not significantly impairing the ability of the structural frame of the house structure to carry normal imposed loads in a safe manner.

### **Engineer's Judgment of Foundation Serviceability Performance**

In the judgment of this engineer, the foundation is performing in a serviceability sense within what I consider to be an acceptable range of structural performance given the apparent age, construction and location of the structure.

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### Engineer's Judgment Concerning Foundation Underpinning

Underpinning a foundation will normally, but not always, reduce the amount of movement the foundation is undergoing. The normal foundation repair company warranty only guarantees against future movement of more than 1 inch of deflection for every 360-inches of span. (The span is normally taken as the length or width of the foundation.) I would not normally, therefore, recommend underpinning a foundation unless there was clear evidence that the foundation is deflecting more than 1 inch for every 360-inches of span.

One of the aspects we consider in whether to recommend underpinning is whether, in my judgment, underpinning the foundation is likely to make a significant difference to the future performance of the foundation. In a formal engineering evaluation of the performance of a slab-on-ground foundation, various types of damage to the supported structure can be calculated using structural engineering models with an assumed foundation distortion pattern. A foundation distortion pattern conforming to the foundation repair company warranty can be used to develop a damage matrix such as shown in Table 1 above. The calculated damage can then be compared to the existing visible damage in the supported structure. If the calculated damage is greater than the visible damage, underpinning may not be a rational option. On the other hand, if the calculated damage is less than the visible damage, underpinning may be a reasonable choice.

There are two key questions concerning foundation underpinning that we give an engineering judgment on:

- **Is foundation underpinning necessary?** It is my judgment that this question should be answered in the affirmative only if foundation movement is clearly causing significant structural damage to the house or if the foundation movement is resulting in structural safety issues that cannot be addressed without underpinning the foundation. It is my judgment that foundation underpinning is not structurally necessary for this house.
- **Is foundation underpinning recommended?** Foundation underpinning is an option if you find the performance of the foundation inadequate. It is my judgment that this question should be answered in the affirmative only if foundation is clearly distorting to a degree that foundation underpinning is likely to make a significant improvement to the future performance of the foundation. It is my judgment that foundation underpinning is not recommended for this house; it is my judgment that any improvement in the future performance of the foundation is outweighed by the risk of damage to both the house and the foundation that could result as an unintended consequence of the foundation underpinning process. I recommend that the two trees that are close to the house at the left side be removed. The bare soil should be covered with a ground cover or mulched. Proper drainage should be created and the air conditioning condensate made to discharge on the ground at least 5-feet away from the foundation. If after 6-months the situation has improved or at least stabilized, foundation underpinning should not be considered. If, after 6 months, the situation is continuing to deteriorate, foundation underpinning the left side of the foundation should be considered.

It should be understood that our engineering judgment as to whether a foundation should be underpinned is based on our observations during the inspection as well as our experience including our experience in developing and working with structural engineering models used to relate foundation deformation patterns to damage to the supported structure.

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### Engineer's Judgment Concerning What Should be Done Regarding Repairs to Foundation Related Distress

Many people want to know what can be done to repair visible distress due to foundation movement. Our answer to that question is below:

- In my opinion, the distress evident in this house (brick veneer cracks, sheetrock cracks and minor door issues) cannot be repaired by making adjustments to the foundation. There is no clear evidence, in my opinion, that the foundation movement has been excessive. There are only 2 reasonable options, in my view. Since there were no structural safety issues observed, it is acceptable to simply live with it if that is acceptable to you. A second option is to repair the objectionable distress using normal carpentry and masonry repair techniques..

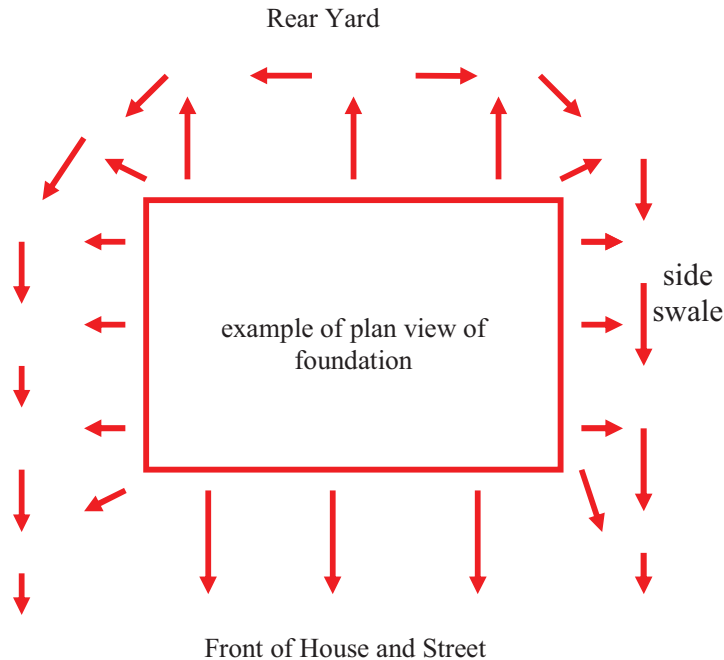
### Other Observations

The following observations were noted during the inspection. Please note that any of these conditions could have an adverse effect on the future performance of the foundation.

- **Area:** This building is located in an area which is known to contain active or expansive soils. This means that the building is at a higher risk for foundation induced distress, especially if the foundation is not properly maintained.
- **Vegetation:** There are several trees that are close enough to the foundation that they are highly likely to be adversely impacting the performance of the foundation. I do not recommend removing such trees unless they are clearly causing severe damage to the supported structure. Another, less drastic action, would be to have a tree service company install a root barrier between the foundation and the tree.
- **Drought:** The Greater Houston Area periodically experiences a severe drought. In expansive soil areas, this type of weather can result in soil movement that can cause foundation movement that is significantly in excess of what foundations are normally expected to experience. In drought situations, foundations are at risk of experiencing rapid and severe movement that, in turn, can result in damage to the house in the forms of cracks in wall covering materials (especially brick veneer, stone veneer, stucco and sheetrock) and floor tile.
- **Soil Grading and Drainage:** The grade of the ground adjacent to the slab-on-ground foundation is poor. The ground adjacent to the foundation should be graded so that it falls 6-inches in 10-feet (or to the property line if it is closer than 10-feet) as you move away from the foundation. The grading and drainage of the ground adjacent to the foundation is very poor at this house. The ground should be graded so that water clearly flows away from the foundation. At the front the water should flow directly away from the foundation and to the street. Alternatively the water can flow to a swale that is at least 10-feet from the foundation and is shaped to direct the water to a side swale. The ground between the house and the adjacent house should be shaped so that the water flows into a swale that is shaped to direct water to the street. The ground in the rear should fall at least 6-inches in 10-feet as you move away from the foundation. The ground should be shaped so as to direct the water to the side and into a side swale. The following sketch gives a general idea of how water should flow away from the foundation to promote better slab-on-ground foundation performance. The arrows show the desired direction of the water flow away from the foundation and off the site.

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- **The Importance of Soil Grading and Drainage to Future Foundation Performance:** We are sometimes asked how important proper soil grading and drainage is to the future performance of a foundation. What we must emphasize is that, in an expansive soil area, the most important controllable factor that drives the swelling and shrinking of the supporting soil is changes in the soil moisture. Proper soil grading and drainage helps mitigate swelling of soil supporting the foundation. If the soils supporting the foundation for this house are not expansive and if the house has a history of little or no damage due to foundation movement, improving the grading and drainage may not improve the performance of the foundation.
- **Air conditioning Condensate Drain Line Discharge:** The primary air conditioning condensate line discharges adjacent to the slab-on-ground foundation. This is a poor practice; it should discharge at least 5-feet away from the foundation.
- **Previous Under-Slab Plumbing Repair:** It is my understanding that there was a previous under-slab plumbing repair at the right side of the foundation. The repair required tunneling underneath the slab. Although this was done some years ago, the shape of the foundation at the left side and the pattern distress suggests that the tunneling may be a cause of the foundation movement.
- **Bare Soil:** Some of the soil at the left side is not covered by vegetation or any other ground covering. This makes the ground more susceptible to excessive drying which can lead to settlement.
- **Concrete Repairs:** During the visual inspection I did not see anything that indicated to me that any concrete repairs are necessary at this time.
- **Comments Concerning Previous Reports:** There were no previous reports available.

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**OTHER INSPECTION OPTIONS:**

*This section describes inspection options that are different from and go beyond a visual **Foundation Performance** inspection. The inspection options we provide are listed below:*

- **Formal Engineering Foundation Performance Evaluation Option:** We can furnish a higher level of foundation performance evaluation than that provided in this report. We refer to this higher level of foundation performance evaluation as a formal engineering foundation performance evaluation.<sup>3</sup> A formal engineering foundation performance evaluation requires a full day at the house and a full day to perform the structural analysis and prepare the written report. The fee depends on the size of the house but will be at least \$1500. The fee must be paid prior to the work being scheduled and is nonrefundable.
- **Exposed Slab Crack Evaluation:** We can evaluate the structural significance of all cracks on the top slab surface that are visible when the floor coverings are removed. We require that you arrange to have all floor coverings, including wood flooring, tile flooring, carpet, etc. removed. The client will be responsible for marking all cracks you would like me to evaluate. The evaluation of each crack will be based on the crack location, orientation, width, the presence or absence of any apparent faulting, and an engineering estimate of the apparent deflection of the foundation across the crack based on a regression analysis of foundation elevation data. The fee depends on the size of the house but will be at least \$3600. The fee must be paid prior to the work being scheduled and is nonrefundable.
- **Materials Testing Option:** We can furnish a report on materials testing of the foundation materials. My fee for specifying the tests, ordering the tests, interpreting the test results and writing a report is \$1200. The costs of the tests vary depending on the number and types of tests requested, but typically start at around \$1000.
- **A Foundation Repair Contractors Perspective:** I know of no foundation repair contractor in the Greater Houston Area who is qualified to make an engineering evaluation of the performance of a foundation. However, there are honest foundation repair contractors who have extensive and valuable experience in the repair of foundations. Asking a foundation repair contractor to give you some advice is an option you might want to exercise. Just remember that the sales representative makes his living selling his product.

A useful website address that gives the contractor's perspective is [www.foundationrepair.org](http://www.foundationrepair.org). This is the web site of the Foundation Repair Association, Inc. located in Dallas, Texas.

- **Under-Ground Plumbing Leak Inspection:** Underground plumbing leaks that are under or near the foundation can cause foundation problems. It is not possible to evaluate this possibility without first having a licensed plumber test the system for leakage and identifying the location and severity of any concealed leaks.
- **Offer to Negotiate a Higher Maximum Liability:** After this preliminary visual inspection is complete and the report is published, I am willing to negotiate a higher maximum liability than that specified in the agreement. If the client wishes to negotiate with me to accept a higher maximum liability, you agree to notify me in writing by return receipt certified mail of this wish within 10-days of the date of the inspection. I will then quote you a fee for a more intensive and extensive foundation performance evaluation that includes material testing including destructive testing, soil testing, monitoring of soil

<sup>3</sup> R. Michael Gray, P.E., *A Structural Analysis Approach to Residential Foundation Performance Evaluation*; Proceedings Texas Section American Society of Civil Engineers, Fall Meeting, Waco, Texas; October 2-5, 2002

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movement and soil moisture content, monitoring the response of the frame structure to soil movement and foundation movement, and monitoring of the distortion of the foundation in response to soil movement. Please be advised that this work will cost at least several thousand dollars, will require the owner's permission and may require up to 2-years to perform. After this work is performed, I will negotiate a fee for accepting whatever higher maximum liability you want me to accept. The fee must be paid prior to the work being scheduled and is nonrefundable.

**AN INTERNET SOURCE OF INFORMATION CONCERNING FOUNDATION PERFORMANCE**

We strongly encourage you to visit the website, [www.houston-slab-foundations.info](http://www.houston-slab-foundations.info) for more information concerning the performance of slab-on-ground foundations on expansive soils. This is the premier source on the internet for information on the performance evaluation of slab-on-ground foundations. It includes 37 frequently asked questions with answers. There also other informative resources on the website including several valuable items you can download.

**YOU CAN OBTAIN A FREE BOOK ON SLAB-ON-GROUND FOUNDATIONS BY SENDING AN E-MAIL TO [BUYERSGUIDE@R-MICHAEL-GRAY-PE.COM](mailto:BUYERSGUIDE@R-MICHAEL-GRAY-PE.COM)**

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**PROFESSIONAL ENGINEERING CONSULTING AGREEMENT  
(please read carefully – this is a binding legal agreement)**

**DEFINITIONS:** When used in this agreement, the words “we”, “us”, “my”, “I”, “me” and “our” refer to R. Michael Gray. The terms “you” and “your” refer to the client named below.

**OWNERSHIP OF ANY REPORT:**

This agreement is for the provision of a professional engineering consulting service. Any written report summarizing our findings and opinions will be provided to the client and will be copyrighted by me and is and will remain my property.

**POST CONSULTING SERVICE PROCEEDINGS:**

**Questions and Problems:** We are available without charge for telephone consultations.

**Assignment:** This agreement is a personal agreement between you and R. Michael Gray. No person other than you has a right to rely on the contents of this agreement or on any report for any reason whatsoever.

**Certificate of Merit:** The client shall make no claim of professional negligence unless the client has first provided me with a written certification executed by an independent Texas Professional Engineer currently practicing in the Greater Houston Area. The certification shall: a) contain the name and license number of the certifier; b) specify the acts or omissions that the certifier contends are not in conformance with the standard of care for a registered structural engineer performing professional services under similar circumstances; and c) state in detail the basis for the certifier’s opinion that such acts or omissions do not conform to the standard of care. This certificate shall be provided to me not less than thirty (30) days prior to the presentation of any claim, or the institution of any arbitration or legal proceeding. This certificate of merit clause will take precedence over any existing state law in force at the time of the claim or demand for arbitration.

**Limitation of Consulting Service and Liability:** The consulting service is offered for a limited, fixed fee and is performed within a limited amount of time. Our liability, therefore, is limited, specifically by the following terms and conditions.

**Limitation of Consulting Service:** This report is neither an expressed nor implied warranty and/or guarantee as to future life and/or performance of the items inspected. Since the inspection procedure used is visual only and is not intended or designed to be diagnostically and/or technically exhaustive, an inherent risk remains that undiscovered problems exist and/or future problems will develop. For these reasons, it is not intended to be, nor should it be implied, that the inspection process could or is intended to identify and/or discover all defects of whatever nature. Client agrees not to rely on the report as the basis for the establishment of property values, for the purchase of the building or for obtaining any type of financial arrangements. Client acknowledges that I am not an insurer and it is not the intent and/or purpose of this inspection procedure to provide client with a risk free purchase or usage of the structure. There are no expressed or implied warranties that all problems and/or existing defects of any and all nature have been discovered and noted in the report.

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**Maximum Liability:** Since the consulting service provided is based in part on a preliminary visual inspection, it is not possible to eliminate all risks involved in the purchase and/or ownership of the subject property. Client agrees, to the fullest extent provided by law, that our liability for all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, including attorneys' fees and costs and expert witness fees and costs, so that the total aggregate liability of the engineer to the client shall not exceed amount of the fee paid for the consulting service. This limitation shall apply regardless of the cause of action or the legal theory pled or asserted specifically including, but not limited to, negligence. This clause is a material inducement for you and me to enter into this agreement.

ACKNOWLEDGMENT: THE UNDERSIGNED HAS REVIEWED THIS DOCUMENT, UNDERSTANDS ITS CONTENT AND AGREES TO THE TERMS AND CONDITIONS CONTAINED HEREIN SPECIFICALLY INCLUDING THE CLAUSE TITLED MAXIMUM LIABILITY. THE CLIENT FURTHER REPRESENTS AND WARRANTS THAT HE OR SHE HAS FULL AND COMPLETE AUTHORITY TO EXECUTE THIS CONTRACT ON BEHALF OF ANY SPOUSE, AND TO FULLY BIND ANY SPOUSE TO ALL THE TERMS, CONDITIONS, EXCLUSIONS AND LIMITATIONS OF THIS AGREEMENT.

Client Signature	Printed Name of Client
Client E-mail Address:	