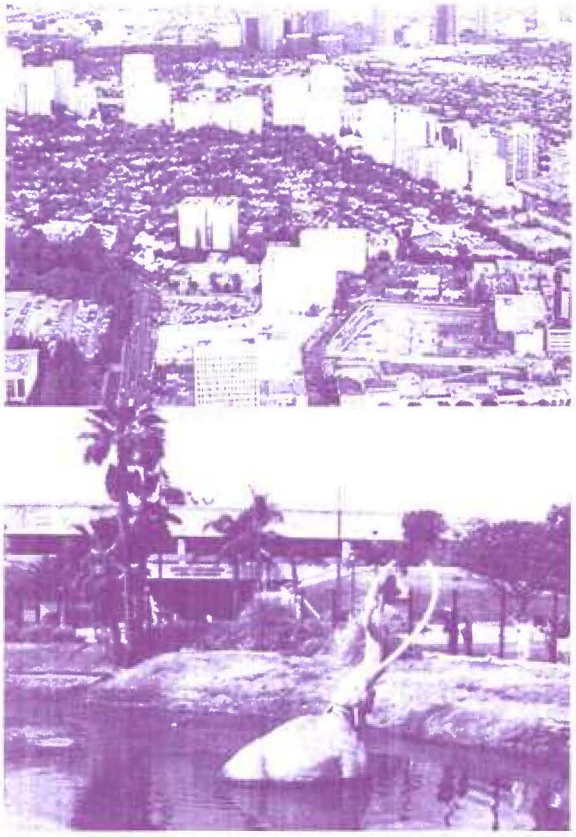

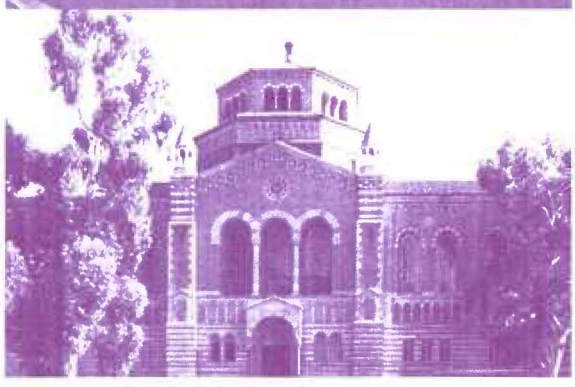

WESTSIDE SUBWAY EXTENSION PROJECT

Contract No. PS-4350-2000

Response to Hazard Assessment Study by Exponent

Westside Subway Extension Project

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April 4, 2012

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Executive Summary

This report responds to the *Hazard Assessment Study, Westside Subway Extension Project Century City Area* (February 7, 2012), which was prepared by Exponent Failure Analysis Associates (Exponent). Exponent's opinions are based on its review of two reports prepared by Metro: The *Century City Tunneling Safety Report* and the *Century City Area Fault Investigation Report* (Tunneling Safety and Fault Investigation Reports, respectively), which were issued on October 19, 2011, in response to a request by Mayor Brucker of the City of Beverly Hills.

Metro reconfirms the following conclusions provided in the two reports and in its *Tunnel Advisory Panel (TAP) Report* issued on October 19, 2011:

- Because of known active faulting, station sites along Santa Monica Boulevard are unacceptable for a subway station.
- There is no active faulting at the Constellation Station site and the location is suitable for a station.
- Tunneling can be safely accomplished along the Constellation alignment and under Beverly Hills High School and adjacent properties.

Metro disagrees with Exponent's opinions and finds serious flaws in the conclusions drawn from its investigative approach. In a number of cases, Exponent does not acknowledge or is unaware of information and analyses that Metro conducted. Moreover, Exponent's opinions frequently reflect a lack of familiarity with and expertise in underground construction and fault investigation, and are unsupported by facts.

Metro responds in detail to Exponent's opinions in this report. The salient features of Metro's response are summarized under the headings that follow. A table at the end of this section provides a brief summary of Exponent's comments and Metro's responses.

Risk Management

The Exponent report states that its *"overarching opinion is that neither* [Fault Investigation or Tunneling Safety] *report demonstrates the presented findings as based on rigorous risk assessment(s) on these subjects. Specifically, no attempt is made to quantify or even qualitatively assess the potential risks from these scenarios. No quantitative or qualitative risk assessments have been presented to either a) estimate the likelihood of such events or b) characterize the potential severity of such events to the public."*

Metro disagrees with Exponent's opinion. The probability based risk analysis that Exponent suggests is not standard practice for major civil engineering projects except for high-hazard nuclear power plants. Instead, Risks are accounted for explicitly in Metro's design approach. It is not possible to ensure life safety for a subway station in an active fault zone. Accordingly, any station on Santa Monica Boulevard has unmanageable risks. However, the Constellation station is not sited on an active fault, and other risks such as gas risks, can be mitigated effectively. Metro's risk management approach uses engineering solutions to mitigate the risks related to tunnel safety, rather than estimating probabilities associated with identified risks.

In all work, Metro develops solutions to mitigate risks to levels that are as low as reasonably practicable through the use of scientific and engineering judgments based on widespread experience. Moreover, extensive experience in Los Angeles and other cities show that this risk management process results in safe and effective construction. Fundamental to this approach is that engineering to mitigate risks is conducted by multidisciplinary teams of experts whose designs and recommendations are reviewed by independent, expert

panels. Such an approach conforms to accepted best practices of the underground construction industry and embodies the successful risk management procedures used on major civil works, including transit projects, throughout the U.S. and many parts of the world.

Active Faulting at the Santa Monica Boulevard Station Site

Exponent states that "*additional subsurface exploration parallel to Santa Monica Boulevard* [should] *be performed to evaluate a potential "central alternative" for the station location between the two Santa Monica station sites.*"

With respect to a potential "central alternative," Exponent appears not to have considered the likelihood of significant tectonic disturbance within the structurally complex zone of the intersection of the northern Newport-Inglewood and the Santa Monica fault zones within this area. These fault zones are not single fault strands (fault "lines" on a map) but rather are broad, complex zones of faulting with many potentially active strands. When such large faults converge with one another, they do not converge at a single point. Rather, they "blend into" one another over a structurally complex zone of distributed deformation that may be hundreds of feet wide. Thus, it is not be possible to identify all potential seismic threats within the complicated zone of intersection between the Santa Monica and northern Newport-Inglewood fault zones.

The geomorphic expression of a scarp (short for escarpment or bluff) associated with active faulting along the Santa Monica fault zone does not extend east of the West Beverly Hills Lineament (WBHL), a northwest-trending topographic rise (bluff) present along the western boundary of Beverly Hills. Rather, the easternmost part of the scarp diverges from Santa Monica Boulevard, assumes a more northeasterly trend through the Los Angeles Country Club, and merges with the northern part of the WBHL about ¾ mile north of Santa Monica Boulevard. However, this section of the scarp within the country club appears to have been eroded by a southwestward-flowing drainage emanating from the Benedict Canyon drainage to the east, which may also be influenced by the WBHL. Thus, although the scarp provides a northernmost-possible location for the main trace of the north-dipping Santa Monica fault zone in the country club area, the surface traces of the main, active strands of the fault zone responsible for initially generating the scarp may lie somewhat to the southeast of the surface scarp, and closer to, or even coincident with, Santa Monica Boulevard.

Exponent suggested that trenching along Santa Monica Boulevard could resolve this issue. Trenching, however, is not a feasible approach because construction and the installation of subsurface infrastructure along Santa Monica Boulevard have destroyed the stratigraphy due to construction excavations needed to identify the location and degree of activity of faulting. While trenching is often used as a means to examine faulting, it is often extremely difficult to excavate continuous trenches and obtain meaningful data to characterize active faults in urban environments. Although access for continuous trenching may be possible at individual properties and building sites, Metro structures are long and linear and complete access for such a long trench precludes trenching in these areas—particularly when located in the street (and cross streets) containing utilities such as the Benedict Canyon storm drain in Moreno Drive. Accordingly, it is not possible to continuously trench to obtain positive evidence that active fault strands are not present. A non-continuous trench will not resolve the uncertainties but will likely add uncertainties.

Constellation Station Site

A review of all topographic, stratigraphic, and geophysical data confirms there is no active faulting at the Constellation site. In marked contrast to the topographically obvious Santa Monica and northern

Newport-Inglewood (WBHL) fault scarps, the absence of topographic indication of active faulting at the Constellation Station provides very strong evidence that this site is clear of active faults.

With respect to subsurface gas hazards, Exponent stated the following: *"...the alternative Constellation Boulevard station, while generally in a more favorable location with regards to faulting issues, is instead faced with potential methane gas hazards that could represent at least as great a hazard to the public as the faulting hazards associated with the Santa Monica Boulevard station."*

Comparison of gas hazards with siting a station on an active fault is inappropriate. The risk of an earthquake and fault rupture at a station location cannot be practically mitigated while gas hazards can and are successfully mitigated for Metro stations and deep basements throughout Los Angeles, including areas with much higher gas concentrations than at the Constellation site. Metro's engineering consultants have developed systems for mitigating and preventing gas inflows in the proposed stations along the Westside Subway Extension Project (Westside Extension) corridor using proven designs and construction procedures.

Tunneling Safety and Future Development

Exponent raises several questions related to general tunneling hazards with respect to potential for building damage, tunneling in fault zones, tunneling under Beverly Hills High School (BHHS) damage to utilities, and applicability of data from previous projects to the Westside Extension.

Exponent states that *"...according to reports (e.g., Bell Consulting, 2004) describing surface effects during tunneling of the Metro Red line subway, settlements were much higher (2 to 10 inches) than originally predicted (0.5 inches)."* Exponent then concluded that higher differential settlements and cosmetic and even structural damage should be expected for the Century City Constellation alignment.

Exponent's reference to tunneling and settlement on the Red Line is not relevant to current Metro tunneling technology and its conclusions regarding settlements and damage at Century City are invalid. The tunneling projects it references are outdated in that the tunnels were driven with open-face tunnel shields that could not effectively control ground loss and settlement when tunneling in soils susceptible to running or flowing. The shields were last used by Metro in the mid 1990s and have been replaced on Metro projects (as well as tunnel projects worldwide) with tunnel boring machines (TBM) that provide positive support of the tunnel face, thereby preventing ground settlements.

Metro specified the pressure-face method for the Eastside Gold Line project (MGLEE), and in 2006, the tunneling was successfully accomplished with surface settlements of 0 to 0.3 inches and no damage to structures. This method is being applied successfully worldwide and is being applied specifically for current Metro tunnel projects. The capabilities demonstrated on the MGLEE project are applicable directly to the Century City Area. One of the main advances in tunneling technology has been the development of comprehensive procedures for controlling TBM operations and monitoring. These methods will be conducted during all tunneling to confirm that ground movements have been controlled to specified levels.

The gasketed lining installed as the tunnel is advanced prevents inflow of water and gas into the tunnel, and grouting around the tunnel lining is used to prevent flow of gas and water along the tunnel perimeter. The presence of the tunnel will not impact gas conditions or the effects of faulting and earthquake shaking at the surface.

Exponent claims that "*frequent reference is made to previous favorable experience in the Los Angeles Basin with pressure-face tunneling methods*" and that "*these references have little meaning in the absence of detailed data from the earlier projects.*" Metro does not understand how Exponent can come to such a conclusion. As is clearly demonstrated, reference to the earlier Red Line project is not relevant because technology has undergone profound changes since that time. The pressure-face tunneling machines, which will be used on the Westside Extension, proved their safety and effectiveness on the MGLEE project and are being continuously improved.

Exponent also stated that future development at BHHS and at other properties and residences would be impacted. The tunnels have been established at a sufficient depth that development for BHHS or other properties can be accomplished above the tunnels. Foundations can be built on slabs above the tunnels or with foundations between the tunnels so that major bridge structures with wide spans are not required.

Exponent raises concerns about fragile water mains and has indicated that special precautions are needed to safeguard the lines. Soil movements on MGLEE were controlled to such low levels that no damage in fragile cast-iron water mains was reported throughout the entire distance of tunneling. Metro is applying the same pressure-face tunneling technology used on MGLEE, where ground conditions were similar to those on the Westside Extension and cast-iron water mains of similar age and size were protected from damage. Clearly, the use of proven tunneling methods, consistent with the best current technology, is highly relevant for the proposed construction in the Century City area, and in fact, is one of the most effective ways to reduce risk.

In response to Exponent's concerns about life cycle analyses, life cycle costs were addressed in the evaluation of alternatives with respect to both capital and operations and maintenance costs. Life cycle costs—within the broader spectrum of environmental and economic aspects of the selection process—are systematically addressed throughout all phases of the project to comply with Federal Transit Administration (FTA) requirements and are included in Metro's analyses.

Summary of Exponent Comments and Metro Response

Exponent Page No.	Exponent Comment	Metro Disagrees	Metro Response
ii, 2, 17	Presented findings were not based on rigorous risk assessment(s). Specifically, no attempt is made to quantify or even qualitatively assess the potential risks...	✓	Risks are accounted for explicitly in Metro's design approach. Metro's risk management uses engineering solutions to mitigate the underground construction risks, rather than estimating probabilities associated with potential future events.
ii, 17	...Constellation Boulevard station, while generally in a more favorable location with regards to faulting issues, is instead faced with potential methane gas hazards...	✓	The gas hazards at Constellation are lower than those on the existing Red Line – and therefore Metro has demonstrated they can be mitigated
7	...additional investigation [that] could be performed to vet the potential "central alternative" include: [Trenching and additional borings] ... (paraphrased)	✓	Exponent appears not to have considered the likelihood of significant tectonic disturbance within the structurally complex zone of intersection of the northern Newport-Inglewood and Santa Monica fault zones within this area. These fault zones are broad, complex zones of faulting with many potentially active strands. Thus, it is not be possible to identify all potential seismic threats within the complicated zone of intersection between the two Santa Monica Station sites.

Exponent Page No.	Exponent Comment	Metro Disagrees	Metro Response
10	"...according to reports describing surface effects during the tunneling of the Metro Red Line subway (Bell Consulting, 2004[2]), settlements were much higher than originally predicted..."	✓	Exponent's reference to tunneling and settlement on the Red Line is not relevant to current Metro tunneling technology and its conclusions regarding settlements and damage at Century City are invalid. The Red Line was tunneled with open face shields susceptible to large settlement which have been replaced on all Metro projects with tunnel boring machines that provide positive support of the tunnel face, thereby preventing ground settlements.
6, 7, 8, 12	With respect to Metro's evaluation of no evidence of faulting on Constellation site: • "...The precise locations of the inferred faults are in some places not tightly constrained." • .. "the faults may not offset Holocene sediments," (paraphrased) ..."Lateral discontinuities in Quaternary strata may be unrelated to faulting, ..." (paraphrased) • ...."The westernmost trace of the WBHL may underlie the Constellation station location...." (paraphrased)	✓	No evidence of faulting is demonstrated through the review of three data sets: Soil borings, geophysical data and the topography. Exponent only considered the soil boring data set.
10	...earlier projects (Gold Line tunnel) were used as examples of tunneling success, but no data was provided for their review...	✓	Data was not only cited in the Tunneling Safety Report, but also was readily available in published literature about the Gold Line, as well as in publications well known in the tunneling industry.
11	..."the geological conditions that would be encountered at tunneling depth beneath BHHS would differ, perhaps significantly..."	✓	Soil conditions at BHHS are similar to those encountered on the Goldline tunnel and well-suited for pressurized face tunneling methods that control ground movements to small values.
10	..."It is also important to note that settlement calculations described in the Safety Report do not appear to consider consolidation settlements due to ground water loss."	✓	As described in the Tunneling Safety and TAP reports, pressure face Tunnel Boring Machines operate without lowering the groundwater and consolidation is not an issue. It therefore should not be, and was not included in the settlement calculations.
11, 12	...older, fragile water lines could be damaged by tunnels..." (paraphrase)	✓	Utilities and structures above the tunnel are evaluated during the design process. Pressure face tunneling minimizes settlement to the levels that utility damage does not occur. Similar age utilities exist over the Metro Gold Line tunnels and were not damaged.
15	"... The Safety report does not address any plans for reconnaissance or monitoring of structures or utility lines before or during tunneling operations."	✓	The TAP report, did address the evaluation and monitoring of structures and utilities, which is a Metro (and industry) standard, and emphasized that monitoring will be conducted prior to reaching structures to confirm that movements are within specified levels.
11	"...The sub-vertical faults underlying the campus, presuming they exist, represent discontinuities in the soil mass. Surface deformations will likely be concentrated above these faults during drilling (sic) as a result of differential settlements."	✓	The pressure-face tunneling method will control ground movements in soils of variable strength, including the fracture planes and shear zones in a faulted soil mass without causing differential settlements.

Exponent Page No.	Exponent Comment	Metro Disagrees	Metro Response
3, 15, 18	...lacked a life cycle analysis to allow a "consideration of the safety risk management issues of the project within the broader spectrum of environmental and economic aspects of the selection process". ..	✓	Life cycle costs are systematically addressed with respect to both capital and operations and maintenance costs. Life cycle costs.
8, 9	...Exponent questioned placement of the Santa Monica-Constellation Station within the San Pedro formation... [that had high gas levels in mid-City]	✓	Metro has constructed tunnels and stations in on the Red Line in areas with higher gas measurements than those in the Century City area, and has developed designs for the Westside stations to control gas and prevent inflow into the station. In addition, deep excavations for underground parking in the Century City Constellation Station area have been operating safely for more than 40 years.
13	"...dangerous levels of methane gas may accumulate under building foundations or developed areas on the surface (Hamilton and Meehan, 1992)."	✓	Over the past 25+ years, the Cities of Los Angeles and Beverly Hills have developed methods to measure gases, design for their presence, and monitor for control. Metro has also demonstrated designs and operating systems for these conditions.
iii, 13, 14, 17, 18	...probing in advance of the tunnel boring machine is needed to locate the presence or confirm the absence of oil well casings		Metro agrees and made this recommendation in its Tunneling Safety Report.
15	...future development at BHHS and other properties would be expected to be impacted.	✓	Foundations can be built on slabs above the tunnel or with foundations between the tunnels so that major bridge structures with wide spans are not required. The High School and other properties for which subsurface easements will be obtained are documented in the Environmental Report. Any future project to be developed adjacent to Metro right-of-way will need Metro approval prior to construction. This does not preclude development.

1.0 INTRODUCTION

This report provides Metro's response to the issues raised in the Hazard Assessment Study, Westside Subway Extension Project Century City Area report, which was prepared by Exponent Failure Analysis Associates on February 7, 2012 (hereafter referred to as the Exponent Report).

The project is following the comprehensive National Environmental Policy Act/California Environmental Quality Act (NEPA/CEQA) process as well as the Federal Transit Administration's (FTA) requirements for projects entering its New Starts program. This requires evaluation of cost, risks, and benefits of all alternatives—with technical reports by experts in their fields—to support the studies.

In addition to these in-depth studies, the Metro's Westside Subway Extension Project team responded to specific questions raised by the Metro Board of Directors in October 2010 on the safety of tunneling in Century City. Reponses to the Metro Board were addressed in the two reports reviewed by Exponent: The Century City Tunneling Safety Report and The Century City Area Fault Investigation Report (Tunneling Safety Report and Fault Investigation Report, respectively). In addition, the independent Tunnel Advisory Panel (TAP) prepared a summary report addressing both fault and tunnel safety issues. All the reports were prepared and reviewed by internationally recognized experts.

Metro re-confirms the following conclusions presented in the Tunneling Safety, TAP and Fault Investigation Reports:

- the Century City Constellation Station site—and tunneled approaches—are safe; and
- the proposed Century City Santa Monica Boulevard Station is not viable because of active faulting present in the area.

This report provides 1) an elaboration on the fault studies to further clarify Exponent's questions about fault interpretation; 2) a summary of Metro's approach to evaluation of tunneling safety; with detailed responses to Exponent's questions/comments on assessment of risks, tunneling methods and ground response and tunneling beneath structures, including those pertaining to tunneling in gassy ground.

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2.0 ACTIVE FAULTING

The determination of active faulting along the Santa Monica Boulevard alignment option is foremost in Metro's recommendation to pursue the Century City Constellation Station (Constellation Station). Subway stations nor any other public facility for human occupancy cannot be located on an active fault. Metro's seismic design criteria (described in Section 3.1) require life safety performance of structures, which cannot be met for an underground station design and Maximum Design Earthquake (MDE) fault offset. With respect to faulting in the Century City area, Exponent's evaluation of the Fault Investigation Report contains a number of limitations, which may be due in large part because Exponent did not fully review the paleoseismic investigations, including Metro's use of multidisciplinary data sets to identify and characterize active faults. Specifically, Exponent focused almost entirely on the borehole and cone penetration test (CPT) results, without considering the geomorphic (landscape) features and the seismic reflection profiles. Moreover, the statement by Exponent that "... the choice between the two stations [one on Santa Monica Boulevard and the other on Constellation] is more likely to be made on the basis of risk perception rather than risk quantification" is without merit.

A "quantitative" risk assessment for a station on Santa Monica Boulevard (including Exponent's proposed "central alternative") is unwarranted, because any of the alternative station locations on Santa Monica Boulevard would be within either of the active Santa Monica or Newport-Inglewood (NI)/West Beverly Hills Lineament (WBHL) fault zones or both zones [because stations cannot be built within active fault zones, there is no need for a detailed risk analysis comparing the two station alternatives]. In contrast, there is no evidence for active faulting near the Constellation Station option. Therefore, the subject of risk-based decisions on the alignment selection is discussed in Section 3.0.

Exponent raised specific issues, and several are intimately linked; however, for clarity, each is addressed below.

2.1 Fault Locations

The Exponent Report stated in Section 3.2 that, "The precise locations of the faults are in some places not tightly constrained," suggesting that Metro's data are limited because of the boring and CPT spacing and thus is not sufficient.

The precise locations of many of the faults identified are not well constrained since it was not the purpose of the fault investigation to do so. The purpose of the fault investigation was to determine whether the station alternative locations would be in zones of surface rupture hazard - not to determine precise locations of faults. The fault investigation concluded that evidence of active faulting at the Santa Monica Station locations exists, and Holocene fault activity cannot be precluded from any of those locations. This conclusion was demonstrated through the combined evaluation of borehole and CPT data, analysis of the topography, interpretation of the seismic reflection profiles and relationship to demonstrated Holocene faulting.

There is no evidence for the presence of recent activity of a westernmost hypothesized strand of the WBHL near the Constellation Station location, although, in this case, it is not relevant because other observations including topography and stratigraphic markers in bedrock units show no indication of late Pleistocene or Holocene activity. Analysis of historic photography in this area shows no indication that

faulting has caused disruption of the surface topography. The age of the strata at Constellation Station is not well constrained, but it is likely greater than 100,000 to 200,000 years old.

It is the geomorphic expression of surface topography upon which the active Newport-Inglewood fault zone was extended northwest to include the WBHL (as originally documented by Dolan and Sieh, 1992), and it is also the surface topography that delineates the location and degree of activity of active traces of the Santa Monica fault zone in Century City and to the west. In a similar fashion, the absence of tectonic geomorphic indicators of active faulting in ancient landscapes along the Constellation Station alignment and continuity of stratigraphic marker beds in San Pedro formation Meistocene bedrock precludes the presence of active faulting. Accordingly, a more detailed boring and CPT array was not warranted for the purpose of selecting an alignment. This point is explained in more detail below.

It appears that Exponent's evaluation of the data focused entirely on the borehole and CPT results. These data, while valuable in terms of locating the near-surface traces and geometries of these faults, represent only part of the multidisciplinary data set that was brought to bear on the fault activity evaluation. For example, Metro's Fault Investigation Report was careful to point out that in the Century City/West Beverly Hills area, a primary means by which to determine the locations of active faulting is through analysis of the landscape. As noted, when faults rupture to the surface resulting in large earthquakes, they leave characteristic signatures in the landscape. These signatures can include "scarps" (short for escarpments), deflected or captured drainages, and offset landforms. A first-order indication of the location of active faulting is provided by the landscape.

Active faults do not occur randomly. Rather, they typically occur in well-defined zones. The topographic signatures of the Santa Monica and northern Newport-Inglewood fault zones in the Century City/West Beverly Hills area are particularly well defined. The prominent scarps associated with the Santa Monica and northern Newport-Inglewood fault zones were first identified on the basis of detailed analysis of the topography. These scarps clearly delineate the general trends and locations of these major active faults. The north-side-up scarp associated with the Santa Monica fault extends continuously for approximately 7 miles—from the Los Angeles Country Club in the east across Century City, West LA, and Santa Monica—before heading offshore at Pacific Palisades, where it continues westward along the Malibu coast as a submarine feature. In the Century City area, this prominent scarp forms the hill along the northern edge of Santa Monica Boulevard and is particularly prominent as the sloping lawn of the nearby Mormon Temple.

Likewise, the topographic expression of the northern part of the Newport-Inglewood fault system (referred to as the WBHL) is a prominent feature of the landscape. One of the most obvious surficial expressions of this fault zone is the linear topographic uplifted features that separate the low-lying alluvial plain on which most of Beverly Hills is built from the higher topography to the west of the fault zone.

Landscape analysis uses geomorphic analyses to identify signs of active faulting and works in two ways—it not only provides the most basic and compelling evidence of the locations of active faults, but also shows, by the absence of such active fault-related landforms, where active faults are not present. This point provides basic evidence that the site of the proposed Constellation Station alternative is free of active faulting. No fault-related landforms were observed at the site, either in the landscape as revealed by detailed, 1920's vintage topographic maps or the earliest-available aerial photographs from the late

1920s. In contrast, the topographic evidence of active faulting along the Santa Monica and northern Newport-Inglewood fault systems is clearly visible on these vintage photographs and maps.

Exponent also did not consider the importance of the third major data set in the Metro Fault Investigation Report—namely the many seismic reflection profiles that were collected and processed for this work. This may explain their interpretation that some of the faults that were identified could be manifested in the subsurface as "*monoclinal folds*." Not only do the seismic reflection data provide the deeper structural context for the borehole and CPT data, but they also reveal the deeper geometry and extent of the faulted and folded strata. This is further addressed in the next section.

2.2 Possibility of Folding

The Exponent Report states in Section 2.2, point 2 that, "*It is possible the offsets on Plate 5 (Transect 2/2E) are monoclinal folds,*" offering that data shown on the Metro profiles (Plate 5) could also be interpreted as folds rather than vertical fault offsets. Along the northern Newport-Inglewood fault zone, the seismic reflection profiles show that there is indeed a monoclinal fold along the eastern edge of the WBHL. This monocline likely overlies a west-dipping thrust fault that would project to the surface in western Beverly Hills to the east. This thrust fault at the base of the WBHL escarpment is probably responsible for most of the topographic uplift along the WBHL. To the west of the topographic scarps, however, there is evidence of no folding, and the strands of the northern Newport-Inglewood fault zone identified in the seismic reflection, borehole, and CPT data are almost certainly steeply dipping active strike-slip faults.

This distribution of different types of faulting—steeply dipping strike-slip faults in the middle and thrust faults/monoclinal folding on the flanks—is typical of the transpressional uplifts that characterize the northern part of the Newport-Inglewood fault zone from Long Beach to Beverly Hills (e.g., Baldwin Hills, Rosecrans Hills, Dominguez Hills, Signal Hill, and Cherry Hill). The WBHL is considered in the literature to be the northernmost of these uplifted zones.

The complex zone of near-surface deformation that characterizes the Santa Monica fault has been studied in detail at the VA Hospital just west of I-405, which is less than 2 miles west of Century City, along the same laterally continuous fault scarp. There, Dolan et al. (2000) documented that the scarp formed in response to thrust faulting and monoclinal folding within and along the southern edge of the topographic scarp. But within and to the north of the topographic scarp, the fault consists of a broad zone of distributed, steeply dipping strike-slip faults. The total width of the fault zone is several hundred feet. The continuity and similarity of the fault scarp between the VA Hospital and the Century City area demonstrates that deformation patterns in the Century City region should be similar.

2.3 Offset of Holocene Sediments

The Exponent Report implies that (Section 3.2, point 3) that the faults may not offset Holocene sediments, that is, the ages of sedimentary units have not been well defined, and suggests that statutory restrictions to construction would not necessarily apply. There are little or no Holocene sediments that overlie these faults in the areas of any of the proposed stations. The Holocene sediments are generally isolated in the incised drainages and canyons and low-lying alluvial plain, most of which have now been disturbed (and/or removed) by development and/or overlain with artificial fill. Other than localized Holocene deposits, the only "sediment" of Holocene age in the uplifted areas would be the original surface A horizon, or topsoil, that caps the Pleistocene fan surfaces in the region. In many or most areas

in the built environment, this layer is disturbed or has been removed. If the A horizon is faulted, late Holocene activity is demonstrated. However, A horizons reform very rapidly and the absence of a faulted A horizon is not evidence against Holocene faulting (see Rockwell, 2000, for a more complete discussion on the use of soils in fault studies). This cannot be resolved with borehole and CPT data alone, and continuous trenching along the entire alignment of all Santa Monica Boulevard station alternatives in a northeast-southwest direction (to evaluate the WBHL) and northwest-southeast direction (to evaluate the Santa Monica fault zone) is likely impossible because of the extensive disruption of the native soil materials along the utility alignments of the utility lines.

Both the Santa Monica and Hollywood fault zones have been well documented and proven to be Holocene-active, with the northern part of the WBHL forming a tear between the eastern end of the Santa Monica fault zone and the western end of the Hollywood fault, thereby accommodating motion on each fault independently. Thus, the WBHL also must be Holocene-active. Moreover, the WBHL is Holocene-active by virtue of being the northern extension of the Holocene-active Newport-Inglewood fault zone.

2.4 Interpretation of Lateral Discontinuities

The Exponent Report (Section 3.2, point 4) states, *"The WBHL is manifested at the ground surface as a boundary between two disparate geomorphic and sedimentary environments. As a result, non-tectonic lateral discontinuities in the Quaternary stratigraphy should be anticipated to occur across this feature."* The Exponent implication is that the discontinuities are unrelated to faulting, and thus questions Metro's interpretation of these discontinuities. Although there may be other features such as filled channels or lateral variation in stratigraphy that make correlations challenging, when there are laterally continuous and distinct markers over reasonably large distances that are then truncated abruptly, faulting is most commonly the reason. This is especially true where several horizons at varying depths are truncated or disrupted at the same location. Such patterns are unlikely to be caused by anything other than fault offsets. Moreover, in many cases, the laterally continuous feature is simply stepped up or down across the fault and continues. In these cases, faulting is almost always the reason for the abrupt lateral discontinuity.

2.5 Exploration of a Central (station) Alternative on Santa Monica Boulevard

The Exponent Report (Section 3.4) states that, Additional subsurface exploration [parallel to Santa Monica Boulevard] could be performed to vet a potential 'Central Alternative." This suggests that there may be sufficient room for such a station location along Santa Monica Boulevard. It suggests that the observed offset of a marker bed that transects the "central alternative" station location as not caused by faulting. However, faults within the Newport-Inglewood fault zone are predominantly strike-slip and potentially significant fault offsets are not readily apparent along nearly horizontal beds, particularly in late Quaternary and Holocene sediments where total accumulated horizontal offsets could be tens to hundreds of feet. The reinterpretation is therefore not necessarily valid and does not preclude fault offset.

Exponent suggested that trenching along Santa Monica Boulevard could resolve this issue. Santa Monica Boulevard gives the appearance that it is a wide open street with a large, apparently undisturbed median strip. The suggested continuous trenching, however, is not logistically feasible because of the presence of subsurface infrastructure and consequent destruction of the stratigraphy needed to identify faulting as well as the fact that there is not a continuous median strip.

While trenching across the entire width of a fault zone is often used as a means to examine faulting, it is often extremely difficult to excavate continuous trenches and construct meaningful data in urban environments. Access for continuous trenching may be possible at individual properties and building sites. However, Metro structures are long and linear, and complete access for such a long trench, particularly when it needs to be located in the street and cross streets with utilities, including the large storm drain under Moreno Drive, precludes such trenching in this area. Accordingly, it is not possible to continuously trench to obtain positive evidence of the absence of all active fault strands. Once the subsurface geology has been disturbed by utility or storm drain excavations, it becomes unsuitable for the kind of analysis necessary to evaluate the locations of active faults.

There are well over 15 separate utility lines running within Santa Monica Boulevard. In fact, the original boring and CPT layout on the eastbound side had to be moved to the westbound side because of the dense presence of utilities, although the numerous utility lines were also present on the westbound side. Although the boulevard is wide enough to have zones that may be free of major utilities, particularly in some of the median strips (where only irrigation lines may be present which could disrupt Holocene sediments), there are utility lines and storm drains crossing perpendicular in Santa Monica Boulevard, not only at the intersections with South Moreno Drive, Century Park East, and Avenue of the Stars, but at additional locations between these intersections as well. At all of these locations the stratigraphy necessary to evaluate potential faulting has been destroyed. This is important because unless trench exposures are completely continuous across the zone of interest, the results will be inconclusive. Even gaps as short as a few feet can miss faults. Metro has carefully evaluated possible locations for trenching on or across Santa Monica Boulevard and has not identified locations that could provide conclusive evidence of the presence or absence of active faulting over the entire length of the potential station sites.

With respect to a possible "central alternative," Exponent appears not to have considered the likelihood of significant distributed deformation within the structurally complex zone of intersection of the northern Newport-Inglewood and Santa Monica fault zones within this area. Fault zones such as the Santa Monica and northern Newport-Inglewood are not single fault strands (fault "lines" on a map), but rather are broad, complex zones of faulting with many potentially active strands. When such large faults converge with one another, they do not converge at a single point. Rather, they "bleed into" one another over a structurally complex zone of distributed deformation that may be hundreds of feet wide. Thus, it would not be possible to identify all potential seismic threats within the complicated zone of intersection between the Santa Monica and northern Newport-Inglewood fault zones for reasons described in above.

The scarp associated with active faulting along the Santa Monica fault zone does not extend east of the WBHL, a northwest-trending topographic rise present along the western boundary of Beverly Hills. Rather, the easternmost part of the scarp diverges from Santa Monica Boulevard, assuming a more northeasterly trend through the Los Angeles Country Club, and merges with the northern part of the WBHL about ¾ mile north of Santa Monica Boulevard. However, this section of the scarp within the Country Club appears to have been eroded back by a southwestward-flowing drainage emanating from the Benedict Canyon drainage to the east, which may also be influenced by the WBHL or Santa Monica fault zone. Thus, although the scarp provides a robust northernmost-possible location for the main trace of the north-dipping Santa Monica fault zone in the Country Club area, the surface trace of the main, active strands of the fault zone responsible for initially generating the scarp may lie somewhat to the southeast of the surface scarp, and closer to, or even coincident with, Santa Monica Boulevard east of

Avenue of the Stars. If the main trace of the Santa Monica fault were to continue eastward, coincident with Santa Monica Boulevard in the area of the "Central Alternative," locating a station along Santa Monica Boulevard in the Century City area would be precluded.

For these reasons, Metro strongly disagrees that there may be sufficient room for a "central alternative" station location along Santa Monica Boulevard.

2.6 Location of the Westernmost trace of the WBHL

The Exponent Report again questions fault location with respect to the Constellation Station site in section 4.2: *"the inferred fault could pass much closer (possibly beneath) the eastern end of the proposed [Constellation] station (area indicated as "Uncertain Structure" on Figure A-3)."* This issue is addressed in Section 2.1 above; based on topographic observations, boring data, and all other observations, active faulting does not underlie the Constellation Station location and there are sufficient data to confidently select an alignment.

2.7 Summary – Active Faulting

In summary, Exponent's review of Metro's Fault Investigation Report was technically incomplete as it did not consider all the multidisciplinary data and the implications of those data of the Metro reports. Metro performed and assembled a very large, multidisciplinary data set presented in the Fault Investigation Report, and along with the collective wisdom and experience of the many expert earthquake geologists who compiled and who reviewed this report, provide strong confirmation of the report's conclusions.

In addition, the risk analysis suggested by Exponent for any of the Santa Monica Boulevard sites (including their proposed "central alternative") is unwarranted, as any of these station alternatives would be within either (or both) the Santa Monica or northern Newport-Inglewood active fault zones. As documented in the Metro FEIR, Metro Design Criteria will not permit siting a station on an active fault. Hence, since it is not possible to preclude Holocene activity of fault strands no location along Santa Monica Boulevard for a Century City/West Beverly Hills Station is viable.

In contrast to the Santa Monica Station alternatives, the Constellation Station alternative has no evidence of active faulting. In fact, there is significant evidence that the Constellation Station option is clear of active faulting. In marked contrast to the topographically obvious Santa Monica and northern NI\WBHL) geomorphology, the absence of any topographic indication of active faulting at Constellation Station and stratigraphic continuity of marker beds within bedrock more than 700,000 years old provides compelling evidence that this site is clear of active faults.

3.0 RISK ASSESSMENT

Exponent's "*overarching* opinion" is that Metro did not conduct a rigorous probabilistic risk assessment for 1) selecting station sites and 2) quantifying the level of risk for tunneling. Metro strongly disagrees with Exponent's opinion and does not recommend the use of their approach for assessing risk for the purpose of selecting an alignment.

Metro has used powerful, practical, and accepted state of the practice engineering procedures for evaluating and mitigating risk. Metro used a risk management approach in which risks were identified and engineering solutions were developed to mitigate the risks to levels that are not only as low as reasonably practicable (ALARP) but, from extensive experience in Los Angeles and on other transit projects, have been proven to be safe and reliable. Fundamental to this approach is that the risk evaluation and the engineering to mitigate risks to ALARP are conducted by teams of experts in the relevant disciplines, and the effort and results are reviewed by expert panels. Such an approach is the well accepted, preferred, and successful risk management procedure for major civil works projects, including transit projects, throughout the U.S. and in many parts of the world.

Metro and its engineering consultants have abundant experience designing and building tunnels and station excavations in Los Angeles, dealing with active fault crossings, probing for oil wells, controlling ground movements, and evaluating and controlling gas inflows both during construction and operation. Metro conducted extensive reviews by teams of experts covering the relevant disciplines

One team specialized in gas monitoring and mitigation and in probing for and re-abandoning oil well casings. Another team that investigated and reviewed faulting included the project geotechnical consultant, and three internationally-recognized individual consultants in fault geology with extraordinary personal experience and expertise regarding the Santa Monica and the Newport-Inglewood faults. The work was then reviewed by two independent panels of internationally recognized experts, all of whom have also had extensive experience applying their expertise to issues in the Los Angeles region: Metro's Tunnel Advisory Panel (TAP) evaluated the work throughout the investigation and reviewed the reports; further review of the reports and assessment of the level of the Metro's effort was provided by the Independent Review Panel convened specifically for this project. This extensive effort is equivalent to Levels 1 and 2 of the 4-Level risk used by Senior Seismic Hazard Analysis Committee (SSHAC) developed by the USNRC (2012) in their Risk Management methodology. Levels 1 and 2 exceed the standard for selecting an alignment or site for traditional civil works projects. Accordingly, Metro has accomplished the work needed to conduct a risk analysis. It is shown elsewhere in this report that Metro's engineering is greater in depth and in scope than typically used to establish an alignment, and that the data, analysis, and conclusions are sufficient to select an alignment through Century City. With such abundant engineering data, there are very few unknowns or uncertainties that a probabilistic risk analysis is unwarranted for selecting the alignment.

3.1 Selection of Station Sites

Exponent criticizes Metro's evaluation of the station sites by stating that *"....the choice between the stations [one on Santa Monica Boulevard and the other on Constellation Avenue] is more likely to be made on the basis of risk perception rather than risk quantification".*

A "quantitative" risk assessment for a station on Santa Monica Boulevard (including Exponent's proposed "central alternative") is unwarranted. Any of the alternative station locations on Santa Monica Boulevard would be within either the active Santa Monica or Newport-Inglewood (NI)/West Beverly Hills Lineament (WBHL) fault zone or both zones. The fact that stations cannot be built within active fault zones obviates the need for a detailed comparative risk analysis between the two station sites.

Metro's Fault Investigation report states for the fault displacements that could occur, "design of Metro's underground stations (complex two-story structures up to 1,000 feet long, including systems and ventilation equipment) to withstand such displacements without significant damage and potential loss of life, would be impractical and without precedent. Damage levels would require a complete rebuild of the stations and associated tunnel sections, with a construction time frame of several years." In addition, the State of California does not permit construction of structures for human occupancy in active fault zones. Thus, founding a station within an active fault zone is not consistent with Metro Design Criteria and the State of California laws. Moreover, Metro Design Criteria does recognize and provide guidelines for tunnels to cross active faults. Neither the Design Criteria nor good engineering judgment allow locating a tunnel within an active fault zone for a significant distance - but rather it must cross at an angle to the fault.

Therefore, from Metro's engineering perspective, the operable standard is no loss of life and repairable damage. Given this standard and the confirmed presence of an active fault, further probabilistic analysis applied to "vetting" the Santa Monica Boulevard alignment is not appropriate. Such analysis puts probabilities against certain events and, typically, estimates a range for possible impacts to project objectives (e.g., cost, duration, safety, and quality). This information is then combined and a Monte Carlo analysis is done to determine the range of possible outcomes against the probability of those outcomes.

The strength of such a process—that thousands of possible futures are simulated to see how events are likely to play out—is also a weakness in cases such as this where events with extremely small probabilities, but catastrophic impacts, are being considered. When the probability is multiplied by the potential impact to determine an expected value, the tiny probabilities tend to subsume the potential impacts—the "smallness" of the probability overwhelms the "largeness" of the impact. The tools also tend to obscure the reality that such an event either happens or it doesn't. In the event that a station was built on Santa Monica Boulevard and an earthquake resulted in deaths and/or irreparable damage, it will provide no relief to know how improbable such an event was or that in a thousand other "futures" in a Monte Carlo simulation, the station was never impacted by an earthquake.

Experts can and will disagree as to the probability or return period of a seismic event in the area, and experts can and will disagree as to the likely "strength" of that event should it happen. Given that this is an active fault, it can be said that the risk of a catastrophic seismic event is not zero, and that when such an event occurs, loss of life will occur and the stations and the connecting services would be rendered irreparable. Any further analysis, beyond the identification of the location of an active fault upon which

the Santa Monica stations and tunnels would be located, would imply that building a station in a location unprecedented in the U.S.—a location that would expose the people using the station to a continuing and arguably growing risk of a catastrophic event and a risk that would exist for the lifetime of the facility—is still a location reasonable enough to continue investigating. In short, it implies that the unprecedented siting of an underground station in an active fault zone, contrary to the intent of the Alquist-Priolo Earthquake Fault Zoning Act, is acceptable.

Exponent's Executive Summary also states that *"It is Exponent's view that the alternative Constellation Boulevard station, while generally in a more favorable location with regards to faulting issues, is instead faced with potential methane gas hazards that could represent at least as great a hazard to the public as the faulting hazards associated with the Santa Monica Boulevard station."*

Exponent's statement is incorrect and misleading. Comparison of gas hazards with siting a station on an active fault is inappropriate. An active fault at the Santa Monica boulevard station site cannot be mitigated. On the other hand, gas hazards can be mitigated as has been demonstrated on Metro stations and deep basements throughout Los Angeles, including areas of much higher gas concentrations than at Constellation, and will be mitigated not only at Constellation but at other locations along the Westside corridor using updated, proven designs and construction procedures.

3.2 Assessment and Mitigation of Risks for Tunneling Below BHHS

Exponent states that their *"overarching opinion is that neither report (Fault or Safety) demonstrates the presented findings as based on rigorous risk assessment(s) on these subjects. Specifically, no attempt is made to quantify or even qualitatively assess the potential risks from these scenarios. No quantitative or qualitative risk assessments have been presented to either a) estimate the likelihood of such events or b) characterize the potential severity of such events to the public."*

Exponent's opinion is very surprising because the three Metro reports consist almost entirely of identification of risks, detailed qualitative as well as quantitative descriptions of the risks and the engineering procedures used to mitigate the risks. However, the Metro studies were focused not on estimating the likelihood (probability) of an event but rather on utilizing experts in the relevant geologic and engineering disciplines to provide solutions to mitigate the risk of an event occurring and then to establish controls and monitoring to confirm that the risk has been mitigated.

Metro responded to the motion made by the Metro Board of Directors in October 2010 on the safety of tunneling in Century City, including exploring, *"risks associated with tunneling under the [Beverly Hills] High School, including but not limited to the following: risk of settlement, noise, vibration, risks from oil wells on the property, impact to use of the school as an emergency evacuation center, and overall risk to student faculty and community"*

Metro's approach was to concentrate on conducting the necessary engineering to confirm a safe alignment and then to fully do engineering on that alignment, not only to prove that the alignment is safe [risk mitigated to acceptable levels], but also to increase safety and conveniences -using tried and proven methods. A detailed engineering study was conducted on each risk to quantify each contributing factor associated with that risk and to provide engineering solutions to reduce the risk to ALARP. Rather than concentrating on only risks, Metro adopted an aggressive safety verification and improvement approach.

The three (Metro) Century City reports [Tunneling Safety, Fault Investigation, and Report by the Metro Tunnel Advisory Panel (TAP Report)] contain the results of this safety investigation. The reports not only rigorously identify and comprehensively describe the risks but they also provide the background and studies used in evaluating the risks as well as descriptions of what future work needs to be done *[to confirm the safety]* in the next phases of work including final design, construction, and operation.

The approach used in the Tunneling Safety Report was to describe the risk and state how the risks would be mitigated. These included a conservative approach to design, conservative construction procedures, comprehensive and continuous monitoring during design and operation, as are re-iterated in sections 4.0 through 6.0. Examples include the following related to ground movements:

- Siting the tunnel with adequate cover to reduce or eliminate impacts from tunneling below a structure. The tunnel depth provides more than two diameters of cover above the tunnel crown.
- The alignment was selected to avoid passing close to the BHHS swimming pool building.
- Design and specifications requiring proven and updated tunneling technology for controlling ground conditions and preventing inflows. Pressurized closed-face TBM required with surface settlements to be held to less than 0.5 inches.
- Pre qualification requirements for bidding contractors and their senior engineers, supervisors and operators that include experience in operating and controlling pressurized face tunnel boring machines.
- Monitoring of machine functions and ground movements to verify that ground conditions are controlled and to make timely adjustments in procedures before reaching structures.

Metro disagrees with Exponent's opinion. The probability based risk analysis that Exponent suggests is not standard practice for major civil engineering projects except for high-hazard nuclear power plants. Instead, Risks are accounted for explicitly in Metro's design approach. It is not possible to ensure life safety for a subway station in an active fault zone. Accordingly, any station on Santa Monica Boulevard has unmanageable risks. However, the Constellation station is not sited on an active fault, and other risks such as gas risks, can be mitigated effectively. Metro's risk management approach uses engineering solutions to mitigate the risks related to tunnel safety, rather than estimating probabilities associated with identified risks.

3.3 Summary

The three (Metro) Century City reports (Tunneling Safety, Fault Investigation, and TAP Reports) contain the results of this safety investigation. The reports not only rigorously identify and comprehensively describe the risks, but they also provide the background and studies used in evaluating the risks as well as descriptions of what future work needs to be accomplished in the next phases of work, including final design, construction, and operation.

Through a geotechnical investigation, detailed in the Fault Investigation Report, it was determined that the location of a station along Santa Monica Boulevard would be within either the active Santa Monica or Newport-Inglewood Fault Zone/West Beverly Hills Lineament fault zone or both zones and thus not viable for a subway station.

The Westside Subway Extension Project has exercised industry standards of best practice for the minimization and management of risks associated with the design and construction of tunnels, shafts, and associated underground structures. Metro's approach of conducting the necessary engineering to confirm a safe alignment—and then to do sufficient engineering on that alignment to prove that the alignment was safe—is considered appropriate and adequate.

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4.0 SAFETY OF TUNNELING

Exponent raises several questions related to General Tunneling Hazards with respect to potential for building damage, tunneling in fault zones, and tunneling under BHHS and damage to utilities, and applicability of data from previous Metro tunnel projects to the Westside Subway Extension Project. Each of these is addressed in the sections below.

4.1 Control of Ground Movements During Tunneling

The Exponent Report does not differentiate between open shield tunneling methods used in constructing the Metro Red line tunnels in the 1990s and the major advances in current tunneling technology that have produced proven systems for controlling ground movements and inflow of water and gas in a wide range of soil and groundwater conditions. Thus, this subsection, reviews the pressurized, closed-face tunneling systems now used on Metro projects (also described in the Tunneling Safety Report).

Pressurized-face tunnel boring machine (TBM) technology has been demonstrated on many projects in the U.S. and throughout the world to minimize ground surface movement. In the past 20 years, improvements in design and operation of these machines have continued, and successes have been well documented on projects and in published literature. In Los Angeles, the success of the method has been demonstrated, on the Metro Gold Line Eastside Extension (MGLEE). As described in the Tunneling Safety Report, minimal ground movement is achieved through continuous support of the tunnel face by pressurizing the face of conditioned excavated soil, continuous pressurization and filling of the annular gaps around the shield, and immediate pressure grouting around the segmental tunnel lining installed as the tunnel shield is advanced. This pressurized-face TBM technology along with the immediate installation of gasketed tunnel liners allows tunneling below the groundwater table such that water and gas do not enter the tunnel and cause drawdown and associated surface settlement. The tunneling method has also been described in Section 4.15 of the Draft Environmental Impact Report/Draft Environmental Impact Statement (DEIS/DEIR) and its Appendix E, readily available on Metro's website. The pressurized-face technology is being specified for Metro TBM tunnels in soil.

Professor Eisenstein, former member of Metro's TAP, and former president of the International Tunnelling Association (ITA), presented the results of the monitoring at MGLEE in his keynote address to the 2007 ITA World Tunnel Congress, noting that most of the ground movements were within the range of survey accuracy and essentially zero. Dr. Eisenstein also described similar experience on the Canada Line light rail project in Vancouver, where very small ground movements were measured during Earth Pressure Balance (EPB) tunneling including directly under high rise buildings. In his conclusions he states:

> "With [earth pressure balance] EPB TBM loss of ground 0.3 percent should be achievable for most cohesive soils without other protective measures.
>
> As demonstrated on the example of Los Angeles Metro tunnels, a zero loss of ground tunneling is now a reality. This outstanding achievement was accomplished due to a combination of innovative features of the TBM used and the skill of its operators."

Many other tunnel projects are being driven with little or no settlement. Currently on Seattle's Sound Transit's two University Link tunnel contracts, both contractors are using pressurized face (earth pressure balance) tunnel boring machines in soils consisting of glacial till, lacustrine clay and silt, and

outwash sands and gravel. On both contracts, the first tunnel drives of the twin tunnels have been completed and the second drives are nearing completion. Most of the tunnel length was beneath structures, including homes, apartment buildings, a school, commercial structures and an interstate highway. There have been no significant settlements or building damage. One contractor conducted a concentrated monitoring program in the first 500 feet of the tunnel drive to confirm that the tunneling methods and ground control procedures were effective in preventing ground movements (DiPonio, et al, 2012). Pressure sensors on the shield face and perimeter continuously recorded the positive pressures supporting the ground at both the tunnel face and around the perimeter of the tunnel shield, and provided direct evidence of why the tunneling system was able to prevent ground movements. Deep extensometers located immediately above the tunnel showed that there was no settlement as the tunnel boring machine passed the instrument location.

4.2 Metro Gold Line Eastside Extension Data and its Applicability to Century City

The Exponent Report states that earlier projects (e.g., MGLEE) were used as examples of tunneling success, but no data was provided for their review.

It is incorrect to state that no MGLEE data was provided in the Tunneling Safety Report. The Tunneling Safety Report summarized the magnitude of the settlements measured at the surface and on buildings. It provided a typical settlement cross section and summarized the deep extensometer settlement measurements, noting that all of the measurements were far below the established action levels. The volumes containing the original data plots were not provided in the report, but that data received extensive review by experts in tunneling and ground control during and after construction, and in preparing the Tunneling Safety Report. Furthermore, the MGLEE tunneling work was documented in published papers by Robinson & Bragard (2007), Chouiery, et.al (2007), and Eisenstein (2007).

Throughout the MGLEE construction, the real settlement data was used to verify that ground movements were being controlled as the TBM was advanced, and the results were evaluated throughout the project by project participants and the TAP.

More recently, during the planning and preliminary engineering (PE) phases for planned Metro tunneling projects, including the Westside Subway Extension, Metro's TAP reviewed all the surface and building settlement data and the deep extensometer data for the MGLEE project. The TAP Report stated:

> "Throughout the two tunnel drives, procedures were in place to closely control the tunneling operation and limit settlement. A comprehensive program of instrumentation and surveying was conducted to monitor ground movement around and above the tunnels. Seventy-five extensometers were installed in vertical borings along the two tunnel centerlines to measure ground movement near the crown of the advancing tunnels and at mid-depth between the tunnel and the ground surface. Displacements immediately above the tunnel crown were typically less than 0.1 inch and an order of magnitude less than the specified Action and Maximum allowable settlement levels, confirming that the EPB operation was effective in minimizing ground movement."

As stated in the Tunneling Safety Report (Section 4.2), no substantiated settlement claims were made at MGLEE during or after construction. This tunnel passed as shallow as 35 feet directly below existing building foundations while they were occupied. In contrast, the tunnels at Century City are more than 50

feet below the surface. The Metro Independent Review Panel (IRP) also reviewed the MGLEE settlement data and agreed with Metro's assessment.

4.3 Soil Conditions in Century City, Beverly Hills and East Los Angeles (Gold Line)

The Exponent Report (Section 5.1.2) commented that *"the geological conditions that would be encountered at tunneling depth beneath BHHS would differ, perhaps significantly, from those considered typical during drilling of the MGLEE. This difference may or may not affect the tunneling performance of the* pressure-*face TBMs anticipated for use in the project."* The report also noted the importance of *"minimizing water loss from the saturated sands during drilling (sic) that could result in ground settlement, including during an unplanned halt beneath the high school."*

The pressurized-face TBM systems are designed to operate efficiently and control the ground in the range of ground conditions encountered at both Century City and at MGLEE, and the experience on MGLEE is fully applicable, as well as the current and extensive excellent experience with pressurized, closed-face TBMs throughout the tunneling industry. The minimum pressures on the face of the TBM are specified and controlled to be above the groundwater pressures, thus preventing inflow of water. Tunneling can be planned to advance continuously directly beneath structures. Furthermore, as noted below, the soil conditions at MGLEE are similar to those at Century City.

A schematic profile of soil conditions at MGLEE (shown on Figure 4-3 of the Tunneling Safety Report) shows that the MGLEE tunnel was advanced in the Older Alluvium formation, which included zones of predominantly sandy soils and zones of predominantly clayey soils. The text in the Exponent Report states that the sandy soils were somewhat clayey at MGLEE, whereas those at Century City were different. However, in the Westwood area, the soils are Older Alluvium, which also contains both sandy and clayey zones. Furthermore, as described below, the sandy soils in the Lakewood formation at BHHS have similar gradations to those in the sandy zones at MGLEE. Such ground conditions are amenable to efficient pressurized-face tunneling, which can be accomplished with very small ground movements, as was experienced at MGLEE.

One difference between Century City and MGLEE is that the tunnel alignment for Century City is deeper than at MGLEE. A deeper alignment reduces the magnitude of the surface settlements for a given tunnel's ground loss. Another desirable condition at BHHS for ground behavior at tunnel level is the presence of more very stiff to hard older alluvium above the tunnel crown.

4.4 Surface Settlements

The Exponent Report states in Section 5.1.1. that *"...according to reports [Bell Consulting, 2004] describing surface effects during tunneling of the Metro Red Line subway, settlements were much higher (2 to 10 inches) than originally predicted (0.5 inches)."* The Exponent Report uses this statement to conclude that higher differential settlements and cosmetic and even structural damage should be expected for the Century City alignment.

Exponent incorrectly references a report that describes earlier Metro tunneling experience with open-face digger shields that are no longer being used or proposed for Metro tunnel projects, and does not acknowledge the quantum leaps in proven tunneling technology for controlling ground movements, as evidenced by the tunneling experience on MGLEE. The Exponent Report statement was made in spite of the extensive discussion and explanations in the Tunneling Safety Report and the TAP report that the

Red Line tunnels constructed in the 1990s used open-face shields, which were subject to larger settlements than the pressurized closed-face TBMs now being used throughout the tunneling industry. For this reason, pressurized closed-face TBMs were recommended by the Metro TAP in the 1990s (see Section 9-2 of the Tunneling Safety Report and Section 4.1 of the TAP report). Metro accepted the recommendation, and pressurized-face machines were then specified and used on the MGLEE project where settlements were held to 0 to 0.3 inches Pressurized-face machines are being specified for Metro tunneling projects currently in design, and will be used for tunneling in Century City.

Open-face digger shields not only had the potential for large ground movements into the unsupported tunnel face, but they had no method for preventing the regular ground loss into the overcut annulus around the shield. Additional ground loss also occurred behind the tail of the shield during the time it took to install and expand the tunnel lining. With open shields, dewatering is required to prevent inflows of groundwater and soil.

Therefore, past experience with ground losses around open shield is not applicable to pressurized closed-face TBM. The ability to control ground movements and limit ground loss to small values (less than 0.5%, equivalent to approximately 0.5 inches for the tunnel depths being considered) is being achieved with pressurized-face machines on projects all over the U.S. and worldwide. Monitoring of ground movements and pressures around the TBM shield has shown that pressurization of the shield perimeter as well as the tunnel face prevents significant ground loss. As stated above, pressurized-face machines are being specified for Metro tunneling projects currently in design, and include requirements for pressurizing the shield perimeter as well as requirements for pressurization of the tunnel face and for immediate grouting around the segmental tunnel lining as the shield has advanced.

4.5 Differential Settlements Along the Tunnel Axis

The Exponent Report states in Section 5.1.1: *"It appears that settlement considerations in the Safety Report only account for deformation along a profile perpendicular to the centerline of the tunnels. Differential settlements would also be expected between areas ahead of and behind the advancing boring machine."*

Exponent correctly notes that differential settlements do occur along the axis of the advancing tunnel. However, it is incorrect to conclude that Metro does not consider them. Metro consultants have, over many years, monitored and developed relationships between the longitudinal settlement slopes (along the axis of the tunnel) and the lateral settlement slopes (along a profile perpendicular to the centerline of the tunnel). The conclusion is that the lateral settlement slopes provide an upper limit to the longitudinal slopes and, therefore, estimating the lateral settlement slopes from a profile perpendicular to the tunnel axis is sufficient for determining the relation between building distortion and damage.

Metro's consultants made the pioneering early measurements of the three-dimensional pattern of settlements around an advancing tunnel shield (Cording and Hansmire, 1975, Hansmire, 1975) and reported on the relationship between settlement slopes in the longitudinal direction and those in the tunnel cross section perpendicular to the tunnel axis. Such measurements have been made on a number of projects. The results indicate that the maximum settlement slopes in the longitudinal direction (along the tunnel axis) are equal to or less than the average slope of the settlement trough in the cross section. Thus, the average settlement slope in the tunnel cross section provides an upper limit to the longitudinal slope. Therefore, it is appropriate to use the relationship between ground movements in a

profile perpendicular to the tunnel axis in assessing maximum damage levels, and is not necessary to report the longitudinal settlements and distortions. The settlement slopes and lateral strains in the longitudinal direction are considered when evaluating the distortions imposed on structural walls and utilities that are oriented in the direction of the tunnel drive (Cording 2010).

4.6 Consolidation Settlements

The Exponent Report states in Section 5.1.1, *"It is also important to note that settlement calculations described in the Safety Report do not appear to consider consolidation settlements due to ground water loss."*

This statement confirms Exponent's lack of understanding of current tunneling technology. Consolidation settlements due to ground water loss during tunneling are not an issue as there is no water loss. It is most important to note that pressurized-face tunneling balances ground water pressures and the liner is water-and-gas tight so that drainage into the tunnel producing dewatering and consolidation settlements do not occur. Furthermore, the dense and stiff soils around the tunnels in Century City will not be subject to measurable consolidation due to stress and groundwater changes during tunneling. Moreover, as described in the DEIS/EIR, the Los Angeles area has been subjected to many cycles of fluctuation in groundwater levels, and soils are generally not subject to further consolidation with groundwater changes.

4.7 Protection of Utilities

The Exponent Report suggests that older, fragile water lines could be damaged by tunnels. Section 5.2 states, *"Consideration must be given to the possibility that these very old utility lines may be brittle and unable to tolerate even the projected differential settlements."*

Utilities along the tunnel alignment are routinely assessed and evaluated during design and construction. Using similar analysis methods as for settlement of buildings, standard practice in the tunneling industry is to identify and evaluate utilities' locations with respect to the tunnel (depth and offset, material composition, age, type of joints, and contents). The major lines are identified for relocation as required at station locations and for coordination with the utility owner. Where analysis of a utility shows that additional protection is needed, steps are taken prior to tunneling—such as replacement or repair of the utility, or by other methods such as ground modification—to further reduce settlement.

With respect to Exponent's concerns about brittle utilities, it should be noted that even the old cast iron water mains overlying MGLEE were not damaged by the EPBM tunneling. Metro engineers have abundant understanding and experience with the behavior and protection of utilities. In fact one of the members of the IRP panel is a consultant for the Los Angeles Department of Water and Power (LADWP) and is a co-author of the comprehensive LADWP report on the condition and protection of these same types of cast iron water lines that exist at both MGLEE and the Constellation alignments (Bardet, et al, 2010).

As for tunneling methods, Exponent comments in Section 5.2 on large ground movement and formation of a sinkhole in 1995 on the Red Line and incorrectly relates it to the sensitivity of utilities and TBM tunneling. The 1995 sinkhole in Hollywood did not occur during TBM tunneling. The sinkhole resulted from re-mining (removal and resetting of the installed support) of a misaligned tunnel. The method used

resulted in instability in the tunnel, large ground movements, breakage of a waterline, and the ensuing collapse of the street. Subsequently, Metro convened the three-person TAP to assess the feasibility of safe tunneling in Los Angeles. The TAP's report contained recommendations for future tunneling, which included the use of pressurized-face TBMs, which were successfully used on the MGLEE project.

4.8 Condition Surveys and Monitoring of Structures

The Exponent Report states in Section 5.6, *"The Safety report does not address any plans for reconnaissance or monitoring of structures or utility lines before or during tunneling operations."* Comprehensive discussions of surveys and monitoring are presented in a number of reports, including the TAP report and the Draft EIS/EIR. Exponent should be aware that this is standard practice in the tunneling industry.

Instrumentation and monitoring during tunneling are absolutely key—this is standard practice in the tunneling industry and is described in the Draft ESI/EIR. Designs for instrumentation and monitoring, as well as preconstruction surveys, are carried out in final design. Furthermore, preconstruction surveys must be carried out as late as practical before tunneling so that the survey reflects conditions immediately prior to tunneling. Detailed inspections are carried out as part of the normal design and preconstruction process. Settlement monitoring points are placed on buildings, and a pre-condition survey is performed for comparison with conditions after tunneling has been accomplished.

The TAP noted in its safety report:

> "Design criteria and construction procedures will be in place to ensure that the ground movements are controlled to required levels. Action and Maximum levels for settlement will be specified and monitoring sections will be established to measure ground movements prior to and during tunneling beneath the high school and other structures along the alignment. The monitoring will be used to confirm that ground movements are being controlled to required levels or to make any required adjustments in tunneling procedures."

4.9 Procedures for Assessing and Controlling Ground Movements

Proven methods have been used and are appropriate for analyzing the magnitude and distribution of ground movements and their impact on structures for the soil conditions in the Century City/Beverly Hills area. The methods are based on extensive experience monitoring deep-ground movements around the advancing tunnel shield, measurements of the surface settlement and lateral displacements over a wide range of ground conditions, and correlations with numerical analyses. In the design of Metro tunnels and excavations, a full range of methods is used for evaluating ground movements, including compiling field measurements and numerical analyses. Further evaluations and analyses are conducted during the final design and construction planning; however, the current analyses are not only sufficient, but well proven for establishing that movements can be controlled to required levels.

Metro tunnel contracts will specify requirements for controlling ground movements, including use of pressurized-face TBMs and requirements for pressurizing the tunnel face and shield perimeter and pressure grouting in the tail in order to prevent settlement. The contracts will have prequalification requirements that will require tunneling contractors and their individual operators and tunnel managers to have had experience in driving pressurized-face TBMs on similar projects.

In the past 10 years, one of the key advances in pressurized-face tunneling has been the improved control procedures, with real time, continuous monitoring and digital readout of key machine functions to confirm or adjust the various functions to meet required target levels and to provide an archival record for later review and evaluation.

The Exponent Report notes that recorded settlements or damage during tunneling should be correlated with model predictions.

Metro consultants have correlated observations of ground movements, building distortion and building damage with appropriate scaling relationships, closed form solutions, physical models, and numerical models, including distinct element analyses and two- and three-dimensional finite element analyses using advanced constitutive models. The results of these investigations have been used to develop damage criteria, such as the relationship provided in the Tunnel Safety Report for relating building strains and distortions to damage levels (Boscardin and Cording, 1989).

However, the primary method for controlling ground movements and preventing damage is not to observe damage during tunneling and correlate it with model predictions. Rather, it is to control ground movements to prevent damage. The measurements of interest are obtained using deep extensometers to determine the settlement and ground loss immediately around the TBM as it is driven past the extensometer location. This information, along with monitoring of machine functions, is used either to confirm that ground movements are under control or to identify the location of any ground loss around the shield so that adjustments can be made to reduce ground losses prior to reaching structures. In the case of the MGLEE project, 75 deep extensometers were in place, measuring ground loss as the tunnel shield passed. In all cases, the extensometers showed that deep settlements were very small—on the order of 0 to 0.1 inches—and an order of magnitude less than the action level. As a result, there was no damage and no opportunity to correlate damage with any model predictions.

4.10 Tunneling Through Faults

The Exponent Report (Section 5.1.2) states the following: *"A final geotechnical issue, not addressed in the reviewed documents is the potential interaction between tunneling, mapped faults and structures on the BHHS campus. The sub-vertical faults underlying the campus, presuming they exist, represent discontinuities in the soil mass. Surface deformations will likely be concentrated above these faults during drilling (sic) as a result of differential settlement."*

As noted in the Tunneling Safety Report, faulted material of the soil formations along the alignment do not have as large a contrast in stiffness, strength and permeability between the fault and the surrounding ground as do faults in rock. Pressurized-face TBMs are designed and operated so that, as they are driven, they will support soils of variable strength—including weak soils as well as the soil materials in a fault zone—without causing differential settlement.

4.11 Tunnel Schedule

In their conclusions, Exponent recommended that tunneling beneath BHHS be conducted when school is not in session.

The current accepted practice on tunneling projects is to provide good control of the tunneling operation by using state of the practice real time interactive monitoring so that access to and use of the

surface and buildings is not restricted as the tunnel is advanced beneath them. This is done when there is adequate cover between the tunnel and the surface. At BHHS, the planned tunnel depth provides sufficient cover above the tunnel (2.5 to over 3 times the tunnel diameter). Because of the nature of tunneling work and workmanship, there is better control of the tunnel operation and the behavior of the ground when a consistent, uniform rate of advance is maintained. This is one of the reasons that tunnel operations usually are 24/7 operations. Only on projects where there is only a few feet of clear distance to overhead activities are special measures required.

5.0 GAS CONDITIONS AT CONSTELLATION STATION OPTION

The Exponent Report (Executive Summary) states: *"It is Exponent's view that the alternative Constellation Boulevard station, while generally in a more favorable location with regards to faulting issues, is instead faced with potential methane gas hazards that could represent at least as great a hazard to the public as the faulting hazards associated with the Santa Monica Boulevard station."*

Exponent's statement is incorrect. Comparison of gas hazards with siting a station on an active fault is inappropriate. An active fault at the Santa Monica Boulevard Station site cannot be mitigated. Gas hazards can be mitigated and are routinely mitigated for Metro stations and deep basements throughout Los Angeles, including areas of much higher gas concentrations than at Constellation Station, and will be mitigated in the stations along the Westside corridor using proven designs and construction procedures. Metro has assembled an outstanding team of highly experienced consultants with decades of experience in evaluating gas and designing and constructing stations and deep basements in gassy areas.

The Los Angeles building and fire departments promulgated official methane mitigation standards as early as 1985. These standards have been used successfully to mitigate methane hazards all over Los Angeles, including numerous schools, basements, and underground stations for more than 25 years.

Underground Construction Constellation Boulevard

Also, as presented in the Tunneling Safety Report, the gas hazard relative to tunnel and station excavation safety was evaluated using data from new borings taken by Metro and from existing projects constructed in the Century City area. The levels of methane found were compared to those found in the *existing* Metro tunnels (e.g., Red Line downtown). While methane gas was measured in borings at the Constellation Station area, the fact that tunnels and stations have been constructed in similar or higher levels of gas—and there are several *existing* deep underground structures in the Century City ground conditions—demonstrates feasibility both for construction and for operation. For example, the Theme building with multiple levels of underground parking (refer to photo) was built more than 40 years ago in Century City adjacent to the Century City Station area. The Westside project has evaluated requirements for constructing subway stations along the Westside alignment in gassy ground and has prepared Preliminary Engineering (PE) designs for lining the stations using systems for preventing infiltration of gas. During excavation, construction procedures, including ventilation methods, are designed to ensure that gas concentrations are below required limits in both covered and open excavations. Mitigation measures for controlling and preventing gas inflow at stations along the Westside corridor, including at Century City, have been investigated during the PE phase. Proven mitigation measures will be incorporated into the design, construction, and operating plans.

5.1 Station in San Pedro Formation

In the Exponent Report (Section 4.3), Exponent questioned placement of the Santa Monica-Constellation Station within the San Pedro formation. Exponent's conclusions were apparently mistakenly based on recommendations from a report prepared for the Mid-City Extension in the 1990s that do not apply to the conditions at Constellation. While tunnel and geotechnical engineers often use data from nearby sites to gain additional knowledge on ground conditions, they do not base foundation or subsurface designs on data from another site, especially if it is several miles away. Since the Alternatives Analysis Study quoted by Exponent was completed, site-specific borings have been completed for the Westside Subway Extension.

Gas concentrations at the Pico/San Vicente station area (over four miles from Century City) were generally higher than those found in Wilshire/Fairfax area—particularly concentrations of toxic hydrogen sulfide gas. At the Pico/San Vicente station location, the vast majority of the gas was confined to the upper, unsaturated portion of the San Pedro formation. At that location, the San Pedro formation was "capped" by a deposit of clay and an associated zone of perched groundwater. Those conditions resulted in potentially trapping and pressurization of the gas.

The subsurface conditions at the Westside Subway Extension station locations differ significantly from those found at the Mid-City's Pico/San Vicente station site. As presented in Figure 5-8 in the Tunneling Safety Report, the gas measurements in Century City are lower than those Metro encountered in the existing Red Line, particularly with respect to hydrogen sulfide. As noted above, deep excavations for underground parking in the Century City Constellation Station area have been constructed in the San Pedro formation and have been operating safely for more than 40 years.

5.2 Potential for Gas Release to the Surface

The Exponent Report (Section 5.3) reiterates properties of methane and the importance of safety precaution. Metro agrees with these statements and its construction specification will require compliance with all applicable state and federal regulations. And as discussed extensively in the Tunneling Safety Report, subsurface gases are common in the Los Angeles Basis. Figure 5-2 of the Tunneling Safety Report shows that almost the entire Westside Subway Extension alignment is within the city of Los Angeles' Methane Zone. Using "Lessons Learned" over the past 25+ years, the Cities of Los Angeles and Beverly Hills have identified geographic areas of concerns, developed methods to measure gases, designed for their presence, and monitored for control. Metro has also demonstrated designs and operating systems for these conditions.

Travel of water and gas along the tunnel are prevented by pressure grouting around the tunnel. Grout is specified to be injected under pressure through the tail of the tunneling shield as it is advances. This is done not only minimize settlements, as discussed in Section 4.1, but to provide continuous support of the segmental tunnel lining and to prevent flow of water and gas along the contact between the tunnel and the ground. Monitoring of grout pressures and volumes injected is conducted during each advance of the tunnel shield, and a continuous digital record is obtained for immediate viewing by the contractor's engineers and operators and for later review and evaluation. In addition, if necessary a program of check grouting can be carried out to test for grout placement around the lining after the initial grout is in place.

Gas flow to the surface is controlled by the soil profile, and the presence of the tunnel will not change the flow. The presence of fractures and faults within the soils can affect flow, but soils do not show the strong contrasts seen in rock between the permeability of the surrounding ground and the fault, which contains broken and fractured rock. With respect to the state Department of Toxic Substance Control referenced by the Exponent Report in Section 5.3, presently, any need for special procedures will be identified during final design. Requirements may range from monitoring the ground (and residences and school buildings) to installation of Methane Mitigation Systems. These systems have commonly been installed for Los Angeles schools and other structures within the Methane Zone where subsurface gas conditions warrant. In any case, Metro will comply with all state requirements.

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6.0 OIL WELL HAZARDS

The Exponent Report (Section 5.3) notes that the shallow geophysical exploration does not have a sufficient range to locate well casing at tunnel depth, states that magnetometer probing "cannot therefore be considered a robust screening tool for old well casings", and states that probing at the tunnel depth would be necessary.

That is correct. The Tunneling Safety Report discussed these issues in detail, including the limited sensing depth, and made the recommendation that magnetometer probing at tunnel depth through horizontal probes was necessary, thus recommending the horizontal directional drilling (HDD). In addition, the TAP made the following recommendations in their report:

> "Conduct magnetometer surveys in probe holes drilled along the tunnel alignment in oil fields where there is the possibility of intersecting well casings, either ahead of the advancing tunnels or prior to tunneling, using horizontal directional drilling. It is recommended that, to the east of the Constellation Station and on the Beverly Hills High School property, the surveys be conducted during the design phase using horizontal directional drill holes."

For exploration beneath the BHHS buildings during the next phases of design, HDD investigation will be conducted along the alignment at tunnel level. A magnetometer probe survey will be conducted in the drilled hole to detect metal casings so that if found, they can be re-abandoned properly below the tunnel depth prior to tunneling. This HDD methodology was invented by metro to respond to the specific needs of this project.

Moreover, during tunnel construction in Los Angeles, magnetometer surveys have been conducted in probe borings extending in front of the TBM to ensure that obstructions, such as well casings, are detected before they are reached by the TBM. In suspected oil field areas, probing of the tunnel zone will be carried out either by HDD before tunneling or ahead of the face during tunneling.

While detecting and removing oil wells in advance of tunneling is preferable, should they be encountered during tunneling, procedures have been developed and implemented to evaluate the well conditions and safely re-abandon them. Abandoned oil wells have been encountered in the past during tunneling in Los Angeles, as described in the Tunneling Safety Report.

Chapter 6.0 of the Tunneling Safety Report addresses active and abandoned oil wells. Metro researched oil well records (maps and well information) kept by the State of California, reviewed historic photos, and performed detailed scanning using state-of-the-art geophysical and magnetic scanning methods—where the surface is accessible. While no wells in the tunnel alignment were confirmed, the report clearly addressed the risk of uncertainty and potential for unknown wells at inaccessible or deeper locations; one example might be under the parking garage east of Century Park East, above the Constellation Station alignment. For this reason, Metro has recommended that additional exploration be carried out prior to tunneling, using methods such as HDD and further magnetic probing (Section 6.4.1). Should a well be identified, procedures for abandonment (also provided in the report) will be followed.

A comprehensive study of all available information found that there was one mapped abandoned oil well close to or within the proposed tunnel alignment. The location of this well does not lie within the BHHS campus. The magnetic survey program and other inconsistencies in mapping (also noted by Exponent) indicated that the mapped locations of abandoned oil wells could be inaccurate by 50 to 200

feet. Therefore, a geophysical (magnetic) survey was performed on the BHHS campus to detect metal, which would indicate the presence of an abandoned oil well casing. The survey identified only one anomaly on the BHHS campus that is close to the alignment but is east of the mapped well mentioned above. It is on the west edge of the lacrosse field and is located 5 to 10 feet north and outside of the tunnel envelope. The anomaly may or may not be a well casing, and likely remaining material from the previous structure on this site. It will be further investigated and addressed appropriately. Additionally, studies to locate oil well casings were clearly described in the Tunneling Safety Report.

7.0 FUTURE DEVELOPMENT

In the Exponent Report (Section 5.5), Exponent states, *"At this time Exponent does not have information regarding potential future development plans at other businesses or residences along the proposed tunnel alignment. In general, future development at other properties would be expected to be impacted in the same manner as discussed above for BHHS."*

Future development of other properties has similar issues and solutions as BHHS. Subsurface easements would need to be obtained (as for any tunneling project under private property) also described in the DEIS/EIR.

Metro specifically addressed future development at BHHS at the request of the Metro Board. Like Exponent, Metro was unable to obtain future development plans for the high school. Given the depth of the tunnel, and working with BHHS designers, further construction on the BHHS would not be precluded with the presence of tunnels. This is discussed in detail in Section 8.0 of the Tunneling Safety Report.

Exponent (in their presentation to the City of Beverly Hills) described the use of major bridge structures above the tunnels to support foundations for structures placed above the tunnels. Such bridge-like structures are not required and they would only add cost and unnecessary disruption. As discussed in the Tunneling Safety Report, foundations can be built on slabs above the tunnel or with foundations between the tunnels so that major bridge structures with wide spans are not required.

Other properties for which subsurface easements will be obtained are documented in the Environmental Report. Any future project to be developed adjacent to Metro right-of-way will need Metro approval prior to construction. This does not preclude development; in fact sometimes it even encourages use as seen at many locations along the existing Red Line. Examples of adjacent property development over the tunnels and stations include the Wilshire/Vermont, Hollywood/Western, and Union Station apartments joint developments.

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8.0 CONCLUSIONS

Metro reconfirms the conclusions given in the three Century City area reports (Tunneling Safety, Fault Investigation, and TAP Reports) and recommends that the Constellation Station alignment be selected for the Westside Subway Extension. Active faulting is present on Santa Monica Boulevard, and no 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 safety constructed and operated. Tunneling can also be safely accomplished along the Constellation Station alignment under BHHS and adjacent properties.

Metro conducted its investigations with world-class scientists and engineers with extensive experience in applying their expertise to infrastructure design in the Los Angeles region. Throughout their distinguished careers, these individuals have been working on specific issues such as those they addressed for Metro in these investigations. Their areas of expertise include seismicity and fault geology geotechnical and earthquake engineering, paleoseismology, geomorphology, tunneling and ground control, risk management, gas occurrence and mitigation, and oil well detection and abandonment.

Tunneling through active faults can be safely accomplished. Metro has developed designs for crossing active faults and installing tunnel linings using pressurized, closed-face TBMs.

Metro's reports are the result of a comprehensive investigation of the specific issues requested by its Board of Directors to assess risks and to develop plans to mitigate risk. The methodology and standards used are the same used for selection of all other transit projects, requiring review and approval by the FTA and its Project Management Oversight representatives, as well as the qualified designers and their specialty experts and review panels. This assures Metro that it has addressed safety and the engineering and management actions needed to assure safety.

The specific type of probability-based risk analysis that Exponent suggests is not appropriate for responding to the questions asked by the Board and does not provide information or data that can readily used by the Board to make decisions. It is more appropriate to identify then mitigate the risks.

Metro's Risk mitigation (reduction) measures include subsurface investigations, design quality assurance through design reviews, procedures for qualifying construction contractors and their key personnel, contract specifications that address specific measures for controlling risk, and monitoring throughout construction to confirm that the measures have been achieved.

The successful tunneling on the MGLEE is just one of numerous case histories in the U.S. and worldwide that demonstrate the ability of the current tunneling technologies to control the tunneling process and minimize settlements. Exponent's reference to tunnel methods and impacts (such as a sinkhole or larger settlements) during Red Line construction has no relevance to the vastly improved tunneling technology currently employed on Metro projects. In the 1990s, Metro's TAP reviewed Red Line tunneling methods as well as tunneling construction worldwide, stated that tunneling could be accomplished under control, and recommended that Metro require the use of pressurized, closed-face TBMs. Metro required the technology on MGLEE and is specifying it for projects currently in the design phase. One of the main advances in tunneling technology has not only been the ability to pressurize and support the tunnel face, but has also been the development of comprehensive procedures for controlling TBM operation and for monitoring to ensure that control of the ground, groundwater and gas, has been achieved.

Risks from oil wells or other subsurface obstructions have also been minimized. Oil wells, if present, will be discovered in advance of tunneling by proven methods and safely re-abandoned if in the path of the tunnel.

Gases such as methane and hydrogen sulfide have been encountered to some degree in most of the tunnel projects in the Los Angeles area. Metro's own safety record of no serious incidents in more than 20 miles of tunneling and more than 20 years of operation overwhelmingly demonstrates safety. Improved methods for gas monitoring and control will be conducted in all phases of the project—design, construction and during operations.

In summary, there is sufficient reliable information for the Board to make a decision on the alignment:

- Current information on the location and character of the fault zones is sufficient to select the alignment.
- The Constellation Station location is recommended and can be built and operated safely.
- It is safe to tunnel under Westwood, Century City, West Beverly Hills, and BHHS using design and tunneling procedures outlined in Metro's reports.
- The presence of a tunnel will not prevent BHHS from being used as an Emergency Center or from developing their site by placing new facilities over the tunnel.
- Metro's broad-based engineering and risk reduction program will continue into final design and construction. Comprehensive investigations will be conducted during detailed engineering to address areas where additional information is needed as outlined in Metro's three Century City Area Study Reports

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