Predicting Earthquake Damage in New Jersey

Damaging earthquakes are rare, but not unknown, in New Jersey (fig. 1). Earthquakes with an estimated magnitude of 5.2 on the Richter scale occurred in the New York City area in 1737 and 1884. In historic times, earthquakes with magnitudes between 6 and 7 have occurred in the Boston, Massachusetts and Charleston, South Carolina areas, and in the St. Lawrence Valley of Quebec. New Jersey is in a similar tectonic setting as these places and earthquakes of this magnitude are possible. The risk of a damaging quake, in combination with the density and value of the buildings, place New Jersey tenth among all states for potential economic loss from earthquakes.

Predicting the location and extent of damage is key to preparing for earthquakes. Damage depends on the location, depth, and magnitude of the earthquake, the thickness and composition of soil and bedrock beneath the area in question, and the types of building structures. A computer model commissioned by the Federal Emergency Management Agency (FEMA), now used as a nationwide standard, analyzes these factors to generate damage estimates.

Soils influence damage in two ways. Soft soils amplify the motion of earthquake waves, producing greater ground shaking and increasing the stresses on structures. Loose, wet, sandy soils may lose strength and flow as a fluid when shaken (a process known as liquefaction), causing foundations and underground structures to shift and break. Mapping the ground-shaking and liquefaction potential of soils is an essential component in predicting earth-

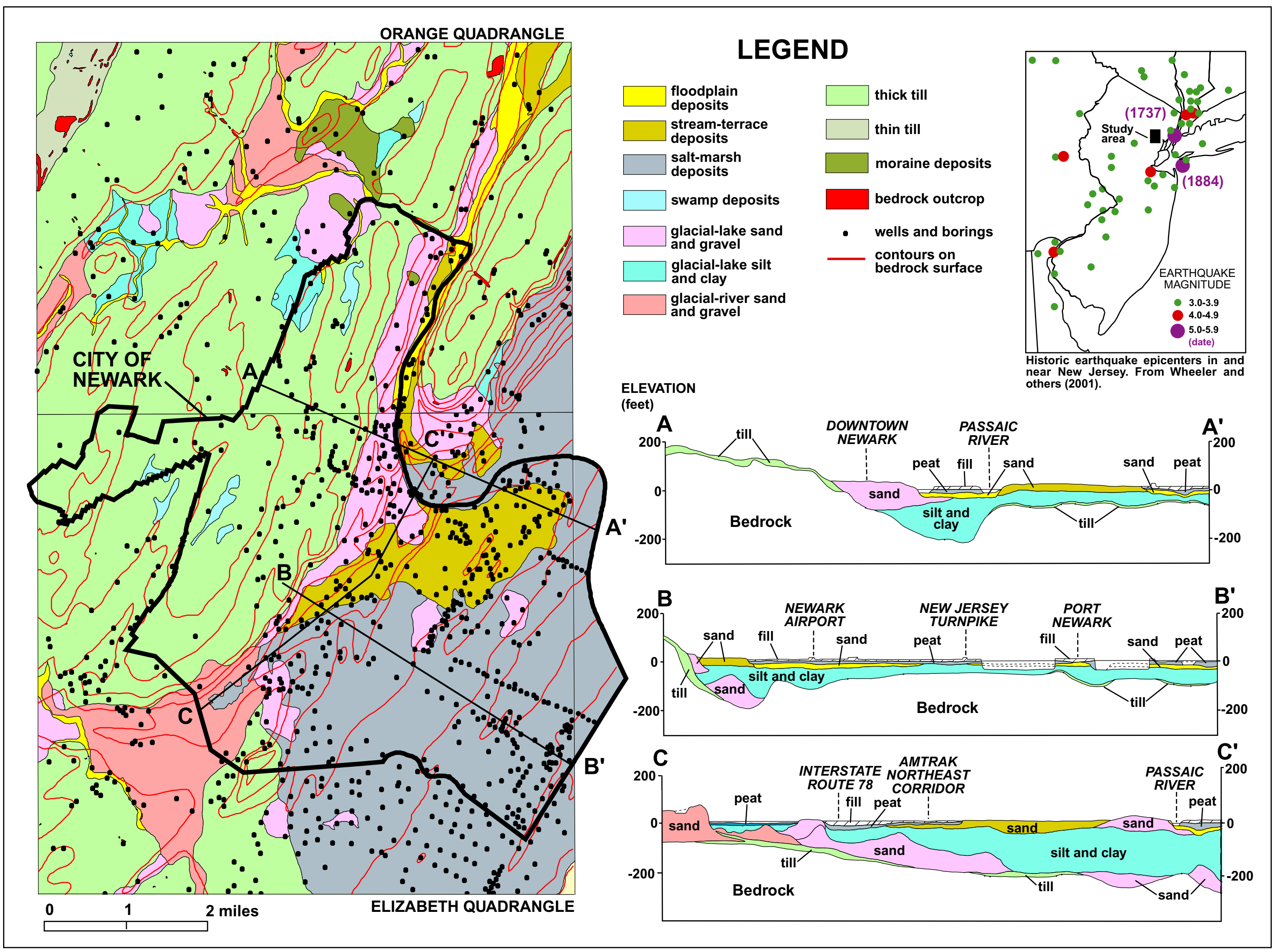

Figure 1. Surficial geology of the Newark area (from Stanford, 2002a, 2002b) and location of historic earthquake epicenters in and near New Jersey.

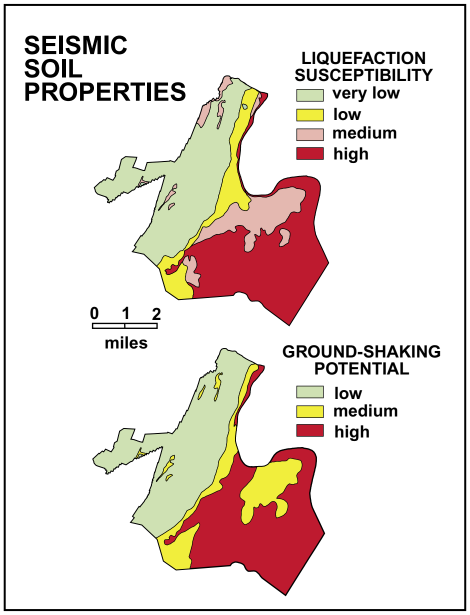

Figure 2. Liquefaction susceptibility and ground-shaking potential for Newark.

quake damage. Ground-shaking behavior is mapped by summing physical measures of the density and compaction of soil and rock layers to a depth of 100 feet. Liquefaction susceptibility is determined by the geologic history, depositional setting, and topographic position of the soil.

Newark, New Jersey's largest city, is built on glacial and postglacial deposits that overlie sandstone bedrock (fig.1). The glacial deposits include till, a compact sediment deposited beneath the glacier, sand and gravel deposited in glacial lakes and river plains, and silt and clay deposited in glacial lakes. The glacial deposits are as much as 250 feet thick. In places they are overlain by postglacial sediments laid down in floodplains, swamps, salt marshes, and river terraces. The postglacial sediments are less than 20 feet thick.

Data acquired during the geological investigation of these deposits include soil observations at several hundred field stations, review of more than 800 boring and well logs, and archival maps that show the extent of swamps and salt marshes prior to landfilling in the early 20th century. These data permit mapping of the bedrock surface, the thickness and layering of the glacial deposits, and the extent of swamp and salt-marsh peats that are now completely covered by fill. Engineering data from the many boring logs provide information on the density and compaction of the sediments.

This information was used to generate maps of liquefaction susceptibility and ground-shaking potential (fig. 2). Till, which underlies the western half of the city, is compact and has low liquefaction and ground-shaking potential. Peat, deposited in wetlands, and silt, clay, and fine sand deposited in floodplains and glacial lakes, are soft, saturated soils that are highly susceptible to shaking and liquefaction. These underlie much of the eastern half of the city. Sand and gravel deposited in glacial-lake deltas and river plains, which form a narrow belt through the center of the city, are of intermediate compaction and have medium shaking and liquefaction potential.

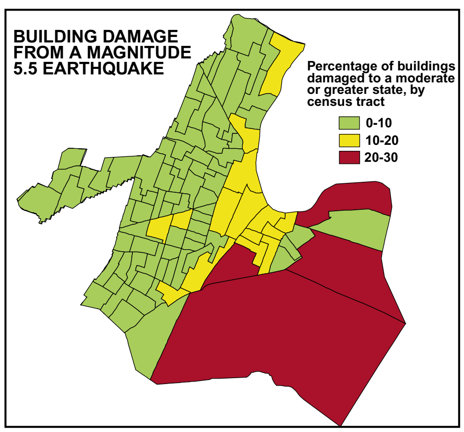

Figure 3. Building damage in Newark for a magnitude 5.5 earthquake.

A 5.5 magnitude earthquake, centered about five miles northwest of the center of Newark, was simulated on a computer using the geologic data outlined above. In the simulation (fig. 3), less than 10% of the buildings underlain by till were significantly damaged, whereas between 20 and 30% of those buildings underlain by wetland and glacial-lake deposits were significantly damaged. Utility pipelines also suffer significantly increased damage on these soft, liquefiable soils. The vulnerable eastern section of the city contains within it vital transportation links, including Newark-Liberty International Airport, the New Jersey Turnpike, Interstate Route 78, the Amtrak Northeast Corridor rail line, and the Port Newark marine terminal. The mapping and simulations indicate that this is a priority area for strengthening vulnerable structures.

Similar soil mapping and earthquake simulations have been completed for Hudson, Bergen, Essex, and Union counties, and are planned for eight additional counties, in northern New Jersey.

References

Stanford, S. D., 2002a, Surficial geology of the Orange quadrangle, Essex, Passaic, Hudson, and Bergen Counties, New Jersey: N. J. Geological Survey Open-File Map OFM 41, scale 1:24,000.

——— 2002b, Surficial geology of the Elizabeth quadrangle, Essex, Hudson, and Union Counties, New Jersey: N. J. Geological Survey Open-File Map OFM 42, scale 1:24,000.

Wheeler, R. L., Trevor, N. K., Tarr, A. C., Crone, A. J., 2001, Earthquakes in and near the northeastern United States, 1638-1998: U. S. Geological Survey Geologic Investigations Series Map I-2737, scale 1:1,500,000.

STATE OF NEW JERSEY

James E. McGreevy, *Governor*

Department of Environmental Protection

Bradley M. Campbell, *Commissioner*

Land Use Management

Ernest P. Hahn, *Assistant Commissioner*

New Jersey Geological Survey

Karl Muessig, *State Geologist*

Prepared by Scott Stanford - 2003

Funding for this study was provided by New Jersey State Police, Office of Emergency Management

Comments or requests for information are welcome.
Write: NJGS, P.O. Box 427, Trenton, NJ 08625
Phone: 609-292-2576, Fax: 609-633-1004
Visit the NJGS web site @ www.njgeology.org
This information circular is available upon written request or by downloading a copy from the NJGS web site.