

DISCUSSION

Introduction

Much of the 1906 earthquake damage in the downtown areas of San Francisco has been attributed to ground failure that probably resulted from liquefaction of artificial fill or granular sediments associated with Holocene estuarine (young bay mud) deposits (Youd and Hoose, 1976). Liquefaction of even relatively thin granular layers can produce lateral spreading and differential settlement of overlying cohesive clayey sediments. In an attempt to determine the distribution of such sediments as a guide to future land-use decisions and construction projects along the bay margins of San Mateo County, over 1000 borehole logs were collected, located, examined, and ultimately stored on magnetic tape for retrieval and compilation by computer.

The accompanying map shows the location of most boreholes used in the compilation. Those areas in which granular sediments were recorded as occurring above, within, or beneath young bay mud are indicated by distinctive map patterns. Granular sediments may be present in areas where borehole data were not available and, in some cases, where boreholes do not record such sediments because sampling was discontinuous or the sampling techniques used failed to retrieve loose granular materials. For these same reasons, granular sediments may occur at stratigraphic levels other than those indicated. Also, granular sediments may not occur in some areas indicated on the map because of arbitrary extrapolation of boundaries between boreholes. Additional borehole data probably exist for many areas and, if examined, could serve to enlarge and refine the areas of granular sediments indicated on the map.

Methods of analysis

Borehole localities were plotted as accurately as possible on 1:24,000-scale USGS quadrangles and indexed by California coordinates. The descriptive logs, coordinates of boreholes, engineering test data, and other pertinent information were put in computer-compatible format to be stored in a computer file utilizing the General Information Processing System (GIPSY) data storage and retrieval program. Print-outs of the logs were examined for engineering test data and descriptions indicating the presence of granular, largely noncohesive materials. The locations of boreholes with such materials at three separate stratigraphic positions were retrieved on computer-generated maps at 1:24,000 scale: one map showing logs having granular materials resting on young bay mud, one of logs showing such materials within young bay mud, and one of logs having granular materials within 10 feet below the base of young bay mud. Areas of granular materials at each stratigraphic position were arbitrarily outlined by hand where the density of available borings was sufficient to suggest continuity of a particular layer. The borehole locations and patterns of granular materials were subsequently reduced and combined on a 1:62,500-scale base map using a focalmatic projector.

The lack of a pattern showing granular sediments should not be construed to mean that such sediments do not exist, except where a borehole log symbol is present on the map outside a patterned area. Even at these locations, thin layers of granular sediments could be present but remain undetected because they were not visually apparent if sampling was discontinuous or the techniques commonly used to sample cohesive materials failed to retrieve granular sediments. Also, sinuous, narrow channel fillings of silt, sand, and gravel could remain undetected where a subsurface exploration program was based on a widely spaced borehole grid.

Granular materials recorded for this compilation were generally described in the logs as: sand, silty sand, sandy silt, gravel, sandy gravel, and gravelly sand; layers of clayey sand, clayey gravel, sandy clay, silty clay, and gravel clay were included in this compilation. Logs showing granular materials less than 1 foot thick above bay mud and indicating the presence of these materials were not used. All layers of noncohesive granular sediments observed within bay mud deposits, other than "sand" patches, were compiled without regard to the thickness of the layers; these are believed to have low density and may be subject to liquefaction during seismic ground motions (Youd and others, 1975). Such layers, however, may be too thin, discontinuous, or confined to produce differential surface settlement or ground failure even if they do liquefy. Granular materials recorded beneath bay mud were generally described as: loose, moderately loose, moderately dense, and dense, but because engineering tests commonly were not available to indicate density, all such materials were compiled for the purpose of this map. Granular materials at depths of more than 10 feet beneath the base of bay mud are assumed to be too dense, too deeply buried, or too confined to liquefy or to produce settlement or ground failure at the surface.

Use of the map

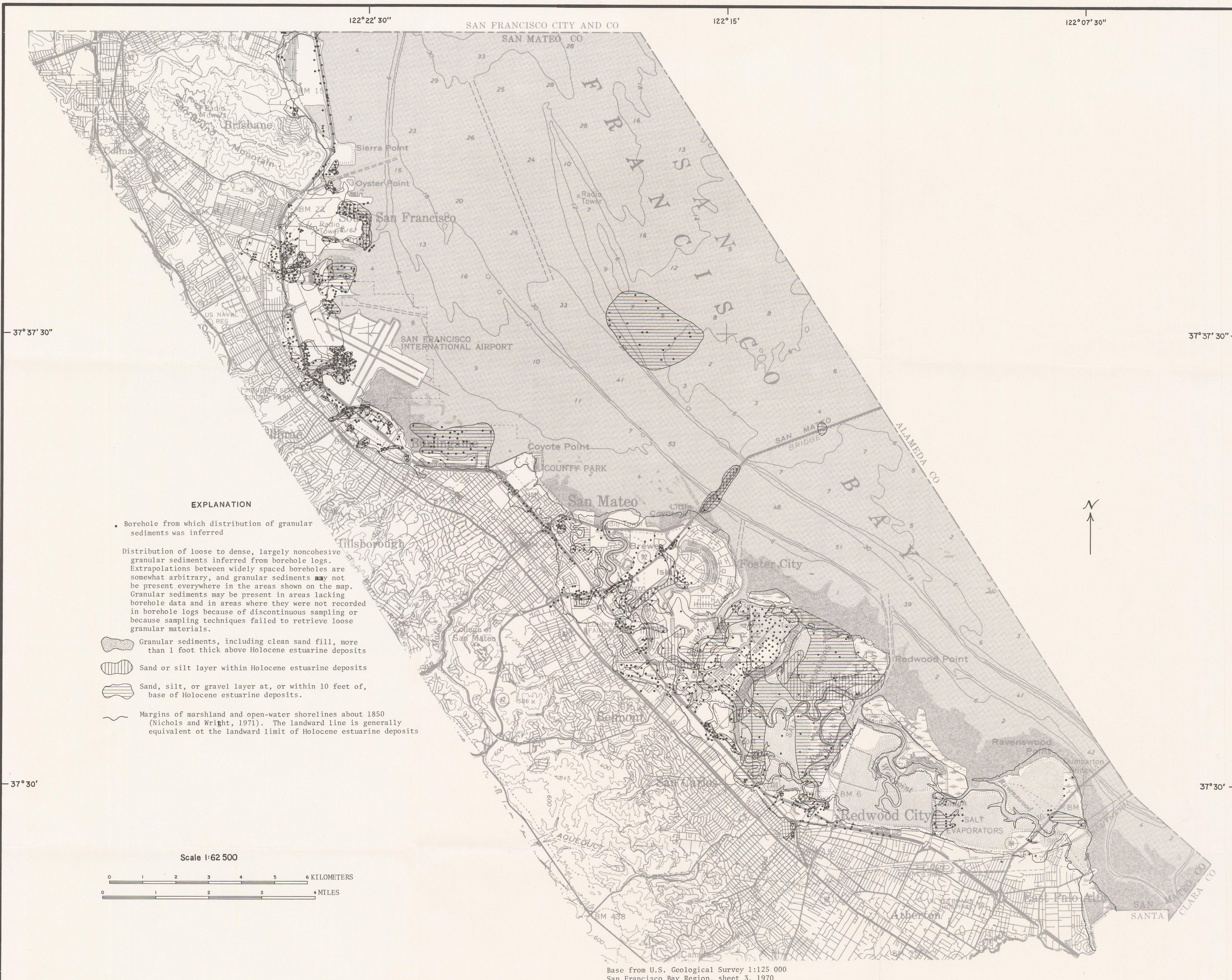
This map is intended to provide a general indication of the possible presence of potentially liquefiable materials where subsurface information was available in areas underlain by bay mud. It is not intended, nor should it be used, for design or in place of site investigations for construction projects, or as a prediction of areas of future liquefaction; detailed subsurface exploration and engineering tests, including determination of density and dynamic analyses, are required for these purposes. This map, however, in the design of subsurface exploration programs and in the land-use planning process as a guide to general areas where hazards may occur and where subsurface geologic and engineering exploration and studies are desirable in advance of subdivision or building permit approvals. We hope that the map may also be helpful in locating areas of possible sand deposits, and in stimulating research on geologic processes that resulted in the deposition of granular sediments.

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MAP SHOWING DISTRIBUTION OF GRANULAR SEDIMENTS ABOVE, WITHIN, AND BENEATH
HOLOCENE ESTUARINE DEPOSITS, SAN MATEO COUNTY, CALIFORNIA

By
D. R. Nichols and N. A. Wright

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