CRITIQUE OF THE MTA CENTURY CITY AREA FAULT INVESTIGATION: HOW DID THINGS GO SO WRONG IN THE FAULT ANALYSIS OF THE CENTURY CITY - BEVERLY HILLS AREA?

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INTRODUCTION

The Los Angeles County Metropolitan Transportation Authority (LACMTA, or "MTA") published a seismic fault investigation report titled Century City Area Fault Investigation Report (Parsons Brinkerhoff, 2011). The report was used by MTA to justify a new subway alignment decision, resulting in the choice of a subway station location on Constellation Boulevard over Santa Monica Boulevard. This paper is written for several purposes: (1) to place the report and all of the subsequent investigation and analysis that it triggered into a historical context that will facilitate the understanding of how the MTA investigation became driven by a predetermined concept of area geology (Figure 1); (2) to provide an analysis of how technical errors in investigation, analysis and interpretation allowed that predetermined concept to survive; and (3) to demonstrate the serious public injury that can occur when a flawed geologic investigation report is issued under the color of public authority and without regulatory oversight or balance. This paper analyzes and evaluates all of the investigations conducted to date in the area and concludes that the MTA active fault map is in serious and substantial error and must be revised and reissued. This paper also addresses the disparate standards of investigation and analysis used by the MTA in its seismic studies.

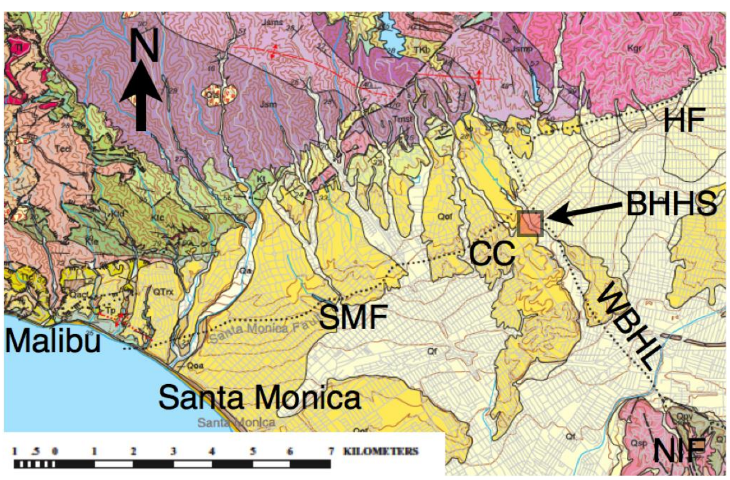

Figure 1: Geologic index map of the Beverly Hills High School (BHHS) project site and the Century City (CC) area, showing the predominantly Mesozoic metamorphic and crystalline rocks of the Santa Monica Mountains to the north and the Quaternary alluvial fan and fluvial deposits to the south. The Santa Monica (SMF) and Hollywood (HF) faults, along with the West Beverly Hills Lineament (WBHL), are shown as dotted lines, which mean their traces are concealed by burial with surficial sediments. From Yerkes and Campbell (2005).

The stimulation for this paper was the extensive series of geological investigations triggered by the planning process undertaken by the MTA for the Westside Subway

Extension (WSE) and the resultant Active Fault Map (Figure 2). The WSE is an 8-mile long subway crossing the western side of Los Angeles. Project planning and the associated geologic investigations date back to the 1960's. By 2010 MTA had chosen a base alignment option down Santa Monica Boulevard, west from Wilshire Avenue through the Beverly Hills and Century City area (Figure 2) and westward through Westwood to Santa Monica. The WSE included a station serving Century City and proposed the station be located on Santa Monica Boulevard at Century Park East, with an alternative southerly alignment and station at Constellation Boulevard and Avenue of the Stars. The Santa Monica Boulevard station was believed to be located near the intersection of the Santa Monica fault (SMF) and the West Beverly Hills Lineament (WBHL), neither of which had been geologically studied in the prior feasibility investigations by MTA (Figures 1 & 2). A fault investigation of the Century City area and station locations was ordered by the MTA in late 2010 (MACTEC, 2010; PB, 2011).

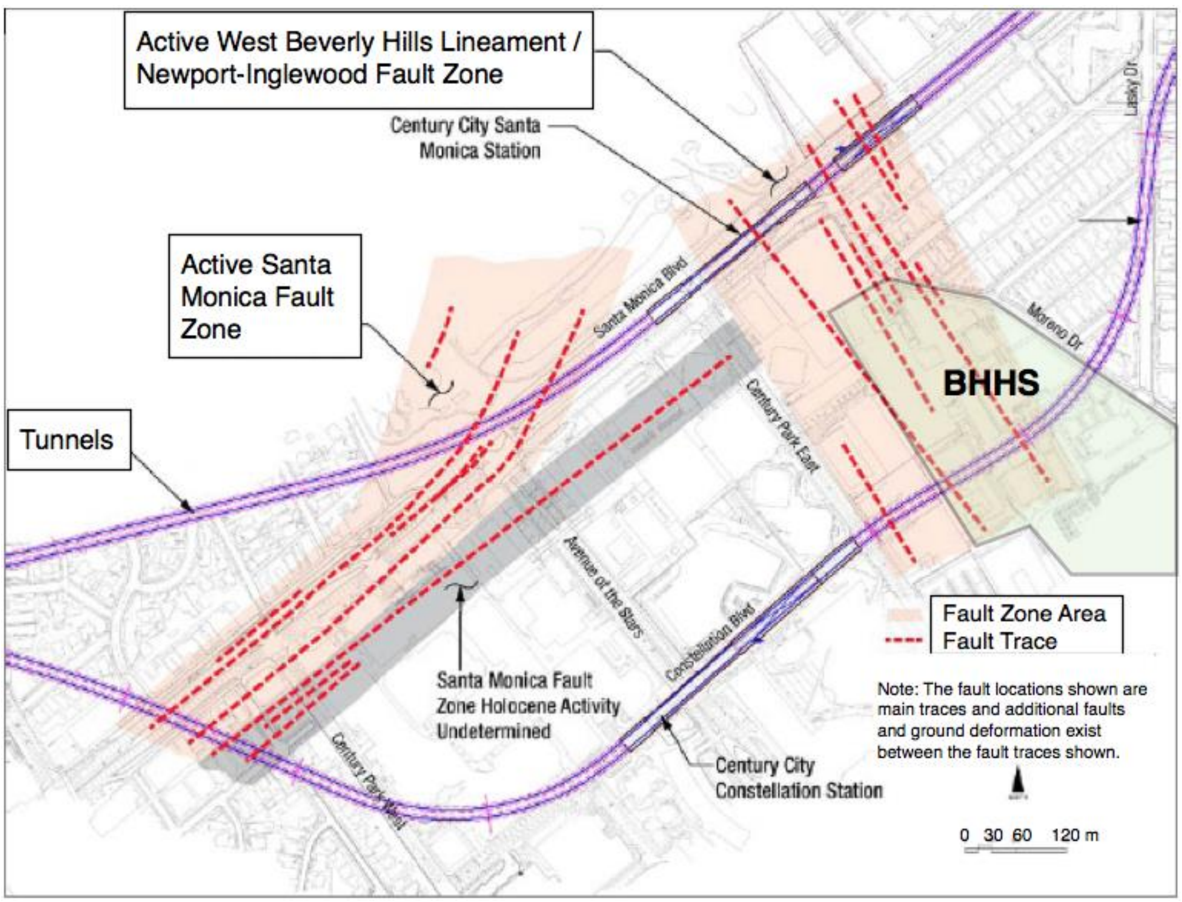

Figure 2: The active fault map released to the public (PB, 2011) showing the two fault zones and the proposed tunnel alignments and station locations. BHHS (shaded green area) is the approximate footprint of the Beverly Hills High School property.

The results of the MTA Century City Fault Investigation (PB, 2011) were first disclosed in a public hearing on Oct. 19, 2011 at which they presented a new map of "Active Fault Zones" of the SMF and WBHL (Figure 2). The MTA active fault map showed two wide zones of faults, one trending generally ENE as active strands of the Santa Monica fault zone and another generally NNW as active faults of the West Beverly Hills Lineament, which was also directly linked to the active Newport-Inglewood fault 5 km to south at the Baldwin Hills. Although the map labels some faults as "Holocene Activity Undetermined" the accompanying text and public statements clearly indicate that MTA considered all fault strands in this area as active, including many smaller faults they did not show in the map. The public release also announced the study conclusion that the Santa Monica – Newport-Inglewood – Hollywood faults were interconnected by the West Beverly Hills Lineament, and that the entire system was confirmed as an active fault zone of significant width.

The active fault map released to the media was highly alarming for the community. Century City is a highly urbanized commercial center with over 30,000 people working in an area of less than one-quarter square mile. High rise buildings line the length of Santa Monica Boulevard right on top of MTA's newly plotted active fault zones (Figure 3). The report was especially alarming to the Beverly Hills Unified School District (BHUSD). Several of the WBHL faults traversed buildings of the Beverly Hills High School (BHHS), a 1920's era campus with a daytime population of nearly 3,000 (Figure 2).

Figure 3: Row of Century City commercial and office buildings that suddenly found themselves on top of an active Santa Monica fault zone. Project geotechnical investigations and excavation observations on those buildings failed to identify seismic faults.

The release of the MTA fault investigation triggered the school district to immediately launch an extensive seismic investigation, initially charged with quantifying the risk of continued occupancy of the school, and secondarily with characterizing these faults for future campus planning and development (Figure 4). Multiple geologic studies were undertaken simultaneously by other affected private properties in the Century City and West Beverly Hills area. Millions of dollars have been spent in reaction to the MTA active fault map.

Figure 4: Fault investigation drilling begins at Beverly Hills High School. Several of the Century City high rise buildings in background are on top of faults mapped by MTA.

And the result? None of these studies have found any active faults where they had been interpreted, mapped, and published by MTA, or any active faults anywhere else in the MTA study area. On the WBHL no faults were found at all. Indeed, the reality is that no one working for MTA directly observed active faults in their investigations either. The faults were all interpreted on the basis of geophysical reflection lines, geomorphic mapping, and borehole and cone penetrometer stratigraphic correlations. All of these are traditional geologic tools, which in this case, led to highly inaccurate conclusions. How did this come about? How could this have been better handled? This paper attempts to answer these questions.

THE HISTORY

The earliest researchers (Hoots, 1931; Castle, 1960) on the Santa Monica fault (SMF) did not map it through the area of Century City along Santa Monica Blvd as it is currently shown on Figure 1. Instead, Hoots (1931) mapped only discontinuous segments of what have become known as the SMF well to the west of Century City at the marine bluffs in Santa Monica (Figure 1), but did map what could be a westward continuation of the Hollywood fault farther to the north generally along Beverly Blvd. An examination of this area reveals a series of north-south canyons which appear to be right laterally deflected similar amounts lending support to a continuation of a Hollywood fault at the base of the Santa Monica Mountains, but a Hollywood fault that might turn out to be right-lateral as opposed to the generally assumed left-lateral (Figure 5).   Or the deflections could be a coincidence, but a consistent coincidence.

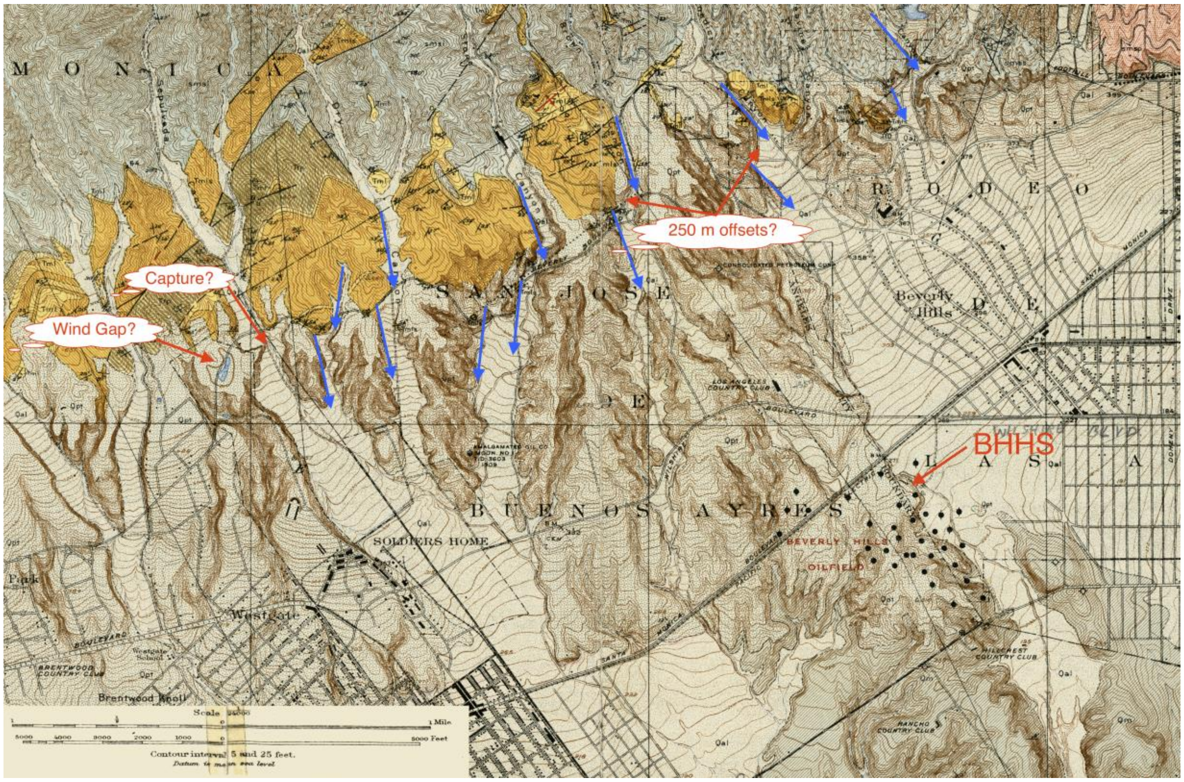

Figure 5: Early geologic map of the Santa Monica - Century City – Beverly Hills area (modified from Hoots, 1931) showing no faults mapped within the Beverly Hills HS area, but a series of fault segments farther north that appear to define a trend of similar magnitude (250 m), right-laterally deflected drainages along a discontinuously mapped fault trace. The fault could be a westward extension of the Hollywood fault far distant from its assumed extension as the Santa Monica fault down along Santa Monica Blvd. The black dots near the BHHS campus are the first wells of the Beverly Hills Oil Field which eventually expanded eastward to over 300 wells.

The most exacting review of the subsurface geology of the BHHS region was by Wright (1991). His work compiled all of the available oil field data into a massive synthesis of all of the LA Basin (Figure 6). Although small in scale, the detail within the Beverly Hills – Cheviot Hills area is informative as to the nature of the geologic structural interpretations within the oil field community, prior to the Dolan and Sieh (1992) proposal of the West Beverly Hills Lineament (Figure 7). What is clear is that this nexus of faults has a long and complex geologic history, and must be considered as a temporally-evolving system that would require considerably more and better data before it can be fully understood.

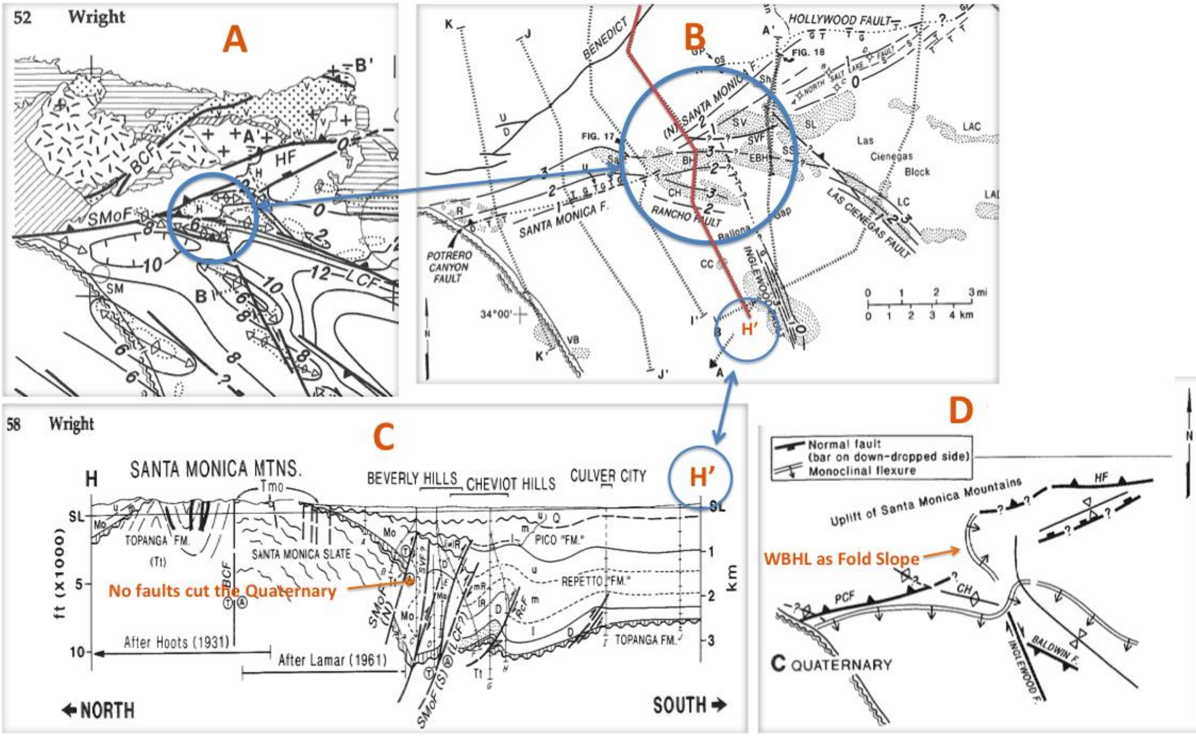

Figure 6: Series of figures from Wright's (1991) synthesis of the stratigraphic and structural geology data for the Beverly Hills and Century City area. In A, he shows the Newport-Inglewood fault bending sharply westward forming a series of WNW-trending thrusts south of the Cheviot Hills, similar to the interpretations of Lang and Dreessen (1975). In B, this area is expanded slightly, and the thrusts are named the Rancho and Santa Monica South faults, from south to north. In C, the cross section H from B, the structural complexity of the area of the Cheviot Hills is illustrated. Of note is that none of these faults are shown as cutting the Quaternary sediments, and most do not cut the Pliocene layers. In D, Wright shows his interpretation of the WBHL as a flexural fold scarp within Plio-Pleistocene sediments, and terminates the Inglewood fault into a similar fold at the southern margin of the Cheviot Hills.

The 1992 Association of Engineering Geologists' Annual Meeting Field Trip Guidebook (Ehlig and Steiner, 1992) is the document where the Santa Monica fault was mapped easterly into Century City using a series of topographic scarps that were interpreted as the surface expression of the fault (Dolan and Sieh, 1992). The SMF was terminated on the east against a West Beverly Hills Lineament (WBHL), a newly-interpreted geomorphic feature which stepped the SMF northward to the Hollywood fault and also connected southerly to the Newport-Inglewood fault (Figure 7). This was the first designation and labeling of the WBHL and also the first time it was identified and labeled as a northward extension of the Newport-Inglewood fault (Dolan and Sieh, 1992). For purposes of the field trip, this was an interesting suggestion, stimulated considerable discussion, and appeared to form a viable explanation for some structural questions about how (or if) the Hollywood and Santa Monica faults interacted. This structural model was never published in a peer-reviewed journal until the later Santa Monica and Hollywood fault trenching results were published (Dolan et al., 1997; Pratt, et al., 1998; Dolan et al., 2000a and 2000b), but Hummon and Schneider both adopted it for their MS thesis work (Hummon et al., 1994; Schneider, 1994). Left unexplained was how a right-lateral strike slip fault was able to left-laterally separate the two faults, or how a left-step in the Inglewood fault over to the WBHL would result in a depression and not a continuing uplift north of the Baldwin Hills, or even how the Cheviot Hills were uplifted on the west side of the lineament, but it was a hypothesis from which to start to explore these questions.

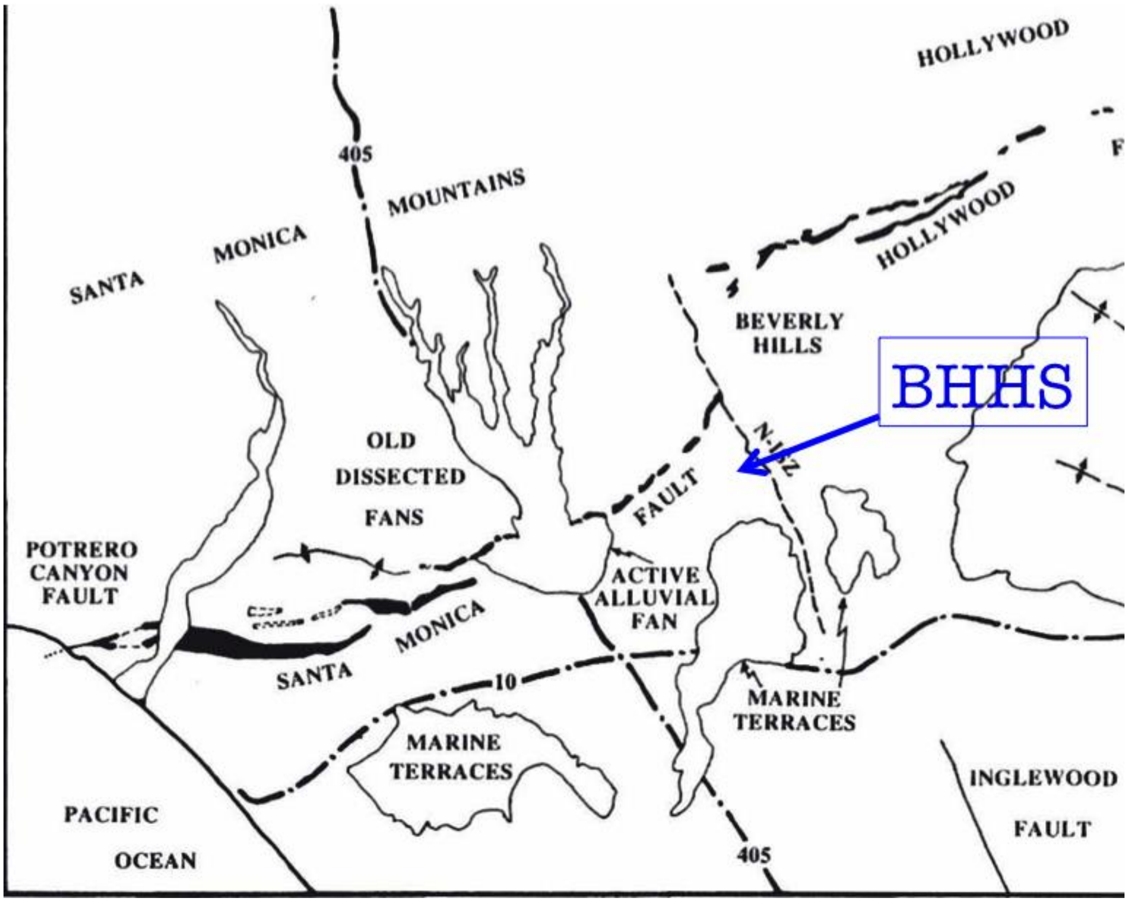

Figure 7: Geomorphic and structural features map of the region, showing the Santa Monica fault interpreted as an en-echelon series of scarps before stepping northward along the Newport-Inglewood fault (N-IFZ) just east of Beverly Hills High School (BHHS) and onto the Hollywood fault (Dolan and Sieh, 1992). The northward projection of the Inglewood fault was subsequently identified as the West Beverly Hills Lineament.

The 1994 Northridge earthquake and its occurrence on a blind reverse fault stimulated the geoscience research community to examine similar southern California basin areas for their potentially hidden seismic hazard. One of the first to publish was Hummon et al. (1994) on the western LA/Hollywood Basin, and the WBHL became a convenient westerly stopping place for her modeling of the Hollywood Basin (Figure 8). What is unfortunate is that the interpretation of Dolan and Sieh (1992) was assumed to be correct in all ways, meaning the location of the Santa Monica and Hollywood faults were defined by the scarp mapping, and the WBHL was assumed to be a major linear structural boundary and the northward extension of the Newport-Inglewood fault.

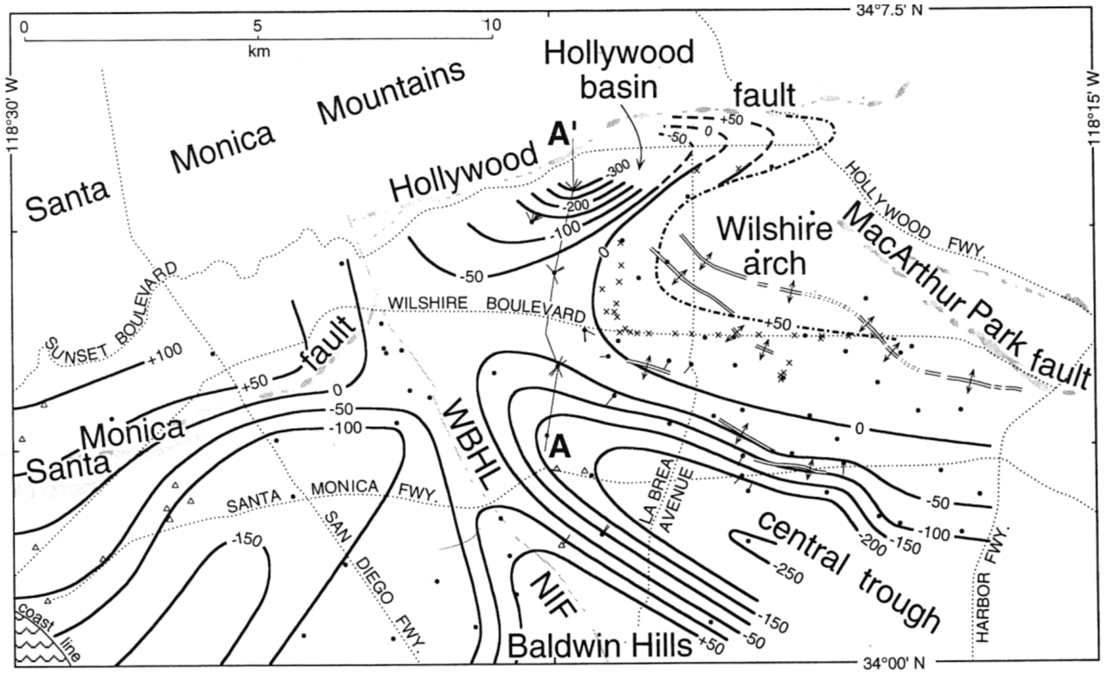

Figure 8: This subsurface structural model from Hummon et al., 1994, identifies the West Beverly Hills Lineament (WBHL) directly along the northern extension of the Newport-Inglewood fault NIF) and also includes the Santa Monica and Hollywood faults from Dolan and Sieh (1992).

Schneider (1994) completed a similar analysis on the oil field structures to the south of Hummon's (et al., 1994) modeling (Figure 9), and also made the same assumptions by adopting the map from Dolan and Sieh (1992) as the base map for the thesis. The Dolan and Sieh geomorphic map was now established in the peer-reviewed literature, and still, no one had yet to physically see actual evidence for any of these faults at the ground surface, only the surface geomorphology that was interpreted to be fault-related.

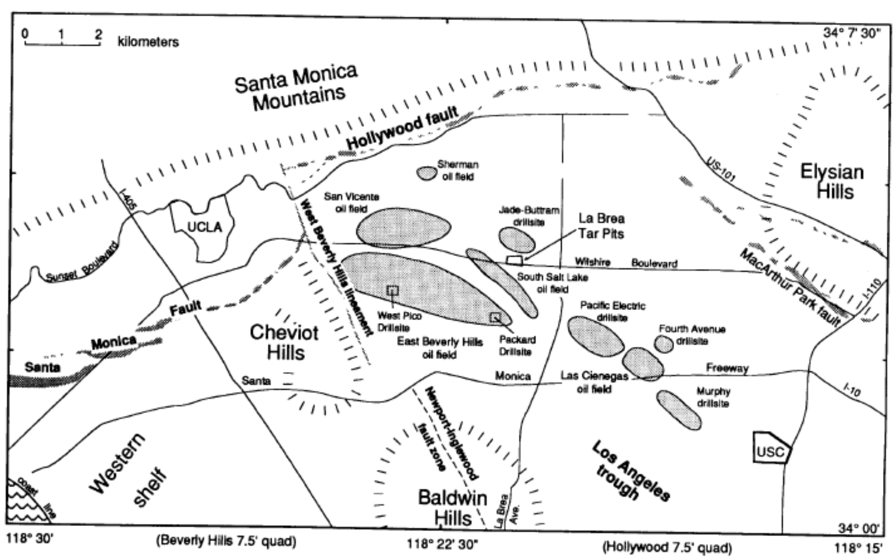

Figure 9: This figure from Schneider, 1994, shows the West Beverly Hills Lineament as a disconnected westward step of the Newport-Inglewood fault zone. Once again, the fault scarps of Dolan and Sieh (1992) have been adopted as the location of the Santa Monica and Hollywood faults.

Following publication of the Hummon et al. (1994) paper, a Comment was posted by a former Division of Oil and Gas geologist (Lang, 1994) who had studied the Beverly Hills Oil Field (Figure 10). Lang and Dreessen's (1975) structural model shows the Inglewood fault bending sharply to the west as a thrust fault along the southern Cheviot Hills (Figure 11), which is similar to Wright's Rancho fault Wright (1991). In Lang's (1994) Comment, he expands on the earlier work and places their 1975 map on top of the SMF/HF/WBHL traces of Hummon et al (1994) in an attempt to illustrate the differences (Figure 12). Despite apparently valid objections to the Hummon model, including a definite statement by Lang that, based on over 300 oil well logs, no fault is possible along whatever is the WBHL, the WBHL endured as a *"… fundamental geomorphic feature … requires a tectonic explanation …"* (excerpts from the Hummon et al. (1994) Reply to Lang's Comment).

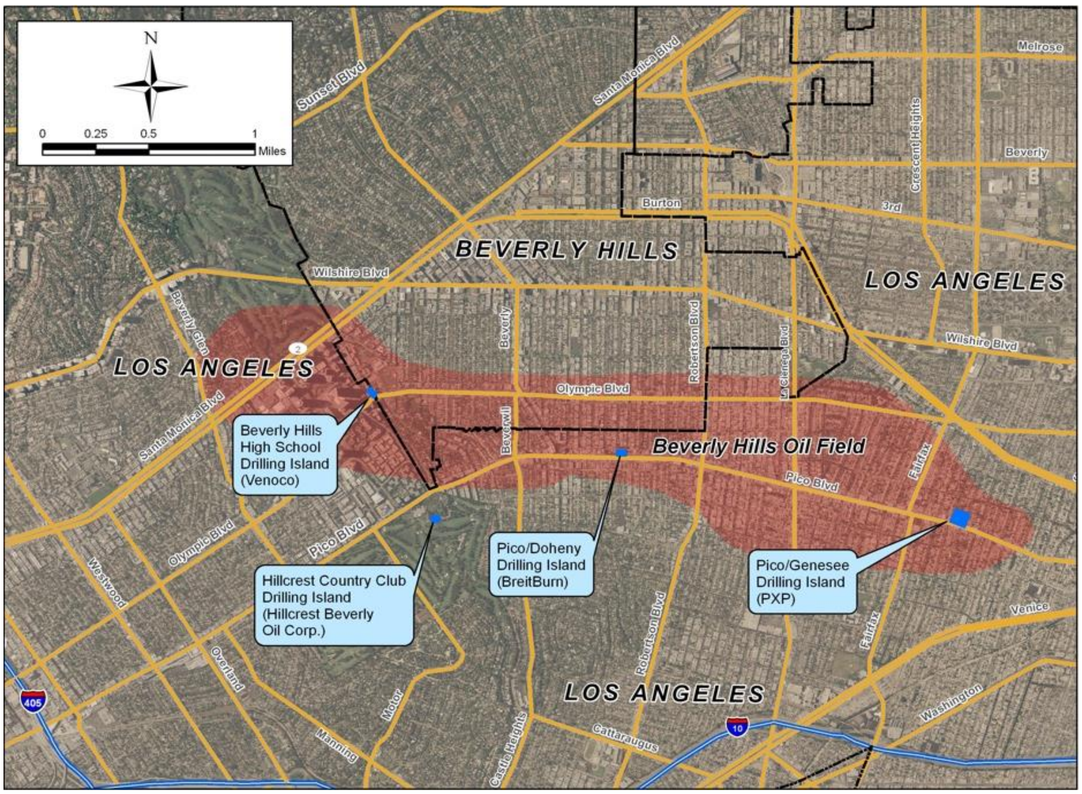

Figure 10: The outline of the Beverly Hills Oil Field extending east west across the Cheviot Hills and into the LA Basin. According to Lang (1994) no north-south faults are possible to be interpreted through the oil field.

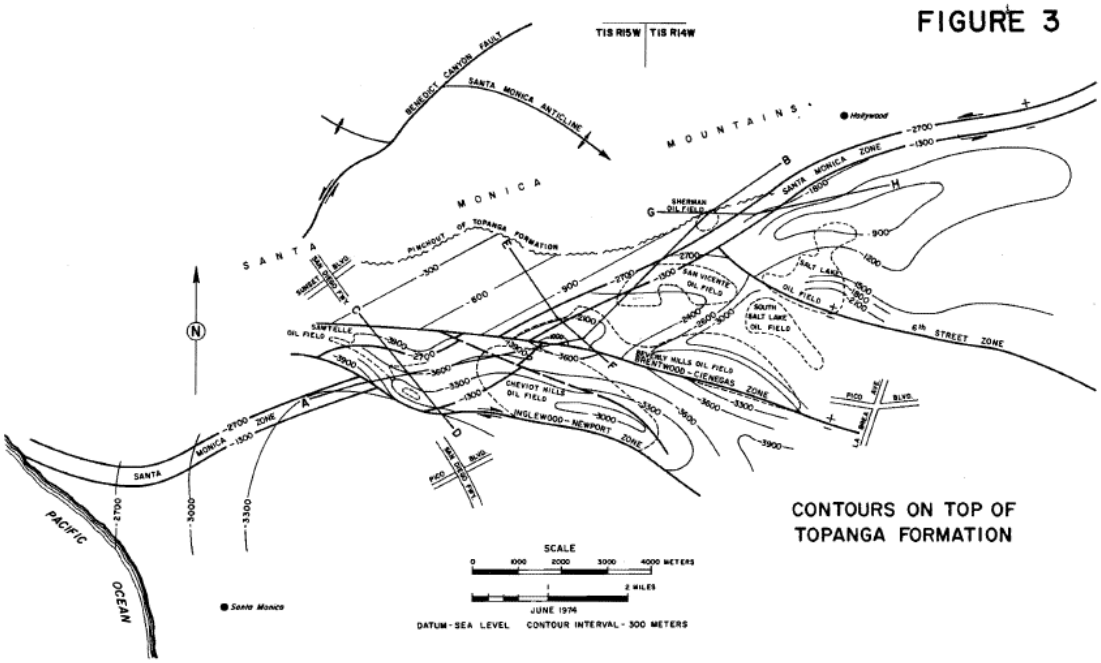

Figure 11: Structure map of the principal faults affecting the primary production zones in the Beverly Hills Oil Field (Lang and Dreessen, 1975). Per the authors, no north-south trending faults intersect the dominantly WNW trending structures. Their map does continue the Santa Monica fault well to the east of the Cheviot Hills, but they show it to be interrupted several times by other WNW-trending structures, including the Newport-Inglewood fault along the southern margin of the Cheviot Hills.

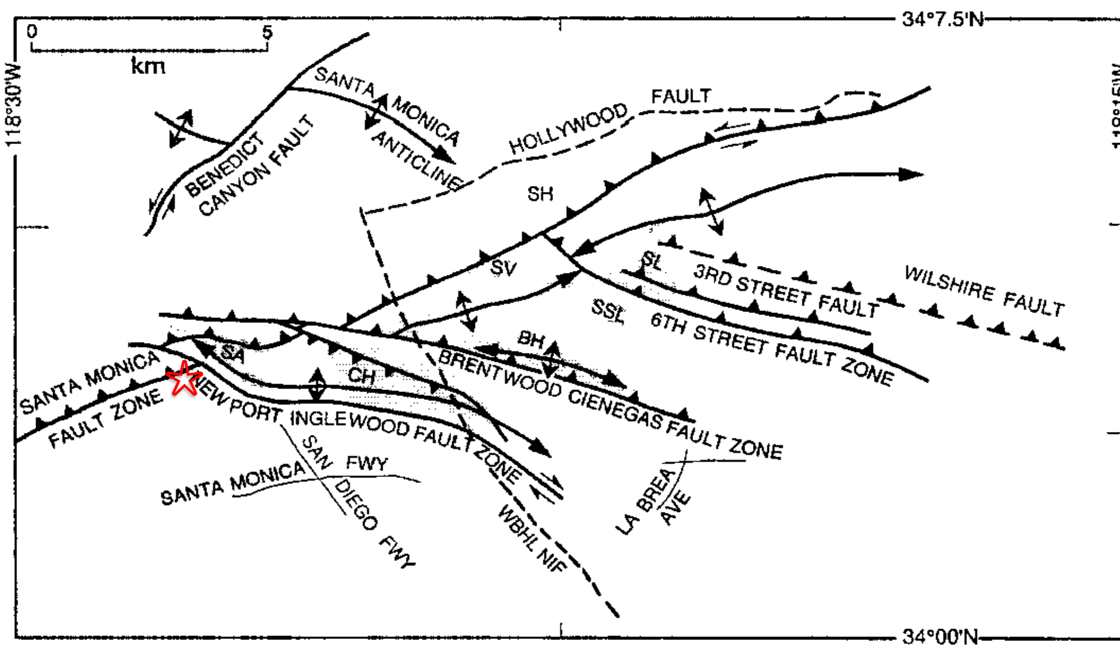

Figure 12: The same structure map from Figure 10 above, but with the Hummon et al. (1994) locations of the West Beverly Hills Lineament and Hollywood faults superimposed (Lang 1994). Lang's point is that the WBHL-NIF line is crossed by multiple other structures without apparent effect. The red star shows the location of the paleoseismic trenching site of Dolan et al. (2000b) on the Santa Monica fault, leaving open the question of whether the Dolan trench was actually on the Santa Monica fault, or, if Lang's structural model is correct, on the Newport Inglewood fault.

The most surprising thing is that none of the papers published after the Lang (1994) Comment and its alternative structural interpretation map appeared in print ever considered either the Lang and Dreessen (1975) or the Lang (1994) structural interpretation (Figures 11 & 12), but rather continued to exclusively use the geomorphic interpretation by Dolan and Sieh (1992) (Figure 7) of fault scarps for the Santa Monica and Hollywood fault locations as well as the WBHL being the Newport-Inglewood fault's northern continuation.

Paleoseismic studies of the Santa Monica and Hollywood faults were completed in the late 1990's (Dolan et al., 1997, 2000a & 2000b) and showed evidence for a single Holocene event on each fault, but the two events could not be temporally correlated and the faults had long average return periods of about 10 ka. The most recent event on the Hollywood appears to have been about 8.5 ka, while on the Santa Monica fault it is inferred to have been ~3 ka, but that date is equivocal, and could be anytime between 3 and 17 ka. This lack of temporal correlation on the two faults could obviate the need for a step-over fault along the WBHL, but this was never really proposed and the WBHL continued to be included on the paleoseismic papers and on all following papers and maps as a confirmed fault, and thereby eliminating any consideration of alternate causes (Figure 13).

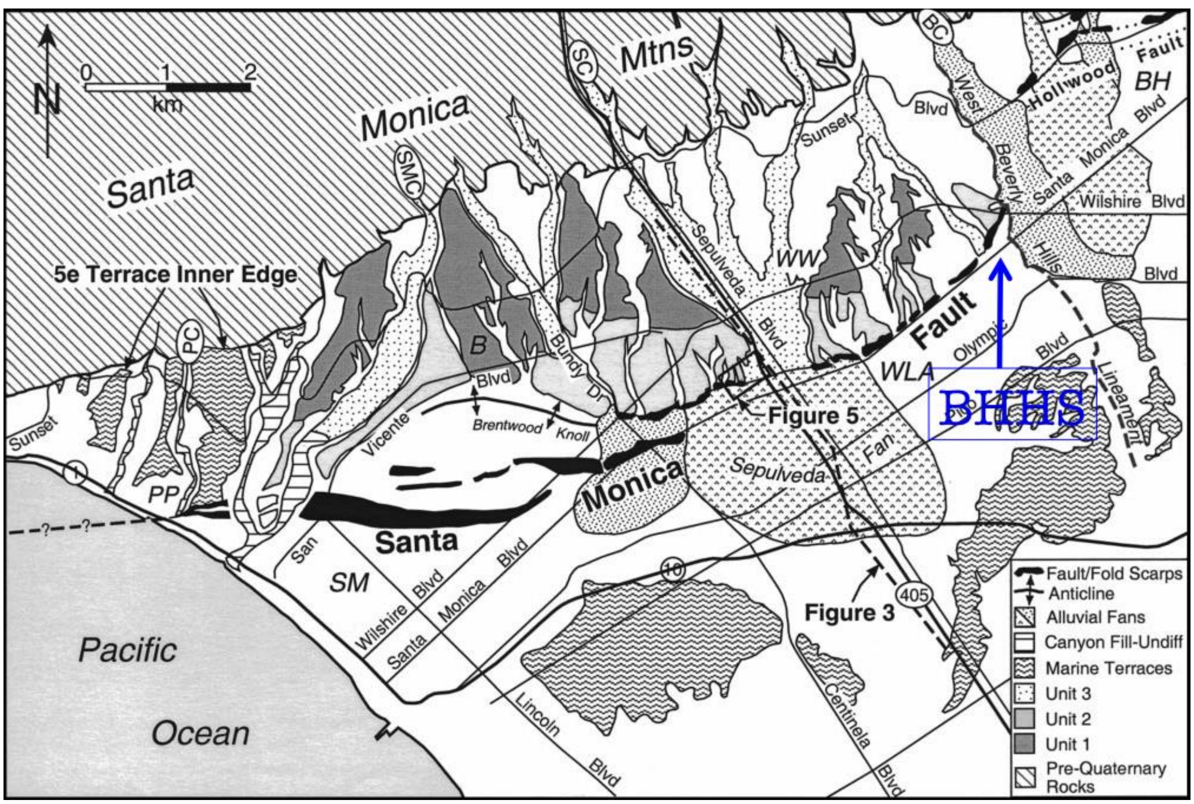

Figure 13: The map from Dolan, Sieh and Rockwell (2000b) prominently showing the scarps mapped and interpreted as the surface traces of the Santa Monica and Hollywood faults. The Santa Monica fault paleoseismic trenching site (Figure 14 below) is labeled as "Figure 5" on this map.

Dolan's study resulted in the excavation of a 110-meter long and 5-meter deep trench across the topographic escarpment on the US Veterans Administration hospital grounds that had been consistently interpreted as a fault scarp (Figures 11, 12 & 13). The trench revealed >50 ka alluvial fan deposits tilted and faulted against younger fan deposits that were radiocarbon dated at ~17 kya. A younger earthquake rupture was inferred by interpreting a fault (Fault 4, Figure 15) to separate and thicken an overlying paleosol that was dated at <3 ka.

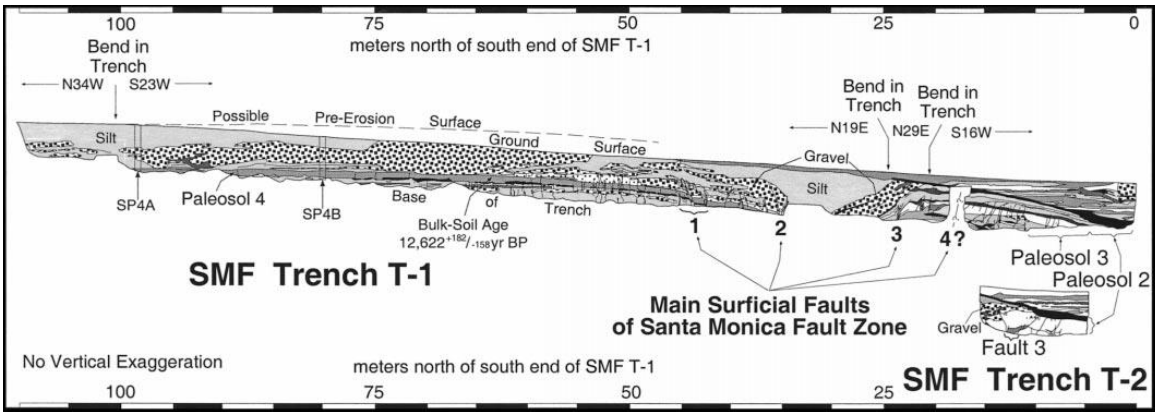

Figure 14: The log of the paleoseismic trench across the Santa Monica fault showing the main surface faults displacing older alluvial fan deposits but overlain by late Holocene fan deposits from Sepulveda Canyon (Dolan et al. 2000b).

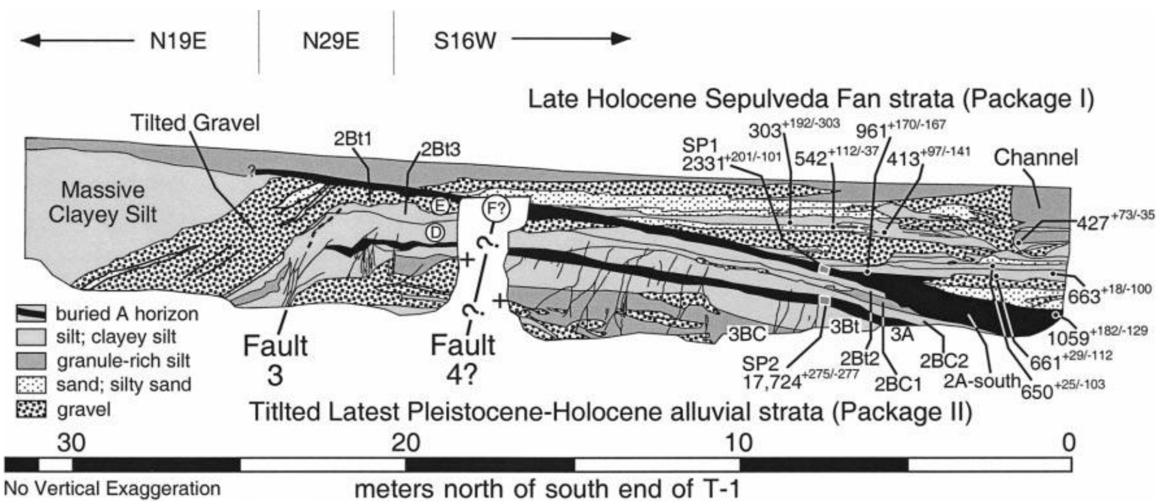

Figure 15: Expanded detail of the southern part of trench T-1 (Figure 14) log showing the tilted >50 ka fan deposits in apparent fault contact with ~17,000+ year old younger deposits. The most recent earthquake is interpreted to have occurred along inferred Fault 4 because of thickness variations on the two (shaded black) paleosols that were dated between 2 and 17 kya. No fault was actually observed.

None of these faults are candidates to form the topographic scarp as they have south-side up separation and must also have significant lateral slip to explain missing and differential thicknesses of the alluvial units across the faults. As such, they are considered to be secondary, hanging-wall faults above a main Santa Monica fault that would underlie the trenches, and which was geophysically-imaged by Pratt (et al., 1998)

Even before the publication of the Santa Monica fault's paleoseismic trenching results, Pratt (Pratt et al., 1998) published a geophysical survey that was completed simultaneously with the trenching study. Pratt's paper used the same map as would be used by Dolan et al. (2000b) later, continuing to use the Dolan and Sieh (1992) scarp map as the basis for the fault locations. This was the first published study to confirm that there was a late Pleistocene and maybe Holocene fault associated with the interpreted scarps, at least to the west of the I-405. The conclusions were that there had been as many as six paleoearthquakes on the fault within the last 50,000 years, and that the last event was probably Holocene in age (Pratt et al., 1998).

The Pratt paper included a deeper structural model of the Santa Monica fault system (Figure 16), interpreting the Santa Monica fault as the uppermost tip of the blind Elysian Park fault system that would extend east under Los Angeles and west along the entire Malibu Hills. They also did not interpret the trenched faults as the Santa Monica fault proper, but as secondary faults on the upper plate (hanging wall) of a deeper Santa Monica fault that would project to the surface south of the trench termination (Figure 17). No mention was made of Lang's (1994) structural interpretation that showed the fault through this exact area as the northwestward extension of the Inglewood fault.

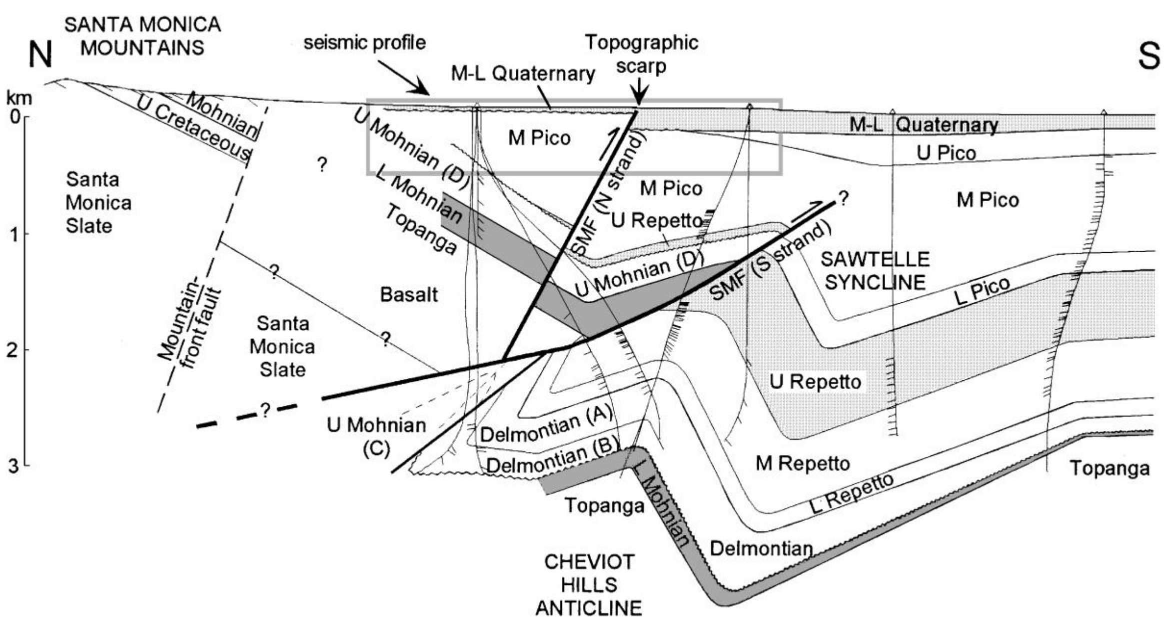

Figure 16: Interpreted structural cross-section of the tip of the Santa Monica Fault showing an older, blind strand to the south and the younger, active strand to the north. The trench and high-resolution profile locations (Figure 17) are approximately indicated by the box area at the top of the active strand and over the topographic scarp (Pratt et al., 1998).

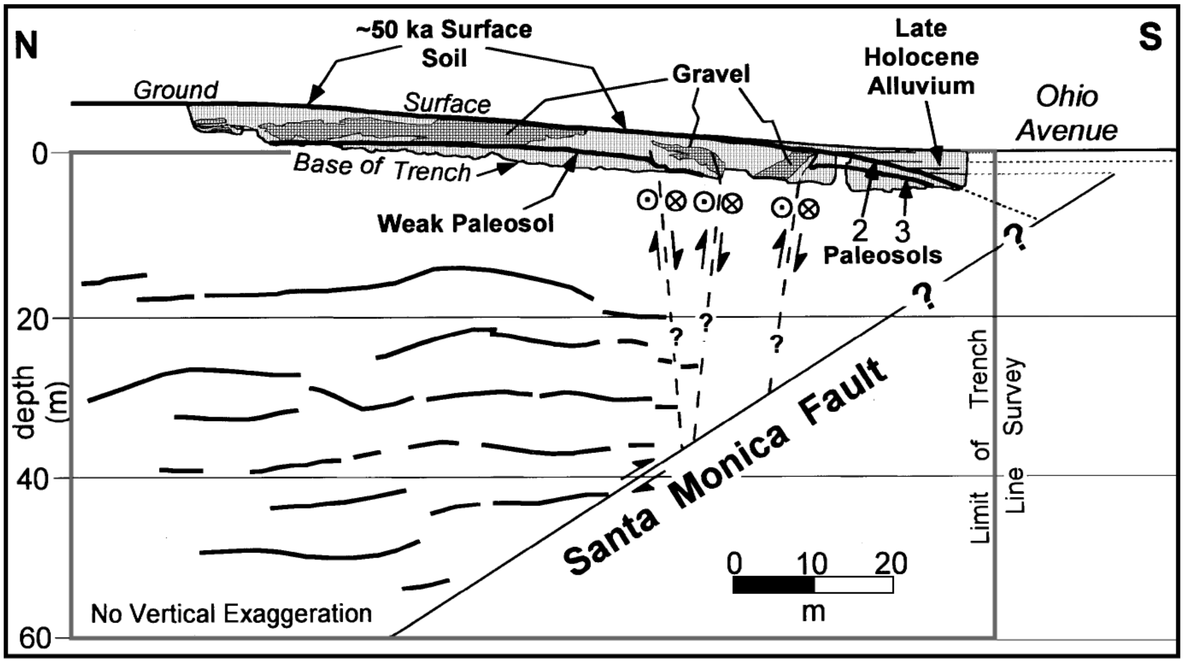

Figure 17: Figure from Pratt (et al., 1998) showing their interpretation of the faults exposed in the Veterans Hospital trench (Dolan et al., 2000) and their relationship to the interpreted deeper Santa Monica fault. Because of the steepness of the exposed faults, and stratigraphic mismatches across them, Pratt interpreted a dominant component of strike-slip movement on the faults.

Following up after the publication of the paleoseismic trenching studies, Tsutsumi (et al., 2001) reassessed all of the new structural data and models (Hummon et al., 1994; Schneider, 1994; and Pratt et al., 1998), but as everyone else did, he also ignored any of the ideas put forth by the oil field geologists (Lang and Dreessen, 1975; Wright, 1991; and Lang, 1994). As per all those others, the Tsutsumi map (Figure 18) simply assumed the same surface fault model for the Santa Monica and Hollywood faults, and similarly connects the WBHL to the Inglewood fault as a basic fact in their structural modeling. Indeed, those features are now labeled as “Active fault scarps” and this could be interpreted to include the WBHL in that same category as a confirmed active fault (Figure 18).

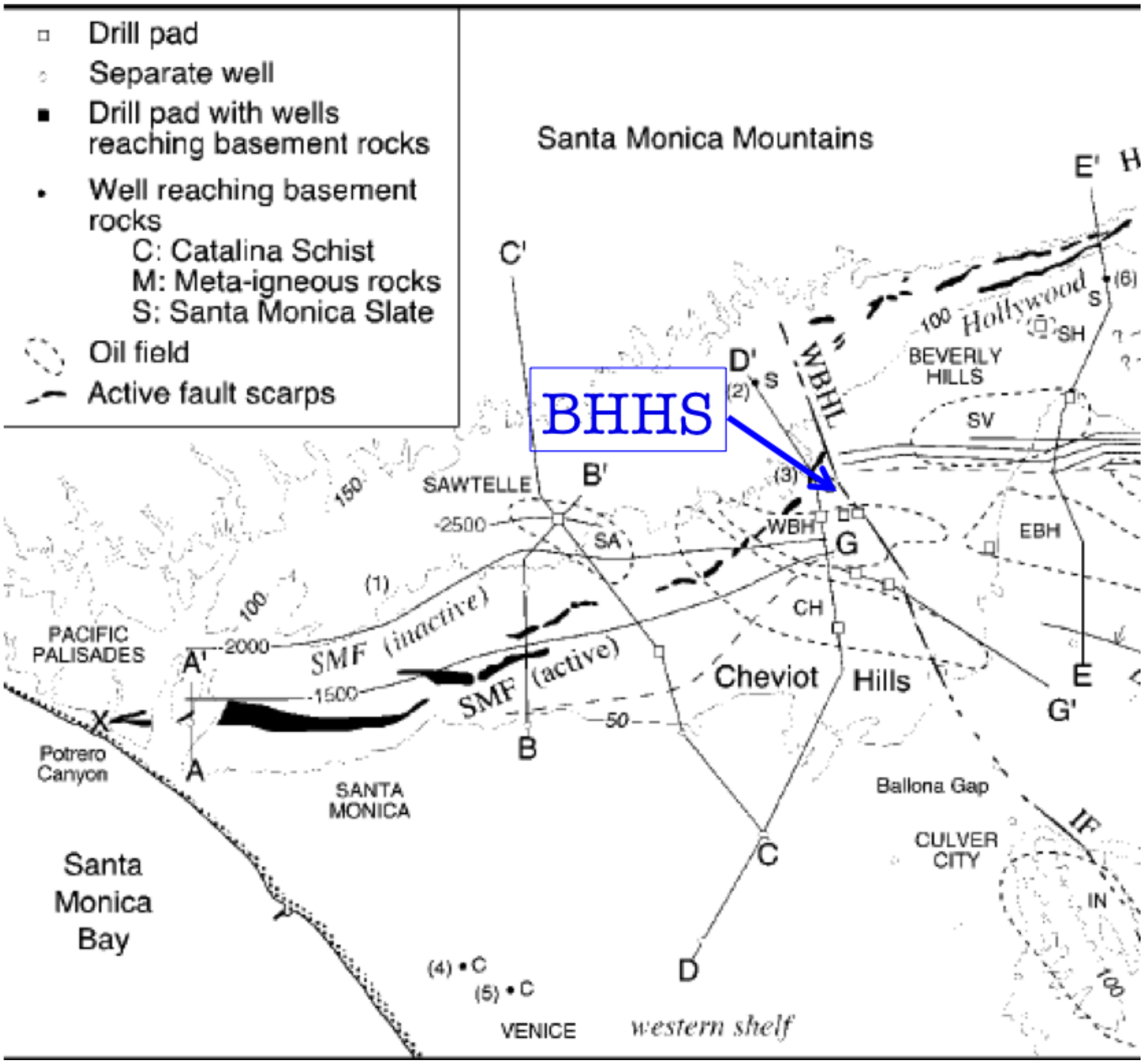

Figure 18: The structural mapping by Tsutsumi (et al., 2001) also shows the same Santa Monica and Hollywood fault scarps (and WBHL) as Dolan and Sieh (1992), but now they are labeled as “active fault scarps” for the first time, a label that also appears to apply to the WBHL.

In a later paper Catchings (Catchings et al., 2008) again reprises the Dolan and Sieh fault scarps as the base map (Figure 19). But, Catchings et al reinterpret the Santa Monica fault as a pair of geophysically-interpreted shallowly north-dipping faults with multiple near-vertical faults on the hanging walls (Figure 20), the uppermost of which were captured in the trench excavation (Dolan et al., 2000 (Figures 14 & 15)). The upper of these north-dipping faults comes near the surface of the VA hospital trench site, while the other deeper fault would project to the surface about 200 meters farther to the south to project to the surface near Santa Monica Blvd. Catchings at al point out the discrepancy between the need for north-up vertical separation across the fault to generate the topographic scarps and the observations in the VA trench of north-side down separation across near-vertical faults, and propose that these newly-interpreted low-angle faults would fit this model. The authors do not explain why the new thrust faults would lie so far to the south of the topographic scarps that the thrust faults are supposed to form; however they do show an elevation profile across the alluvial fan surface indicating a subtle inflection point where their more active fault projects to the surface. The inflection point is located near Santa Monica Blvd, approximately 200 meters south of the topographic scarps.

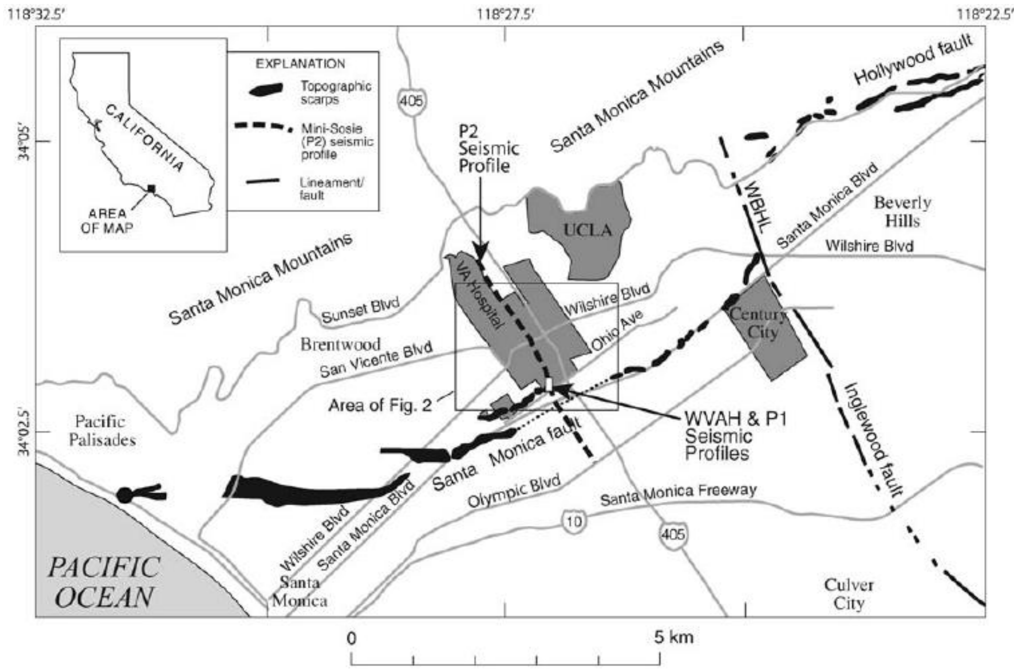

Figure 19: Catchings (et al., 2008) uses the same topographic scarps from Dolan and Sieh (1992) to illustrate the fault locations but then shows their SMF traces projecting well to the south (Fig. 20).

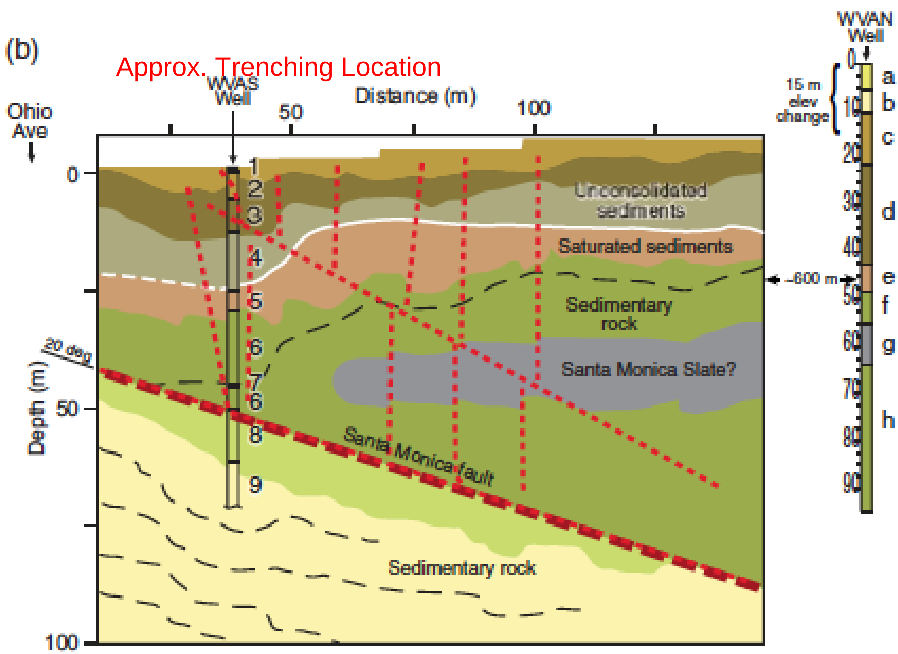

Figure 20: The newly interpreted geophysical model at the VA Hospital site (Catchings et al., 2008) showing the principal trace of the Santa Monica fault lying about 50 meters below the ground surface where the paleoseismic trenching was performed (Dolan et al., 2000). How the activity would be partitioned across the two thrust faults is not discussed.

Neither the Santa Monica nor Hollywood faults have been zoned as active under the California Alquist-Priolo Earthquake Fault Zone Act despite the 14 years since the trenching studies were published (Dolan et al., 2000a and 2000b), but they are shown as Holocene active on the CGS 2010 Fault Activity Map of California (Figure 21). Why the West Beverly Hills Lineament came to be shown as an active (Holocene) fault on this map is not explained in the accompanying materials. In January 2014, the CGS released a Preliminary Map of the Hollywood quadrangle proposing, multiple strands of the eastern part of the Hollywood fault for AP Zoning, but this map is still in review as of this writing.

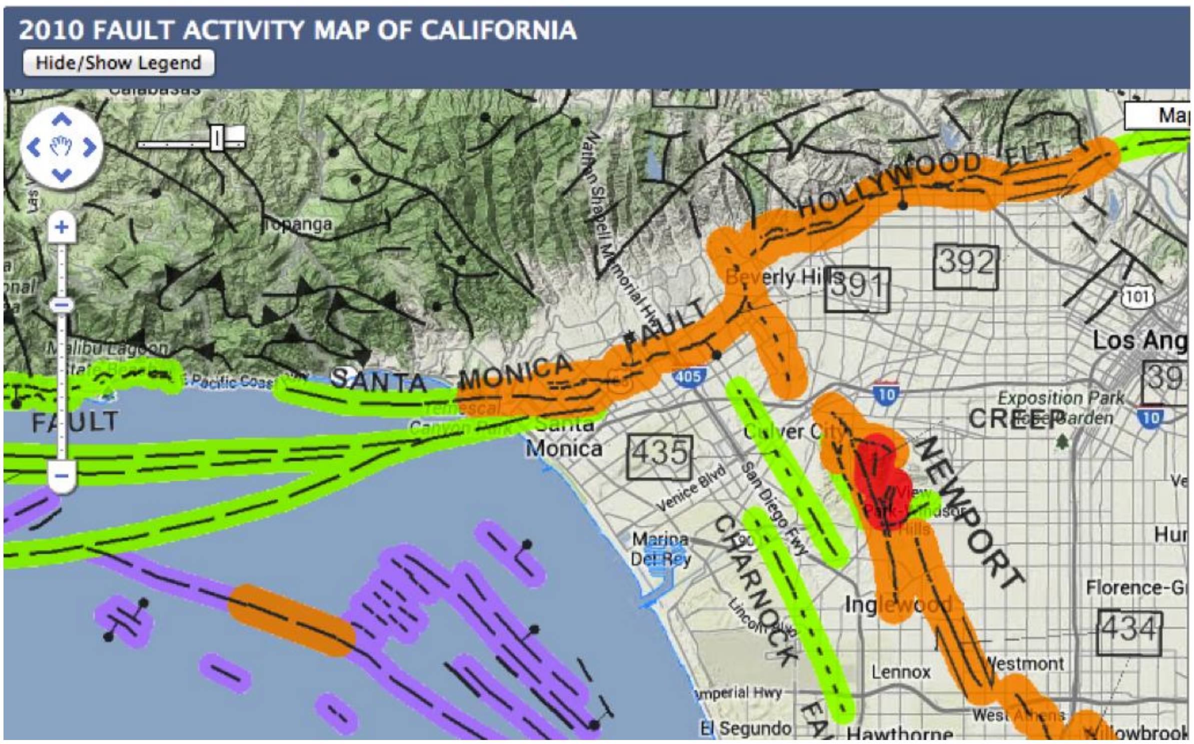

Figure 21: CGS 2010 Fault Activity Map of California – The red color indicates Historic Movement, orange color indicates Holocene level activity, green faults cut Late Pleistocene, while purple are faults with displacements of undetermined Quaternary age. The WBHL did not appear on the 2000 version of this map. http://www.consrv.ca.gov/cgs/cgs_history/Pages/2010_faultmap.aspx

What began as a hypothesis published as a non-peer reviewed field trip guidebook paper (Dolan and Sieh, 1992), has culminated 18 years later in the WBHL being considered as an active fault by the CGS (Figure 21). Before 1992, no geologist had mapped a fault along the WBHL and oil field geologists specifically refuted there being a N-S fault at this location (Lang, 1994). Between 1992 and 2010, no investigations ever physically identified a fault along the WBHL, but every paper published during that period assumed one, eventually linking it to the Newport-Inglewood fault to the south and forming a step-over from the Hollywood fault to the Santa Monica fault to the north. There was never any discussion about the geomorphology of the drainage deflections (Figure 5) that continue well to the west of the WBHL indicating possible right-lateral slip on the Hollywood fault continuing well past the theorized WBHL fault location.

Essentially the same history of assumptions were followed with respect to the “scarps” that were mapped in that same 1992 field trip guidebook paper (Dolan and Sieh, 1992) as the surface manifestations of the Santa Monica and Hollywood faults, despite no, or very limited, physical observations of faulting associated with the scarp locations. These scarps were assumed to be the surface trace of the two faults in all subsequent papers, eventually being labeled as “active fault scarps” in 2001 (Tsutsumi et al., 2001), likely because of the two paleoseismic studies of the SMF and HF (Dolan et al., 2000a & 2000b). But, those studies, especially the SMF study, have issues with respect to the location of the SMF.

Lang and Dreessen’s (1975) structural model may indicate that the VA Hospital trenches were actually dug across the western extension of the Newport-Inglewood fault system. The trenches revealed the faults to be well up on the scarp face, exposed movement contrary to forming a large, south-facing scarp, and indicated dominantly strike-slip faulting (left or right lateral unknown). No effort was made to refute the Lang and Dreessen model, it was simply ignored, along with other older publications regarding alternative local structures. The trenched faults, and all presumed faults underlying the scarps to the east and west, were assumed to be part of the Santa Monica fault system, the sense of slip was assumed to be left-lateral, and they were assumed to be secondary hanging wall faults on top of the main Santa Monica fault which was now geophysically-imaged as a shallow thrust fault - and no other options were assumed possible. That Lang and Dreessen also show the NIF as a low angle thrust was never mentioned, not in 1994 starting with Hummon and Schneider, not through the trenching era of 1997-2001, or through the later decade leading up to the CGS active fault map in 2010, and culminating in the MTA’s Active Fault Map (Fig. 2).

ENTER THE MTA

Preliminary geologic studies of the Westside alignment options by the MTA date back to 1962 in this area (MTA Kaiser, 1962).[1] Even through March 2010 the

[1] One of the prevailing issues in the MTA-sponsored series of investigations is the inability to determine which firms and which individuals retain professional responsibility for the various portions of the investigation. The published reports are uniformly unstamped and unsigned by any licensed individual and are simply labeled as MTA reports. However, MTA lacks the staff or expertise to have done this work and as a general practice assigned the work to a series of consultants working under its General Engineering Consultant for the WSE, Parsons-Brinckerhoff. Where possible, this paper has assigned responsibility for various reports and documents to the firm that appears to be most responsible based on secondary documents (e.g. letterhead on source documents like boring logs within the report) and MTA work assignments to Parsons-Brinckerhoff. It is uniformly not possible to identify which professional engineers or certified engineering geologists were in responsible charge of the various investigations or technical memoranda. For example, even during the very public presentations of the Century City Area Fault Investigation report, the presentation and public comments were made by

WBHL was still not considered a fault by MTA (Figure 22) in the Westside Subway Extension, Geotechnical Evaluation and Tunneling Technical Report (MTA MACTEC 2010). When the MTA Board selected the preferred alignment in September 2010, the preferred station location in Century City was close to the published map location of the Santa Monica fault and tunneling on any alignment would cross the Santa Monica fault and the WBHL. The MTA assessment of the WBHL had changed in 2010; although still not listed as a fault, the WBHL was apparently now considered something more than a mere geographic label, since it made the map's legend (Figure 23). But it was clearly still not considered as a real fault because that is a different line on the map.

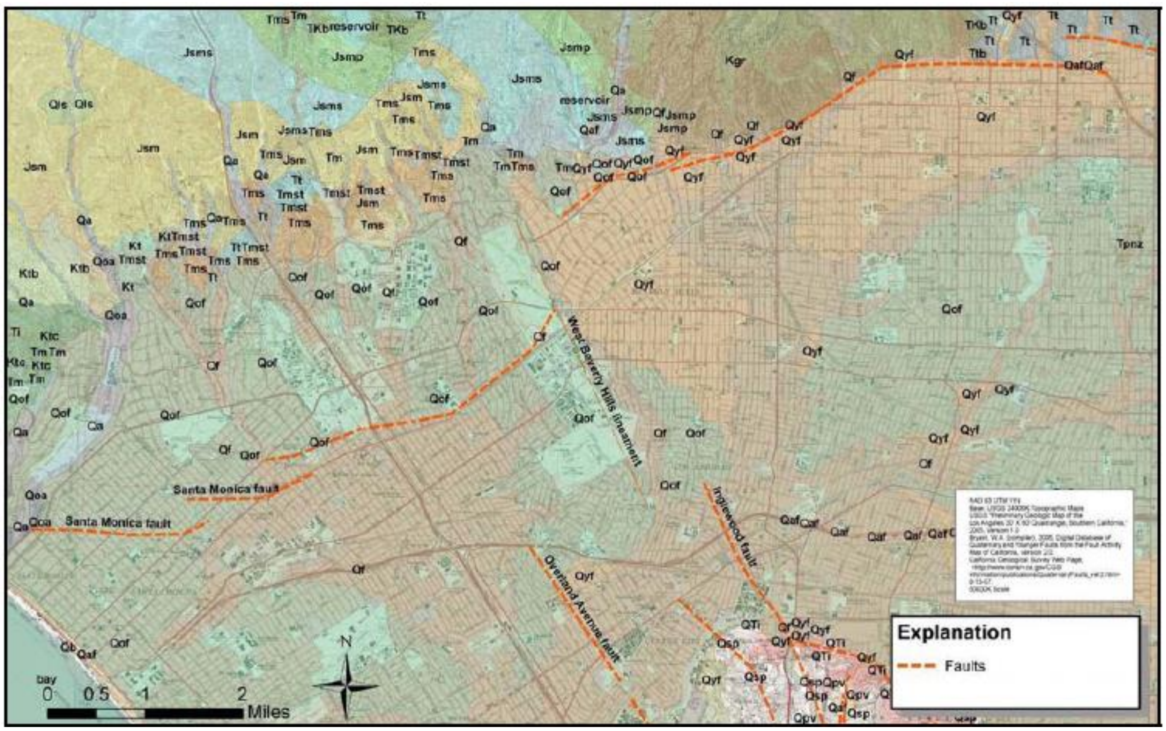

Figure 22: MTA area fault map 2008 MTA Final Geotechnical Evaluation and Tunneling Technical Report March 2008 (PB, 2008). Note that the WBHL is not considered a fault, which is typical of all MTA maps in reports before 2010.

members of the Independent Review Panel, not by the individuals in responsible charge of the investigation.

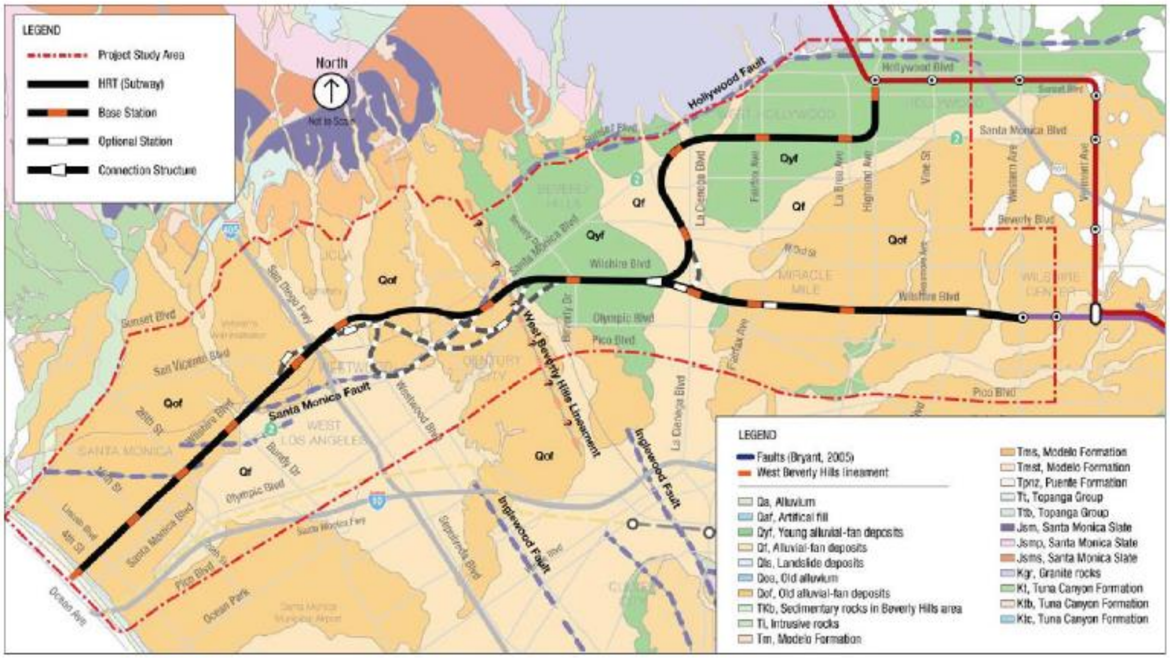

Figure 23: MTA fault map in August 2010 – the WBHL designation has changed, perhaps indicating that it may now be considered as a fault (MTA PB, Aug 2010). Base subway alignment is shown in solid black with orange stations; alternative alignments show in dashed grey.

The MTA in its investigation was challenged by a lack of prior seismic investigation in the Century City area. Extensive development had occurred within Century City over the years all without site-specific fault investigations. Although the Santa Monica fault was shown on the various maps, no local investigation had confirmed the presence of the Santa Monica fault through Century City, nor its level of activity. No study anywhere had confirmed that the West Beverly Hills Lineament was even defining a fault system, let alone an active fault system. MTA's preliminary geotechnical report in 2010 summarized the then current level of understanding regarding the WBHL (Figure 24).

> Various tectonic interpretations have been proposed for the WBHL. For example, Dolan et al (1997) speculated that it may represent an east-dipping normal fault associated with extension along the left step between the Hollywood and Santa Monica faults, or afold scarp along the northern extension of the back limb of the gently east dipping Compton blind thrust fault. However, Lang (1994) reported that subsurface mapping of petroleum well data within the Cheviot Hills and Beverly Hills oil fields, constrained by dense subsurface control, precludes the existence of the WBHL. Thus, the prospect that the WBHL is the surface manifestation of an active fault has not been confirmed. Further evaluation of the WBHL and its significance to the project will be performed during forthcoming design level investigations of the project.

Figure 24: Excerpt from the MTA Final Geotechnical Technical Report – November 2010 (PB, Nov 2010), summarizing their state of knowledge about the WBHL, and confirming that no fault had yet been identified along the WBHL.

Additional fault-specific investigations were authorized by the MTA Board in Oct. 2010 to better understand the neotectonic structures and fault rupture hazards of the Century City / Beverly Hills area of western Los Angeles (Figure 1), particularly as they related to proposed subway station locations in Century City. . While the MTA Century City fault investigation was underway, MTA publicly announced an alternate Century City station location on Constellation Boulevard. This location was controversial and engendered strong local opposition particularly related to potential impacts on the Beverly Hills High School. That controversy continues.

The result of that work was the MTA-authorized fault-specific investigation, the MTA Century City Area Fault Investigation Report (PB, 2011). This report was simultaneously released by the MTA to the public via press releases, newspapers, and an open Board meeting at MTA who posted videos of the meeting onto YouTube [http://www.youtube.com/watch?v=Omx2BTIpzAk]. The MTA public statements presented the report conclusions with great certainty and gravity. It was presented as absolutely certain that active Santa Monica fault strands intersected one of the proposed station locations on Santa Monica Boulevard and that active WBHL fault strands intersected the second location. The linkage of the Santa Monica-Hollywood-Newport-Inglewood-WBHL fault zones into one integrated active fault zone was presented as definitive. Several members (but not all) of an Independent Review Panel convened by MTA were present and announced that the report conclusions had been corroborated by and were uniformly supported by the Independent Review Panel. The report conclusions were presented by MTA as definitive and incontrovertible. But were they?

This was the first broadly-based and systematic geological investigation of the WBHL and the Santa Monica fault in the Century City area. The two-volume report presents a significant quantity of data, but under critical review the "weight" of evidence is lacking. The scope of work for the studies included thousands of feet of geophysical refraction profiles, dozens of core borings, and hundreds of cone penetrometer probes. The volume of data generated appears large but not in proportion to the project dimensions (a typical station is well over 1,000 feet in length and MTA was investigating three separate station locations and over two miles of associated tunneling). The density of data is especially light with respect to the alignment they ultimately selected. MTA consultants relied primarily on transects of cone penetrometer (CPT) probes spaced about 50 feet apart and supplemented with occasional cored borings and seismic reflection geophysical profile lines. The CPT logs were compiled into interpreted sections (transects) showing the stratigraphy and the interpreted faults.

The entire study is based solely upon indirect observation and inferred faults: there is no direct observation of any faults by MTA. MTA did not excavate a single trench to confirm or deny the existence of any of the faults it inferred from the CPT transects. MTA merely announced that such studies were impossible due to the built-up urban area. Most important, the new studies did not include a site-specific geomorphic analysis to reassess the hypothesis of Dolan and Sieh (1992). MTA simply presumed that those findings were valid and extended into the Century City area. The impact of this line of logic is clear: any faults inferred in Century City were presumed to be part of the Santa Monica fault zone and were further presumed to be active.

MTA deemed any field verification of these presumptions to be impossible. MTA ignored the possibility of trenching a large and apparently undisturbed landscaped median strip and adjacent golf course – areas in which MTA mapped the majority of its presumably active Santa Monica fault strands and areas that also contain several of the scarps identified by Dolan as part of the Santa Monica fault zone. MTA did considerable investigation work in both areas demonstrating that the decision to not trench was driven by factors other than practicality or urban development. The level of investigation in the study area is very uneven: more substantial investigative effort was employed along Santa Monica Blvd. and in the vicinity of the Beverly Hills High School, while little investigative work was undertaken at the newly proposed Constellation Station location.

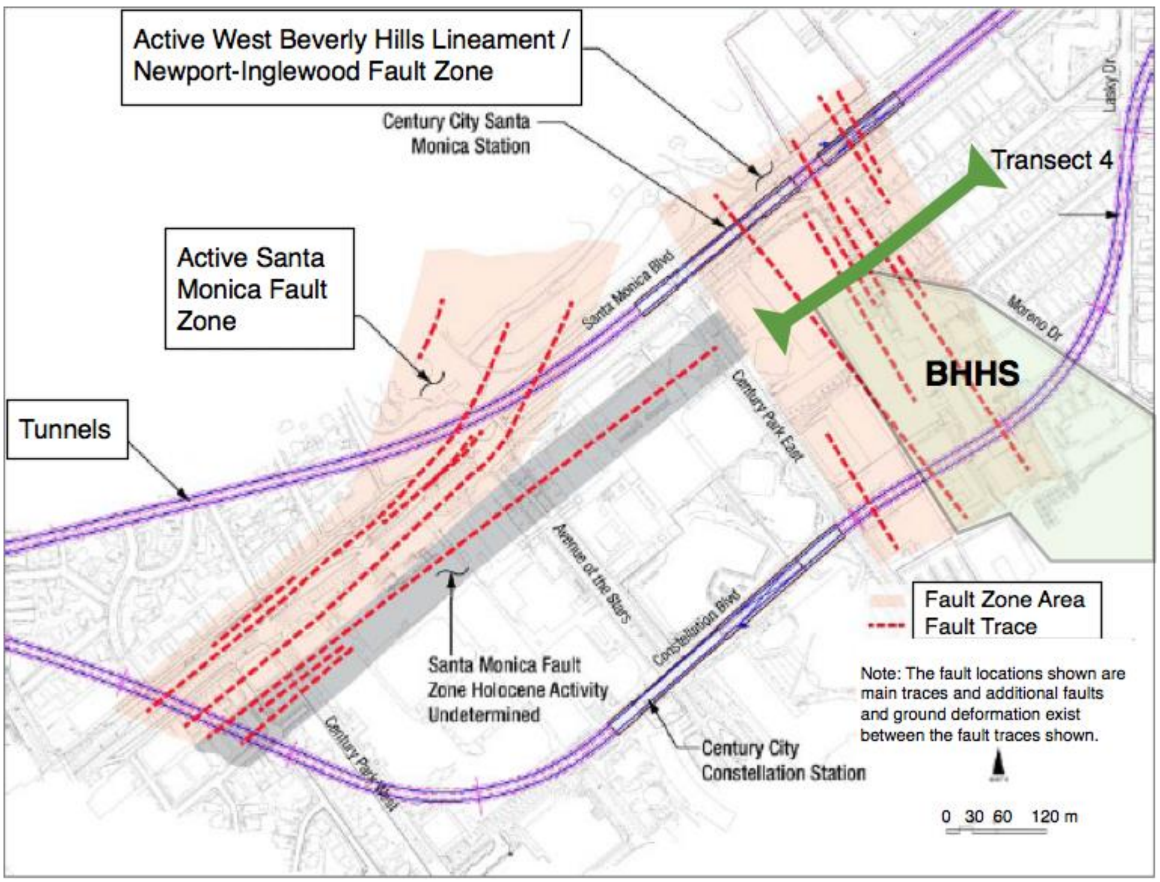

Figure 25: The MTA Active Fault Map of the Century City – Beverly Hills area showing the active faults in red, the active fault deformation zones in red shading, the proposed transit tunnels in purple, and the proposed subway station locations (labeled). Existing major building outlines are shown in greyscale. BHHS is shown by green shading and Transect 4 (Figure 26) is identified by the green bar, both added to the original MTA figure. (Low resolution present in original MTA report map.)

The most significant part of the report was an Active Fault Map of the Century City – Beverly Hills area showing a broad E-W zone of active faulting along the Santa

Monica fault zone and a similarly broad zone of active N-S faulting associated with the WBHL - Newport-Inglewood fault that correlated perfectly with the original Dolan and Sieh (1992) geomorphic map (Figure 25). The map was very definitive, using heavy red lines to indicate the active fault traces, and then zones of shading within which additional active faults and ground deformation could be expected. The base that the map used was unusual for a geologic map in that it was the street and building map for the area. That the faults were drawn through specific buildings made it easier to appreciate the hazard posed to everyone in the area. But the lack of any equivocation on the map's labels (or the accompanying text and public presentation) made it highly unusual for a geologic hazard map that was based strictly upon interpretation of secondary data (geophysics, CPT probes, and borehole correlations) with no actual physical observations of a fault anywhere in the mapped area, nor any discussion of the ages of the units that were interpreted to be offset.

MTA Transect 4 is of greatest relevance to BHHS (Figures 25 and 26). This transect lies along the northern boundary of BHHS, and identifies seven active faults through, or trending towards, the school campus.

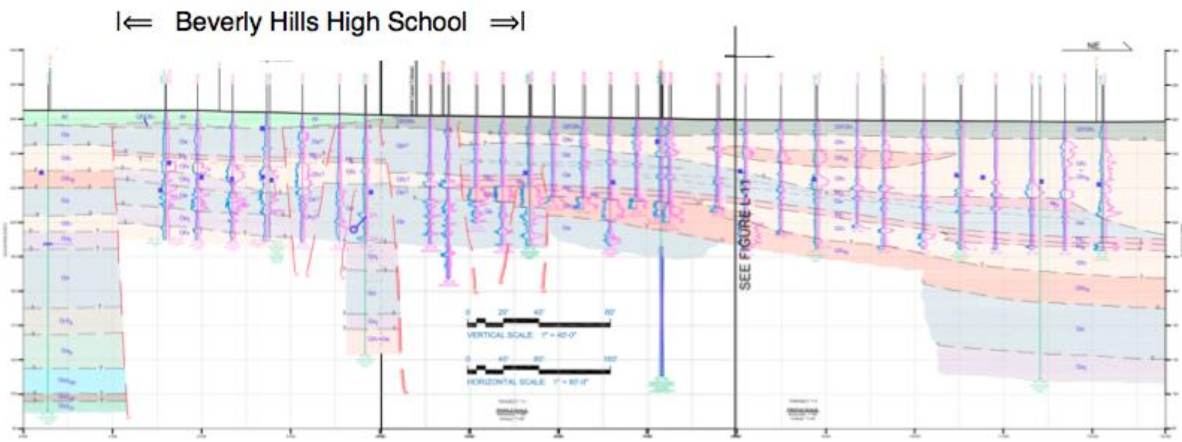

Figure 26: The MTA Transect 4 cross-section lying immediately north of BHHS (Fig. 25) showing the alluvial stratigraphy and the multiple faults, as originally interpreted from the cone penetrometer test probes and borings (PB, 2011).

As mapped, almost the entire WBHL fault zone trended directly through the BHHS campus (Figure 25), necessitating immediate concern for the safety of the students and employees within the iconic 1920s school building. Within weeks of the report's release, BHUSD contracted Leighton Consulting Inc. (LCI) to undertake a detailed geologic investigation to locate and more accurately map the faults through the campus, and if possible, to better quantify the hazard that they posed (Figure 27). All work performed by Leighton was under the regulatory authority and review of the California Geological Survey.

Leighton's work was the first investigation in the area to employ geological exploration trenches to supplement their CPT and core borings. Leighton failed to locate any of the WBHL faults interpreted by PB and instead revealed solid geological evidence to refute the existence of faults within 300 ka to ~1 Ma sediments.

Subsequent work by Leighton did expose an E-W trending fault that had been interpreted by PB as “Santa Monica Fault, Holocene Activity Uncertain” (grey shaded zone in Figure 25) in Leighton’s trench #5 (Figure 28). The fault was shown in the trench to rupture a former ground surface, likely generating a moletrack across the landscape as the fault branched upwards forming multiple splays and minor stepovers. However, subsequent pedogenic development partially obscured the fault traces and fractures, and later alluvial sediments of the ancient Benedict Canyon drainage that are 150-300+ ka in age (based on pedogenic development of multiple buried paleosols) buried the fault rupture landscape. The fault has not broken these old alluvial deposits. The Leighton study is described in more detail below.

THE BHHS INVESTIGATION

To locate and map the faults accurately enough for campus planning, the BHHS consultants relied upon a suite of investigative tools similar to PB's consultants (borings and CPTs) but also excavated ~900 feet of exploratory trenches (Figures 27 and 28) across available portions of the BHHS campus to precisely locate, geologically log, and kinematically quantify the fault displacements that had been mapped through the school property. In total, 5 trenches were excavated to expose the faults, 12 CPTs were pushed to reevaluate MTA's Transect 4, and 26 borings were continuously cored along two transects, one through the middle of the school and one along Transect 4 (Figure 28).

In the Leighton investigation, the initial 21 borings were emplaced E-W across the center of the campus to correlate with the best location for the surface trenching (T-2 on Figure 27). Early in the investigation, BHHS experts realized that the borings should extend through the alluvial fan deposits, upon which the school was built, and into an underlying ~1Ma marine unit (San Pedro Formation) because this contact was easily identified and readily correlated from boring to boring.

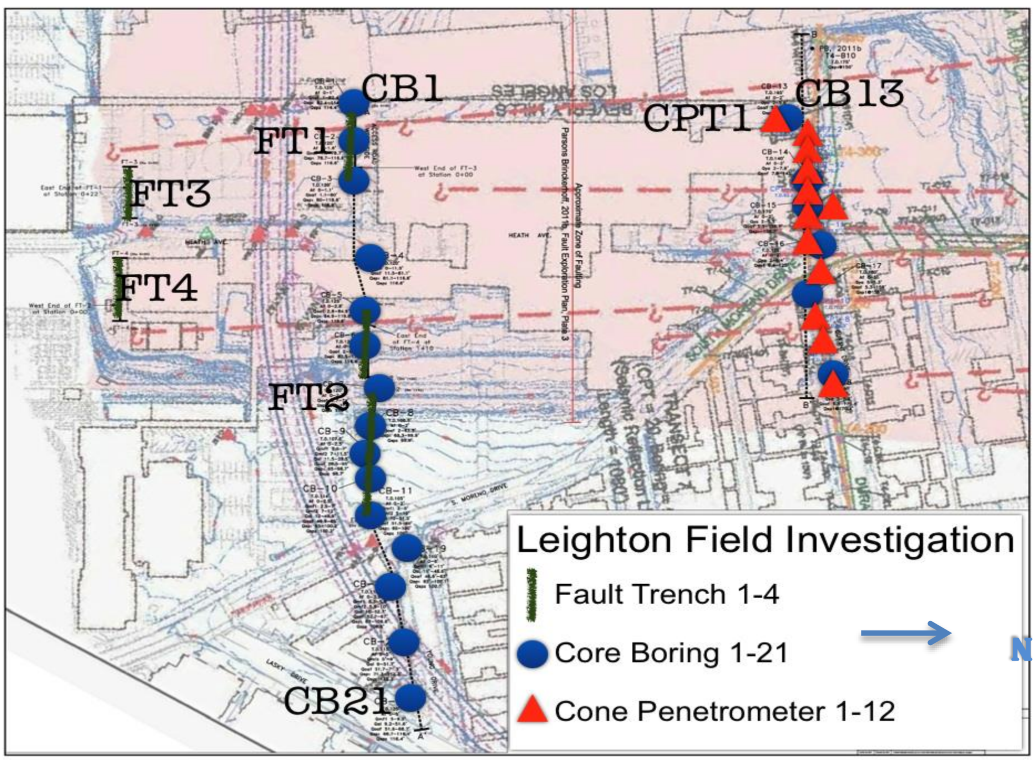

Figure 27: The Leighton field investigation plan included borings, CPTs and trenches. The transect CB1-CB21 was done in the first phase, followed by fault trenches FT1-FT4. The second phase used continuous core borings and cone penetrometers in an effort to replicate MTA Transect 4 data. The third phase of investigation ran between CB1 and CB 13 with additional core borings and FT-5 (Figure 28). The red dashed lines are the WBHL active faults as initially mapped by MTA. North is to the right.

The initial set of borings were followed by a series of trenches FT-1 through FT-4. Trenches FT-1 and FT-2 were located over the line of borings; Trenches FT-3 and FT-4 were offset to cover gaps in the mid-campus transect caused by existing buildings and utilities. All four trenches were at least 10 feet deep, and in some cases, deeper. Where possible, the trench was benched for easier access and viewing, but where that was not possible, the trench was shored (Figure 29). Pedogenic (soil development) profiles were described from FT-1, at several locations in FT-2, and from several of the boring cores. These profiles were completed under contract to Leighton by Glenn Borchardt of Soil Tectonics and by Tania Gonzalez of Earth Consultants International (ECI, 2012a and b; LCI, 2012a and b; Soil Tectonics, 2012). Because the majority of the sediments exposed were considerably older than the 50 ka maximum dating age for radiocarbon, their pedogenic development became the primary method used for estimating the stratigraphic ages; both of the geomorphic surfaces and the buried sedimentary units.

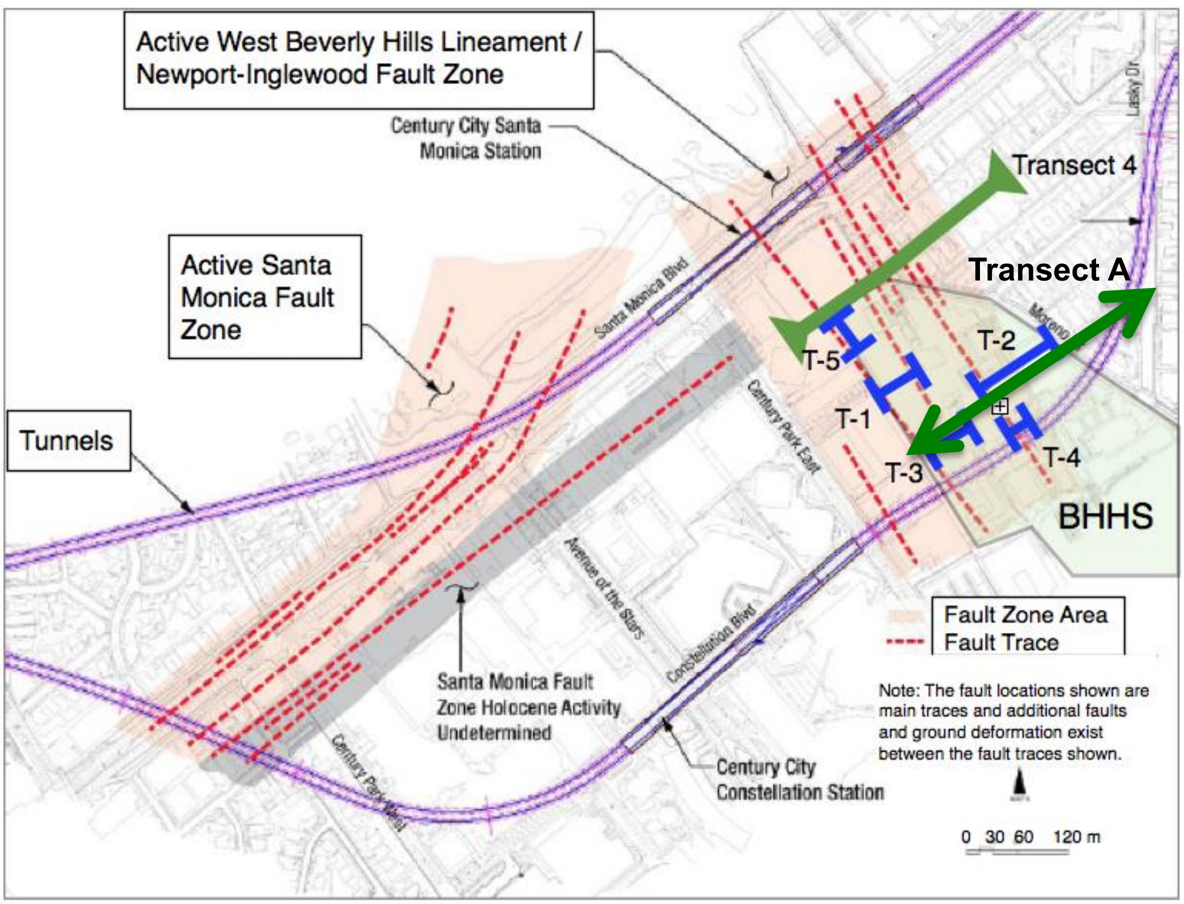

Figure 28: Location of Leighton fault trenches schematically shown on the MTA Active Fault Map. The first four trenches were excavated to explore for the WBHL faults mapped by MTA. Trench FT-5 was excavated later to evaluate a step in the stratigraphy that could be the eastern extension of the E-W trending fault shown in grey and labeled as Holocene Activity Undetermined on the MTA map. A new Transect A was constructed by Leighton, and MTA's Transect 4 was redone and reinterpreted by Leighton using their new data.

Pedogenic development of the geomorphic surface that forms the primary school site indicated that the capping soils are a minimum of 80-100 ka (ECI, 2012a), but subsequent work on site indicates that the surface is more likely a minimum of 200 ka (ECI 2012b). This surface soil development combined with the time required to form the multiple buried paleosols found in the exploratory trenches showed that the alluvial fan deposits are of considerable age, a discovery that raised questions with respect to the degree of hazard posed by the mapped faults.

MTA made no stratigraphic age estimates in its investigation (PB, 2011); the faults were simply presumed to be Holocene in age and thus active by definition. In addition to locating and mapping the faults in this new study, Leighton needed to determine the faults' rupture age. Per California criteria, if faults could be shown to have no Holocene-age displacements the faults would be considered inactive and the hazard to BHHS would be negligible. Borings alone were not adequate to determine the faults' rupture age: the faults needed to be exposed in trenches where their rupture age could be documented.

Figure 29: Leighton trench FT-2, excavated down the slope that was defined as the West Beverly Hills Lineament. This is one of five exploratory trenches excavated at the BHHS, part of which is seen at the top of the picture. Trenches were placed to cross and to expose the faults that were mapped by PB (2011) intersecting the BHHS. Despite the fault map (Figure 2), no faults were found in this trench.

The primary trench (FT-2) was excavated ~300 feet long, down the eastern lawn (Figure 29). The slope that forms this dramatic presentation to the school is the scarp-like feature that defines the WBHL. Continuous, mid-early Pleistocene alluvial fan stratigraphy lay unbroken along the entire trench until erosionally removed by incision of Benedict Canyon wash (which is the same wash area that the current Moreno Creek flows in) on the eastern margin (Figure 30). The fan deposits dip 3° NE, as correlated in the boring transects (Figure 30), and extend directly out the slope face, demonstrating that the genesis of the slope is erosional and not structural. The incision of Benedict Creek would have isolated the upper geomorphic surface, allowing the surface soil to form. Based on that pedogenic profile alone (ECI, 2012) this occurred ~100+ ka. Subsequent alluvial fill buttressed the lower 50 feet of the slope (Figure 30). Two buried paleosols within the upper Benedict Canyon alluvium provide a minimum pedogenic age of ~40 ka for the uppermost 15 feet, and a similar OSL age of ~25 ka (ECI, 2012; LCI 2012). The investigation showed that no fault offsets were present within the Benedict Canyon alluvium, nor within the older alluvial fan deposits.

The only N-S fault observed by Leighton was in one of the shorter trenches (T-3) where two fault-like features, 3 m apart, were observed to vertically displace an alluvial layer by 10 cm, with an unknown, but minor, lateral slip component. This fault was vertically truncated by an overlying cobble deposit and all subsequent strata. The depth of the event horizon was 2-3 m beneath the >80-100 ka surface soil, and with other intervening paleosols adding to the age, it is reliably concluded that this fault's single displacement event occurred at least 300 ka. Although unproven, it is more likely that this minor feature was not a tectonic fault, but the geologic evidence for a >300 ka seismic event (a seismite) that generated a liquefaction failure within the alluvial channel deposits.

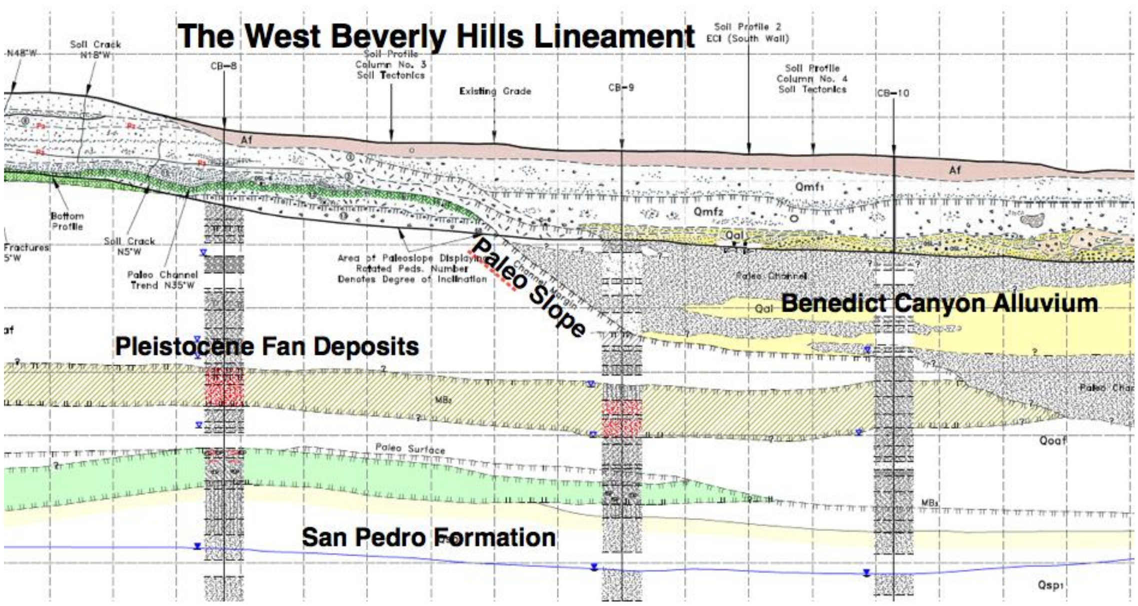

Figure 30: T2 trench log (from Figure 29) and extended cross section showing the alluvial unconformity that explains the origin the West Beverly Hills Lineament as an erosional channel margin that has been partially backfilled by undeformed 30-200+ ka Benedict Creek sediments.

The Leighton mid-campus borings and trench data were sharply at odds with the MTA fault map and transect profile at the north end of the BHHS campus (MTA T-4; Figure 26). The Leighton study failed to encounter any of the specific faults predicted by MTA or other evidence of a broad zone of faulting, and instead presented solid geological data that prevented the interpretation of active faults.

Following the release of Leighton's initial investigation data, MTA issued a report arguing that the Leighton mid-campus investigation was inadequate to refute the MTA conclusions regarding WBHL faulting (MTA Response to Leighton Consulting Report, May 14, 2012). MTA presented a revised map identifying a new fault running to the west of the BHHS western property line, (an area unavailable for investigation by Leighton) which reportedly was "confirmed" by small tectonic geomorphic features interpreted from the old topo base of Hoots (1931). By incorrectly interpreting the Leighton data, MTA concluded that this new fault had over 300 feet of right-lateral offset.

The MTA report then went on to modify the other MTA fault locations by shifting them to the residual small gaps not covered by Leighton's trenches, which were in areas covered by existing buildings or utilities or otherwise not available for trenching (Figure 31). MTA's simplistic readjustment of their prior fault traces completely fails to account for the presence of the consistent 3-degree dip to the strata, and instead continued to assume that all layers are horizontal. The fallacy of this point was demonstrated to the MTA during the March 2012 public hearings, and yet inexplicably was still ignored by MTA. Subsequently, the trench excavation at 10000 Santa Monica conclusively demonstrated the absence of the new WBHL fault.

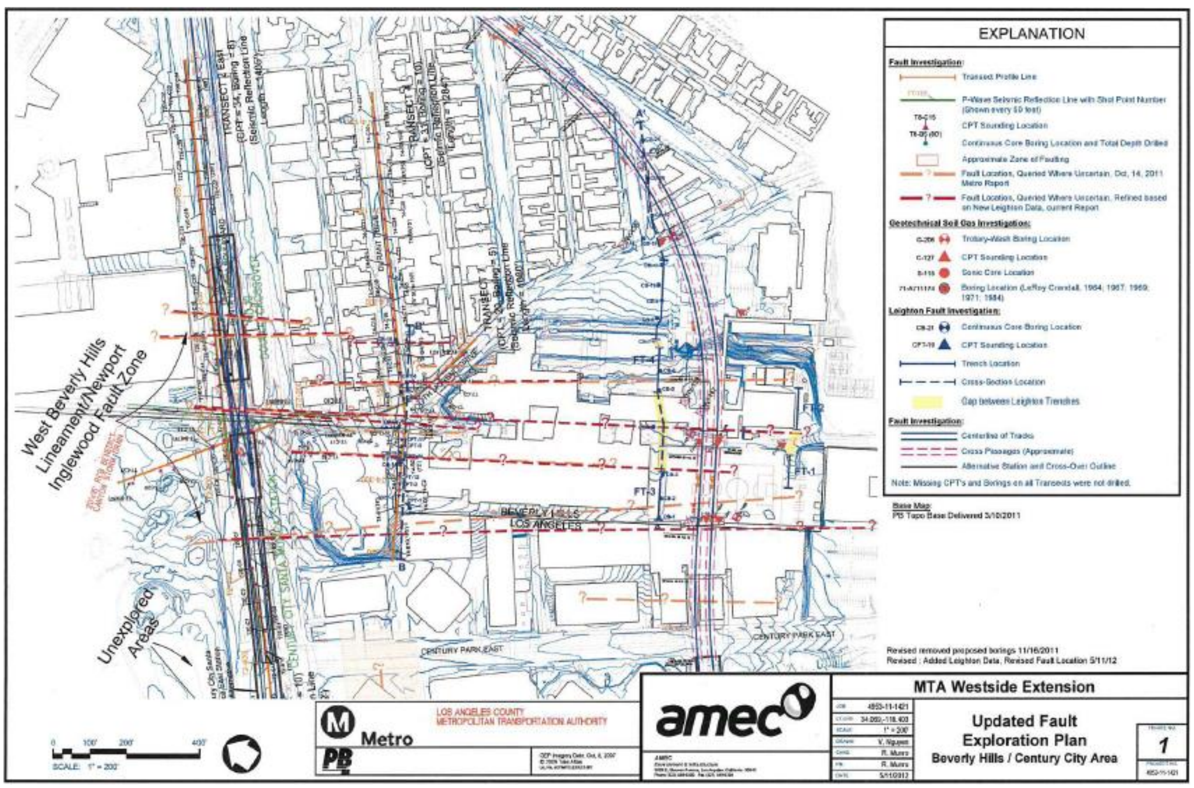

Figure 31: Updated Fault Exploration Plan – MTA Response To Leighton Consulting Report May 2012. MTA revised WBHL fault locations following failure of Leighton to find predicted faults in mid-campus. Revised locations generally not conducive to investigation by trenching (PB, May 2012).

From its inaccurate assumption, clearly ignoring the visual reality of the Leighton trench exposures and boring correlations, MTA revised its fault traces in a highly non-scientific manner by making selective and inconsistent correlations. While minor strike slip faults may not be resolvable with borings alone, the combination of the trenches with the boring profiles (Figure 30), the exposed dip to the strata, and the multiple correlations across the entire transect, do make it impossible to accurately interpret a fault, let alone an active fault. The scientific method must consider all of the data available, and in this case, the data totally refutes the presence of the MTA-interpreted active faults of the WBHL (Figure 32).

CGS subsequently directed Leighton to perform an additional investigation at the north end of the campus to resolve the apparent inconsistencies between the MTA's continued interpretation and the Leighton mid-campus findings. Leighton then attempted to replicate the MTA findings at MTA Transect 4. The MTA Transect 4 relied primarily on CPTs with widely spaced borings. Leighton Transect 4 consisted of matched CPTs and closely adjacent borings. The Leighton borings were drilled deeper than the MTA borings in order to reach the San Pedro contact (Figure 33).

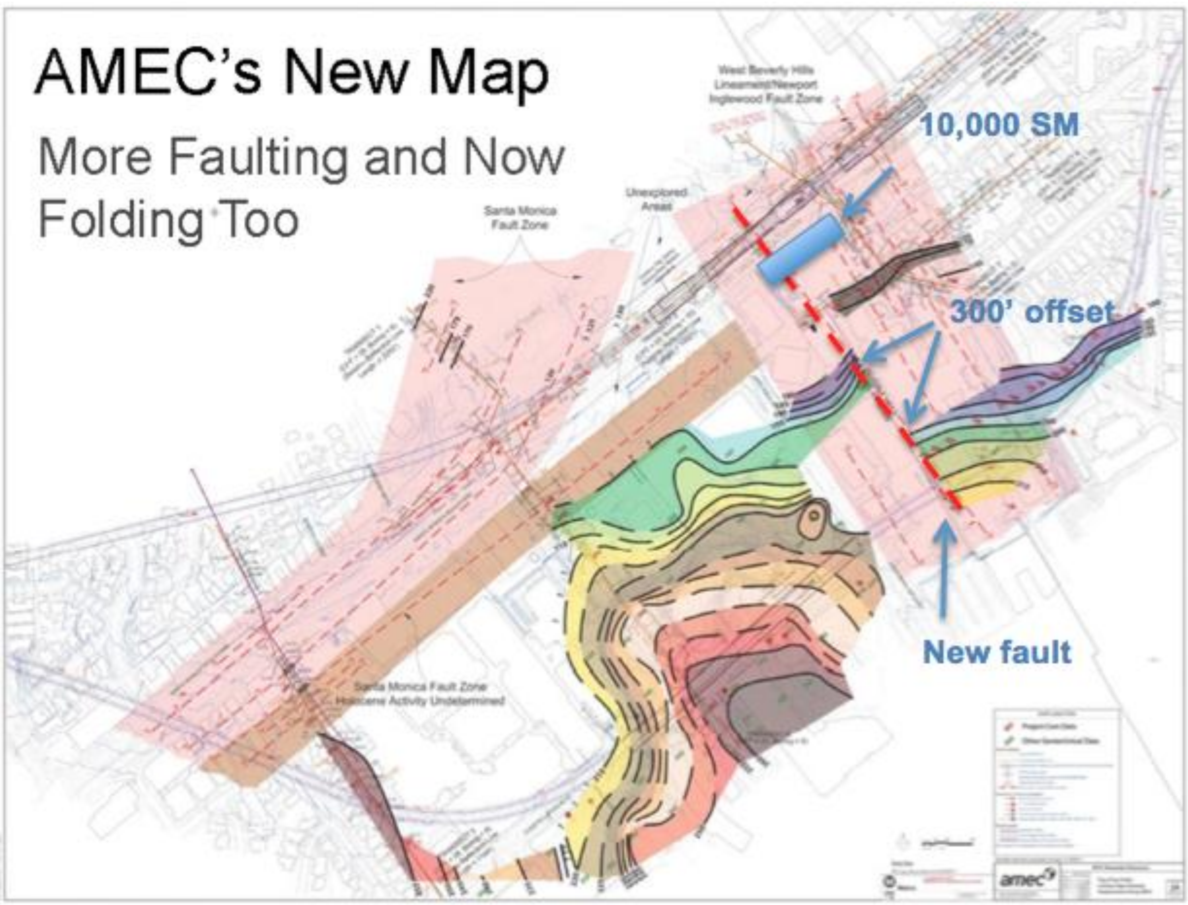

Figure 32: The MTA Response to the Leighton Consulting Report, May 14, 2012 included this new contour analysis indicating 300 ft. of displacement along a new location for the WBHL fault line now well to the west of the geomorphic feature upon which it was first defined. Using true strike and dip data this plot is shown to be wrong. A trench at the 10000 Santa Monica project north of BHHS intersected the MTA faults but found no evidence of faulting in 300 ka sediments.

Where possible, Leighton CPTs and borings were placed as close as possible to MTA CPT locations.

The alluvial fan stratigraphy was correlated using mainly the boring cores because the physical recognition of stratigraphic correlations could be observed, discussed, and agreed upon. CPT correlations suffer from cone variations, divergence from vertical, and indirect subjectivity. For this reason, Leighton made more extensive use of continuously cored boreholes, all of them penetrating to the deep ~1 Ma San Pedro contact. This contact was used because it was very clearly recognizable in the cores (Figure. 33). Within the alluvial stratigraphy, a series of buried paleosols were observed and these provided the most powerful correlations across the borings (Figure 34).

CGS was satisfied by this round of investigation that there were no active WBHL faults intersecting the BHHS campus (CGS, 2013).

Figure 33: Borehole correlations were made across all of the borings on the Leighton transects to look for vertical separations of key marker units that might confirm the faults shown by PB. Here, there is excellent correlation of the underlying San Pedro contact between borings CB-3 (left) and CB-4 (right) at ~25-30 m, despite being on opposite sides of a mapped fault. The BHUSD team then conducted a similar side by side core comparison of the MTA cores, which encountered and resolved numerous MTA boring log errors.

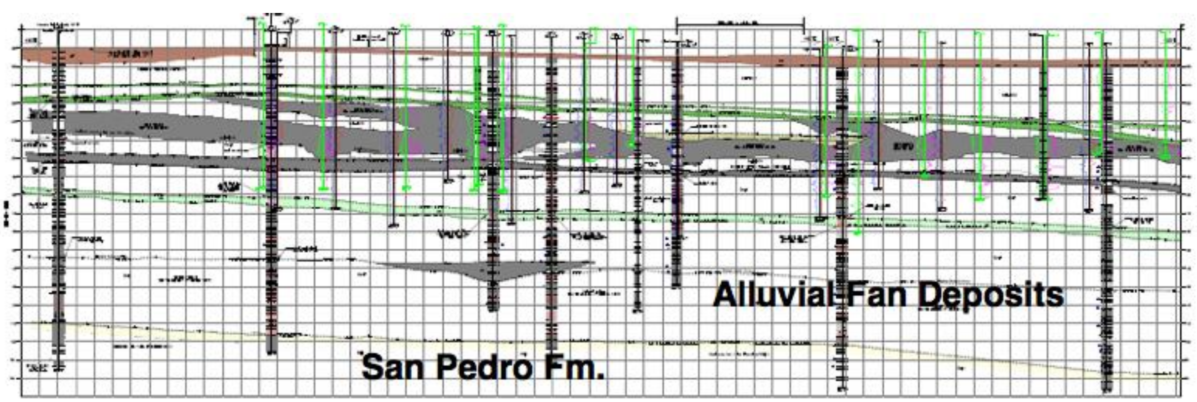

Figure 34: MTA's Transect 4 (Figure 26), as revised by the new cone penetrometers and borings from the Leighton study. The green highlighted layers are paleosols that have been correlated across the section, effectively eliminating the necessity for fault offset anywhere in the section. The base of the section is the ~1 Ma San Pedro marine sand at ~150 feet depth (LCI, 2012).

A third round of investigation was conducted by Leighton to connect CB-1 north to CB-13 (Figure 27) in order to evaluate the possible E-W fault that MTA has shown as “Santa Monica Fault, Holocene Activity Uncertain” on Figure 28 and continued onto Figure 32. The earlier Leighton work showed a 75-foot drop in the San Pedro contact between the two transects that was anomalous with the prior dips. This study was also motivated by a revised interpretation of the MTA PB (2011) data by KGS (2012) that suggested that north-northwest trending faults associated with the WBHL fault zone by MTA PB (2011) were actually east-west trending faults associated with the Santa Monica fault zone and so could be Holocene faults. The LCI study resulted in another geologic transect that used 5 more borings to correlate geologic strata, narrowing down the zone within which the 75-foot vertical differential correlation anomaly of the ~1 Ma San Pedro contact occurred to between two borings. A 75-foot long trench T-5 (Figure 35) was then excavated to physically evaluate stratigraphy between the borings. The anomaly was confirmed to be an E-W trending fault, directly on trend with the MTA and KGS fault, and which would appear to extend the MTA fault farther eastward.

Figure 35: Leighton’s FT-5 trench excavation looking south down the center of the access driveway between the school (left) and the western property line (right). The trench was excavated to view an anomaly in the otherwise well-correlated older alluvial stratigraphy, and did reveal that the anomaly was caused by a fault, probably the fault shown on Figure 28 as “Holocene Activity Uncertain.” The geologic log of the trench is shown on Figure 36.

Note the level of urban development in this area – three and four story school buildings to the left and high rise parking and office buildings to the right. MTA dismissed the use of trenching as impractical in the urban environment and relied exclusively on indirect inference of faulting. Clearly trenching is possible in this area as demonstrated by Leighton at BHHS and by investigators on other sites in the area.

There are many existing buildings located over the faults mapped by MTA. All of these buildings required geotechnical investigations: none of those investigations identified faults. Many buildings required deep excavations with geologic mapping of the cuts; none of them identified faults during the excavation.

In the trench exposure (Figure 36), the fault was shown to offset the upper part of the older alluvial fan deposits by several feet, but mismatched stratigraphic units clearly indicated a large component of strike-slip offset. The fault ruptured to a former ground surface as numerous upwardly expanding fault traces and fractures, forming a moletrack across the landscape. Subsequent pedogenic development degraded the fault expression in the subsurface, and sometime later, it was buried by the 150-200+ ka alluvial deposits of the old Benedict Canyon wash. The evidence clearly establishes that no surface rupturing events have occurred on this fault trace since that time.

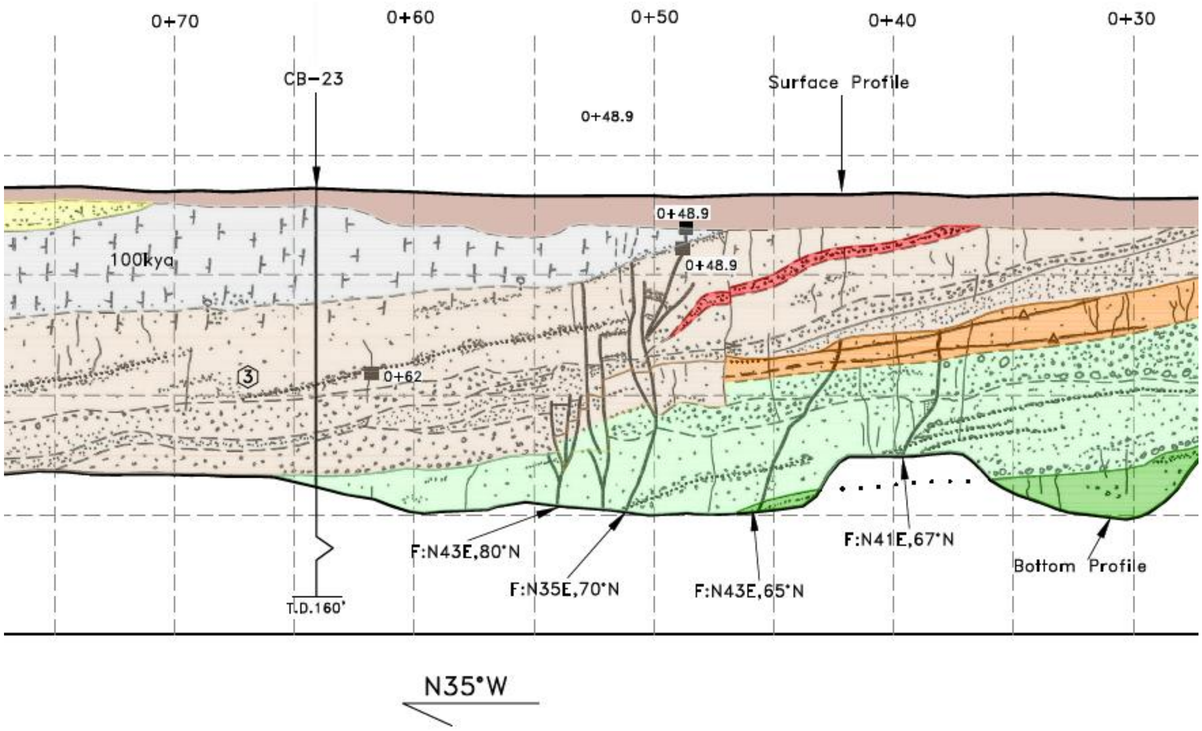

Figure 36: Leighton's FT-5 trench log across the E-W trending fault. Several upwardly terminated fault splays were noted within the older (>300 ka) alluvial deposits that form the elevated surface upon which BHHS sits. The youngest rupture event on the fault is well expressed as an upwardly branching flower structure that would indicate a surface-rupturing event, but which is pedogenically obscured by subsequent soil development. That event horizon is overlain by unfaulted Benedict Canyon deposits of at least 100 ka age determines onsite, but, within which several paleosols show a minimum age of 200-300 ka from the adjacent 10000 Santa Monica trench (Feffer-Geocon, 2012).

Figure 37: Mixed team peer review of trench FT2 on BHHS campus. Present were representatives of CGS, USGS, and City of Beverly Hills and BHUSD consultants. All trench logging and core comparisons and conclusions were peer reviewed in the field, which also included several MTA consultants at various times. This openness to discuss varying interpretations in front of the physical data led to consensus of interpretation and facilitated the CGS regulatory review.

At this point the CGS issued a final acceptance letter on March 15, 2013 (CGS, 2013) declaring the investigated portion of the BHHS campus free of active faulting and acceptable for continued occupancy and future development (Figure 37).

While the Leighton trench was being planned, another deeper and longer trench was excavated immediately to the north of the BHHS campus at the 10000 Santa Monica development site (Feffer-Geocon, 2012). This trench was parallel to MTA and Leighton Transect 4 and was excavated at the requirement of the City of Los Angeles to look for the MTA faults shown on their Transect 4, as well as their original and revised fault maps (Figures 26, 28, 31, and 32). The 30-foot deep trench exposed additional sedimentary fill of the old Benedict Canyon Wash, similar to that in Leighton's FT-5. But, the 10000 Santa Monica trench, being in the middle of the former drainage, exposed a more complete stratigraphic and pedogenic profile, resulting in better age control for the section. The 10000 investigation exposed sediments exhibiting minimum pedogenic ages of ~100-235 kya at the surface of the trench to 320-580 kya at the base of the trench. These results added additional age to the upper surface of the high school site (FT-1) and pushed back the age of last fault rupture on the E-W fault in FT-5 to 200-300 ka. No faults were present in the entire length of the 10000 trench.

So what happened? At the completion of the Leighton investigations and during the CGS approval process, MTA prepared several internal reports, not initially made public, which attempted to reconcile the Leighton findings with the MTA Century City Fault Investigation. MTA had two parallel transects in this area – Transect 2 on Santa Monica Boulevard and Transect 4 on the northern edge of the BHHS and several of the faults mapped by MTA were interpreted on both transects. Initially, MTA argued that because the Leighton reanalysis of their own Transect 4 is located more than 100 feet from Santa Monica Boulevard and Transect 2, and because it investigated only a "portion" of the WBHL/NIFZ, it could not preclude the presence of active WBHL faulting at the proposed station site north of the BHHS investigation (MTA, May 2013). MTA's refutation failed to address the fact that the Leighton work at Transect 4 revealed inconsistencies that were equally likely to be present elsewhere in the MTA study. Further, Leighton's correction of MTA's Transect 4, when combined with the 10000 Santa Monica trench, covered the entire zone of faulting that MTA's consultants had interpreted for the WBHL, resulting in the conclusion that none of those faults actually existed in 300+ ka to possibly ~1 Ma sediments.

Upon completion of the Leighton Trench 5 work and CGS concurrence, a second MTA report again shifted course:

> *The new Leighton trench data from Beverly Hills High School, however, indicate that the Santa Monica fault zone is a much wider feature than previously known. Thus, it is possible that the fault strands beneath Santa Monica Boulevard in the vicinity of South Moreno Drive could be associated with the ENE trending Santa Monica fault zone, rather than the NNW trending Newport Inglewood fault zone. (MTA, June 2013)*

Despite the additional contradictory information available to it, MTA continued to cling to its interpretation of faults at the Santa Monica station location, under the assumption that those faults had to come from somewhere. Once Leighton and the CGS demonstrated that those faults could not be from the WBHL, the only candidate left was the Santa Monica fault. Therefore, MTA concluded, the faults that MTA inferred at the Santa Monica station site must be associated with the Santa Monica fault. It is not explained how a Leighton study that found that there are no faults associated with the WBHL trend and only an inactive fault along the SMF trend, can be interpreted as showing "that the SMF zone is a much wider feature than previously known." MTA attempted to maintain this position despite the fact that MTA's statement is totally inconsistent with the data and conclusions of the Leighton report, that there is no other evidence to support this inference, that this theory contradicts MTA's own transect findings at Avenue of the Stars, that this theory contradicts MTA's own transect findings along Santa Monica Boulevard, and that the geometry of the area simply does not lend itself to this interpretation.

MTA has never addressed the inconsistencies between its investigation and analysis on Transect 4 and the Leighton investigation. MTA has never publicly considered or even acknowledged the very real possibility that similar inconsistencies were to be found elsewhere in its investigation and that its interpretation of active faulting was simply incorrect. MTA has refused to take the next step and critically examine their process for the interpretation of any of these faults. If its WBHL fault interpretation is so badly flawed, as MTA now seems to accept from the MTA June 2013 quote (above), and the same people and process were used along Santa Monica to interpret those faults, then couldn't the same flaw be present there as well? The fact that it hasn't, that it stands silent, raises the impression that the MTA Century City fault investigation has become a conclusion driven investigation and analysis: the answer must be correct regardless of any and all contravening data and evidence.

So the final MTA conclusion is that the WBHL fault zone does not exist – or maybe it does exist but somewhere further east – but it does not matter because Leighton proved that the Santa Monica fault zone is even bigger than previously thought (without really saying how Leighton proved this when Leighton found no active faults) and it is now the most likely source of the faulting observed on MTA Transect 2 down Santa Monica Blvd. Lest we forget the importance of the Santa Monica fault zone, the reports remind us that:

> *The Santa Monica fault system has been shown to be active at a site several kilometers [4 km, 2.5 miles] to the west of Century City, and since the Santa Monica fault zone extends northeastward as the Holocene-active Hollywood fault, it is active in Century City. Thus, at least some of the numerous strands identified in the various investigations described above must be active and capable of generating damaging earthquakes. Moreover, the presence of active fault strands at both Santa Monica Boulevard station locations cannot be disproven, due to local disturbances (utility lines, other historical excavations) and removal of Holocene-age sediments or soil horizons. (MTA, May 2013)*

Note how this extract continues to build upon the shaky foundation of the 1992 guidebook article and map, and by doing so, it assumes as fact all of that hypothesis and all subsequent studies that have assumed it as well. First, there is the possibility, never evaluated, that the Veterans Administration site trenching study mentioned was not on the Santa Monica fault, or at least not on a Santa Monica fault that runs through Century City, and even if it was, there is considerable variation in how to interpret the timing and kinematics of the structures that were observed in the trenches. Second, it is a hypothesis, never proven, that the Santa Monica fault extends eastward along Santa Monica Blvd., or that it even connects to the Hollywood fault. These are all hypotheses. Third, there is nothing factual from which to state, "at least some … strands must be active …". This is a model driven assumption, based upon nothing but unproven interpretations and paradigms. And, fourth, MTA's statement that the presence or absence of active fault strands cannot be proven because of logistical and site difficulties reflects a decision by MTA to decline to investigate, not an absolute fact. The fact is that the BHUSD has done exactly what MTA deemed impossible: go out and prove whether or not active faults are present in the area.

The BHUSD has now been joined by numerous private party investigations all stimulated by regulatory requirements that arose due to the Active Fault Map's release. Multiple subsequent private party investigations have also consistently refuted the MTA fault map while adding additional support and confirmation to the Leighton BHHS findings. The 10000 Santa Monica and Westfield investigations are but two we discuss here.

The 10000 Santa Monica project site is located immediately north of the BHHS campus (Figure 38) and lies immediately adjacent to the MTA Santa Monica station site and between MTA Transects 2 and 4. The 10000 investigation included a trench across the entire site that paralleled the Leighton/MTA Transect 4 and the MTA Transect 2. The trench crossed the location of several fault strands proposed by MTA (PB, 2011) associated with their WBHL fault zone (Figure 28) as well as the new WBHL fault location (Figures 31 and 32), newly interpreted by MTA after reviewing the Leighton study findings. MTA's analysis resulted in the conclusion of a major WBHL fault, essentially just past the western BHHS property line, which had a 300-foot horizontal offset of the San Pedro Formation contact (Figure 32). Leighton's reanalysis of Transect 4 showed no such offset, and an accurate plotting of the data used by MTA's consultants to make Figure 32, eliminated any such fault, but these were simply similar interpretations as MTA used, not field-verifiable and exposed evidence. However, no faults, active or otherwise, were found in the 10000 Santa Monica trench to depths of 30+ feet and ages of >300,000 years. The trench did confirm the accuracy of the Leighton transect cross-section at the north end of the campus, including exposing key marker beds and confirming the Leighton soil age dating overlying the E-W trending fault exposed in FT-5 (LCI, 2012b). The 10000 Santa Monica investigation was conducted under the regulatory authority of the City of Los Angeles Department of Building & Safety, which subsequently approved the construction of a 40-story tower on the site – immediately adjacent to an area MTA has declared unsafe for subway station construction.

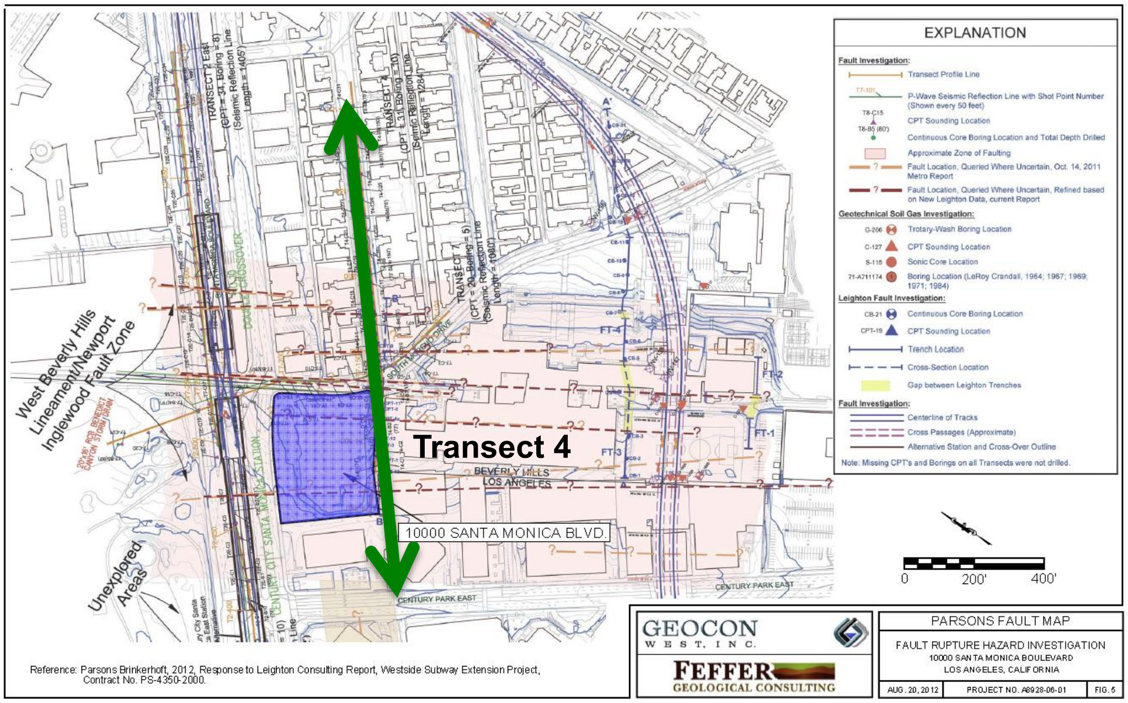

Figure 38: – Feffer Geocon (2012) investigation of 10000 Santa Monica Boulevard; investigation area is blue shaded area and included an E-W trench the full width of the site. The trench intersected the WBHL fault locations mapped by MTA in the original Century City Fault Investigation (PB, 2011) (Figure 28) and in their revised location (PB, 2012) (Figure 32). The trench paralleled Leighton's redo of MTA's Transect 4, and replicated the findings by Leighton. Despite excavating 30+ feet and into 300+ ka sediments and having ideal stratified alluvial deposits and paleosols, the trench failed to expose any faults. The investigation also included a N-S transect that found no evidence of E-W faulting.

The Westfield project site lies at the SW corner of Santa Monica Boulevard and Avenue of the Stars at the intersection of the two Santa Monica fault zones mapped by MTA in the Century City Fault Investigation (Figure 39) (Geocon, 2013). It is fully impacted on the north and east sides by the broader zone of Santa Monica faulting as shown by MTA in its 2012 reports (Figure 28). The Westfield investigation replicated MTA transects on the west and east sides of the property. MTA relied primarily on CPTs with an average spacing of 40 ft. Geocon relied on continuous core borings spaced at 15 feet in open areas and 5 foot on center in areas of suspected fault (Geocon, 2013).

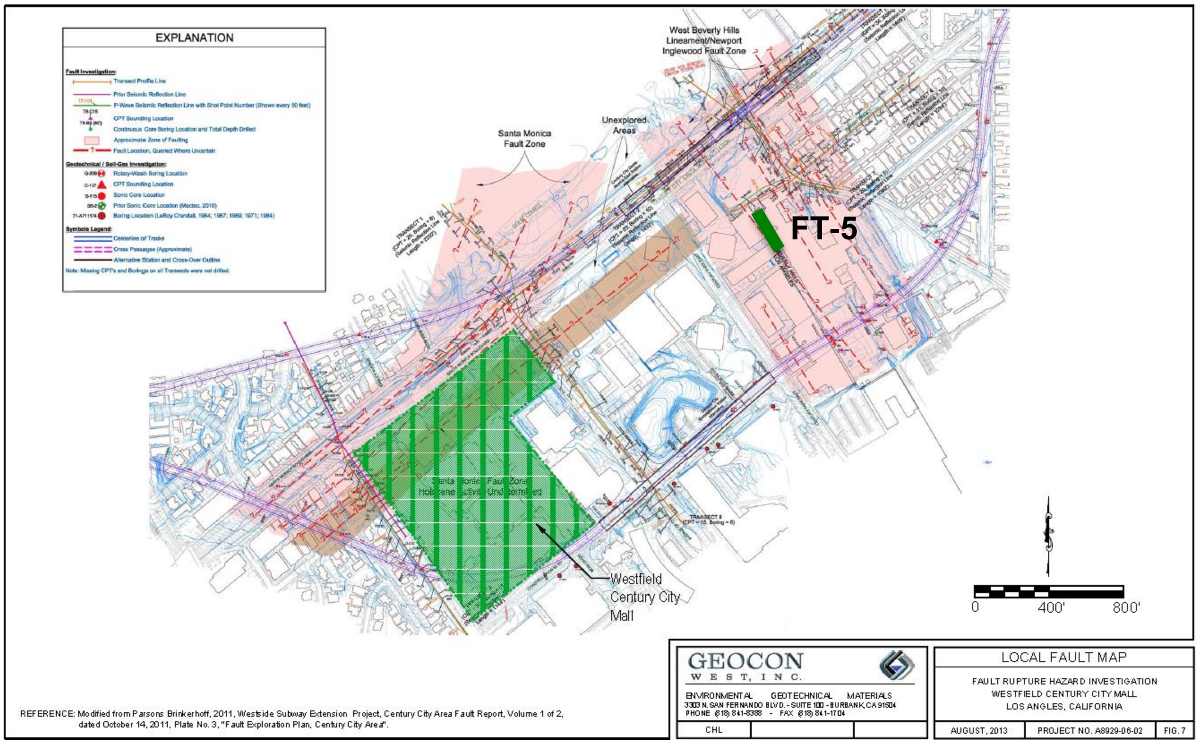

Figure 39: Geocon (2013) investigation of the Westfield site (green shaded area). Geocon investigated a zone of faulting running sub parallel to Santa Monica Boulevard and identified a fault zone with similar characteristics of faulting to that encountered by Leighton at the NE corner of BHHS in trench FT-5.

The Westfield investigation encountered a narrow zone of E-W trending Santa Monica fault strands south of Santa Monica Boulevard that were strikingly similar to the zone of faulting encountered by Leighton in FT-5 (Figures 35 & 36). Westfield's investigation concluded that it was the same set of faults. The majority of these are the faults shown in the grey shaded zone of the Active Fault Map (Figure 28) and considered by Metro as "Holocene Activity Undetermined." However a couple of faults in the northwestern corner of the Westfield site were identified as "active" by the MTA's PB (2011) investigation. The apparent continuity of this fault zone further disproves the MTA conclusion of major offset along their newly interpreted location for the WBHL west of the BHHS and the boundaries of the Leighton investigation (Figure 32). The Westfield investigation encountered an intact late Pleistocene layer over the entire zone of faults and they were able to identify minimum ages for the unbroken layers of between 34 and 127 ka. The minimum ages at Westfield were controlled by more recent alluvial scour and backfill from Brown Canyon, rather than the older Benedict Canyon alluvial deposits preserved at the BHHS site. If this is the same fault zone, as seems likely, then the older minimum age at the BHHS site (150-300+ ka) is actually the more accurate age for the last displacement. But whichever age is used, the most recent fault offset is clearly pre-Holocene in age, and the fault is no longer active.

The MTA internal reports argued that the Santa Monica faults encountered by Leighton at the NW corner of the campus were younger than 100 ka and therefore consistent with the MTA theory of a younger and much broader and active Santa Monica fault system.

> "Metro concurs with LCI's assessment that the major fault they discovered in their trench FT-5 is a continuation of the same fault observed in Metro subsurface and geophysical data farther to the west. This fault cuts through soil ~100,000 years old, demonstrating fault activity after that date, but the age of most recent activity cannot be determined from the LCI trench data due to the loss of younger geological strata through erosion and urban development." (PB, 2012).[2]

Actually, Leighton found that the faults were a minimum of 100 ka based on the unfaulted soil developing down into the fault zone (Figure 36) but construction removal of overlying deposits prevented a more accurate age for these faults. Integrating the results of the 10000 Santa Monica study however, indicates that the unfaulted layer (and last event on the fault) is at least 150,000 years ago, and perhaps 300,000+ years ago. These results are perfectly compatible with the minimum age of faulting determined at the Westfield site because of the larger temporal gap (unconformity) between the faulted sediments and their ~100 ka overlying, unfaulted sediments. Based upon the evidence, MTA's statement is misleading and wrong.

The Westfield seismic fault investigation was conducted under the regulatory control of the City of Los Angeles Department of Building & Safety, which subsequently approved the site for a ~$1 billion redevelopment – also immediately adjacent to an area that MTA has deemed unsafe for subway station construction.

A third project, 9900 Wilshire (Geocon, 2014) completed geophysical transects, borings, CPTs and three trenches to screen the property of active faults. Some faults were interpreted from the geophysics and boring and CPT data within the 9900 Wilshire property, but, if they even exist, these faults were all shown to be pre-Holocene based on undeformed strata correlated above them in the boring transects, and from unfaulted late Pleistocene deposits in the trenches that had screened most of the interpreted faults. The extensive trenches failed to find any faults. One trench ran along Santa Monica Boulevard and effectively extended the exploration range of the trench at 10000 Santa Monica. It was specifically intended to evaluate the active WBHL faults mapped by MTA that were east of the BHHS investigation area. This trench failed to find the faults in ~30+ ka sediments. Two other trenches were excavated perpendicular to Santa Monica Boulevard and were specifically intended to encounter any SMF strands in the "gap" between the Santa Monica Boulevard and the more northern fault strands mapped by MTA. This would be the area in which the latest MTA report insists the SMF is a "*much wider feature than previously known"* (MTA 6/30/13). These trenches also failed to find any faults in similarly-age sediments. The report did conclude that [potentially] active faults exist off-site to the northwest of the 9900 property. This conclusion was drawn from

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[2] This extract exemplifies the issue raised earlier in the first footnote. Although this extract was taken from a Parsons Brinkerhoff report, it is quoting Metro as the decision-maker. Does PB agree with this Metro opinion? Who is the person(s) at Metro that they are quoting? Who are the licensed geologist and engineer that are in responsible charge of this opinion?

mismatched stratigraphy as logged strictly from the cores and CPTs as no trenching was performed off-site. The report was approved by the City of Beverly Hills as to the absence of active faults through the 9900 Wilshire property but preserving in the public record the possibility of active faults off-site and encouraging further investigation.

A review of this finding is currently underway (LCI/ECI) and preliminary findings are that the stratigraphic correlations that led to the interpretation of active faults are flawed by assuming (as per the MTA report) that the alluvial stratigraphy is horizontal (dips of 4-6 degrees appear more likely) and by failure to recognize that the sediments are probably all pre-Holocene. Geocon (2014) assumed horizontal stratigraphy to interpret a fault between every boring off-site but applied gentle dips on-site to eliminate the need for faults. It also appears that Geocon (2014) assumed a consistent stratigraphic alluvial section completely across what is now the Moreno Creek (storm drain) without recognizing that there would be erosional trimming of the older sediments on the west side before backfill, identical to the case in Leighton's FT-2, illustrated in Figure 30. Instead, Geocon interpreted the probable geologic unconformity as a fault. An active investigation is currently underway across Wilshire Blvd to shed light on these 9900 Wilshire findings by employing additional core borings and trench excavations at the El Rodeo elementary school and duplicating the same borings within Wilshire Blvd. Preliminary findings are that there are no late-Pleistocene faults under the school buildings but the playground area is still being evaluated. CGS review of the trenches has occurred but final review of the boring core correlations is still pending.

Additional investigations are also underway across Century City and Beverly Hills in response to the MTA Century City Fault Investigation. To date, no other fault investigation has found a WBHL fault as predicted by MTA. To date, no other fault investigation has found an active strand of the Santa Monica fault as mapped by MTA. No faults, active or otherwise, have been found in these trenches to the depths they have been excavated. As they are all exposing mid to late Pleistocene sediments, and they remain unfaulted, it is clear that there are no Holocene active faults cutting through the trenches. Despite these continued and consistent findings that the MTA active fault map is seriously flawed, MTA itself has never retracted nor modified its active fault map, nor any portion of the Century City Fault Investigation report, and continues to argue that the entire Santa Monica Boulevard area remains unsafe for subway station construction based solely on an investigation that has been proven to unreliable.

THE KENNEY GEOSCIENCE INVESTIGATION

At the same time that the Leighton investigations of the BHHS campus were underway, the school district authorized a separate analysis and investigation by Kenney GeoScience (KGS). The school district became alarmed by the dramatic inconsistencies between the initial Leighton investigation at mid-campus and the MTA findings and repeated representations, and desired a separate, independent overview of everything. KGS was tasked with completing a stratigraphic analysis of the entire area, using all available information and data, and developing a structural model which could reliably explain the seemingly conflicting results generated by the MTA and Leighton. KGS also produced an independent geomorphic analysis of the Cheviot Hills to test the Dolan and Sieh (1992) model in 2012. This report concluded that the Santa Monica fault in Century City was likely dominantly strike-slip and not reverse, and that the "scarps" that Dolan and Sieh identified were not fault scarps, but instead associated with erosion along an old, now inactive fault zone by a now abandoned westerly flowing Benedict Canyon drainage. KGS (2012) also suggested that the Hollywood fault may cross the WBHL as a blind structure in the northern Cheviot Hills.

Figure 40: Parking lot side-by-side core comparisons were ultimately conducted to include every core taken by Leighton and many of the MTA cores. Reviews were conducted by full peer team of BHHS consultants, plus CGS and City of Beverly Hills as regulators, and also included AMEC representatives (who took the core samples for MTA). MTA boring logs were corrected and amended to reflect group observations. Visible team members are from CGS and Leighton.

KGS prepared two interim reports, one released in May 2012, and the second in May 2013. The final report was completed July 8, 2014 KGS, among other steps, did a detailed side-by-side comparison (Figure 40) of every core boring made by Leighton and every core boring made available by MTA. KGS also had access to several private party investigations in the area plus extensive soil dating work from the BHHS site as well as other locations across the study area. KGS assembled all of this data to construct a detailed reinterpretation of all of the MTA cross sections to develop a detailed stratigraphy and structure of the area that was internally consistent across all of the transects. The MTA geophysical data for the area were also reinterpreted with the assistance of Legg Geophysical.

The KGS reports make several important observations. MTA had identified several clay-rich marker horizons within the subsurface stratigraphy that were actually paleosols (buried soils) capping large stratigraphic units. In many cases, MTA had these layers forming the base of stratigraphic units, when in reality, the layers were capping the lower unit and demonstrating a temporal gap in the sedimentation sequence. By recognizing these layers as paleosols capping grossly upward fining sedimentary packets, KGS was able to consistently identify and correlate these soil capped alluvial sequences between the various borings for the area. This allowed KGS to redo all of the MTA transects in the area using an internally consistent and geologically coherent stratigraphic profile. Once the stratigraphy became defined, KGS was able to build up an overall model that identified the various geomorphic and tectonic elements that have temporally defined the Century City area, particularly the impacts of Benedict Canyon and Brown Canyon washes, and use those elements to constrain (location and time) the structural features that have deformed them. KGS issued an interim map in 2013 that showed the multiple fault traces interpreted from all of the available data (Figure 41).

The map and its accompanying analysis is striking in what it did and did not find. KGS, using different methodologies than those used by Leighton, confirmed the absence of WBHL faulting at BHHS. KGS did interpret several other faults further to the east of the WBHL (Fault Zone H in Figure 41), but also concluded that these faults did not penetrate soil layers at least 450 ka, which is not consistent with the Holocene active WBHL/NI fault system proposed by MTA. KGS predicted the location of a fault through the area of Leighton's FT-5 trench, and that this fault would extend westward to the Westfield Mall site. KGS predicted that this fault would deform sediments as young as 200-300 kya and die out after that, which is exactly what was observed and documented by the Leighton-BHHS and Geocon-Westfield investigations. This field verification of the KGS interpretations is important and in total contrast to the lack of any field verification of the MTA interpretations. The verifications establishes that KGS' enhanced correlation methodology works and should be considered by MTA. But it has been ignored by MTA, and, again MTA stands silent.

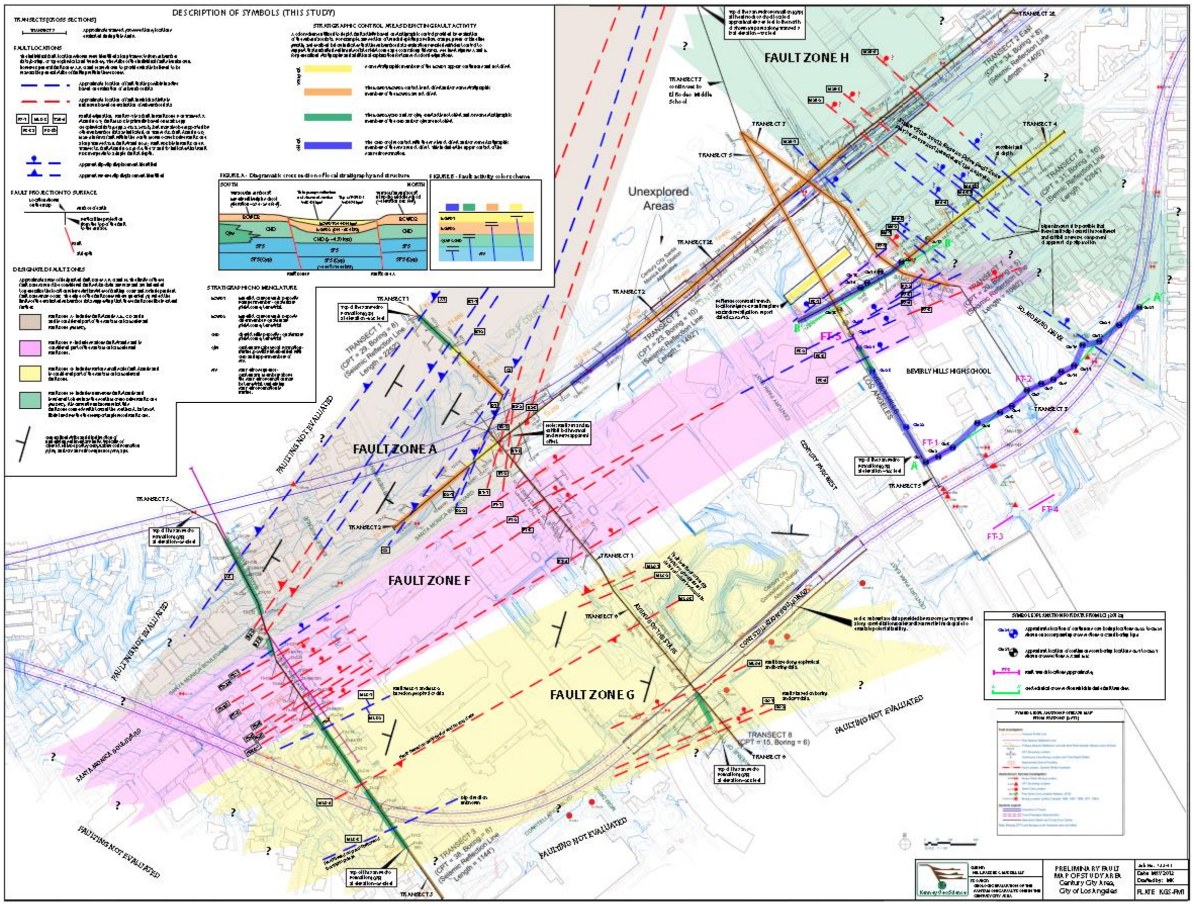


Figure 41: Kenny GeoScience fault map from the May 2013 interim report. KGS interpreted new zones of faulting that intersects the Constellation station (yellow shading) as well as a zone of faulting lying to the east of the BHHS (green shading).

In the Santa Monica Boulevard area, KGS interpreted many of the same fault strands mapped by MTA (KGS Fault Zones A and F – Figure 41) but with subtle differences.

- KGS proposed that faults MTA's PB (2011) had identified as associated with their proposed north-northwest WBHL fault zone were in fact part of the east-northeast trending Santa Monica fault zone. KGS' hypothesis was confirmed by fault trenching conducted by LCI (FT-5; 2012).
- KGS confirmed the general orientation of the northernmost zone of faulting (Fault Zone A), but observed that there was insufficient data, and no MTA effort, to correlate these fault strands with fault strands identified in the transect to the west (Kenny's Fault Zone F). This interpretation separates the fault structures rather than simply making them one fault zone that bends to the north. While there does not seem at first blush that there is much difference, there is. When faults bend, they generate a different topographic signature. If, as assumed (Dolan et al, 2000), the Santa Monica fault is dominantly a left-lateral strike slip reverse fault (oblique), then the northward bend in the fault, as drawn by MTA, should result in a substantial depression on the west side of Fault Zone . But there is not. Instead, there are the same

"scarps," now oriented more northeasterly. This is not possible for a left-lateral strike slip fault, and establishes that the MTA model is incorrect, and that KGS Fault Zones A & F are structurally and probably temporally disconnected. However, KGS also points out that the dip of the faults in Fault Zone A still remains unknown. Hence, if these faults dip toward the southeast, then left-lateral motion across the local Santa Monica fault zone could still produce the local scarp but associated with normal and not reverse faults. In any case, the KGS findings suggests that Fault Zone A and F may be separate structures. The bottom line is that the varying interpretation options indicate just how complex and poorly understood some of the fault systems remain.

- KGS (2013) determined based on a geomorphic analysis of the Cheviot Hills fan system from the base of the Santa Monica Mountains to their southern end, that the Santa Monica fault in the Cheviot Hills is not reverse, but likely a dominantly strike-slip fault zone. This is a contradiction to the generally assumed left-lateral reverse. Subsequent evaluation of the subsurface data in Century City seemed to confirm this hypothesis. Hence, this finding raises many new questions regarding the real location of the basal Santa Monica fault, or if the Santa Monica fault system, and including the Hollywood fault system even accommodate compressional strain.
- KGS discovered that MTA PB (2011) had assumed that the local sediments in the Century City area were horizontal, and therefore not dipping. This was significant for a number of reasons. First, this assumption by MTA PB (2011) led to the interpretation of numerous faults because the correlated units did not line up. However, if the units are assumed to have a gentle of dip of 3 to 4 degrees, then the units line up quite well without the need for interpreting faulting. Additionally, the assumption by MTA PB (2011) that the local stratigraphy was horizontal indicates that MTA was assuming that faulting, and not folding, likely produced the uplift of the Cheviot Hills even though numerous publications including Hoots (1931) indicated that folding was likely occurring in the Cheviot Hills.
- KGS interpreted multiple faults in the MTA transects at Century Park West and Avenue of the Stars that MTA did not include on its fault map for reasons unexplained by MTA. These faults appear in both the MTA geophysical interpretations and in its CPT correlations with the same characteristics that MTA elsewhere defined as active faulting. KGS interpreted a new fault zone trending SE across Century City and intersecting the MTA Constellation station (Fault Zone G). There was no discussion in the MTA PB (2011) report as to why these geophysically-interpreted faults were not shown on MTA's published fault map.
- KGS also concluded that the soil dating and stratigraphic information available indicated that many of the Santa Monica faults in the Century City area do not breach soil layers with a minimum age of late Pleistocene, and therefore pose no further hazard. KGS was consistent to point out that its data and interpretations were indicative of inactivity, but lacked sufficient

resolution to absolutely determine that the faults in question are or are not active.

- KGS also concluded that all of the faults along Santa Monica Boulevard share secondary fault characteristics not consistent with a primary Santa Monica fault, and they do so for a considerable distance to the west, perhaps all the way to the VA Hospital investigation site 2.5 miles to the west where only secondary faults were encountered (Dolan et al., 2000). KGS noted that none of the MTA investigations in Century City or by anyone else to the east of the VA Hospital investigation site have encountered a Santa Monica fault strand displaying the common characteristics of a primary fault. KGS postulates that the basal Santa Monica fault, although not yet detected, must turn to the SE and probably misses Century City altogether.

The KGS report, and the system of stratigraphy and associated dating in it, has been used by other investigators in the area. At BHHS, Leighton confirmed the structural and stratigraphic interpretations by KGS in Leighton's trench FT-5 excavation within the KGS Fault Zone F. At Westfield, Geocon (2013) used the KGS stratigraphy as the basis for its investigations and its conclusions. Geocon also used the KGS reports for their analysis at 10000 Santa Monica (Feffer-Geocon, 2012) and at 9900 Wilshire (Geocon, 2014).

THE MTA RESPONSE

What has been the MTA response to the series of reports and investigations that have challenged, contradicted, and generally disagreed with the conclusions presented in the Century City Fault Investigation (PB, 2011)? Again, MTA stands silent. MTA has never revised, retracted or otherwise qualified its active fault map (Figure 2). Instead it has issued a series of reports or memoranda that have challenged the various new findings, though never with any new data. Note that MTA has maintained this position even though several of MTA's consultants participated in and confirmed the interpretation of the BHHS investigation data.

- As discussed above, when the initial Leighton mid-campus investigation failed to find the WBHL faults plotted by MTA, MTA thanked Leighton for helping to refine the fault locations, and issued a report that adjusted the location of the faults to small gap areas that were inaccessible to Leighton's trenches, and insisted that their proposed WBHL zone still existed in the area suggested by the MTA (PB, 2011) report, and remained an active fault zone. This response completely ignored the overwhelming data supporting a lack of faulting shown by the boring correlations across these small gaps.
- When the initial Leighton mid-campus investigation raised a serious challenge to the concept that the WBHL is associated with a fault zone, MTA offered up to CGS a new theory, purportedly based on a contour analysis (inaccurately using Leighton's data) that MTA claimed indicated a 300-foot offset along one of the MTA mapped faults – a fault located just west of the BHHS property line, and under a high rise building in an area that could not be investigated by Leighton.
- When Leighton issued its second report detailing its attempts to replicate the MTA transect 4 data and detailed divergences between the MTA CPT data and interpretation and the Leighton borings and interpretation which identified a lack of faulting across the northern end of the BHHS campus, and eliminating the possibility of the 300-foot offset fault by using MTA's own offsite boring, it went without any acknowledgement by MTA. MTA has never acknowledged the systemic errors and interpretation errors uncovered by Leighton, and confirmed by CGS, on Transect 4. MTA also has never acknowledged even the possibility that since it applied the same drilling, logging and interpretation techniques across its entire investigation that other areas of its investigation may be similarly flawed.
- In response to the second Leighton report, MTA conducted an internal review that reached the following conclusion:

  > "The new Leighton trench data from Beverly Hills High School, however, indicate that the Santa Monica fault zone is a much wider feature than previously known. Thus, it is possible that the fault strands beneath Santa Monica Boulevard in the vicinity of South Moreno Drive could be associated with the ENE trending Santa Monica fault zone, rather than the NNW trending Newport Inglewood fault zone." (MTA, June 2013)

- When Leighton issued its third report that found an inactive fault strand traversing the northern edge of the campus and parallel to Santa Monica Boulevard, the MTA rationalization became:

  > "The eastward widening of the Santa Monica fault zone revealed by the new LCI trench data confirms that the Santa Monica fault is actually a wide zone of active and potentially active fault strands extending sub-parallel to Santa Monica Boulevard." (MTA, May 2013) MTA went on to say: "The LCI observations and investigations do not extend beyond 100 feet north of the northern portion of the Beverly Hills High School campus, and the LCI report and CGS letter do not address the presence of faulting at the previously considered station sites along Santa Monica Boulevard." (MTA May 2013)

- There is no explanation of how this could be so. MTA is referring to its Transect 2-2E, which runs along Santa Monica Boulevard and is less than 300 feet north from Transect 4, which interpreted the very same WBHL faults as shown on Transect 2 by using identical boring and interpretation methodology. Rather than considering those faults to be suspect, MTA simply reoriented all of them 90 degrees on Transect 2 and relabeled them to be Santa Monica faults – with no evidence to support that change and despite the fact that this conclusion is sharply at odds with MTA's own findings on Transects 1-8, 2E, and 7.
- Particularly troubling is the continuing MTA assertion that the failure of Leighton, Kenney GeoScience, and Geocon (10000 Santa Monica, Westfield, and 9900 Wilshire) to actually find an active strand of the Santa Monica fault simply means that there must be an active Santa Monica fault strand somewhere else, "*because it must be in the area somewhere*." The fact is that there is no evidence of active faulting in this area of Century City and Beverly Hills and plenty of evidence to show that any faults that have been found have been inactive for hundreds of thousands of years.
- The MTA's former WBHL fault zone, now-Santa-Monica fault zone claimed by MTA to lie under the Santa Monica station site, would have to cross the 10000 Santa Monica site and the 9900 Wilshire site. The borings and trenches on both sites failure to find any faults from either the Santa Monica or the WBHL faults in 300+ kya alluvial deposits would seem to kill the last theory. However, MTA continues to this day to insist that the Santa Monica east station is underlain by active faults. (MTA court filings, December 2013).
- When the KGS interim report was issued, MTA noted the Fault Zone H identified by KGS (Figure 41), and declared that this was evidence that the WBHL fault zone is in fact real and a part of the Newport Inglewood Fault Zone. Left unaddressed by MTA was the KGS observation that the majority, and perhaps all, of the fault strands inferred in Fault Zone H do not breach a soil layer with an estimated age of 250-450 ka. Toward the east, KGS inferred faults with younger minimum ages, but cautioned that the data in this area was limited, that the fault ages given were minimums, that there is no geomorphic expression of these faults on the Benedict Canyon fan surface, and that the faults are probably substantially older than Holocene. This age

does not seem consistent with the Holocene age activity of the Newport Inglewood fault zone seen in the Baldwin Hills. Also unaddressed by MTA was that none of these faults run anywhere near the Santa Monica station location.

- When the KGS interim report was issued (KGS, 2013), MTA continued to defend the conclusion that there was no faulting at the Constellation station. MTA has variously said that the faults identified by KGS do not exist, or that they exist but are inactive (with no supporting investigation), or that they are disproved by other means. MTA has failed to undertake any investigation of the site.
- In its formal response to the KGS interim report, MTA stated that KGS presented no new information and that there was no evidence of faulting at the Constellation site and that the Santa Monica station site remained unsafe. In an effort to support this conclusion, MTA presented three photos of a 1960's vintage construction excavation annotated to show that the exposed continuous stratigraphy does not allow for faults to be present. These photos are discussed later in this paper, but it is clear that the MTA statement is unsupportable and widely divergent in geologic rigor, as has been required in all other investigations to refute MTA's active fault map.

In summary MTA has failed to edit, modify or retract any portion of the fault investigation it so publicly issued almost three years ago despite the expenditure of millions of dollars in geologic investigation by other parties and the steady and consistent flow of hard data that directly contradicts its methodology, findings, conclusions, and decisions. Any party operating under CGS oversight would be required to revisit the conclusions under these circumstances.

DISCUSSION

The result of the MTA fault investigation report and the manner of its very public release led to the unexpected and unwelcome expenditure of millions of dollars by the BHHS and other affected property owners, and created extensive permitting delays on several properties in the City of Los Angeles and the City of Beverly Hills until the owners could address this new fault concern. Meanwhile, MTA used the findings of its fault report to change the preferred and locally supported subway alignment on Santa Monica Boulevard to an unpopular and controversial location on Constellation Boulevard.

The finding by BHHS that the faults mapped by MTA through the school do not exist came as welcome news to the school's Board and community leaders. Similar findings by other affected property owners and developers are still coming in, but to date, none of them have found active faults through their properties as interpreted and mapped (Figure 2). The consistent refuting of the MTA active fault map is alarming.

The proposed WBHL fault zone started its life as a hypothesis, and became a foundational element for many structural geology papers, which led to it becoming an established fault, then an active Holocene fault, then an MTA investigation target, then a reason to relocate the Westside subway station, then a serious hazard for BHHS to quantify, and … <u>it does not exist as a fault</u>. The pathway to this error is very clear:

- The WBHL became a fact because of its initial hypothesis being accepted without evidence.
- Numerous published papers simply accepted the WBHL as a fault, and eventually as a Holocene fault due to its assumed connection with the active Newport-Inglewood fault to the south.
- When the MTA studies were being conducted, the presence of WBHL faults was anticipated, so it was easy to interpret even minor, stratigraphic irregularities as faults within the zone anticipated to contain the WBHL fault zone.
- The Santa Monica fault zone was presumed to extend to the area based on an intermittent series of scarps. When faults were interpreted near the scarps, they were presumed to confirm the theory.
- The Santa Monica fault was presumed to be active without any local evidence and based solely on the presumed extension of the Santa Monica fault into Century City.
- When the presence of faults was interpreted by MTA, the faults were presumed to be active, without any consideration of sediment ages or alternate theories.
- The client developed and expressed a strong preference for the reported outcome, which became politicized and may have compromised the investigation/interpretation process.

In hindsight, it is easy to see how the investigation was distorted and its conclusions distorted – an important caution to every investigator on the perils of embracing a single theory too early and too strongly. But other professionally challenging issues are raised by the MTA investigation methodology, report preparation and release and follow-on actions. They range from technical quality issues to larger questions of appropriate policy, investigation and procedure, including:

- The failure to record the tip angle in the CPTs to be able to correct for non-vertical probe deflections due to the type of sediments being explored and construction of resulting anomalies as faults. When coupled with the relative scarcity of continuous core borings, there was no ability to detect the misinformation.
- The failure to do core by core "parking lot" comparisons to ensure consistency in boring logs and their interpretation. Even competent loggers often detect subtleties and differences in assessment between the first and last boring that requires revision to early logs. Side by side comparisons frequently reveal subtle patterns not readily obvious in individual cores.
- The presumption that any change in strata elevation between holes reflected a fault, to the apparent exclusion of all other natural geomorphic or stratigraphic explanations.
- It is almost impossible to evaluate the competence and accuracy of boring logs without actually viewing the cores themselves. However, there is no evidence that the people who wrote the fault report or made the public presentations ever directly viewed a single core.
- When a fault was interpreted it was drawn essentially perpendicular to the transect line, despite having no trend (strike) information from the 2-D transect.
- One zone of presumed active faulting was "bent" northward without any supporting confirmation. The bending compromised a station location without compromising adjacent high value properties. There was no data to support it.
- The interpreted faults were extended long (but seemingly random) distances from the transect locations from which they were interpreted, and as such they impacted numerous high-value properties.
- Faults were labeled as "active faults" because of the paradigm within which they were modeled, despite having no age control on the sediments that were interpreted as offset.
- MTA (PB, 2011) dismissed the idea of trenching or other forms of confirming the actual existence of proposed fault zones and their activity level as impossible due to the built up nature of Century City, buried utilities, and other expected disturbances of Holocene era soils. Hence, MTA made no effort to actually reveal any interpreted/proposed fault. They were simply assumed to be real.
- MTA (PB, 2011) reveals no effort for age dating any stratigraphic unit or geomorphic surface. It also did not even discuss the age of the preserved

fan terraces in the area. Had it done so, it likely would have been quickly apparent to MTA how old the faults (if present) could be.

- Some faults interpreted from the CPT electronic signature, geophysical lines, and core interpretations were excluded from the active fault map based solely upon the paradigm in which they were modeled.
- It is clear that some of the MTA CPT and boring locations were not located properly on the MTA transects and fault map.
- The Santa Monica Fault was presumed to run across the north side of Century City although all of the faults detected by MTA along Santa Monica Boulevard display secondary fault characteristics, and a MACTEC (2010) geophysical line detected a primary fault to be present to the south. This primary basal fault identified by MACTEC, working for MTA, was never included on the fault map.
- The closest direct observation of (inferred; 3-17 ka) active faulting was over two miles away to the west (Pratt et al., 1998; Dolan et al., 2000), with inadequate data to show that the active faulting observed even extends to Century City. Instead, continuous faulting has been presumed by the presence of intermittent escarpments – despite a substantial body of investigation that has failed to encounter faulting predicted by those escarpments.
- The MTA failed to discuss why it proposed that the faults along Santa Monica Boulevard in Century City did not exhibit a reverse component of slip when MTA was proposing that this fault zone is the same reverse left-lateral Santa Monica fault zone as identified at the VA Hospital west of Highway I-405. This issue is very important because if the faults in Century City are not in fact the mapped Santa Monica Fault that was exposed to the west, then it implies that the two fault zones may not share the same activity level.
- It has never been explained how a fault, assumed to be a left-lateral oblique reverse fault based on en-echelon stepping “fault scarps” can be formed by the lateral slip faults near the base of the scarp, while the thrust fault lies well to the south where it produces no topographic expression. If the paradigm does not fit the actual structural data, the paradigm should be redone.
- Instead, MTA presumed that the intermittent “scarps” along Santa Monica Boulevard were the result of underlying tectonic motion to the exclusion of all other explanations. Evidence of alternative explanations was ignored. For example, cross sections perpendicular to the presumed faults correlated with soil dating indicate that both sides of the presumed fault are consistent with a gradual alluvial fan slope displaying little or no vertical displacement on either side of the presumed fault relative to the overall slope line, indicating that the escarpment could easily be the result of erosion. Kenney GeoScience presented these data and interpretations as far back as 2011, but MTA ignored it.
- The WBHL was also presumed to be the result of faulting related to the Newport-Inglewood fault zone to the exclusion of all other explanations – like the very well defined Benedict Canyon Wash running along the edge of the WBHL and clearly eroding into the WBHL deposits.

- No faults shown on the Active Fault Map were ever directly observed by any of the geologists involved in the study. None. An urban area with billions of dollars of development and tens of thousands of people was seismically compromised without a direct observation of a single fault.

It is the responsibility of the consulting geologists to prepare maps for their clients, and sometimes those maps contain alarming new hazard information for their clients and the community. However, the manner in which this Active Fault Map was prepared, used, and released has had serious repercussions for the Century City and Beverly Hills communities. Its accuracy has been refuted at BHHS and at several surrounding properties, yet MTA has never modified or retracted its Active Fault Map. That it was used to reroute an already long planned subway route, and that its geologic basis for that route change has now been confirmed to be wrong, should cause MTA to publicly disclose the flaw and reconsider making that route change. And lastly, the claims that faults do not impact the newly proposed Constellation Station because geology shows this to be a fact, appear to be based upon the same geologic errors that led to the WBHL mistake.

MTA/PB Transect 4 (Figure 26) at the north end of BHHS interpreted faults of the WBHL because of vertical stratigraphic irregularities in the CPT data and the presumption that faults needed to reside there. MTA/PB assumed horizontal stratigraphy and failed to consider any other possibility for the miss-matched layers other than faults. Simply correcting the interpretation to reflect a 3-4 degree NE dip to the alluvial sediments would have been an essential alternative hypothesis that should have been considered, but it was not. Had it been considered, most of the "faults" would need to have been removed (Figure 34).

Now consider the MTA cross section which includes both the Constellation station and the middle portion of BHHS (Figure 42). In the portion of the cross section that underlies the Constellation station, the section shows significant folding of the alluvial deposits, and does not interpret any of it to be due to Holocene faulting.

However, in making this determination, MTA mis-plotted the location of some of its own marker beds and contacts relative to the true location on the boring logs. Then, in the portion of the section that underlies the BHHS, MTA reverts to the presumption that any change in stratigraphic elevation is evidence of faulting, and must be presumed to be active. There is no explanation given for the disparate treatment. However, the practical implications are obvious: the interpretation avoids the identification of faults under the Constellation station location, while finding faults at Santa Monica Boulevard to support the route change to Constellation. This inconsistency in the basis for MTA's interpretations is alarming. When the MTA Board was made aware of these issues in the March 2012 public hearing, separately by both ECI and KGS, the MTA Board chose to ignore them.

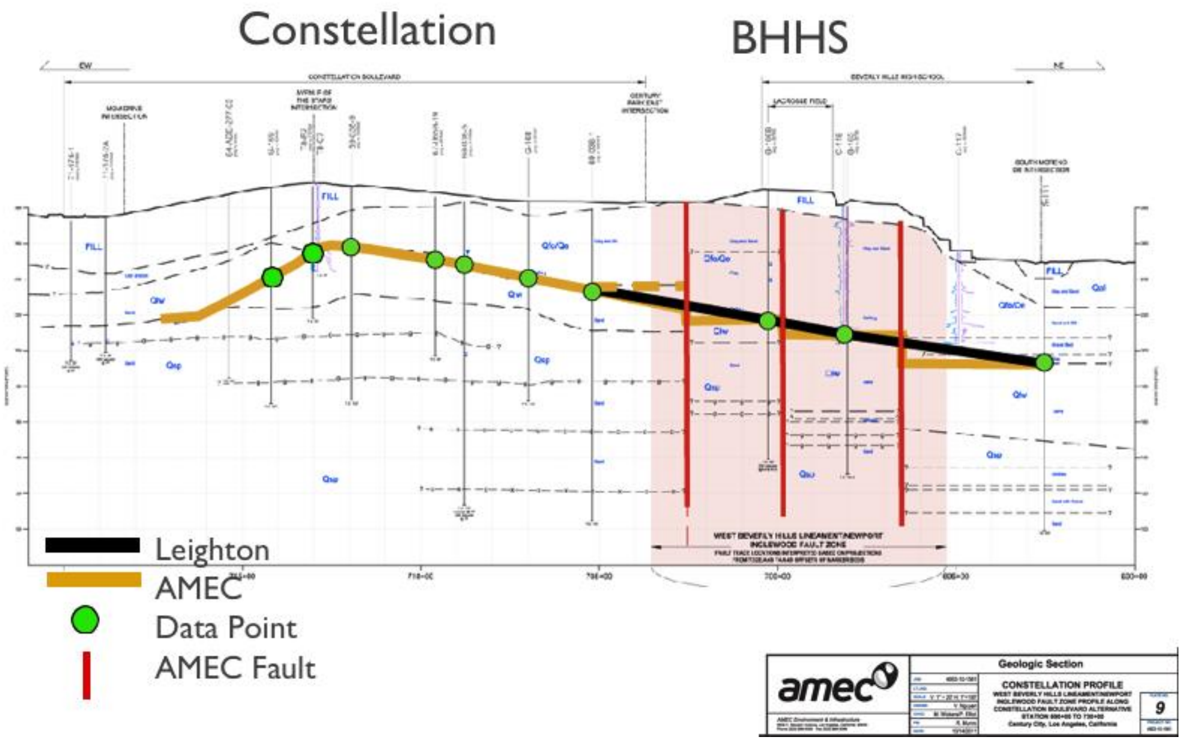


Figure 42: MTA/AMEC's Constellation transect, showing the inconsistency in geologic interpretation along their own transect. The heavy brown line is the top of the San Pedro contact. The profile was constructed using mostly older geotechnical borings, not continuously cored borings or supplemented with dense CPTs as were done for the Santa Monica Boulevard station. MTA/AMEC assumes that the alluvial deposits under BHHS are horizontal and so they interpret a fault between almost every data point. However, throughout the Constellation area they assume that the sediments are anticlinally folded and so no faults are necessary to the interpretation. There is no technical justification for such blatantly disparate treatment. Not discussed is whether the folding through the station is Holocene in age, nor whether it poses a hazard to the station design.

MTA's data generation and analysis for the Century City Fault Investigation are also different – again without reason or explanation. The Santa Monica station site was extensively investigated by MTA. However, the Constellation site was practically ignored: in contrast to its investigation of the Santa Monica site, there was not a single continuous core boring and only one CPT within the entire Constellation station footprint (Figure 43).

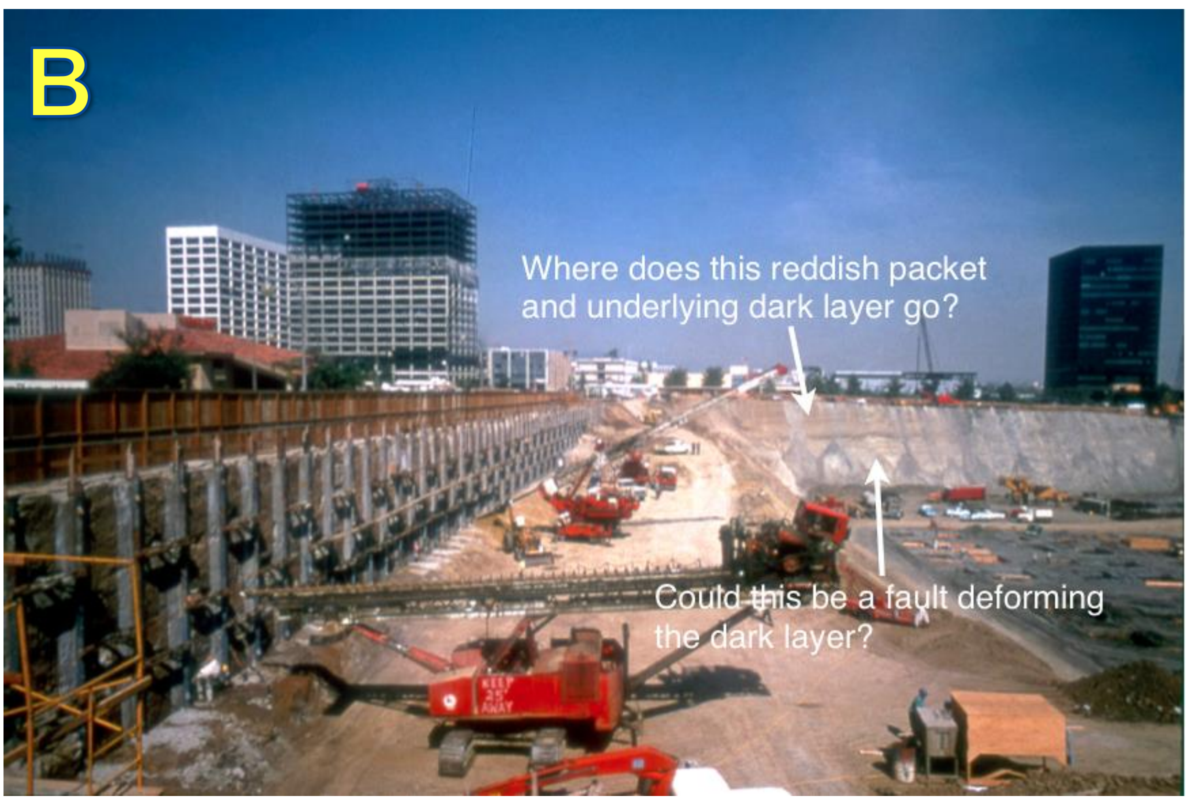
MTA Geo Investigations	Constellation Station	Santa Monica Stations	BHHS Campus	Other Areas
Continuous Core Borings	0	20	5	68
Cone Penetrometer Test (CPT)	2	58	28	229
Rotary Wash Borings	2	4	6	7
Sonic Core Borings	0	1	1	2

Figure 43: Summary of MTA investigation by area. The Santa Monica station includes two sites, so should have a higher number of investigation points. Note the absence of testing at the Constellation station site. Other areas include the various transects beyond the station boundaries. Note the quantity of testing done at BHHS by MTA – even though it was nowhere close to either station location. Numbers aggregated from the MTA Century City Fault Investigation report (PB, 2011.)

MTA concluded that the Constellation site was seismically safer than the Santa Monica site because there was “no observed faulting” at the Constellation site. As the discussion above indicates, MTA disregarded boring evidence that would otherwise have been considered evidence of faulting. There are “data gaps” in the MTA Transect T1-8 that influenced KGS’ the ability to identify potential faults that would intersect Constellation Blvd. There are also clear interpretations of faulting in the geophysical transect that intersects Constellation. Although reported as faults by the geophysics team, the faults were omitted from the final map without explanation. KGS has also carefully correlated the few MTA continuous cores located on the Transect 1-8 along the Avenue of the Stars and has interpreted some faults that intersect the Constellation station or are located close to the Constellation station. Some of these faults were initially identified by MTA (PB, 2011), but they failed to plot them on their fault map. The KGS evaluation determined that there is stratigraphic evidence of faulting that correlates well with the geophysical interpretations (Figure 41, Fault Zone G). These faults may or may not be active as the data is inconclusive, but the evidence for the presence of faulting is as strong as the evidence used by MTA to identify active faults elsewhere.

MTA has disputed the KGS conclusions based primarily on its photographic analysis of basement construction. MTA has provided the following three images (Figure 44, a-c). The images are made from low-resolution 35-mm slide reproductions taken during construction, and cannot be enhanced more than shown here. As such, it would be impossible to use these images for any definitive statement about the absence or presence of faulting.


A
Where does this reddish packet
and underlying dark layer go to
the right?
You cannot reliably correlate
anything in this area.
What is causing this vertical
"fracture" pattern? Faults?


B
Where does this reddish packet
and underlying dark layer go?
Could this be a fault deforming
the dark layer?

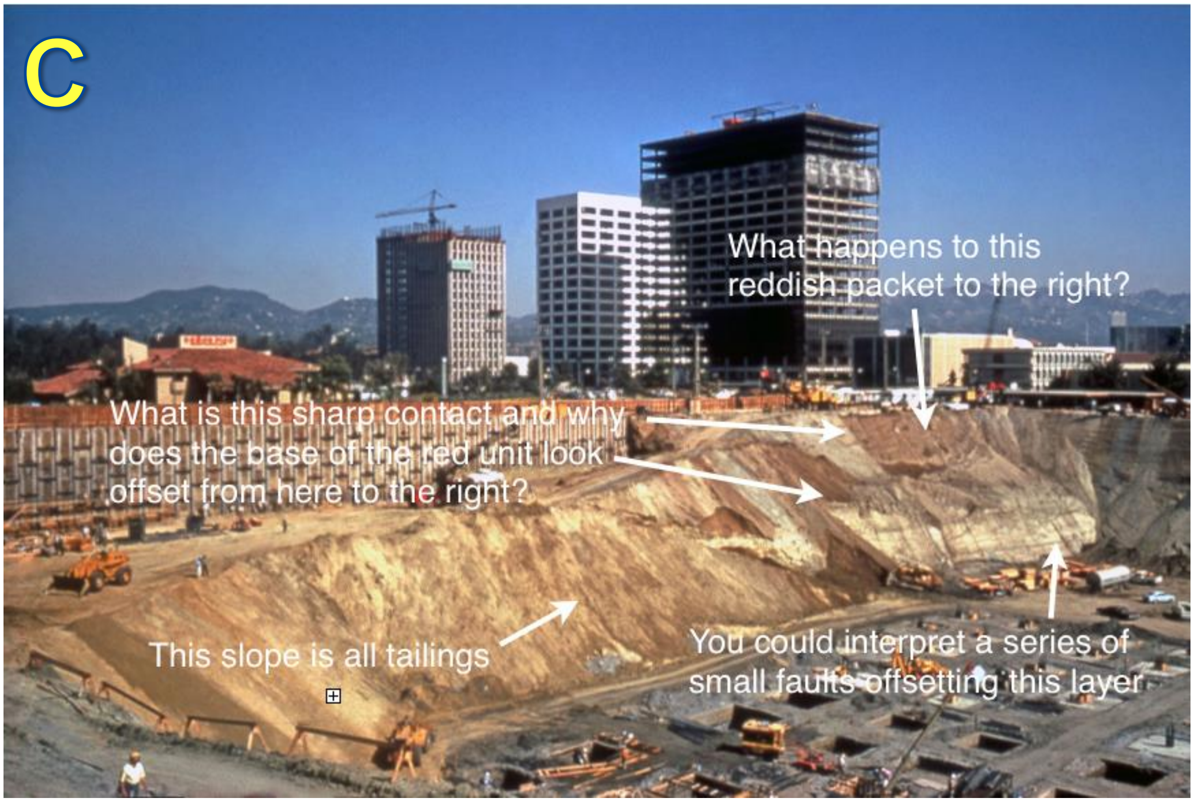


Figure 44 a-c: Three photos (a-c from top to bottom) reprinted from 35mm slides taken at an indeterminate time during building foundation construction at a site immediately south of the Constellation site, and used in support of the geological conclusion that there are no faults through the Constellation station site. The KGS faults, assuming their orientation was accurate, would appear under the foremost drill rig in the second picture and under the loader in the third picture, passing through a part of the excavation that is totally covered by a retaining wall. The first picture is looking at the excavation corner furthest from the mapped KGS fault location, more than 1,000 feet away. Only a scant percentage of the excavation is exposed well enough to provide any information. These photos are totally inconclusive to support any conclusion regarding the presence or absence of faults.

Large-scale stratigraphic packages appear to disappear across the cut face, much of the slope is obscured by tailings or lagging, and as one can tell from using the vehicles for scale, only features of +3 feet can be reliably discerned and mapped on the slope face. Several of the faults interpreted by PB on the BHHS Transect 4 have vertical separation offsets of only a few feet, and MTA and the CGS expressed considerable alarm over features that contained only inches of apparent offset in Leighton Trench FT-2 across the front yard area of the high school. Nothing in these photos would be discernable at that scale, and it again demonstrates the difference in rigour between the PB studies of the Santa Monica Blvd station locations versus the Constellation station site.

The three photos (Figure 44, a-c) are the only construction photos or documentation made available by MTA. But, MTA has used these photos to specifically rebut the KGS interpretation of faults within in Fault Zone G (Figure 41). Note that the faults inferred by KGS have a vertical displacement of approximately 1-5 feet, similar to many of MTA's faults on Transects 2, 4, and 7 that were affecting the BHHS campus. The photos clearly cannot confirm or deny the presence of the inferred faults.

Similarly, MTA has urged that its investigation was supported by over 80 borings obtained from private party investigations in the area (Figure 45a). MTA has released only a handful of these reports, but the following observations apply. None of the reports provided by MTA were detailed fault investigations – because at the time that these reports were completed nobody believed that there were any faults in their area. As MTA has confirmed (PB May 2012), only a few of the borings in Century City in this era were sufficiently deep to encounter the San Pedro formation. It is unlikely that any of the borings used continuous core sampling; the handful of boring logs released were shallow, had recovery ratios of approximately 25% and were only logged every five feet, appropriate to geotechnical purposes – but not nearly enough information to identify or clear a site of active (or inactive) faults. MTA has not provided any report which would support its investigative conclusions.

As for the value of construction excavation observation in noticing and evaluating faults revealed during excavation, reference the map of deep basements in the Century City area provided by MTA (Figure 45b). Note that none of the six deep basements on the south side of Santa Monica Boulevard noticed the Santa Monica fault strand passing through them – the same fault mapped by MTA and now indisputably identified by Leighton (LCI, 2012b) and Westfield (Geocon, 2013), though also shown to be inactive. If all six of those excavations failed to notice a very significant and obvious fault structure, labeled a “major fault” by MTA, why should MTA presume that other excavation observations (all done by the same firm) are more reliable?

Figure A-3: Past and Current Boring Locations, Century City Area

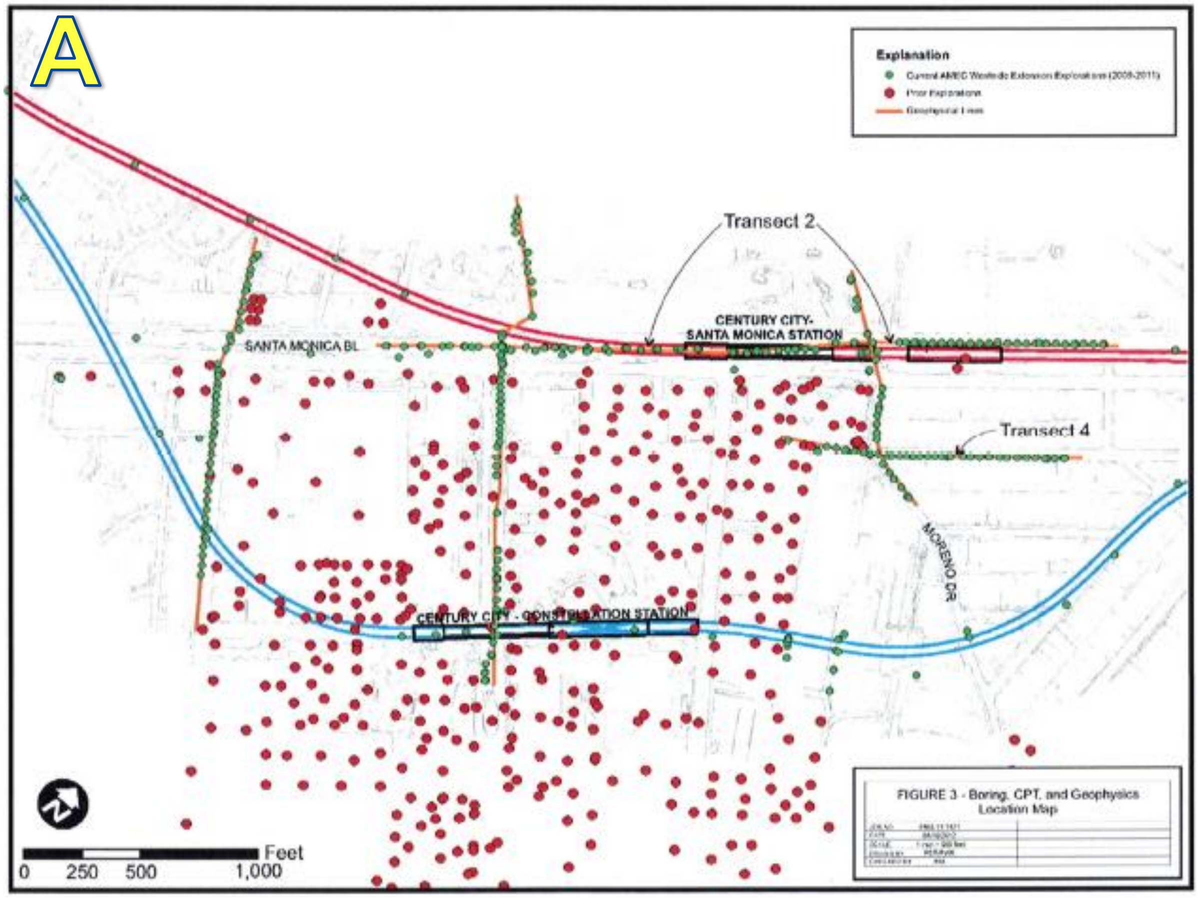
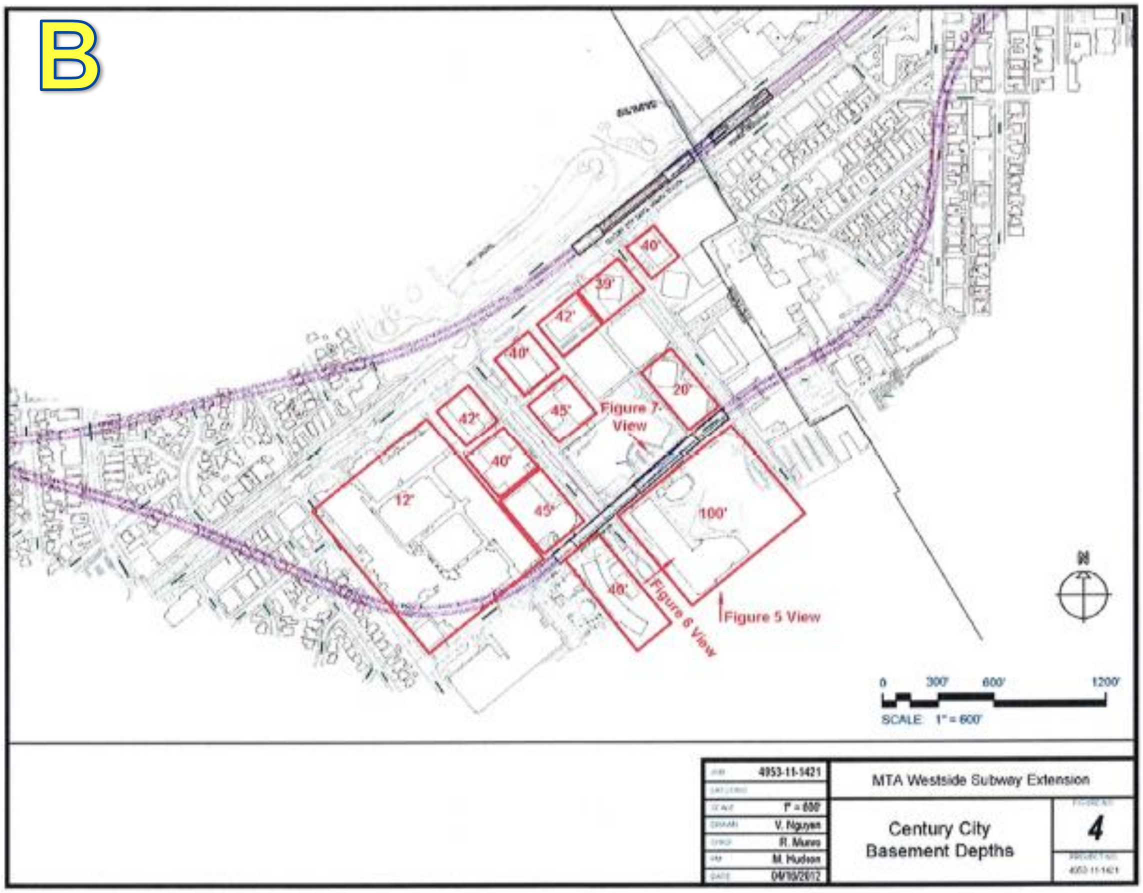


Figure 45a (above) and b (below): Maps of private party borings and basement excavations in the Century City area (PB April 2012). MTA has repeatedly made the claim that this data significantly augments investigations made by MTA. MTA has made only a portion of the associated soils reports available. Note that six of the deep basements are located immediately over the faults found south of Santa Monica Boulevard. The presence of these faults was confirmed by the Leighton trench and closely spaced borings at Westfield in addition to the MTA evidence. There is little doubt that the fault is present. However, none of the basement excavations or their associated investigations even noticed the fault.

Figure A-4: Deep Basements & Underground Parking



The single most troubling aspect of the fault investigation and its very public release was the fact that MTA issued the report without exposing a single fault. Every fault shown on the map was inferred, with very little control or other efforts to confirm the interpretations. Even worse, almost every E-W fault was determined to be active based solely on its construed connection to an active fault two miles away, or a N-S fault even farther south than that. There was zero local effort to confirm this model: MTA refused to even try to expose or to date the faults it placed onto the Active Fault Map. Instead, it rationalized that the level of urbanization and associated presence of buildings and utilities would make such an effort difficult and problematic. However, the billions of dollars invested in those buildings was precisely the reason that MTA was obligated to make an effort to ensure that its work was accurate. It issued an active fault map that potentially impacted billions of dollars of existing buildings and tens of thousands of lives and it did so without making any effort to answer the most basic and simple question facing any inferred geologic condition: is it real?

MTA determined that it would be fruitless to attempt to date the faults it inferred. However, the BHUSD and several private parties have accomplished exactly that feat (Geocon, 2014; Geocon, 2013; LCI, 2014; LCI, 2012). And the results obtained uniformly contradict MTA's primary conclusion that the area around Santa Monica Boulevard is underlain by multiple active faults. MTA continues to insist to this day that it does not matter how many of its mapped faults are found to be inactive because that simply means that there must be an active fault somewhere else. This attitude must be because there has to be an active fault somewhere in here due to their insistence that the fault zones in Century City are the same fault as the Santa Monica fault zone identified and trenched over 2 miles to the west by Dolan (Dolan et al. (2000b).

MTA refuses to even consider an alternative theory to its findings regardless of the quantity of evidence that continues to accumulate in opposition. Maybe the Santa Monica fault mapped down Santa Monica Boulevard is inactive, as all of the current data is suggesting? Why would any public agency refuse to accept that this is a finding of incredible public safety value to the community, and to its own project's economics and safety, and work as hard to confirm it as they did to create the hazard in the first place?

All of the reports released by MTA after the introduction of contradictory investigations and analysis return to a single conclusion: any subway station on Santa Monica Boulevard is unsafe, and any station at Constellation is safe. The observations and discussion above raises a fundamental question regarding the objectivity of the entire MTA investigation and analysis. MTA's extrinsic considerations include the following:

- MTA was opposed to a station anywhere on Santa Monica Boulevard.
- MTA conducted an exhaustive investigation on Santa Monica Boulevard and interpreted evidence of faulting.
- MTA established the rule that any fault interpreted on Santa Monica Boulevard must be presumed to be active unless proven otherwise.
- MTA then refused to take any action that may have shown the Santa Monica Boulevard faults to be inactive, or to not exist.
- MTA wanted a station on Constellation.
- MTA did the least investigation possible at Constellation and declared that it found no evidence of active faulting.
- MTA determined that the faults that MTA did interpret at Constellation were inactive without any quantitative investigation – because they had to be inactive.
- BHUSD was opposed to the MTA Constellation station.
- MTA did an exhaustive investigation of BHUSD – nowhere near the MTA stations or tunnels - and alleged that there were active faults all through an occupied campus.
- MTA triggered an expensive investigation by the BHUSD – of something that was not real.

The MTA Century City Fault Investigation, the associated high profile press release, and the subsequent letters and reports challenging the findings of others also raise serious questions. The MTA reports are uniformly not signed and not stamped, contrary to the requirements of public licensing law in California for engineers, geologists and geophysicists. It is impossible to determine who was in responsible charge of portions of the investigation or of any of the follow-on reports. MTA is not a geologist; it is an agency. Parsons Brinkerhoff is the program manager and general engineering consultant for MTA. AMEC provided geotechnical and geological investigation services. However, the public presentation of the report and its conclusions did not include any geologist from either Parsons Brinkerhoff or AMEC.

MTA is self-regulating under the California Alquist-Priolo Earthquake Fault Zone Act, but only up to a point (see below). MTA has defined its seismic safety standard thusly: if faults are present, station construction will not occur unless the faults are shown to be inactive. MTA is certainly free to define a higher standard of acceptable level of seismic risk, and it is free to choose whether to investigate faults sufficiently to determine their activity level or to abandon a site without any investigation.

However, the MTA went well beyond ensuring that its own risks were controlled. The MTA fault investigation and accompanying press release announced without reservation or condition that the faults on its map were active – and it did so without actually confirming the existence of the inferred faults or their actual level of activity. It issued a seriously flawed report, making false positive declarations of active faulting around the Santa Monica Boulevard stations, and making unsupportable negative declarations of the absence of faulting at the Constellation station.

Alquist-Priolo Act Considerations

California passed the groundbreaking Alquist-Priolo Earthquake Fault Zone Act (A-P Act) almost four decades ago to prevent the construction of structures intended for human occupancy over an active fault trace. The A-P Act also established a regulatory framework for local building officials to administer the A-P Act, including the requirement for the California Geological Survey and the State Mining and Geology Board to establish technical guidance on the preparation and review of seismic fault investigations. That system has evolved over the decades as expertise and experience across the State has developed, although the prohibition of construction over any active fault has remained intact.

MTA has limited independence from the State regulatory system. It is self-regulating only to the extent that it is not subject to the approval a local building authority. It is still required to comply with all codes and practices. In this situation that independence did not serve the public or the spirit and letter of the A-P Act.

The A-P Act empowers the State Mining and Geology Board (SMGB) to establish the policies and criteria for the approval of projects (A-P Act, para 2623(a)). CGS and the SMGB have issued numerous rules and guidelines that create a framework for the preparation and review of seismic investigations (e.g. CGS Special Publication 117 Guidelines for Evaluating and Mitigating Seismic Hazards in California). That framework is intended to provide rigor and fairness to the process. The preparation and release of the MTA WSE Century City Area Fault Investigation Report runs afoul of several of the most important guidelines.

CGS spells out clear roles and responsibilities. Here, The MTA/PB reports and conclusions are unsigned, unattributed, and unstamped. It is unclear who was personally responsible for overall reports and conclusions or any of the subparts leading up to those conclusions.

CGS requires an independent review of all seismic investigations. The purpose is clear: to assure the public of the integrity of the final report and that any conclusions – good or bad – are supported by evidence and solid, professional analysis. This is good practice in many regards. It is an axiom in engineering that no one checks their own work. Most seismic investigations are reviewed by a local building authority – a review by a public agency beholden to public interests not project interests. CGS specifically cautions against conflicts of interest in the review process and prohibits self-review (CGS Special Publication 117 – Chapter 8, page 69). CGS notes the practice of public agencies using other public agencies to conduct reviews. There is no evidence that anything like a formal review took place within MTA, much less an independent, critical review.

MTA did retain a panel of experts to present the report findings. However, at least one of the presenters actually worked on the preparation of the report –thus, not an "independent" expert. Moreover, CGS details the minimal contents of a review procedure and record file (CGS Special Publication 117 – Chapter 8, page 69). There is no evidence that the members of the panel actually fully reviewed the report. There is no review report at all.

Geological interpretation is somewhat subjective and requires judgment – judgment based on direct observation of source data. CGS strongly encourages reviewers to observe cores and trenches directly. There is no evidence that any review panel member looked at a single core. Worse, there is no evidence that any of the individuals who were apparently responsible for the report conclusions and final mapping directly observed any cores. (In MTA's case it appears that no one other than the original loggers actually viewed the project cores.) Worst of all, there is strong evidence that a side by side core comparison – a fundamental step in determining whether strata do correlate between two adjacent borings – was not conducted by anyone directly preparing or reviewing the report.

The Alquist-Priolo Act is clearly intended to protect the community interest, not merely the interest of any particular project.   CGS guidelines seek a balance between project and community interests; the duty to protect community interests is specifically and repeatedly addressed. For example:

> "Under the Seismic Hazards Mapping Act, the reviewer is responsible for determining that each seismic hazard site investigation, and the resulting report, reasonably address the geologic and soil conditions that exist at a given site. The reviewer acts on behalf of a governing agency- city, county, regional, state, or federal – **<u>not only to protect the government's interest but also to protect the interests of the community at large.</u>**" (CGS Special Publication 117 – Guidelines for evaluating and Mitigating Seismic Hazards, Chapter 8, page 68, emphasis added)

MTA conducted the report for its own purposes – the evaluation of the seismic safety of alternative station sites. However, the consequences went well beyond the MTA project limits. The report produced a map of active faults that extended across a large and heavily developed portion of the cities of Los Angeles and Beverly Hills. MTA announced as fact the conclusion that it had proven the interconnection of the Santa Monica–Hollywood-Newport-Inglewood-West Beverly Hills Lineament faults into a single very large and active fault system. That conclusion affected hundreds of homes and businesses across a large portion of the west side including the communities of Santa Monica, Westwood, Century City, Beverly Hills, West Hollywood, Culver City and Los Angeles. Those consequences were obvious on the face of the report; they even showed the building outlines on the fault map to make it more obvious.

MTA did this without consulting with any of the affected building authorities, without allowing them to review or critique the report, without allowing them to contribute contradictory information – without any consultation at all. Most remarkable is that MTA now refuses to consider, or reconsider, its active fault maps in the face the ever-mounting series of reports and actions by other regulatory agencies that flatly contradict the MTA assertions. This conduct clearly violates one of the most fundamental aspects of the building regulatory system.

In the very legitimate concerns over the larger regional issues triggered by the MTA Century City Fault Investigation, it is easy to lose sight of the fact that MTA also failed in its very narrow, minimal obligation under the Alquist-Priolo Act: to prohibit the construction of an occupied structure on an active fault unless it has clearly met the requirements of a seismic investigation and review. Note that MTA not only rejected the Santa Monica Boulevard station sites, it also approved the Constellation station site. In its approval, MTA: (1) failed to do even a minimal investigation within the project limits performing only 2 CPT probes and no continuous core borings within the project station limits; (2) ignored its own geophysical evidence of faults crossing the site; (3) ignored the KGS report and its interpretation of faults crossing the site; (4) produced a cross section that on its face construes data as evidence of faults when off the site and evidence of folding when on the site with no explanation; (5) rationalizes its non-investigation through the use of adjacent excavation photos that lack the resolution to clear any kind of fault presence or absence – and raise obvious anomalies on their own; and (6) failed to conduct any kind of external and independent investigation review.   The MTA approval of the Constellation station project is inconsistent with the spirit and intent of the Alquist-Priolo Act in almost every way possible. It is difficult to imagine any building authority accepting the MTA work as a sufficient seismic investigation.

CONCLUSIONS

The geologic studies conducted for the Century City Fault Investigation were very extensive and contain a large amount of good data. However, the density of data was inadequate and the interpretation of that data was flawed. MTA had a predefined paradigm of geomorphology, fault location, orientation, and activity. The interpretation of fault presence was conditioned by that paradigm: faults were expected in a certain location, so any evidence of faulting was presumed conclusive, with no effort to actually verify its presence; similarly, where faults were not anticipated, data that could be used to interpret the presence of faulting was ignored. The paradigm determined that active faulting must be present, so almost every fault encountered was presumed to be active without any attempt at verification. In the face of mounting evidence of the lack of faulting and inactivity of the few strands actually encountered (Figure 46), MTA insists that active faults must be somewhere in the area – because the paradigm says so.

The ready interpretation of faults, because they fell within a predefined paradigm of fault location and orientation, was wrong. The absolute conclusion that all of the inferred faults were active Holocene faults without any supporting investigation or age data was wrong. The completion and publication of this fault investigation without exposing a single one of the faults was wrong.

That the Active Fault Map's WBHL fault zone has been shown to be merely an erosional margin of Benedict Canyon and not a series of active faults at BHHS is not too surprising when you consider that the interpretation of its very existence was founded upon a hypothesis thrown out during a geological field trip. How the WBHL as a fault zone became so rooted in the geological literature and eventually ended up as a Holocene fault on the CGS map, is shown to be a house built of cards, and having no foundation (Figure 46).

The density of data collected by PB's consulting team for the fault evaluation of the stations along Santa Monica Blvd is significant. The density of data collected at the newly proposed Constellation station location is negligible. MTA clearly applied an inconsistent and uneven standard in the evaluation of the two sites.

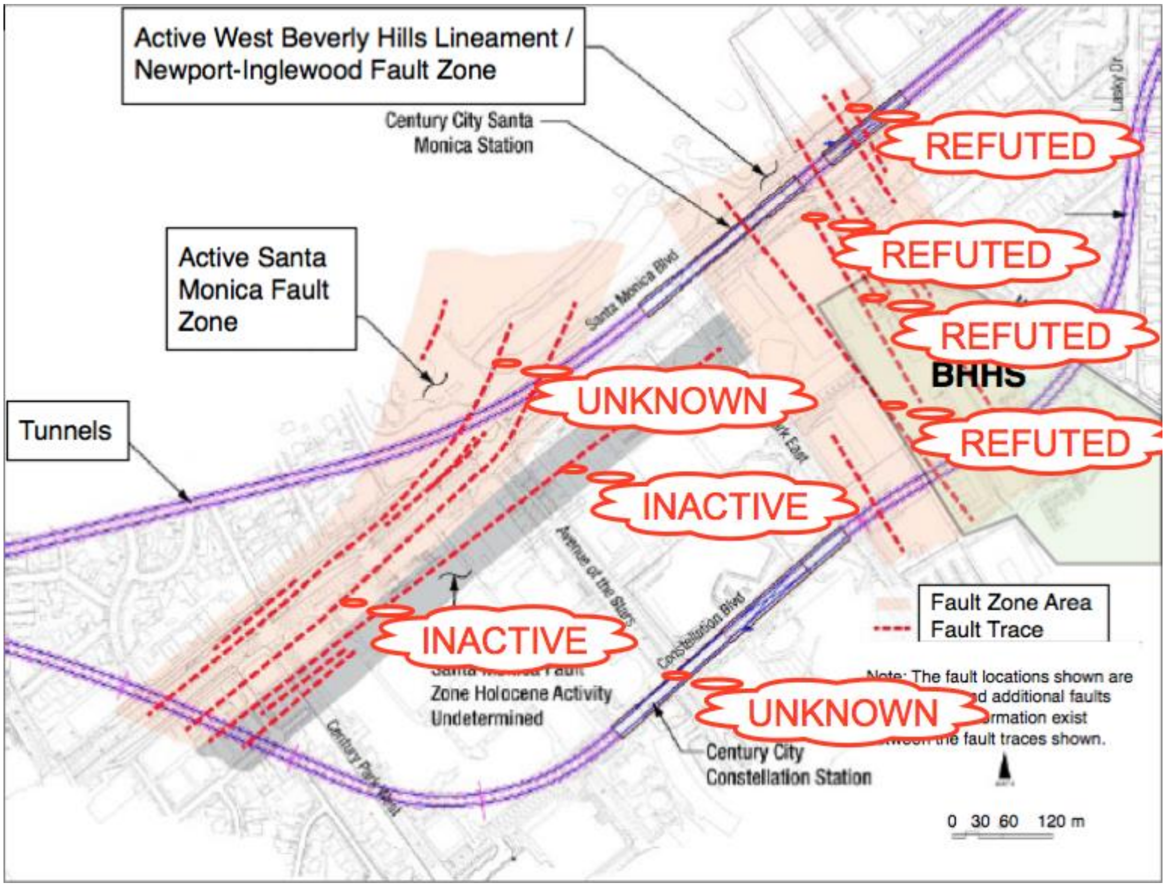


Figure 46: Summary of results from the various fault investigations in the Century City – Beverly Hills area, all done in response to the MTA Active Fault Map (Figure 2). To date, no faults have been found anywhere within the MTA's "Active West Beverly Hills Lineament / Newport-Inglewood Fault Zone." To date, all faults found within the MTA's "Active Santa Monica Fault Zone" have been shown to have been inactive for a minimum of 120 ka at one site, and 200-300+ ka at another. Investigations of faulting where the Santa Monica fault is inferred to bend to the northeast are as yet incomplete, and so similarly rigorous studies have never been done at the proposed Constellation station site.

At least four geological studies have been completed, and more are underway or contemplated, assessing the true risk to public and private property from the faults mapped as present and active by MTA (Figure 46). None of these studies have found an active fault, many did not even find a fault where there were mapped, and all have strong evidence for the absence of active faults. While there may well be a hazard from surface rupture somewhere in the Century City – Beverly Hills area this has not yet been proven and so its location, if existing at all, is currently not constrained.

The lack of WBHL faults was unanticipated when starting the BHHS investigations. While it had been optimistically hoped that maybe the WBHL faults could be demonstrated to be inactive, there was no expectation that faults would not be present. Faults had been interpreted from considerable data, subjected to expert analysis, had been through a Metro peer review process, were labeled as dangerous in public hearings, and yet they were not there.

It is well past time for MTA to acknowledge that its prior fault assessment work is severely flawed, and that decisions made by using that work are likely to also be flawed. What is needed is a completely new and comprehensive analysis of the fault hazard issue, incorporating all of the actual data from all of the studies, and leaving behind the prior model-driven paradigms and interpretations. When hypotheses become models, and when models drive interpretations, and when interpretations become data, one must proceed carefully, because, as we have seen, things can go terribly wrong.

THE END

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