DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AND SAN MATEO COUNTY

MISCELLANEOUS FIELD STUDIES
MAP MF-575

SHEET 2 OF 2

DATA FOR PROPERTY OWNERS — PLANNING DATA — GEOLOGIC DATA — ENGINEERING DATA

GEOLOGIC DATA

Geologic unit and map symbol	Geologic period	Geologic epoch	Informal grouping of geologic units	Physical description and lithology	Thickness	Age	Distribution and stratigraphy
Qcl Colluvium	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Unconsolidated, gravelly rock debris in a poorly sorted matrix of silt to coarse sand. Generally massive but has irregular bedding locally. Rock debris consists of local bedrock lithologies which range from granodiorite and weathered basalt to sandstone and siltstone.	From 0 to 5 feet thick on upland slopes. Deposits shown on this map are probably greater than 5 feet thick and locally may be as much as 30 feet thick.	Variable in age. Some colluvial deposits may be inactive and therefore quite old (>5,000 yrs.?) while others are presently forming and moving and are therefore very young.	Colluvium probably covers most upland slopes in San Mateo County but is restricted on this map to deposits at the base of steep slopes and in small gulleys where it is most likely greater than five feet thick. Interfingers with and grades into alluvial deposits (units Qyf, Qyfo, and Qof) at the heads of canyons and at the base of steep canyon walls. Overlies bedrock.
Qyf Coarse-grained younger alluvial fan deposits	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Unconsolidated, moderately sorted, permeable sand and silt with coarse sand and gravel becoming abundant toward fan heads and in narrow canyons. Well bedded. Locally contains aboriginal artifacts and skeletal remains.	Thickness varies from less than 10 feet to as much as 50 feet. Thickest deposits in valley bottoms and at the heads of alluvial fans.	Presently forming. Oldest deposits probably 5,000 to 7,000 years old.	On active stream terraces and as valley fills in narrow canyons where it interfingers with and grades into colluvium along the walls and at the heads of the canyons. Found along streams in the lower parts of broad valleys and at the heads of alluvial fans where streams flow from narrow bedrock canyons onto alluvial plains marginal to the bay or onto low marine terraces along the Pacific coast. Interfingers with and grades into finer-grained alluvial deposits (Qyfo) or floodplains in broad valleys and at the outer edges of alluvial fans. Overlies bedrock at fan heads and in valleys; overlies older alluvial fan deposits (Qof) and the Colma Formation (Qc) on the alluvial plain marginal to the Bay; overlies Qof and Qmt on the lower marine terraces along the Pacific Coast.
Qyfo Fine-grained younger alluvial fan deposits	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Unconsolidated, moderately-sorted, moderately permeable fine sand, silt, and clayey silt with occasional thin beds of coarse sand. Well bedded. Locally contains minor amounts of organic matter including fresh-water gastropod and pelecypod shells. Locally contains aboriginal artifacts and skeletal remains.	Thickness varies from 0 to about 12 feet thick. Generally thickest in levees along streams and where deposits interfinger with and grade into coarse-grained younger alluvial fan deposits (Qyf).	Presently forming. Oldest deposits probably 5,000 to 7,000 years old.	In some narrow canyons as valley fills and stream terraces. Interfingers with and grades into coarser grained Qyf along streams in broad valleys and on floodplains in broad valleys and on the outer edges of large alluvial fans on the broad alluvial plain marginal to San Francisco Bay. Interfingers with and grades into finer grained basin deposits (Qb) in the lower parts of broad coastal valleys and in the interfluvial basins adjacent to San Francisco Bay. Overlies bedrock in narrow valleys; overlies older alluvial fan deposits (Qof) on the alluvial plain marginal to the Bay and older alluvial fan deposits (Qof) and marine terrace deposits (Qmt) on the lower marine terraces along the Pacific Coast.
Qb Younger basin deposits	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Unconsolidated, plastic, moderately- to poorly-sorted, organic-rich silt and clay. Seasonally saturated. Irregularly bedded. Locally contains fresh-water gastropod and pelecypod shells. Locally contains aboriginal artifacts and skeletal remains.	Generally less than 10 feet thick.	Presently forming where basins not artificially drained or filled. Oldest deposits probably 5,000 to 7,000 years old. Locally contains Holocene molluscan fossils.	Found in poorly-drained, near-horizontal basins between active and abandoned stream levees at the outer margins of alluvial fans adjacent to San Francisco Bay and in the lower parts of broad coastal valleys. Interfingers with and grades into coarser-grained stream deposits (Qyfo) toward higher elevations and with finer-grained salt-water marsh deposits toward lower elevations. Overlies older alluvial fan and stream terrace deposits (Qof) and older basin deposits (Qob) on the Bay margin and bedrock along the coast.
Qym Younger estuarine mud	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Unconsolidated, water-saturated, dark, plastic, organic-rich clay and silty clay. Locally contains lenses and stringers of well-sorted silt and sand. Locally contains fresh- and brackish-water gastropod and pelecypod shells and beds of peat. See Petrong (1972) for more detailed information on composition and physical properties of Bay mud.	As much as 120 feet thick beneath the bay. Thins to less than 1 foot thick around the margins of the bay. Probably less than 10 feet thick in small coastal lagoons and estuaries.	Presently forming. Oldest deposits in bay basin probably about 7,000 to 9,000 years old (Story, et. al., 1966). Locally contain Holocene molluscan fossils. Upper part locally contains molluscan species introduced in past 100 years.	Underlies the waters of San Francisco Bay and small coastal lagoons and estuaries. Found generally below 8 feet above mean sea level. Interfingers with Qyf, Qyfo, and Qb along margins of the Bay and in the lowest parts of broad valleys along the Pacific Coast. Overlies undifferentiated young alluvial deposits (Qyf, Qyfo, and Qb) and older alluvial and marsh deposits (Qof and Qob). Much of the area of exposure shown is used as salt-water evaporating pounds and much is covered by a thin veneer of artificial fill (af, vertical line pattern) (Brabb and Pampeyan, 1972). See Nichols and Wright (1971) for more detailed information on distribution of young Bay mud.
Qs Beach and dune sand	QUATERNARY	HOLOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); YOUNGER UNDEFORMED DEPOSITS	Loose, well-sorted, fine- to medium-grained sand. Includes some small deposits stabilized by vegetation. Mineral composition is variable and generally reflects local bedrock lithologies. Locally may contain lenses of gravel or organic-rich clay. Dune deposits locally contain aboriginal artifacts and kitchen middens.	The thickness of beach sand varies seasonally. Heavy surf strips sand from beaches and deposits it in shallow water offshore during the winter. Milder surf pushes the sand back onto the beaches during the summer. Dune sand thickness varies constantly but may locally exceed 25 feet.	Presently forming. Large dune fields on Franklin Point and Año Nuevo Point probably initially formed about 5,000 years ago when sea level attained its present elevation.	Beach sand occurs intermittently along the Pacific Coast of San Mateo County close to sea level. The largest, most permanent deposits occur in sheltered coves and embayments such as Half Moon Bay. Dune sand occurs locally above beaches but is most extensive on the two headlands, Franklin Point and Año Nuevo Point, at the southern end of San Mateo County. Beach sand overlies bedrock except in the Half Moon Bay area where it overlies marine terrace deposits (Qmt). Dune sand generally overlies marine terrace deposits (Qmt).
Qof Coarse-grained older alluvial fan deposits	QUATERNARY	PLEISTOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); OLDER UNDEFORMED DEPOSITS	Weakly-consolidated, slightly-weathered, poorly-sorted, irregularly interbedded clay, silt, sand, and gravel. Grades progressively from coarse-grained stream deposits on abandoned terraces in bedrock canyons and at the heads of old alluvial fans into fine-grained alluvial fan and fresh-water marsh deposits (Qob) near the present shore of the Bay. Contains local accumulations of fresh-water gastropods and pelecypods and continental vertebrate fauna including camel, bison, horse, sloth, and mammoth.	Maximum thickness unknown, but at least 150 feet thick. Maximum thickness of entire sedimentary pile beneath Qob is probably between 1,000 and 2,000 feet.	About 10,000 years old and older. Maximum age unknown but probably between 35,000 and 70,000 years old. Locally contain late Pleistocene (Rancholabrean) vertebrate and invertebrate fossil fauna.	Exposed primarily along the highest part of the broad alluvial plain marginal to the bay. Along the northern Bay margin and along the Pacific Coast occurs on abandoned floodplains deeply incised by channels which are partly filled by younger alluvial deposits (Qyf and Qyfo). Along the southern Bay margin overlapped by younger deposits (Qyf, Qyfo, Qb, Qym). Interfingers with and grades into older basin deposits near and under the Bay. Overlies bedrock and marine terrace deposits (Qmt) along the Pacific Coast. Overlies bedrock, the Colma Formation (Qc) and deformed older sedimentary deposits (Qfs) on alluvial plain marginal to the Bay.
Qob Fine-grained older alluvial fan and basin deposits	QUATERNARY	PLEISTOCENE	UNDEFORMED DEPOSITS (UNCONSOLIDATED TO WEAKLY CONSOLIDATED); OLDER UNDEFORMED DEPOSITS	Weakly-consolidated, plastic, organic-rich clay and silty clay with occasional irregular stringers of well-sorted coarse sand and fine gravel. Contains same fossil assemblage found in older alluvial fan deposits (Qal).	Similar to older alluvial fan and stream terrace deposits (Qof).	About 10,000 years old and older. Maximum age unknown but probably between 35,000 and 70,000 years old. Locally contain late Pleistocene (Rancholabrean) vertebrate and invertebrate fossil fauna.	Exposed along margins of San Francisco Bay. Interfingers with and grades into older alluvial fan deposits (Qof) toward higher elevations. Underlies younger sedimentary deposits (Qb, and Qym) along Bay margin and beneath the Bay. Overlies older, undifferentiated Bay sediments and continental deposits beneath the Bay.
Qmt Marine terrace deposits	QUATERNARY	PLEISTOCENE	DEFORMED DEPOSITS (WEAKLY CONSOLIDATED TO MODERATELY CONSOLIDATED); SLIGHTLY DEFORMED DEPOSITS	Weakly-consolidated, slightly weathered sand and gravel. Usually consists of undifferentiated lower part of shallow-water marine sediments and upper part of alluvium and colluvium. Lower part commonly consists of conglomeratic sand or fine- to medium-grained micaceous sand overlain by horizontally bedded and cross-bedded medium- to coarse-grained sand. Upper part generally consists of poorly sorted, irregularly bedded sand and gravelly sand. Lower part of deposits on youngest terrace contains shallow water molluscan shells and occasional marine mammal skeletal remains.	As much as 70 feet thick in the Half Moon Bay area but generally less than 30 feet thick.	Deposits on the lowest and most extensive marine terrace are probably 70,000 to 120,000 years old. The deposits on the highest terraces may be one-half to one million years old and may correlate with the Colma Formation (Qc) in the northern part of the county. Lower part of younger (lowest) terrace deposits contain late Pleistocene marine molluscan fauna.	Occurs on flat, gently sloping, wave-eroded platforms along Pacific Coast between sea level and 500 feet above sea level. Overlies bedrock. Locally overlain by alluvial deposits (Qyf, Qyfo, and Qof) and by sand dunes (Qs). Some of the deposits on the highest terraces in the southern part of the county may correlate with the Colma Formation in the northern part of the county.
Qc Colma Formation	QUATERNARY	PLEISTOCENE	DEFORMED DEPOSITS (WEAKLY CONSOLIDATED TO MODERATELY CONSOLIDATED); SLIGHTLY DEFORMED DEPOSITS	In the northwest and central portions of exposure area consists of pale-colored, loose or friable, well-sorted, fine- to medium-grained sand with subordinate gravel, sandy silt, and clay. In the southeast portion of area consists mostly of sand and silty clay. See Bonilla (1960) for more complete description.	Maximum thickness about 200 feet (Bonilla, 1960).	Exact age unknown but may be one half to one million years old.	Occurs in a narrow zone between Burlingame on the southeast, through Colma Valley to Daly City on the northwest. Overlies Merced Formation. Locally overlain by younger deposits (Qyf and Qym). Probably correlates with oldest marine terrace deposits (Qmt) in the southern part of San Mateo County.
QTm Merced Formation	QUATERNARY	PLEISTOCENE	DEFORMED DEPOSITS (WEAKLY CONSOLIDATED TO MODERATELY CONSOLIDATED); HIGHLY DEFORMED DEPOSITS	Unconsolidated to moderately consolidated sandy silt and fine sand in beds 5 to 20 feet thick. Contains subordinate coarse sand lignite, and volcanic ash. Lower part contains marine invertebrate and vertebrate fossils. Upper part locally contains continental invertebrate and vertebrate fossils. See Hall (1966) for more detailed description. Marine fossils in lower part; continental fossils in upper part.	Stratigraphic thickness is about 5,000 feet but maximum depth to underlying bedrock is probably about 2,000 feet (Bonilla, 1964).	A volcanic ash bed in the upper part is dated at 1.5 million years old (Hall, 1966). Entire unit probably one million to four million years old.	Occurs in northwest part of the county. Prominently exposed in sea cliffs between Thornton Beach State Park and Mussel Rock. Lower part correlative with upper part of deformed older sedimentary deposits (QTs). Overlies and is in fault contact with bedrock. Intense faulting and folding have altered original distribution and depositional relationships. Underlies Colma Formation (Qc) in Colma Valley.
QTs Deformed older sedimentary deposits	TERTIARY	PLIOCENE	DEFORMED DEPOSITS (WEAKLY CONSOLIDATED TO MODERATELY CONSOLIDATED); HIGHLY DEFORMED DEPOSITS	Weakly consolidated to moderately consolidated, irregularly bedded gravel, sand, silt and clay. Contains subordinate fine-grained lacustrine deposits, lignite, and volcanic ash. Comprises the Santa Clara Formation and additional unnamed deposits in the Burlingame area. See Cummings (1968) for more detailed description.	Maximum stratigraphic thickness about 2,000 feet. Maximum depth to underlying bedrock is unknown but is probably variable.	Upper part of stratigraphic section correlative with lower part of Merced Formation therefore is about 1.5 million years old.	Comprised of the Santa Clara Formation primarily in discontinuous segments along the San Andreas Rift Zone and other unnamed deposits in the vicinity of San Bruno. The upper part of the stratigraphic sequence is correlative with the lower part of the Merced Formation. Overlies and is in fault contact with bedrock. Erosion and intense faulting and folding have changed original distribution and depositional relationships. Overlain unconformably by younger alluvial deposits (Qyf, Qyfo and Qof).
br Bedrock	PRE-TERT			Varies from well-consolidated sediments to deeply weathered igneous intrusive and extrusive rocks. See Brabb and Pampeyan (1972) and Ellen et. al. (1972) distribution and detailed description of various lithologic units. See Wentworth and others, (1973) for engineering properties.		Igneous intrusions about 80 to 90 million years old. Sedimentary rocks range from 7 to 200 million years old.	Underlies all unconsolidated deposits. Exposed in uplands throughout San Mateo County.

PLANNING DATA / ENGINEERING DATA

Geologic unit and map symbol	Origin of deposit	Topographic form and relationship to modern drainage	Potential resources and uses [1]	Potential geologic hazards and problems	Permeability and drainage	Penetrometer test [2] (blows/ft)	Natural dry density [2] (pounds/ft[3])	Natural moisture content [2] (% dry wt.)	Void ratio [2]
Qcl	Derived from weathered bedrock. Forms residual mantle on upland slopes. Moves downslope by soil creep and slow mudflows. Accumulates in gulleys and swales.	Forms smooth floors of small gulleys and sloping aprons at the base of steep slopes. Follows contours of hills where it mantles entire slopes.	No mineral resources.	Liquefiable when saturated; severe gulleying on slopes; soil creep and small landslides; high shrink-swell potential. Fair to poor earthquake stability. Fair to poor foundation conditions.	Variable; poor sorting and local high clay content cause moderate to low permeability.	No direct data but probably below 30.	No data	No data.	No data.
Qyf	Fragmented and transported material derived from bedrock uplands and older unconsolidated deposits. Deposited by flowing water on active stream levees and floodplains primarily during floods. When streams overflow their banks during floods the coarsest debris is deposited close to stream channel to form natural levees. The factors which initiated the cycle of deposition represented by the younger sedimentary deposits (Qyf, Qyfo, Qb, and Qym) are probably related to the climatic and base-level changes associated with the drastic rise in sea level between 15,000 and 5,000 years ago. Depositional processes disrupted severely by modern cultural activity.	Forms flat floodplains and terraces in narrow valleys. Forms well-drained levees and flat floodplains in broad valleys. Forms well-drained small alluvial fans where small streams flow from narrow bedrock valleys onto marine terraces. Forms well-drained stream levees and flat floodplains near the heads of large alluvial fans on the alluvial plain marginal to San Francisco Bay. Presently being deposited by modern streams but cultural activity has disrupted formative processes.	Gravel deposits may occur at heads of alluvial fans near base of hills. Class I and II Agricultural soils developed on these deposits; excellent to good agriculture. Excellent groundwater aquifer.	Undercutting and small landslides along active stream channels; periodic flood inundation. Excellent to good foundation conditions. Good to fair earthquake stability.	High permeability; well drained.	15 ± 13 (33 tests 7' ± 5' below surface). 30 ± 19 (109 tests 29' ± 13' below surface) for undif. Qyf, Qyfo, Qb buried and interfingered with young bay mud (Qym).	109 ± 11 (46 tests 7' ± 5' below surface). 115 ± 9 (127 tests 29' ± 13' below surface) for undif. Qyf, Qyfo, Qb buried by and interfingered with young bay mud (Qym).	19 ± 7 (46 tests 7' ± 5' below surfact) 22 ± 4 (127 tests 29' ± 13' below surfac surface) for undif. Qyf, Qyfo, Qb buried by and interfingered with young bay mud (Qym).	0.6 ± 0.1 (8 tests 7' ± 5' below surface). 0.7 ± 0.3 (44 tests 29' ± 13' below surface) for undif. Qyf, Qyfo, Qb buried by and interfingered with young bay mud (Qym).
Qyfo	Origin similar to younger alluvial fan deposits (Qyf) but deposited farther from source therefore finer grained than Qyf. Local bedrock characteristics may control grain size in narrow canyons. Presently being formed but depositional processes disrupted severely by modern cultural activity.	Forms flat floodplains in some narrow valleys. Forms active levees and floodplains in broad valleys and at the outer margins of large alluvial fans on the broad alluvial plain marginal to San Francisco Bay. Presently being deposited by modern streams but recent cultural activity has disrupted formative processes.	Class I and II Agricultural soils developed on these deposits; excellent to fair agriculture if well drained. Good groundwater aquifer.	Undercutting and small landslides along streams; periodic flood inundation; potentially liquefiable where shallow well-sorted silt or sand beds occur and are saturated; local shrink-swell problems. Good to fair foundation conditions. Fair to good earthquake stability.	Moderate to high permeability; well drained to moderately drained; water table may be close to surface during rainy season.	About 16.[3]	About 116.[3]	17-22.[3]	No data.
Qb	Deposited from standing floodwaters which periodically innundate low interfluvial basin areas, and locally from seasonal fresh-water marshes. Presently being formed but depositional processes severely disrupted by modern cultural activity.	Forms flat floodbasins between stream levees at or near sea level. Presently being deposited by modern streams but recent cultural activity has disrupted formative processes.	Class II and III agricultural soils developed on these deposits; good to fair agriculture if well drained.	Shrink-swell problems; periodic flood inundation; poorly drained, seasonal standing water due to high water table; potentially liquefiable where local shallow sand beds exist and are saturated. Poor to fair foundation conditions. Poor earthquake stability. Very poor septic tank drainage.	Low permeability; poorly drained; high water table; standing water on these deposits during rainy season.	About 18.[3]	About 117.[3]	About 26.[3]	No data.
Qym	Between mean sea level and high tideline (+8') deposited primarily in brackish- to salt-water marshes along the margins of the Bay and in coastal lagoons. Below mean sea level deposited on tidally-exposed mudflats and beneath the shallow waters of the Bay. Presently being formed but depositional processes severely disrupted by modern cultural activity.	Forms flat marshlands with low levees adjacent to tidal sloughs and gently sloping mudflats exposed only during low tides. Presently being deposited in modern estuaries but recent cultural activity has disrupted formative processes.	Oyster beds dredged for cement production (Hart, 1966). Areas underlain by mud used as salt evaporators, diked off and marsh vegetation cleared. Undisturbed marshes on muds provide wildlife habitat. See Goldman, (1969), for more detailed discussion of mineral resources of San Francisco Bay.	Very low shear strength; potentially liquefiable where shallow sand beds exist; inundated by tides under natural conditions; compaction and subsidence where drained; ground motion amplification during earthquakes. High salt concentration may occur in areas used as salt evaporators. Extremely poor foundation conditions. Very poor earthquake stability.	Low permeability; poorly drained; tidally inundated.	Push by hand.[4]	Ranges from about 21 to 37.[4]	Ranges from about 90 to 300.[4]	Not applicable to clays. About 0.5 to 13. in fine- to medium-grained sand lenses in mud.[4]
Qs	Beach sand is generally derived locally by wave abrasion of sea cliffs and by stream erosion in adjacent hills. Wave action winnows silt and clay from rock debris supplied to the beaches and leeves a residuum of clean, well-sorted sand. Dune sand is derived from beaches by the wind. Cultural activity such as damming streams and stabilizing sea cliffs and beaches may have locally disrupted sand supply.	Beach sand forms seasonally changing configurations ranging from broad, flat, gently sloping beaches to steep beaches with high berms. Dune sand forms low mounds in small deposits but forms parabolic dunes (U-shaped in the direction of the wind) and longitudinal dunes (linear ridges oriented parallel to the wind direction) in the large deposits of Franklin Point and Ano Nuevo Point. Being formed and deposited along modern coastline. Cultural activity has locally disrupted formative processes.	Local high quality sand. Very high recreational value. Beach sand provides local erosion protection for sea cliffs.	Local movement by wind a and waves. Permanent changes in wave. and current patterns along coast by artificial means may disrupt natural movement of sand which may cuase destruction of beaches and/or cliff erosion.	Extremely high permeability; well drained above water table.	No direct data but probably low.	No direct data but probably about 110.[5]	No direct data but probably very low in dune sand and well-drained beach sand.	No direct data but probably between 0.3 and 0.8.[5]
Qof	Deposited from flowing water on stream terraces and alluvial fans. Similar in origin to younger alluvial fan deposits (Qyf), greater age is reflected in slight consolidation and better soil profile development than on younger deposits. The upper part of this unit in the Bay basin was deposited by streams graded to lower stands of sea level; the Bay did not exist during period of deposition.	Forms old, slightly dissected alluvial fans with subdued levees and stream channels. Forms dissected, abandoned floodplains in bedrock canyons and on coastal marine terraces. Incised by modern streams in canyons and at the heads of old alluvial fans. The fluvial regime which deposited these sediments was very similar to the recent one which deposited the younger alluvial deposits.	Gravel deposits near base of hills. Class I, II, and III soils developed on these deposits; fair to excellent agriculture.	Local shrink-swell potential. Excellent to fair foundation conditions. Excellent to good earthquake stability.	Low to moderate permeability. Moderately drained.	88 ± 23 (44 tests).	136 ± 10 (44 tests).	13 ± 5 (44 tests).	No data.
Qob	Deposited mainly in fresh-water marshes and from sluggish streams at the outer margins of old alluvial fans. Streams were graded to lower stands of sea level; the Bay did not exist during period of deposition.	Forms old mudflats.	None	Potential liquefaction where shallow, well-sorted silt and sand beds occur. Fair to poor foundation conditions. Fair to poor earthquake stability.	Low permeability. Poor drainage.	18 ± 10 (42 tests).	97 ± 6 (47 samples).	27 ± 4 (47 tests).	0.7 ± 0.1 (14 tests).
Qmt	Lower marine part deposited in shallow, near-shore marine environment. Upper continental part deposited as alluvium and/or colluvium by streams and/or mudflows. Marine terraces and their deposits formed by periodic high-stands of sea level. All terraces were probably formed at or near present sea level but have been subsequently uplifted, tilted and folded by tectonic forces.	Forms flat, gently tilted and folded terraces along the Pacific Coast. Lateral continuity of terraces has been destroyed by faulting, folding and stream dissection. Terraces have generally been elevated above sea level and are not part of the modern terrace erosion cycle which was initiated about 5,000 years ago when sea level reached its present elevation.	Class II and III Soils developed on these deposits; fair to good agriculture. Ground water aquifers.	Severe gullying in artificial cuts. Potential salt-water encroachment where in hydrographic continuity with ocean water (primarily in Half Moon Bay area between Miramontes Point and Pillar Point). Severe cliff erosion potential where exposed to wave attack (primarily in Half Moon Bay area). Good foundation conditions. Good earthquake stability except near sea cliffs.	Surface may have low permeability; below 5-foot depth permeability is probably moderate to high.	No direct data but probably similar to Qof.	121.4 ± 6 (17 tests).	14.3 ± 5 (17 tests).	No data but marine sands in lower part probably have higher void ratio than colluvial and alluvial deposits in upper part.
Qc	Deposited in shallow marine and continental environment. The Colma was probably deposited at or near present sea level and has been subsequently uplifted and tilted to the east by tectonic forces. Colma Valley was a shallow marine passageway connecting the ocean with an ancestral bay during the time the Colma Formation was deposited.	Forms southeasterly tilted floor of Colma Valley. Modern streams dissecting original flat surface forming low rolling hills. Late Pleistocene and Holocene alluvial deposits partially fill the lower parts of small valleys eroded into the Colma Formation.	Sand	Gullying in artificial cuts. Good foundation conditions. Good earthquake stability if not disturbed by artificial cuts.	Moderate to high permeability; generally well drained.	No data.	No data.	No data.	No data.
QTm	Lower part of 5,000-foot stratigraphic sequence was deposited in a shallow marine environment. The upper part of the sequence was probably deposited by streams on continental alluvial fans.	Original depositional morphology destroyed by faulting and folding. Tilted and deformed beds have been eroded into steep sea cliffs and rolling hills and narrow canyons occupied by modern streams. Many small canyons artifically filled for construction sites.	Local sand and gravel	Severe landslides in sea cliffs and artificial cuts; primarily Westlake area. Moderate to low resistence to wave erosion at base of sea cliffs; primarily Westlake area. Excellent to poor foundation conditions depending on slope and local lithology. Good earthquake stability except near high sea cliffs (primarily Westlake area).	No direct data. Permeability probably variable but very low.	No direct data but probably variable and higher than value for Qof.	No direct data but probably variable and greater than values for Qof.	No data.	No direct data but probably variable and lower than values for younger units.
QTs	Coarser-grained units probably deposited by streams. Finer grained units probably deposited in local lakes.	Original depositional morphology destroyed by faulting and folding associated with movements primarily on the San Andreas fault. Tilted and deformed beds have been eroded into rolling hills and narrow canyons occupied by modern streams.	Local sand and gravel	Landslides on steep slopes and in artificial cuts. Good to fair foundation conditions depending on slope. Good earthquake stability except on steep slopes.	No direct data. Permeability probably variable but very low.	No direct data but probably variable and higher than value for Qof.	No direct data but probably variable and greater than values for Qof.	No data	No direct data but probably variable and lower than values for younger units
br	Varies from marine sedimentation to igneous intrusion.	Varies from low rolling hills to ridges of moderate relief throughout uplands of San Mateo County.	Local aggregate and limestone quarries.	See Brabb and Pampeyan (1972) and Brabb, Pampeyan and Bonilla (1972) for discussion of slope stability in upland areas.	No direct data. Permeability probably variable but extremely low except where rocks are highly fractured.	No direct data but probably very high if not complete refusal.	No direct data but probably varies from 125 for sedimentary rocks to 180 for igneous rocks.[5]	No direct data but probably variable and low.	No direct data but most likely very low.

FOOTNOTES

1. Agricultural information for deposits in southwestern part of county derived from the Soil Survey of San Mateo County (U. S. Soil Conservation Service, 1961). Agricultural information for deposits in northeastern part of County estimated from soils mapped on equivalent deposits in Santa Clara County (U. S. Soil Conservation Service, 1968; Helley and Brabb, 1972).
2. Except where otherwise indicated numerical values compiled from unpublished engineering tests by the State of California Division of Highways.
3. No direct data. Values estimated from tests on equivalent deposits in adjacent Santa Clara County.
4. See Pestrong (1972), Nichols and Wright (1971), Goldman (1969), Mitchell (1963), Treasher (1963), Trask and Rolston (1951) for detailed discussions of physical properties of young Bay mud.
5. Estimated from values in the Handbook of Physical Constants (Birch and others, 1942).

TABULAR DESCRIPTION OF UNITS FOR GEOLOGIC MAP OF UNCONSOLIDATED AND MODERATELY CONSOLIDATED DEPOSITS OF SAN MATEO COUNTY, CALIFORNIA

BY

K.R. LAJOIE, E.J. HELLEY, D.R. NICHOLS, AND D.B. BURKE

1974

USES OF MAP AND TABULAR DESCRIPTION

The primary purpose of this map and tabular description is to provide information about the unconsolidated deposits in San Mateo County for land-use planning. The physical properties and origin of the various map units summarized in this tabular explanation are the geologic factors which should be considered in conjunction with other types of information when determining the best use of the low, relatively flat land of San Mateo County. In addition to providing information on beneficial uses, the data also indicate the limitations and probable detrimental effects of certain uses for some lands.

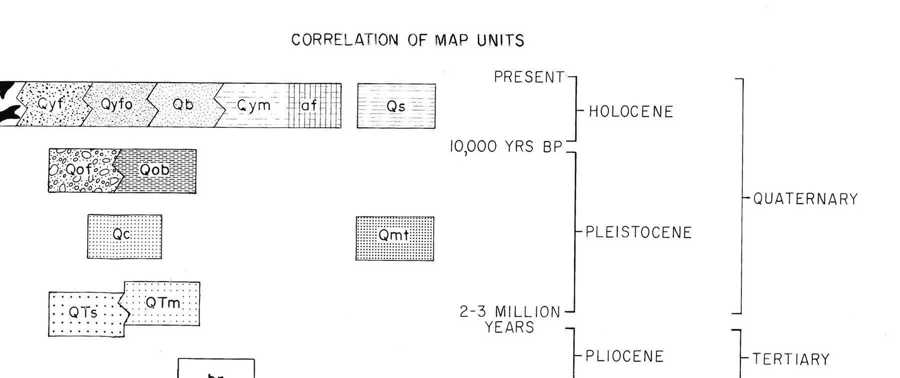
For example, areas underlain by fine-grained deposits, such as Qob and Qb, having expansive soils, low penetrometer values, and high moisture contents generally have low bearing strengths and would therefore constitute an engineering problem in stabilizing building foundations. Because these same deposits have low permeabilities and occupy low topographic sites, they are very poorly drained and would be poor materials in which to place septic tank drain fields. The young, well-drained, coarser-grained deposits such as Qyf, on the other hand, generally are permeable and have high infiltration rates. Such deposits present minimal foundation problems and provide potential sites for percolation ponds and septic tank drain fields. They also are the best agricultural deposits in the county and are a potential local source of sand and gravel.

As another example, geologic units close to the bay margin such as the younger mud, younger basin sediments, younger fluvial deposits and older fluvial and basin deposits contain complexly interstratified and potentially liquifiable layers of silt and fine sand, some of which lie at shallow depths. Development near the Bay margins should be preceded by thorough and detailed investigations to assess this potential problem. During earthquakes these water-saturated layers may liquify and move, thus causing damage to structures built over them. Zoning of land underlain by these younger deposits should reflect the fact that these unconsolidated and easily compressed materials are likely to experience greater amplification of seismic shaking during earthquakes than the older, coarse-grained, partially consolidated deposits.

Because much of the land underlain by sedimentary deposits has already been developed in San Mateo County, the map can also be used for emergency planning to outline those areas where cultural features are subject to potentially greater damage during natural events such as earthquakes or floods. For example, access routes through areas underlain by younger mud have a higher chance of being damaged during an earthquake than those on firmer deposits (Qyf, Qyfo, and Qof), so allowances for this possibility should be made in emergency contingency plans.

Because of its scale and content, this map is not intended as a substitute for detailed geologic evaluations or site investigations for individual buildings or developments. Rather it is a general geologic guide to the land-use constraints and the best uses of the various unconsolidated deposits found in San Mateo County. Similarly, the information in the tabular explanation indicates only the general range of physical properties and genetic characteristics of the different map units.

CORRELATION OF MAP UNITS



SUMMARY OF DEPOSITIONAL HISTORY

The distribution and ages of units shown on this map indicate that profound and rapid changes occurred in the San Francisco Bay region during the past two to three million years. These major geologic events included the uplift of the Coast Ranges of central California to their present heights and the formation of the broad valley which now contains San Francisco Bay. Elevation changes, local folding and tilting, and accompanying erosion and deposition resulted from the movements of crustal blocks which are in part defined by major northwest-trending faults in the area.

Highly Deformed Sedimentary Deposits:

The oldest units on the map are composed of marine and continental sediments that were deposited between about four million and one million years ago in a geographic setting far different from that of the present. Shallow marine embayments lying between low hills in the area of the present Santa Cruz Mountains were partly filled with near-shore marine deposits of the lower part of the Merced Formation (QTm). An abrupt mineralogical change in the upper part of these deposits indicates that the drainage from interior California started supplying detritus to this portion of the coast about two million years ago (Hall, 1966). Prior to this time the Sierran drainage probably reached the ocean farther to the south and all the rock material which forms the Merced Formation was derived from local land masses. Lacustrine and alluvial deposits of the Santa Clara Formation (QTs) and the upper part of the Merced Formation filled inland valleys at the same time and overlapped the marine deposits (Cummings, 1968). Sarna-Wojcicki (1971) found that a volcanic ash bed in the upper part of the Merced Formation exposed in the sea cliffs at Daly City correlates with an ash bed penetrated by a drill 283 feet below present sea level beneath the Bay indicating that deposits equivalent to the Merced underlie younger sediments in the Bay basin.

The shape of these old depositional basins has been greatly obscured by faulting, folding, and erosion. For example, about 17 miles of right-lateral offset of the Santa Clara Formation has occurred on the San Andreas fault since the unit was deposited (Cummings, 1968). Tectonic stresses associated with faulting have locally folded and overturned strata of the Merced and Santa Clara Formations. The result of this deformation has been the severe derangement of the drainage patterns and depositional basins in which the Merced and Santa Clara Formations were deposited.

Slightly Deformed Sedimentary Deposits:

The tectonic activity that deformed the Merced and Santa Clara Formations created geographic setting and depositional regime substantially like that of the present during middle to late Pleistocene time (within the past one million years). The effects of major sea level changes--resulting from fluctuations in the size of the polar and continental ice sheets during this time--were superimposed on those produced by crustal warping and faulting. Each major melting of the sheets resulted in a high-stand of sea level (near present sea level) which formed a marine terrace capped by shallow-water marine deposits (Qmt) along the coast of central California. A succession of at least six of these terraces on the San Mateo County coast have been faulted and warped and clearly record some of the tectonic activity which has continued to affect this area. The oldest recognizable terraces (probably around one-half million years old) have locally been uplifted as much as 600 feet above present sea level. Relative soil-profile development suggests that deposits on the highest (oldest) preserved marine terraces in the southern part of the county correlate with the shallow marine deposits of the Colma Formation (Qc) in the northern part of the county. Colma valley was a broad channel connecting the bay and the sea when the Colma Formation was being deposited, perhaps leaving the present-day site of San Francisco an isolated group of islands. The Colma Formation probably also correlates with some of the old estuarine deposits in the upper part of the thick sedimentary sequence beneath the Bay.

The youngest marine terraces were probably formed during the last major high stand of sea level between 120,000 and 70,000 years ago. The broad, low terraces at Half Moon Bay and Año Nuevo Point were both probably formed during this time, but subsequent faulting, folding, and uplift, as well as the lack of diagnostic fossils in the terrace deposits prevent definite correlation of the discontinuous terrace remnants between these areas.

Older Undeformed Sedimentary Deposits:

Two distinct periods of alluviation are recorded by the late Pleistocene and Holocene deposits of the county. The older period is represented by stream terrace, alluvial fan, and fresh-water basin deposits (Qof & Qob) and the younger period is represented by the presently forming alluvial fan, basin and estuarine deposits (Qyf, Qyfo, Qb, and Qym).

The base of the older fan system in the Bay basin has not been clearly defined and its maximum age therefore not determined. These deposits probably overlie sediments equivalent to the Merced and Santa Clara Formations, but the nature of the contact (i.e., unconformity or disconformity) is not known.

The upper part of this older fan system contains a vertebrate fossil fauna of the latest Pleistocene age (called Rancholabrean) and wood which yields C^{14} ages of about 20,000 years.

During the late Pleistocene glacial advance between about 30,000 and 10,000 years ago, sea level stood about 300 to 400 feet below its present elevation (Milliman and Emery, 1968). During that time the coastline was near the present site of the Farallon Islands (about 30 miles west of San Francisco) and there was no San Francisco Bay. The streams which drained the Bay side of the San Francisco Peninsula joined a large, northward-flowing stream near the center of the basin which in turn joined a larger river draining the Great Valley through the Carquinez Straights and the Golden Gate. Camels, bison, mammoths, sloths, and horses roamed this broad inland valley whose nearly flat floor was partly covered by fresh-water marshes and open woodlands. The upper part of the older fan sequence (Qof and Qob), which contains the wood dated at 20,000 years BP, was deposited by the sluggish streams and in the fresh-water marshes of the Bay basin during that time.

During the late Pleistocene low-stand of sea level the streams draining the coastal side of the San Francisco Peninsula were graded to elevations lower than present sea level, and alluvial sediments (Qof) locally containing Rancholabrean vertebrate fossils were deposited on their floodplains.

Younger Undeformed Sedimentary deposits:

About 15,000 years ago sea level began to rise as glaciers in the northern latitudes began to melt. Carbon-fourteen dates on peat deposits at the base of the young bay mud (Qym) indicate that this rise in sea level initially inundated the bay basin about 7,000 years ago (Story, et. al., 1966). The ocean reached its present elevation about 5,000 years ago, so the Bay attained its maximum and present size at that time. As sea level rose throughout this interval the base levels of the streams in the Bay basin were raised slightly and the younger alluvial sediments (Qyof, Qyfo, and Qb) were deposited on the floodplains around the growing Bay, and the younger Bay mud (Qym) was deposited beneath its waters. All of these younger deposits are therefore less than about 7,000 years old.

In most areas along the coast, the post-Pleistocene rise in sea level inundated the lower parts of the deeply incised valleys of the large coastal streams and caused them to partially fill with sediment during Holocene time. Major valleys such as Pescadero Valley are not completely filled and generally have lagoons and marshes in their lower reaches. In the area between Half Moon Bay and Tunitas Creek, however, cliff retreat caused by wave erosion has lowered base level of the streams causing them to cut into and abandon their Pleistocene floodplains.

Because the younger alluvial deposits were transported and deposited by the present-day pattern of streams, their distribution generally indicates the area of flooding during the past 5,000 years. Cultural activity during the past 100 years has disrupted the processes which are forming all of the younger undeformed sedimentary deposits.

REFERENCES CITED

Association of Bay Area Governments, 1966, General soil map, nine Bay Area counties, California (based on soil surveys by U.S. Soil Conservation Service).

Birch, F., Schairer, J. F., and Spicer (eds.), 1942, Handbook of physical constants: Geol. Society of America Special Papers, no. 36.

Bonilla, M. G., 1964, Bedrock-surface map of San Francisco South Quadrangle, California: U. S. Geol. Survey Miscellaneous Field Studies Map, MF-334.

Bonilla, M. G., 1965, Geologic map of the San Francisco South Quadrangle, California: U. S. Geol. Survey open-file map, scale 1:20,000.

Brabb, E. E., and Pampeyan, E. H., 1972, Preliminary geologic map of San Mateo County, California: U. S. Geol. Survey Misc. Field Studies Map MF-328, scale 1:62,500.

_____1972, Preliminary map of landslide deposits in San Mateo County California: U. S. Geol. Survey Misc. Field Studies Map MF-344, scale 1:62,500.

Brabb, E. E., Pampeyan, E. H., and Bonilla, M. G., 1972, Landslide susceptibility in San Mateo County, California: U. S. Geol. Survey Misc. Field Studies Map MF-360, scale 1:62,500.

Cummings, J. C., 1968, The Santa Clara Formation and possible post-Pliocene slip on the San Andreas fault in central California in Dickinson, W. R., and Grantz, A. (eds.), Proceedings of the conference on geologic problems of the San Andreas fault system: Stanford Univ. Pubs. Geol. Sci., v. 11, p. 191-207.

Ellen, S. D., Wentworth, C. M., Brabb, E. E., and Pampeyan, E. H., 1972, Description of geologic units, San Mateo County, California: Accompanying U. S. Geol. Survey Miscellaneous Field Studies Map, MF-328.

Goldman, H. B. (eds.), 1969, Geologic and engineering aspects of San Francisco Bay fill: Calif. Div. Mines and Geology, Special report 97.

Hall, N. T., 1966, Late Cenozoic stratigraphy between Mussel Rock and Fleischhacker Zoo, San Francisco Peninsula: in A walker's guide to the geology of San Francisco, Calif. Div. of Mines and Geology, Special Supplement to Mineral Information Service, Nov. 1966.

Hart, E. W., 1966, Shell deposits of southern San Francisco Bay: Calif. Div. Mines and Geol., Mineral Information Service, v. 19, no. 3.

Helley, E. J., and Brabb, E. E., 1971, Geologic map of late Cenozoic deposits, Santa Clara County, California: U. S. Geol. Survey Misc. Field Studies Map MF-335, scale 1:62,500.

Helley, E. J., Lajoie, K. R., and Burke, D. B., 1972, Geologic map of late Cenozoic deposits, Alameda County, California: U. S. Geol. Survey Misc. Field Studies Map MF-429, scale 1:62,500.

Milliman, J. D., and Emery, K. O., 1968, Sea levels during the past 35,000 years: Science, v. 162, p. 1121.

Mitchell, J. K., 1963, Engineering properties and problems of the San Francisco Bay mud: Calif. Div. Mines and Geology, Special Report 82, p. 25-32.

Nichols, D. R., and Wright, N. A., 1971, Preliminary map of historic margins of marshland, San Francisco Bay, California: U. S. Geol. Survey open-file map, scale 1:125,000.

Pestrong, R., 1972, San Francisco Bay tidelands: California Geology, v. 25, no. 2, p. 27.

Sarna-Wojcicki, Andrei, 1971, Correlation of late Cenozoic pyroclastic deposits in the central coast ranges of California: unpub. Ph.D. dissertation, Univ. of California, Berkeley, 170 p.

Story, J. A., Wessels, V. E., and Wolfe, J. A., 1966, Radiocarbon dating of recent sediments in San Francisco Bay: Calif. Div. Mines and Geology, Mineral Information Service, v. 19, no. 3.

Trask, P., and Rolston, J. W., 1951, Engineering geology of San Francisco Bay, California: Geol. Soc. America Bull., v. 62, p. 1079-1110.

Treasher, R. C., 1963, Geology of the sedimentary deposits in San Francisco Bay, California: Calif. Div. Mines and Geology, Special Report 82, p. 11-24.

U. S. Soil Conservation Service, 1961, Soil survey of San Mateo area: U. S. Soil Conservation Service Series 1954, no. 13.