PREPARED FOR:

COLORADO GEOLOGICAL SURVEY
and
EAGLE COUNTY, COLORADO

PREPARED BY:

CHARLES S. ROBINSON & ASSOCIATES, INC.

GOLDEN, COLORADO

1975

TABLES OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

EAGLE COUNTY, COLORADO

CONTENTS

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W. ROLD, DIRECTOR

BEDROCK UNITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Quaternary Volcanics Qv	This series of rocks included extrusive, intrusive and pyroclastic material found in the Dotsero area. The intrusive rocks are small sills and dikes that intrude older sedimentary rocks in the Cinder Cone area. The rock is a very fine-grained, dark gray to black vesicular olivine basalt, which is dense, hard, and locally fractured. The extrusive volcanics are vesicular olivine basalt flows up to about 35 feet thick that occur in the Eagle River Valley. These extrusive basalts are similar in composition to the intrusive rocks. The most widespread material is the pyroclastic material of volcanic cinders and ash, with larger pieces of basalt and sedimentary rock scattered throughout, which consists of boulders, cobbles, sand and silt sized material deposited by gaseous explosions from a main vent. The pyroclastic deposits are somewhat consolidated but will not stand vertically. It is well bedded and occurs in some areas underlying thin colluvial material.	The basalt forms prominent outcrops and mesas. The pyroclastic material covers the gently rolling topography as a blanket like deposit.	Weathering affects not prominent.	Excavation: Easy to difficult. Easy in pyroclastic material, difficult in basalt; may require blasting. Compaction: Easy to moderate. Vibratory compactors suggested in the pyroclastic material. Basalts may have to be crushed and mixed with binder before emplacement. Drilling: Easy to difficult. Infiltration: Moderate to high. Pyroclastic material gives highest infiltration rates.	Runoff: Low to moderate, moderate on basalts. Erodibility: Moderate by sheet and gully wash, high by stream scour in pyroclastics. Basalts very resistant.	Permeability: Moderate to high in pyroclastics. Low to moderate through fractures in basalt. Water Table: Not known, probably varies greatly from place to place. Yield to wells: Not developed. Could be good in thick pyroclastic deposits. Use: Not used.	Septic Systems: Generally unsuitable, percolation rates too high or too low. Dump Sites: Generally poor. Deposits relatively thin with wide range in permeability and ease of excavation and compaction. In basaits excavation difficult.	Fair to good. Good on basalts away from cliff edges. Fair on pyroclastic material because of uncemented nature and susceptible to sliding near edges of excavations.	Pyroclastic material is stable at angle of repose. Excavations will ravel and slump.	Unstable slopes in uncemented pyroclastic material. Rockfall hazard near base of basalt cliffs.	Good source of high quality light weight aggregate in coarser pyroclastic material. Basalts are good dense riprap and aggregate source. The occurrence of some of the youngest volcanic rocks in Colorado may indicate possible geothermal energy source at shallow depth.
Quartz Monzonite Tqm	An igneous rock composed of about 60% feldspar, 20-30% quartz, 10-15% hornblende and biotite; texture is medium to fine grained. The intrusion is zoned and contains compositional variations. Sills and dikes are included in the classification and are genetically related to the Porphyry Mtn. Stock. The composition is principally the same and the engineering geologic characteristics are identical. Hard, dense, well jointed, impermeable.	Forms low hummocky hills around Porphyry Mountain.	Very resistant, grayish mottled surface.	Excavation: Very difficult, blasting required. Compaction: Difficult, generally requires crushing and mixing with binder material, steel-wheeled and rubber tired rollers suggested. Drilling: Difficult.	Infiltration: Negligible in rock, moderate to slow through fractures. Runoff: Rapid to moderate. Erodibility: Very resistant.	Permeability: Low to moderate near surface through fractures, becomes negligible at 200 to 400 feet. Water Table: Not known, probably locally present in fractures, probably nonexistant on ridges and hills. Yield to wells: Not developed, probably undependable, best in fractured zones. Quality: Not known, probably good. Use: Poor to fair source for domestic and stock supply.	Septic Systems: Unsatisfactory, chiefly because material for burial lacking, and slight to moderate risk of polluting ground water and nearby wells through fractures. Dump Sites: Unsatisfactory because excavation too difficult. Material for sanitary layering lacking and too porous. Slight to moderate risk of polluting nearby water supplies and wells through fractures.	Good. Blocks may slide into excavations.	Caution advised within 25 feet of large excavations material very slabby and slides may occur along foliations, joints or fractures.	Rockfall hazard at base of steep cliffs. Detached slabs may slide on foliations, joints and fractures.	Good source of riprap, flagstone, aggregate. Has been prospected for gold, silver and base metal sulfides.
Extrusive Volcanics Tv Intrusive Volcanics Ti	The extrusive rocks include about 300 feet of basaltic lavas with interbedded flow breccias, ash flows, and tuffaceous sedimentary rocks. The basalt flows are dark gray, fine-grained to aphanitic, porphyritic and amygdaloidal. The flow breccias consist of angular to rounded pieces of basalt from microscopic size to a foot in diameter in an aphanitic or glassy scoriaceous matrix or cemented with calcite. The interbedded sedimentary rocks are mostly calcareous, tuffaceous siltstones and fine grained sandstones with thin beds of limestone and volcanic ash locally. Lenticular beds of conglomerate composed of pebbles and boulders of lava in a calcareous sandstone matrix are associated with the lava flows and flow breccias. Baking of underlying sediments may have occurred in some areas. Unit is probably well jointed but jointing is obscured because of vegetation and soil cover. These units are generally flat lying on top of gently dipping sedimentary rocks. The tertiary intrusive dikes vary from 3 to 5 feet in thickness and are composed of dark gray to greenish-gray fine grained to aphanitic vesicular basalt. The areal extent of these dikes is for practical purposes insignificant and is similar to the extrusive type material in its engineering geologic characteristics. Includes lava flows of the North Park Formation. In some areas referred to as the Piney Ridge Volcanics.	Underlies prominent divides and hills throughout the sedimentary sequence. Generally well vegetated.	Generally is resistant except in interbedded sedimentary section. Intermittent streams on flow surfaces may show some joint control. At edges of volcanic flows coarse talus tends to accumulate.	Excavation: Difficult to very difficult; degree of jointing is the critical factor. Blasting will probably be necessary over much of the area. Compaction: Difficult, generally requires crushing and mixing with binder material; steel wheeled and rubber-tired rollers suggested. Drilling: Moderate to difficult; sedimentary units moderately difficult.	Infiltration: Negligible into rock, moderate to slow through fractures. Runoff: Rapid to moderate. Erodibility: Very resistant for igneous rocks. Ash flows and tuffaceous sedimentary rocks easily eroded.	Permeability: Generally depends on joint and fracture density. Generally poor. Water table: Not known, may be essentially nonexistant in most places. May be locally present in open but discontinuous fractures and in shallow depressions of former ground surfaces now buried by flows: probably undependable. Yield to wells: Not developed; fractures probably not dependable; yields water in small amounts as generally temporary springs at base of unit, notably after snow melt and heavy rains. Quality: Not known, probably good; moderately mineralized. Use: Has been developed as minor source for stock use in some areas.	Septic Systems: Unsatisfactory, chiefly because of lack of material for burial. Pollution of local ground water sources by leakage through fracture or joint systems. Dump Sites: Unsuitable, chiefly because of excavation of sanitary cover difficult; broken rock extremely permeable as cover material. Great risk of ground water pollution through joints and fracture systems.	Excellent for extrusive and intrusive igneous rock. Poor for interbedded tuffaceous sedimentary rock, and ash flows; excessive swelling. Caution advised within 25 feet of margins of excavations because of hazard of unstable slopes and rockfalls adjacent to large excavations.	Varies, mostly excellent, poor to fair at margins. Should be considered hazardous within 25 feet of margins. Natural face nearly vertical in igneous rock; ash flows and tuffaceous sedimentary rocks stability poor. Failure of ash flows and sedimentary rocks below resistant extrusive layers form small landslides covered with blocks of lava.	Rockfall hazard should in general be considered high near the margins of the flows. Talus slopes are developed along many of the margins overlying potentially unstable materials. Large blocks along margins may fall as an occasional occurrence. Small landslides common on ash flows and tuffaceous sedimentary rocks.	Extrusive and intrusive igneous rocks source of riprap, crushed aggregate and road aggregate.
North Park Formation Tnp	Consists of approximately 1500 feet of interbedded lava flows, flow breccias, ash flows, and tuffaceous sedimentary rocks. The unit occurs in the valleys of the Piney and Colorado Rivers and on the adjacent divides. In the valleys the deposits are deeply dissected by recent fluvial and glacial erosion. The volcanic rocks are described under the Tertiary volcanics. The sedimentary rocks include beds of fine-grained pinkish sandstone of predominately rounded quartz, that is friable and poorly indurated. In some areas, white to gray tuff beds occur. Other rock units are coarse, gray conglomerates, poorly sorted and containing boulders up to several feet in diamenter. Thin interbedded lavas occur locally. The pebbles in the conglomerates are derived from lavas, quartz, chert, granites and gneisses. This catagory will include the Cedar Mountain Formation in the Radium area, although evidence points to a younger date for this formation. Includes the Brown's Park Formation.	Forms terrace like benches along the Piney and Colorado River where it is best exposed.	Easily weathers generally to a buff silt or sand.	Excavation: Easy to moderate. Easy in sands and gravels, moderate in thin lavas. Compaction: Easy to moderate. Vibratory compactors suggested, lavas may have to be crushed and mixed with binder before emplacement. Drilling: Moderate to difficult.	Infiltration: Moderate to high. Runoff: Low to moderate. Erodibility: Slight by sheet and gully wash, moderate by stream scour.	Permeability: Moderate to high, depending upon cementation of beds. Water Table: Not known but probably occurs near interface between the older formations and the Brown's Park Yield to wells: Not developed, locaiiy might be good. Springs and seeps may occur where lava flows crop out. Quality: Not known. Use: Not known	Septic Systems: Satisfactory to unsatisfactory, percolation rates will range from too high to too low depending on unit involved. Dump Sites: Unsuitable, percolation rates generally too high locally, Hazard of polluting ground-water source.	Poor to fair. Sedimentary rocks not fully lithified and poorly cemented. Failure may occur near large excavations or edge of outcrops. Tuffaceous beds will contain swelling clays, that will also compact if dried.	Slope failures common, sedimentary rocks not well cemented and when disaggregated will assume the angle of repose for the material.	Rockslides and rockfalls may occur near edge and base of deposits. Slope failures common when oversteepened.	Locally lava beds used as source of crushed rock aggregate.
Pierre Shale Kp Mancos Shale Kmc	Consists chiefly of dark-gray or dark brownish-gray clay shale. The thickness is about 3600 feet. Thin limestone and siltstone units are interbedded with the shale in the lower part. Two distinctive shaley and silty sandstones occur in the upper part. The uppermost sandstone is about 120 feet thick. Limonite stained calcareous concretions are typical of the Pierre Shale. Gypsum can be found throughout the formation in various amounts. The shales generally contain expansive clays. Mancos Shale is equivalent to Pierre Shale and Benton Shale and occurs where the Niobrara in absent is sequence. Measurements in the area indicate a dry unit weight of 109.8 - 117 pcf; a liquid limit of 34 - 40%; a plastic limit of about 20%; moisture content of 13 - 20%; a permeability of 3.2 x 10^{-7} cm/sec.; a cohesion of 4.4 psi, with 6.4° angle of shear on a sample saturated at 5 psi. These data are recovered from samples at less than 20 foot depth. Fresh unweathered samples may show different characteristics.	Generally forms gently rolling hills in shaley zones. Where prominent sandstones occur it usually forms steep gullied ridges. May form steep slopes where more resistant units occur.	The Pierre Shale is easily weathered and 30 feet of unweathered bedrock is not uncommon. Generally weathered horizon consists of light-gray to gray claystone broken into irregular fragments that increases in size with depth.	Excavation: Easy to base of weathered and fractured material with most power equipment, including tractor drawn scrapers and backhoes; adheres when wet. Increasingly difficult with depth, requiring heavy equipment where unweathered and unfractured. Most difficult in siltstone and sandstone beds and in concretionary zones. Compaction: Easy for shale, and most siltstone, moderately easy for most siltstone and some sandstone; sheepsfoot rollers suggested; trafficability poor when wet. Drilling: Easy to moderately easy; tends to clog toothed bits.	Infiltration: Negligible through the rock, negligible to low through fractures. Runoff: Generally rapid, water may accummulate in scattered depressions. Erodibility: Moderate by gully wash; slow to moderate by wind deflation where loosened by plowing or construction. Difficult to establish vegetation on slopes steeper than 25°.	Permeability: Negligible in upper weathered horizon, negligible to low through fractures in lower horizon; negligible in unweathered rock. Water Table: Not known. Probably varies greatly from place to place. Yield to wells: Not developed; small quantities from sandy beds; also from fractured rock in outcrop area, otherwise negligible. Perhaps best yield is at the base of the overlying surficial materials. Quality: Highly mineralized, iron and sulfate content probably high, locally may react with some concrete and corrode steel pipe. Use: Possible stock supply.	Septic Systems: Generally unsatisfactory, percolation too slow. Dump Sites: Commonly excellent: excavation easy; and risk of ground water pollution negligible; locally fair to good when excavation becomes more difficult in coarser grained and concretion bearing zones.	Very poor to fair. Locally expands excessively and exerts high swell pressures when moisture content increases; shrinks on drying.	Generally fair to poor on gently dipping bedrock slopes. Poor on steep slopes except where more resistant sandstones occur. Cut slopes less the 45° and less than 20 feet high generally satisfactory except under high moisture condition where they could fail. Cuts should be perpendicular to strike of the bedrock or failure along bedding planes may occur. Large thin slope failure complexes are found on dip slopes in the area and bedrock failures along fractures are common on scarp slopes.	Soils and bedrock are expansive and corrosive in part. Massive to small slope failures are common on gentle dipslopes. Large bedrock slides occur on steep scarp slopes. A minor rockfall hazard is found in the more resistant sandstone units but in general the sandstone does not form large blocks and weathers rapidly.	Source for manufacture of light weight aggregate in other areas of the state.

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W. ROLD, DIRECTOR

BEDROCK UNITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Niobrara Formation Kn	Consists of about 1200 feet of shale and thinbedded limestones. The base of the formation consists of a 10 to 15 foot thick, thinbedded limestone unit with calcareous shale partings. Above the basal bed is about 500 feet of dark-to light-gray calcareous shale with thinbedded limestone beds of less than 1 foot to 5 feet in thickness. The next 450 feet consists of dark-gray, non-calcareous shale. The upper 250 feet consists of light-and dark-gray calcareous shale with thin beds of limestone and calcareous siltstone. All data derived from samples recovered from less than 20 feet below surface: liquid limit, 30-8 - 47.8%; plastic limit, 15.8 - 32.8%; plasticity index, 13.2 - 26; moisture, 5.3 - 19.9%; optimum moisture 15.3 - 17.9%; density, 101.8 - 117 psf; permeability, 7.6 x 10^{-8} cm/sec.; cohesion of 29 psi and an angle of shear of 10.5° with sample saturated at 5 psi. Soils may be expansive and corrosive in part.	Shaley units develop gently rolling topography. Cuesta topography formed by resistant limestone units forming steep scarp slopes and gentle dip slopes.	Shales prone to gullying. Shales generally weather to a light gray. Upper weathered zone consists of shaley fragments in a silty clay matrix.	Excavation: Easy to base of weathered zone with most power equipment. Increasingly difficult with depth, requiring heavy equipment where unweathered and not fractured. Compaction: Easy for shale, moderately easy for limestones and siltstones. Sheepsfoot rollers suggested; trafficability very poor when wet. Drilling: Easy to moderately easy. Tends to clog toothed bits.	Infiltration: Negligible through the rock, negligible to low through fractures. Runoff: Generally rapid, water may accumulate in scattered shallow depressions. Erodibility: Moderate by gully wash and stream scour, rapid by sheet wash. Slow to moderate by wind deflation where loosened by plowing and construction; difficult to reestablish vegetation on slopes greater than 25°.	Permeability: Negligible in upper weathered horizon, negligible to low through fractures. Water Table: Not known, may vary greatly from place to place. Yield to wells: Not developed; small quantities from limestones, also from fractured rock in outcrop areas. Perhaps best yield is at the base of the overlying surficial deposits. Quality: Highly mineralized; iron and sulfate content probably high, locally may react with some concrete and steel pipe. Use: Possible stock supply.	Septic Systems: Generally unsatisfactory, percolation too slow. Dump Sites: Commonly excellent; excavation easy, and risk of ground water pollution negligible; locally fair to good where limestones are encountered.	Poor to fair. Locally expands excessively and exerts high swelling pressures when moisture content increases; shrinks on drying.	Mostly good where undisturbed and cuts are less than 45° and less than 20 feet high perpendicular to the strike of the bedrock. Cuts or slopes on the bedrock dip slope tend to have large thin failures in the weathered bedrock zone. Control of drainage important.	Minor rockfall hazard on scarp slopes in limestone units. On gentle dipslopes slope failures are common during high moisture conditions. Soils are expansive and corrosive in part.	Limestones may provide a local source of aggregate for most construction purposes.
Benton Shale Kb Mancos Shale Kmc	About 500 feet in thickness. The lower 50 feet consists of very fine grained clayey and locally carbonaceous sandstone and sandy carbonaceous shale. The middle 400 feet consists of gray clay shale with thin seams of white clay from 0.1 to .5 feet in thickness. The upper 60 feet consists of interbedded dark gray shale and fine-grained, brownish-gray clayey sandstone. The shale and sandstone become calcareous in the upper part. Mancos Shale is equivalent to the Pierre and Benton Shale and occurs where the Niobrara Formation is absent in the sequence. The sample data are derived from shallow as well as unweathered bedrock samples and should be considered as ranges; liquid limits, 24.6 - 104.6%; plastic limits 14.8 - 35.4%; plasticity index, 9.8 - 69.2; moisture content 3.9 - 13%; density, 118.7 - 126.5 lbs/ft^3; dry density 154.4 - 160 lbs/ft^3; unweathered bedrock shear strengths; 2119.5 - 3544 psi; modulus of elasticity 76.7 - 92.5 x 10^4 psi.	Gently rolling topography overlain by colluvium and alluvium; gentle dip slopes to moderate scarp slopes.	Generally deeply weathered dark-gray carbonaceous shale chips in a silty claystone matrix. Upper zone, rapid weathering.	Excavation: Easy to base of weathered fractured material with most power equipment including tractor drawn scrapers and backhoes; adheres when wet. Increasingly difficult with depth. Requiring heavy equipment where unweathered and unfractured. Most difficult in siltstones and sandstones. Compaction: Easy for shale, and most siltstone; sheepsfoot rollers suggested. Trafficability poor when wet. Drilling: Easy to moderately easy.	Infiltration: Negligible through shale, poor to fair through siltstones and sandstones. Runoff: Generally rapid, but water may accumulate in scattered shallow depressions. Erodibility: Moderate by gully wash and stream scour, rapid by sheet wash, slow to moderate by wind deflation where loosened by construction or plowing. Difficult to reestablish vegetation on slopes greater than 25°.	Permeability: Negligible in upper weathered zone, low in siltstones and sandstones in weathered zones. Water Table: Not known probably varies greatly from place to place. Yield to wells: Not developed; small quantities from sandy beds also from fractured rock in outcrop area otherwise negligible. Perhaps best yield at base of overlying surficial materials. Quality: Highly mineralized; iron and sulfate content probably high, locally may react with concrete and corrode steel pipe. Use: Possible stock supply.	Septic Systems: Generally poor except fair in sandy units because of percolation rates. Dump Sites: Generally good except in sandy zones where pollution of ground water could be moderate.	Fair to moderate, may locally expand excessively on wetting and shrink on drying.	Fairly stable, shows accelerated creep on gentle dipslopes; cuts should be perpendicular to strike slopes; should be layed back 1:1 and not exceed 20 feet height. May have local bedding plane failures during high moisture conditions. Control of drainage critical.	Main geologic hazard is slope failures on gentle to moderate dip slopes. May be in part expansive and corrosive.	May be possible fill material and source of manufactured light weight aggregate.
Dakota Sandstone Kd	Consists of about 75 feet of sandstone and conglomeratic sandstone at the base, about 50 feet of interbedded sandstone and shale locally with beds of carbonaceous shale or coal in the middle, and about 75 feet of medium-grained crossbedded sandstone at the top. Shales generally have a swell index of 800-1300 psf. Jointing is prominent.	Makes prominent resistant ridges and is generally found with a large talus apron. Usually supports coniferous vegetation. Jointing controls stream patterns in most areas.	Surface of the sandstone generally ease-hardened where naturally exposed; sandstone, conglomerate and most siltstone moderately to highly resistant to weathering; shale and some siltstone weathers to silty sandy clay only a few feet deep.	Excavation: Generally difficult, commonly requires blasting, in places has been excavated with heavy tractor-drawn rippers. Compaction: Moderately difficult; generally requires some crushing and mixing with binder material before compaction; hauling equipment and smooth tired rollers suggested. Drilling: Moderately difficult to difficult.	Infiltration: Generally moderate to slow, rapid along fractures. Runoff: Moderate to rapid. Erodibility: Generally resistant to stream scour and gully wash; shales eroded rapidly by sheet wash.	Permeability: Probably moderate, but high through fractured rock, particularly near outcrop areas; shales negligible to low. Water Table: Not known, may contain water, perhaps under artesian pressure, in areas downdip away from the outcrops. Yield to wells: Not developed, perhaps small to moderate quantities, quantity at depth unknown, could be significant. Quality: Probably mineralized, perhaps high. Use: May be principle domestic aquifer in some areas; probable domestic and livestock supply.	Septic Systems: Generally unsatisfactory as difficult to excavate, and moderate risk of polluting ground water supply; shales relatively impermeable. Dump Sites: Very poor because excavation difficult and risk of polluting ground water supply.	Generally excellent; poor to hazardous on dipslope where rocks can fall and slide off of resistant cliffs.	Dipslopes away from edge of cliffs are stable. Inspection of rock on and above building sites recommended. Hazardous if bedding surfaces dip into cuts; debris and blocks may slide on bedding surfaces.	Rockfall hazard below cliffs is very high. Loose talus block beneath cliffs can be activated by improper excavations and construction practices. Blocks of bedrock can be found overlying expansive and corrosive soils.	Large talus slopes is a probable local source of lichen covered decorative stone. Material makes poor to fair riprap, dissintegrates rapidly on fresh surfaces.
Morrison Formation Jm	Consists of about 500 feet of interbedded lenticular sandstone, variegated claystone, calcareous claystone and fine-grained fossiliferous fresh-water limestone. Generally non-critical but expansive clays. Fractures; numerous, short, scattered, irregular, nearly closed.	Underlies the Dakota Sandstone and is usually covered by talus on steep slopes below the Dakota. Generally step-like slopes relating to the hard and soft layers of the different units.	Where naturally exposed, surface of siltstone and sandstone commonly case hardened; limestone surface roughened and pitted by solution; claystone generally altered to silty sandy clay at surface and broken irregular pieces to depth of 3 to 6 feet. Unit weathers moderate to rapid.	Excavation: Moderately difficult in sandstone, limestone and siltstone with heavy rippers and scrapers; claystone easy with most power equipment to base of weathered fractured material; adheres when wet. Increasingly difficult with depth; may require heavy equipment. Heavy equipment needed for sandstone and limestone beds. Blasting may be needed locally. Compaction: Moderately difficult for siltstone, sandstone and limestone; hauling equipment and smooth tired rollers suggested. Easy for claystone; sheepsfoot and rubber tired rollers used. Drilling: Easy in claystone moderately difficult in sandstone and limestone; claystone may clog toothed bits.	Infiltration: Low in sandstone, low to negligible in siltstone negligible in claystone. Runoff: Moderate on sandstone; rapid on siltstone and claystone. Erodibility: Low for sandstone; claystone moderate by gully wash, rapid by sheet wash. Difficult to reestablish vegetation on steep slopes.	Permeability: Varies, probably low in sandstone and siltstone, negligible in claystone. Water Table: Not known, probably varies greatly from place to place. Yield to wells: Not developed; may yield small to very small quantities, particularly in fractured rock in vicinity of outcrop area. Quality: Probably highly mineralized. Use: Probably fair livestock supply.	Septic Systems: Generally unsatisfactory as percolation rates are too slow. Dump Sites: Poor to fair; slopes may be too steep and locally may be difficult to excavate.	Generally fair to good; depending mainly of slope and expansive nature of soil.	Generally good, as beds dip into slope fractures may permit fall of sandstone blocks. If bedding surfaces slope towards a deep cut sliding may occur.	Generally a minor rockfall hazard which is usually associated with steep cliffs below the Dakota. Minor expansive soil problems.	Generally satisfactory for most construction purposes; i.e., fair road fill, and land fill layering.
Entrada Formation Je	About 75 feet thick and forms a single bed. It is a massive, crossbedded sandstone. The sandstone is light reddish-orange, fine-grained and typified by aeolian crossbedding. Samples from drill holes indicate the following general parameters; moisture content, 3.78%; density, 137.3 pcf; shear strengths, 2100 psi with a modulus of elasticity of 5.44 x 10^5 psi.	May be found on steep unvegetated slopes associated with coarse talus. May be vegetated similar to the Dakota on gentle dipslopes. Generally a prominent ridge former.	Resistant in part. Closely spaced jointing gives small easily eroded blocks.	Excavation: Difficult may require blasting; may be worked with heavy tractor drawn rippers. Compaction: Difficult, generally requires crushing and mixing with binder material before compaction; hauling equipment and smooth tired rollers suggested. Drilling: Difficult.	Infiltration: Generally moderate, rapid along fractures. Runoff: Moderate. Erodibility: Very resistant to stream scour and to gully and slope wash.	Permeability: Probably moderate to high near out-crop area, high where fractured, probably moderate with depth. Water Table: Not known; probably varies greatly from place to place; possibly contains water under artesian pressure at depth. Yield to wells: Not developed; perhaps small to moderate quantities locally; quantity at depth unknown. Quality: Probably moderately to highly mineralized. Use: Probably fair domestic and livestock supply.	Septic Systems: Generally unsatisfactory as excavation difficult and hazard of polluting potential ground water supply. Dump Sites: Very poor, as difficult to excavate and hazard of polluting potential ground water supply.	Generally excellent; vertical walls generally stable but small blocks may fall into excavations.	Hazardous if bedding surfaces dip into the cut; debris and blocks may slide on dipslope; inspection of rock above and on building sites recommended.	Generally associated with steep cliffs and rockfall hazards within the influence of other units. May form local small talus deposits.	Generally satisfactory for most construction and nonconstruction purposes; i.e. drain filters, some riprap, construction fill. In the Brush Creek area silver mineralization is associated with faulting.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant

CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W ROLD DIRECTOR

BEDROCK UNITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Chinle Formation Tc	Consists of about 200 feet in thickness of chiefly reddish-brown fine-grained sandstones and sandy shale. Lenses of limestone conglomerate composed of pebbles of limestone in a sandy limestone matrix occur locally. Sample data derived from deep drill hole sampling, can be considered averages for unweathered bedrock; liquid limit, 40%; plastic limit, 18%; plasticity index, 23%; moisture content, 10%; density, 135 lbs/ft^3; shear strengths, 29-430 psi; modulus of elasticity from 4 to 10 x 10^4 psi.	Generally forms bluffs and steep unvegetated slopes, harder units form steps.	Weathers to form a red sandy clay shale with limestone pebbles in some areas. Sandstones relatively resistant.	Excavation: Moderate to difficult; weathered shale easy, becomes harder with depth, sandstones difficult but may be worked with tractor drawn rippers, may require some local blasting. Compaction: Moderate. Thorough mixing with binder material may be necessary before compaction. Hauling equipment and smooth tired rollers suggested. Drilling: Moderately difficult to difficult.	Infiltration: Generally moderate to slow, rapid along fractures. Runoff: Moderate to rapid. Erodibility: Sandstone units generally resistant to stream scour and gully wash. Shales eroded rapidly by sheet wash.	Permeability: Probably moderate but high through fractured rock. Negligible through shales. Water Table: Not known, probably varies from place to place. Yield to wells: Not developed, perhaps small to moderate quantities from sandstone units. Quality: Probably mineralized. Use: Probable livestock supply.	Septic Systems: Generally unsatisfactory as excavation difficult and hazard of polluting water supply. Dump Sites: Poor because excavation difficult and risk moderate of polluting ground water supply.	Generally excellent. Poor to hazardous on scarp slopes where rocks may fall or slide.	Hazardous if bedding surfaces dip into cuts, debris and blocks may slide on scarp slopes.	Minor rockfall hazards in most areas usually associated with steep slopes.	Generally satisfactory for most construction and non-construction purposes; i.e., shaley units could be used for layering in land fills.
State Bridge Formation TPsb	The State Bridge Formation is thickest in the southwestern part of the County and consists of three units. In the State Bridge area only two units are found. The lower unit is continuous over the outcrop area of the State Bridge Formation and consists of a moderately reddish-orange clay-free, well sorted, sandstone thought to be of aeolian origin. The South Canyon Creek member is found in the Ruedi area and separates the lower unit from the middle unit in the southwestern part of the County. It correlates with the Yarmony Limestone member in the State Bridge area. In the State Bridge area, the State Bridge Formation consists of only two units separated by the Yarmony Limestone. The upper unit in the northeastern part of the County is termed the Sloane Peak member and consists of a homogenous fine-grained sandstone. The upper most unit is referred to as the Toner Creek member and occurs only in the southwestern part of the County. It consists of poorly to moderately sorted sandstones, pebbly sandstones, conglomerates with pebbles as much as six inches across and silty and sandy claystones. It has a maximum thickness of 388 feet and crops out in very restricted areas. The State Bridge Formation ranges from 500 feet in the State Bridge area to about 2400 feet in the Ruedl area.	The units form vertical cliffs or underlie large dipslope areas.	Highly resistant to weathering but may weather to thin slabby units.	Excavation: Difficult with most power equipment. May require blasting. Compaction: Difficult, may have to be crushed and mixed with binder before emplacement. Drilling: Difficult.	Infiltration: Slight to moderate, varies greatly from place to place. Runoff: Moderate to high. Erodibility: Very resistant to erosion.	Permeability: Varies greatly from place to place. Water Table: Not known, probably varies greatly from place to place depending upon lithology. Yield to wells: Not developed, should be poor to good depending on lithologic unit present. Quality: Not known. Use: Possible stock and domestic.	Septic Systems: Generally unsatisfactory. Percolation too high in some areas, hazard of polluting ground water source and other wells in nearby fractured zones. Dump Sites: Generally poor, excavation too difficult and hazard to pollution of ground water source.	Excellent. Blocks may slide or fall into open excavations.	Blocks may slide on bedding and joint surfaces on steep dipslopes.	Rockfall hazard at base of cliffs. Blocks may slide on dipslopes.	Some members have been quarried for building stone and is suitable for most construction and non-construction purposes; i.e., good aggregate, some riprap.
Weber Formation IPw	Consists of a buff the gray, fine-to coarse-grained, subangular to rounded, quartzose sandstone with calcareous cement. The grain size and composition are different vertically and laterally. Where the grains are coarse, much muscovite is present. In general, the coarser zones are massive where as the fine-grained beds are finely laminated, thus displaying a carved appearance. Light-colored layers alternate with dark-colored layers. The units thickens northwestward and thins east and southward from the west central part of the county. It is approximately 50 feet thick in the Gypsum Creek area. Sometimes referred to as the Schoolhouse Sandstone tongue of the Weber Formation.	Forms cliffs and ridges.	Weathers to a buff quartz sand.	Excavation: Difficult with most power equipment, blasting may be necessary. Compaction: Difficult, should be crushed and mixed with binder before emplacement. Drilling: Difficult.	Infiltration: Fair in unweathered rock, moderate in fractured and jointed zones. Runoff: Moderate to high. Erodibility: Resistant, only slightly affected by stream scour.	Permeability: Fair in unweathered rock, moderate in fractured and jointed zones. Water Table: Not known, varies from place to place. Yield to wells: Not developed, should be good in northwestern part of the county. Quality: Probably good. Use: Could be used for stock and domestic supplies.	Septic Systems: Unsatisfactory; excavation difficult; hazard of polluting ground water source. Dump Sites: Generally unsatisfactory, excavation difficult.	Good. Blocks may slide or fall into excavations.	Good. Bedrock may slide if bedding planes or joint dip into cuts.	Susceptible to rockfall hazard near base of cliffs. May slide on bedding surfaces.	Suitable for most construction and non-construction purposes; i.e., fair road fill, some drain filter material.
Maroon Formation PPm	Consists of about 4000 feet of red mudstones, or shale, siltstone and fine-grained sandstone in the vicinity of Red and White Mountain. The formation thins to about 1700 feet to the east and 1000 feet to the west in Eagle County. About 2/3 of the county is underlain be this and older formations. The unit is designated as all rocks above the Jacque Mountain limestone and below the Weber Sandstone or the Chinle whichever is present. The following sample data are from deep drill holes and can be considered as average data for unweathered bedrock. Moisture content, 1.05-5.05%; density, 141-164 pcf; shear strengths 231-6254 psi, with a modulus of elasticity of 6.3-102x10^4 psi.	South facing scarp slopes are generally grassy or shrub covered; north facing scarp slopes are generally wooded. Scarp slopes are gentle to greater than 40°. The bedding is generally seen as light and dark colored bands on grassy slopes.	Weathers to a fine red silty clay.	Excavation: Easy to moderate in the weathered zone; becomes more difficult with depth. Tractor drawn scrapers and rippers suggested. Compaction: Generally good, sandstones may have to be combined with a binder before compaction with smooth tired rollers. Drilling: Moderate to difficult.	Infiltration: Generally negligible in shales, negligible to low in siltstones and sandstones. Moderate along fractures and joints. Runoff: Moderate. Erodibility: Fairly resistant to stream scour and moderately resistant to gully and slope wash.	Permeability: Generally negligible to low, low in the weathered zone. Water Table: Not known; probably varies greatly from place to place. Yield to wells: Not developed, probably poor to fair depending upon location, siltstones and sandstone probably give best yield. Quality: Probably highly mineralized. Use: Possible stock use.	Septic Systems: Generally unsatisfactory; shales too impremeable and in siltstones pollution of ground water source is a possibility. Dump Sites: Generally fair to poor. Difficult to excavate in many areas; and hazard of polluting ground water.	Good. Blocks may slide on bedding planes into excavations, shales may be expansive in part.	Dipslopes on shale may tend to slide. Bedding that dips into cuts may slide on the dipslopes. In many areas, if very steep slopes are developed construction may alter drainage in the weathered zone and may initiate slides.	Potentially unstable slopes and snow avalanche hazard at higher elevations in the steep valleys are the primary hazard involved. Dipslope sliding of weathered bedrock is also possible.	Generally suitable for most constuction and non-construction purposes; i.e., road fill, layering in land fills.
Eagle Valley Formation fPe fPeg-bedded Evaporites	The evaporite interval consists of a lense shaped deposit about 3,000 feet in thickness in the deepest portion near the center of the County and thinning at the edges. It interfingers with the Minturn Formation of the east and the Morgan Formation on the west, generally outside the County. At the type locality it is mainly a light colored gypsiferous mudstone and siltstone containing some bedded gypsum, a few cherty dark gray limestone beds, about 1 foot thick, and a few beds of reddish shale and siltstone. In some areas the gypsum, formerly anhydrite, is massively bedded. In bluffs it displays chaotic internal structure. Halite is locally common. In some areas, potassium salts have been identified in drill holes.	Irregular topography with bluffs and sinkholes. Landslide topography in areas of steep slopes.	Originally anhydrite; when exposed to water becomes gypsum. Weathers very rapidly and is water soluble. Forms large solution cavities in some areas. Slopes are generally unstable in the bedded deposits.	Excavation: Very easy. Compaction: Poorly consolidated, generally easy. Not recommended for road beds or foundations. Drilling: Easy. May clog bits at high rotation speeds.	Infiltration: High in many areas, moderate in gypsiferous mudstones and shales. Runoff: Moderate. Erodibility: Easily erodible by stream, gully wash and slope wash. Poorly cemented by water soluble materials.	Permeability: Generally high permeability, moderate in impure rock materials, i.e., gypsiferous mudstones etc. Water Table: Not known. Yield to wells: Not known, probably unreliable. Quality: Highly mineralized, and highly corrosive. Use: None.	Septic Systems: Unsatisfactory because of high permeability and hazard of polluting ground water system. Dump Site: Very poor because of high permeability. Hazard of polluting ground water.	Fair, control of surface and sub-surface drainage is critical.	Subsidence of the surface due to solution. Landslides and general instability of the slopes are the major geological hazards.	Relatively unstable slopes, numerous landslides because of infiltration and solubility of the bedrock. Sink holes and solution caverns.	Gypsum and other evaporites may be economically feasible under part of the Eagle River Valley in the future. Various agricultural purposes.
Minturn Formation fPm	Consists of about 6,000 feet of interbedded medium to very coarse grained gray to reddish-brown sandstone, conglomeratic sandstone, thin beds of reddish-brown siltstone and sandy and silty shale with distinctive interbedded pink to gray limestones and dolomites. The Minturn Formation overlies the Belden or on Precambrian rocks and is below the Maroon. It interfingers with the Eagle Valley Formation west of Dowds Junction. In the southwestern part of the County the Gothic Formation is included with the Minturn Formation. The following data is the result of testing of unweathered bedrock composed of sandstones and conglomerates in the Minturn Formation; moisture content, 1-10.9%; unit weight, 130.9 pcf-166.5 pcf; modulus of elasticity, 1.0-12 x 10^5 psi. Shales can be expected to have different values.	Generally forms steep slopes with limestones making prominent steps on the slopes. Forms both grassy and tree covered slopes.	Similar to the Maroon Formation, thin soils with prominent recognizable steps formed by resistant limestone units. The formation weathers to a red silty clay staining the gray limestones a pinkish color.	Excavation: Easy to moderate in the weathered zone, becomes more difficult with depth. Blasting may be required for deep cuts or excavations. Compaction: Generally good except in coarser sandstones and limestones where they will have to be mixed with a binder before compaction. Drilling: Moderate to difficult.	Infiltration: Generally negligible in shales, negligible to low in siltstones, sandstones, and limestones; low in conglomerates. Moderate along fractures and joints. Runoff: Moderate to high. Erodibility: Fair resistance to stream scour and moderately resistant to gully and slope wash.	Permeability: Generally negligible to low, low in the weathered zone, moderate in fractured areas. Water Table: Not known, probably varies from place to place. Yield to wells: Not developed, probably poor to fair depending upon location. Siltstones, sandstones, conglomerates and limestones probably best. Quality: Probably mineralized. Use: Probably stock and some domestic.	Septic Systems: Poor, hazard of ground water pollution in sandstones and siltstones may be moderate. Dump Sites: Generally unsatisfactory excavation difficult and hazard to ground water source.	Generally good.	Dipslopes on shale may tend to slide. Bedding that dips into cuts may slide on bedding planes. In many areas as steep slopes are developed, construction may alter drainage in the weathered zone and may initiate slides.	Potentially unstable slopes and snow avalanches at higher elevations in the steep valleys are the primary hazards involved. Landsliding in the weathered zone and on bedding surfaces.	Generally suitable for construction and non-construction purposes. Limestones may provide a local source of aggregate. In the Vail area has been prospected for uranium.
Belden Formation fPb	Alternating beds of dark gray or black fine grained, fossilliferous limestones and gray to black fissile shale. Two massive, arkosic, conglomeratic sandstone units occur near the middle of the formation and a few beds of micaceous siltsone occur near the top of the unit. The formation ranges in thickness from 700 feet in the Ruedl dam area to 125 feet in the Gilman area. Generally two-thirds of the formation is shale. The beds are discontinuous and lie on a karst surface at the top of the Leadville Limestone. The cave fillings and red regolith on top of the Leadville is termed the Molas Formation and is included with the Belden Formation for simplicity. The formation contains thin gypsum beds in the vicinity of Ruedl. Sandstone porosity is 10 to 15 percent. Shales may be expansive in part.	Generally occurs in valleys and is poorly exposed. Limestones and sandstones form resistant ridges on the slopes.	Weathers to a gray to buff slit with small pieces of limestone, sandstone and shale.	Excavation: Easy to difficult with most power equipment. Thin limestones and shales are ripable. Thicker sandstones and limestones may require blasting. Compaction: Easy in shales, limestones, and sandstone should be removed, crushed and mixed with binder before emplacement. Sheepsfoot and smooth tired rollers suggested. Drilling: Moderate to difficult.	Infiltration: Negligible in shales, sandstones moderately high, limestones less so. Fractures and solution channels along fractures will allow infiltration in local areas. Runoff: Moderate to high on shales less so on sandstones and limestones. Erodibility: Moderate in shales by gully wash and stream scour, slight by sheet wash.	Permeability: Generally poor, may be fair at base of weathered zone, moderate through sandstones and in areas of solution channels. Water Table: Not known. Probably varies greatly from place to place. Quality of Water: Probably mineralized.	Septic Systems: Generally fair to poor. Risk of polluting ground water source in sandstone and limestone. Dump Sites: Fair to good. Good in thick shale units. Fair to poor in sandstone and limestones where there is a hazard to ground water pollution.	Fair. Shales may be expansive in part.	Expansive, in part, susceptible to low angle slumping, and slope failures. Beds dipping into cuts may fail.	Formation is susceptible to slope failures and may contain expansive clays in part.	Suitable for most construction and non-construction purposes; i.e., sanitary land fill layering, some road fill.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant

CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W ROLD DIRECTOR

BEDROCK UNITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Leadville Limestone Ml	The formation consists of two members in Eagle County. The lower sandstone unit, called the Gilman Sandstone member, ranges from 10 to 50 feet in thickness and is discontinuous in some areas. It is composed of thin and uneven beds of grayish-brown medium-grained calcareous sandstone. The lower few feet consist of a light-gray, sandy, dolomite breccia that fills depressions in the underlying Dyer Dolomite. Above the Gilman member is about 75 feet of dense, hard, locally silicified dark-gray lithographic limestone. It is generally evenly massive bedded except the lower units that are thin and contain limestone pebbles. The thickness may range between wide limits in some areas because of post Leadville erosion. Beds are continuous.	Forms prominent ridges and cliffs.	Gilman sandstone weathers to a yellowish-brown sand. The main dolomitic limestone unit has a characteristic bluish-gray color with even smooth surfaces. In some of the mining districts it is hydrothermally altered.	Excavation: Difficult, blasting required. Compaction: Difficult, must be crushed and thoroughly mixed with binder before emplacement. Drilling: Difficult.	Infiltration: Slow except through fractured and jointed areas and solution cavities. May be moderate in altered Gilman sandstone member. Erodibility: Negligible by sheet wash, gully wash, slight by stream scour. Some solution. Runoff: High.	Permeability: Negligible except through fractures and solution cavities. May be fair in altered sandstone. Water Table: Varies greatly from place to place. Only occurs in fractured zones. Yield to wells: Not developed. Because of solution cavities and karst upper surface. Is a good aquifer in other areas of the state. Quality: Mineralized, hard. Use: Domestic, stock, industrial.	Septic Systems: Poor, great hazard of polluting widespread ground water supply. Dump Sites: Poor, difficult to excavate.	Excellent.	Excellent.	Rockfall hazard near cliffs, subsidence in some areas where solution cavities are developed. Block slides may occur along bedding planes on steep dip slopes.	Limestone could be a source of good quality aggregate and agricultural lime. Large deposits of lead and zinc with associated gold, silver and copper have been mined in the Gilman area. Gold and copper were found in the Fulford area. These deposits were found in hydrothermally altered areas.
Chaffee Formation Dc	The chaffee Formation in Eagle County consists of two members; the Dyer Dolomite and the Parting Quartzite. The Dyer member is uniformly thin bedded, very finely crystalline, dense, hard, gray dolomite. The unit thickens from the East Lake Creek area where it is 100 feet thick to the west to a thickness of 150 feet in the Fulford area and thins to the east of the Lake Creek area to a thickness of 75 to 80 feet in the Gilman area. The upper part of the Parting Member is a white medium to coarse grained quartzitic sandstone. It is ususally massive and crossbedded with conglomeratic lenses. Bedding is massive and uneven, the lower 5 to 10 feet consists of a gray shale. The Parting member thins towards the Gore Range and thickens southwestward from the East Lake Creek area where it is 75 feet to about 100 feet in thickness in the Fulford area.	Forms prominent ridges and out-crops.	Weathered surfaces of the Dyer are light-brown to light-gray.	Excavation: Difficult, blasting may be required. Compaction: Should be crushed and mixed with binder. Drilling: Difficult.	Infiltration: Negligible to slow, slow through fractured and jointed zones. Runoff: Moderate to high depending on slopes. Streams may be joint controlled. Erodibility: Low by sheet and gully wash and stream scour.	Permeability: Generally low except along joints and in fractured zones where it may be moderate. Water Table: Not known. Yield to wells: Not developed. Quality: Not known.	Septic Systems: Poor, percolation rates too low. Dump Sites: Poor, excavation difficult.	Excellent.	Good. Hazard of rockfall if bedding planes dip into steep cuts and jointing is prominent.	Rockfalls are hazard near cliffs.	Parting quartzite member could be useful as crushed aggregate. Suitable for most construction and non-construction purposes.
Harding Quartzite Oh	The formation consists of an upper unit of primarily white, medium-grained, vitreous orthoquartzites. The lower few feet consist of irregular brown, dolomitic and calcitic cemented sandstone beds with conglomeratic lenses. The beds in the upper unit are massive and occasionally cross-bedded. The beds in the lower unit are lenticular and cross-bedded. Yellowish gray-green sandstone is locally interbedded with the quartzite. The formation is 50 feet thick in the Stone Creek area but thins abruptly to the west and southeast and is not always present.	Resistant unit that forms ridges.	Weathers to a gray sandstone. Angular blocks at base of cliffs.	Excavation: Difficult, blasting may be required. Compaction: Material will have to be crushed and mixed with binder before emplacement. Vibratory compactors suggested. Drilling: Difficult.	Infiltration: Negligible in upper quartzite slight in underlying sandstone. Probably best in fractured and jointed material. Runoff: Moderate to high. Erodibility: Slight by sheet and gully wash, moderate by stream scour.	Permeability: Poor. May be fair in fractured zones and poorly cemented sandstones. Water Table: Not known. Probably varies from place to place. Yield to wells: Not developed. Quality: Not known.	Septic Systems: Poor, difficult to excavate, percolation too low. Dump Sites: Poor, excavation difficult.	Excellent. Blocks may fall into excavations.	Rocks dipping into steep cuts may fail along bedding or jointing.	Rockfall hazard near base of cliffs.	Upper unit may be good riprap material and building stone.
Manitou Dolomite Om	The formation is a thin-bedded crystalline dolomite. Bedding is usually thin and even, but massive-bedding and cross-bedding are also observed. The color ranges from dark gray to reddish-brown or purple, and streaks of yellow and green give the rock a mottled appearance. The unit is 30 to 40 feet thick in the West Lake Creek area and is reported to be up to 60 feet in the Fulford area and in the Fryingpan Creek area 103 feet are exposed. The formation is absent to the east of Lake Creek and the upper surface is an erosional contact.	Forms cliffs and ridges.	Weathers to a dark color with reddish or brown hues. Mottled surface.	Excavation: Difficult, blasting may be required. Compaction: Material would have to be crushed and mixed with binder before emplacement. Vibratory compactors suggested. Drilling: Difficult.	Infiltration: Slight in fractured and jointed areas. Runoff: Moderate to high. Erodibility: Slight by sheet and gully wash and stream scour.	Permeability: Negligible in fresh unfractured bedrock. Water Table: Not known. Yield to wells: Not developed, yield depends upon fracture porosity. Quality: Not known.	Septic Systems: Poor, percolation generally too low, hazard of polluting ground water source in fractured areas. Dump Sites: Poor; excavation difficult.	Excellent; blocks may fall into excavations.	Rocks dipping into steep cuts may fail along bedding or jointing.	Rockfall hazard near base of cliffs. Bedrock may fail along bedding and joint surfaces.	Suitable for most construction and non-construction purposes; i.e., aggregate, road fill, construction fill.
Peerless Formation €p	The composition is highly varied but, in general, is a brown, sandy dolomite, with streaks and laminae of greenish-gray or dark red dolomite. The dolomite grades laterally and vertically into dolomitic sandstone. Brown or gray shale is interbedded with the dolomite in the middle parts of the formation and becomes predominant at the top. The dolomite beds are thin and lenticular. The sandstone beds are usually more massive, and show some crossbedding. The thickness ranges from 35 to 112 feet in the Pando area, is 65 feet in Eagle Canyon, from 50 to 107 feet in the East Creek area, and 50 feet to 100 feet int he Thomsville-Woods Lake area.	Moderately resistant unit forming low rounded ridges.	Weathers to a dark - to - light reddish-brown color.	Excavation: Very difficult, drilling and blasting required.	Infiltration: Slight, may be moderate in fractured and jointed zones. Runoff: Moderate to high. Erodibility: Slight by sheet and gully wash, moderate by stream scour.	Permeability: Poor. May be fair in fractured zones and poorly cemented sandstone. Water Table: Not known. Probably varies greatly from place to place. Yield to wells: Not developed. Quality: Not known.	Septic Systems: Poor, excavation difficult, percolation rates slow. Dump Sites: Poor, excavation difficult.	Excellent. Blocks may fall into excavations.	Bedding dipping into cuts may cause failures of jointed bedrock.	Rockfall hazard near base of steep slopes. Bedrock may fail where bedding and joints dip into cuts.	Suitable for most construction and non-construction purposes.
Sawatch Quartzite €s	The Sawatch quartzite consits of three lithological units. The lower unit is a medium-grained, vitreous, white, orthoquartzite; the middle unit is alternating beds of medium-grained, dolomitic, brown sandstone and white orthoquartzite; and the upper unit is fine-grained, vitreous, white orthoquartzite; and an upper zone of fine-grained, viterous, white orthoquartzite. The quartzites are medium-bedded to massive, and show some cross-bedding. The middle zone is thin bedded; and the individual dolomitic beds are lenticular, grading into quartzite laterally. The thickness of the formation ranges from 190 to 216 feet, but on the average is about 200 feet thick.	The upper and lower zones are highly resistant and form prominent ridges across divide areas and cliffs where the beds are more gently dipping. The middle zone froms a steep slope between cliffs.	The upper and lower zones weather to angular light brown or gray cliffs or large blocks. The middle zone weathers to a dark brown steep slope.	Excavation: Very difficult, drilling and blasting required. Compaction: Rock would have to be crushed and would require mixing with binder. Drilling: Difficult.	Infiltration: Negligible through rock, slow to moderate through fractures. Runoff: Rapid to moderate. Erodibility: Very resistant.	Permeability: Slight to low, low in fractured and jointed areas. Water Table: Not known, may be present in fractured areas. Yield to wells; Not developed, probably unreliable.	Septic Systems: Unsatisfactory, excavation and burial difficult, no infiltration. Dump Sites: Unsuitable chiefly because excavation for sanitary layering difficult.	Excellent.	Rockfall hazard. Blocks may fall into cuts if bedding and jointing dip into cuts.	Rockfall hazard near edge and base of cliffs.	May be good riprap, crushed aggregate and road aggregate. Suitable for construction and non-construction purposes.
Ingeous and Metamorphic Rocks p€	The Precambrian rocks include granites, schists, gneisses and lamprophyres of the Sawatch and Gore Ranges. The rocks are fine-to coarse-grained, with interlocking granular borders. Most have a pronounced layering or foliation, are dense, hard, well jointed and locally sheared. Grain-sizes range from 1 mm to 5 mm, with coarse-grains to 10 cm locally. The different mineralogic units generally cover large areas but individual rock types may be discontinuous over short distances.	Rugged rolling hills and mountains, with numerous low rounded exposures. Underlies the glacial topography and forms the cores of the Gore and Sawatch Ranges.	Extremely resistant and is generally lichen covered, soils when present are very clayey sand indicating decomposition of the feldspars. May develop good weathered horizon in sheared zones.	Excavation: Very difficult in unweathered rock, generally requires blasting. Moderately easy to moderately difficult in weathered rock; commonly can be excavated with rippers and scrapers, locally with front end loaders. Compaction: Very difficult. Material would have to be crushed and mixed with linder before emplacement. Drilling: Very difficult.	Infiltration: Negligible into rock, moderate to slow through widely spaced fracture systems, moderate into fracture zones of faults. Runoff: Rapid to moderate. Erodibility: Generally moderately resistant, moderately erodible where weathered.	Permeability: Moderate to high near surface through fractures and weathered rock, decreases to negligible at 200 to 400 feet depth. Water Table: May be present locally, mainly in fractures and weathered rock, depth varies from place to place, depends on extent of weathering and openness and continuity of fractures. Yield to wells: Generally small to very small, perhaps 0-3 gpm; may be much greater in fracture zones and shear zones. Depends on openness and continuity of fractures. Quality: Fair to good locally moderately hard. Use: Poor to fair source for domestic and stock wells.	Septic Systems: Locally unsatisfactory as percolation too slow and material for burial lacking except where well weathered and decomposed. Risk moderate to high for pollution passing through fractures and into nearby water supplies. Dump Sites: Unsuitable chiefly because excavation for sanitary layering difficult, and material too permeable, access locally difficult; slight to moderate risk of polluting reservoirs and wells in vicinity. Sealing of fractures before use advisable.	Excellent. Caution advised within 25 feet of margin of excavation because of slope instability and rockfalls.	Mostly good, locally hazardous. Risk moderate of rockfalls and small rock slides along steep slopes. Cuts locally controlled by attutude of foliation, compositional layering and fractures. Hazardous where these are undercut. Stable highway backslopes cut nearly vertical are common.	Rockfall or rockslide hazard, avalanche hazard high above timberline.	Fair to good; possible source of aggregate and riprap. Generally satisfactory for most construction and non-construction purposes. Gold and silver deposits in quartz veins have been worked intermittenly over parts of the outcrop area.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant
CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W ROLD DIRECTOR

SURFICIAL DEPOSITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Alluvium Qal	Alluvium of streams tributary to Eagle, Colorado, and Fryingpan Rivers. Composition depends on source. Generally consists of fine-grained sandy silts and silty clays with minor gravel. Generally less than 20 feet thick. May show bedding in part but changes abruptly laterally. Deposit generally thick in the middle and thin on the edges.	Generally flat with a thin vegetative cover. The area is subject to recurrent erosion and deposition.	Composed of transported colluvium, or material weathered from bedrock. Not appreciably affected by additional weathering.	Excavation: Easy with backhoe and other power equipment, may have a local high water table. Compaction: Moderately easy, rollers and vibratory compactors suggested; if organic material constitutes more than 10 percent by volume, the material should not be used in emplaced, compacted fill as it may rebound when wet. Drilling: Easy.	Infiltration: Rapid in sandy areas. Slow in clayey areas. Runoff: Rapid when water table is at the surface. Moderately rapid during periods of high rainfall. Erodibility: Easily erodible by both gully wash and stream scour.	Permeability: Moderate. Water Table: At or near the surface. Yield to wells: Not developed, normally high during water flow in stream but is tributary. Quality: Generally highly mineralized. Use: Stock use.	Septic Systems: Very poor, hazard of polluting ground water high. Dump Sites: Very poor, hazard of polluting ground water high.	Generally good but high ground water table common.	Generally stable. May have high ground water table.	Within physiographic flood plain. May be susceptible to recurrent flooding.	Generally suitable for most construction and non-construction purposes, i.e., Suitable for layering in land fill and local source of fair road fill.
Alluvium of major Tributaries Qt_0-Qt	Boulders, gravel, sand, silt and clay, composed of sandstones, limestones, granites and gneisses in lenses throughout the main valleys. Originally deposited by meltwater from glaciers. Thickness of deposit varies with age of deposit. Older terrace deposits generally up to 200 feet. Recent alluvium up to about 40 feet. Qt_2 generally thickest.	Forms generally flat vegetated surfaced above present stream level. Usually grass covered. Qt_0 has large trees in some areas.	Top few feet may show weathered and decomposed boulders. This zone may be thicker in older terraces.	Excavation: Easy with power equipment. May encounter large boulders. Compaction: Moderately easy; vibratory compactors and smooth tired rollers commonly used; easy where large boulders are absent or removed before emplacement. Drilling: Easy to difficult; difficult where cobbles and boulders are numerous.	Infiltration: Generally moderate to rapid. Runoff: Slow where slopes are nearly level, moderately slow on slopes. Erodibility: Slight by sheet and gully wash, moderate to high by stream scour.	Permeability: Moderate to high. Water Table: Generally several feet beneath the land surface. Yield to wells: Not determined but should be excellent. Quality: Moderately hard to hard; calcium bicarbonate content high, sulfate content locally high. Use: Can be extensively used for domestic, stock and industrial purposes.	Septic Systems: Satisfactory to unsatisfactory depending upon percolation rates and level of ground water table. Higher terraces good. Dump Sites: Very poor because of ground water pollution.	Generally good below a depth of about 2 feet. Heavy structures founded on lenses of compressible organic clay may settle unevenly. Generally satisfactory for most construction and non-construction purposes.	Good, newly cut vertical slopes as much as 15 feet high commonly stand for months in gravel pits, but slump and ravel to angle of repose on wetting and drying over a period of several years of if below water table. State regulations require support on 45° angle of repose in excavations.	Qt_0 is physiographic flood plain and as such may be susceptible to recurrent flooding.	Source of good quality aggregate, crushed road metal, filter drains, etc.
Glacial Moraine Qm gravel deposit undifferentiated Qg	Boulders, gravel, sand and silt deposited by glaciers. Generally less than 100 feet in thickness; may reach 200-300 feet in thickness. Consists primarily of Precambrian granites and gneisses.	Low hummocky topography, generally vegetated, with local high water table.	Little soil mainly forest mat over the hummocky topography. Rocks in the moiaine may be decomposed.	Excavation: Difficult to easy. Large boulders may be encountered making excavation difficult. Backhoe can be used locally. Compaction: Moderately easy; vibratory compactors and smooth tired rollers commonly used; easy where large boulders are absent or removed before emplacement. Drilling: Easy to difficult; difficult where cobbles and boulders are numerous.	Infiltration: Generally moderate to rapid; may be local ponding in clay enriched areas. Runoff: Moderately slow on slopes. Erodibility: Slight by sheet and gully wash, moderate to high by stream scour.	Permeability: High. Water Table: At or near the land surface. Yield to wells: Not developed. May be a good supply but is seasonal. Quality: Varies, generally good. Use: Domestic and stock use.	Septic Systems: Satisfactory to unsatisfactory depending on percolation rates and ground water levels. Dump Sites: Poor because excavation may be difficult and hazard of pollution of ground water source is high.	Generally good below frost heave zone.	Moderate. Material is generally unconsolidated and may slide if it becomes water saturated on moderate to steep slopes. Vertical cuts may stand for several months but will ravel and slump on wetting and drying over several seasons. Angle of repose about 35°.	May have potentially unstable slopes in steeper areas and in water saturated area.	Possible local source of fair quality aggregate. May locally be good for filter drain.
Pediment Fan Qpf	High sloping bedrock benches covered by thin capping of boulders, gravel, sand and silt. The gravels are made up of sandstones, limestones, basalt, and Precambrian granites and gneisses. Deposits generally about 5 feet in thickness.	Gently to steeply sloping bedrock benches with a thin gravel capping.	Mostly weathered decomposed material deposited as the area was eroded. Generally lies on weathered bedrock.	Excavation: Easy with power equipment, locally may be somewhat more difficult because of numerous boulders near the source area of the material. Compaction: Moderately easy, vibratory compactors suggested; easy where large boulders absent or removed before emplacement. Drilling: Easy to moderately easy because of boulders.	Infiltration: Generally moderate to rapid, very rapid where clay enriched horizon absent. Runoff: Slow; water may puddle in shallow depressions underlain by clay enriched zones. Erodibility: Slight by sheet and gully wash, moderate by stream scour.	Permeability: High to moderate. Water Table: Generally several feet beneath the land surface. Yield to wells: Unit generally thin, not developed, may be best at base of unit in contact with bedrock. Quality: Varies. Use: Some domestic and stock purposes.	Septic Systems: Generally unsatisfactory as percolation too fast. Potential for pollution of adjacent water supplies. Dump Sites: Very poor because of thin deposits and possible risk of ground water pollution.	Generally good below a depth of about 2 feet. Deposit may be located on unstable bedrock. Control of drainage around foundation is critical.	Generally good but may be a thin deposit over corrosive and expansive soils. Local slides may occur near margin of deposit.	Unstable slopes near margin of deposit.	Fair source of low quality aggregate for local area.
Colluvial Wedge Qcw	Fine-grained sand and silt derived from weathered bedrock by slopewash. Usually with a high porosity. Generally does not exceed 10 feet in thickness. Generally very weak because of high void ratio.	Generally found at the base of cliffs in areas of poorly developed drainage. Gentle slopes.	Consists mostly of weathered material derived from local bedrock.	Excavation: Easy with most power equipment. Compaction: Easy; water added will collapse weak intergranular bonds making compaction easier. Drilling: Easy.	Infiltration: Generally moderately rapid to rapid. Runoff: Slow. Erodibility: Moderate to high by sheet and gully wash, high by stream scour.	Permeability: Generally high. Water Table: Generally seasonal. Yield to wells: Not developed, probably best at base of deposit. Quality: Probably highly mineralized. Use: Possibly some stock supply.	Septic systems: Satisfactory to unsatisfactory. Areas may be subject to hydrocompaction. Percolation in general is too fast. Dump Sites: Generally poor, permeability too high and hazard of polluting ground water supply.	Fair to poor; may be subject to hydrocompaction.	Will stand vertical but may be subject to hydrocompaction. Mudflows may develop from saturation along steep cuts.	Subject to hydrocompaction. May fail abruptly in open cuts.	Suitable for most construction and non-construction purposes, i.e., May be local source for material in land fill layering and fair road fill material.
Alluvial Fan Qaf older Alluvial Fan Qof Alluvial apron Qaa	Cone-shaped deposits formed where tributary streams enter into larger stream valleys. Several fans may coalesce to form alluvial aprons. Fans composed primarily of silty sand, sandy silt with intermixed sandstone, and limestone cobbles and boulders in some areas. Other debris (trees, large boulders, etc.) may be found on more active fans. Size of material generally decreases outward and downslope from the mouth of the tributary stream. Generally not greater than 50 feet in thickness.	Cone shaped deposits commonly without trees at the mouth of small tributaries.	Easily weathered, may have poorly developed soil profile. Cobbles and boulders on surface may be indurated and show wind abrasion.	Excavation: Easy with most power equipment. Compaction: Sheepsfoot rollers suggested in some areas; vibratory compactors may be needed in coarser material. Drilling: Easy to moderate because of boulders.	Infiltration: Generally rapid. Runoff: Generally low except during periods of high rainfall. High rainfall periods may trigger debris flows depositing material on the fan surface. Erodibility: Moderate by sheet and gully wash, high by stream scour.	Permeability: Moderate to high. Water Table: Will be near surface during periods of high rainfall but in general will be several feet below the surface. Yield to wells: Not known. Probably seasonal peaks. Quality: May have seasonal high silt concentration corresponding to recurrent high rainfall. Use: Stock and some domestic.	Septic Systems: Suitable to unsuitable, percolation rate locally high; hazard of polluting ground water source. Dump Sites: Poor, hazard of polluting ground water source.	Good below the depth of frost heave.	Good, should be stable at 1:1 but cuts deeper than 15 feet will ravel and may require support.	Main process in the formation of alluvial fans is alluvial. Areas may be susceptible to recurrent mudflows, debris flows, flooding and hydrocompaction. Little hazard on older fans because depositional stream cut below the surface of the deposits.	In some areas may be a good aggregate source. Most material is suitable as drainage filters.
Talus Qta	Large blocks of bedrock material deposited by sliding, falling, or rolling of material down steep slopes or cliffs. The formations that locally may form talus slopes are the Sawatch, Manitou, Harding, Chaffee, Leadville, Minturn, Maroon, State Bridge, Shinarump, Chinle, Entrada, Dakota, the limestones in the Niobrara, the sandstones in the Pierre. The edges of the lava flows that cap many of the hills and the Tertiary quartz monzonite and the Pre-Cambrian igneous and metamorphic rocks also develope large talus slopes. The deposit is generally cone-shaped and may form aprons below cliffs where many talus cones coalesce. Above about 11,000 feet talus cones may be ice cored and flow down slope. These lobate forms are termed rock glaciers. The thickness seldom exceeds 50 feet. Composed of large boulders (5 feet in diameter) to small boulders and cobbles with interstitial gravel, silt and clay.	Generally form large cones or aprons of unstable material near the base of cliffs or very steep slopes. Little vegetation. Commonly found on south facing slopes.	Weathers slowly. Large blocks generally lichen covered some blocks decompose rapidly others become case hardened.	Excavation: Generally easy with bulldozers and large power equipment. Compaction: Boulders have to be removed befor emplaced or mixed with binder if they are small. Drilling: Difficult.	Infiltration: High, coarse blocky nature of material indicates total infiltration except in finest of talus slopes. Runoff: Negligible by stream scour, gully or slope wash. Erodibility: Negligible by stream scour, gully or slope wash.	Permeability: Extremely high. Water Table: Occurs at the base of the deposit but is highly variable; generally only is present during high rainfall period. Yield to wells: Not developed. Minor springs may be developed near base of deposit. Quality: Generally good. Use: Stock use, from basal springs.	Septic Systems: Unfavorable because excavation generally too difficult and percolation too high. Dump Sites: Very poor, percolation too high, hazard to pollution of nearby ground water sources high. Excavation too difficult.	Talus slopes are in general in a metastable condition and may be overlying unstable bedrock. Foundations are marginally stable in most talus areas.	Metastable slopes that are continually adjusting.	Susceptible to rock fall hazard. Large blocks may move if undercut. Locally bedrock may have expansive and/or corrosive properties. Above 11,000 feet these may be ice cored. Small localized debris flows may occupy this area.	May be local source of riprap, road metal, and drain filters.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant
CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975

DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
JOHN W ROLD DIRECTOR

SURFICIAL DEPOSITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Landslide Deposits Qbs, Qsfc, Qds, Qac	The material may be composed of an assorted mixture of large bedrock blocks angular boulders, colluvium, gravel, sand, silt, and clay. Bedding fine to non-existent, usually distorted. All these deposits generally have definite boundaries and have failed along weak surfaces. These may be joints, bedding planes, faults, fractures, colluvium-bedrock contacts, etc. The thickness of the deposit varies from place to place. It is thinner towards the top of the slope and thicker at the toe. The thickness in some slides may exceed 100 feet at the toe. Failure has come about by a combination of physical features or characteristics that affect the stability, some of which may be gravity, slope, water saturation, etc. The units generally have low cohesion, low angles of internal shear and high moisture contents. Bedrock slides generally have flat slide planes rather than curved ones as debris slides do. Bedrock slides may have large (100 - 200 feet in largest dimension) blocks of bedrock included.	Generally forms extremely hummocky topography, distorted drainages; upper arcuate scarps are generally easily recognized; many perched-water tables and swampy areas. Vegetation may be disorientated in actively moving areas. Many of these areas have lobate fronts.	Weathers rapidly to a sandy or silty clay. In many areas material was deeply weathered before failure.	Excavation: Easy except where boulders are present. Compaction: Easy, sheepsfoot rollers recommended. Large blocks will have to be removed or throughly mixed with binder before emplacement. Drilling: Easy to moderate, moderate where boulders occur.	Infiltration: Slight to moderate, moderate through fractured areas and slide planes. Runoff: High to moderate. May be locally ponded because of poorly developed drainage net. Erodibility: Material unconsolidated. Moderate by stream scour, sheet wash and gully wash.	Permeability: Varies. Water Table: Varies, probably many perched water zones. Yield to wells: Not developed probably unreliable. Quality: Variable. Use: Possible stock and domestic supply.	Septic Systems: Generally unsatisfactory as percolation too slow and seepage through fractures and shear zones may be a hazard to nearby ground water sources. Dump sites: Fair to poor, control of surface and subsurface drainage critical. Excavation may be difficult. Hazard to pollution of ground water supplies may be moderate locally.	Generally fair to poor, control of surface and subsurface drainage critical.	Marginally stable, cuts should be avoided, control of surface and subsurface drainage critical.	Local mudflows and debris flows. Slide may be reactivated by improper construction practices. Boulders may become dislodged by improper or poorly placed excavations.	May be processed for fill.
Lake Deposits Ql Swamp Deposits Sw	Consists of interbedded organic material clays, silts, sands and fine gravel formed by the damming of a stream valley by moraines, lava flows, landslides, beaver dams, or other processes. Bedding is generally even, distinct, continuous, clays may be expansive in part. Organic material is commonly present. Thickness ranges from a few inches to more than 50 feet.	Flat areas up drainage of obstruction to the drainage.	Typically covered with vegetation, may have high ground water table.	Excavation: Generally easy with most power equipment. Compaction: Generally easy, sheepsfoot rollers suggested. Drilling: Easy.	Infiltration: Poor, much impervious clay. Runoff: Moderate. Erodibility: Negligible by sheet wash, moderate by gully wash, high by stream scour.	Permeability: Low. Water Table: At or near the surface. Yield to wells: Not developed probably poor. Quality: Questionable, depends on arnount of organic material. Use: Limited stock and wildlife from dug or eroded pits.	Septic Systems: Generally unsuitable, percolation too slow, hazard of polluting nearby water supplies. Dump Sites: Fair to poor. Impermeable zones vary in thickness. Slight to high hazard of polluting nearby water resources. Areas generally too small for major sites.	Fair to poor. Organic material may compress. Some clays may be expansive, high ground-water levels.	Cut slope will slump if material is wet.	Expansive clays in part, soils may be corrosive in part, slumping, compaction of organic material.	Lake sand and fine gravel. Excellent fill material and source of concrete sand. Maybe source of peat for agricultural purposes.
Colluvium Qc (Ti, Tv, Qv, Tnp)	Consists of 5-15 feet of brown to buff silty to clayey sand and silt, derived by weathering of underlying bedrock. May contain fragments of volcanic materials. Bedding thin, discontinuous laterally, boundaries indistinct, surfaces uneven, loose to dense. Weathered tuffaceous bedrock yields expansive clays.	Grass covered flat topped areas and gently rolling slopes.	Soil profiles weakly developed.	Excavation: Easy with most power equipment. Compaction: Easy, smooth tired and sheepsfoot rollers suggested. Drilling: Easy.	Infiltration: Moderate to high. Runoff: Low to moderate. Erodibility: Moderate by sheet or gully wash. High by stream scour.	Permeability: Moderate. Water Table: Ground water, when present, moves in thin zone near base of unit. Yield to wells: Negligible. Quality: Not known. Use: Small temporary stock supply.	Septic Systems: Suitable to unsuitable as percolation may locally be high. Dump Sites: Poor to fair. Locally deposits too thin.	Poor; thin, saturated at times and entire thickness subject to frost heave; may swell or compress unevenly under load, and change in moisture conditions.	Generally good. Material may fail on moderate to steep slopes if it becomes saturated.	Slopes may fail if saturated or oversteepened; expansive clays locally.	Possible source of topsoil and binder for compacted fills. Generally satisfactory if tested for most construction purposes.
Colluvium Qc (Kp, Kb, Kn, Kmc)	Derived from weathering of bedrock; composition depends upon composition of bedrock; silty to cobbly, locally silty clay. Unit thickness probably doesn't exceed 15 feet. May vary greatly in a short lateral distance. Beds commonly absent, when present they are discontinuous laterally, surfaces uneven to even; loose; dense; derived from shales and thin limestones and sandstones; gradational contact with bedrock. Expansive and corrosive. Includes areas of accelerated creep. Deposit thinner on steep slopes.	Hummocky, gently rolling topography.	Weathers to a light to dark gray silty clay with some small pieces of weathered bedrock.	Excavation: Easy with all power equipment. Compaction: Easy, sheepsfoot rollers suggested. Drilling: Easy.	Infiltration: Moderate in silty and sandy zones and slow in shaley zones. Runoff: Generally high may pond in shaley areas. Erodibility: Moderate by sheet and gully wash, high by stream scour.	Permeability: Varies from place to place depending upon bedrock. Water Table: Perched water tables occur in more clayey zones. Yield to wells: Not developed, probably insignificant. Quality: Probably highly mineralized. Use: Possible limited stock use.	Septic Systems: Satisfactory to unsatisfactory. Percolation rates depend on origin of material.	Generally fair to poor. Expansive and corrosive soils; may have moderate swell pressures in part. Lawn irrigation and septic systems could initiate slope instability and high swell pressures.	Slopes are potentially unstable, avoid excessive cuts, some perched water tables. Control of surface and subsurface drainage critical.	Expansive and corrosive soils locally and potentially unstable slopes if saturated.	May be processed for fill and layering in land fills.
Colluvium Qc (Ml, Om, €p)	Gray to buff calcareous silts and sands with dolomite, limestones, and sandstone fragments from less than 1 to 15 feet thick. Bedding indistinct, discontinuous laterally, fills low spots on bedrock surfaces. Derived by weathering of thick limestones and dolomite with interbedded sandstones.	Gently rolling; fills low areas on bedrock surface between areas of outcrop.	Generally develops poor to fair soil profile.	Excavation: Easy with most power equipment. Compaction: Easy, sheepsfoot and smooth tired rollers suggested. Drilling: Easy.	Infiltration: Moderate. Runoff: Low to moderate, low in fractured areas. Erodibility: Moderate by sheet and gully wash, high by stream scour.	Permeability: Moderate. Water Table: Varies from place to place and season. Yield to wells: Negligible. Quality: Probably hard. Use: Limited stock and wildlife.	Septic Systems: Generally unsatisfactory, deposits too thin, percolation rates too fast locally. Dump Sites: Generally unsatisfactory; deposit too thin locally, hazard of polluting nearby water sources.	Fair to good; generally thin.	Fair to good; may fail if oversteepened.	Oversteepened slope may fail when saturated.	Suitable for most construction and non-construction purposes; i.e., Road fill and land fill layering.
Coiluvium Qc (Je,Kd) (Oh,€s,Dc,Pw)	Silty sands to sandy silts locally may contain pebble and sandstone fragments. Deposit generally less than 20 feet in thickness. Discontinuous laterally, dense, layer boundaries indistinct, sharp contact with bedrock. Surfaces even to irregular.	Usually found on dipslopes at or near exposed bedrock. Supports conifers in most areas.	Weathers to a pure quartz or limestone sand.	Excavation: Easy with most power equipment. Compaction: Easy, vibratory compactors may be needed in gravelly areas. Drilling: Easy.	Infiltration: Moderate to high in gravelly zones. Runoff: Low to moderate. Erodibility: Low by slope and gully wash, and moderate by stream scour.	Permeability: Moderate, high in gravel and sand zones. Water Table: Near surface in downslope areas. Yield to wells: Not developed probably unreliable. Quality: Probably hard. Use: Possible stock use.	Septic Systems: Satisfactory to unsatisfactory, hazard of polluting ground water source high. Dump Sites: Hazard of polluting ground water source high.	Excellent; Sandy, stable, free draining.	Excellent; Generally thin, may fail if slopes are oversteepened and saturated.	None recognized.	Suitable for construction and non-construction purposes; i.e., fill material, free draining purposes.
Colluvium Qc (Jm)	Reddish and greenish-gray silty clay and silts. Contains expansive clay minerals in part. May contain small pieces of weathered sandstones. Generally doesn't exceed 15 feet in thickness. Gradational with bedrock. Generally discontinuous laterally. Uneven to even bedding surfaces; layering indistInct.	Gently undulating slopes.	Pink to buff colored with greenish-brown zones.	Excavation: Easy with most power equipment. Compaction: Easy sheepsfoot or smooth tired roilers recommended. Drilling: Easy.	Infiltration: Varies Greatly. Runoff: Moderate. Erodibility: Generally moderate, locally high by slope and gully wash and stream scour.	Permeability: Generally slow, locally moderate. Water Table: Varies. Yield to wells: Not developed, probably unreliable. Quality: Probably mineralized. Use: Possible stock use.	Septic Systems: Satisfactory to unsatisfactory, locally marginal; moderate hazard for ground water pollution. Dump Sites: Poor. Deposit generally too thin.	Probably good may have local high swell potential.	Cuts may fail if saturated and are greater than 1:1.	Expansive soils and in some areas rockfall hazard. Some sliding may occur on shale slopes.	Suitable for most construction purposes; i.e., road fill, layering in land fills.
Colluvium Qc (Tlc, TPm, TPPm) (TPb, TPsb)	Reddish to gray silty sands to sandy clays. May contain small unweathered pieces of sandstone, limestone, and shale. Unit does not generally exceed 15 feet in thickness. Bedding indistinct, discontinuous laterally; dense, loose to firm material derived from red shales and sandstones and pink limestone.	Generally is found between hard resistant limestones and sandstones lying on the easily eroded shales.	May have thin soil developed in local areas.	Excavation: Easy with most power equipment. Compaction: Easy, sheepsfoot or smooth tired rollers recommended. Cobbles may have to be removed or mixed with binder before emplacement. Drilling: Easy.	Infiltration: Varies, but generally moderate. Runoff: Varies but slow to moderate on steep slopes. Erodibility: Generally moderate by sheet and gully wash and stream scour.	Permeability: Slow to moderate, moderate in sandy zones. Water Table: Varies, probably near surface in downslope areas. Yield to wells: Not developed, probably unreliable. Quality: May be mineralized. Use: Possible stock use.	Septic Systems: Fair to good when thick, poor when thin. Locally percolation may be too slow. Moderate hazard of ground water pollution. Dump Site: Poor, deposit too thin and hazard of polluting ground water.	Good; Generally thin, may fail near edges of excavations.	Good; Coiluvium on dipslopes may slide if oversteepened or if colluvial surface dips into cuts.	May be susceptible to thin slides on bedrock if undercut during high moisture periods.	Suitable for most construction and non-construction purposes; i.e., road fill, layering in land filis.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant
CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975

SURFICIAL DEPOSITS

GEOLOGIC MAP UNIT & LETTER SYMBOL	DESCRIPTION & PHYSICAL CHARACTERISTICS	TOPOGRAPHIC EXPRESSION	WEATHERING & WEATHERING EFFECTS	WORKABILITY	SURFACE DRAINAGE & ERODIBILITY	GROUND WATER CHARACTERISTICS	SUITABILITY FOR WASTE DISPOSAL	FOUNDATION STABILITY	SLOPE STABILITY	RELATED GEOLOGIC HAZARDS	KNOWN, REPORTED & POSSIBLE RESOURCES
Colluvium Qc (Pe, Peg)	Buff, gypsiferous silts and clays. Many contain pieces of unweathered bedrock. Up to 15 feet in thickness. Bedding indistinct, thin, discontinuous laterally. Material derived from bedded gypsum, gypsiferous mudstone and shales.	Generally underlies smooth hummocky topography.	Easily weathered. Contains water soluble minerals.	Excavation: Easy with most power equipment. Compaction: Not recommended for compacted fills, water soluble in part. Drilling: Easy.	Infiltration: High. Runoff: Generally slow on flat slopes. Moderate on steep slopes. Erodibility: Generally moderate by sheet wash, moderate to high by stream scour.	Permeability: Moderate to high. Water Table: Varies, may be controlled by fractures in some areas. Yield to wells: Not developed mostly seasonal. Quality: Highly mineralized. Use: Possible limited stock use.	Septic Systems: Unsatisfactory, deposits generally too thin, water soluble in part, may increase subsidence in local areas. Dump Sites: Poor. Water soluble. Permeability too high. Hazard of polluting ground water source in downslope areas.	Marginally stable, highly corrosive, control of surface and subsurface drainage critical.	Failures common. Cuts over 10 feet should be avoided. Bedding dipping into cuts, may fail.	Highly corrosive soils. Failures are common in many areas.	Suitable for some light construction and non-construction purposes.
Colluvium Qc (pЄ, Tqm)	Gray to buff, clayey to silty sand composed of mineral grains of feldspar, quartz and mica and small rock fragments, layering indistinct, discontinuous, non-expansive clays. Occurs in irregularly shaped pockets on bedrock; ranges from less than an inch to 10 feet in thickness in most areas, may be thicker along fractured zones in bedrock.	Thickly timbered to barren bedrock slopes above treeline.	Poor soil profile may be developed.	Excavation: Easy with most power equipment. Compaction: Easy, unit generally thin, smooth tired or sheepsfoot rollers suggested. Drilling: Easy.	Infiltration: Moderate. Runoff: Moderate to high. Erodibility: Moderate by sheet and gully wash, high by stream scour.	Permeability: Moderate. Water Table: Generally found near base of deposit except during period of spring runoff. Varies depending upon location of deposit and time of year. Yield to wells: Negligible, not developed. Springs on slopes at contact of colluvium and bedrock. Quality: Good. Use: Springs used by stock and wildlife--some springs developed by dug wells.	Septic Systems: Unsuitable; too thin, percolation generally too slow. Dump Sites: Fair, percolation may be too fast locally, generally too thin.	Fair to good; may fail on oversteepened slopes.	Generally good, will stand at 1:1, may fail on steep slopes or where saturated.	Small local slope failures of steep slopes or where water table close to surface.	Suitable for most construction and non-construction purposes, i.e., roadfill, layering in land fills, construction fills.

Adapted from H.E. Simpson, M.E. Gardner and S.S. Hart, 1971

TABLE OF ENGINEERING GEOLOGIC FACTORS FOR LAND USE

COMPILED BY William A. Gallant
CHARLES S. ROBINSON & ASSOCIATES, INC.
GOLDEN, COLORADO 1975