



WESTSIDE SUBWAY EXTENSION PROJECT

Contract No. PS-4350-2000

Response to Preliminary Review Comments of Century City Area Fault Investigation Report by Shannon & Wilson

Westside Subway Extension Project

Prepared for:

Metro

Prepared by:

PARSONS BRINCKERHOFF
777 South Figueroa Street
Suite 1100
Los Angeles, California 90017

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1.0 INTRODUCTION

This report responds to the *Preliminary Review Comments of Century City Area Fault Investigation Report, Westside Subway Extension Project Century City and Beverly Hills Area* (March 8, 2012) prepared by Shannon & Wilson, Inc. (Shannon & Wilson), which formulated its comments based on reviews of two reports prepared by Metro on October 19, 2011: the *Century City Tunneling Safety Report* and the *Century City Area Fault Investigation Report* (Tunneling Safety and Fault Investigation Reports, respectively).

Metro has responded to the following three topics discussed in the Shannon & Wilson comments:

- Safety of tunneling beneath Beverly Hills High School and other properties
- Faulting and fault investigations in the Beverly Hills and Century City area
- Feasibility of an at-grade station on Santa Monica Boulevard

2.0 TUNNELING SAFETY

Shannon & Wilson agrees with Metro's assessment of subway construction and operation in Century City and Beverly Hills, concluding the following:

- Tunneling can be accomplished safely beneath properties using the tunneling technology used successfully by Metro on the Metro Gold Line Eastside Extension (MGLEE). This includes tunneling under the Beverly Hills High School (BHHS) and accommodating future development at the school.
- Gas conditions can be mitigated by the tunnel boring machine (TBM) technology referenced above and its proposed tunnel lining system.
- Noise and vibration during tunnel construction can be limited generally to the tunnel access points, and Metro's predictions are that noise from the operating trains would be below Federal Transit Administration (FTA) thresholds.

The Shannon & Wilson report stated further that specification details, TBM procurement, and construction by experienced contractors are essential to achieve little or no impacts on overlying and adjacent buildings. Metro concurs and will have contract specifications that detail stringent requirements for TBM procurement, operation, and control of ground. In addition, bidding contractors and their key personnel will be prequalified to ensure that they have experience appropriate to the proposed tunneling methods.

Shannon & Wilson also indicated that instrumentation and survey systems similar to those used on MGLEE should be included throughout the Westside Subway Extension Project. The program should include instrumentation on buried utilities and buildings, and borehole extensometers to provide information on the source of ground losses immediately above the advancing TBM, with the information shared with City of Beverly Hills staff and building owners. Once more, Metro agrees. Such a program was carried out on MGLEE and Metro is currently improving this program to take into account new technology. These systems are outlined in the Metro Tunnel Advisory Panel (TAP) report (TAP 2010), *Century City Area Tunneling Safety and Fault Investigations Report* (2011) and will be carried out by Metro and its tunnel contractor. In particular, deep extensometers, TBM pressures, annular grouting,

and excavation volumes will be monitored—particularly as structures are approached and passed—to confirm that ground control is within specified limits.

Other specific references that illustrate points of agreement with Metro's tunneling approach noted in the Shannon & Wilson comments, as well as clarification of Metro's position on certain issues are provided in Table 1.

Table 1. Summary of Tunneling Comments and Metro Responses

	Shannon & Wilson Statement	Metro Response
1.	"… construction of tunnels, using state-of-the-practice closed-face Tunnel Boring Machines (TBMs) can result in negligible to minor settlements, and little to no impacts from gas, groundwater, and soil variability is a generally realistic assessment." *(Section 7.3.1 pg 13)*	**Agree**: Accordingly, concerns about the dangers of construction or operation of tunnels should be relieved. Metro understands how those unfamiliar with tunnels would initially express concerns. However, tunneling is safe, especially at the depths the tunnels would go beneath BHHS. Nevertheless, Metro is committed to satisfactorily addressing all public concerns
2.	"We agree that closed-face TBMs provide the best means, methods and opportunities to achieve negligible ground losses and small to unmeasurable settlements… Overall, our experience with closed-face TBMs has been good…" *(Section 7.3.2 pg 13)*	**Agree**: Metro and its consultants have confirmed this conclusion on MGLEE and on other projects.
3.	In reference to closed-face TBMs in the United States in the last 15 years "measured settlements …are generally less than 1 inch, and are often less than 0.25 inch, which is about the level of accuracy of most standard surface surveying." *(Section 7.3.2 pg 15)*	**Agree**: Metro requirements are to limit surface settlements to a level that is achievable for the specified ground-control procedures and for the planned tunnel depths.
4.	"However, large ground losses and surface settlements have occurred on a small percentage of international projects, and over a small percentage of the length of these projects…more frequently occurred where the TBM exits and enters the stations or shafts, where mixed-face conditions occur…" *(Section 7.3.2 pg 13)*	**Agree**: Selected tunnel depth and soil conditions at Century City are amenable to control of TBM operation and prevention of large amounts of ground loss and settlement. Additional ground-control procedures, such as grouting, will be specified and used to stabilize the soils, particularly adjacent to tunnel-station connections, if deemed necessary.

	Shannon & Wilson Statement	Metro Response
5.	"Beneath the BHHS, the top or crowns of the proposed tunnels are 50 to 70 feet below ground surface. This should provide adequate depth for future development of parking garage/basements down about three to four levels or 30 to 50 feet deep. Normally, construction is limited to no closer than one tunnel diameter above the crown or to the sides of a tunnel. However, closer excavation may be permitted by Metro with adequate design evaluation, lateral support, and protection of the transit tunnels." *(Section 7.3.6 pg 18)*	**Agree**: The Tunneling Safety Report states that the design of foundations above the tunnels foundations can be built on slabs above the tunnels or with foundations between the tunnels. Costly "bridging" structures with wide spans are not required.
6.	"Construction related vibrations are likely to be transitory, since the tunnel heading will be advancing at the average rate of about 50 to 100 feet per day beneath and beyond any one single property." *(Section 7.3.3 pg 15)*	**Agree**: Metro will monitor and control noise and vibration during tunneling, including the operation of construction of trains in the tunnel.
7.	Noise and vibration "measurements would be made under BHHS during construction…. However, there is no indication that these would be used as "not to exceed" baselines for construction." *(Section 7.3.3 pg 15)*	**Disagree**: Metro's standard construction specifications provide not to exceed limits for construction-induced noise and vibration. Contractors will be required to maintain noise within specified limits. No complaints about noise from the TBMs were received during the MGLEE tunneling.
8.	"There should also be comments, and eventually specification requirements on using sound-damping noise walls, low noise fans, and minimizing trucks entering and leaving staging areas during hours that would disrupt local residents, businesses, and public facilities" *(Section 7.3.3 pg 15)*	**Agree**: Such procedures will be implemented at construction sites and station excavations. (The comments do not apply to tunneling.)
9.	"… a Metro test programs had indicated no adverse noise or vibration due to transit tunnel operations along both the Red and Gold Lines. The [Metro] Tunneling [Safety] Report notes that noise and vibration tests have already been performed on the BHHS and indicate that construction and train operation noises and vibrations will be below FTA limits." *(Section 7.3.3 pg 15)*	**Agree**: No noise complaints were received during tunneling of MGLEE, and non have been received for the operating Red Line or MGLEE.

	Shannon & Wilson Statement	Metro Response
10.	"..Metro Gold line specifications required the installation of double-gasketed segmental liners coupled with high ventilation rates for either an [Earth Pressure Balance Machine] EPBM or [Slurry Pressure Balance Machine] SPBM along with continuous monitoring for gas concentrations. Similar specification requirements should be applied to the [West Side Extension] WSE to provide sufficient redundancy to prevent methane and hydrogen sulfide buildup in the tunnel during construction and operations." *(Section 7.3.4 pg 16)*	**Agree**: Metro will require double-gasketed segmental liners on the Project, use of either EPBM or SPBM TBMs, and robust ventilation requirements.
11.	"Metro has [extensively tested and] implemented the use of double-gasketed, bolted concrete segments for tunnel lining in order to greatly reduce the potential for gas and groundwater entering the tunnels." *(Section 7.3.4 pg 16)*	**Agree**: In addition, the system is performing well.
12.	"Lastly, the contractor is required, in potentially-gassy and gassy ground to install gas detection monitoring systems to continuously monitor the tunnel atmosphere for gas." *(Section 7.3.4 pg 17)*	**Agree**: Metro and its contractors have pioneered and improved methods to ensure tunnel safety through gas-bearing soils.
13.	"Based on review of the Tunnel Report, only boring C-119B involved gas testing at three elevations at the Santa Monica Station; whereas, six borings were tested for gas concentration at multiple elevations at the Constellation Station. Additional borings should be drilled and tested for gas concentrations, along with groundwater levels along the final tunnel alignment." *(Section 7.3.4 pg 17)*	**Agree**: During final design, additional borings will be drilled (at all station locations) and will include monitoring of gas concentrations and groundwater levels along the selected tunnel alignment.

3.0 FAULTING AND FAULT INVESTIGATIONS

Shannon & Wilson concurs with Metro on two important conclusions:

- Construction of subway stations within active fault zones is unprecedented world-wide. Tunnels, on the other hand, have been designed and constructed through active fault zones at an angle.
- The area in the "gap" between the main identified traces of the Santa Monica fault zone and the West Beverly Hills Lineament (WBHL) along Santa Monica Boulevard may contain fault traces and may be subject to ground deformations because of too complex fault movements in the Santa Monica fault zone.

This is consistent with the results of Metro's investigation of faulting along Santa Monica Boulevard showing there is a particularly complex intersection of multiple faults and fault strands in the area. This complexity makes it difficult to find positive evidence for the absence of active fault strands over a site that can accommodate the length of a long, linear Metro station with its station platforms, access structures, crossover, and approach tunnels.

There is also general agreement that continuous trenching of sufficient width and depth through undisturbed, Holocene age, native sediments along Santa Monica Boulevard—both north-south and east-west—would be necessary to rule out active faulting, both due to the Santa Monica fault zone and the WBHL. However, Metro questions the feasibility of achieving continuous trenching of sufficient size in these areas, where active faults are shown on state maps, given the existing conditions in this densely developed area. Holocene (younger than 11,000 years) sediments have been largely removed by utility construction in the area.

Investigation at Constellation Station Location

Shannon & Wilson Notes that "studies for this (Constellation) station are not as thorough as for the Santa Monica Station" and recommends additional investigations at Constellation. Metro agrees that more of the effort in the fault investigation was focused on Santa Monica Boulevard, because there was evidence for the presence of the Santa Monica Fault based on regional mapping and the geomorphology. Further, the effort to evaluate a second alternative site on Santa Monica Boulevard required significant additional investigations. Whereas for the Constellation Station site, the geomorphic evidence is that the site is not located in an area of active faulting. Moreover, Metro tried very hard to find a suitable site on Santa Monica Boulevard which required more investigation. As described below, Metro considers the exploration adequate for siting the Constellation station.

Shannon & Wilson questioned that a fault strand may be located "as close as 100 feet from the east end of the station/crossover." Topographic information and considerable geotechnical data including a 100 foot deep basement excavation essentially exposing the soils for the south wall of the station supplement data from the two borings cited by Shannon & Wilson as described further below

Fault investigations to the level of detail performed for the Santa Monica Boulevard station site are not done routinely. No other stations along the Westside Subway Extension alignment have been either investigated for active faulting, or has this level of study been done routinely for other types of structures around Southern California. This level of fault investigation is done only when there is earlier information suggesting the likely presence of active faulting. Active faults do not just occur anywhere.

They are localized into discrete zones that are readily identifiable from characteristic deformation features prominent in the landscape. For example, the escarpment associated with the active zone of the Santa Monica fault is clearly defined along the northern edge of Santa Monica Boulevard. Likewise, the WBHL is a prominent, continuous feature of the landscape that was identified more than 20 years ago and is considered to be the northernmost continuation of the Newport-Inglewood fault zone (NIFZ). Both fault zones are shown on fault maps prepared by the State of California as being active, as shown on Figure A-1 (CGS, 2005), in the Figure Appendix of this report. Metro concentrated its detailed fault investigations on these prominent fault zones.

In marked contrast to the Santa Monica and WBHL/NIFZ scarps, the site of the Constellation Station exhibits no topographic evidence for active faulting. Not only are there no scarps discernible on detailed pre-development topographic maps (the Santa Monica fault and WBHL show up prominently on these maps), but none are visible on very early aerial photos (e.g., oblique aerial photos taken in the early 1920s, as well as the earliest vertical-incidence aerial photographs taken in the late 1920s).

Nevertheless, Metro did undertake significant analysis of the subsurface structure of the area of the proposed Constellation Station site. Specifically, this exploration has included examination of the following multiple data sets:

- Review of historical data, including historic aerial photographs, topographic maps, and geologic maps.
- Review of data from previous geotechnical investigations in Century City. This area has been extensively investigated and developed for other properties, including those directly adjacent to the south of the Constellation Station site. The data included borings and photographs from the deep excavation for underground parking garages more than 50 feet deep.
- New borings, cone penetration tests (CPTs), and observation wells (gas and water) for the Metro alignments.

Geologic maps dating back to the early 1900s—such as Hoots (1930)—do not show faults in the Constellation Station area. Historic aerial photographs and topographic maps—including topographic maps and photos dating back to the 1910s and 1920s such as the 1922 photograph in Figure A-2 from the Spence Collection at UCLA (Spence, 1922)—show no geomorphic evidence of faulting.

Metro reviewed data from previous geotechnical investigations and construction observations included boring logs from the investigations and photographs taken during excavations for deep underground parking garages. Figure A-3 shows the locations of the extensive geotechnical explorations conducted in the Constellation Station area dating back to 1959. In addition to the borings drilled for the foundation investigations, geotechnical observations were performed during construction, and the excavations were documented in photographs. Most of the buildings in the area have underground parking garages (Figure A-4). Figure A-4 also shows the locations of the construction excavation photographs in Figure A-5, 6, and 7. These photos show the 80- to 100-foot-deep underground parking excavation for the building adjacent to Constellation Boulevard to the south. Figure A-5, looking northwest along Constellation Boulevard, shows what will be the southern wall of the Constellation Station excavation. Based on the construction photos taken periodically during the excavation process (Figure A-5, Figure A-6 and Figure A-7), offsets of horizontally bedded sediments are not observed across the excavation.

New borings, cone penetration tests (CPTs), and observation wells were excavated in Constellation Boulevard along the station alignment, and new borings, CPTs, and a seismic reflection line (crossing perpendicular to Constellation Boulevard along Avenue of the Stars) were performed during Metro's recent Westside investigation. These are also shown on Figure A-3

Review of the historical data and excavations described above (together with the new data) revealed absolutely no evidence of faulting in the Constellation Station area. It can be seen that Metro based this conclusion on substantial evidence from multiple data sets and not just on data from 2 borings. Metro concludes that Constellation Station and tunnel alignment to have been explored in sufficient detail with respect to faults to recommend the alignment selection.

Newport-Inglewood Fault Zone and West Beverly Hills Lineament

A prominent fault scarp along the northern extent of the Newport-Inglewood Fault Zone defines the West Beverly Hills Lineament. North of Santa Monica Boulevard, the West Beverly Hills Lineament forms a tear or connection on between the Santa Monica fault and the Hollywood fault.

The kinematics (geometry of slip) of the Santa Monica fault system requires that the northern Newport-Inglewood Fault Zone extend all the way north to the surface trace of the Santa Monica fault. Specifically, as noted by Dolan et al. (2000), the Santa Monica fault exhibits a much more-pronounced component of reverse slip than does its eastern extension, which is known as the Hollywood fault. The Hollywood fault exhibits predominantly left-lateral strike-slip motion (north side to the west, refer to Figure A-8) (Dolan et al., 1997), whereas the Santa Monica fault exhibits a combination of reverse and left-lateral motion (north side up and to the west). Given that the Santa Monica and Hollywood faults have the same approximately east-west strike, the more-pronounced reverse component of slip on the Santa Monica fault requires that this "extra" component of slip is added to the system along the WBHL by right-lateral strike-slip. These relationships are shown in simplified form in Figure A-8. The Newport-Inglewood fault system is a predominantly right-lateral fault system. The change from strike-slip on the Hollywood fault to reverse-strike-slip on the Santa Monica fault occurs at the WBHL. The inescapable conclusion is that the active northern Newport-Inglewood fault system must extend northward along the West Beverly Hills Lineament to the surface trace of the Santa Monica fault.

Trenching to Preclude Faulting/Ground Deformation

Shannon & Wilson questions the presence and activity of the West Beverly Hills Lineament based on trenching performed at the BHHS campus.

The data from that investigation—described, in part, by the letter report by Roy J. Shlemon and Associates, Inc. (Appendix B)—are not available to Metro so comment cannot be made on them. However, the results of that investigation would not preclude the presence of faults of the WBHL in Santa Monica Boulevard. Based on the closely spaced borings and CPTs, the seismic reflection data, and the review of historical topographic maps and aerial photographs performed in Metro's investigation, there are unquestionably faults present in Santa Monica Boulevard. These faults are clearly seen in the geophysical survey line Transect 4 shown on Figure A-9. The difficulty is determining the level of activity of the faulting.

While it may be possible to find Holocene sediments in a trench in the old railroad right-of-way along Santa Monica Boulevard, a trench there (if permission could be obtained from the owner of that

property) would not address the area at the intersection of Santa Monica Boulevard and South Moreno Drive, where significant fault offset was observed in the borings, CPTs, and geophysical survey line (second fault from the left on Figure A-10). In addition to the 10 (or more) north-south trending utility lines in the intersection, there is a 20-foot-wide box culvert more than 24 feet deep in South Moreno Drive at the intersection (Figure A-11). Excavation of trenches to emplace these subsurface utilities has destroyed the original layering necessary to identify faults (or the lack thereof), and there is no possibility that undisturbed Holocene sediments that could be used to evaluate the activity of that faulting remain in the intersection.

To preclude the potential for north- and northeast-trending faults and ground deformation associated with the Santa Monica fault zone and the complexities at the intersection of the two fault zones in the "gap" area between the faults on Santa Monica Boulevard (and to evaluate the activity of features encountered), numerous very long trenches in a northwest-southeast orientation that provide continuous exposure of Holocene sediments would be required. There are at least 17 utility lines and trenches along this portion of Santa Monica Boulevard that would have to be crossed (Figure A-12), including sewer, water, gas, electric, storm drain, telephone, cable, and fiber optic cable. The trenches excavated to emplace these utility lines would disturb and/or remove the Holocene sediments at these locations, which is important because unless trench exposures of undisturbed (by man) sediments are completely continuous across the area of interest, the results will be inconclusive. Even gaps as short as a few feet would miss faults and ground-deformation features. Trenching in Santa Monica Boulevard would almost certainly be inconclusive and therefore not possible to preclude active faulting and ground deformation.

Groundwater Barrier

Shannon and Wilson recommended that additional borings with wells and piezometers be installed and a map of contoured groundwater levels be developed to help identify the location, orientation, and cause of the "groundwater barrier" to the Northwest of the Constellation station. Borings along Santa Monica Boulevard have demonstrated that the Santa Monica fault zone forms a barrier to southward flow of groundwater to the west of Avenue of the Stars. The barrier is created by permeable sand beds to the north being faulted against relatively impermeable silt and clay beds to the south. To the east of Avenue of the Stars, the older alluvial deposits are thicker and more sand and gravel beds are present. There was no observed pattern of groundwater levels or apparent relationship to faults.

Conclusions

Metro reconfirms the conclusions reached in the three Century City area reports (Tunneling Safety, Fault Investigation, and TAP Reports) and the recommendation that the Constellation Station alignment be selected for the Westside Subway Extension. Active faulting is present on Santa Monica Boulevard in the Century City/Beverly Hills area, and no subway station location on Santa Monica Boulevard in Century City will meet Metro's criteria. The Constellation Station site is suitable for a Metro station and can be safely constructed and operated. Tunneling can also be safely accomplished along the Constellation Station alignment under the BHHS and adjacent properties.

Table 2 summarizes Metro's response to the issues concerning fault and faulting investigations raised in the Shannon & Wilson report.

Table 2, Summary of Fault Investigation Comments and Responses

	Shannon & Wilson Statement	Metro Response
1	"studies for this [Constellation} station are not as thorough as for the Santa Monica Station." *(Executive Summary pg 1)*	**Agree**: Metro expended significant effort along Santa Monica Boulevard to find a suitable location for a station. Fewer borings were drilled at Constellation Boulevard because there was no fault identified at this site on geologic maps. However, borings from extensive prior subsurface investigations, as well as other data (maps, photos, etc) were used to support Metro's findings at the Constellation Station site.
2	"we recommend that comparable geological and geotechnical explorations be carried out for the Constellation Station." *(Executive Summary pg 1)*	**Disagree**: Abundant existing information is available in the vicinity of Constellation Station (Figure A-3) from previous investigations. These other studies show no evidence of faulting at the site.
3	"Relocating the station further south or east along Santa Monica Boulevard, including the gap … has risks similar to the current proposed Santa Monica Station owing to high probability of ground deformation stemming from earthquakes originating from the SMFZ or by previously unmapped fault splays." *(Executive Summary pg 1)*	**Agree**: There is considerable uncertainty in the relationships between the Santa Monica fault, Hollywood fault and the WBHL, but since the Santa Monica fault zone and the Hollywood fault zone are active, the connecting WBHL fault must also be active. The topography confirms these relationships.
4	"We recommended fault trenching occur at the station location." *(Executive Summary pg 1)*	**Disagree**: Trenching, especially in this urban area with large storm drains and utilities, can not conclusively resolve whether there is any zone that is not in an active zone of deformation. Even if faults are not identified in the trenches, there would still be uncertainty because of the kinematic relationships of the faults. Therefore, trenching will create more questions not answers.
5	"…recommend that additional borings with wells and piezometers be installed and a map of contoured groundwater levels be developed to help identify the location, orientation, and cause of the "groundwater barrier." *(Section 7.3.5 pg 18)*	**Disagree**: the Santa Monica fault zone forms a barrier to southward flow of groundwater to the west of Avenue of the Stars caused by permeable sand beds to the north being faulted against relatively impermeable silt and clay beds to the south. To the east of Avenue of the Stars, the older alluvial deposits are thicker and more sand and gravel beds are present. Based on water levels in extensive prior geotechnical borings, there was no observed pattern of groundwater levels or apparent relationship to faults.

	Shannon & Wilson Statement	Metro Response
6	With respect to the Alquist-Priolo (A-P)Act (Section 8.3), and Stations subject to fault displacement: "We did not find references to stations knowingly placed across an active fault trace." *(Section 8.3.2 pg 21)*	**Agree**: Design for fault displacement would be impractical without precedence, and would not meet Metro's Life-Safety Standards..

4.0 ALTERNATIVE STATION DESIGNS

Shannon & Wilson described what they believed were some alternative station configurations that should be investigated: moving the station on Santa Monica Boulevard farther to the east; the other, to consider at-grade (surface) options. Metro has looked at these as well as an aerial station concept.

Move Underground Station East

The first alternative, moving the underground station to the east, is shown in Figure A-13. The station has been moved northeast to just clear the Benedict Canyon box culvert in an attempt to clear the fault zone (refer to Figure A-14 for the station against the fault zone locations), but portions of the station platform would remain in the fault zone. There is just enough room at that location to fit the station box and crossover and still have room for a reasonable curve onto Wilshire Blvd. The west end of the station structure does not clear the fault zone, but this is as far east as the station box can practically be moved. Aside from being in the fault zone, this does not appear to be a practical solution from a planning perspective because it moves the station entrance farther away from the major pedestrian activity center. The entrance is now more than 700 feet from Century Park East.

At-Grade Station

The second concept, Putting the station at-grade was studied earlier by Metro but was discounted as impractical because of the impact on the traffic circulation on Santa Monica Boulevard. In this option, the station platform would remain in an active fault zone. The long approach structures would also need to be designed for fault rupture for a relatively long distance (parallel to) the Santa Monica fault zone.

The concept for this alternative has been to use the abandoned railroad right-of-way to construct a trench so the train could transition from a subway on Wilshire Boulevard to an at-grade alignment in the center median/bus lane of Santa Monica Boulevard. To maximize the use of this former railroad right-of-way, Figure A-15 shows the east portal of the proposed at-grade section beginning at the intersection of Wilshire and Santa Monica Boulevards. The transition trench from below ground to at-grade would extend for about 900 feet and the tracks would reach the surface approximately 200 feet west of Charleville Boulevard. The train would then run in an at-grade configuration with a crossover track and at-grade station at either Century Park East or Avenue of the Stars.

On the West side of the station, another transition trench from at-grade to below ground would be required which would extend for another 800 feet. If the at-grade station were located at Century Park East, the total length of the combination open trench and above-ground section would be over 3,200 feet in length. If the at-grade station were located between Avenue of the Stars and Century Park East, the total length of the combination open trench and above-ground section would be of similar overall length and would extend approximately 800 feet west of Avenue of the Stars. Figure A-16 shows the station located at Century Park East against the Fault Zones. Access to the station platform from Century City would need to be grade separated over the tracks and Santa Monica Boulevard (Figure A-17).

A major issue with the at-grade alignment is Santa Monica Boulevard is that it is too long to fit within the abandoned railroad right-of-way. The right-of-way is approximately 1,700 feet in length, but the length required for the two transition trench sections and the at-grade section is over 3,200 feet. Therefore a large portion of the above ground alignment would need to be located in the center of Santa Monica Boulevard and would cause severe impacts to existing traffic movements on that street.

The Metro Purple Line heavy rail system is designed for trains to operate at service frequencies of every four minutes, meaning that trains at the intersections along Santa Monica Boulevard would pass in the eastbound direction every four minutes and also in the westbound direction every four minutes resulting in a combined frequency of one train passing through each intersection every two-minutes. The speed limit leaving the station is 70 mph. From a traffic perspective, the design headways with at-grade crossings create a situation where crossing protection gates would be required. Because of the frequency of the train service, these gates will be down longer than up resulting in a severe impact on travel in and out of Century City as well as travel on Santa Monica Boulevard east of Century City. Intersections impacted would include Moreno Drive, Century Park East, Avenue of the Stars and the transition roadways between Big Santa Monica Boulevard and Little Santa Monica Boulevard near the Beverly Hills City Limit. Thus, it would almost certainly be necessary to fence off the at-grade section and close these portions of Santa Monica Boulevard that would then cross the Shannon & Wilson proposed layout, effectively precluding access to westbound Santa Monica Boulevard from these intersections.

From a safety perspective, heavy rail systems like this one, have an exclusive right-of-way to keep trains from hitting cars or people on the tracks, and to protect people from the electrical hazard of the third rail. The Shannon & Wilson report notes that there are examples of at-grade street crossings on commuter rail systems on Long Island and in Tokyo. Whereas the Long Island Rail Road has commuter trains at long headways crossing some streets at-grade, the frequent headways for the Westside Subway Extension would require grade separated crossings and fencing along the right-of-way to protect the public. For these reasons, the concept of an at-grade section of the transit system in this congested urban area is dangerous to both the trains and the public and would have significant traffic impacts. This proposed concept should not be considered.

Shannon & Wilson also suggested that the station could be located on the edge of Santa Monica Boulevard, rather than within the current center of the ROW. If such an alignment were located along the northern edge of the right-of-way, the current traffic lanes could be relocated to the south so that there would be no locations where the at-grade trains would operate through traffic intersections. Such an alignment would work quite well along the edge of the Los Angeles Country Club where no access to the north is currently provided, however, such an alignment in the Beverly Hills or Comstock Hills portions of Santa Monica Boulevard would sever all access to the properties along the northern edge of the street. Access would be blocked to the Beverly Hilton Hotel, the Robinsons-May site and portions of Santa Monica Boulevard west of the Los Angeles Country Club. For an at-grade station, this would require the reconfiguration of Santa Monica Boulevard which is divided into north and south by the center median ROW. This would disrupt the vehicular traffic flow because the traffic lanes would not be configured to match the lanes on the east side of Wilshire Boulevard.

For the reasons above, the concept of an at-grade section of the transit system along the northern edge of Santa Monica Boulevard in this seismically active, congested urban area would have significant impacts to properties located along the northern edge of Santa Monica Boulevard. This proposed concept should not be considered.

Aerial Station

With the aerial station concept, the structure would have the same seismic design concerns as an underground station in an active fault zone. Transit stations – or any structure designed for human

occupancy should not be placed on an active fault. Design for life safety would be unprecedented. Other issues with this configuration are described below.

Putting the Station in an aerial configuration was suggested as an option to remove some of the traffic impacts associated with the at-grade alternative, but this would introduce other issues. The concept for this alternative shown in Figure A-18, shows the east portal of the proposed at-grade section at the intersection of Wilshire and Santa Monica Boulevard. The transition trench from below ground to aerial would extend about 800 feet west of Wilshire Boulevard. The train would then transition from at-grade to aerial on an aerial structure that would be constructed in the center median of Santa Monica Boulevard. The trains would run in an aerial configuration with a crossover track and an aerial station between Century Park East and Avenue of the Stars. On the West side of the station, the structure would descend to grade and then enter another transition trench from at-grade to below ground which would extend for another 2,100 feet. The combination open trench and above-ground section would be about 5,800 feet in length, extending from Wilshire Boulevard to beyond Beverly Glenn. Access to the station platform from Century City would need to be grade separated over the tracks and Santa Monica Boulevard as shown in Figure A-19.

There are other issues associated with the concept of an aerial alignment for the Santa Monica Boulevard Station. First, using the maximum grade of 4 percent, the portal structure distance between the track portal and the level aerial structure is approximately 1,500 feet In this portion of the alignment the track would need to be fenced and it would be impossible for cars to cross over or under the track. At the west end of the portal structure, this same length would severely impact on access into Century City between Avenue of the Stars and will block traffic beyond Beverly Glenn. The portal structure and its retaining walls will also be in the fault zones.

As mentioned above accommodating pedestrian movement from the aerial station across Santa Monica Boulevard. To get the large number of riders from the Century City Station across Santa Monica Boulevard, the aerial structure needs to be high to allow a grade separated walkway. This would mean that the track is over 55 ft above the roadway, and creates a structure for the station that is quite high in this seismic zone (Figure A-19). The distance from end to end of the aerial structure and the portal structures is now almost 900 feet longer than the at-grade concept . This begins to impact the alignment of the tunnel that traverses across to Wilshire Boulevard and UCLA Station.

For the reasons above, the concept of an aerial section of the transit system in this seismically active congested urban area is dangerous to both the trains and the public and will have significant traffic impacts. This proposed concept should not be considered further.

Summary of Alternative Station Designs

- Moving subway station east: Station remaining on Santa Monica Boulevard, the entrance would be over 700 feet east of Century Park East, no longer in Century City. In addition, the west end of the station would still be in the active fault zone.
- At-Grade options: These options would place the station at-grade, however the platforms would still be in the fault zones. Traffic would be blocked across Santa Monica Boulevard from Wilshire Boulevard to east of Avenue of the Stars.

- Aerial option: This would require a structure over 1 mile in length from Wilshire Boulevard to beyond Beverly Glenn. Aerial stations across fault zones are unacceptable. Traffic management issues also appear unacceptable.

5.0 REFERENCES

Bryant, W.A, Fault Activity Map of California, (2005), California Geological Survey website

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Shannon & Wilson, Preliminary Review Comments of Century City Area Fault Investigation Report, Westside Subway Extension Project Century City and Beverly Hills, CA

Spence Aerial Photos, 1922, UCLA Photo Collection

APPENDIX A FIGURES

List of Figures

Figure A-1: California Geologic Survey Active Fault Map

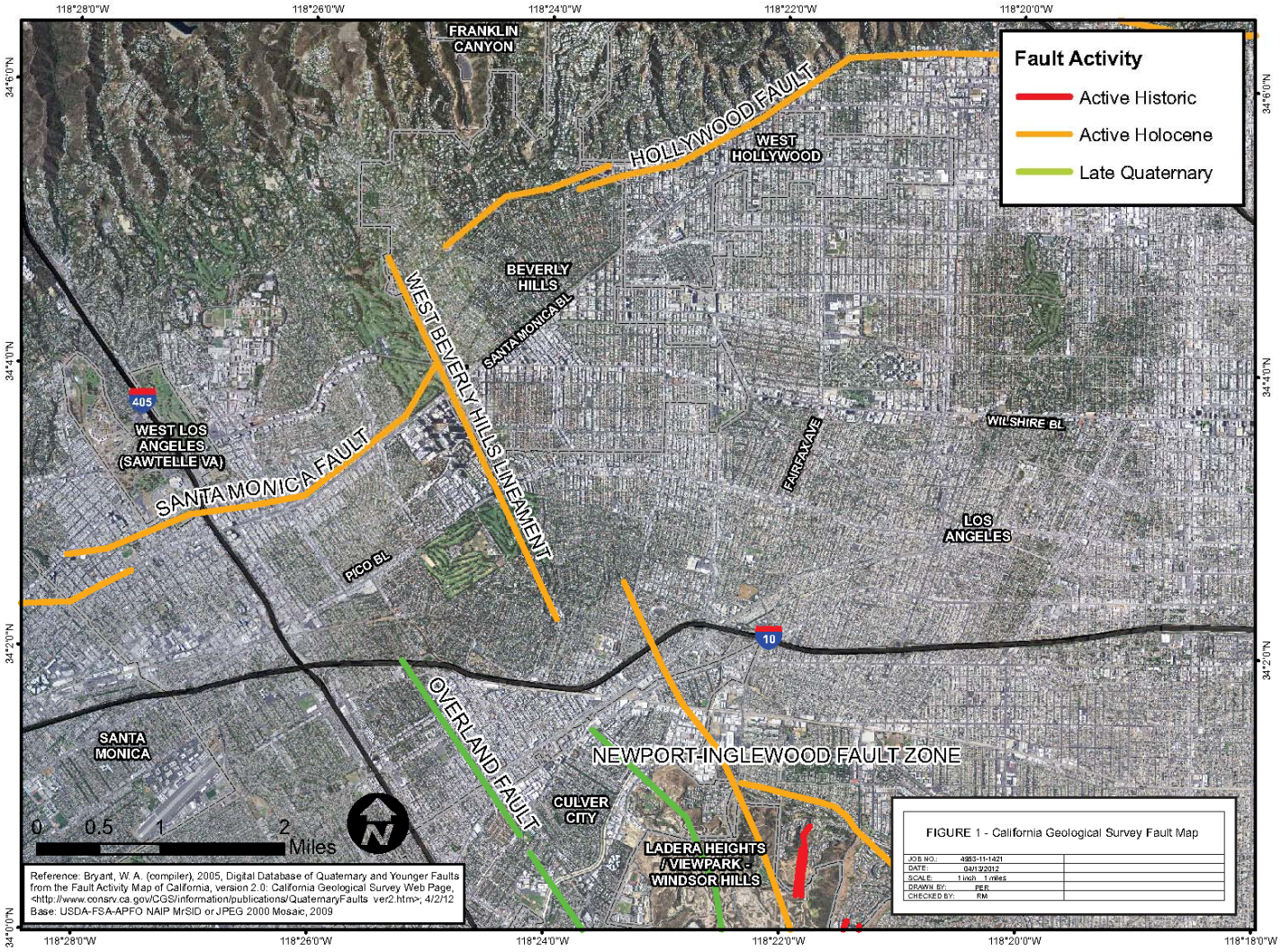

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Figure A-2: Historic Aerial Photo Century City Area

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

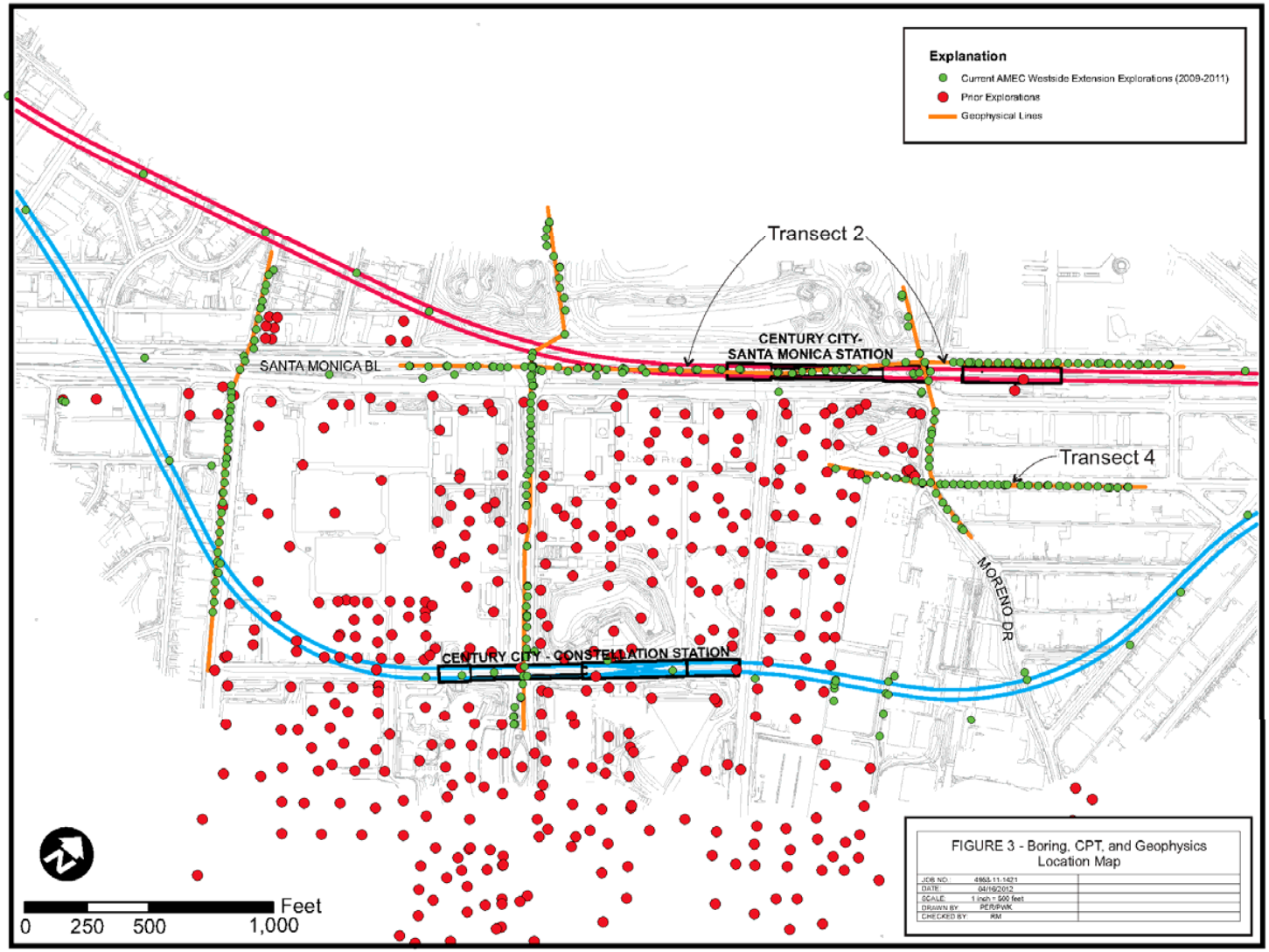

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Figure A-4: Deep Basements & Underground Parking

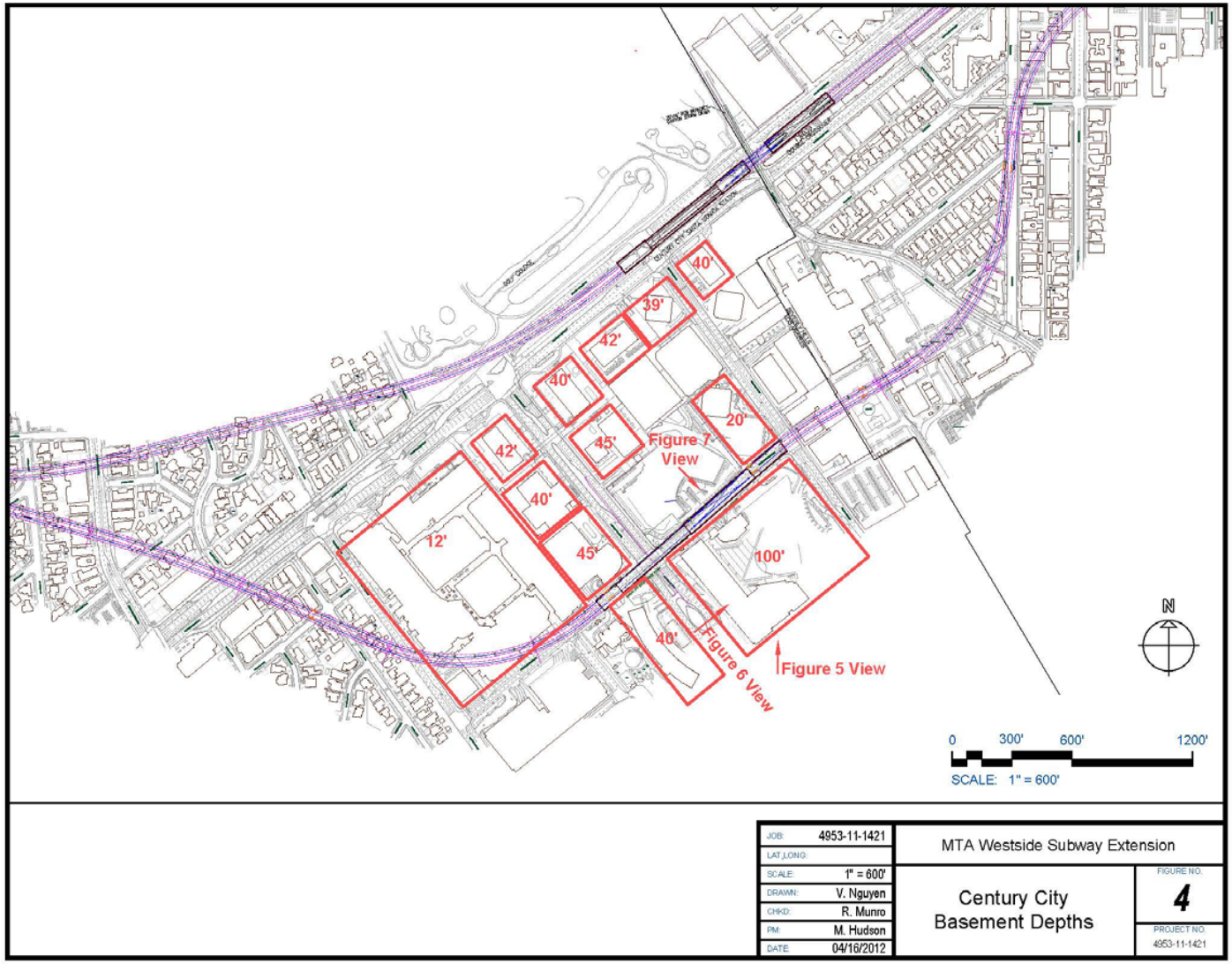

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Figure A-5: Construction of Deep Excavation, Century City Looking North

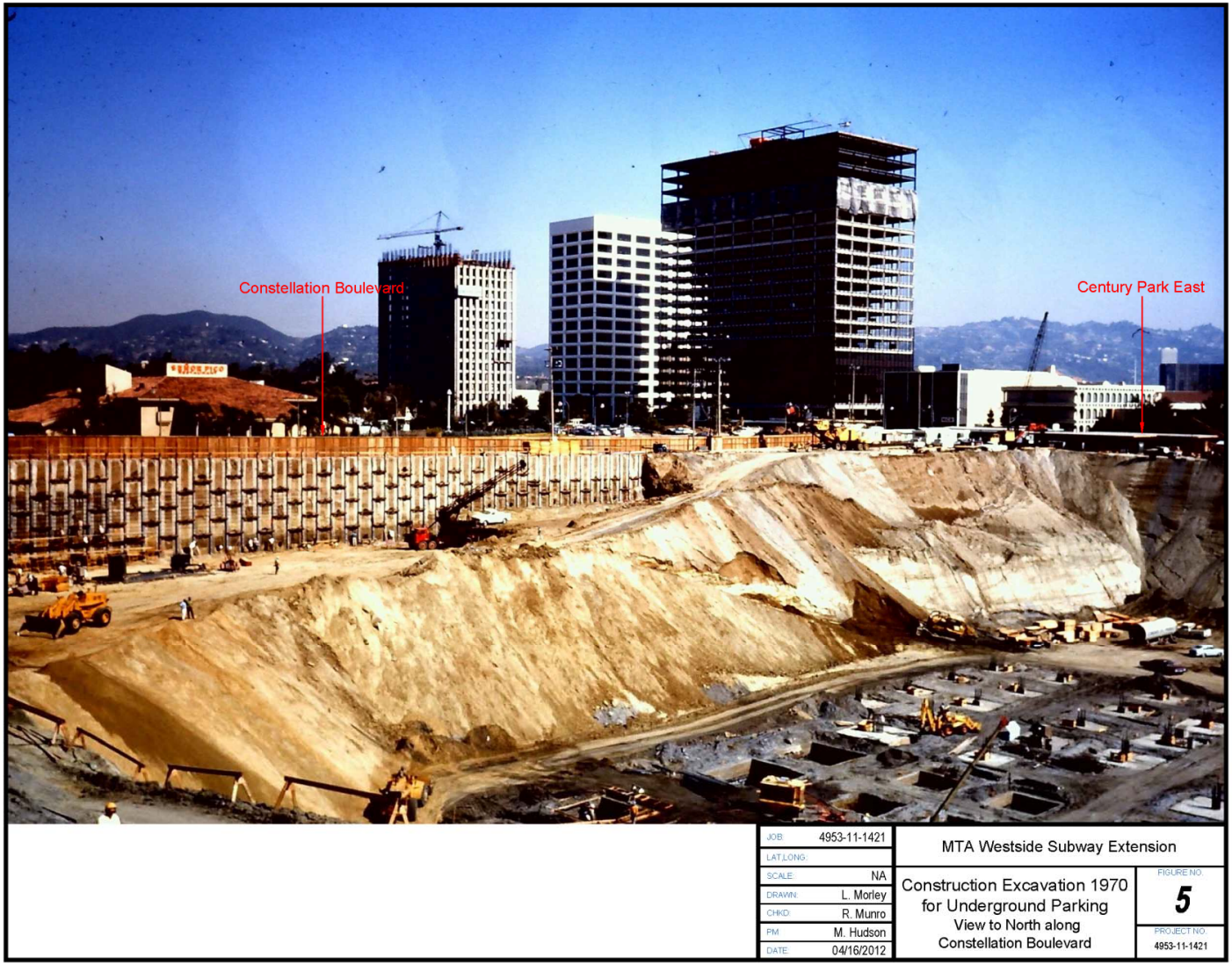

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Figure A-6: Deep Excavation, Century City, Constellation Boulevard Looking East

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Figure A-7: Deep Excavation, Constellation Boulevard, Looking South

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Figure A-8: Fault System and Tear Fault Schematic

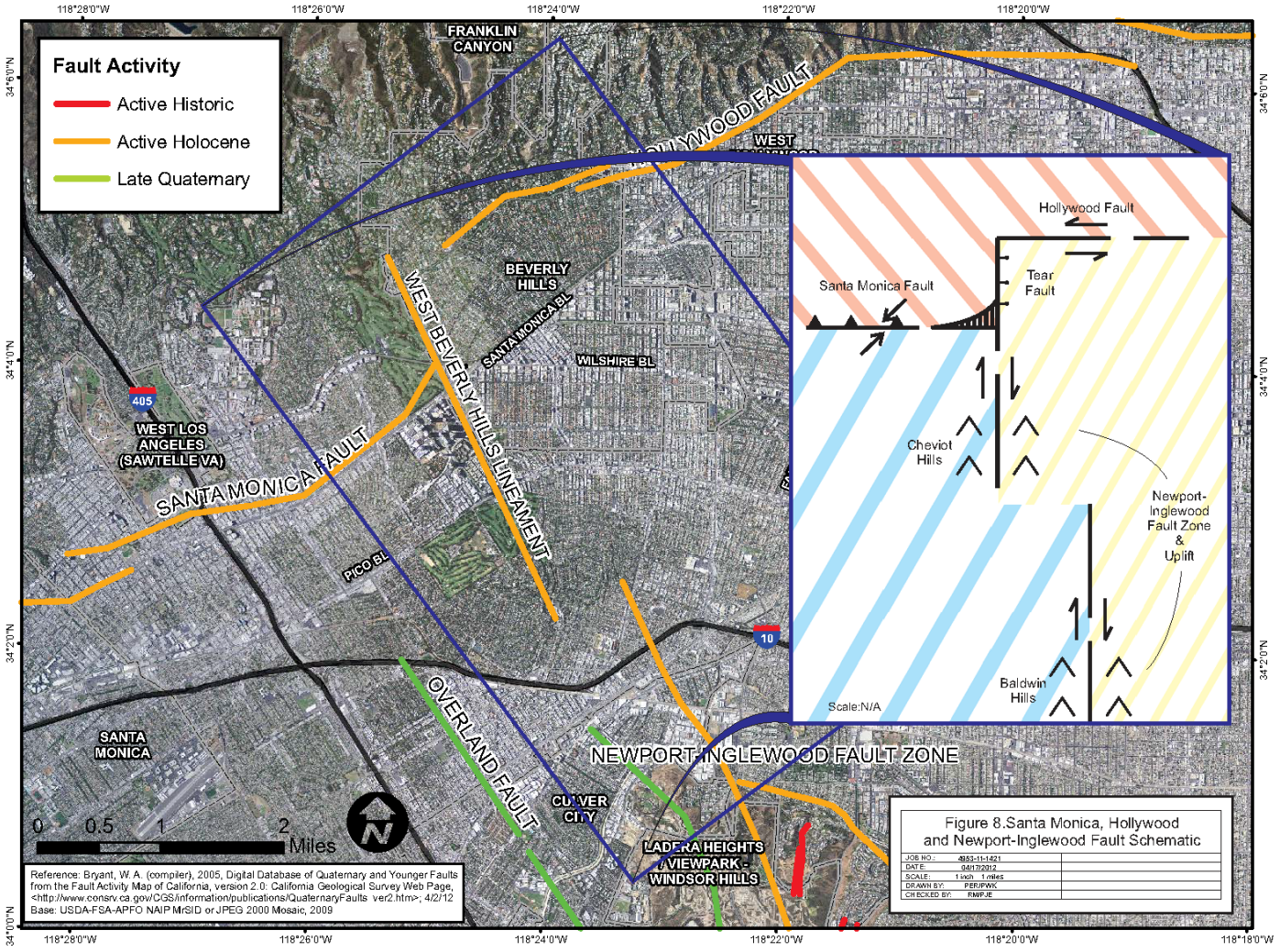

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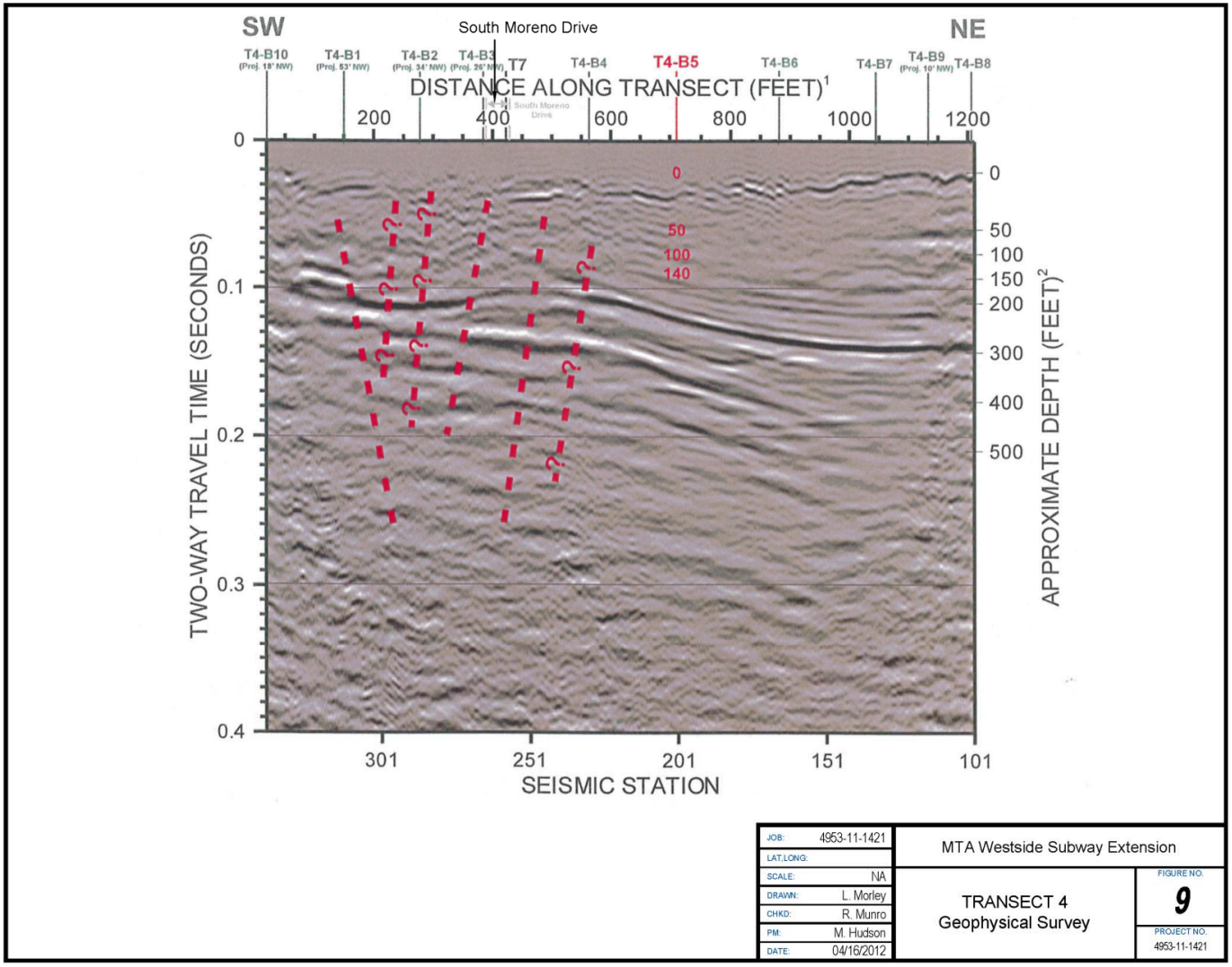
Figure A-9: Transect 4, Century City Fault Investigation



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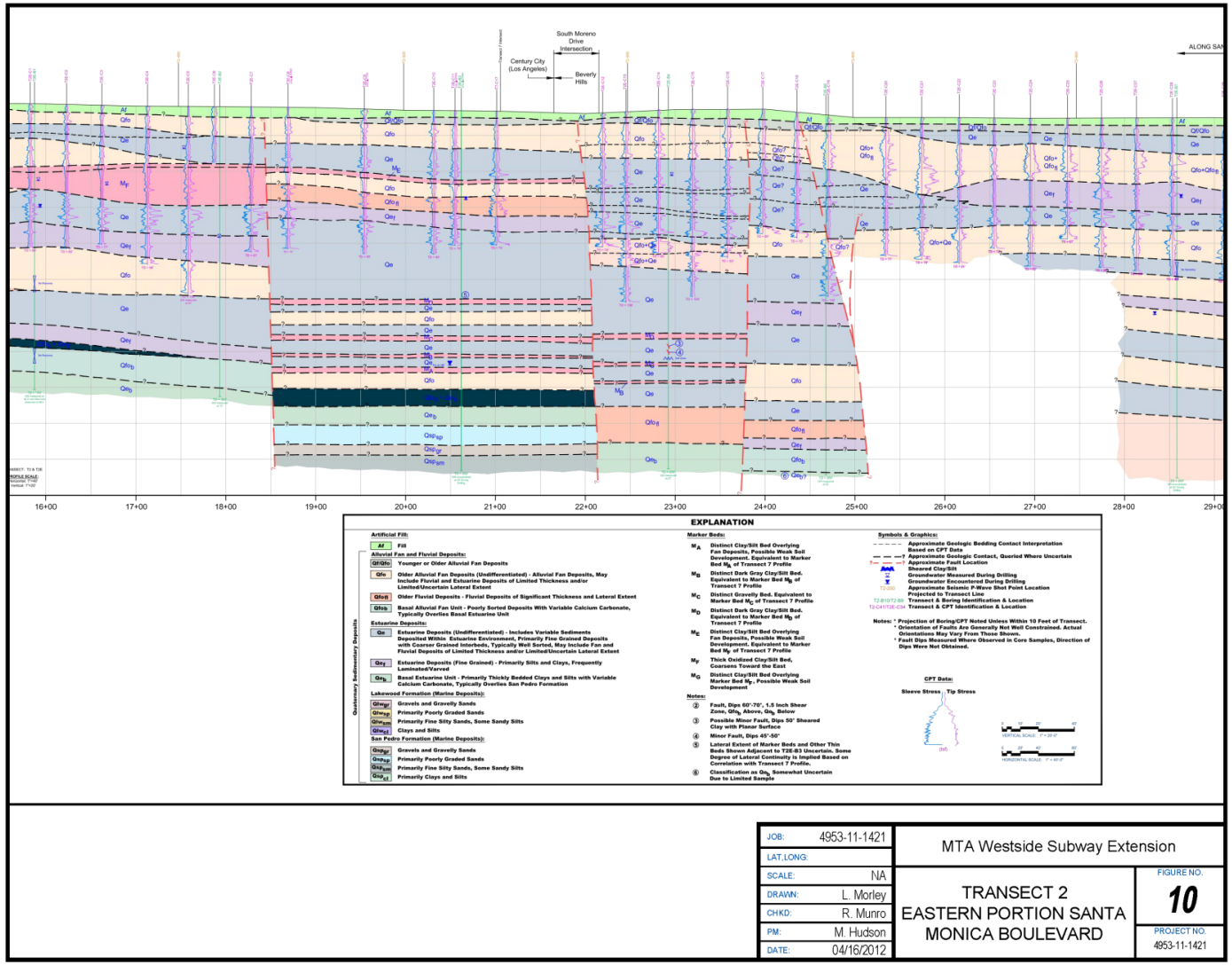

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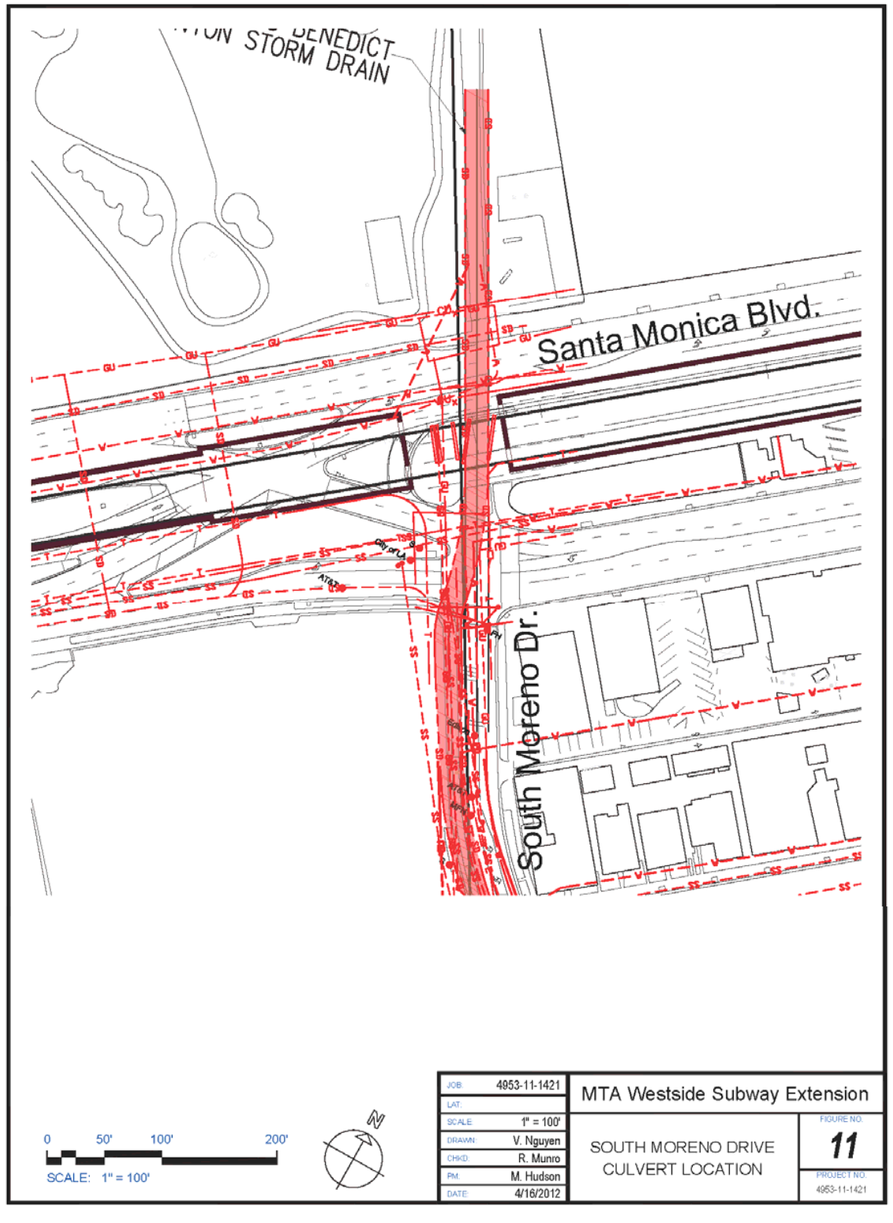
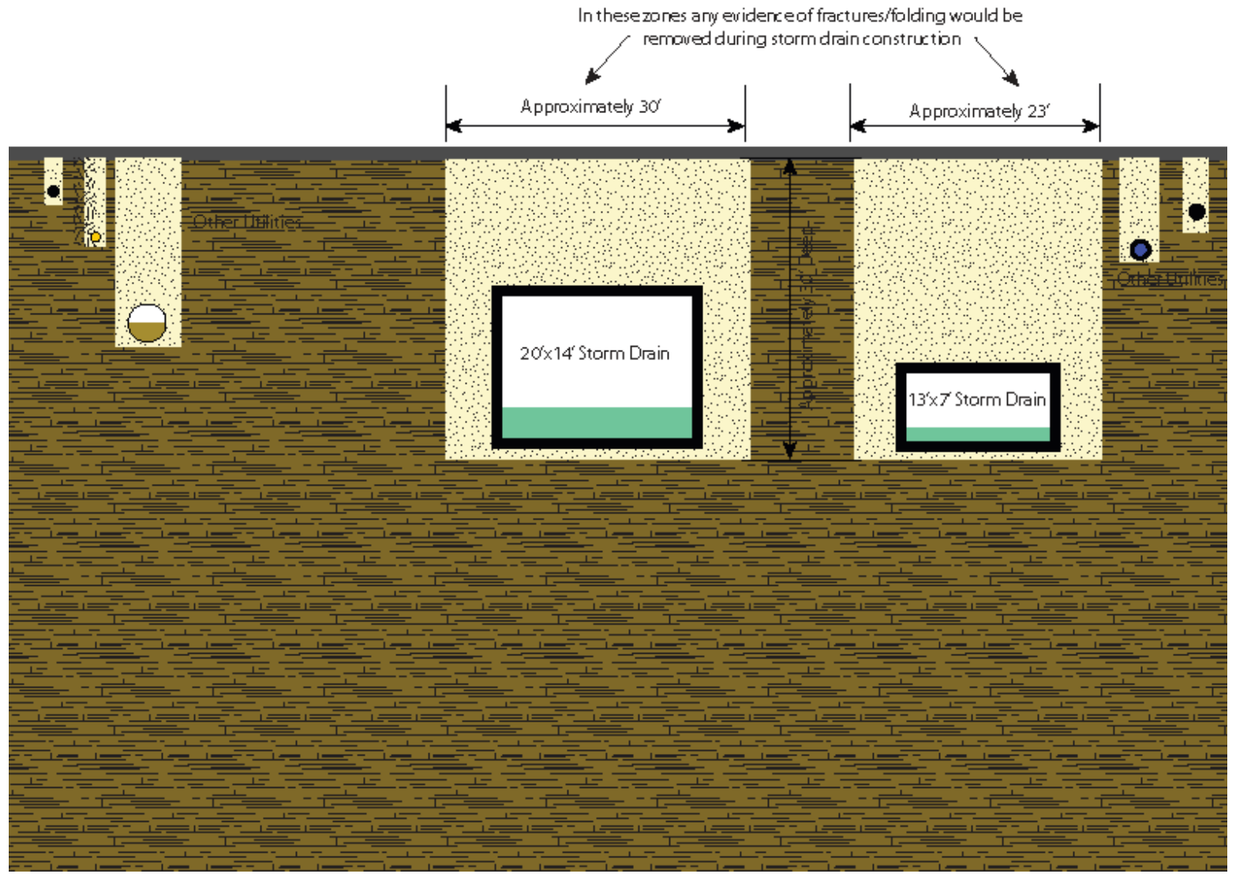
Figure A-11: Underground Utility Location Plan, Santa Monica & South Moreno Drive





Schematic Cross Section

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Figure A-12: Subway Station East of Moreno Drive on Santa Monica Boulevard

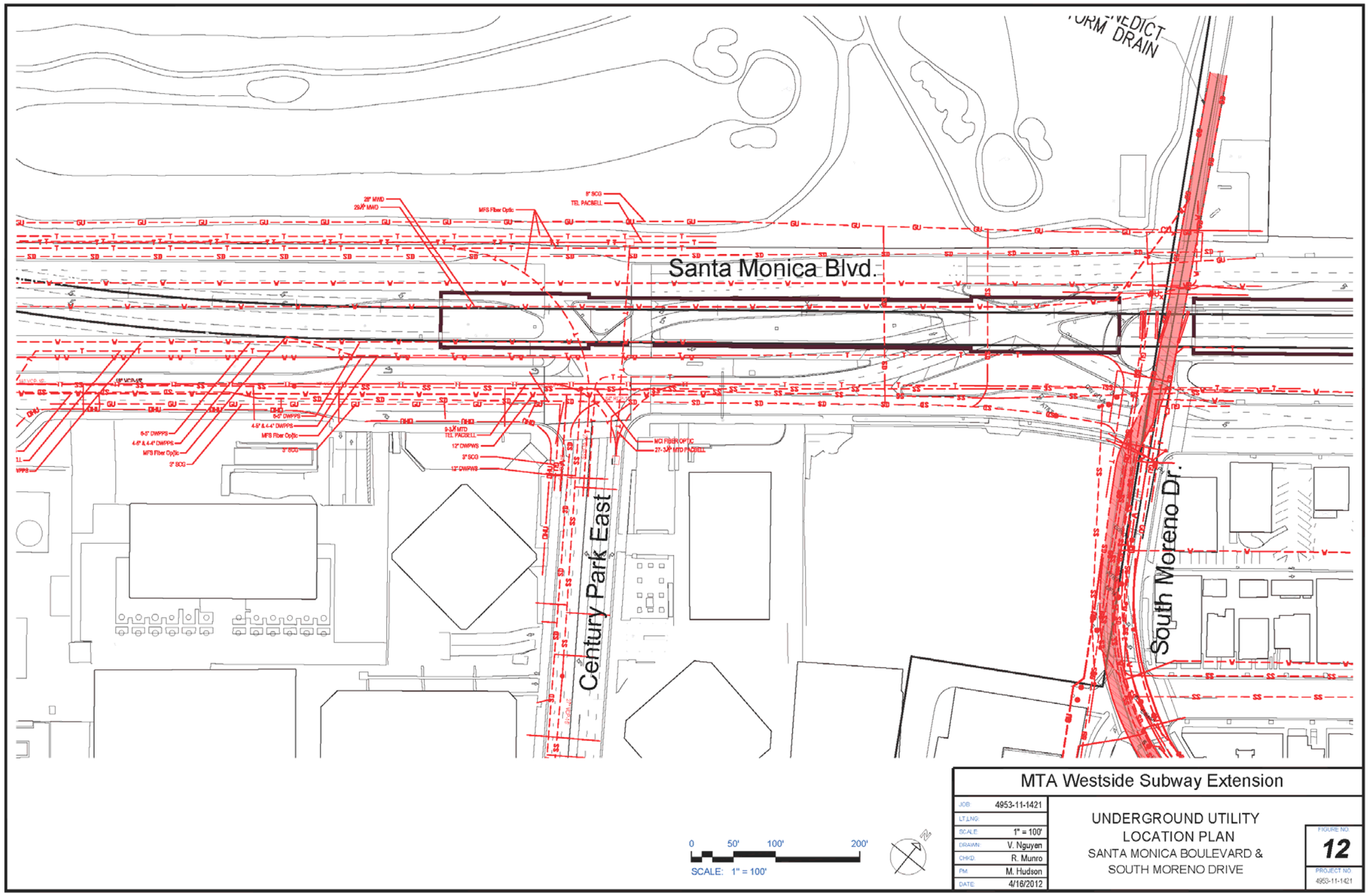

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Figure A-13: Subway Station East of Moreno Drive

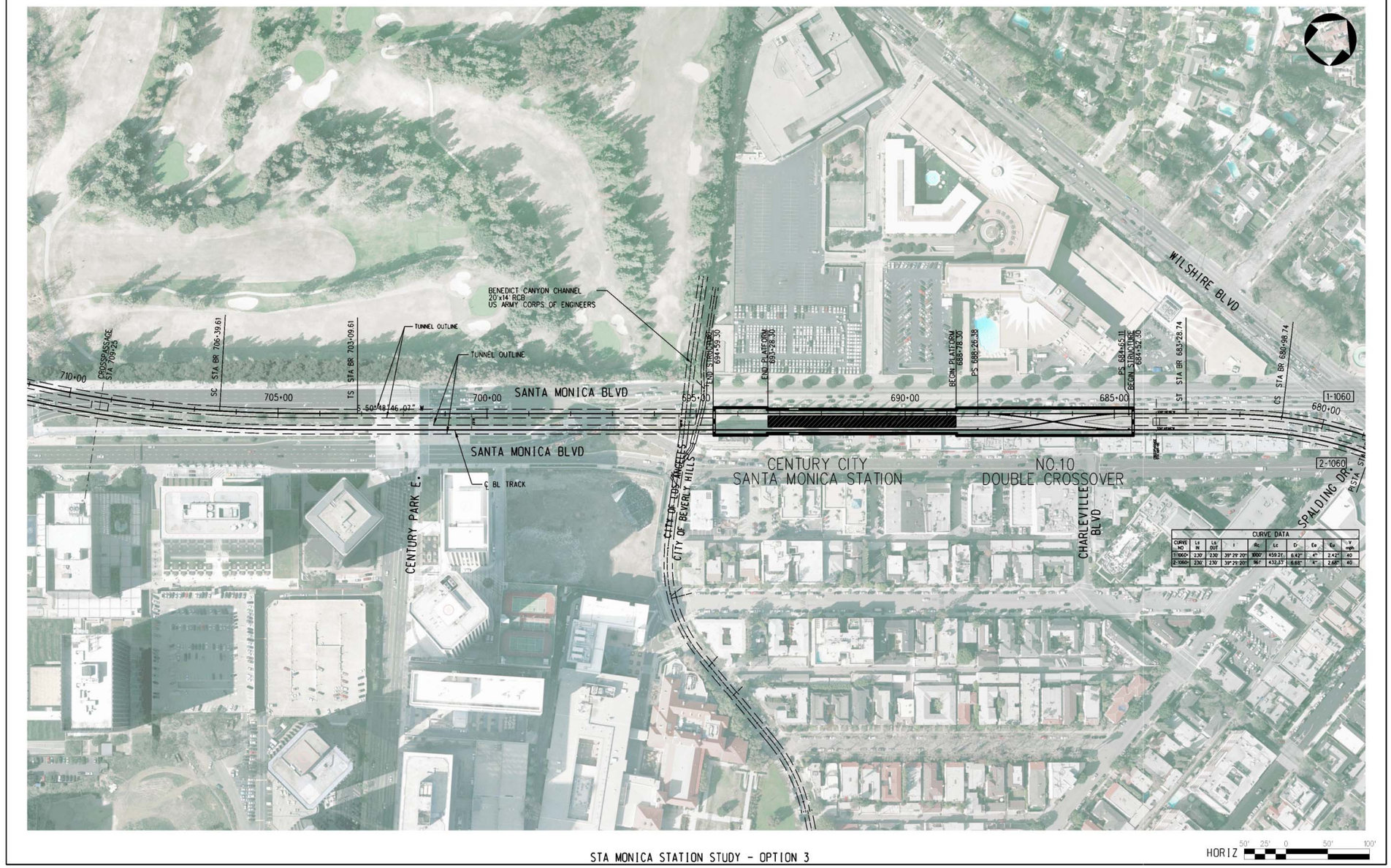

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Figure A-14: Fault Zones, Century City, Santa Monica Boulevard Underground Station (Station East of Moreno Drive)

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Figure A-15: Plan of At-Grade Station Concept

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Figure A-16: Fault Zones, Century City, Santa Monica Boulevard At-Grade Station

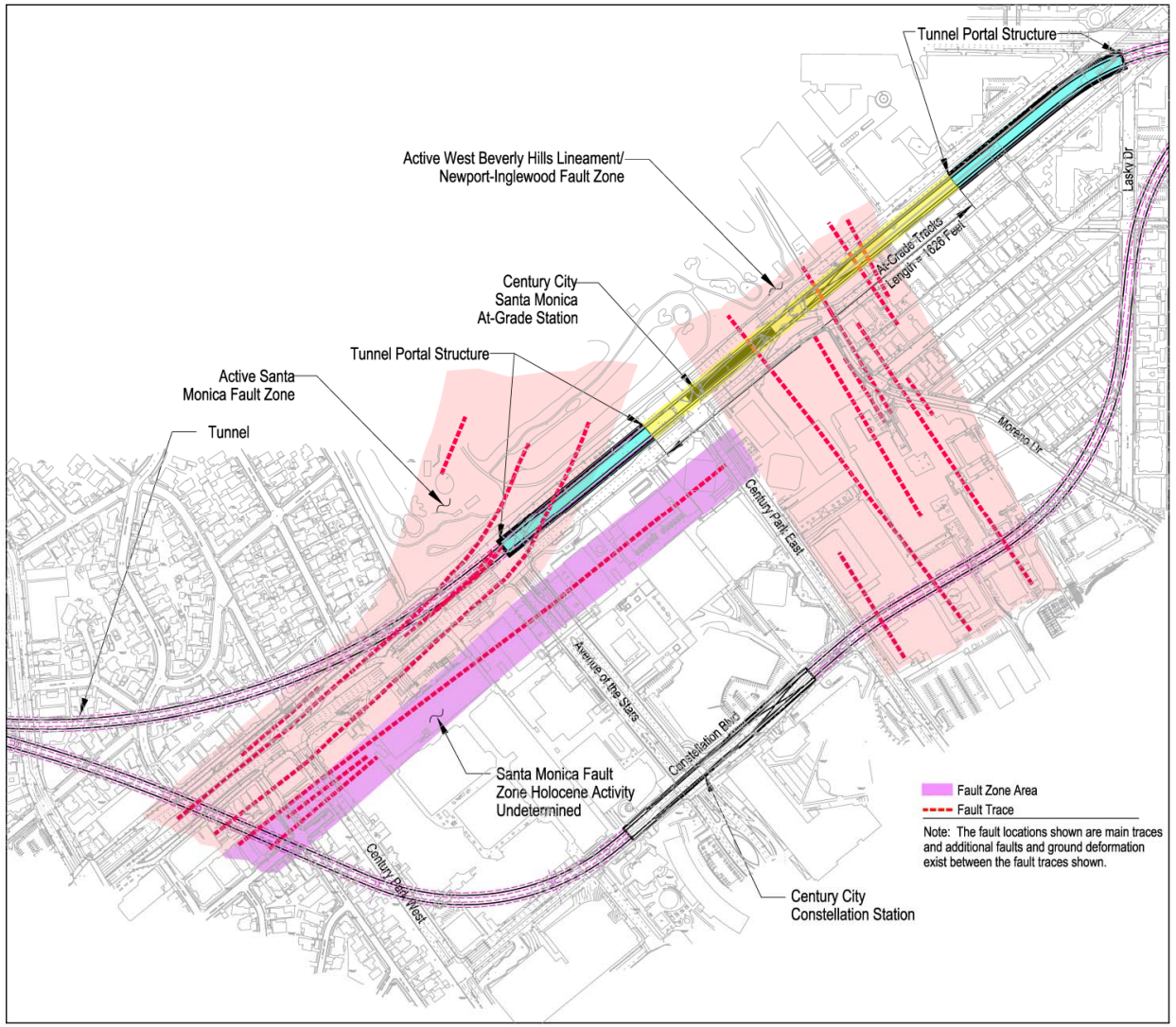

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Figure A-17: At Grade Platform, Typical Cross Section at Platform

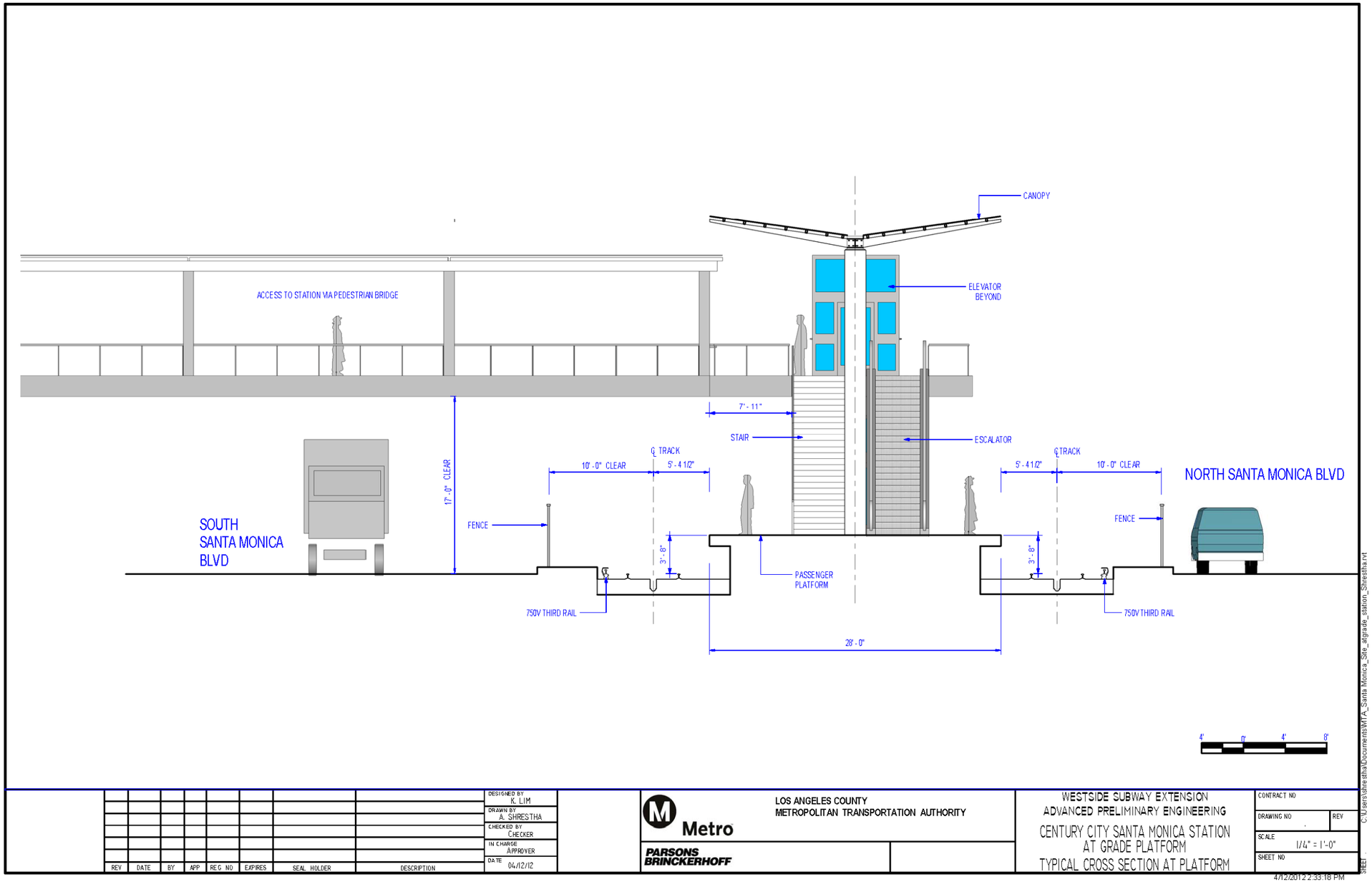

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Figure A-18: Plan of Aerial Station Concept

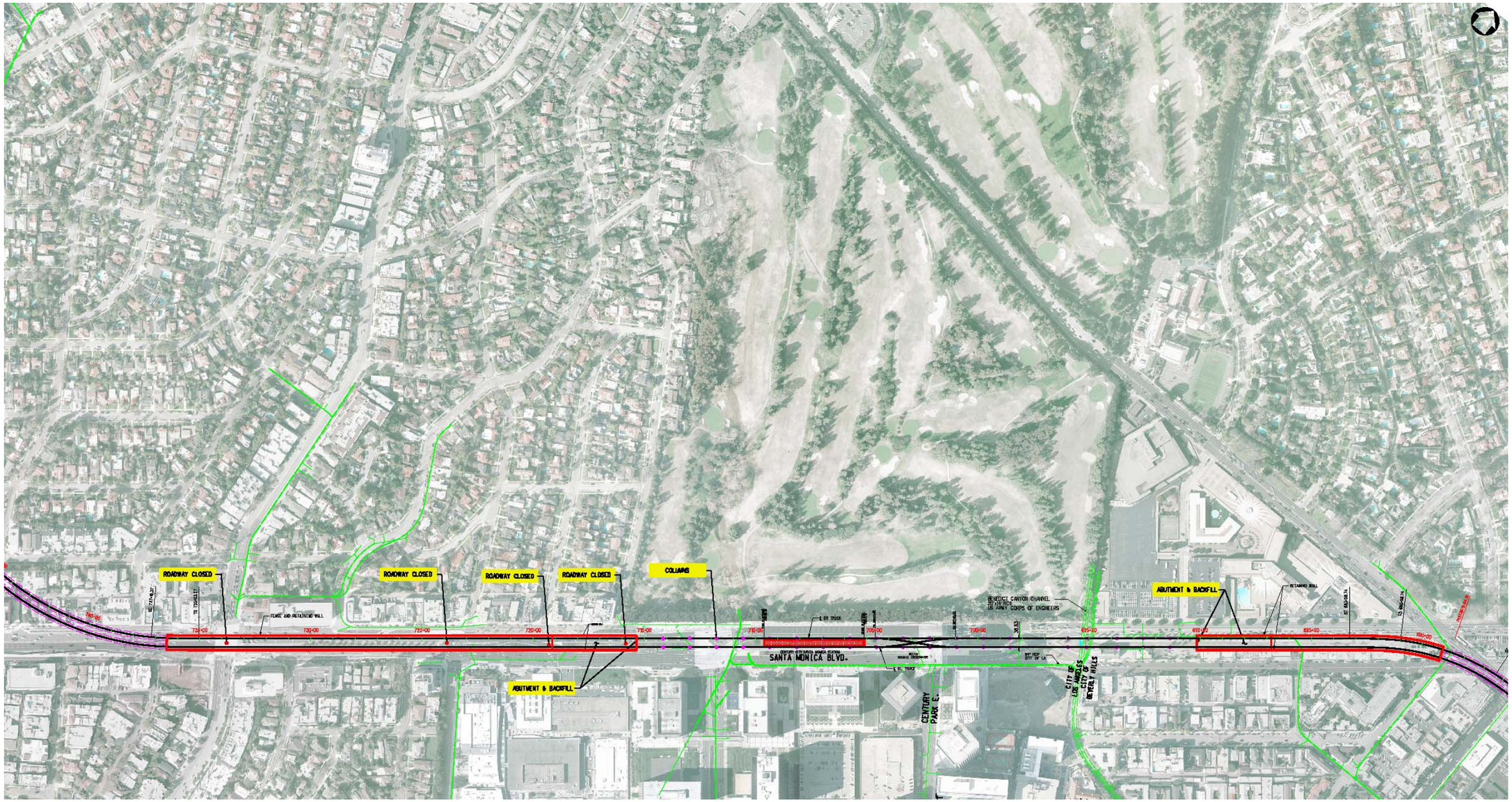

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Figure A-19: Fault Zones, Aerial Station Concept

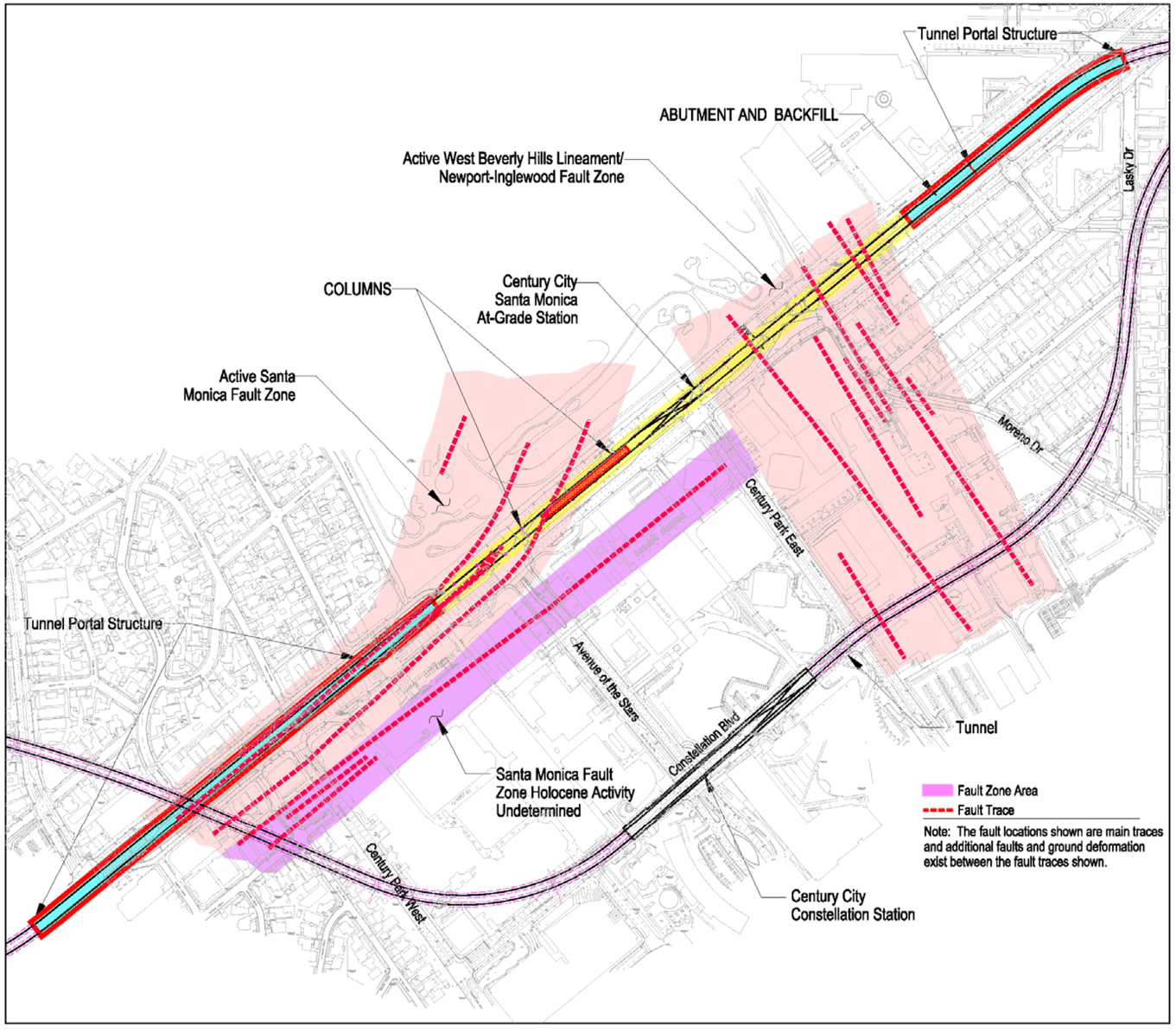

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Figure A-20: Cross Section, Aerial Station and Pedestrian Overpass Concept