Date: May 29, 2014

From: **Miles Kenney PhD, PG**
Kenney GeoScience
1105 Vista Bonita Drive,
Vista, CA 92083
Professional Geologist PG 8246

To: **Beverly Hills Unified School District**
Mr. Gary Woods
Superintendent
Administrative Office
255 South Lasky Drive
Beverly Hills, CA 90212-3697

Subject: **Letter summary report - Deformation in the northern Los Angeles Basin since the middle Pleistocene, a kinematic model, California**

The determination that the "Santa Monica Fault Zone" in the Cheviot Hills (Century City are) is dominantly strike-slip and does not exhibit a significant reverse component of slip (KGS, 2011, 2012) since the mid-Pleistocene suggests that the strike-slip motion may be the primary mode of deformation across not only the Santa Monica fault zone, but also other generally east-west trending faults along the southern boundary of the Western Transverse Ranges. Namely, the Santa Monica, Hollywood and North Salt Lake fault zones. Tectonically, the northern Los Angeles Basin represents a zone of deformation between the Western Transverse Ranges to the north and the Peninsular Ranges to the south. The exposed portion of the Western Transverse Ranges extends approximately 275 miles from the Pacific Ocean to the San Andreas Fault along the western margin of the Mojave Desert (Yerkes, et al., 1965). The approximately east-west trending southern boundary of the Western Transverse Ranges is a zone exhibiting complex deformation between the mid-Miocene and late Pliocene exhibiting numerous faults and regions of folding, uplift and subsidence as described by Wright (1991). The boundary is delineated by an east-west trending zone of faulting that involves the Santa Monica Fault (North branch)-Hollywood-Raymond fault system. This fault system extends from the Pacific Ocean to the southern San Gabriel Mountains. During the mid-Miocene and Pliocene, this zone has accommodated various styles of deformation (normal, reverse, left-lateral) during various tectonic stress regimes indicating that it remained a local tectonic boundary till the present time. South of this relatively continuous seismic zone, faulting and folding occurred across numerous faults in the northern limits of the Peninsular Ranges including southern branches of the Santa Monica Fault (South) and the Las Cienegas fault zone. These faults and associated folds were deformed during clockwise block rotation of the Western Transverse Ranges to the north, which also deformed the previously "linear" Santa Monica Fault (North branch)-Hollywood-Raymond fault system.

Pleistocene deformation across the Santa Monica Fault (North branch)-Hollywood-Raymond fault system is generally considered to be left-lateral reverse (oblique); hence, accommodating some compressional strain (reverse component) and allowing for the Western Transverse Ranges to "escape" toward the west (left-lateral component - see Humphreys, 1996). This style of deformation likely occurs in the boundary region of the Western Transverse

Ranges and Peninsular Ranges. However, it is poorly understood whether the total tectonic stress is accommodated dominantly by oblique faults alone, or whether strain partitioning is occurring by which some fault zones exhibit primarily left-lateral deformation and others reverse motion. It is proposed herein that strain partitioning is occurring within the boundary of the Western Transverse-Peninsular Ranges consistent with findings by Haukson (1990). Faults accommodating the compressional component of stress are active in the northern Los Angeles Basin across blind faults that project to the surface south of the Santa Monica-Hollywood Basin region (i.e. the Los Angeles Fault proposed by Schneider et al. 1996 east of the Newport-Inglewood fault). Dominantly left-lateral displacement is occurring in hanging wall rocks associated with the deeper reverse fault across pre-existing faults associated with the Santa Monica-Hollywood-North Salt Lake fault system (Figure 1 and Plate 1).

Dominantly left-lateral motion occurs on the Santa Monica fault zone as identified by Dolan and Seih (1992) west of the northern extension of the Newport-Inglewood fault zone located east of the southern Cheviot Hills (Plate 1). This fault segment includes the left-stepping series of scarps proposed by Dolan and Seih (1992) in the region of Brentwood Knoll (modified on Plate 1), and the proposed Santa Monica Boulevard fault zone along Santa Monica Boulevard in the Cheviot Hills (KGS, 2012). Local vertical uplifts occur along this fault segment where fault strands turn toward the northwest resulting in local restraining bends (Plate 1). The western portion of this fault zone dips steeply toward the north and connects with the South Santa Monica Fault (S) of Wright (1991; see Figure 1) at depth. The eastern portion of this fault system between approximately the VA Hospital and Beverly Hills High School exhibits dominantly left-lateral slip and may trend approximately parallel to the regional left-lateral slip vector. This segment of the fault system connects at depth with the re-activated North Santa Monica Fault of Wright (1991; see Figure 1). The boundary between the west and eastern segments occurs above the original boundary between Wrights (1991) North and South Santa Monica fault strands. This region occurs near the Mormon Temple where the "Santa Monica Fault" turns more northward within the Cheviot Hills (Plate 1).

East of the Cheviot Hills, left-lateral displacement is accommodated on the Hollywood fault zone (Lindvall et al., 2003), the re-activated North Salt Lake fault and an eastward extension of the Santa Monica Boulevard fault zone in Century City (see East Santa Monica Blvd. fault zone on Plate 1). The Santa Monica Boulevard Fault Zone connects at depth with the North Santa Monica Fault Zone (N) of Wright (1991; see Figure 1). The North Salt Lake fault is located along the southern margin of the eastern Hollywood Basin (Hill et al., 1979; Hummon, 1994). The boundary between the East Santa Monica Boulevard fault zone and the western North Salt Lake fault zone is the region of the western Salt Lake Oil Field where it turns abruptly northward (Plate 1). This fault zone may step over to the East Santa Monica Boulevard fault zone.

The northwest trending, right-lateral Newport-Inglewood fault zone likely occurs in the eastern Cheviot Hills as shown on Figure 1. Northern strands of this fault zone likely occur as far north as the Beverly Hills Oil Field and likely separate the West and East Beverly Hills Oil Fields (Erickson and Spaulding, 1975; Wright, 1991). Strands are also proposed in this region based on groundwater data by Mendenhal (1905; also see Poland, et al., 1959). Some strands of this fault zone likely occur immediately east of Beverly Hills High School (Plate 1; KGS, 2013). Fault evaluation in the Century City area (KGS, 2014, in preparation) indicate that strands of the Newport-Inglewood and Santa Monica Boulevard fault zones were active during a similar period of time (since mid-Pleistocene). However, LCI (2012) and Geocon (2013) provide strong evidence that the Santa Monica Boulevard fault zone is not active by the definition of the State of California (no offset during past 10,000 to 11,000 years), but was active in the latest

Pleistocene. Hence, it is possible that the northward migrating Newport-Inglewood fault zone (see Wright, 1991) is offsetting the Santa Monica Boulevard fault zone since the late Pleistocene.

Uplift and folding has occurred in the Cheviot Hills since the mid-Pleistocene. An open northwest trending antiform occurs in the southern Cheviot Hills that plunges toward the north (KGS, 2012; Parsons, 2012). This fold extends to the easternmost Cheviot Hills to strands of the Newport-Inglewood fault zone. This fold also deforms preserved fan terrace surfaces that are estimated to be 200 to 350 Kya (KGS, 2013). It is proposed that this fold developed as a result of collective left-lateral motion on the Santa Monica-Santa Monica Boulevard fault zones and right-lateral motion across the Newport-Inglewood fault zone (Plate 1).

In summary, it is proposed that since the mid-Pleistocene, a dominantly left-lateral fault system exists along the southern Western Transverse Ranges that has utilized pre-existing fault structures at depth. The mid-Pleistocene faulting splayed off of the deeper older structures with steep northward dips to offset Pleistocene age sediments and extend close to the surface to result in numerous scarps (Figure 1). This model provides insights into regional seismic hazards. For example, it suggests that most faults that would be placed within a "Fault Hazard Zone" are dominantly strike-slip and that most reverse faults are likely blind and fairly deep. Extending the length of the Newport-Inglewood fault zone to the Hollywood Basin suggest larger estimated moment magnitudes for this zone.

MDK

Figure 1: Map showing major structures in the northwestern Los Angeles Basin modified from Wright (1991).

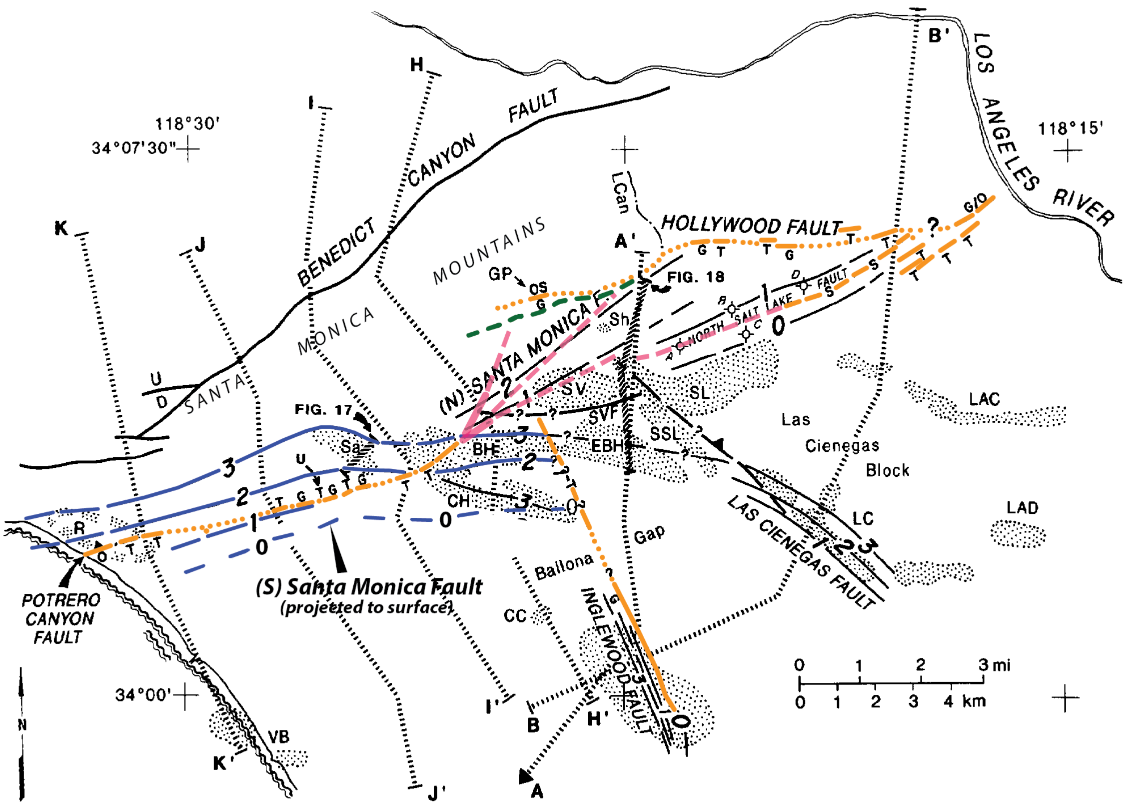
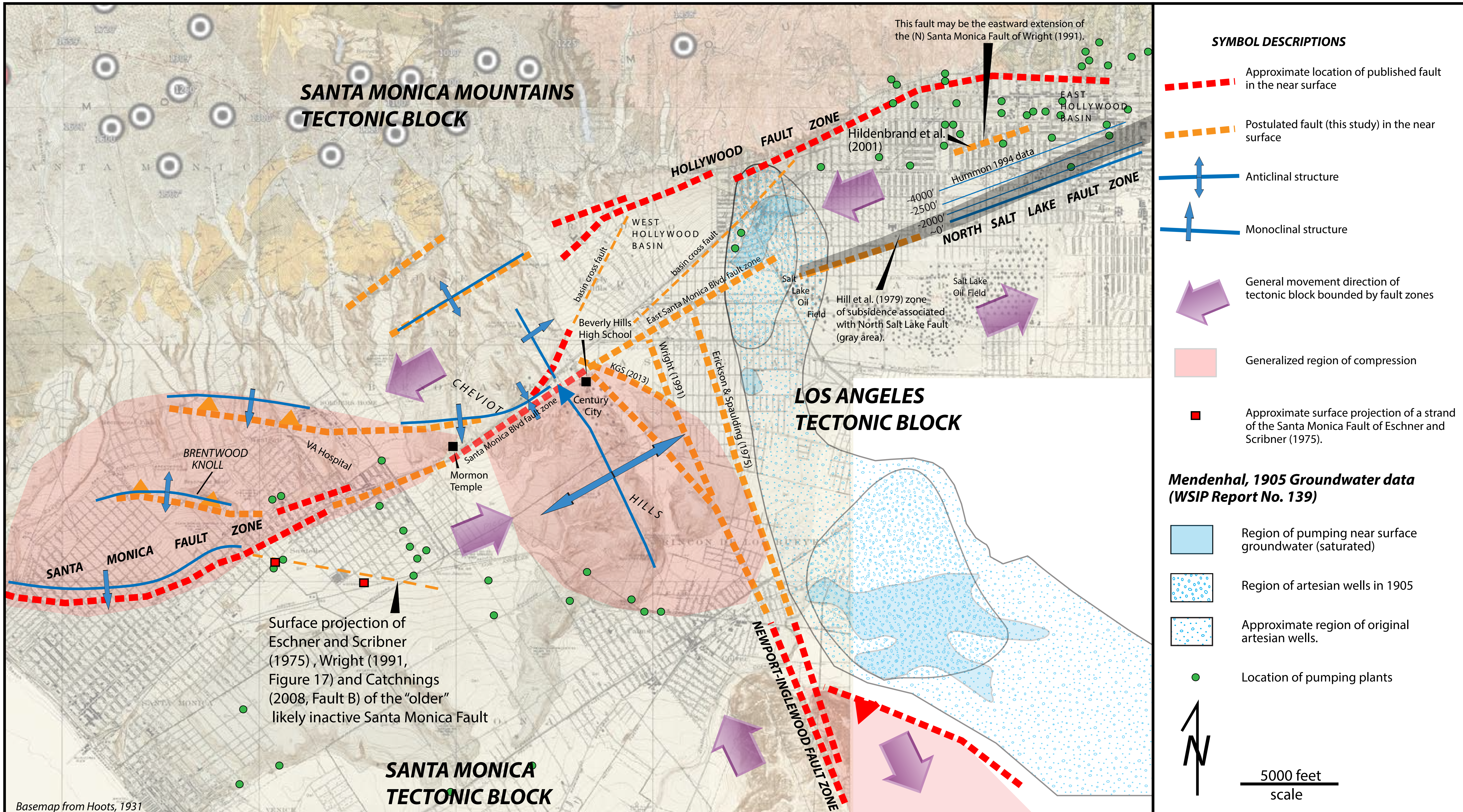


Figure 14. Map showing major faults in the northwestern Los Angeles basin. Fault-plane contours on the Inglewood, Las Cienegas, North Salt Lake, Rancho, and Santa Monica faults are based on subsurface well data. Contour interval: 1 km. Evidence of the surface traces of the Hollywood and Potrero Canyon faults and the northern extension of the Inglewood fault includes outcrop data (O), topography (T), and geotechnical data (G) from trenches and borings, plus soil contacts (S) and oil seepages (OS) (see text for sources). For other symbols, etc., see Figure 9.

Cross sections AA′ and BB′ are in Figure 8; cross sections HH′ to KK′ are in Figure 15. Also shown are locations of four core holes (listed in Appendix 2) that define the North Salt Lake fault and cross sections through the Sawtelle oil field (Figure 17), the East Beverly Hills, and San Vicente oil fields (Figure 18). Oil fields (stippled) are Beverly Hills (BH), Cheviot Hills (CH), Culver City (CC), East Beverly Hills (EBH), Inglewood (I), Las Cienegas (LC), Los Angeles City (LAC), Los Angeles Downtown (LAD), Salt Lake (SL), San Vicente (SV), Sawtelle (Sa), Sherman (Sh), South Salt Lake (SSL), Venice Beach (VB), and the undeveloped Riviera (R) discovery. GP is Greystone Park, LCan is Laurel Canyon, U is University High School.

SYMBOL DESCRIPTIONS

- Approximate location of near surface fault by Wright (1991). Dotted where concealed
- Subsurface contours of the (S) Santa Monica Fault of Wright. Depths in Kilometers; surface projected location of fault shown.
- Approximate location of the Hollywood Fault Zone by CGS where it differs significantly from Wright (1991).
- Approximate location of fault (KGS, 2014)
- Approximate location of proposed fault (KGS, 2014)



Kenney GeoScience

CLIENT:
PRIMESOURCE PM LLC

REPORT:
Deformation in the northern Los Angeles Basin since the mid-Pleistocene, California

NEAR SURFACE STRUCTURAL MAP OF THE NORTHERN LOS ANGELES BASIN

Job No. 723-11

Date: May, 2014
Drafted by: MDK

PLATE 1