

DEPARTMENT OF THE INTERIOR
UNITED STATES
GEOLOGICAL SURVEY

Generalized description of engineering-geologic aspects of surficial deposits in the Boulder quadrangle, Colorado

Engineering geology unit name and map symbol	Equivalent geologic unit (s)	Description and thickness	Other features	Topographic form and surface relief	Weathering and ancient soils	Workability	Surface drainage and erosion	Ground water	Suitability for waste disposal	Foundation stability	Slope stability	Probable earthquake stability	Use
Sanitary landfill	Manmade fill	Waste and rubbish, excluding garbage; some logs and broken concrete. Noncompacted; density extremely variable. Covered and locally interlayered with earth 1-3 ft thick. Total thickness as much as 25 ft.	Compressibility high where density low.	Nearly level where covered by earthfill; irregularly uneven surface elsewhere.	None.	Excavation: varies; easy to difficult with power equipment. Compaction: generally moderately difficult; improved by addition of water during placement; density increases with age of deposit. Drilling: usually moderately easy; locally difficult because of logs and concrete.	Infiltration: medium to rapid. Runoff: slow. Susceptibility to erosion: slight in rubbish; very high in earthfill cover. Yield to wells: negligible. Quality: probably polluted. Use: none practical.	Permeability: high in rubbish; low in earthfill layers. Water table: depth varies; water may puddle in depressions on underlying surface. Yield to wells: negligible. Quality: probably polluted. Use: none practical.	Septic systems: generally satisfactory. Dump sites: most now abandoned.	Generally very poor; settlement excessive; improves with age of deposit but probably poor at best.	Very poor.	Extremely poor. Maximum damage to structures on this of material reported elsewhere in seismically active areas.	Nonconstruction purposes only. Reclaimed land desirable for parks, playgrounds, golf courses, trailer courts, etc.
Earthwork	Manmade fill	Earth and rock mostly obtained locally and built into earthwork including land fills, and highway and dam embankments. Most is composed of silt-clay placement. Thickness of deposits mapped ranges from 5 to 30 ft.	Older dam embankments may have variable density, and may overlie "Organic silty sand and gravel (Sm)" and "Silty clay (Sc)".	Ridgeline or terracelike. As much as 30 ft of surface relief locally.	None.	Excavation: generally easy with power equipment. Compaction: generally easy with power equipment. Drilling: generally very easy.	Infiltration: varies; depending chiefly on soil texture, slope, and vegetation cover, and compaction. Runoff: slow where surface flat, medium to rapid where erosion: moderate by sheet and gully wash where unprotected by vegetation or surfacing, and by stream scour where not protected from stream by riprap.	Permeability: varies both among fills and within individual fills and embankments. Highway embankments generally well drained near base. Water table: absent in most highway embankments; varies in most dams. Yield to wells: varies. Quality: varies. Use: none practical.	Septic systems: varies; percolation too slow to marginal. Dump sites: poor to fair in abandoned ponds and reservoirs because risk of local ground-water pollution.	Varies; fair to good for roads and light structures; locally poor for heavy structures.	Generally good, if compacted; locally poor in a few places potentially hazardous. Side slopes 1 1/2 horizontal to 1 vertical generally safe where well compacted and fill and subsoil well drained. Stability investigations recommended for existing fills--and prior to building on or near new fills--on hillsides having slopes greater than 1 1/2:1 (20 percent) and on other fills more than 30 ft high. State regulations require support or 45° repose in excavations.	Mostly poor, particularly where thick, or where fill overlies alluvium or landslide deposits.	General construction purposes.
Cobbly gravel and sand	Post-Piney Creek alluvium (in part) Broadway Alluvium (in part) Slocum Alluvium (in part)	Gravel and sand, cobbly to bouldery; (GS, GM), poorly graded (well sorted); dense to very dense; cross stratification crude in 2- to 5-ft-thick lenses; locally as much as 40 ft; light-yellowish-brown to pale-reddish-brown color from iron oxide. Derived mostly from igneous rocks; some common, equidimensional and rounded. As much as 25 ft thick.	Free of silt- and clay-size fractions in comparison with "Silty bouldery sand and gravel (Smb)" and "Silty clay (Sc)".	Bed of, and low flat terrace along Boulder and Left-hand Creeks; high terrace remnants resembling small flat-topped mesas north of Boulder Creek within the city of Boulder.	Well-developed ancient soil profile commonly present near surface; clay-enriched zone (hardpan) 12-18 in. thick is underlain by carbonate-enriched zone, which appears as faint pale-brown to white layer in subsol along major streams; loosely cemented caliche as much as 2 ft thick along outer margins of Boulder Creek valley.	Excavation: moderately easy with power equipment; slowed by numerous boulders; boulders decrease in frequency from mountain front eastward. Compaction: moderately difficult; vibratory compactors commonly used; removal of large boulders makes easier. Drilling: generally moderately difficult because of boulders.	Infiltration: mostly medium to rapid; very rapid where clay-enriched zone absent. Runoff: slow; water may puddle in low depressions for as long as a day; susceptible to erosion: moderate by sheet and gully wash near major streams. Susceptibility to erosion: moderate by stream scour; slight by sheet and gully wash.	Permeability: very high. Water table: generally 3-10 ft below terrace surface along Boulder and Left-hand Creeks. Yield to wells: as much as 40 gpm. Quality: very hard; dissolved solids and sulfate content high. Use: estimated good source for certain industrial uses, cooking, irrigation and stock water; requires treatment for domestic and public supply.	Septic systems: generally unsatisfactory; percolation too fast, water table locally too shallow. Dump sites: very poor because risk of great ground-water pollution.	Generally good below depth of about 2 ft. Heavy structures founded over sparse small lenses of compressible silty clay may settle unevenly.	Good; newly cut vertical slopes as much as 15 ft high commonly stand for months in gravel pits, but ravel or slump to angle of repose (about 30°) during or over period of several seasons, or if below water table. State regulations require support or 45° repose in excavations.	Fair.	Major local source of good-quality aggregate; previous shells of dams and dikes; crushed road metal.
Silty bouldery sand and gravel	Post-Piney Creek Alluvium (in part) Broadway Alluvium (in part) Verde Alluvium (in part)	Sand and gravel, very silty, pebbly to bouldery; (SM, GM; some SC, GC); well graded (poorly sorted); stratification poor, beds 2-5 ft thick, discontinuous; locally, reddish-brown color from iron oxide. Derived mostly from granite, sandstone boulders common; stones commonly irregular in shape and angular. As much as 30 ft thick.	Large silt- and somewhat smaller clay-size fractions. Grades into "Cobbly gravel and sand (GS)" and "Bouldery gravel and sand (GCB)".	Parts of broad, flat slightly stream-dissected mesa east of mountain front; surface slopes east about 10-30°. Also, concave sloping surfaces along lower sides of mountain valleys and small fans near mouths of intermittent mountain streams.	Granite cobbles slightly weathered throughout, otherwise very similar to stones in "Cobbly gravel and sand (GS)".	Excavation: generally easy with power equipment; generally difficult for light backhoes and trenchers within 1 mile of mountain front because of numerous large boulders; boulders decrease in frequency eastward. Compaction: moderately easy; vibratory compactors and smooth-tired rollers commonly used; easy where large boulders are absent or removed. Drilling: generally moderately easy; moderately difficult where large boulders numerous.	Infiltration: generally medium; rapid where clay-enriched zone absent. Runoff: slow where surface flat, medium to rapid where erosion: moderate by sheet and gully wash; high along banks of streams and where unprotected in construction areas.	Permeability: medium to high. Water table: generally 7-25 ft below surface. Yield to wells: as much as 20 gpm. Quality: very hard; dissolved solids and sulfate content high; polluted locally. Use: reported good source for lawn irrigation, cooling and stock water; requires treatment for domestic use.	Septic systems: generally satisfactory; percolation locally too fast. Dump sites: poor because risk of moderate ground-water pollution.	Generally good below zone of clay enrichment and front leave (about 2 ft). Heavy structures founded over sparse small lenses of compressible silty clay may settle unevenly; slabs may be heaved by swelling in clay-enriched zone.	Fair; newly cut nearly vertical slopes as much as 10 ft high commonly stand several months in borrow pits, but ravel or slump on wetting and drying over period of several seasons, or if below water table. Slopes higher than 10 ft probably safe 1 1/2 horizontal to 1 vertical where subsoil well drained. State regulations require support or 45° repose in excavations.	Fair.	Source locally for good-quality road metal and embankment fill.
Organic silty sand and gravel	Piney Creek Alluvium (in part)	Sand and gravel similar to "Silty bouldery sand and gravel (Smb)" but with upper 1-5 ft commonly pebbly organic silt. (O1a). Upper part very well graded (poorly sorted); stiff, brittle when dry; soft, sticky when wet; stratification moderately good, beds several inches to as much as 3 ft thick, fairly continuous laterally. Total thickness as much as 15 ft.	Large silt- and somewhat smaller clay-size fractions. Grades into "Cobbly gravel and sand (GS)" and "Bouldery gravel and sand (GCB)".	Long, narrow low terrace along some streams east of mountains; gentle slopes adjoining gullies locally within the mountains.	Poorly developed ancient soil profile generally present at surface; clay-enriched zone characteristically about 3 in. thick. Granite pebbles slightly weathered throughout unit.	Excavation: generally easy with power equipment; locally difficult for light backhoes and trenchers within 1 mile of mountain front because of numerous large boulders; boulders decrease in frequency eastward. Compaction: moderately easy; vibratory compactors and smooth-tired rollers commonly used; easy where large boulders are absent or removed. Drilling: generally moderately easy; moderately difficult where large boulders numerous.	Infiltration: generally medium; rapid where clay-enriched zone absent. Runoff: slow to medium; susceptible to flooding near streams. Susceptibility to erosion: moderate by stream scour on surface; high along banks of streams.	Permeability: low to high. Water table: generally 5-15 ft below surface. Yield to wells: Same as for "Silty bouldery sand and gravel (Smb)". Quality: Same. Use: Same.	Septic systems: Same as for "Silty bouldery sand and gravel (Smb)". Dump sites: Same.	Poor in organic layer, which may heave slabs or compress under structures when water added. Same as for "Silty bouldery sand and gravel (Smb)".	Same as for "Silty bouldery sand and gravel (Smb)".	Poor to fair.	Organic layer possible source of topsoil for landscaping if pebbles removed; generally unsuitable for construction purposes.
Pebbly sand, silt, and clay	Colluvium (in part) Alluvial fan deposits Landslide deposits (in part)	Sand, silt, and clay, pebbly, micaceous; (SC, some GC, SM, GM); very well graded (very poorly sorted); stratification crude to absent, discontinuous, locally contorted; sand mostly medium dense, some dense; clay generally stiff, where overlies "Red siltstone (ms)" plasticity slight, plasticity mostly medium in other areas. Reddish-brown color of sand and silt from iron oxide; grayish-brown color from clay matrix. Stones mostly siltstone and sandstone, sub-angular; blocks or flaggy boulders common; in places weathered and friable. Thickness differs from place to place; maximum about 25 ft.	May flow when saturated by water, and slide when downhill support removed or when loaded by construction.	Gently undulating surfaces sloping 10°-30° into valleys adjacent to hogbacks. Fans and aprons with gently to moderately rolling surfaces near mouths of some streams draining hogbacks.	May locally contain carbonate-enriched zone as in "Cobbly gravel and sand (GS)". Pebbles and cobbles of granite and reddish-brown conglomerate pebbles and cobbles slightly decomposed.	Excavation: generally easy with power equipment; locally difficult for light backhoes and trenchers within 1 mile of mountain front because of numerous large boulders; boulders decrease in frequency eastward. Compaction: moderately easy; vibratory compactors and smooth-tired rollers commonly used; easy where large boulders are absent or removed. Drilling: generally moderately easy; moderately difficult where large boulders numerous.	Infiltration: slow to medium. Runoff: medium where surface flat; rapid on slopes. Susceptibility to erosion: moderate; high where unprotected by vegetation. Susceptible to mud flowage where loosened by excavation and saturated.	Permeability: varies; negligible to medium; commonly low. Water table: varies; water may puddle in depressions on underlying bedrock surface; clay locally may be subject to high pore water pressure. Yield to wells: probably negligible. Quality: probably very hard; iron and sulfate content high; corrosive to steel pipe. Use: generally not practical.	Septic systems: mostly satisfactory; percolation marginal to too slow; generally unsatisfactory where thin, but depends chiefly on nature of underlying bedrock. Dump sites: fair in valleys adjacent to hogbacks; locally risk moderate of ground-water pollution.	Varies; very poor to fair depending chiefly on thickness and texture of material, slope of bedrock surface, and ground-water conditions, and loading.	Generally poor because of steep terrain; nearly vertical cuts as much as 10 ft high commonly stable where crown of back-slope and subsoil well drained; slope failures observed in higher, poorly drained cuts. Potentially hazardous in landslide deposits. Failures in natural and cut slopes most commonly occur where ground water is excessive as indicated by springs, seeps, or water-loving plants, where inclined bedrock surface undercut, or where crown of slope loaded excessively. Stability investigations recommended before grading. State regulations require support or 45° repose in excavations.	Generally poor; very poor on landslide deposits.	Source locally for fair-quality road metal and embankment fill.
Bouldery gravel and clay	Slocum Alluvium (in part) Verde Alluvium (in part)	Gravel and clay interbedded. Beds range in composition from very clayey silty bouldery gravel to very pebbly silty bouldery clay. The gravel (GC) is medium dense to dense, reddish-brown color from iron oxide; the clay (CL) is stiff, plasticity low to medium, yellowish-brown color from iron oxide. Includes 5-ft-thick zone of caliche which generally lies about 2 ft below surface; dense, upper part locally cemented, pale-brown color from calcium carbonate and some iron oxide. Generally very well graded (poorly sorted); firmly cemented by caliche near foot of hogbacks, stratification crude, lenticular, lenses mostly 2-5 ft thick. Derived mostly from sedimentary rocks. Stones commonly sandstone, sub-angular, some granite; 18-in. block boulders common. As much as 25 ft thick.	Large clay- and silt-size fractions. Contains lenses of compressible silty clay commonly a few feet thick and covering, in the sub-surface, as much as a few acres. Hard desiccated clay immediately overlying claystone (chiefly cm-ms and cm-sh) probably will swell moderately to excessively if moistened.	Parts of broad, flat moderately dissected mesa; surfaces slope east about 10-30°.	Well-developed ancient soil profile generally present; clay-enriched zone (hardpan) near surface as much as 18 in. thick is underlain by carbonate-enriched zone (caliche). Granite boulders within ancient soil zone weathered, some decomposed; slightly weathered in rest of unit.	Excavation: generally easy with heavy power equipment; moderately difficult with light backhoes and trenchers within 1 mile of mountain front because of numerous large boulders; boulders decrease in frequency eastward. Cemented zones near foot of hogbacks probably can be worked with moderate soil power equipment. Compaction: moderately easy; smooth-tired rollers commonly used; where boulders absent or removed, sheepfoot rollers most commonly used. Drilling: generally moderately easy; moderately difficult where large boulders numerous.	Infiltration: slow to medium. Runoff: medium. Susceptibility to erosion: moderate by gully wash and stream scour over surface, high by sheet wash where unprotected by vegetation.	Permeability: varies locally from low to high. Water table: ranges widely, from 5 to 30 ft below surface, depending chiefly on bedrock topography and permeability. Yield to wells: commonly 15 gpm or less; locally yields as much as 40 gpm. Quality: very hard; dissolved solids and sulfate content high; polluted locally. Use: reported good source for lawn irrigation, cooling and stock water; requires treatment for domestic use.	Septic systems: generally satisfactory; percolation marginal to too slow locally. Dump sites: poor because risk generally moderate of ground-water pollution.	Generally fair to good below zone of clay enrichment and front leave (about 2 ft). Heavy structures founded over numerous lenses of compressible silty clay may settle excessively or unevenly. Slabs may be heaved by swelling in clay-enriched zone.	Same as for "Silty bouldery sand and gravel (Smb)".	Fair.	Source locally for fair-quality road metal and embankment fill.
Sandstone blocks	Colluvium (in part) Landslide deposits (in part)	Sandstone blocks commonly in chaotic masses. Exposed in places between Twiss Canyon and Sunshine Gulch where blocks are embedded in "Pebbly sand, silt, and clay (SCP)". Bedding absent; caliche zone, 3-5 ft thick, commonly near surface in exposures. Caliche dense, locally cemented, pale-reddish-brown to white color from calcium carbonate and some iron oxide. Adjacent to Fourmile Canyon blocks of hard sandstone as much as 10 ft maximum dimension are scattered over ground surface; slabs, as much as 50 ft maximum dimension, probably buried locally within deposit. Thickness differs from place to place; maximum possibly 50 ft.	May slide along wetted surface of underlying claystone and shale (cm-sh, ms-sh and cm-sh) when downhill support removed, or when loaded by construction.	Strongly undulating boulder-strewn surfaces; maximum slopes as much as 26° along easternmost flank of hogback.	Carbonate-enriched zone common near surface probably as result of formation of an ancient soil. Granite and reddish-brown conglomerate cobbles and boulders decomposed in parts of unit.	Excavation: generally moderately difficult with most power equipment. Compaction: very difficult with most power equipment because of abundant very large boulders. Drilling: generally difficult.	Infiltration: varies, depending chiefly on texture of deposit, topography, and vegetation cover. Runoff: medium on gentle slopes to rapid on high slopes. Susceptibility to erosion: varies, generally slight to moderate; high where unprotected by vegetation. Probably susceptible to mud flowage where loosened by excavation and saturated.	Permeability: varies widely. Water table: depth varies widely; locally absent. Deposits dry in places. Yield to wells: mostly negligible. Quality: unknown. Use: none practical.	Septic systems: generally unsatisfactory but percolation may vary locally from too fast to too slow. Dump sites: very poor chiefly because of access and excavation difficulties.	Varies; poor to good depending chiefly on thickness and texture of material, slope of terrain, slope of bedrock surface, ground-water conditions, and loading.	Varies; generally fair but potentially hazardous locally. Sandstone blocks apparently are deposits of chiefly ancient rock slides, and some ancient debris slides. Slope failures in natural and cut slopes possible where ground water is excessive as indicated by springs, seeps, or water-loving plants, where inclined bedrock surface undercut, or where crown of slope loaded excessively. Stability investigations recommended before grading, particularly in or near toe of landslide deposits.	Generally poor; very poor near toe of landslide deposits.	Possible source of riprap located near mouth of Fourmile Canyon.
Silty clay	Piney Creek Alluvium (in part) Colluvium (in part)	Clay, silty; (CL2/), mostly clayey near water table, plasticity low to medium; stratification poor, lenticular, lenses several inches to as much as 2 ft thick, lateral extent of lenses as much as 100 ft. Slight organic content in upper 5 ft. Sparse pebbly lenses. Total thickness as much as 20 ft.	Moisture content commonly near plastic limit in deposits along streams; compresses when loaded by more than 1,000 psf. Commonly desiccated near margins of valleys and where underlies colluvial slopes; test indicated potential for slight swelling in upper part, high swelling common in lower part.	Broad, flat-floored valleys and colluvial slopes east of mountain front in areas underlain by claystone, siltstone, and shale (cm-ms, cm-sh, ms-sh, and cm-sh).	Poorly developed ancient soil profile generally present at surface; clay-enriched zone characteristically about 6 in. thick.	Excavation: easy with most power equipment. Compaction: generally easy; sheepfoot and lightweight rollers commonly used. Trafficability very poor when wet. Drilling: very easy.	Infiltration: negligible to low. Runoff: medium where surface flat, rapid on slopes; water may accumulate in shallow depressions for as long as a week; susceptible to flooding near streams. Susceptibility to erosion: moderate by gully wash and stream scour along banks; high by sheet wash particularly on slopes; moderate by wind deflation where loosened by plowing or construction.	Permeability: negligible to low. Water table: generally 1-5 ft below valley surface near streams. Commonly absent; water may puddle in valley walls. Yield to wells: negligible to low. Quality: very hard; sulfate content very high; corrosive to steel pipe. Use: estimated fair source locally for stock water.	Septic systems: generally unsatisfactory, locally poor at best; percolation marginal to too slow; water table mostly too shallow. Dump sites: good; slight of ground-water pollution.	Generally poor; highly susceptible to frost heave in upper 2 ft; heavy structures settle excessively; unsuitable for roads without adequate gravel base.	Poor, but vertical streambanks common. Upper few inches to few feet of material underlying slopes subject to slow movement by soil creep and soilification; rate of movement increases with angle of slope. State regulations require support or 45° repose in excavations.	Poor to very poor.	Source of poor-quality fill; possibly good for core material of earthfill dam.

1/Unified Soil Classification (U.S. Army Corps Engineers, 1953).

THIS REPORT IS PRELIMINARY AND HAS NOT BEEN EDITED FOR CONFORMITY WITH U.S. GEOLOGICAL SURVEY STANDARDS AND NOMENCLATURE