1 INTRODUCTION

1.1 Project Objective

The vulnerability of Downtown Anchorage to seismically-induced ground failure, particularly in the 1964 Alaska Earthquake, is well documented. The downtown geologic hazard is mapped in Figure 1.1.

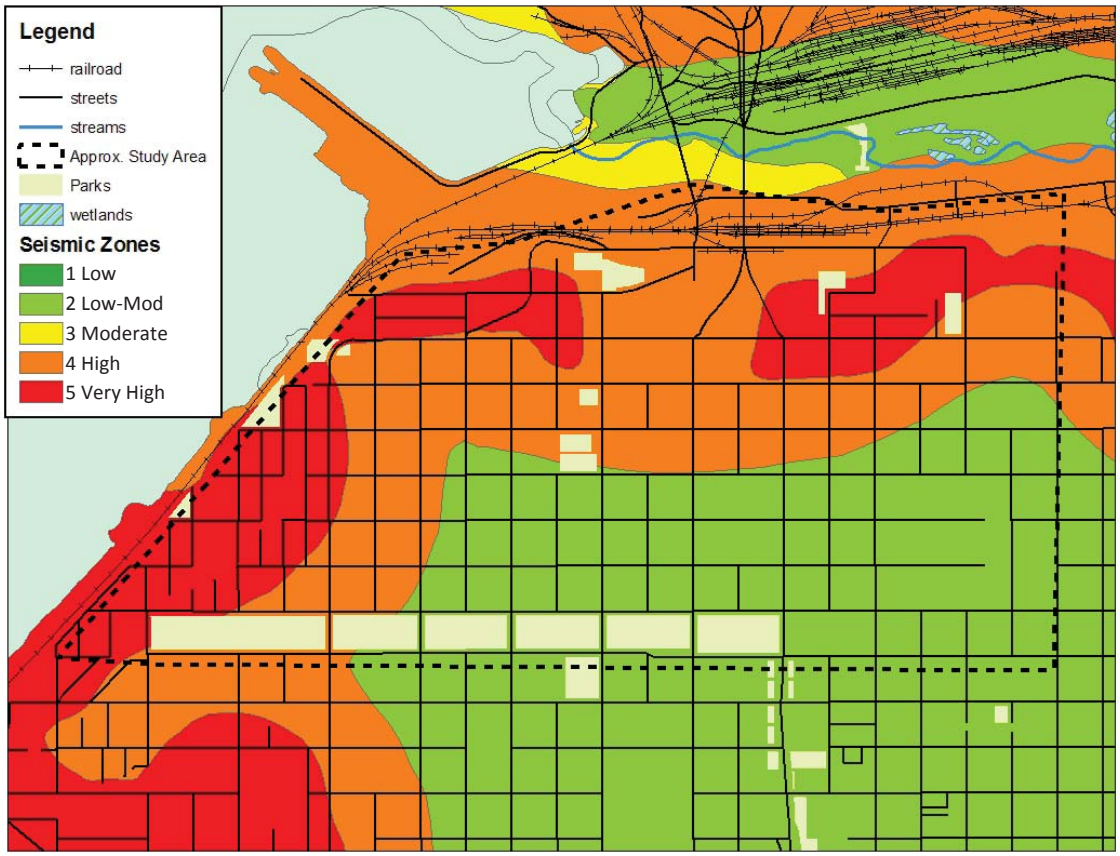

Figure 1.1 Map of Downtown Anchorage Seismic Zones

In recognition of this high vulnerability, the Anchorage Downtown Comprehensive Plan (*Plan)* proposes to "ensure seismically safe development" as one of the seven primary goals to guide downtown's land use and development patterns."[1] The *Plan* states that safe development shall:

> *Minimize the life safety risks to building occupants and economic vulnerability of property owners and the community as a whole for any future development proposed in areas with potentially high or very high ground failure susceptibility.*

To implement seismic hazard reduction goals, the *Plan* requires a response to seismic hazards consisting of two tasks: [2]

[1] Anchorage Downtown Comprehensive Plan Adopted December 11, 2007 Assembly Ordinance 2007-113 (pg. 41)

[2] LU -16 and LU17

1) Conduct a seismic hazard risk assessment study; and

2) Enact a seismic overlay zone to address land use and development in areas with greatest potential for ground failure.

This project conducted the seismic hazard risk assessment and has developed a draft seismic overlay zone. This is an important study because there is a high potential for seismically induced ground failure in Seismic Hazard Zones 4 and 5 that would likely result in casualties and building damage in the repeat of an earthquake similar to 1964 Alaska Earthquake.

Other governmental bodies have developed regulations and ordinances to address geologic and seismic hazards. The most significant is the Alquist-Priolo Earthquake Fault Zoning Act in California limiting the type of development that can occur within the vicinity of active earthquake faults. This law has been in place since 1972. The City of Seattle regulates the development of areas in proximity to environmentally critical areas such as creeks and shorelines, geologic hazard areas prone to liquefaction and landslide, and flood-prone areas

The risk assessment, undertaken in response to the Comprehensive Plan mandate, uses *Hazards U.S.* (HAZUS), a nationally applicable standardized software-based methodology developed by FEMA to estimate potential economic losses and human casualties. A key element of the Downtown Anchorage HAZUS model was to apply parameters based on a design earthquake to analysis of ten prototypical buildings that are representative of uses and building types identified in downtown Anchorage. The model input describes the buildings in terms of structural and occupancy categories derived from HAZUS. The 10 prototype buildings defined for the study resulted in 32 basic prototypical variants with their associated structural configurations. Each variant was modeled in two ways: 1) with a shallow foundation, and 2) with a mat foundation, bringing the total number of modeled buildings to sixty-four.

1.2 1964 Alaska Earthquake

Ground failures in the 1964 Alaska Earthquake serve as a reminder of the geotechnical vulnerability of downtown Anchorage. The magnitude 9.2 subduction earthquake hit Alaska on Good Friday, March 27, 1964, the second largest recorded earthquake in history. Shaking lasted nearly five minutes. Ground failures, collapsing buildings, and a tsunami resulted in 131 deaths. In downtown Anchorage, the shaking resulted in the failure of the Bootlegger Cove Clay formation, causing both vertical and horizontal geotechnical displacements exceeding 10 feet. Large blocks of earth moved towards the water leaving grabens behind (Photos 1.1, 1.2, and 1.3) and pushing up a pressure ridge in front (Photo 1.4). Figure 1.2 shows a schematic of the movement. The areas with the most significant movement are mapped in Seismic Zone 5 (Figure 1.1).

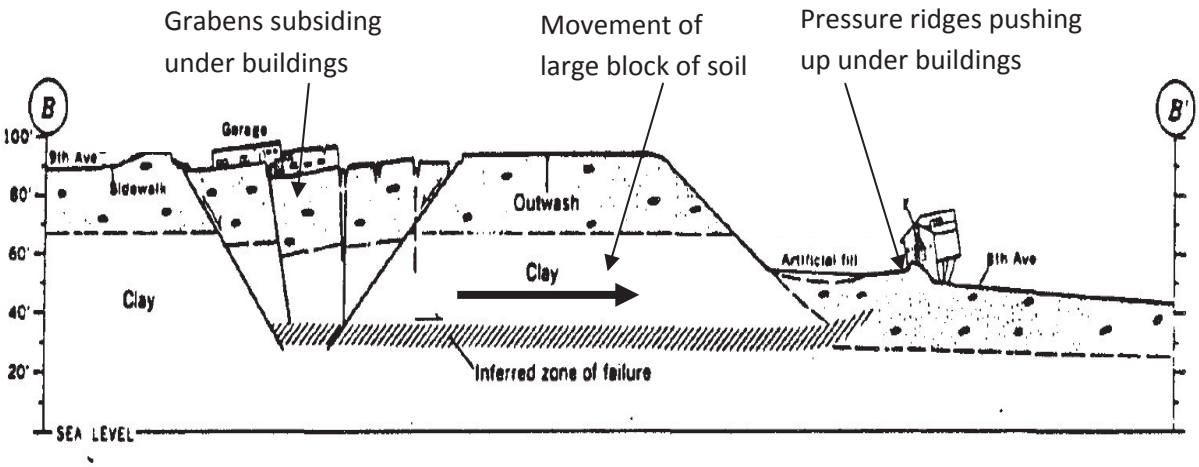

Figure 1.2 Cross section of soil strata in L Street slide area in 1964 Earthquake. (Moriwaki et al, 1985)

Photo 1.1 Collapse of Fourth Avenue near C Street, due to earthquake caused landslide. Before the earthquake, the sidewalk at left, which is in the graben, was at street level on the right. The graben subsided 11 feet in response to 14 feet of horizontal movement. Source USGS.

Photo 1.2 The marquee of the Denali Theater, which was in the graben of the Fourth Avenue landslide in Anchorage, subsided until it came to rest on the sidewalk in front of the theater, which was on ground that was not involved in the landslide. Source USGS.

Photo 1.3 A graben formed at the head of the L Street landslide in Anchorage during the earthquake. The slide block, which is virtually unbroken ground to the left of the graben, moved to the left. The subsidence trough sank 7 to 10 feet in response to 11 feet of horizontal movement of the slide block. The volume of the trough is theoretically equal to the volume of the void created at the head of the slide by movement of the slide block. A number of houses seen in this photograph were undercut or tilted by subsidence of the graben. Source USGS.

Photo 1.4 House displaced by compressional ridge formed at toe of L Street landslide. Source USGS.

The objective of this project is to quantify the risk of similar damage in a future earthquake, and to develop a seismic overlay zone to address land use development in the area.

1.3 Project Approach and Report Overview

The report is divided into eight sections followed by Appendix A, the Draft Ground Failure Susceptibility Hazard Overlay District, and six additional attachments, the six Technical Memoranda deliverables that were submitted during the course of the project.

- Section 1 - Introduction – this section
- Section 2 - Earthquake Scenario – covers the background for selection of the earthquake scenario used for the project.
- Section 3 - Geologic Hazard – quantifies the expected ground deformation that would result from soil failure in the scenario earthquake.
- Section 4 - Prototypical Buildings – lists the ten prototypical buildings selected for analysis of the expected performance in future earthquakes, including a description of additional data provided for each.
- Section 5 - Risk Assessment Approach – describes the approach used to estimate losses to the prototypical buildings due to shaking, ground failure, and the combination of the two.
- Section 6 - Results, Analysis, and Recommendations – presents the risk analysis results in terms of casualties and economic losses. The sensitivity of underlying fragility assumptions is explored, and recommendations are made to reduce the risk.

- Section 7 - Draft Zoning Ordinance Development – the general approach is described, and the Draft Ground Failure Susceptibility Hazard Overlay District is included in Appendix A.

- Section 8 - References

1.4 Project Team

The project team consisted of: Donald Ballantyne, Hope Seligson, and Paul Summers of MMI Engineering, Jennifer Donahue and Jonathan Bray of Geosyntec, Jane Preuss and George Williamson of Planwest Partners, Charles Kircher of Charles Kircher Associates, Keith Mobley of Northern Geotechnical, and various staff from USKH.

The Municipality of Anchorage project manager was David Tremont with direction and review provided by the Geotechnical Advisory Commission.