DEPARTMENT OF CONSERVATION

CALIFORNIA GEOLOGICAL SURVEY

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November 14, 2014

Erik Sanjurjo, Vice President
Hollywood United Neighborhood Council
(213)949-3128

RE: Town Hall Meeting on the Hollywood Fault and Development Activity

Dear Mr. Sanjurjo:

I regret that CGS will not have a representative at your Town Hall Meeting on November 20th. However, I do wish to relate to you and your organization some background information on the Alquist-Priolo Program and what happens now that the zone maps are official. The Alquist-Priolo Earthquake Fault Zoning Act (the "Act") was passed in 1972 as a direct result of surface rupture damage to buildings in the 1971 M 6.6 San Fernando Earthquake.

The intent of the Act is to reduce the risk from surface fault rupture by prohibiting "the location of developments and structures for human occupancy across the trace of active faults" (Calif. Public Resources Code (PRC), Div.2, Chapt.7.5, section 2621.5). This goal is achieved through a division of responsibilities between the State, local government and landowners/developers.

- It is the responsibility of the State Geologist to issue maps depicting zones of required investigation for the hazard of surface fault rupture (Earthquake Fault Zone or EFZ maps) (PRC, sec. 2622). These zones, typically 1000 feet wide or greater, are established to include identified active faults and an area around those faults where secondary fault traces might exist. The zoned faults are those that have had surface fault rupture within the past 10-12 thousand years and which may be found at or near the surface, so that they can be avoided.

- It is the responsibility of the local permitting agency (city or county) to require and approve, for developments within the EFZ, a "geologic report defining and delineating any hazard of surface fault rupture" (PRC, sec.2623a). Most structures for human occupancy may not be built across the trace of an active fault (Calif. Code of Regulations (CCR), Title 14, Division 2, sec.3603a).

- It is the responsibility of the property owner or developer to cause the property to be investigated by a California licensed geologist who will identify, through exploration and mapping, the location of any active fault traces (CCR, sec.3603d). The geologist will also, typically, recommend necessary structural setbacks from the identified faults.

Since 1972 the State has issued 558 new or revised maps. Also during this period 169 maps have been revised and 4 have been withdrawn.

For our evaluation of the Hollywood Fault we made use of all available data. Our evaluation of regional and detailed data indicated that the Hollywood Fault is active and comprises a sometimes complex zone of breaks that extends in a generally east-west direction across the Hollywood area.

The data used included that provided by developers and their consultants. Although we were looking at the same geologic data, such data rarely provides a complete picture of the subsurface geology and, utilizing sound geologic principles, we may have different interpretations of that data and reached different conclusions than those of the project proponents. The data we used and the decisions made based on that data are presented in the initial Fault Evaluation Report released in February (FER-253) and the recent supplement to that report released earlier this month. Additional detailed fault investigations for future development will lead to a more precise understanding of fault locations.

We are continuing to evaluate the location and activity of the Hollywood Fault to the east and the west of the area depicted on the Hollywood EFZ map.

Sincerely,

John G Parrish, PhD., PG
State Geologist

The Hollywood Fault — Prudent Steps Forward in 2015

by Robert H. Sydnor
California Certified Engineering Geologist #968

November 20, 2014

prepared for: **Hollywood United Neighborhood Council**
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1. Background and Purpose of Report

This is a preliminary geology report intended for homeowners and residents of the Hollywood United Neighborhood Council who are concerned about the recently-zoned Hollywood Fault. The author was invited to attend and speak at an evening meeting of local homeowners which is to be held at the First Presbyterian Church, 1760 North Gower Street, Hollywood 90028, on November 20, 2014; but regrettably could not do so.

The homeowner audience would be presumably composed of university-educated citizens who reside in the Hollywood district, and who are justifiably concerned that a newly-zoned Holocene-active fault has been legally delineated through their neighborhood.

The purpose of this interim report is: ① to assist concerned Hollywood homeowners understand several geologic hazards (= active faulting, earthquake ground-motion, landslides, and liquefaction) that occur in Hollywood and the Santa Monica Mountains; ② to provide hyperlinks to geologic reports; and ③ to make prescient scientific recommendations for prudent steps forward.

2. Legal Zonation of Active Faults under the Alquist-Priolo Act

The Hollywood Fault was legally zoned on November 6, 2014 as an active fault by the State Geologist under the Alquist-Priolo Earthquake Fault Zoning Act. There was an official press-conference in Los Angeles for this event and it was carefully reported in the Los Angeles Times newspaper.

It is recommended that citizens carefully read all of CGS Special Publication 42, published by the California Geological Survey. This is the key document about the Alquist-Priolo Act and the legal zonation of Holocene-active faults throughout California. It is free and on-line for convenient download. It is important for citizens to realize that a legal <u>zone</u> map is not a <u>fault</u> map. Yes, the best interpretation of the fault scarps are shown, but instead, look at the envelope of the legal zone.

http://www.conservation.ca.gov/cgs/rghm/ap/Pages/disclose.aspx

3. CGS Fault Evaluation Report #253

This comprehensive report explains the scientific steps that were carefully taken to evaluate the Hollywood Fault within the Hollywood quadrangle. The report is signed by three California Certified Engineering Geologists, each having many decades of professional experience in the evaluation of Holocene-active faults in California. Citizens can freely download the entire report and the maps at this state government ftp site:

ftp://206.170.189.144/pub/dmg/pubs/fer/253/

It is recommended to refer to CGS Special Publication 42 while reading the scientific terminology within CGS Fault Evaluation Report 253. Some of the complicated geologic terms can be readily discerned by using Wikipedia, or refer to the *Glossary of Geology*, published by the American Geosciences Institute (available in university libraries).

4. Seismic Hazard Zone Maps issued by the California Geological Survey

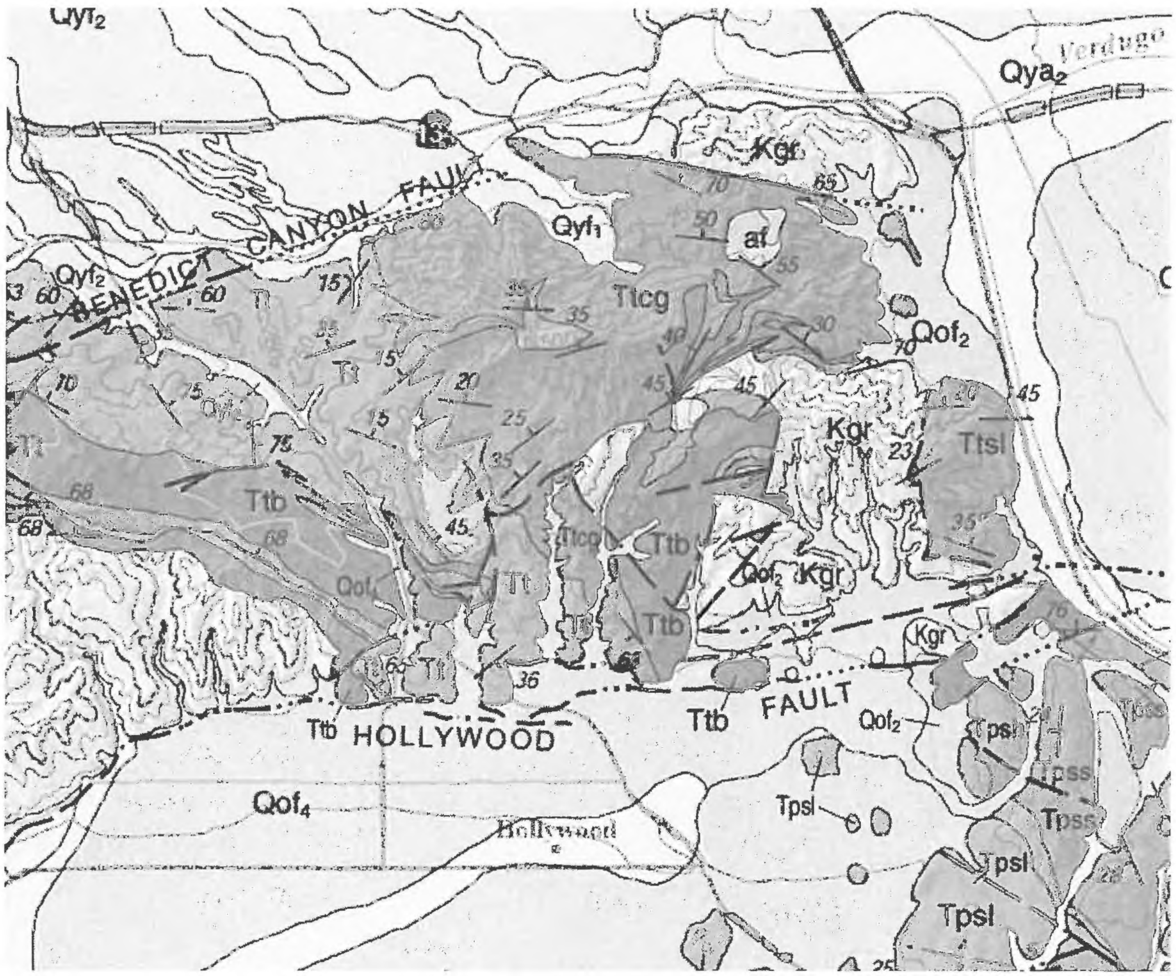
In addition to active faults, the California Geological Survey has zoned more than one hundred quadrangles for landslides and liquefaction. Homeowners can obtain free copies of these maps at:

http://gmw.consrv.ca.gov/shmp/MapProcessor.asp?Action=County&Location=SoCal

Most of southern California has been mapped for landslides and liquefaction by CGS because of the large population center. For the Hollywood 7½-minute quadrangle, both the active fault zone, the landslide zones, and the liquefaction are conveniently shown together on one zone map.

5. New 2014 Regional Geologic Map of the Los Angeles Quadrangle

The California Geological Survey has compiled a new 2014 regional geologic map of the 1:100,00 quadrangle that is centered on the Santa Monica Mountains. The surficial units and bedrock formations are described in a free 119-page booklet that accompanies the 1:100,000 map. At this convenient scale, one centimeter equals one kilometer.



This is an extract of the new 1:100,000-scale regional geologic map, centered on Hollywood and the eastern Santa Monica Mountains. Notice that this is a generalized regional map, not at the detailed 1:24,000 scale. Therefore, do *not* enlarge the geologic map beyond the published 1:100,000 scale. The 119-page booklet describes each of the map symbols, such as Tt and Ttb and Qof_4

6. Published Scientific References

A comprehensive list of published reports is in the back-pages of Fault Evaluation Report 253. It also includes some unpublished reports prepared by consulting geology and geotechnical firms. Shown below is a *partial* list of published references that homeowners can view and photo-copy at university libraries or the main LA City Library. The starred reports are particularly salient. Download reports and geologic maps from the California Geological Survey directly from their website>
www.conservation.ca.gov/cgs

★Bryant, William A., and Hart, Earl W., 2007, Fault-Rupture Hazard Zones in California — Alquist-Priolo Earthquake Fault Zoning Act, with Index to Earthquake Fault Zones Maps: California Geological Survey, Special Publication #42, 48 pages.

California Geological Survey, 2013 edition, Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings: CGS Note 48, two pages. http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/note_48/note_48.pdf

★California Geological Survey, 1997, Seismic Hazard Zone Report for the Hollywood 7½-minute quadrangle: CGS Seismic Hazard Zone Report 26, 61 p.

★California Geological Survey, 2002, Guidelines for Evaluating the Hazard of Surface Fault Rupture: CGS Note 49, 4 p.

★Campbell, Russell H., Chris J. Wills, Pamela J. Irvine, and Brian J. Swanson, 2014, Preliminary Geologic Map of the Los Angeles 30×60-minute Quadrangle, version 2.0, California Geological Survey, scale 1:100,000. http://www.conservation.ca.gov/cgs/rghm/rgm/Pages/preliminary_geologic_maps_1page.aspx

Catchings, R.D, G. Gandhok, M.R. Goldman, D. Okaya, M.J. Rymer, and G.W. Bawden, 2008, Near-Surface Location, Geometry, and Velocities of the Santa Monica Fault Zone, Los Angeles, California: *Bulletin of the Seismological Society of America*, v. 98, no. 1, p. 124-138.

★Crook, Richard Jr., and Proctor, Richard J., 1992, The Santa Monica and Hollywood Faults and the Southern Boundary of the Transverse Ranges Province, *in:* Pipkin, B., and Proctor, R.J., *editors*, Engineering geology practice in southern California: Association of Engineering Geologists, Special Volume, p. 233-246.

Dolan, James F., Sieh, Kerry E., Rockwell, Thomas K., Yeats, Robert S., Shaw, John, Suppe, John, Huftile, Gary J., and Gath, Eldon M., 1995, Prospects for larger or more frequent earthquakes in the Los Angeles metropolitan region: *Science*, vol. 267, p. 199–205.

★Dolan, James F., Sieh, Kerry E., Rockwell, Thomas K., Guptill, Paul, and Miller, Paul, 1997, Active tectonics, paleoseismology, and seismic hazards of the Hollywood Fault, northern Los Angeles Basin, California: *Bulletin of the Geological Society of America*, vol. 109, no. 12, p. 1595–1616.

★Dolan, James F., Stevens, Donovan, and Rockwell, Thomas K., 2000, Paleoseismologic evidence for an early to mid-Holocene age of the most recent surface rupture on the Hollywood Fault, Los Angeles, California: *Bulletin of the Seismological Society of America*, vol. 90, no. 2, April 2000 issue, p. 334–344.

Hummon, Cheryl, Schnieder, C.L., Yeats, Robert S., Dolan, James F., Sieh, Kerry E., and Huftile, Gary J., 1994, Wilshire fault: earthquakes in Hollywood?: *Geology*, v. 22, p. 291–294; *comment and reply*, p. 959–960.

Jennings, C.W., and Bryant, W.A., 2010, Fault Activity Map of California: California Geological Survey, Geologic Data Map #6.

Meigs, Andrew J., and Oskin, Michael E., 2002, Convergence, block rotation, and structural interference across the Peninsular–Transverse Ranges boundary, eastern Santa Monica Mountains, California, *in* Barth, Andrew, *editor*, Contributions to Crustal Evolution of the Southwestern United States – the Perry Lawrence Ehlig volume: Geological Society of America, Special Paper 365, p. 279–293. *Tectonics of the Santa Monica fault – Hollywood fault – Elysian Park anticline.*

Plesch, Andreas; John H. Shaw, Christine Benson, William A. Bryant, Sara Carena, Michele Cooke, James Dolan, Gary Fuis, Eldon Gath, Lisa Grant, Egill Hauksson, Thomas Jordan, Marc Kamerling, Mark Legg, Scott Lindvall, Harold Magistrale, Craig Nicholson, Nathan Niemi, Michael Oskin, Sue Perry, George Planansky, Thomas Rockwell, Peter Shearer, Christopher Sorlien, M. Peter Süss, John Suppe, Jerry Treiman, and Robert Yeats, 2007, Community Fault Model (CFM) for Southern California: *Bulletin of the Seismological Society of America*, v. 97, no 6, p.1793-1802. *(This SCEC report with 28 authors represents the 2007 expert consensus of seismologists& geologists for the 140 active faults in Southern California. Look for periodic updates that reflect new insights about active faults.)*

★Treiman, Jerry, and Hernandez, Janis L., 2014, Fault Evaluation Report for the Hollywood 7½-minute quadrangle: California Geological Survey, CGS FER 253 (pdf format with text, official Alquist-Priolo zone map dated November 6, 2014, and appendices). www.conservation.ca.gov/cgs

6. Lystric Thrust-Faulting

The Hollywood Fault — Santa Monica Fault system is responsible for the active tectonic uplift of the Santa Monica Mountains. Geologists have carefully observed the geometry of the fault plane at a rapid-transit tunnel that was drilled under the Santa Monica Mountains. Refer to a published report by Dolan and others, 1997, in the *Bulletin of the Geological Society of America.* They also prepared boreholes to find the geometry of the fault plane(s). Here is Figure 10 from their 1997 report. Notice carefully that there are multiple lystric (curved) fault planes that are imbricated (like overlapping roofing shingles), and that the black triangles denote perched groundwater. This gives geologists a clear insight into what to expect on the same fault near the Hollywood & Vine and Yucca &Argyle areas. Look for multiple fault planes with a curved dip, with abrupt changes in the water-table (with the North side higher).

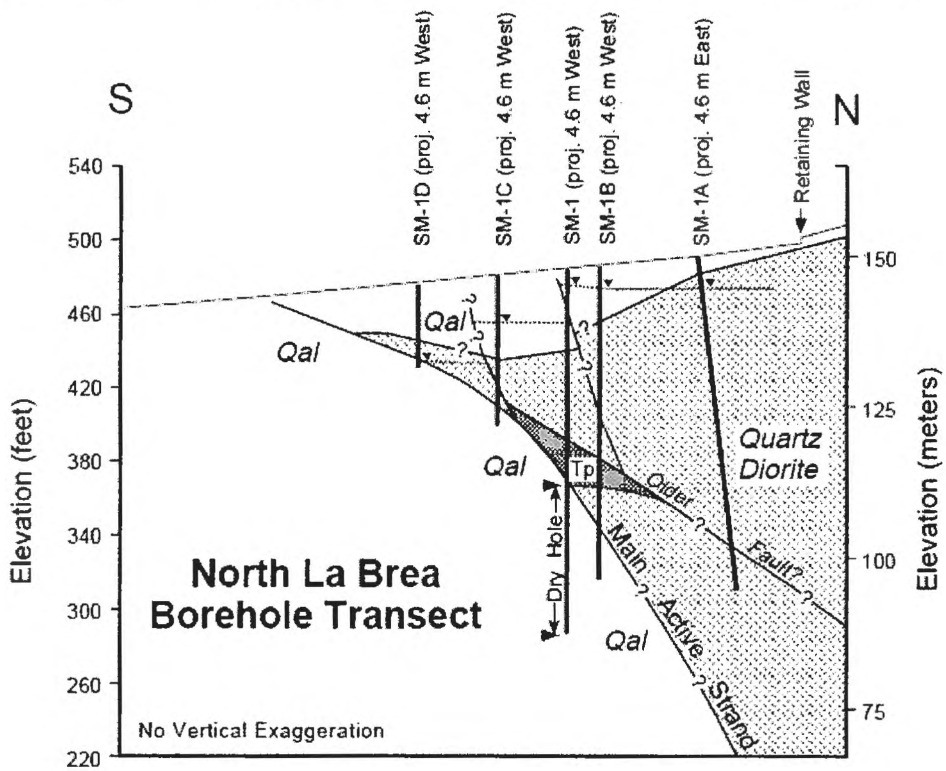


Figure 10. Cross section of North La Brea Avenue borehole transect shows that the Hollywood fault dips moderately steeply at depth but flattens near the surface. The main fault strand acts as a major ground-water barrier, separating a shallow water table to the north from a much deeper water table to the south. Thick vertical lines denote boreholes. Small triangles and gray lines denote ground-water levels in boreholes. Although ground water was encountered at shallow depth in SM-1, the hole was dry below the main fault plane. Modified from detailed borehole logs in Earth Technology Report (1993).

7. Fifty-foot Setback against a Dipping Thrust Fault

It is readily discernible from this complex geometry of the multiple fault planes that structures with deep basements (such as a high-rise commercial building with three or four parking levels in the basement) will have to consider the *subsurface* set-back of 50-feet, not the surface set-back. The deep foundations of high-rises (piles and caissons) will also have to be set-back.

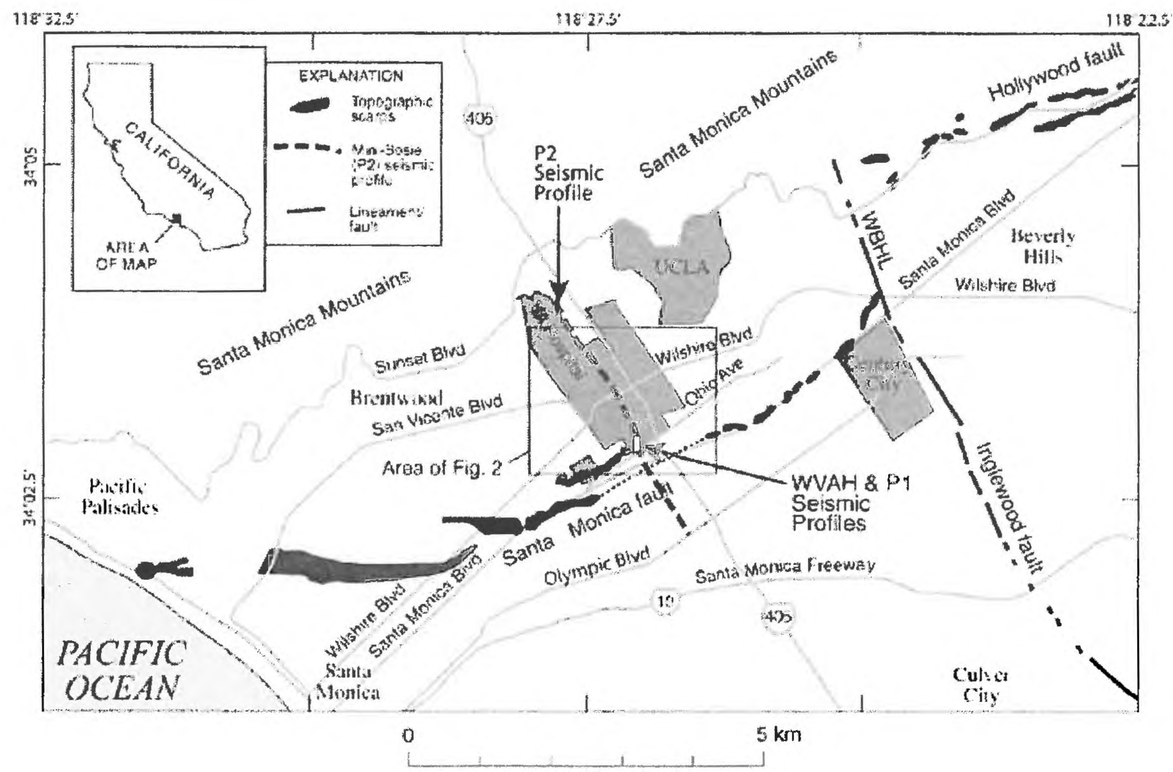
8. Geophysical Survey to Locate Fault Planes

Shallow geophysics can be readily used to find the subsurface geometry of a dipping fault plane in an urban setting. This subsurface information is presently lacking along Vine Street and Argyle Street.

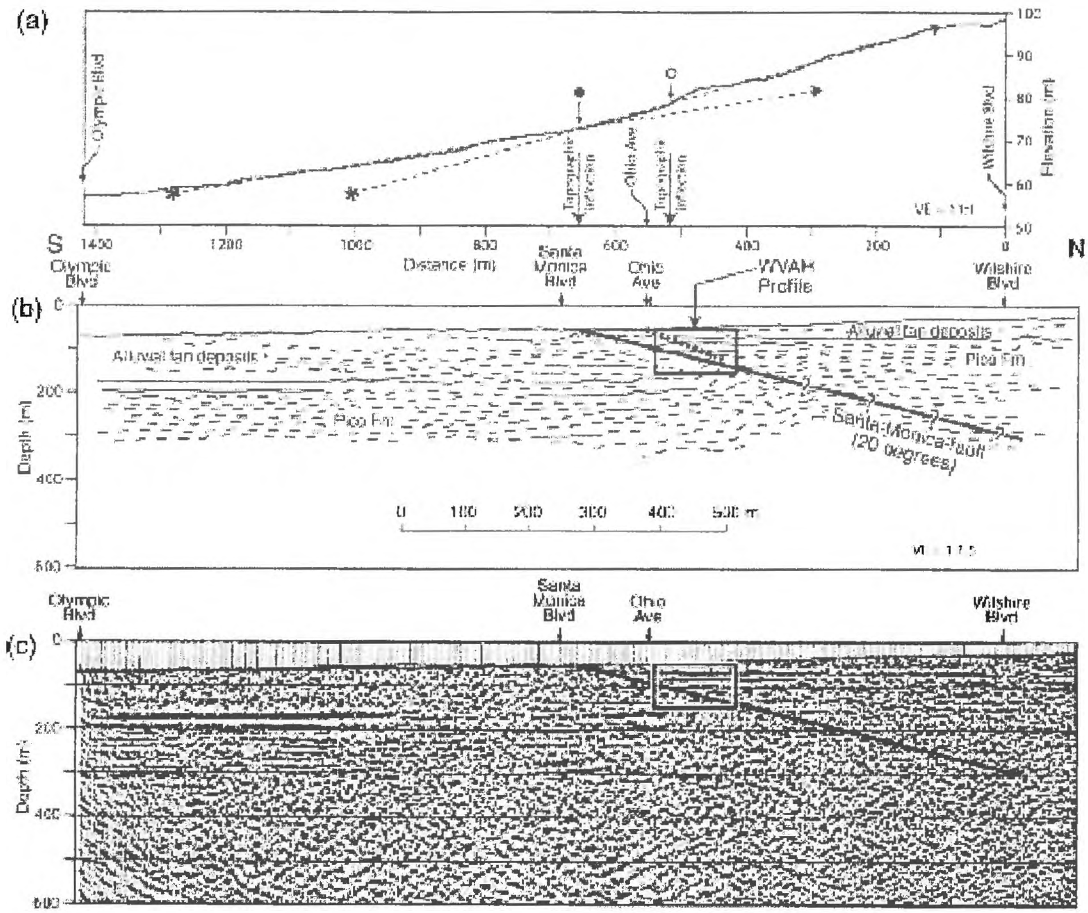
A successful example of a geophysical profile was published in 2008 by the U.S. Geological Survey in the *Bulletin of the Seismological Society of America*. Refer to Catchings, *et al*, 2008 (listed above in paragraph #6). This was performed by the USGS in a geophysical line that was parallel to the 405-Freeway. The USGS study was focused on the Wadsworth Veteran's Administration Hospital. The purpose was to ascertain whether or not this federal hospital was sited on an active fault.

This shows where the geophysical survey was performed by the US Geological Survey:

Near-Surface Location, Geometry, and Velocities of the Santa Monica Fault Zone, Los Angeles, CA 125



Collateral insight: When the California Geological Survey legally zones the Santa Monica Fault in the near future, it will be closely reviewing this published fault map from the USGS. Notice how the Hollywood Fault steps over to the Santa Monica Fault.



This is the North-South geophysical profile of the Santa Monica Fault (dipping 20 degrees) in relation to the Wadsworth Veteran's Administration Hospital, WVAH. The USGS Menlo Park field-work was successfully led by Dr. Rufus Catchings, senior geophysicist. Notice carefully that shallow geophysical surveys are far different than earthquake seismology.

It is recommended that at least **five** geophysical profiles (oriented North-South along existing streets) be performed in the Hollywood district so that the subsurface geometry of the multiple fault planes can be discerned. The recommended geophysical profiles would be along Argyle Avenue, Vine Street, Ivar Avenue, Gower Street, and Cahuenga Boulevard.

Perhaps the City of Los Angeles could fund the neutral-expert U.S. Geological Survey to perform the geophysical work, and then publish the results in a national journal. Partial funding might be available from the LA Department of Water and Power and Caltrans, since both agencies have a vested interest in the precise location of the Hollywood Fault.

Dr. Rufus Catchings (the lead author) is a senior-level geophysicist in the USGS Menlo Park office, phone 650-329-4749 catching@usgs.gov He holds a Ph.D. degree in geophysics from Stanford University, and has more than three decades of experience in using geophysics to locate fault planes in both Southern California and the San Francisco Bay Area. I spoke this afternoon with Dr. Catchings on the telephone, and he is interested in this scientific endeavor on the Hollywood Fault.

9. Downhole logging of 80- to 100-foot deep large-diameter geology boreholes

Once the geophysical survey is performed and the location(s) of the active fault planes are precisely known, then it is effective to drill deep boreholes into the fault planes. These are not 8-inch diameter geotechnical boreholes; instead they are large-diameter 24-inch boreholes wherein the licensed professional geologist enters and descends in the borehole. A safety harness, miner's headlamp, and directly observes the stratigraphy (soil and bedrock), samples the fault gouge, collects *insitu* charcoal samples for carbon-14 dating, and measures the dip on the fault planes plus the azimuth and rake angle of the striations (to determine the geometry of fault movement during an earthquake).

There is a special exemption in CalOSHA rules that allows a licensed geologist to perform this down-hole logging of boreholes. A detailed description of the method is in this published report by the California Geological Survey, CGS Bulletin 210, and the Association of Engineering Geologists:

Johnson, Philip L., and Cole, William F., 2002, Use of large–diameter boreholes and downhole logging methods in landslide investigations, *in* Ferriz, H., and Anderson, R.L., *editors*, Engineering geology practice in northern California: California Geological Survey Bulletin 210 and Association of Engineering Geologists Special Publication 12, p. 95–106.

This paper describes the standard–of–care and typical safety methods for downhole logging of large–diameter boreholes whereby the engineering geologist descends down the24–inch borehole using a safety harness to measure strike & dip with a Brunton compass, observe the slide plane or the fault plane, collect insitu samples of carbon-14 and clay seams, and check for other potential rupture surfaces. Refer to California Construction Safety Orders, CCR Title 8, §1542, Shafts, for the text of California law that permits licensed geotechnical specialists to enter exploration shafts using proper safety equipment.

The careful method for downhole logging of large-diameter boreholes was pioneered more than four decades ago by Dr. F.B. Leighton and Dr. Richard H. Jahns, both Caltech PhD's in geology. Hundreds of Certified Engineering Geologists (including myself) in southern California have safely and successfully downhole logged thousands of large-diameter (24-inch) boreholes for subsurface investigations of active faults and active landslides. *(We graciously infer that this will be startling news for homeowners.)*

More to the point, downhole logging of boreholes has been cleverly used to precisely pierce the plane of the known-active Raymond Fault in San Marino by a University of Southern California geology professor (Dr. James F. Dolan). Notice carefully that the City of San Marino would certainly not welcome a giant bulldozer trench (=the size of the Grand Canyon) costing a huge sum of money that would shut-down Huntington Boulevard in San Marino for many weeks. Instead, a cost-effective 24-inch diameter borehole was quickly drilled, the borehole pierced the active fault plane, and it was expediently downhole logged by an excellent geologist who published the results in a national journal. Allegorically, finding a needle in a haystack is easy .... *if* ....you have a giant magnet. Here is the reference:

Weaver, Kristin D., and Dolan, James F., 2000, Paleoseismology and geomorphology of the Raymond Fault, Los Angeles County, California: *Bulletin of the Seismological Society of America*, vol. 90, no. 6, p. 1409–1429.

Concerned Hollywood homeowners need to know that (as of November 2014) none of the inexperienced consulting firms (who are apparently not geologically trained in advanced methods in fault evaluations) have used this cost-effective two-step method with minimum disruption to the underground utilities in the streets of Hollywood: a geophysical survey to pinpoint the location of the fault plane(s), then followed by downhole logging of large-diameter boreholes that cleverly pierce the fault plane. Giant bulldozer trenches in a dense metropolitan environment (like Hollywood & Vine) are not the optimum cost-effective approach for many geologic reasons. In standard situations, fault trenches are standard protocol and the exposures are excellent. However, since the target depth is on the order of 80 to 100 feet in depth (in the case of the Hollywood Fault), the volume of earth to be moved is huge, cumbersome, and unfortunately quite costly.

Everyone realizes that Hollywood is a densely developed urban area with hundreds of fragile and expensive underground utilities and uncooperative property owners. How to prudently proceed for future development? This three-step approach is recommended for this congested locality: ① geophysical surveys by USGS neutral-expert geophysicists along North-South streets. The imbricate planes of the Hollywood Fault are then illuminated and precisely located; ② down-hole logging of large-diameter boreholes by pre-qualified geologists who have vetted prior experience with this unique method; ③ fault-trenching (by state-licensed professional geologists) at select sites wherein the planes of the known-active Hollywood Fault are reasonably near the surface, and there is a favorable expectation of trenching into the fault. This avoids the tragic and expensive conundrum of a giant deep bulldozer trench with minimal or equivocal evidence of active faulting.

10. State-licensed Professional Geologists

We should not have to state the obvious: Under California state law, the only persons that are legally licensed to evaluate active faulting are Professional Geologists. Read this in CGS Special Publication #42. Refer to CCR Title 14. Also read this in the Business and Professions Code for the California State Board of Engineers, Surveyors, and Geologists.

Next time some opinionated "spokesman" stands up to stridently lecture the public on active faulting, the moderator should quickly cut him/her off, and cogently ask for his/her California state license number as a Professional Geologist. That will cool-down the parvenus, bureaucrats, and self-appointed "experts".....who are unlicensed to practice geology, and legally unqualified to evaluate the presence or absence of Holocene-active faulting.

Insight: we have all been in barbershops, wherein the barber gives strident advice on court-room law, psychology, medicine, political voting, and theology. But, it just a loquacious barber rendering his opinions on life; we clients are glad that he is only licensed to perform a haircut. The rest of his strident opinions are (allegorically) like leaves blowing in the wind. *(a little humor here)*

11. Need for Immediate Update to LA City Zoning for Hollywood District

The long-awaited official fault-zone map for the Hollywood Quadrangle is now extant. The Planning Department for the City of Los Angeles needs to immediately update the city zoning map for the district of Hollywood. This can then be quickly voted on by the Los Angeles City Council. This does not have to be a long and drawn-out process, with malingering by bureaucrats with slow schedules. The official state zone maps under the Alquist-Priolo Act are a legal trump on all of the 58 counties and 480+ cities throughout California. The City of Los Angeles already has more than a dozen Alquist-Priolo quadrangles that are legally extant, and this 2014 quad is just one more.

12. The Concept of Green Belts along the Active Fault Zone

The Planning Department of the City of Los Angeles needs to consider the possibilites of green-belts within the active Hollywood Fault zone. These can actually enhance property values of residential and commercial properties that are outside of the legal fault zone. A successful example is the City of Fremont, wherein the known active Hayward Fault bisects the city. It has taken more than a decade, but the City of Fremont has performed an exemplary job of coping with an active fault. Weak collapsible structures that were bisected by the Hayward Fault were removed, many were retrofitted, and new earthquake-resistant buildings were built nearby ---- but off the fault.

13. Need for Evaluation of Underground Utilities along the Active Fault Zone

The Los Angeles Department of Water and Power has already prudently begun the process of evaluating the public utilities that cross the Hollywood Fault. Right now, they are urgently working on the break of the water-main under Sunset Boulevard that flooded UCLA and made national headlines. The replacement and upgrade of ancient corroded utility pipelines will take billions of dollars and many decades. Homeowners need to be aware of the financial issues involved (perhaps billion dollar bonds, plus federal grants). Ask for periodic updates, but be patient. LADWP has several excellent California Registered Geotechnical Engineers (at the PhD level) who are presciently working on this issue. Sagacious LADWP engineers are well-aware of the faulting situation and are diligently working on it. Akin to many predicaments in life, they need time and money..... and our support. They publish in ASCE scholarly journals, and have lectured at UCLA in January 2014 on the 20th anniversary of the 1994 Northridge Earthquake. LADWP geotechnical engineers are scholarly, candid, frank, and not into denial about seismic hazards for their own lifelines (water-mains and electrical power). I was in attendance at UCLA, sitting in the middle of the front row, right next to my friends who are senior-level reporters from the Los Angeles Times.

It is discomforting to realize that the corroded broken water-main that flooded UCLA campus did do under *static* conditions (that is, no earthquake shaking). Just imagine the implications of surface faulting plus strong earthquake shaking on the ancient corroded water-mains that are prevalent throughout the Hollywood region. The LA Fire Department cannot fight a fire without water.

We re-learned this harsh lesson at the 2014 South Napa Eartquake several months ago. The Napa Fire Department had to rely on a few pumper trucks drawing water from the river, since the fire-hydrants were not operable. Their hook-and-ladder trucks were inoperable. Many homes burned to the ground, with the Napa Fire Department unable use fire hoses. The same problem occurred historically in 1906 for the Magnitude 8 San Francisco Earthquake.

14. Professional Scientific Societies that will be have Reliable Seismology

Homeowners in Hollywood can find reliable scientific and engineering reports in the national journals of these societies:

Earthquake Engineering Research Institute (EERI publishes *Earthquake Spectra*, which contains lots of seismic safety and planning reports); the Seismological Society of America (which publishes the *Bulletin of SSA* and *Seismological Research Letters*); the Association of Engineering Geologists (which co-publishes with GSA, *The Environmental and Engineering Geoscience Journal)*; the American Geophysical Union (which publishes a dozen journals, including the *Journal of Geophysical Research*); the American Society of Civil Engineers (which publishes the *ASCE Journal of Geotechnical Engineering*); and the Geological Society of America (which publishes several journals on geologic mapping and active faults)

Homeowners in Hollywood are very welcome to get on the weekly e-mail notification list of all of these seismology journals. Use Google to find the homepage of each journal. You do not have to be a member to scroll-down and read the table of contents of newly published monthly journals and read the free abstracts. However, the full articles are not free. You can read them at university libraries, or purchase the .pdf on a case-by-case basis.

Good news: The 2015 annual meeting of the **Seismological Society of America** will be held in Pasadena on April 21-23, 2015. *Any* person can attend, although there is a slightly higher registration fee for non-members of SSA. Citizens of Hollywood can adroitly drive to Pasadena and attend this 3-day convention if you are interested in seismology and seismic safety. The SSA President is Dr. Lisa Grant Ludwig, professor of geology at the University of California at Irvine. The SSA past-President is Dr. Thomas Jordan of the University of Southern California. We are indeed fortunate for their leadership.

15. National Academy of Sciences publication on Applied Seismology

Hollywood homeowners are typically university-educated and scholarly members of society. They are tired of platitudes and bureaucracy regarding seismic safety and geologic hazards. These sagacious Hollywood homeowners have long ago switched-off the banal trivia of Hollywood television, TV trash-talk, and Twitter (triple irony here), and are eager to turn to reliable scholarly information. The U.S. National Academy of Sciences was presciently ahead of Hollywood homeowners. NAS commissioned a select panel of seismologists and geologists to prepare a 2003 book with the intriguing title: *"Living on an Active Earth"*

You will enjoy reading the 432-page seismology treatise which has the *imprimatur* of the National Academy of Sciences. This authoritative NAS treatise took two years of editorial work by a blue-ribbon panel of nationally-ranked seismologists to prepare. As you can imagine, many of the authors are from the US Geological Survey in Menlo Park, and various campuses of the University of California, Caltech, and USC. Here is the hyperlink to the National Academy of Science website:

http://www.nap.edu/catalog/10493.html

There is a choice of the free pdf, or purchase a hard-bound copy of the book from the National Academy Press. However, be cautioned that this is a scientific treatise for university-educated readers, not for the general public.

Hollywood homeowners will be delighted to read in the 432-pages that it is heavily slanted towards California and local seismic safety issues .... that means that the **Alquist-Priolo Act** is showcased, plus the **Seismic Hazard Zoning Act** that is administered by the **California Geological Survey** is carefully described. (The *subrosa* reasoning is that National Academy of Sciences wants other states to follow the lead of the California Geological Survey in legal zonation of geologic hazards. Imagine that.)

16. Grading Appeals Board of the City of Los Angeles

For many years, I formerly served on the Grading Appeals Board within the Department of Building and Safety of the City of Los Angeles. I had to gracefully resign in my position when I moved from southern to northern California, since it then became logistically unfeasible me to serve as a scientific juror on complicated cases within the City of Los Angeles. Most of the appeals were about landslides and hillside grading permits in Pacific Palisades, the Santa Monica Mountains, and in Lomita (near San Pedro).

It appears that this scientific and engineering panel for the City of Los Angeles is moribund (??). It would be convenient for it to be resurrected to deal with complicated predicaments along the newly zoned Hollywood Fault. This neutral and expert panel of Certified Engineering Geologists and Registered Geotechnical Engineers could prepare a short but focused checklist for consulting geology firms to use when preparing reports for developers within the legal zone of the Hollywood Fault. That would avoid misunderstandings and short-comings for geology consulting work along the corridor of the active fault. I am the 2004 original author of CGS Note 48 checklist (two pages) for hospitals and public schools within the state of California. A new 2013 edition is available at the hyperlink shown in paragraph 3 on page 3.

A shorter version could be prepared for use by the City of Los Angeles Department of Building and Safety for projects within the active Hollywood Fault Zone. A focused checklist could help developers and Certified Engineering Geologists alike to efficiently prepare complete and adequate consulting reports.

17. FEMA reports for Hollywood Homeowners

The Federal Emergency Management Agency, part of the US Department of Homeland Security, has prepared many scholarly reports that will be helpful to homeowners and small businesses in the Hollywood District of Los Angeles. Go to the FEMA website and scroll-down for seismic safety reports, particularly on seismic retrofit.

For new structures, refer to FEMA Publication P-750, NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, 2009 edition, 388 pages, plus CD-ROM. It is available free as a .pdf from the FEMA website, and also free as a printed volume by US Mail (takes a week or two for delivery).

18. California State Websites

There are several state agencies with lots of salient information in seismic safety for homeowners. Use Google to find the URL of these agencies, then scroll-down for publications and booklets that are pertinent to homeowners:

California Geological Survey, CGS
California Seismic Safety Commission, SSC
California Earthquake Authority, CEA
California Insurance Commission *(regarding earthquake insurance)*
Governor's Office of Emergency Services, OES
California Division of Safety of Dams *(within the Department of Water Resources)*

19. U.S. Geological Survey

Go to the main website of the USGS and bookmark many of their subdirectories in seismic safety. There are dozens of useful publications on seismic safety, plus technical reports and fault maps in .pdf format. Obtain the popular pamphlet **"Putting Down Roots in Earthquake Country"** which has been translated into many languages besides English (principally Spanish and Chinese for California residents). This pamphlet is written for the general public.

****

Epilogue: It is realized that perhaps not all of these 19 paragraphs in 11 pages will be interesting to every homeowner in Hollywood. But perhaps many of you will find several items of scientific value that will prepare you for the road ahead in the coming new year of 2015.

Respectfully submitted,

Robert H. Sydnor

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KQED Science npr PBS

Parks Attract Affluent Homeowners to Earthquake Fault Zones Despite Risks

Andrew Alden, KQED Science Contributor | August 14, 2014 |

The San Jacinto fault cuts through this residential development in Loma Linda's South Pointe neighborhood. State law forbidding construction near the fault has resulted in the fault becoming an amenity as well as a liability (Google Maps)

Since 1972, California law has forbidden builders and homeowners from building on earthquake faults that cross their property. 40 years later, some of those strips of hazardous land have turned into amenities: unexpected greenbelts that have attracted high-value homes and people to match, according to a study in the upcoming issue of the journal Earth's Future.

The 1972 law began as the Alquist-Priolo State Special Studies Zone Act, a name designed to reassure the skittish. It mandates that the state map all hazardous active faults, and all property owners within a certain distance of the fault must disclose the fact to would-be buyers.

Wouldn't this scare people away from houses sitting next to an earthquake fault? The Bay Area's largest set of such homes is on the Hayward fault, which runs the length of the East Bay from Point Pinole to Fremont. I've heard stories of fault-line residents who resent visitors gawking at their cracked sidewalks and warped driveways. I once owned a home in an Alquist-Priolo zone, and it was a nervous-making experience to inform prospects during the sales process. Yet the homes still sell. And now the law has a more straightforward name, the Alquist-Priolo Earthquake Fault Zone Act.

Existing homes on the fault are exempt from doing much about it, which takes some of the sting out of the predicament. So while you'll see decrepit houses or vacant lots here and there along our active faults, studies have shown that the Alquist-Priolo law has little effect on home values. The law makes a real difference in greenfield developments, where new homes are built on previously empty land. In the new study, a team of researchers led by Nathan Toké started out thinking that the law might stigmatize these places, but they found instead that wealthy people appear to be attracted to the fault.

For a fun way to use Google Earth, plug in the government's maps of earthquake faults as you hover over Southern California cities. You'll soon see places where greenbelts and parks line up along an active fault. This image shows part of the suburban town of Highland, just east of San Bernardino, where the San Andreas fault runs.

http://blogs.kqed.org/science/2014/08/14/parks-attract-affluent-homeowners-to-earthquake-fault-zones-despite-risks/

San Andreas fault (approximate location on the red line) runs through Highland at the foot of the San Bernardino Mountains. The young neighborhood is organized around the fault, treating it as a greenbelt and water feature—a real-estate asset. (Sanandreasfault.org)

This curious pattern is familiar to most of us who think a lot about earthquake policy. Toké's team went a step further, using geographic databases to examine the effect more precisely. They had detailed census data to overlay on the official Alquist-Priolo maps—household wealth, residents' ages, minority status, population density, age of the housing stock and so on. From this data they devised a measure of "social vulnerability" for each census tract. As expected, their analysis showed that highly vulnerable tracts are clustered near environmentally toxic locations. But when it came to the hazard of earthquake shaking, Alquist-Priolo zones are favored by what you might call the socially invulnerable—well-off people with good jobs.

Toké's team turned to satellite images and showed that the same pattern holds in terms of green vegetation: while toxic zones (with their socially vulnerable inhabitants) are barren, the Alquist-Priolo zones are lush. Finally, they zeroed in on a handful of these paradoxical places and looked at the real estate. These new developments with their "fault zone parks" have the most valuable land parcels. Toké concluded that "people with access to financial and political resources, those with low social vulnerability, strive to live in neighborhoods with parks, even in the face of forewarned risk from natural hazards."

This all makes intuitive sense once it's explained. And it's plausible that new homes near the fault would be built extra strong for their wealthy buyers. That's how we want things to be. But for the rest of us outside the Alquist-Priolo zones, the law adds no protection against earthquake shaking (or the other hazards endured by the poor). Toké points out that the law's unintended effect was to attract "socially empowered residents" to the fault zone by promoting parks. "The effort to mitigate earthquake hazards thus, in surprising ways, may help reinforce existing environmental injustices." More parks elsewhere might be the key: "One of the most important observations from this study is that the distribution of high social vulnerability is more strongly tied to the absence of the amenity of parks and greenspace than to natural hazards."

A more pressing question that Toké's study did not address is what to do with Alquist-Priolo zones that are covered with pre-existing homes. What can we do on the Hayward fault? We will not know until the next major earthquake clears the ground there, in which case the work of Toké and other researchers may give us some clues for how to rebuild. A telling example might be that of Signal Hill, a little city surrounded by Long Beach. It sits on a hill raised by forces on the Newport-Inglewood fault and is surrounded by Alquist-Priolo zones. The hill was empty and available for residential development because history gave this locality a different sort of earthquake: for over 50 years it was a giant oilfield.

Los Angeles Times

Southland developers learn to coexist with quake faults

A long crack splits the sidewalk at 6.6-acre Discovery Well Park in Huntington Beach, located atop the Newport-Inglewood fault. Officials knew the fault would be an issue when they began drawing up plans that would bring thousands of new residents to the city. (Allen J. Schaben / Los Angeles Times)

By Rosanna Xia

OCTOBER 10, 2014, 5:04 PM

Over the last 20 years, the plateau atop Signal Hill has been transformed from a gritty industrial zone into an upscale neighborhood of homes, parks and hiking trails.

Where hundreds of oil wells once stood, joggers and photographers navigate popular walkways and trails that meander around gated communities with dramatic views of the Pacific Ocean and the L.A. Basin.

The layout of Signal Hill was not dictated simply by aesthetics. The city and developers created this landscaping to protect residents from a danger hidden just below the surface: the Newport-Inglewood earthquake fault.

The fault, responsible for one of the most destructive earthquakes in Southern California history, snakes through the hill north of the Long Beach Harbor. In accordance with state law, homes were carefully built around the fault, and parks and trails buffered areas where the ground could split in two.

Kathy Field takes a sunset walk with her dogs along a Signal Hill walking trail. The city and developers carefully designed landscaping to keep homes away from the Newport-Inglewood earthquake fault. (Allen J. Schaben / Los Angeles Times)

As California this year embarks on a major campaign to better identify earthquake faults across the state, Signal Hill and other communities along the Newport-Inglewood fault offer lessons on how to allow for new development.

California lawmakers this year agreed to spend millions to speed up the mapping of faults, after stalling such work for nearly two decades. The move means that more parts of California will be subject to the state's strict earthquake law, which generally prohibits construction on top of active faults and requires developers to conduct extensive underground studies to pinpoint where the faults are.

The Newport-Inglewood fault was one of the first to be covered by the law, in the 1970s. The fault is about 46 miles long and runs from the Culver City area through Long Beach and into Huntington Beach before it heads offshore.

The Times surveyed newer developments along the fault and found that, to a meticulous degree, cities have been following the law. Large swaths of land along the fault have been transformed into new homes and businesses, but planners have managed to find ways to keep them a safe distance away, according to documents and interviews.

Near the fault's northern terminus in Inglewood, a long, winding road cuts diagonally across a development that brought 374 new homes to the city in 2005. The development was considered a milestone because it was the first new housing in the city in more than 20 years.

The road, Renaissance Way, was designed to follow the path of the Newport-Inglewood fault. Tennis courts, parking lots, a pool and a barbecue area were built on and around the fault.

Developers went to great lengths to keep homes as far from the fault as possible. Geologists did seismic studies in 1986 and 2002 and dug more than seven trenches to pinpoint the fault's location. They were unable to find the fault where the state said it could be.

Planning around the Newport-Inglewood fault

Sources: Signal Hill Community Development Department, California Geological Survey, Google Earth. Graphics reporting by Rosanna Xia   Len De Groot @latimesgraphics

They ended up using an old oil well study that had possibly found the fault. They changed their designs from a straightforward grid layout to a plan that built the houses around the wide curving road. Instead of having the gated entrance in the middle of the block, they moved it to the eastern corner of the development to help keep structures away from the fault.

"It just takes creativity from architects and engineers to design around the issue to make sure it's safe," said Howard Press, president of Watt Communities, the main developer. "You just don't put someone's bedroom on top of a fault. There's a legal issue, but also a moral issue there. It's just something we weren't going to do."

About a mile away, on Market Street near La Brea Avenue, an old warehouse sits on a small lot that developers for years have tried to turn into apartment buildings.

A preliminary underground study showed that the fault cut across the tiny lot in a way that would make it impossible to build apartments while avoiding the fault.

"The fault report was never even finished," said John Jones, a plan checker in Inglewood's building division. "They did some trenching, found faulting, and there was no point going any further."

Similar precautions were taken at the southern end of the fault, in Huntington Beach.

A long linear park stretches along the fault and through two major gated communities. Visitors and residents know the grassy 6.6 acres as Discovery Well Park, where families spend afternoons at the picnic tables and kids play on the basketball courts and the beach-themed playground.

Officials knew the fault would be an issue when they began drawing up plans that would bring thousands of new residents to the city. They discovered the Newport-Inglewood fault was underneath the northern portion of the Seacliff Village shopping center, built in the 1970s before the fault zoning law went into effect.

A lot of the time, there are ways that you make better projects out of it. I don't think this would've happened without the faults. - Scott Charney, Signal Hill's community development director

Developers demolished the center and rebuilt it. Now only the parking lot is directly on top of the fault.

Signal Hill was formulating its hilltop development around the same time.

City officials ordered a preliminary earthquake study upfront, as well as detailed fault studies for each phase of the development.

The fault's location forced the developer to reduce the number of homes from 132 to 110. Roads were rerouted and a scenic hiking trail was designed into the plans to keep all the buildings a safe distance from the fault, according to documents and interviews.

The developer, Bob Comstock, said it came down to being upfront about the fault and disclosing how exactly it was incorporated into the project.

The development was a financial success, and all of the homes were sold by 2002. In fact, having trails and public parks meld right into gated communities has become "a very Signal Hill thing," said Scott Charney, the city's community development director.

Now, the meandering trails are a part of the city's identity, Charney said, and another developer has sought to design them into a housing project that isn't even in the fault zone.

"A lot of the time, there are ways that you make better projects out of it," Charney said. "I don't think this would've happened without the faults."

The Newport-Inglewood fault has received more attention from government officials than some lesser-known faults that crisscross the region in part because of the catastrophic 1933 Long Beach earthquake.

It was the first destructive quake in modern Southern California, killing 120 people, and prompted some of the state's first seismic building regulations. After the state passed the Alquist-Priolo Earthquake Fault Zoning Act in 1972, the fault was one of the first to be mapped. The rules covered new construction, but existing buildings were grandfathered in.

Mapping the fault was contentious at the time, recalls state geologist John Parrish. There was not a lot of underground trenching or useful soil samples in the area for scientists to work with, he said.

"The cities of Long Beach and Inglewood and so forth were not very happy that we were putting the zone through there," Parrish said.

Over the decades, the extensive underground studies required by the law have provided valuable scientific information on the Newport-Inglewood fault, Parrish said.

But implementation of the law has lagged in other parts of the state. Four decades later, about 2,000 miles of faults still need to be zoned — in places such as Los Angeles' Westside, Orange County, Lake Tahoe, San Diego and the San Francisco Bay Area.

After The Times last year reported on the mapping delays, Gov. Jerry Brown signed legislation to renew funding and allocate more than $1 million a year to complete the remaining zones in the state. The funding will be financed by increased building permit fees.

The budget boost has allowed the California Geological Survey to begin mapping the Santa Monica fault, which curves through the Westside and the city of Santa Monica. The state in January released a draft map of the Hollywood fault zone and is expected to finalize it next month.

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www.latimes.com/local/la-me-newport-inglewood-20141011-story.html

CALIFORNIA GEOLOGICAL SURVEY
FAULT EVALUATION REPORT FER 253

THE HOLLYWOOD FAULT
in the Hollywood 7.5' Quadrangle
Los Angeles County. California

by
Janis L. Hernandez
Engineering Geologist
and
Jerome A. Treiman
Senior Engineering Geologist
February 14. 2014

INTRODUCTION

The Hollywood Fault is within the central portion of the Santa Monica-Hollywood-Raymond Fault system. which is collectively part of a greater than 200-km long west-trending system of oblique. reverse and left-lateral faults that separate the Transverse Ranges geomorphic province of California on the north. from the Peninsular Ranges province on the south (Dolan *et al.*. 1997). The Hollywood Fault extends east-northeast for about 17 km through densely populated areas. including the cities of Beverly Hills. West Hollywood. and the community of Hollywood within the City of Los Angeles. trending eastward to the Los Angeles River Valley (Figure 1).

Recent detailed geologic and geotechnical studies for residential and commercial development in the cities of West Hollywood and Los Angeles have reported Holocene faulting at a number of sites along the Hollywood Fault. Infrastructure projects (sewer and subway) and groundwater studies. in addition to gravity data. also provide support that the Hollywood Fault is active and continues eastward toward the Raymond Fault. The majority of the Raymond Fault has been zoned as active. to within about 4 km east of the Los Angeles River at the eastern edge of the Santa Monica Mountains (see Figure 1).

Both the Santa Monica and Hollywood Faults were previously evaluated for Holocene active faulting as part of the 1977 study area of the 10-year program for fault evaluation (Smith. 1978). That study concluded there was insufficient evidence of Holocene faulting to recommend fault traces for zoning at that time. Subsequent geologic and geotechnical studies. paleoseismic studies. geomorphologic studies reported by Dolan *et al.* (1997). Dolan *et al.* (2000). and other published and unpublished research. have prompted CGS review of these recently available data to re-evaluate evidence for Holocene displacement along traces of the Hollywood Fault.

The purpose of this report is to assess the location and activity of fault strands associated with the Hollywood Fault within the Hollywood 7½-minute quadrangle. Those faults determined to be sufficiently active (Holocene) and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Earthquake Fault Zoning (AP) Act of 1972 (Bryant and Hart. 2007). This report does not attempt to reevaluate any strands of the Newport-Inglewood Fault zone.

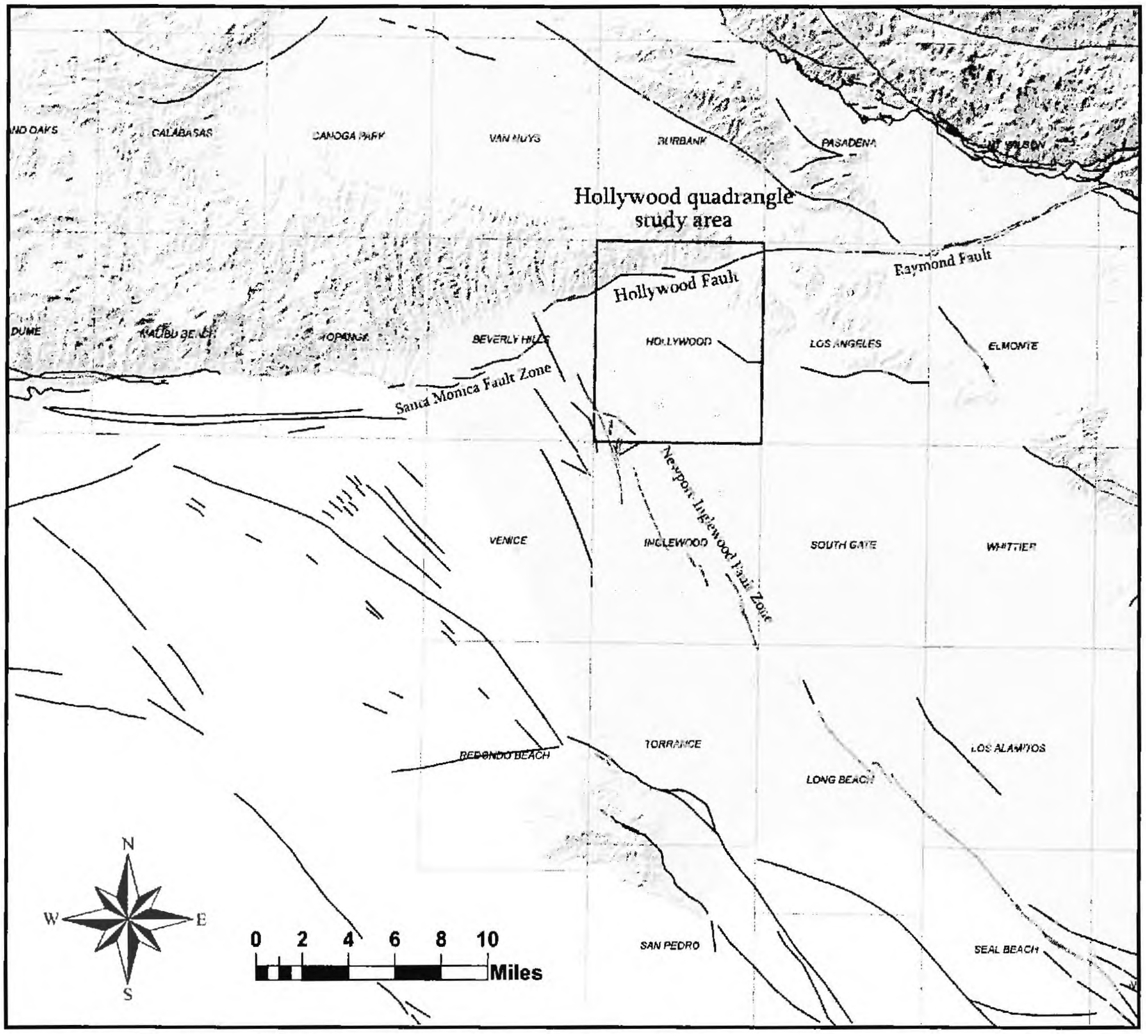

Figure 1- Study area of the Hollywood quadrangle and names of selected faults in the vicinity. Faults within existing Alquist-Priolo Earthquake Fault Zones are within yellow-shaded boundaries; other faults are indicated in black. Fault strands of the Newport-Inglewood Fault Zone are not a part of this evaluation. Source: USGS Quaternary Fault and Fold Database of the United States. (http://earthquake.usgs.gov/hazards/qfaults/)

GEOLOGIC SETTING AND PREVIOUSLY PUBLISHED WORK

The Hollywood Fault is located along the southern boundary of the Santa Monica Mountains. where Cretaceous granitic rocks; mainly quartz diorite. and Feliz biotite granodiorite (as reported in Lamar. 1970). are unconformably overlain by folded and faulted early to middle Miocene Topanga group marine siltstones. sandstones. and basaltic volcanic rocks. and late Miocene Puente Formation marine sandstones. siltstones and shales. Alluvial deposits flanking the mountain front consist of Pleistocene and Holocene alluvial fan deposits. colluvial sediments. and local slope wash.

The Hollywood Fault also defines the northern edge of the Hollywood basin. an asymmetric basin structure that is bound on the south by the North Salt Lake Fault (Figure 1a). Gravity data indicate the basin is deeper along the northern edge. next to the Hollywood Fault (Hildenbrand *et al.*. 2001). In the Los Angeles River floodplain (Figure 1). the Hollywood Fault is defined by a steep gravity gradient (Chapman and Chase. 1979). and a steep drop in groundwater levels as the fault trends eastward toward the Raymond Fault (State Water Rights Board. 1962).

The Hollywood Fault was previously mapped by many workers including Hoots (1930); Lamar (1970); Weber *et al.* (1980); and Dibblee (1991). where they generally placed the fault at the steep break in slope along the southern edge of the Santa Monica Mountains. More recent mapping by Dolan *et al.* (1997) provided a more detailed view of the fault that takes into account geomorphic indicators as well as site-specific data (discussed later in this report).

Mapping by Hill *et al.* (1979) similarly reported the Hollywood Fault trace located at the base of the Santa Monica Mountains. however. they also mapped a southern trace. which they referred to as the Santa Monica Fault. This southern trace delineates the south margin of the Hollywood basin. defined by a zone of differential subsidence (shown on Plate 1). The identification of this zone is supported by their analysis of oil well data. groundwater data. and review of precise leveling surveys. A similar assessment of the structural boundary of the Hollywood Basin was made by Hildenbrand *et al.* (2001) based on gravity data. although they identified the southern bounding structure as the North Salt Lake Fault (Figure 1a).

At the eastern edge of the Santa Monica Mountains. the concealed trace of the Hollywood Fault was previously mapped in various configurations. generally extending east to northeast into the Atwater area. Originally believed to be a reverse fault. more recent research (e.g. Dolan *et al.*: 1997. 2000; Law/Crandall. 2001; William Lettis and Associates. 2004) suggests a dominant strike-slip component. Previous mapping is shown on Plate 1.

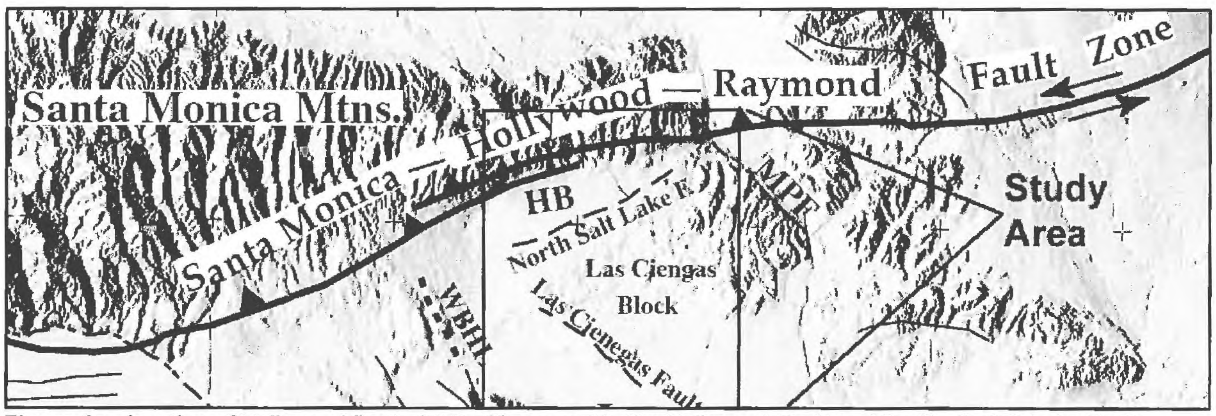

Figure 1a - location of Hollywood Basin (**HB**) with respect to the Hollywood Fault and the North Salt Lake Fault. (clipped/modified from Hildenbrand *et al.* (2001)

SEISMICITY

Regional seismicity records from Hauksson *et al.*. (2012). indicate there have not been any significant earthquake events within the past 30 years that might be confidently associated with the Hollywood Fault (Figure 2). In the Los Angeles region. several historical earthquakes have generated strong shaking in the vicinity of the Hollywood Fault. including: the 1971 M6.6 San Fernando. 1987 M5.9 Whittier Narrows. 1988 M5.0 Pasadena. 1991 M5.8 Sierra Madre. and the 1994 M6.7 Northridge event. The 1988 Pasadena earthquake occurred on the Raymond Fault. Seismic records from the 1988 event provided additional confirmation of left-lateral displacement along the Raymond Fault (Jones *et al.*. 1990).

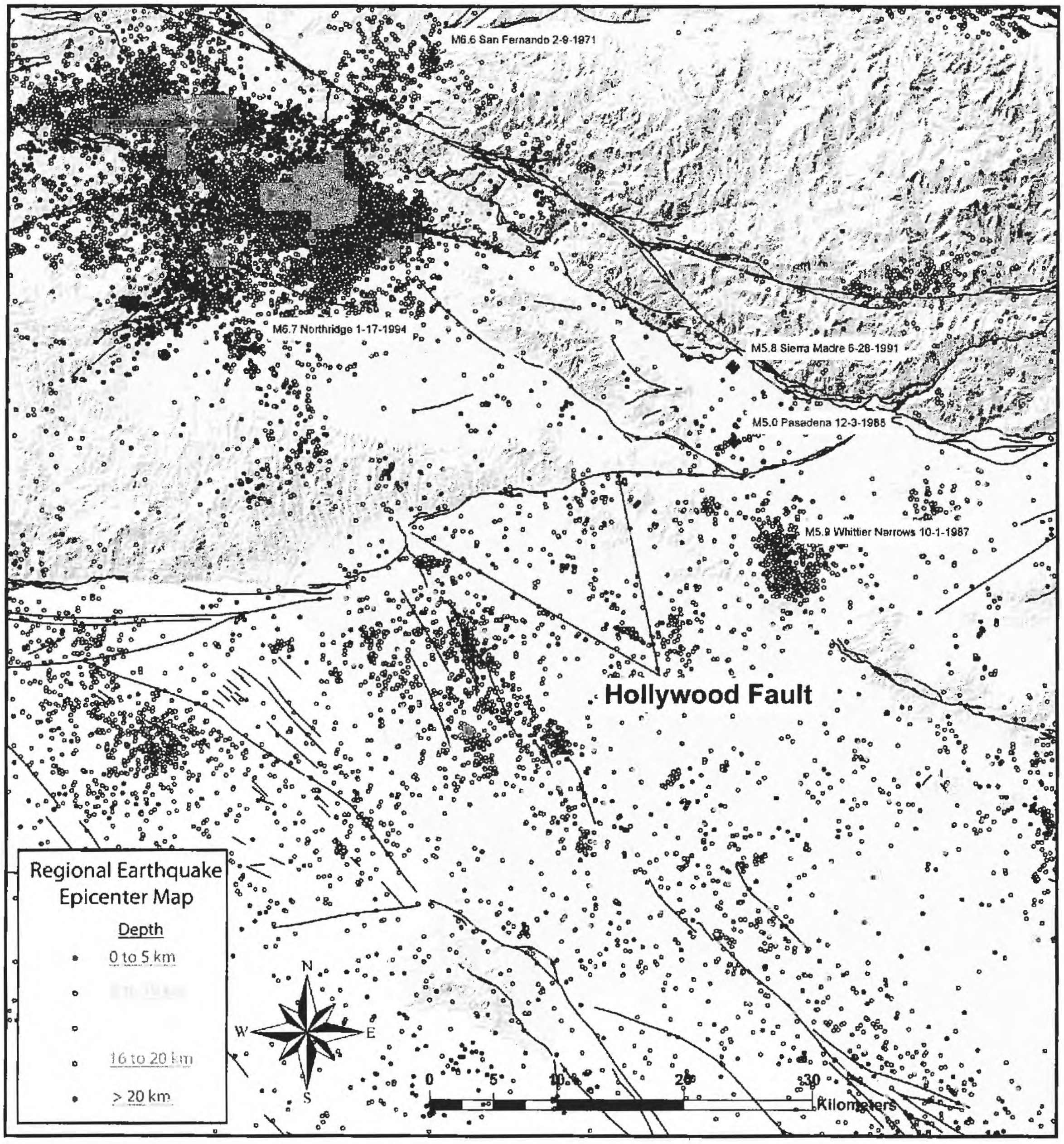

Figure 2 - Regional seismicity from 1981 to June 2011 (Hauksson et al. 2012). including significant faults within the greater Los Angeles basin area. Faults (in black) are from the U.S. Geological Survey and California Geological Survey. 2006. Quaternary fault and fold database. (http://earthquake.usgs.gov/hazards/qfaults/)

SUMMARY OF AVAILABLE DATA

PALEOSEISMIC STUDIES AND CONSULTING REPORTS
(for referenced localities. see Plate 1 and related figures)

Critical studies that bear on the location and recency of faulting along the Hollywood Fault have come from three general areas: (1) geologic and geotechnical studies within the City of West Hollywood; (2) research. geologic. geotechnical and infrastructure studies in downtown Hollywood (Curson Avenue to Highway 101); and (3) groundwater and infrastructure studies in the Los Angeles River area. There has been very little site-specific data generated between Highway 101 and the Los Angeles River.

West Hollywood

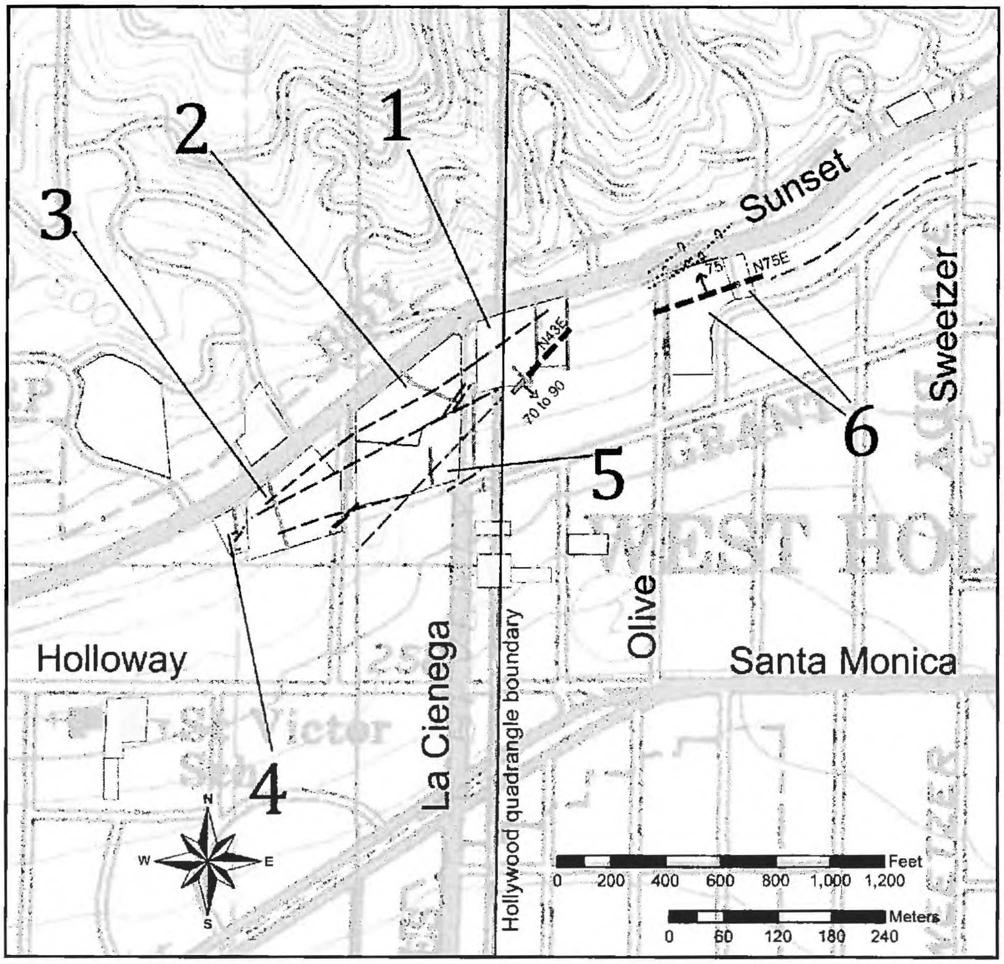

Figure 3- Study site boundaries (light green boxes) where fault studies have provided evidence of faulting (localities 1 through 6. discussed in text; these and other localities are also shown on Plate 1). Un-numbered sites found no evidence of faulting. Faults with evidence of Holocene displacement indicated in red; purple faults are potentially active; black faults are pre-Holocene. Short gold lines are trenches. and blue lines are boring transects. Note: not all exploratory boring transects are shown at this scale.

The City of West Hollywood Fault Precaution Zone Map. and Geologic and Seismic Hazard Technical Background Report. prepared by KFM Geoscience. Inc. (2010) is a crucial part of the City of West Hollywood General Plan. Included in the KFM report is a summary of Fault Rupture Hazard Studies from 29 sites that are on file with the City. collected from 1997 to 2013. Of these reports. 8 sites yielded data that active faulting exists within those sites or otherwise helped constrain the fault location near the western boundary of the Hollywood Quadrangle. Of these 8 sites. several studies were performed adjacent or in close proximity to one another; these are shown on Figure 3.

An investigation by Harza (1998. Figure 3. locality 1) was one of the earliest studies in this area that found two zones of faulting: a northern and a southern fault zone. Paleoseismic studies from borings and trenching at the site indicate these north-dipping faults of the northern fault zone do not offset an argillic soil horizon estimated to be over 120.000 years old based on degree of soil profile development. This northern fault zone includes several strands. which they report strike from N50°E to N70°E. dipping from 50° to 60° NW. Striae and slickensides measured in bucket auger borings provided evidence for north-side-down normal sense of displacement for these northern strands.

The southern fault zone (herein discussed as Fault 1) was reported as a northeast striking. southeast dipping fault that vertically offset Quaternary deposits at least 150 feet and acts as a groundwater barrier. Harza (1998) recommended a building setback zone for Fault 1 as a precautionary method until further studies could be made. Recent work. including observations from down-hole logged bucket auger borings and ^{14}C dating of the soils by WLA (2004) have determined this southern fault zone (Fault 1) is active. Figure 4 illustrates the upward terminations of three strands (D. E. and F) of Fault 1. Fault 1 is oriented N50° to 55°E. dipping 53° to 56° SE as reported from bucket auger down-hole observations. Charcoal samples from faulted soil horizons revealed dates about 9.910 to 10.190 ybp. and 15.250 to 16.650 ybp. WLA (2004) also reported an unfaulted soil horizon above fault strand D to be 8.590 to 8.990 ybp. suggesting a minimum age of faulting at fault strand D. They suggested that. because the fault tips of strands D. E. and F all occur at about the same stratigraphic position. these three closely spaced splays ruptured in the most recent earthquake. Based on the detrital charcoal samples. they concluded the most recent surface-rupturing earthquake on strands D. E. and F of Fault 1 occurred between ~8.500 and 10.000 years ago.

A report by WLA (1998c) at locality 2 finds that four faults underlie the site. They state that these faults are overlain by multiple unbroken Pleistocene soils and that the southernmost fault has displaced Pleistocene deposits and is overlain by unbroken Holocene deposits. Additional details gathered from exploratory borings provided insight that the northern fault zone is found to offset a marine wave-cut (abrasion) platform at depth. Evidence includes a gently dipping. planar surface of quartz diorite bedrock. overlain by a thin veneer of beach sand. and smooth. rounded. non-quartz diorite cobbles and pebbles. They reported the age of this marine wave-cut platform is constrained by the age of the overlying alluvial sediments. where they estimated this abrasion platform to be between 400.000 to 900.000 years old. Further. they report a significant amount of platform tilting is present between fault-bound blocks. However. measurable evidence of late Quaternary folding or tilting of the overlying sediments was not present at the site.

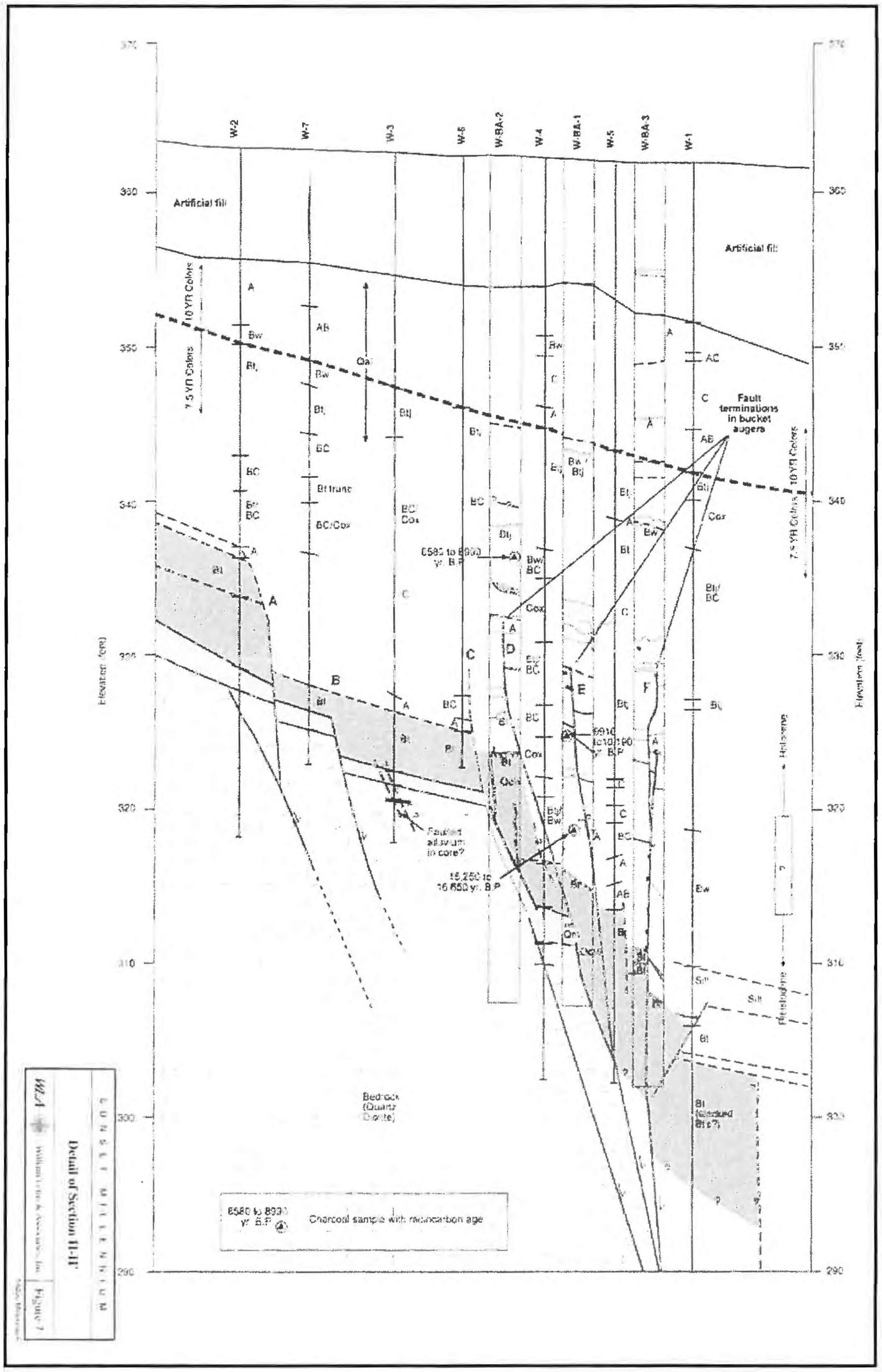

Figure 4 - Upward terminations of fault strands D, E, and F within Fault "1". Locality 1; modified from WLA, 2004.

A study by WLA (1998b). located southwest of Alta Loma Road at Sunset Boulevard (locality 3). mapped four faults across the site that are reported as inactive based on unfaulted late Pleistocene soils that overlie the faults. These faults were reported to be secondary faults and not the main trace of the Hollywood Fault. They report that similar to locality 2. these faults are part of the northern fault zone and are found within the marine wave-cut abrasion platform at depth. They infer the main trace to lie well south of Sunset Boulevard in this location.

An interesting detail about the Hollywood Fault as reported by WLA (1998c) and discussed by T. Rockwell (p.c.. 2013). is that the gently sloping marine abrasion surface consists of one and possibly two paleo-marine terraces at depth in this area. with a terrace riser (or sea cliff) at the back of each terrace. Some of the escarpments observed along the base of the Santa Monica Mountains. previously thought to be the location of the Hollywood Fault. are now interpreted as paleo-sea cliffs.

Work completed by WLA (2007b) south of Sunset Boulevard at locality 4 found no active faults are present at the site. They encountered three inactive secondary faults at the site that were described to be part of the inactive northern fault zone. as noted at localities 1. 2 and 3]. They reported these faults are overlain by distinctive. continuous buried Pleistocene soils.

A study by ECI (1999a) at locality 5. found the northern fault zone and marine abrasion platform to be overlain by unbroken Pleistocene age soils in all of their borings. indicating Holocene faulting has not occurred at this location. Fault 1 underlying the site was also judged to be not active. based on apparent continuity of overlying pre-Holocene stratigraphy as interpreted from their borings. However. the correlated contacts are not clearly continuous and some Holocene offset cannot be precluded. Based on the relatively small offset of the quartz diorite basement terrain (relative to other sites) and the generally normal separation on the on-site faults. ECI (1999a) concluded that the principal trace of the Hollywood Fault must lie to the south of their site.

Studies located on the southeast corner of Sunset Boulevard and Olive Avenue at Locality 6 (Applied Earth Sciences. 1997; Johnson. 1999; Law/Crandall. 2001) found that a northern and southern set of faults crossed the site. The northern fault zone. as in studies to the west. was reported as not active based on unfaulted Pleistocene soils at the site. Additionally. these studies encountered the marine abrasion platform and associated cobble and boulder size clasts of well-rounded quartz diorite and other exotic clasts. with well-sorted. clean. fine- to medium-grained sand. They interpreted the northern fault zone as a minor. secondary fault zone that accommodated local extension in a left step of the Hollywood Fault zone. The active southern fault zone is steeply north-dipping. and extends into alluvial units of Holocene age up to within 15 feet of the ground surface (Figure 5). Law/Crandall (2001) determined this strand is active based on radiocarbon dating of detrital charcoal samples. indicating the faulted soils were approximately 9.000 to 10.000 years old. Both Law/Crandall (2001) and Applied Earth Sciences (1997) recommended structural setbacks from the fault. This southern strand vertically offsets bedrock by at least 150 feet of south-side down separation. and also forms a steep groundwater step. Unfaulted Pleistocene sediments were documented south of the southern fault zone.

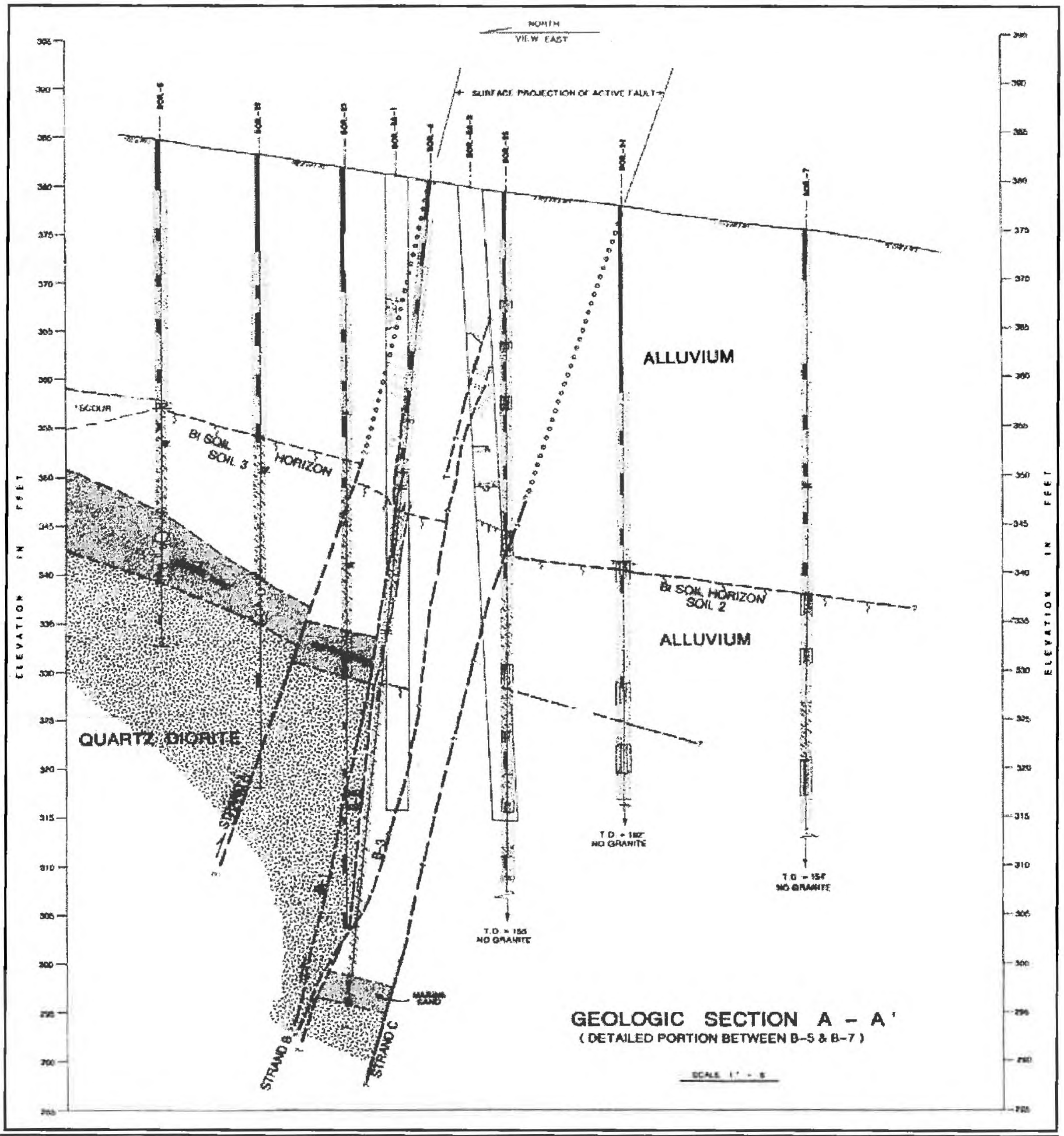

Figure 5 - Cross section showing south-side down offset on the southern fault zone at the southeast corner of Sunset Blvd. and Olive Drive. West Hollywood (site 6). Thickness of marine sand decreases to the south. Modified from Law/Crandall. 2001.

A study by Schell (1998) was performed for a site located south of Sunset Boulevard along Harper Avenue (locality 7. Plate 1). Boreholes were drilled for the site. and were extended north across Sunset Boulevard and a steep escarpment. Borings revealed a steep groundwater step. and an offset of quartz diorite bedrock in excess of 150 feet near Sunset Boulevard. Based on this data and geomorphic expression of the fault scarp. Schell interpreted that the main trace of the Hollywood Fault lies north of his site. along the south edge of Sunset Boulevard. He concluded that there were no significant faults to the south based on apparent continuity of several sediment packages of increasing relative age with depth. with the lower units identified as pre-Holocene.

A study by ECI (2001a) was completed for a proposed development located south of Sunset Boulevard at Havenhurst Drive at locality 8 (shown on Plate 1). This site is adjacent to locality 7 and ECI included data from that work in their analysis (Schell. 1998) in addition to their own borings extending offsite toward Sunset Boulevard. After analysis of groundwater levels. topographic data. soil development characteristics. and stratigraphic correlation across the southern portion of ECI's site. they concluded the fault zone immediately south of Sunset Boulevard may be wider than originally mapped by Schell. where they mapped a second north-dipping active fault strand to the south of Schell's trace. Continuity of pre-Holocene stratigraphy beneath the site. based on borings. was used to preclude any additional young faulting. Ages of stratigraphic units were based on one radiocarbon date and relative soil development characteristics.

Downtown Hollywood

Much of the synthesis and reported details in the downtown Hollywood area go back to Dolan *et al.* (1997). Work by Dolan *et al.* (1997) included geomorphic analysis of tectonic landforms along the fault trace using historic topographic maps (1920s vintage) and field reconnaissance. They also presented and analyzed data from several geotechnical studies. They interpreted at least three major fault splays: the Franklin Avenue strand. the Yucca Street strand. and a northern strand as shown in Figure 6 (see also Plate 1). Details of individual parts of their study are discussed below.

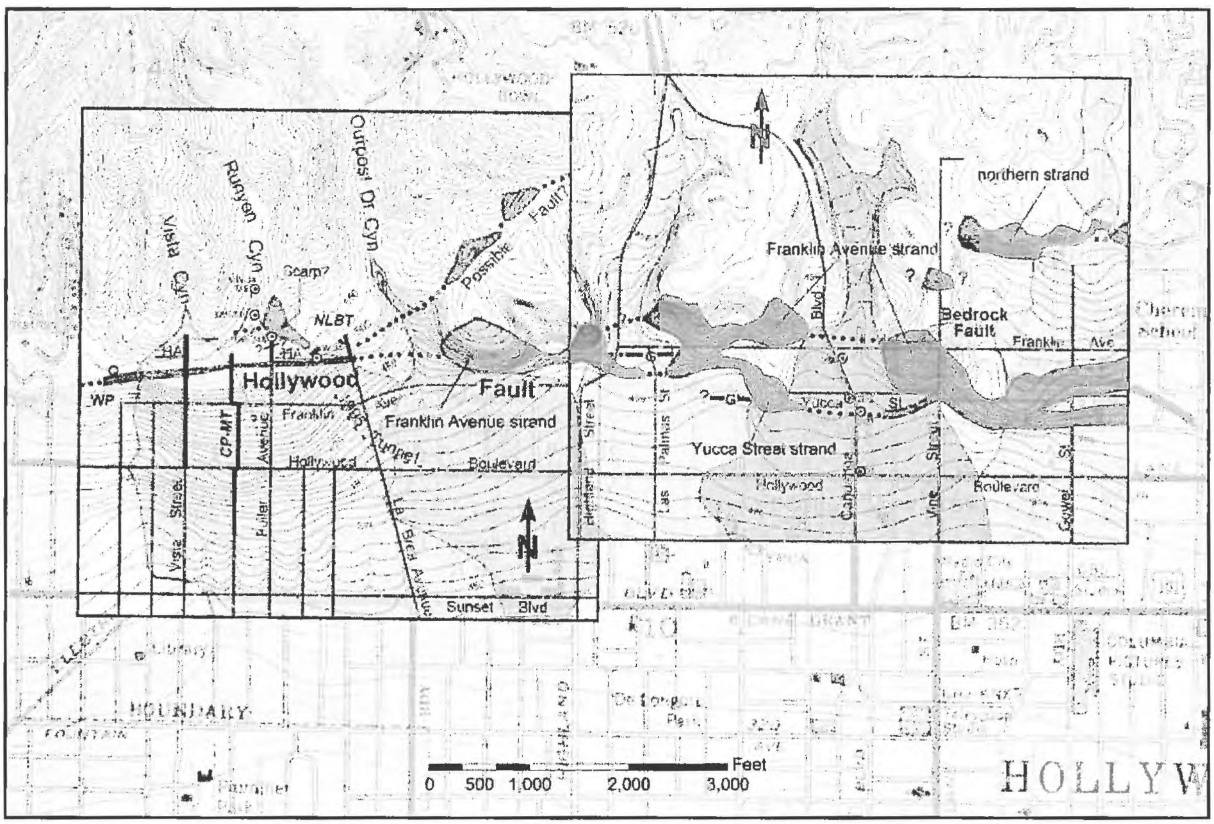

Figure 6 – Detailed mapping and investigations by Dolan *et al.* (1997. their figures 4 and 6). shown overlying a 1953 topographic map base of the Hollywood area. "G" indicates groundwater barrier. Dark shaded areas indicate fault scarps. This historic topographic map is composited from 1923-1925 plane table surveys. with a 5-foot contour interval up to the 500 foot elevation contour and is similar to the topographic data set used by Dolan *et al.* (1997).

Hollywood - Vicinity of La Brea Ave

Earlier work by Crook et al. (1983) and Crook and Proctor (1992) included trenching at a site within the Hollywood area at Wattles Garden Park at Franklin and Sierra Bonita Avenues (locality 9. Plate 1). They found several thin shallowly north-dipping gouge layers and a thicker (60+ cm) gouge mass that they assume to be part of the Hollywood Fault Zone. There were no datable materials. A second trench. further down the fan surface found no faulting but was likely too shallow to be conclusive.

At locality 10. detailed studies by Dolan *et al* (1997). and Earth Technology Corporation (1993) took place at three locations in conjunction with the 1993 MetroRail Boreholes/subway tunnel investigations along the Hollywood Fault Zone: Camino Palmero-Martel Avenue Transect; North La Brea Avenue Transect; and at Vista Street. as shown on Figure 7. Also included in this study were data from Los Angeles County storm drain trenches (Vista Street and Fuller Avenue). and the La Cienega and San Fernando Valley Sewer Relief Tunnel project (1953. as reported by Earth Technology Corp. 1993) west of Vista Street.

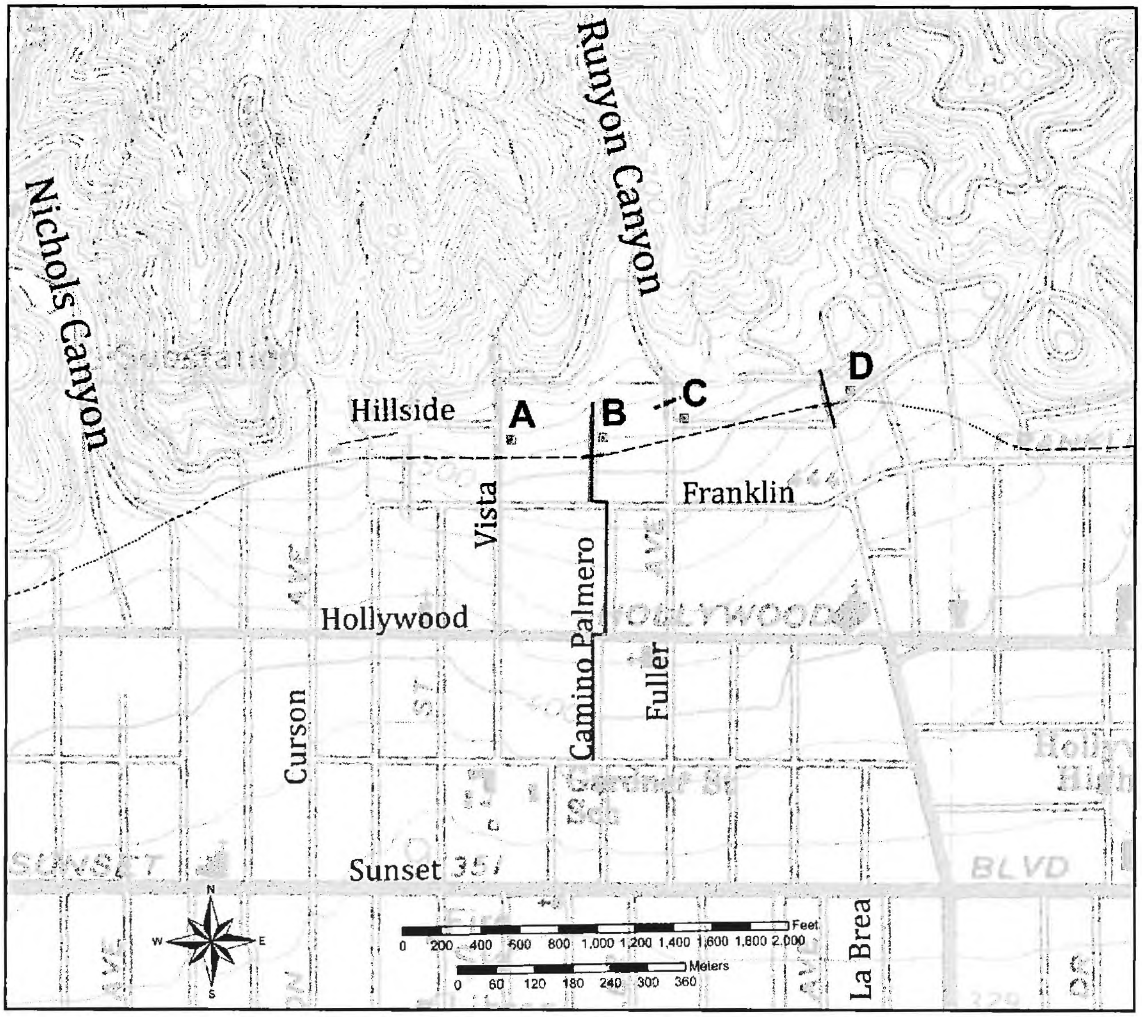

Figure 7 - North Hollywood area. locality 10. showing location of shallow trench data (gold lines) and borehole transects (blue lines) completed for the Metro Red Line study (Earth Technology Corporation (1993). sewer relief trenches and storm drain tunnel. Green squares indicate study localities: A - Vista Street storm drain transect; B - Camino Palmero-Martel Avenue Metro RedLine transect; C- Fuller Avenue storm drain trench; D - La Brea Avenue Metro RedLine transect. Dashed red line segments along transects indicate the active fault trace or projection based on supporting data from adjacent sites. Purple dashed lines represent fault strands of indeterminate age. Black lines are faults recommended herein for zoning.

Along the Vista Street storm drain transect (Figure 7. site A). the Hollywood Fault was not encountered in the ~1400 foot long trench. however (Dolan *et al.*. 1997) reported the depth of this trench was likely insufficient to observe the fault trace. The La Cienega and San Fernando Valley Sewer Relief Tunnel project (1953. as reported in Earth Technology Company. 1993) along Sierra Bonita west of site A. encountered faulted granite with gouge and breccia in test borings.

Along the Camino Palmero-Martel Avenue Metro RedLine transect (Figure 7. site B). evidence for faulting included groundwater barriers and quartz diorite bedrock faulted over alluvium. with average dips of ~77° to the north. Dolan *et al.* (1997) and Earth Technology Corporation (1993) reported up to four fault strands with apparent north side-up displacement of the granitic bedrock at depth (Figure 8). however the southern-most strand appears to be the youngest based on offset younger soils. Groundwater elevation changes were reported on the order of 40 or 50 feet across the fault as shown in Figure 8 (inset). This site was further explored (Dolan *et al.,* 2000) with successive bucket auger borings that revealed additional evidence that one. and possibly two surface ruptures had occurred within the past 20.000 years. the most recent event occurring about 7.000 to 9.500 years ago. Additionally. based on the downhole observations made within the boreholes for this study. Dolan *et al.* (2000) reported that all of the fault strands encountered were near vertical with a dip about 85° northward. and that the most recent surface rupture resulted in north-side down separation. This sense of near-surface separation contrasts with the reverse sense at depth. supporting the contention of Dolan *et al.* (1997) that there is a strong component of strike-slip displacement (presumed left-lateral).

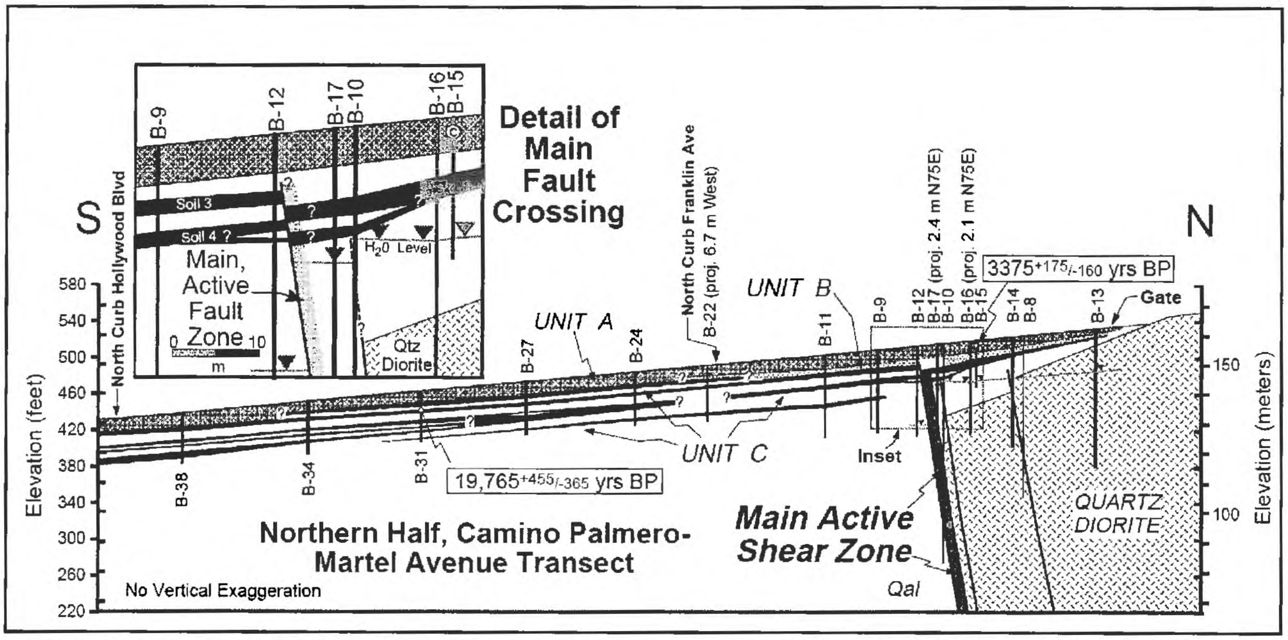

Figure 8 - Cross section of continuously cored boreholes along the northern half of Camino Palmero transect. Note down to the north soil profiles. particularly between B-10 and B-12. across the active fault strand. Depth to groundwater was encountered at about 55 feet on the north. and about 89 feet bgs to the south. Figure modified from Dolan *et al.* (1997).

Storm drain trench excavations by Los Angeles County Department of Public Works along Fuller Avenue (Figure 7. site C). revealed a secondary strand of the Hollywood Fault. oriented N59°E. 74°NW with north-side-up vertical separation (reported by Dolan *et al.*. 1997). This fault displaced the base of a possibly Holocene clayey sand.

At the La Brea Avenue Transect (Figure 7. site D) evidence for faulting includes quartz diorite apparently thrust over Quaternary alluvium. similar to the Camino Palmero site (Dolan *et al.*. 1997; Earth Technology Corporation. 1993). Shallow groundwater was encountered north of the fault at depths between about 10 feet to 43 feet. whereas south of the fault groundwater was not encountered within the upper 200 feet of borings. They reported the fault dip steepens with depth. ranging from 25° to 60° to the north.

<u>*Hollywood - Vicinity of Highland Avenue*</u>

A study by MTC Engineering (2012c). located on the southwest corner of Bonita Terrace and Orchid Avenue (locality 11. Plate 1) found no clear evidence of faulting. although a zone of steepening of the bedrock at depth between two bucket auger borings was noted in our review. They encountered basaltic volcanic bedrock. and they reported clean sandy gravel in each of the bucket auger borings was in sharp contact with the bedrock. Rounded cobbles up to about 10-inch diameter in a fine- to coarse-grained sand matrix. and clean sand layers were encountered directly overlying the bedrock. Our review of this data suggests the marine abrasion platform previously discussed for sites in West Hollywood (localities 1 through 6) may exist in this part of Hollywood.

In studies by Leighton Consulting (2011) and GeoPentech (2013a; 2013b) at 1805 Highland Avenue. evidence was reported for at least three faults at this site (locality 12). Groundwater steps and discontinuous stratigraphy across the site suggest several fault strands may exist within a broad zone of faulting at this site. Three fault strands appear to displace an earliest Holocene/late Pleistocene horizon (approximately 11-14 thousand years old) and at least one of the strands may displace late Holocene sediments (Geopentech. 2013b). Studies are on-going to further characterize the location and orientation of the fault strands. recency of activity. and how these features relate to faults mapped at the site directly to the east.

Studies performed at 1840 Highland Avenue (locality 13) by LAW/Crandall (2000) and GeoPentech (2001a. b; 2013c) found evidence of several well-constrained fault strands crossing the northern portion of the site. The faults in the northern and central portion of the site were judged to be active based on three distinct groundwater steps and offsets in stratigraphic units (including Holocene deposits) observed in continuous core borings and CPT transects. They reported faulting consisted of steeply north-dipping faults (about 80^0) for these northern strands. and have established a building setback zone. In the southern portion of the site. they reported continuous Holocene and Pleistocene soils and stratigraphic units underlie this portion of the site. precluding any additional young faulting. Just to the east of this site. at Las Palmas St.. unpublished studies cited by Crook and Proctor (1992) found a 30-foot difference in groundwater levels between two borings on opposite sides of this fault zone.

A study for the Los Angeles MetroRail project (Converse *et al;* 1981. 1983) found evidence that the Hollywood Fault is located south of Yucca Street at Cahuenga Boulevard (locality 14). Their boring #28B. also described by Crook and Proctor (1992). encountered alluvium to a depth of 120 feet. followed by 10 feet of brecciated sandstone. alluvium and siltstone. which in turn overlies alluvium to the total depth at 205 feet. The location for this fault corresponds well with differences in groundwater reported at locality 15 to the east. and a groundwater barrier just south of Yucca Street to the west (F. Denison. 1991. p.c. *in* Dolan *et al.*. 1997).

Hollywood - Vicinity of Hollywood Boulevard and Vine Street

Geotechnical studies were done by Langan and Associates (2012a; 2012b) for the proposed Millennium Hollywood development located south of Yucca Street. between Ivar Avenue and Argyle Avenue (locality 15). Although faulting was not specifically identified in these reports. our review of the subsurface data from several borings indicated groundwater depth differences across the site as well as significant differences in sub-surface materials that support the presence of a fault beneath the site.

Borings from an adjacent project by Group Delta (2006) located at the southwest corner of Argyle Avenue and Yucca Street (locality 16). revealed groundwater elevation differences across the site. Review of this data when compared to borings from the adjacent sites. also suggest a significant difference in groundwater elevation between this project and the Hollywood Millennium site to the south (locality 15).

Just east of Argyle Avenue and north of Hollywood Boulevard (locality 17) geotechnical studies were done for the Blvd6200 project (Geotechnologies. Inc.. 2006 and 2013). Although faulting was not specifically identified in these reports. a strong break in slope existed across the northern portion of this parcel that has been interpreted as a fault scarp by previous researchers as well as in our review and field reconnaissance. Additionally. geotechnical borings drilled for the project encountered higher groundwater levels in the northern portion of the site. and deeper groundwater levels in the southern portion of the site with recommendations made for a dewatering system. A review of the boring logs and cross sectional analysis reveals the stratigraphy does not appear very continuous in this area. and the drop in groundwater level appears to correlate well with the break in slope at the surface. These two pieces of evidence suggest active faulting exists along a west-northwest trend at this location.

West Los Feliz area

Only one geotechnical study has come to our attention in this area which might bear on the presence of active faulting. A study was conducted by Pacific Soils Engineering (1961). for tract development located north of Los Feliz Boulevard. between Fern Dell Drive and Winona Boulevard at locality 18. They identified a northeast-trending bedrock fault at the northern end of the property. and although the fault appeared to juxtapose granitic basement rock against alluvium. the fault was judged to be not active. A water seep was noted after grading (Pacific Soils Engineering. 1962) that was not on the identified fault. but it did lie along an interpreted geomorphic scarp within the alluvial fan deposits. as noted in our review of vintage air photos (discussed later in this Fault Evaluation Report). Previous mapping by Neuerburg (1953) in this area indicates two roughly parallel fault traces that were mapped in the granitic bedrock northeast of the site and likely project toward this development. The lack of any geomorphic expression in crystalline rock. as well as their location and orientation. suggest that these two fault traces are not active.

Los Angeles River/Atwater Area

Along the west side of Riverside Drive near Los Feliz Boulevard (locality 19). two fault/geotechnical studies were completed by AMEC (2012. 2013) for the City of Los Angeles Northeast Interceptor Sewer (NEIS) project. The 2013 study included data from two seismic reflection surveys. performed by Advanced Geoscience. Inc. (2013). These seismic surveys identified at least 6 fault traces which dip steeply (north and south) and are interpreted to include the north-dipping main trace of the Hollywood Fault Zone. Advanced Geoscience. Inc. (2013) reports that the main fault and several secondary faults appear to be trending to the east. based on two sets of seismic data. Evidence for faulting found in borings along the transect line includes: thickening of young alluvium across several borings within the fault zone. a thickening and offset of older alluvium deep within closely-spaced borings. and deeper offsets within sedimentary bedrock (Puente Formation) and quartz diorite. Artesian groundwater conditions are also reported within a narrow zone as noted in a cross-section prepared by the City of Los Angeles. included here as Figure 9.

In the Atwater area. well data as reported by State Water Rights Board (1962) indicate a steep drop in groundwater levels near the mapped fault trace. They reported shallow Puente Formation bedrock was encountered in borings drilled on the north side of a concealed fault trace. and also noted rising water levels in the area of Los Feliz Boulevard. Fault displacements were postulated to have affected the base of the valley fill within the Los Angeles River narrows area. notably where a small bedrock knob is present north of the fault and has "created a constriction in the water-bearing materials" and a depression in the groundwater level immediately to the south. Further. they reported fairly thick packages of clay-rich sediments predominate to the north. and gravelly sands to the south. generally near San Fernando Road and the northern projection of Silver Lake Boulevard.

Williams and Wilder (1971) reported a steep south-facing groundwater gradient exists about half way between the Forest Lawn wells (near Glendale Blvd and San Fernando Road). and the Pollock Field (near Garden Ave. and Fletcher Dr.). In their cross section. they indicated a gray organic clay layer is vertically offset by a steeply south-dipping fault. with down to the south displacement of the clay. Converse. Davis and Associates (1970) reported on the "top of clay" layers within groundwater wells in the Atwater area. Review of the well logs indicated a groundwater level differential and top of clay differential in the area near Fletcher Dr. and San Fernando Road. Our own review of several of the well logs from the Converse. Davis and Associates report. reveals thick clay zones at depth that appear to be discontinuous in the vicinity of Silver Lake Boulevard and La Clede Avenue. This location is similar to the groundwater differential reported by Williams and Wilder (1971).

Gravity data from Chapman and Chase (1979) reveals a steep gravity gradient along the fault that coincides at depth with the eastern projection of the Hollywood Fault Zone.

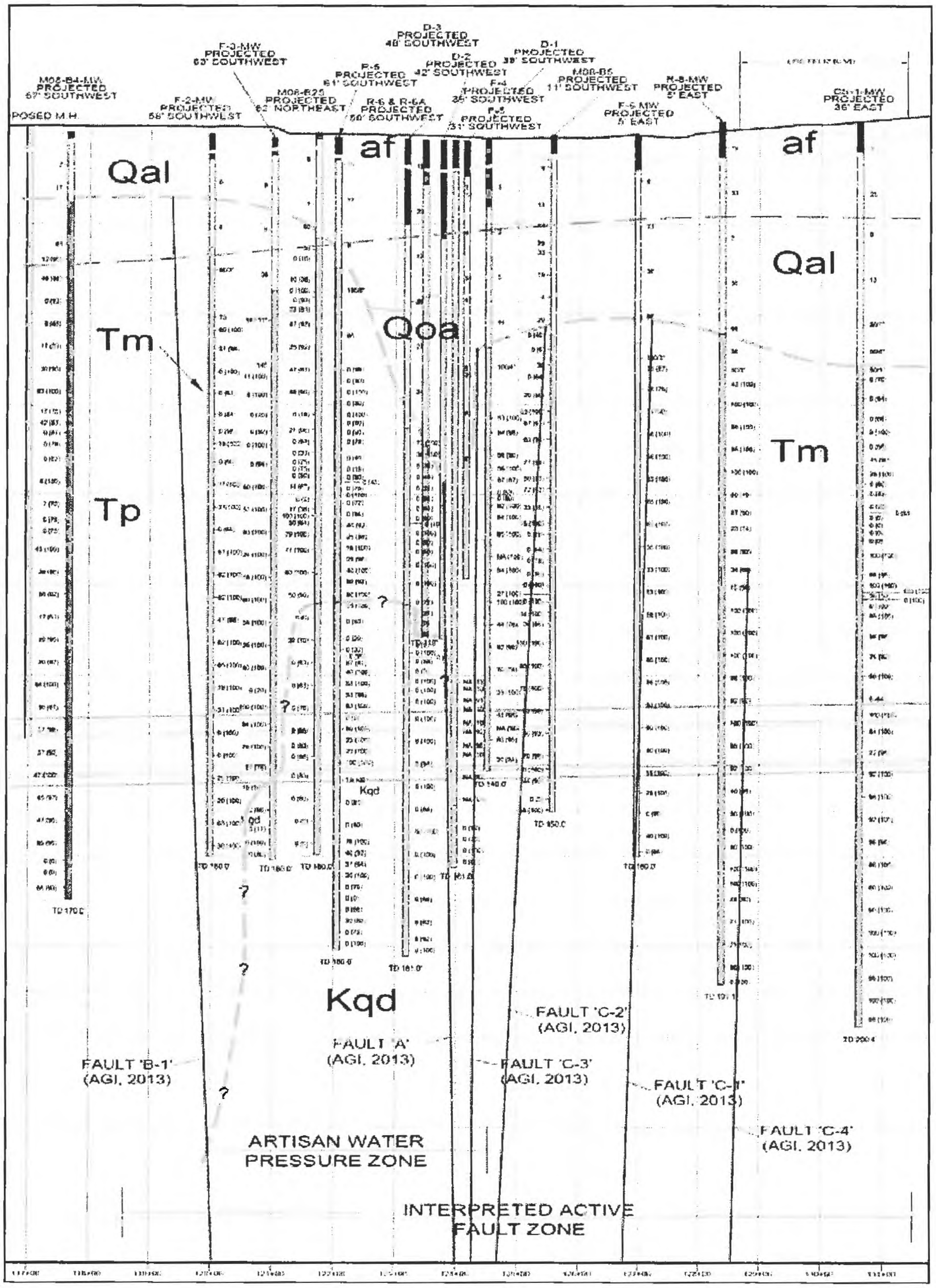

Figure 9 – Cross section with Fault 'A' interpreted as the main trace within the active fault zone. Note differential thickness of recent alluvium. and depth of older alluvium between Fault 'A'. and Fault 'C-3'. Kqd = Cretaceous quartz diorite; Tp = Puente Formation; Tm = Modelo Formation; Qoa = Quaternary older alluvium; Qal = Quaternary alluvium; af = artificial fill.
Cross section modified from City of Los Angeles Geotechnical Engineering Group (2013). Grids are 10' in height and 100' in width.

AERIAL PHOTO, LIDAR, MAP INTERPRETATION, FIELD OBSERVATIONS and GEOMORPHIC ANALYSIS

(for referenced localities. see Plate 2)

The following geomorphic analysis is based on review of vintage aerial photographs, topographic maps, LiDAR data and field observations. Field observations were performed during November and December 2013 for approximately 3 days.

DATA SOURCES

Vertical aerial photographs – 1927-1928

Vertical aerial photographs from two flights (1927 and 1928) by Fairchild Aerial Surveys were studied in stereo pairs to identify and interpret landforms along the fault traces. Development of the landscape (grading for streets. houses and other structures) even at this early date make interpretation a challenge. However. many features of the landscape are still discernible.

Historic oblique photographs – 1921-1938

Vintage oblique aerial photographs provided a unique view of the historic landscape. providing illuminating images of much of the landscape prior to full development. These images provided an independent check on the features interpreted from vertical aerial photos and topographic maps. The vintage photos were taken by Spence Aerial Surveys and Fairchild Aerial Surveys and are archived in the Geography Department at the University of California. Los Angeles.

Historic maps – 1926-1928

A remarkable series of topographic maps was prepared in the 1920s for the County of Los Angeles at a scale of 1:24.000. These were published in the atypical format of a 6-minute by 6-minute quadrangle as opposed to the more standard 7.5-minute map format. These maps are notable for two reasons. First. they capture the landscape at a time when much of the local land development had either not occurred or was of a less disruptive nature. Secondly. these maps have 5-foot contours and were drawn by topographers with an excellent sense of landform. As a result. these maps provide a very illuminating view of the landscape and reveal numerous features that are suggestive of tectonic influences. We analyzed the topography as depicted on the Hollywood and Burbank 6-minute quadrangles from 1926 and the Glendale 6-minute quadrangle from 1928 (all at an original scale of 1:24.000).

We prepared an interpretive map from these topographic bases. delineating locally incised drainages and a complex set of nested alluvial fans being shed from the Santa Monica Mountains (Figures 11. 12. 13. 14 & 17). In particular we have made note of abrupt transitions from erosion (the channels) to deposition (the fans) and. where these are aligned with other corroborative or suggestive features. have interpreted fault movement to explain this change in sedimentary regime.

LiDAR

A digital elevation model derived from a LiDAR survey of Los Angeles County (Los Angeles Regional Imagery Acquisition Consortium. 2006) was useful for verifying some of the geomorphic features identified from other sources as well as detecting additional features.

DISCUSSION

To aid discussion we have divided the fault zone. as it crosses the Hollywood Quadrangle. into five segments (Figure 10). The westernmost segment (segment 1). from within the city of West Hollywood. trends northeast along the southern edge of the Santa Monica Mountains. primarily as a single trace. Segments 2 and 3 trend more east-west and are expressed in several near-parallel left-stepping fault strands. Segment 4 trends east-northeast. paralleling Los Feliz Blvd.. and consists of at least two sub-parallel fault strands. Eastward from the Los Angeles River we describe Segment 5 which appears to consist of a single surface trace until the eastern boundary of the map.

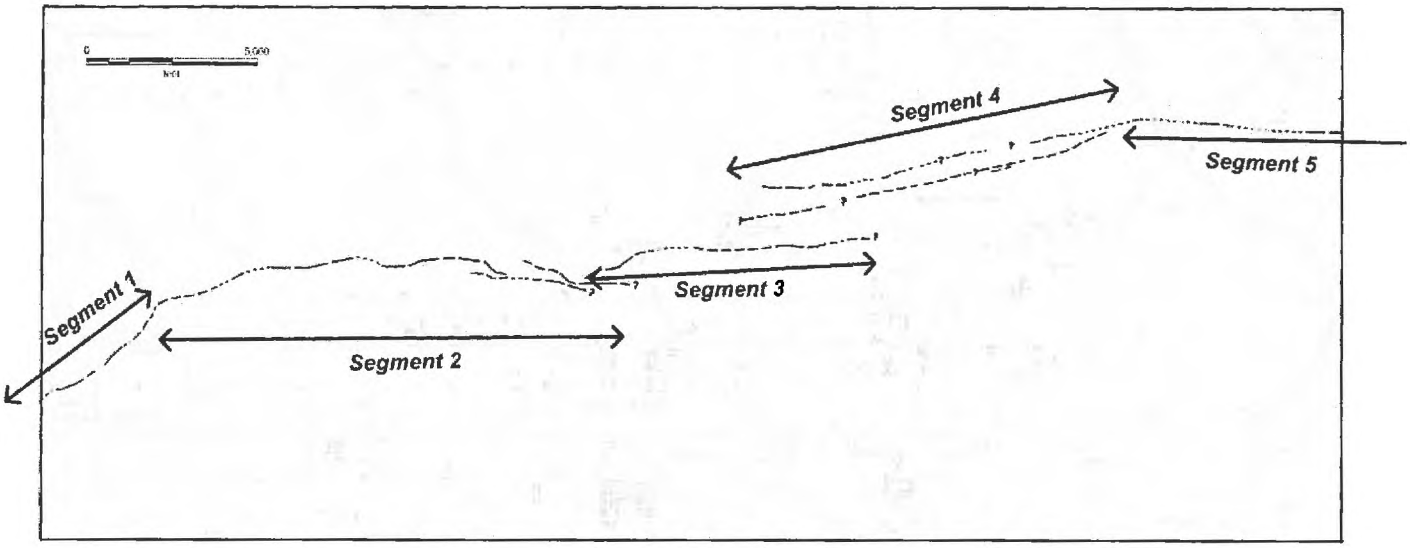

Figure 10 - index to fault segments discussed in the text. Red lines are faults identified for zoning.

Segment 1 extends from the west margin of the map northeasterly to the vicinity of Laurel Canyon (Figure 11). The fault is expressed here by a well-developed scarp along the base of the hills (S1a). Some less-prominent scarps. north of the identified fault. may be related to a paleo-shoreline identified in the area (WLA. 1998c). Several small scarps near the base of the mountain front on Plate 2 (Site A1) are thought to be related to this paleo-shoreline feature. Several subtle slope breaks in the ground surface to the southeast may indicate additional splays. but these are less certain and may just mark the distal extent of fan deposition. A prominent scarp-like feature (S1b) at the edge of the map is crossed. on projection to the west. by fault studies which found no evidence of active faulting along that trend. The young Holocene-age alluvial fan emanating from Laurel Canyon has entirely obscured surface evidence of the fault in that location.

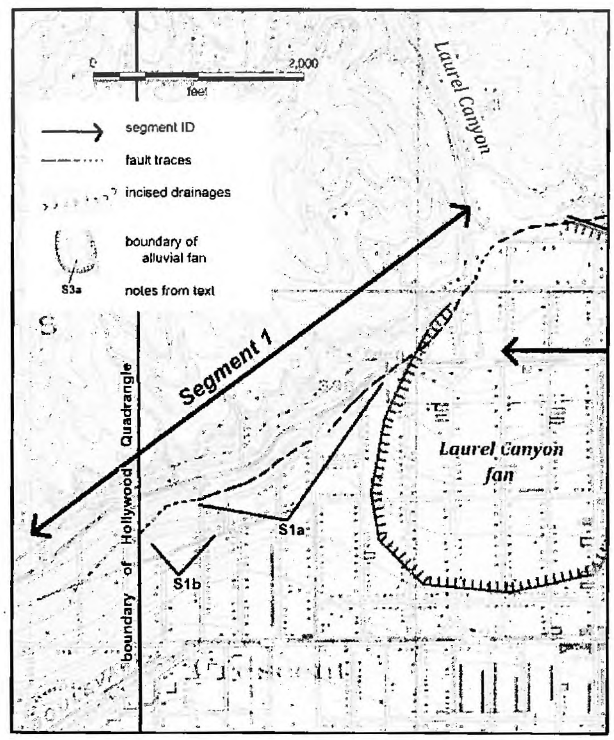

Figure 11 - Geomorphic features along Segment 1. Base map from 1926 Hollywood and Burbank 6' quadrangles.

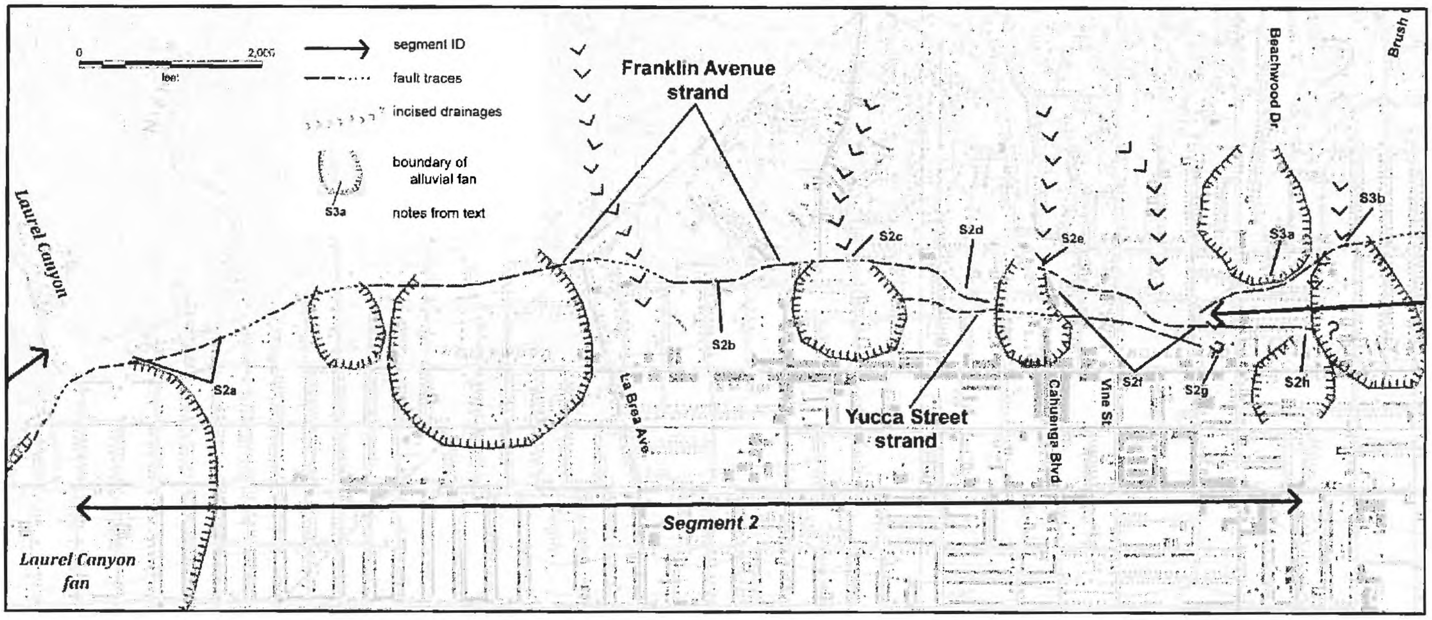

Figure 12 - Geomorphic features along Segment 2. Base map from 1926 Hollywood and Burbank 6' quadrangles.

Segment 2 trends east-west from Laurel Canyon to Beachwood Drive (Figure 12). The western portion is distinguished by a slightly sinuous mountain front with small fans emanating from small to medium-sized canyons. The mouths of these canyons are in rough alignment as far east as La Brea Avenue. suggesting some linear structural control. but the fault may be buried and overlapped by fan deposition so that the fault trace would be somewhat south of the current slope break. Oversteepened and eroded slopes at the south end of several intervening ridges are interpreted to be related to faulting. More subtle breaks in slope gradient to the south are possibly related to the distal edges of the small alluvial fans and cannot be ascribed with any certainty to faulting (Plate 2. site A2). The south end of the first ridge to the east of Laurel Canyon (S2a) appears oversteepened and is likely a fault scarp. Dolan *et al.* (1997) also noted the scarp in this area. A break in slope also veers away from this scarp and across a local fan coming off of the slopes. suggesting young displacement. Subtle tonal lineaments (Plate 2) suggest the fault location to the east across the Nichols Canyon drainage.

East of La Brea Avenue the fault bends or steps southward to create the steep southern front of a prominent knoll (S2b) and several other ridges to the east. Dolan *et al.* (1997) found this Franklin Avenue strand to be the most prominent south-facing scarp in the downtown area. The Yucca Street strand. which exhibits a 5-6 m high scarp. also acts as a groundwater barrier west of the alluvial fan at Cahuenga Blvd.

The drainage from Cahuenga Pass. as it crosses this trend. appears as if it is deflected in a left-lateral sense (S2c) and very shortly changes from an incised channel to a depositional fan. suggesting a change in base level at this point. Another southward step is suggested by the south-trending ridge west of Cahuenga Boulevard (S2d) and then expression is lost across the drainage descending from the Hollywood Reservoir area. However. the channel from that canyon appears to have been incised above the mouth of the canyon (S2e). switching to a depositional mode to the south. which suggests a base level change at a fault at that location. The fault location eastward is indicated by a very steep south margin to the hillslopes (S2f). A distinct change in slope gradient is also visible across several north-south streets in this area in both site reconnaissance and air photo interpretation. including Vine and adjacent streets (Plate

2. site A3). The eastern extension of this fault coincides with the initiation of a small depositional fan indicated in the vintage topographic map (S2h). with an incised drainage visible just to the north in the 1927 and 1928 aerial images. A southern fault splay. indicated to the west from geotechnical studies (adjacent to Vine Street). is supported by the upstream incision of another small drainage near the projected crossing of that fault (S2g).

The Hollywood Bowl Fault is mapped north of Segment 2. Trending northeast. it is discontinuously marked by erosional fault line features. such as topographic saddles and some degraded slope facets (see features identified by Dolan *et al*.. 1997. depicted herein on Plate 2. site A4). These geomorphic features closely follow the mapped fault contact between granitic bedrock to the north and Cretaceous and Tertiary sediments to the south.

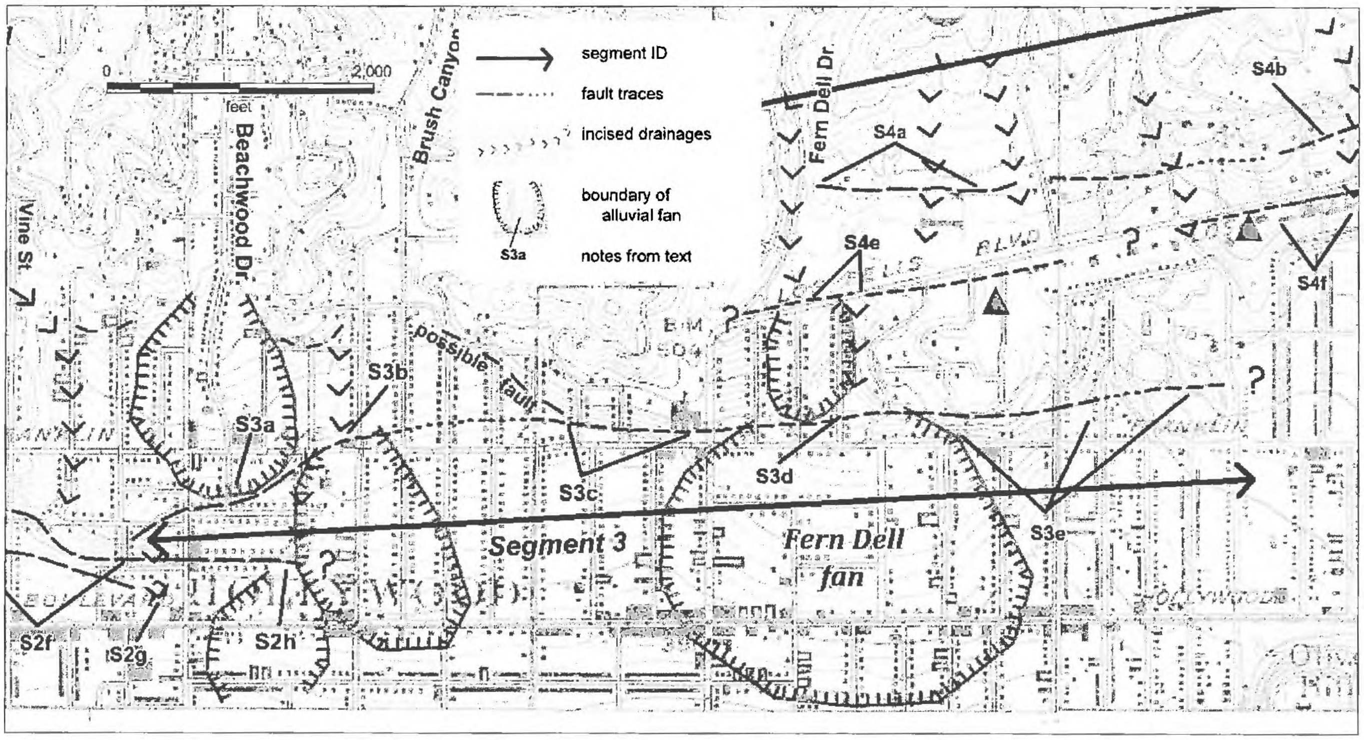

Figure 13 - Geomorphic features along Segment 3. (brown triangles indicate saddles discussed in Segment 4) Base map from 1926 Burbank and 1928 Glendale 6' quadrangles.

Segment 3 overlaps Segment 2 at its west end and Segment 4 at its east end (Figure 13). It appears to function as a transition in the stepover between those two segments. The western end is suggested by a slight steepening of the fan gradient below Beachwood Drive and Franklin Avenue (S3a). and an incision to deposition transition just to the east (S3b). The main alluvial fan of Brush Canyon conceals the trace for a short distance and then the approximate fault location is indicated by the abrupt slopes just north of Franklin Avenue (S3c. S3e). This prominent scarp is also marked by the initiation of fan deposition from the Fern Dell drainage (S3d) as well as a break in the fan gradients. Geomorphic expression of this fault segment dies out about 0.5 km west of Vermont Avenue.

There is another line of subdued and discontinuous scarps. mapped by Dolan *et al.* (1997; also see Figure 6). that splays west-northwest from the main fault trace. This possible fault appears to die out with no expression across Brush Canyon or at the Hollywood Reservoir drainage. although the Beachwood fan might be observed to begin at the postulated fault. Based on aerial photo and field reconnaissance we suggest that these features may be merely related to the break in slope along the mountain front. and not directly related to Holocene faulting.

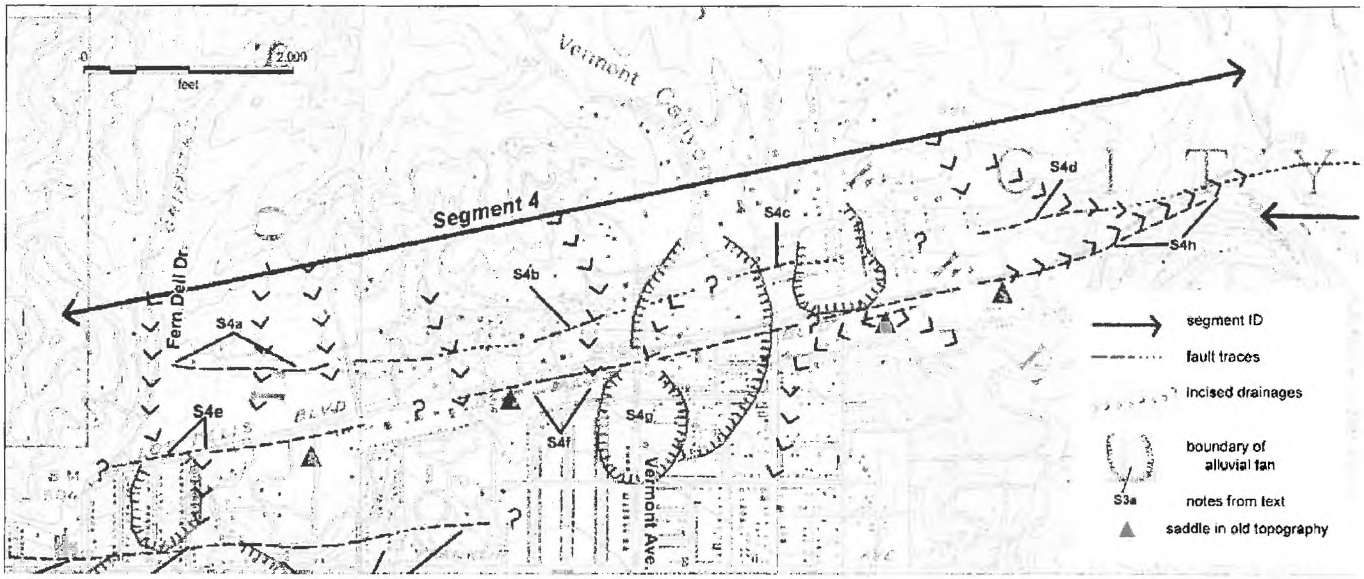

Figure 14 - Geomorphic features along Segment 4. Brown triangles locate prominent saddles along the Los Feliz Boulevard fault strand. Base map from 1926 Burbank and 1928 Glendale 6' quadrangles.

Segment 4 overlaps Segment 3 at its western end and there are geomorphic indications of at least two parallel faults in this segment (Figure 14). This segment is grossly indicated by an east-northeast trending trough that has been breached by erosion. Los Feliz Boulevard follows this trough.

A northern strand is defined at its western end by an offset fan surface (Plate 2. site A5) that is observable in vintage aerial photography as shown on Figure 15. There is at least one principal fault indicated by the steepest drop in the surface (S4a) and possible secondary faults between the principal strand and Los Feliz Boulevard indicated by additional local breaks in the slope gradient. Further east. this fault. as a single strand. is intermittently expressed by steepened slopes along trend (S4b. S4c); the fault is locally overlain by younger fans. such as that emanating from Vermont Canyon. At its eastern end it passes through a local topographic saddle (S4d) and then appears to join the Los Feliz Boulevard fault strand.

What we consider the principal active fault strand has few sharply defined indicators but is taken as the axis of the geomorphic trough that is followed by Los Feliz Boulevard. The general nature of this trough is indicated by several remnants of its eroded south margin with prominent saddles (Figure 14. brown triangles) along the fault trace. and is further confirmed by several profiles constructed from the LiDAR DEM.

Figure 15 - Oblique aerial view of the Mead Estate from 1928. showing principal and minor scarps (Yellow dotted lines) extending across the property. Site is located at the west end of Los Feliz Boulevard (Plate 2. site 5). (Photo by Fairchild Aerial Surveys. 2/25/1938. from UCLA Geography Department).

There are several additional detailed observations that provide better location control and interpretive confidence for this fault. At locality S4e there is an apparent left-lateral offset of the Fern Dell drainage that is on the order of 130 m. A small. steep and inferentially young fan had. prior to modern development. started to build below the cut-off segment of this drainage that lies upstream. Further east. just west of Vermont Avenue. an oblique aerial photo from 1921 reveals some lineaments in a then-recently graded slope below Los Feliz Boulevard (S4f; Figure 16). These lineaments. parallel to the road. may be faults. At Vermont Avenue there is a small young fan that appears to be forming just south of the fault (S4g). Contours on the 1928 topographic map suggest a subtle swale may have been evolving just upstream of the fault at this point across an older. now abandoned. fan that drained Vermont Canyon. The fault location is suggested at the east end of this segment by a linear eroded drainage (S4h) and a coincident tonal lineament visible in the vertical aerial imagery.

A third fault strand. still farther south. may be an eastern extension of Segment 3 but it lacks any youthful expression in this area. Although this strand was previously mapped by others. as shown on Plate 1. field checking and vintage air photo review noted only gentle fan slopes and granitic bedrock outcrops with no indication of any youthful fault-related features along the trace.

Figure 16 - Oblique aerial photo near the intersection of Vermont Ave. and Los Feliz Blvd. showing fresh grading south of Los Feliz. Blvd. Lineaments (highlighted with red) are possible fault traces. (Photo by Spence Aerial Photos. circa 1921; from UCLA Spence collection).

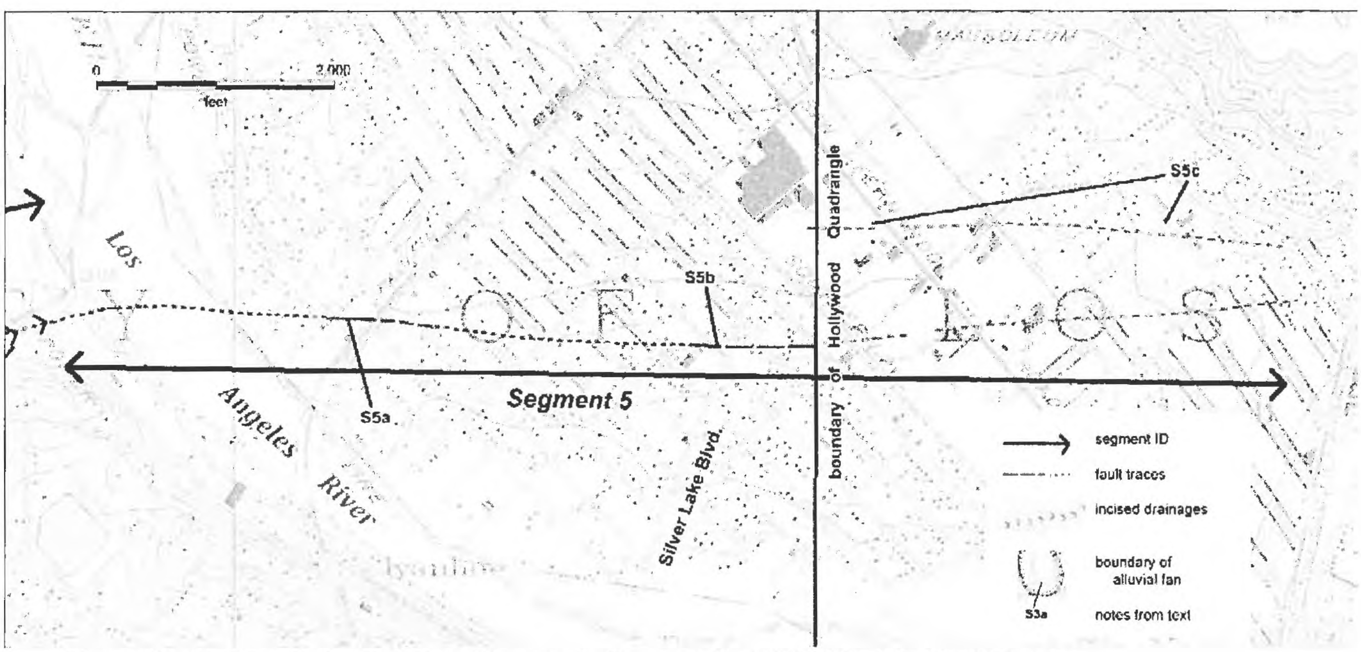

Figure 17 - Geomorphic features along Segment 5. Base map from 1928 Glendale 6' quadrangle.

Segment 5 continues eastward across the abandoned flood plain of the Los Angeles River in the Atwater area (Figure 17). An elongate knoll. just east of the river. has its southern terminus at the inferred fault location (S5a) where there are also some faint tonal lineaments and a possible scarp along the fault. Farther east the Hollywood Fault is expressed as a series of low. discontinuous breaks in the flood plain surface with south side down orientation. as previously observed by Weber (1979; 1980). At the eastern edge of the quadrangle the drop is as much as 2-3 m (Plate 2. site A6). There is a possible pressure ridge where the fault crosses Silver Lake Boulevard (S5b); it is visible in the elevation of several residential lots in spite of the roads having been graded level. Although scarps are noticeable in several of the streets. some of the previously mapped features (scarps and lineaments) have been obscured by development.

East of the map boundary there are additional features to support the location of the fault as it steps northward. including aligned tonal and vegetation lineaments (S5c). The pair of faults appear to define a knoll evident in the older topographic map; the knoll is separated from the adjacent hills by the northern strand.

DISCUSSION and CONCLUSIONS

Segment 1

The trace of the Hollywood Fault has historically been mapped very close to the mountain front in this area (Hoots. 1930; Dibblee. 1991; Dolan *et al.*. 1997). Recent geotechnical studies within the city of West Hollywood have located the principal active trace of the fault at several sites (see Plate 1; figure 3). These studies have also shown that. although the fault is concealed by young sediment in many areas. the Holocene deposits are quite thick and have been displaced by recent faulting (Harza. 1998; ECI. 2001a; LAW/Crandall. 2001; WLA. 2004)). Some scarps. north of the principal fault trace. have been shown to be related to an ancient shoreline and these are not associated with any evidence of active faulting. Several subtle slope breaks further out from the mountain front are ambiguous in origin and not directly attributable to faulting.

Segment 2

This segment of the fault zone is generally located by relatively abrupt. though intermittent. scarps. The fault location has been confirmed by several studies. including those by Dolan *et al.* (1997. 2000). Geopentech (2001 & 2013c) and LAW/Crandall (2000) and studies for the Los Angeles Metro Rail subway project (Earth Technology Corporation. 1993). Additional locations are inferred from subsurface data generated in other geotechnical investigations (Langan 2012 a. b; Group Delta. 2006; Geotechnologies. 2006. 2013). Holocene activity has been documented by Dolan *et al.* (2000) and is also suggested by the interpreted fault effects on young fan development.

The Hollywood Bowl Fault. although identified in bedrock mapping (Dibblee. 1991). and possible scarps mapped by Dolan *et al.* (2000). has only very subdued geomorphic expression that is likely erosional in origin or at least erosionally modified.

Segment 3

Segment 3 partly follows the mapping of Dolan *et al.* (2000). but we have made some different associations across the Brush Canyon fan. connecting those traces that seem to have the strongest influence on recent fan deposition and incision. The fan incision/deposition transitions provide some of our fault location evidence. in addition to interpreted scarps at the base of the hills.

The effects on the fans. as well as an inferred role in transferring slip between segments 2 and 4 suggest Holocene activity on this segment. This fault has been mapped to continue eastward. to join with a bedrock fault mapped just west of the Los Angeles River (Dibblee. 1991; Dolan *et al.,* 1997). but we see little evidence of activity on this eastern extent and. instead. infer that slip is being transferred to the faults of Segment 4. The northern trace of Dolan *et al.* (2000). which cuts across the mouth of Brush Canyon and Beachwood Drive. does not appear as youthful and dies out to the west with little evidence of fault displacement.

<u>Segment 4</u>

This is a somewhat enigmatic fault segment. having at the same time the least geotechnical evidence and little detail in the way of previously mapped fault traces but having some of the strongest geomorphology to indicate the presence of the fault zone.

The northern fault trace was shown by Dibblee (1991) as entirely concealed. Dolan *et al.* (1997. 2000) mapped the fault on the basis of the steepened slopes to the north. Weber showed a less continuous surface expression. We could verify discontinuous weak scarp segments approximately as shown by Weber. but the best evidence of this fault is in the scarps and offset fan surface visible in the vintage images at the west end of the fault (e.g. Figure 15). However. no corresponding features could be seen on further projection to the west. We judge this fault as likely Holocene based on the prominent scarps and its association with other elements of the fault zone.

What we infer to be the principal trace of the fault. roughly followed by Los Feliz Boulevard. had not been previously identified except for a short lineament mapped by Weber. We note that this lineament defines a subtle geomorphic trough indicated by a few eroded remnants of its south margin. Additional evidence comes from the apparent effect on the Fern Glen and Vermont Canyon drainages.

A southern fault. shown by both Dibblee (1991) and Dolan *et al.* (1997. 2000) about 1/3 of a kilometer south of Los Feliz Boulevard. is well expressed geomorphically to the west (part of Segment 3) and in the bedrock to the east (from Lamar. 1970). There may well be a buried continuous fault here but it lacks geomorphic evidence of recency in the central and eastern portions. It is also possible that the eastern bedrock segment of this fault connects to the zone of differential subsidence and the hypothetical Santa Monica Fault extension of Hill *et al.* (1979). discussed below. but there is no surface or subsurface data to support this connection.

<u>Segment 5</u>

The eastward continuation of the Hollywood Fault across the Los Angeles River valley. and possible connection with the Raymond Fault. has been shown in various locations by Dibblee (1991). Hill *et al.* (1979). and Weber *et al.* (1980). Most of these fault representations are shown as concealed and have been poorly constrained. The trace that we have mapped is based on borings and seismic studies along the west side of the Los Angeles River for the City of Los Angeles Northeast Interceptor Sewer Project (NEIS) by AMEC (2012 & 2013) and Advanced Geoscience. Inc. (2013). and geomorphic features mapped by Weber *et al.,* (1980). and is further supported by several groundwater studies and groundwater data (Converse. Davis and Associates. 1970; State Water Rights Board. 1962; Williams and Wilder. 1971).

Activity of this strand is based on detailed subsurface investigations from the NEIS project. tonal lineaments and breaks in slope observed in vintage air photo review and field reconnaissance. and analysis of subsurface clay layers within the groundwater well data (Converse. Davis and Associates. 1970).

Other Faults

The southern fault zone ("Santa Monica Fault") mapped by Hill *et al.* (1979) (or alternately the North Salt Lake Fault by Hildenbrand *et al.*, 2001), does not have any clear evidence as a surface fault. The zone of differential subsidence identified by Hill *et al.* (1979) is from 130 to as much as 400 meters wide and may be attributed to causes other than active fault displacement. There is no indication in the literature, or in our observations, of Holocene surface rupture along this fault projection.

RECOMMENDATIONS

Recommendations for encompassing faults in Alquist-Priolo Earthquake Fault Zones are based on the criteria of "sufficiently active" and "well-defined" (Bryant and Hart, 2007). The principal traces of the **Hollywood Fault** as shown on Plate 3 are recommended for zoning as they are mostly well-defined and believed to be active. The Hollywood Bowl Fault does not have any indication of recent activity and is not recommended for zoning. The southern strand of segments 3 and 4, south of Los Feliz Boulevard, is only well expressed within segment 3 and the remainder of that trace is not recommended for zoning.

Janis L. Hernandez

Janis L. Hernandez
PG 7237, CEG 2260
February 14, 2014

Jerome A. Treiman

Jerome A. Treiman
PG 3532, CEG 1035
February 14, 2014

I have reviewed and concur with the recommendations in this report.
Timothy McCrink
CEG 1649
2/14/2014

AIR PHOTOS AND DIGITAL IMAGERY REVIEWED

Fairchild Aerial Surveys	Flight 113	1927 b/w Stereo-pair	scale 1:18.000 vertical	Frames:74 – 75. 121 – 123. 161 – 164. 188 – 190. 226 – 229. 262 – 264
Fairchild Aerial Surveys	Flight C-300	1928 b/w Stereo-pair	scale 1:18.000 vertical	Frames: K20 – K23. K43 – K47. K72 – K74. K89 – K90. K115 – K118. K141 – K144. K163 – K164. K184 – K187. K200 – K203
Spence Aerial Photography	114. Sec 14	1921	Oblique	Western Ave & Los Feliz Blvd
"	115	1921	Oblique	Vermont & Franklin
"	115	1921	Oblique	Vermont & Franklin – Janss Investment
"	#6126 Sec. 7	06-1924	Oblique	Anthony's Home – Hollywood. Los Feliz Blvd.
"	#6069	unk.	Oblique	Los Feliz Heights
"	#5750	unk.	Oblique	Los Feliz Blvd. near Vermont. Hollywood
"	#2993	unk.	Oblique	Hollywood north of Avenue between Vermont & Commonwealth
Fairchild Aerial Surveys	Group 31B	2-21-1938	Oblique	0-5476: Mead Estate – looking NE along Los Feliz from Western – Glendale in background
"	Group 31B	2-25-1938	Oblique	0-5497: Mead Estate – looking N from Los Feliz & Western
"	Group 31B	2-25-1938	Oblique	0-5500: Mead Estate – looking E on Los Feliz from Western
"	Group 31B	2-25-1938	Oblique	0-5499: Mead Estate – Los Feliz & Western. looking NE

Additional Imagery:

NAIP (National Agriculture Imagery Program): NAIP imagery from 2009 was used as a reference for interpretation of fault-related lineaments and topography. We used a county-wide image of Los Angeles to locate features identified in historical imagery and rectify geotechnical report maps. The images were viewed within the GIS platform (ArcGIS) and interpretation done directly on screen.

Los Angeles Region Imagery Acquisition Consortium: proprietary dataset. LiDAR data acquired 2006. (1.7 m DEM) http://planning.lacounty.gov/lariac

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