APPENDIX J

Preliminary Geological Hazards Evaluation
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Preliminary Geological Hazards Evaluation
Los Angeles Zoo Vision Plan Program Project
5333 West Zoo Drive
Los Angeles, California

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1 INTRODUCTION

Ninyo & Moore was retained by Wood Environment & Infrastructure Solutions, Inc. to perform a preliminary geological hazards evaluation for the Los Angeles Zoo Vision Plan Project located at 5333 West Zoo Drive in Los Angeles, California (hereinafter referred to as the site) (Figure 1). The purpose of our study was to provide a preliminary evaluation of the potential geological hazards in compliance with the California Environmental Quality Act (CEQA).

2 SIGNIFICANCE THRESHOLDS

Based on Appendix G of the State CEQA Guidelines, the Project would have a potentially significant effect on geologic and soil resources if it would:

- Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued but the State Geologist for the area or based on other substantial evidence of a known fault.
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, as defined in Table 18-1B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternatives waste water disposal systems where sewers are not available for the disposal of waste water (not addressed in this report).
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature (not addressed in this report).

3 SCOPE OF SERVICES

Our scope of services for this geological hazards assessment included the following:

- Review of background information, including readily available geotechnical reports, geologic maps, fault maps, landslide maps, flood inundation maps, and aerial photographs.
- Performance of a geologic reconnaissance of the site and surrounding areas.
- Analyses of collected data and observations.
- Preparation of this report presenting our preliminary findings and conclusions regarding potential geological hazards and potential mitigation measures.
4 SITE DESCRIPTION

The Project is located in the City of Los Angeles (City) within southern Los Angeles County. The Project area encompasses the entire existing Los Angeles Zoo (Zoo), located at 5333 Zoo Drive, Los Angeles, California. The Project area is roughly bound by the Golden State Freeway or Interstate 5 (I-5) to the east and the Ventura Freeway or California State Route 134 (SR-134) to the north. The Los Angeles River also borders the north and east boundaries of Griffith Park before continuing south and eventually flowing into the Pacific Ocean at Long Beach.

The Project area lies in the northeastern portion of Griffith Park at the base of the eastern foothills of the Santa Monica Mountains (Figure 1). The Zoo occupies a hilly site with roughly 150 feet of vertical relief (ranging from 460 to 650 feet above mean sea level [msl]). Interior areas of the Zoo are relatively level due to being partially filled as part of original Zoo construction. Development within the Zoo is constrained by two large hills located on the northern and western portions of the site that are 150 feet higher in elevation than the relatively level central interior of the Zoo.

5 PROPOSED PROJECT DESCRIPTION

The City is proposing the Los Angeles Zoo Vision Plan (Vision Plan) (Figure 2) to guide physical transformation and improvement of operations of the Los Angeles Zoo and Botanical Gardens. The Vision Plan would serve as the blueprint for transformation and modernization of the Zoo over the next 20 years (from approximately 2020 to 2040). The Vision Plan would guide comprehensive exhibit improvements and capital projects to upgrade Zoo facilities and circulation City, including expansion of the current elephant exhibit area by approximately 200 percent. The development concept and phased improvements, along with proposed Zoo programming, would facilitate expansion of annual visitation by approximately 1.2 million visitors per year to 3.0 million guests per year by 2040.

We understand that the Zoo Vision Plan project consists of the following phases:

- Phases 1 through 3, planned for completion by 2028
  - Phase 1: Circulation, Parking, and Treetops
  - Phase 2: California Exhibit, Entry Complex, and Zoo Walk
  - Phase 3: Africa

- Phases 4 through 7, to be completed by 2040
  - Phase 4: Asia and Service
  - Phase 5: Water and World Aviary
  - Phase 6: Islands
  - Phase 7: Administration Building
6  GEOLOGY

The project site is located in the northwestern portion of the Los Angeles Basin. The Los Angeles Basin has been divided into four structural blocks, which are generally bounded by prominent fault systems: the Northwestern Block, the Southwestern Block, the Central Block, and the Northeastern Block (Norris and Webb, 1990). The site is located in the Northwestern Block, which is bounded on the south side by the Santa Monica and Raymond Hill faults, which is also the southern boundary of the east-west trending Transverse Ranges physiographic province (Norris and Webb, 1990; Harden, 1998).

The site is located along the western edge of the flood plain of the Los Angeles River near the base of the Santa Monica Mountains. Regional geologic mapping data (Dibblee, 1991), indicates that the lower elevations of the site including the parking lot and the central portion of the Zoo are underlain by younger alluvium consisting of moderately to poorly consolidated clay, sand, and gravel (Figure 3). The hills located on the northern and northwestern portions of the Zoo are composed of igneous quartz diorite bedrock. The quartz diorite is moderately to intensely weathered and composed of plagioclase feldspar, quartz, biotite, and hornblende. The hills along the southern edge of the site and south of the Zoo are composed of sedimentary sandstone and shale of the Topanga Formation.

The alluvium is overlain in the central portion of the Zoo by fill soils placed during the original construction of the Zoo in the early 1960’s and during later projects. Based on review of previous reports for individual projects within the Zoo, the fill soils range in thickness from less than 3 feet in the Jaguar Exhibit area (URS, 2013), to 5 to 20 feet thick in the Gorilla Enclosure area (Kleinfelder, 2000; Kleinfelder, 2004), and from 10 to deeper than 30 feet in the Pachyderm Enclosure area and in other areas of the central Zoo (City of Los Angeles, 2007; City of Los Angeles, 2011; URS 2000). The fill is described as medium dense to dense silty sand and sand and, although generally described as well compacted, some areas of loose and uncompacted fill are reported from these reports.

The Benedict Canyon fault is mapped along the north side of the mountains and has been projected to extend beneath the parking lot on the eastern side of the project area. The Hollister fault is mapped crossing the lower hillside areas and is projected to extend as a buried fault strand beneath the center of the Zoo. Neither the Benedict Canyon or Hollister faults are considered active and are not considered constraints to the project. Our review of geologic literature and stereoscopic aerial photographs did not indicate the presence of landslides on site or on the nearby hillside areas.
Based on groundwater monitoring wells in the project vicinity, the depth to groundwater in the vicinity of the site is reported to be on the order of 20 to 50 feet below the existing ground surface of the lower elevation areas of the site.

7 FAULTING, SEISMICITY, AND GEOLOGIC HAZARDS

The site is not located within a State of California Earthquake Fault Zone (formerly known as Alquist-Priolo Special Studies Zone). However, the site is located in a seismically active area, as is the majority of southern California, and the potential for strong ground motion in the project area is considered significant during the design life of the proposed project. The numerous faults in southern California include active, potentially active, and inactive faults. As defined by the California Geological Survey (CGS), active faults are faults that have ruptured within Holocene time, or within approximately the last 11,000 years. Potentially active faults are those that show evidence of movement during Quaternary time (approximately the last 1.6 million years) but for which evidence of Holocene movement has not been established. Inactive faults have not ruptured in the last approximately 1.6 million years. The approximate locations of major faults in the site vicinity and their geographic relationship to the site are shown on Figure 4.

In addition to the mapped faults shown on Figure 4, the Elysian Park blind thrust fault is located approximately 7.6 miles from the site and the Puente Hills blind thrust fault is located approximately 8.5 miles east of the site (United States Geological Survey [USGS], 2008). Blind thrust faults are low-angle faults at depth that do not break the surface and are, therefore, not shown on Figure 4. Although blind thrust faults do not have a surface trace, they can be capable of generating damaging earthquakes and are included in Table 1.

Table 1 lists selected principal known active faults within approximately 50 kilometers of the site that may affect the project and the maximum moment magnitude ($M_{\text{max}}$) as published by the USGS (2008). The approximate fault-to-site distances were calculated using the USGS web-based program (2008).

<table>
<thead>
<tr>
<th>Fault</th>
<th>Approximate Fault-to-Site Distance $^1$ (miles (kilometers))</th>
<th>Maximum Moment Magnitude $^1$ ($M_{\text{max}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollywood</td>
<td>2.0 (3.3)</td>
<td>6.7</td>
</tr>
<tr>
<td>Verdugo</td>
<td>2.3 (3.7)</td>
<td>6.9</td>
</tr>
<tr>
<td>Raymond</td>
<td>3.2 (5.2)</td>
<td>6.8</td>
</tr>
<tr>
<td>Sierra Madre</td>
<td>5.9 (9.5)</td>
<td>7.3</td>
</tr>
<tr>
<td>Elysian Park Blind Thrust</td>
<td>7.6 (12.3)</td>
<td>6.7</td>
</tr>
<tr>
<td>Puente Hills Blind Thrust</td>
<td>8.5 (13.8)</td>
<td>7.0</td>
</tr>
<tr>
<td>Santa Monica</td>
<td>8.5 (13.7)</td>
<td>6.6</td>
</tr>
<tr>
<td>Newport-Inglewood</td>
<td>9.4 (15.2)</td>
<td>7.5</td>
</tr>
<tr>
<td>San Gabriel</td>
<td>11.6 (18.7)</td>
<td>7.3</td>
</tr>
<tr>
<td>Northridge</td>
<td>10.5 (16.9)</td>
<td>6.9</td>
</tr>
<tr>
<td>San Andreas (1857 Rupture)</td>
<td>29.4 (47.3)</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Notes:

1 USGS, 2008
In general, seismic hazards that could impact the project include ground surface rupture, strong ground motion, liquefaction, and dynamic compaction of dry soils. These and other potential hazards are discussed in the following sections.

7.1 Surface Fault Rupture
Based on our review of the referenced literature and our site reconnaissance, no active faults are known to cross the project site. Therefore, the probability of damage from surface ground rupture is considered to be low and not a constraint to the project.

7.2 Strong Ground Motion
The 2016 California Building Code (CBC) specifies that the Risk-Targeted, Maximum Considered Earthquake (MCE\textsubscript{R}) ground motion response accelerations be used to evaluate seismic loads for design of buildings and other structures. The MCE\textsubscript{R} ground motion response accelerations are based on the spectral response accelerations for 5 percent damping in the direction of maximum horizontal response and incorporate a target risk for structural collapse equivalent to 1 percent in 50 years with deterministic limits for near-source effects. The horizontal peak ground acceleration (PGA) that corresponds to the MCE\textsubscript{R} for the site was calculated as 1.13g using the USGS (2017) seismic design tool (web-based).

The 2016 CBC specifies that the potential for liquefaction and soil strength loss be evaluated, where applicable, for the mapped Maximum Considered Earthquake Geometric Mean (MCE\textsubscript{G}) PGA (PGA\textsubscript{M}) with adjustment for site class effects in accordance with the American Society of Civil Engineers 7-10 Standard. The MCE\textsubscript{G} PGA is based on the geometric mean PGA with a 2 percent probability of exceedance in 50 years. The mapped MCE\textsubscript{G} PGA with adjustment for site class effects (PGA\textsubscript{M}) was calculated as 0.76g using the USGS (2017) seismic design tool.

The impact from strong seismic ground motion may be mitigated by performing a geotechnical evaluation for the specific project and implementing modern structural design in accordance with CBC code requirements for the proposed structures and facilities.

7.3 Liquefaction and Seismically Induced Settlement
Liquefaction is the phenomenon in which loosely deposited granular soils and cohesionless fine-grained soils located below the water table undergo rapid loss of shear strength due to excess pore pressure generation when subjected to strong earthquake-induced ground shaking. Sufficient ground shaking duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure. This causes the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesionless soils at
depths shallower than 50 feet below the ground surface. Factors known to influence liquefaction potential include composition and thickness of soil layers, grain size, relative density, groundwater level, degree of saturation, and both intensity and duration of ground shaking.

Based on groundwater monitoring wells in the project vicinity, the depth to groundwater in the vicinity of the site is reported to be on the order of 20 to 50 feet below the existing ground surface. The State of California Seismic Hazards Zones map has mapped the alluvium beneath the project site as being potentially susceptible to liquefaction during a strong earthquake event (Figure 5). Based on the nature of the underlying materials and the reported groundwater levels, the potential for dynamic settlement due to liquefaction is considered moderate in the lower lying areas of the site including the parking lot and center of the Zoo. The potential for liquefaction in the higher elevations of the site underlain by quartz diorite and sedimentary formational materials is considered to be low. The potential for liquefaction at a particular project location should be further evaluated by a geotechnical evaluation, including subsurface and laboratory evaluation, prior to final design. Based on the site topography, the potential for lateral spread to occur at the project site due to liquefaction is considered to be very low.

If the geotechnical evaluation finds that liquefaction is an issue, mitigation measures such as removal and recompaction, densification of existing soils, or deepened foundations may be employed during design and construction.

### 7.4 Dynamic Compaction of Dry Soils

Relatively dry soils (e.g., soils above the groundwater table) with low density or softer consistency tend to undergo dynamic compaction during a seismic event. Earthquake shaking often induces significant cyclic shear strain in a soil mass, which responds to the vibration by undergoing volumetric changes. Volumetric changes in dry soils take place primarily through changes in the void ratio (usually contraction in loose or normally consolidated, soft soils and dilation in dense or overconsolidated, stiff soils) and secondarily through particle reorientation. Such volumetric changes are generally non-recoverable. Based on the nature of the underlying soil materials, the potential for dynamic compaction of dry soils is considered to be low to moderate. The potential for dynamic compaction of dry soils should be further evaluated by a geotechnical evaluation, including subsurface and laboratory evaluation, prior to final design.

If dynamic compaction of dry soils is found to be an issue, mitigation measures such as removal and recompaction, densification of existing soils, or deepened foundations may be employed during design and construction.
7.5 Landsliding

There are no mapped landslides on site or in the vicinity, and the site is not mapped as having the potential for seismically-induced landslides. In addition, our review of stereoscopic aerial photographs did not indicate the presence of landslides on site or on the nearby hillside areas. Based on this information and the location of the site, large scale landsliding is not considered to be a potential hazard at the site. However, steep slopes along the western and northern portions of the project site expose weathered quartz diorite materials and, in some areas, may be subject to small- to moderate-sized rock fall-type surficial slope failures. These slopes should be observed, mapped, and further evaluated if development is proposed adjacent to steep slopes with exposed rock or development is proposed to create cut slopes within weathered bedrock.

Potential areas of slope instability should be evaluated during the geotechnical evaluation and may be mitigated by design and construction of measures such as retaining walls or graded soil buttresses.

7.6 Tsunamis and Seiches

Tsunamis are long wavelength, seismic, sea waves (long compared to ocean depth) generated by the sudden movements of the ocean floor during submarine earthquakes, landslides, or volcanic activity. Seiches are waves generated in large, enclosed bodies of water. Based on the location and elevation of the site, damage due to tsunamis or seiches is not a design consideration.

7.7 Soil Erosion

Based on the use of the site and condition of the existing exposed soils, the proposed improvements should not lead to additional loss of soil or excess erosion. Erosion and loss of soil may be mitigated through the control of runoff by use of hydrologic engineering controls included as part of the project design and use of best management practices during grading and construction.

7.8 Expansive Soils

Expansive soils are soils that can undergo a significant increase in volume with an increase in water content and a significant decrease in volume with a decrease in water content. Changes in the water content of an expansive soil can result in severe distress to structures constructed upon the soil. Based on review of geotechnical previous reports for projects within the Zoo, the soils on-site are generally low to very low in expansion. The expansion potential for soils in areas for proposed projects should be further evaluated by a geotechnical evaluation, including subsurface and laboratory evaluation, prior to final design.
If expansive soils are found to be an issue during evaluation, mitigation measures such as removal and replacement with low expansive materials or special reinforced design of foundations and slabs may be employed during design and construction.

7.9 Landscape Fill
During our site walk of the Zoo, we observed an area of vegetative and landscape debris fill located south of the Condor enclosure near the top of an existing natural slope. The fill appeared to be in a dumped condition, over 10 feet thick in several areas, and formed slopes with slope inclinations of up to approximately 1:1 (horizontal to vertical). Although the dumped landscape fill appeared to be a temporary stockpile, this material is unstable and compressible and should be removed prior to any future earthwork or construction in this area.

7.10 Methane Zones
The Zoo is not located within a City of Los Angeles Methane Zone or Methane Buffer Zone. Methane seepage is not considered to be hazard or constraint to the project.

7.11 Flood Hazards
Based on review of the Federal Emergency Management (FEMA) website, the site is not mapped as lying within the 500-year floodplain (FEMA, 2008). Based on this review, the potential for flooding of the site is considered low.

8 CONCLUSIONS
Based on the results of our limited geological and other hazards evaluation, the following preliminary conclusions are provided for the proposed Los Angeles Zoo project:

- The site is underlain by fill, alluvium, quartz diorite bedrock, and sedimentary shale and sandstone.
- Although the existing fill soils are generally described as well-compacted, some areas of loose and uncompacted fill soils are described in previous geotechnical reports. Evaluation of existing fill soils should be performed as part of the geotechnical evaluation for individual projects.
- The subject site is not located within a State of California Earthquake Fault (Alquist-Priolo Special Studies) Zone.
- Active faults have not been mapped on or adjacent to the site. The closest known active fault, the Hollywood fault, is located approximately two miles south of the site.
- The site (like the majority of southern California) is located in Seismic Zone 4 according to the 2019 CBC. Accordingly, the potential for relatively strong seismic accelerations should be considered in the design of proposed project.
• The potential for liquefaction and dynamic compaction is considered to be low to moderate. The potential for liquefaction and dynamic compaction of soils should be further evaluated prior to final design. Lateral spreading is not considered to be a design constraint.

• The site is not located in an area considered susceptible to large scale landslides. However, some slopes along the western and northern portions of the site were observed to expose weathered and fractured bedrock and may be subject to small to moderate sized rock falls. These slopes should be observed, mapped, and further evaluated if development is proposed adjacent to exposed rock slopes or is cuts slopes are planned in bedrock areas.

• Areas of dumped landscape fill are unstable and compressible and should be removed prior to any future earthwork or construction in those areas.

• The Zoo is not located within a City of Los Angeles Methane Zone or Methane Buffer Zone.

• The potential for flood hazards and inundation to impact the site is considered low.

• The potential for geologic hazards to impact the site and the proposed Vision Plan Project may be mitigated by performing additional geotechnical evaluation, through engineering design in accordance with CBC code requirements, and modern construction methods.

9 RECOMMENDATIONS

Prior to the design and construction of proposed improvements at the site, a detailed geotechnical evaluation, including subsurface exploration and laboratory testing, should be performed. The purpose of the geotechnical evaluation would be to 1) further evaluate the subsurface conditions, including liquefaction potential, at the site, 2) provide site-specific data regarding potential geologic and geotechnical constraints, and 3) provide information pertaining to the engineering characteristics of earth materials with regard to the proposed project. Recommendations for earthwork, foundations, pavements, and other pertinent geotechnical design considerations may be formulated from the detailed geotechnical evaluation.

Phased implementation of the Vision Plan would involve extensive ground disturbance within existing developed portions of the Zoo. While detailed construction plans are not currently known, our review assumes that the following construction activities may occur. Each of these proposed projects are considered feasible from a geotechnical standpoint provided geotechnical evaluation including subsurface exploration, geotechnical laboratory testing, and engineering evaluation and analyses are performed and the recommendations of the geotechnical report are incorporated into the final design and construction.

• Condor Canyon in the California planning area could include excavation up to 60 feet below ground surface.

• Aerial tram footings and/or foundations could extend up to 30 feet below the existing ground surfaces, cover approximately 100 square feet to 200 square feet, and may require deep foundations (pile driving or pier drilling). The aerial tram alignment could result in this type
and scale of ground disturbance at the Zoo Entry, California, World Aviary, Asia, and Africa planning areas.

- The California Visitor Center, Treetops Visitor Center, and Africa Visitor Center may include foundations extending 20 feet to 30 feet below ground surface. Treetops Visitor Center would include a subterranean level to support a restaurant and service facilities. Given existing topography, the California Visitor Center may result in hillside cuts with footings that may need deep foundations (pile driving or pier drilling).

- Five underground stormwater cisterns proposed for the Zoo Entry, Asia, Rainforest, and Africa would require excavation up to 20 feet below existing ground surfaces. Installation of stormwater pipes and infrastructure at depths of approximately 4 feet to 10 feet below ground surfaces could occur throughout these planning areas, and the overflow line would disturb soils beneath the existing southern surface parking lot to connect to the Zoo’s existing wastewater treatment plant.

- Proposed transportation improvements in Phase 1 would include improvements to Zoo Drive and Western Heritage Way, which may result in excavation of up to approximately 30 feet below the ground surface to lower the road grade and install a bridge/overpass. The proposed 2,000-space parking garage in the northern surface parking lot is envisioned to have all above ground levels; however, in case a subterranean garage is contemplated, this review assumes the garage may require excavation up to 30 feet below the ground surface.

10  LIMITATIONS

The field evaluation and analyses presented in this report have been conducted in accordance with current engineering practice and the standard of care exercised by reputable geotechnical and environmental consultants performing similar tasks in this area. No warranty, implied or expressed, is made regarding the conclusions, recommendations, and professional opinions expressed in this report. Variations may exist and conditions not observed or described in this report may be encountered. Our preliminary conclusions and recommendations area based on an analysis of the observed conditions and the referenced background information.

The purpose of this study was to evaluate geological conditions within the project site and to provide a reconnaissance report to assist in the preparation of environmental documents for the project. A comprehensive geotechnical evaluation, including subsurface exploration and laboratory testing, should be performed prior to design and construction of the project.
11 REFERENCES


California Geological Survey, 1999, Seismic Hazard Zones, Burbank Quadrangle, Scale 1:24,000.


City of Los Angeles, 2003, Methane and Methane Buffer Zones, LADPW Engineering, Basic Grid Map A-13372.

City of Los Angeles, Geotechnical Engineering Group, 2007, Supplemental Geotechnical Report, Los Angeles Zoo – Pachyderm Forest Exhibit, 5333 Zoo Drive, Los Angeles, California, GED File 00-068, dated December 24.

City of Los Angeles, Geotechnical Engineering Group, 2011, Compaction Report, Los Angeles Zoo - Gorilla Holding Area Life Support System Pipe Repair Compaction Report (Permit L.A. Zoo, 5333 Zoo Drive, Los Angeles, California, dated October 7.


Kleinfelder, 2000, Geotechnical Engineering Investigation, Proposed Gorilla Holding Area and Exhibit, Los Angeles Zoo, Los Angeles, California, dated June 5.


URS, 2000, Geotechnical Investigation, Proposed LA Zoo Pachyderm Project, Phase 2, 5333 Zoo Drive, Los Angeles, California for LADPW/GED, dated September 26.


USDA, Aerial Photograph, Date 12-4-52, Flight AXJ-9K, Number 113 and 114, Scale 1:20,000.

FIGURES
LEGEND

af  FILL
Qa  OLDER ALLUVIUM
Ttucg  UPPER TOPANGA FORMATION
qd  GRANITIC ROCKS


FIGURE 3

REGIONAL GEOLOGY

LOS ANGELES ZOO VISION PLAN PROGRAM PROJECT
LOS ANGELES, CALIFORNIA

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**EARTHQUAKE-INDUCED LANDSLIDES**
Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

**Liquefaction**
Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

FIGURE 5

SEISMIC HAZARD ZONES
LOS ANGELES ZOO VISION PLAN PROGRAM PROJECT
LOS ANGELES, CALIFORNIA

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