A LIQUEFACTION HAZARD MAP OF THE LAS VEGAS VALLEY, NEVADA

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ABSTRACT

The potential for basin amplification of ground motion from significant seismic sources 100-200 km (62-124 mi.) from the Las Vegas Valley (such as the Death Valley Fault System) and Quaternary faults in the valley could provide sufficient energy to cause liquefaction. Key criteria of liquefiable soils coupled with a shallow groundwater table (less than 15 m (50 ft)) are met at several sites in the Las Vegas Valley. To investigate the extent of the liquefaction hazard, a map was prepared from existing data compiled from geotechnical reports, using screening protocols for liquefaction potential.

Geotechnical soils reports for the Las Vegas area were screened to establish a database. The data were compiled with geographical coverage of the valley in mind. Emphasis was placed on areas with favorable surficial geology and groundwater conditions. Once established, the data were evaluated using protocol criteria to ascertain the degree of liquefaction hazard present at the site. The final product has been superimposed on the map base used by the Clark County Building Department for other soil constraints mapping in the Las Vegas Valley. Thus, the liquefaction hazard map can be used as a planning tool to indicate whether site-specific investigations for liquefaction susceptibility are warranted.

INTRODUCTION

It has been clearly demonstrated that the geological and historical record suggests that earthquakes can cause widespread destruction to cities established in young alluvial valleys (Hitchcock et al., 1999). Lew (2001) suggests that a combination of the presence of active seismic faults, young loose alluvium and shallow ground water are the ingredients that could result in the occurrence of liquefaction. For Las Vegas Valley,

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research has demonstrated several seismogenic faults (Bell & Price, 1991; Wyman et al, 1993; dePolo and Bell, 2000; dePolo et al., 1989; dePolo and dePolo, 1998; and Slemmons et al., 2001), which occur locally and regionally that could contribute to the potential for liquefaction. In additional, the potential for basin amplification (Su et al., 1998) of ground motion from significant seismic sources 100-200 km (62-124 mi.) from the valley (Sawyer et al., 1998) could provide the mechanism to cause liquefaction in the valley.

Werle et al. (2000) presented the results of a preliminary screening investigation conducted to determine whether there are any indicators of liquefaction potential in the Las Vegas Valley. This investigation revealed that the important criteria for liquefaction susceptibility - liquefiable soils and shallow groundwater table - are met in the Las Vegas Valley. Research by Zikmund (1996) has demonstrated that more than half of the urbanized area of the Las Vegas Valley has a shallow groundwater table, and geologic maps (Bingler, 1977, Matti and Bachhuber, 1985, Matti et al., 1987, and Matti et al., 1993) show that significant portions of the valley consist of Holocene and Pleistocene alluvial and playa deposits that are extensively sand and silt.

The preliminary investigation by Werle and others was a limited evaluation using existing data on a few selected sites. The data were from past geotechnical investigations that were not directed to evaluate the potential for liquefaction as part of the investigation. The investigators concluded that the potential for damage due to seismically induced liquefaction is low for sites located at the economically important Las Vegas Strip and Downtown. On the other hand, a site evaluated in the eastern part of the Las Vegas Valley along Las Vegas Wash had a higher level of hazard. This site and some others reviewed in the area had sand deposits with low SPT (Standard Penetration Test) blow counts (“N-values”) combined with the shallow groundwater conditions.

The goals of this investigation were to develop a more extensive database to ascertain the liquefaction hazard in the Las Vegas Valley and to produce a liquefaction susceptibility map. With this new data and the resulting map in hand, one can better assess whether screening investigations for liquefaction potential should be conducted as a part of geotechnical studies for projects in the affected areas.

DATA COLLECTION AND ANALYSIS

The assessment of liquefaction susceptibility incorporates evaluation of geotechnical borehole data for late Quaternary deposits that exhibit the appropriate age, textural and groundwater conditions conducive to failure. Analyses of liquefaction susceptibility were performed using the Seed Simplified Procedure (Seed et al., 1983) that incorporates data on groundwater conditions, overburden load, SPT data and the cyclic stress ratio.

The data collection procedure was facilitated by a review of geotechnical reports from Converse Consultants in their Las Vegas office. These reports included projects dated from 1997-2001, which was analyzed for liquefaction potential for this study. To help limit the extent of the data collection, the study area excluded portions of the valley unlikely to have liquefaction potential based on soil type and depth to groundwater. The limit of the study area is shown in Figure 1.

The record review was initiated to create a database of sites evaluated for liquefaction potential. A spreadsheet was constructed using projects and data from logging of geotechnical site investigation projects from Converse Consultants. All data reported was from the original logging of the boreholes with no filters applied or any modifications. Township, Range, and Section designations were determined using Thomas Guide 2001, Clark County Street Directory. Latitude and longitude values were determined using Microsoft Map Point 2002.

The database was constructed with the following constraints:

- The geotechnical site investigation projects included boreholes that rarely reached 30 feet and they typically remained opened for variable amounts of time.
- The locations of the boreholes were plotted on a project site map, but not identified as to their surface elevation, longitude, or latitude.
- The geotechnical site investigation projects used in this research were intended for soil foundations reports and varied from single-family homes to miles of lateral pipelines and road construction projects. No report used was identified as intended for or included liquefaction susceptible analysis.
- The borehole depths ranged from 5-80 feet below the surface.
- The data reported was not modified from the original logging for the specific boreholes, especially, no filters nor modifications were applied for this current project.
- The borehole that had the highest liquefaction susceptible was reported even if multiple boreholes were identified during a specific project.
- The sandy material that had the highest liquefaction susceptible was used to assign the protocol criteria within specific borehole for that location.

Thus, the protocol criteria used included soil type, blow count, and groundwater information that were obtained from standard geotechnical site investigation projects without modification or filtering of the original borehole logs.

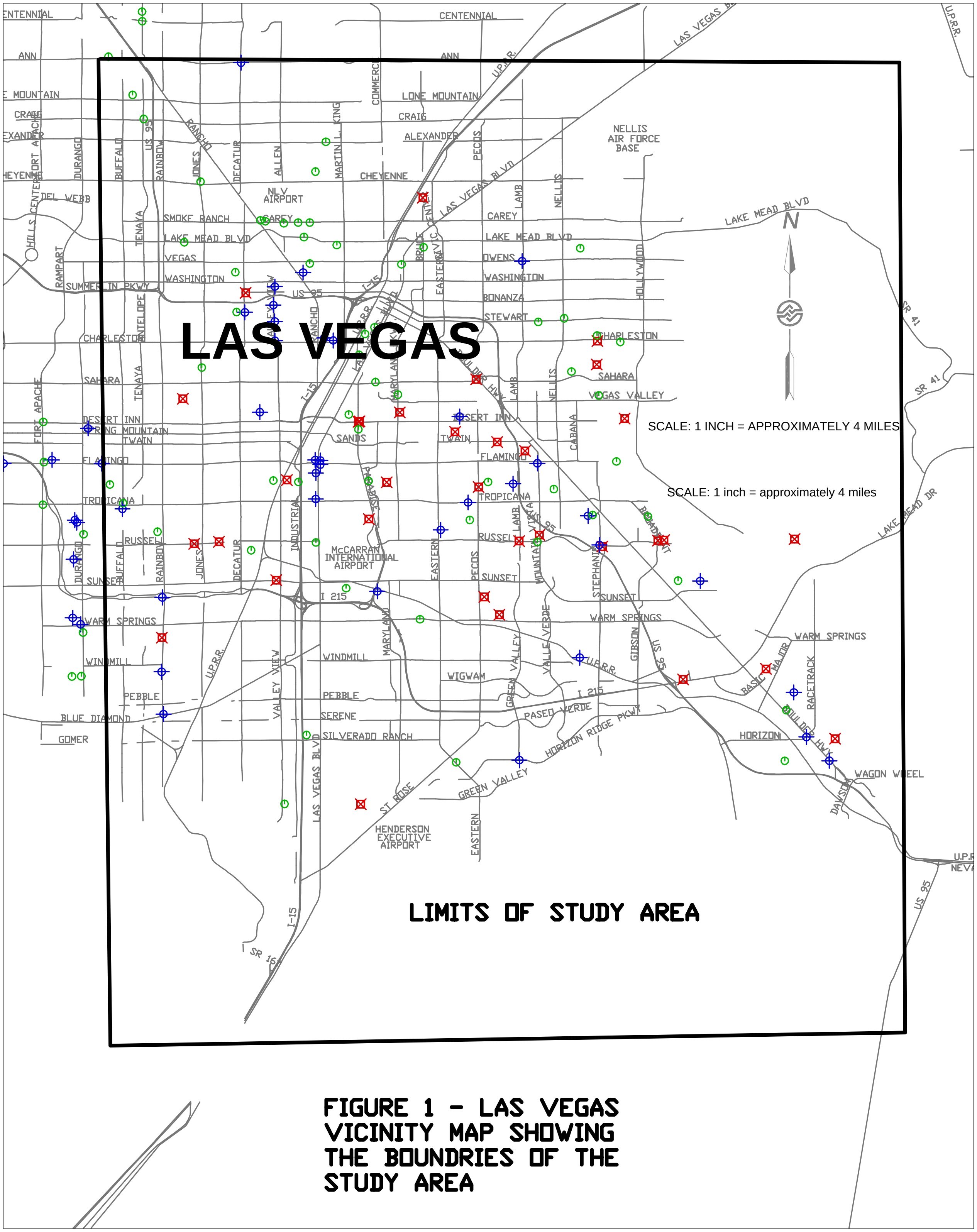

FIGURE 1 - LAS VEGAS VICINITY MAP SHOWING THE BOUNDRIES OF THE STUDY AREA

Protocol criteria as suggested by previous guidelines (Nevada Earthquake Safety Council, Guidelines for evaluating liquefaction hazards in Nevada, 2000; Special Publication 117, Guidelines for evaluating and mitigating seismic hazards in California, 1997; and Lew, 2001) were determined for each selected borehole. This included assigning values based upon blow counts (**less than 30-1 point**), water present (**yes/no-2 points if present and saturated**), and type of sandy material present (**non-clay 1-point; poorly graded sand-4 points; well-graded sand-3 points; silty sand-2 points, sandy clay/clayey sand-1point**). An example of how the point system was applied is point "34" on the database. This point was assigned 1-point for a blow count of 25, 2-points for water being present and saturating the material, 1-point for being a non-clay and 4-points for being a poorly graded sand, which give it a total of 8 points, which would place it in the high liquefaction susceptibility category. The categories were plotted on the map with high values being 7 and 8, moderate values being 5 and 6, and low values being less than 5.

LIQUEFACTION HAZARD MAP

Figure 2 represents the data mapped on a base similar to ones used by the Clark County Building Department for other soil constraints mapping in the Las Vegas Valley. The general limits of the area having the highest liquefaction potential are also depicted.

From Figure 3, it appears as though the areas of concern are generally located in areas of wash flood plains, and in particular the eastern portion of the Valley with shallow groundwater conditions. Thus, areas of surficial recent deposits with high groundwater in Las Vegas Valley may be potentially susceptible to failure from liquefaction during ground shaking in future earthquakes. This indicates that areas of Las Vegas Valley may be analogies to the geological patterns observed in the San Fernando and Simi Valleys of southern California. These valleys were especially hard hit and adversely affected by the Northridge earthquake January 17, 1994. Hitchcock et al. (1999) and Wills and Hitchcock (1999) showed that the Northridge Earthquake produced considerable damage from liquefaction, which was directly related to the ground shaking and the saturated Holocene stream deposits in the region.

SUMMARY AND CONCLUSIONS

Soil data for Las Vegas Valley were compiled with the aid of geotechnical soil reports from Converse Consultants projects over the time period of 1997 to 2001. The purpose of this investigation was to establish a database and to compile a liquefaction

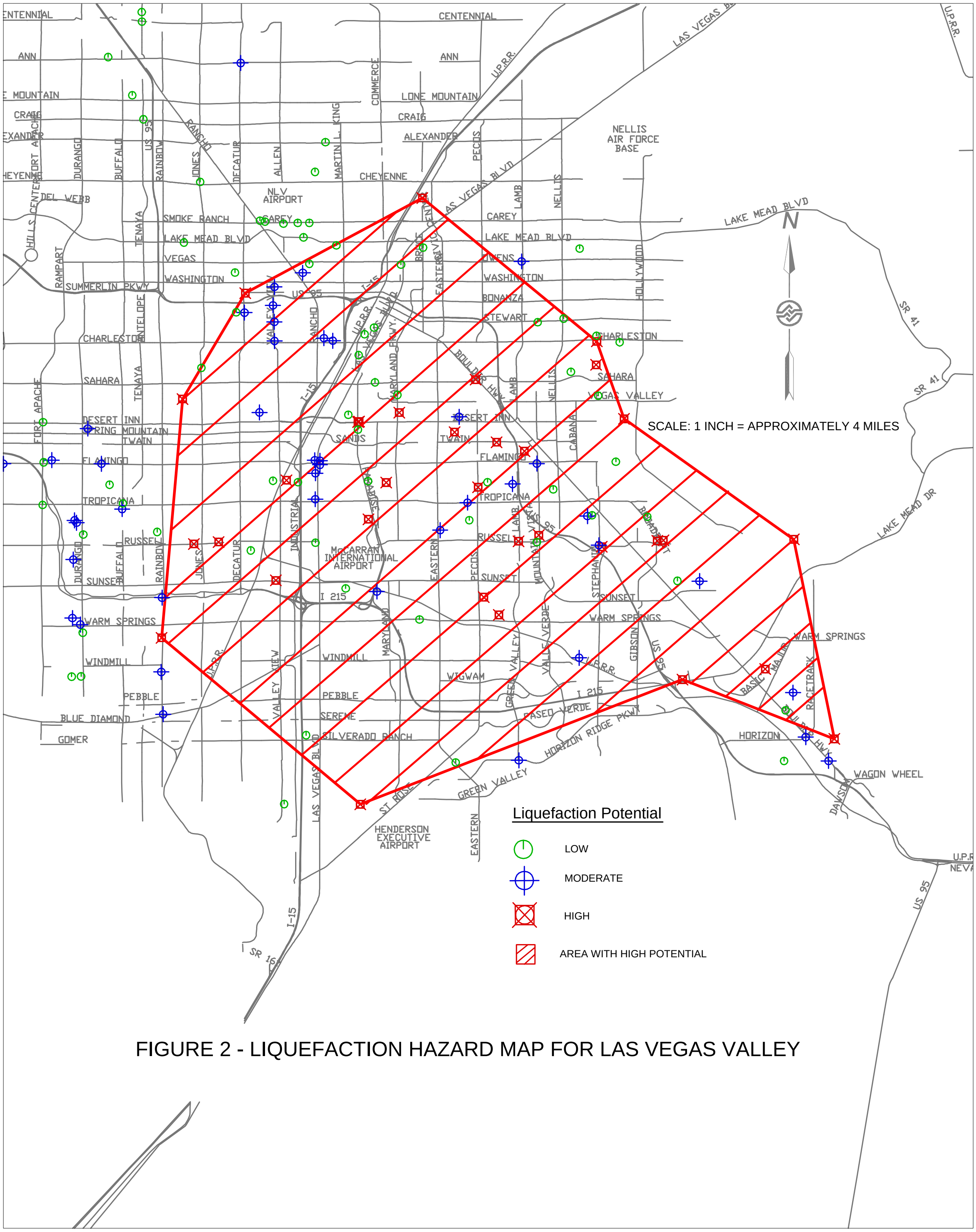

FIGURE 2 - LIQUEFACTION HAZARD MAP FOR LAS VEGAS VALLEY

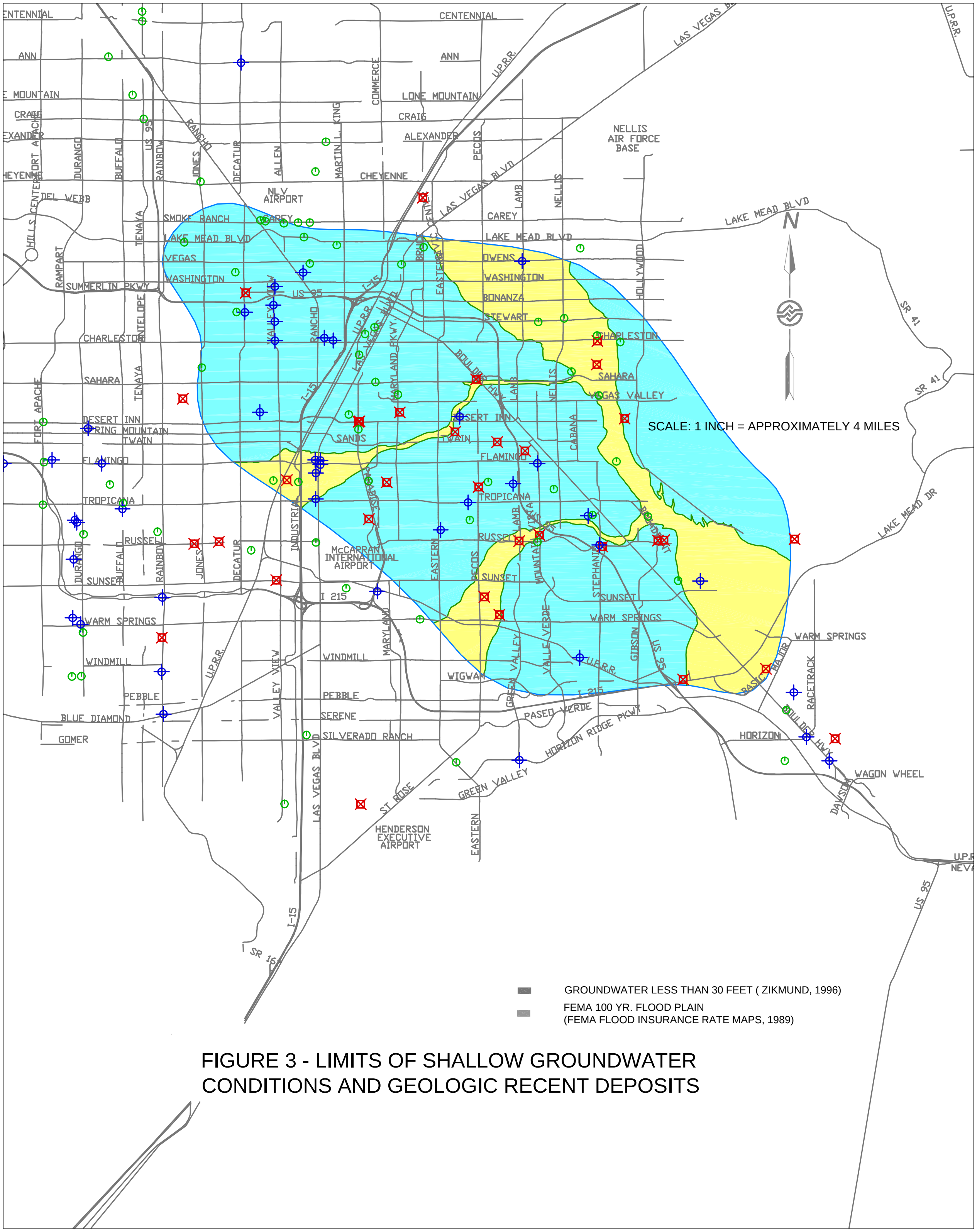

FIGURE 3 - LIMITS OF SHALLOW GROUNDWATER CONDITIONS AND GEOLOGIC RECENT DEPOSITS

susceptibility map. Geographical coverage of the valley with over 150 data points was used to develop the liquefaction susceptibility map. Before plotting each of the points screening protocols for liquefaction potential was applied. The protocols emphasized areas with favorable surficial geology and groundwater conditions. The final product is shown on the map base used by the Clark County Building Department for other soil constraints mapping in the Las Vegas Valley and delineates areas that have conditions recognized to produce liquefaction. Thus, the liquefaction hazard map can be used as a planning tool and provide a guideline for developing site-specific investigations in areas that have liquefaction susceptible conditions.

In summary, the combination of high groundwater within loose sandy sediments constitutes a significant liquefaction hazard beneath portions of Las Vegas Valley. Given the realization that liquefaction does not occur randomly, but is restricted to deposits with geologic and hydrologic characteristics that can be identified and mapped (Hitchcock et al., 1999), the preliminary liquefaction susceptibility map presented shows areas of concern. With this in mind, it is recommended for future projects in areas that are located in designated liquefaction hazard zones that the procedures and guidelines set forth in the State of Nevada in Guidelines for evaluating liquefaction hazards be applied. In general, this would require consultants to perform screening investigations to filter out sites that have no potential or low potential for liquefaction. If the preliminary screening investigation does not clearly demonstrate the absence of liquefaction hazards at a project site, a quantitative evaluation will be required to assess the liquefaction hazards.

ACKNOWLEDGMENTS

This effort was largely supported by the Federal Emergency Management Agency (FEMA) in concert with the Nevada Division of Emergency Management. The authors would also like to thank the Nevada Earthquake Safety Council for their continuing interest. Finally, Mr. Rich Pugliese at Converse Consultants has been particularly helpful in generating the maps shown herein.

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