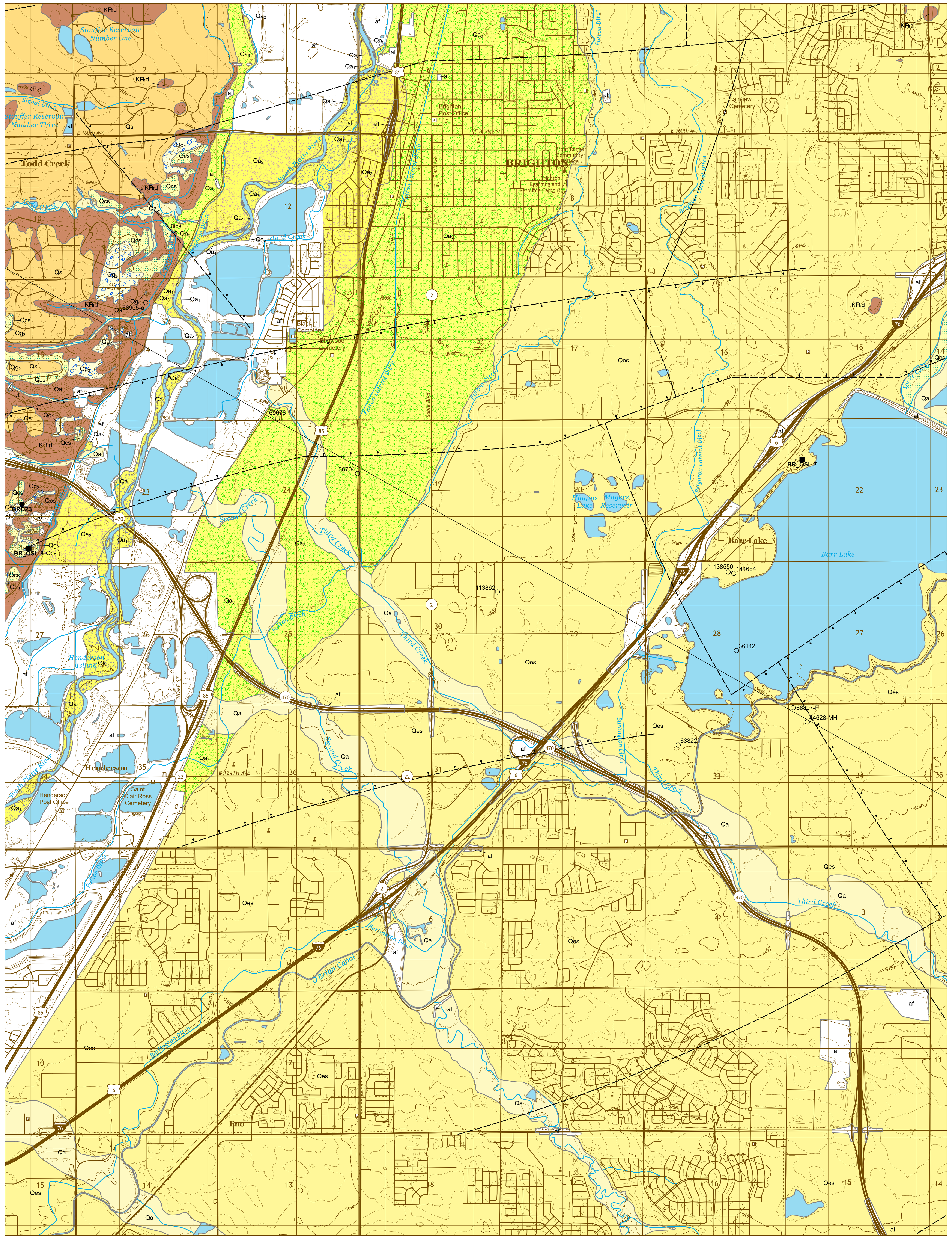
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES
GOLDEN, COLORADO

GEOLOGIC MAP OF THE BRIGHTON QUADRANGLE, ADAMS COUNTY, COLORADO
OPEN-FILE REPORT 22-02
PLATE 1 OF 2
DOI: https://doi.org/10.58783/cgs.of2202.dnna2821



R67W R66W

SCALE 1:24,000

CONTOUR INTERVAL 10 FEET

Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983

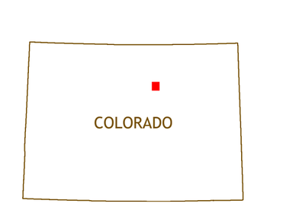
Roads............U.S.Census Bureau, 2016
Names............GNIS, 1978-2018
Hydrography............National Hydrography Dataset, 2004
Contours............National Elevation Dataset, 2015
Boundaries.....multiple sources; see metadata file, 2017-2018
Public Land Survey System............BLM, 2018

This mapping project was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey through the National Cooperative Geologic Mapping Program under STATEMAP agreement G21AC10708-00.

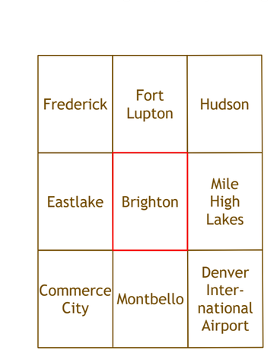
GEOLOGIC MAP OF THE BRIGHTON QUADRANGLE, ADAMS COUNTY, COLORADO

By Matthew L. Morgan, Michael K. O'Keeffe, and Alexander E. Marr

2022



QUADRANGLE LOCATION



ADJOINING QUADRANGLES

Geology mapped in 2021
GIS and cartography by Pangaea Geospatial

DESCRIPTION OF MAP UNITS

A summary of geologic hazards, mineral resources, and groundwater resources within the quadrangle is provided on Plate 2. Geologic time subdivisions follow the International Chronostratigraphic Chart (International Union of Geological Sciences, 2022). Refer to the Udden-Wentworth grain-size scale for particle sizes. Descriptions of carbonate soil development and colors are based on Machette (1985) and the Munsell soil color chart (Munsell Color, 1991), respectively.

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af

Artificial fill (Uppermost Holocene) — Riprap, engineered soil, and refuse used in the construction of buildings, dams, ditches, golf courses, landfills, parks, railroads, roads, and other infrastructure projects. Surficial materials generally consist of unsorted clay, sand, silt, gravel, and rock fragments emplaced and (or) regraded for construction or drainage purposes. The average thickness of the unit is less than 6 m. Artificial fill may be subject to settlement, slumping, and erosion if not adequately compacted and protected by riprap in areas adjacent to streams and waterbodies such as reservoirs. Includes waste rock, sediment, and fill materials where sand and gravel pit operations removed much of the natural deposit. Sand and gravel deposits were extensively mined and reclaimed along terraces and within the South Platte River floodplain. Several pits have been reclaimed with fill and (or) converted into ponds, lakes, and parks. In these areas, the thickness of the unit may be greater than 3 m.

ALLUVIAL DEPOSITS

Qa

Alluvium, undivided (Holocene to Upper Pleistocene) — Unit Qa includes deposits within the active channels and floodplains of several tributaries to the South Platte River, Speer Canal, and Bebee Draw which drains Barr Lake to the east. This unit occurs along Todd Creek and unnamed tributaries draining into the South Platte River from the west and deposits associated with First, Second, and Third creeks draining into the South Platte River from the east. Differentiation of this alluvial unit into units Qa_1 and Qa_2 was not possible due to poor exposure. Unit Qa was subsequently removed by erosion within the South Platte River valley and underlies terrace remnants on both sides of the river ~6 m to 12 m above the modern channel (De Voto, 1968). As described by Schwochow (1972), deposits west of the South Platte River are brown to grayish-brown, fine to coarse grained, silty sand and pebbly gravel with a weak to moderately developed soil profile. The soil profile consists of a moderately developed A horizon, typically 15 cm thick, and an underlying 25 cm-thick C-horizon. Total unit thickness ranges from ~0.5 m to 2 m within the South Platte River valley (Schwochow, 1972). De Voto (1968) indicates that the lithology of deposits in the eastern drainages (e.g., First, Second, and Third creeks; referred to as the "Piney Creek Alluvium") vary between valleys, are well stratified, and consist of up to ~2.4 m of dark-gray, humic silt, clay, sand, and pebbly sand. Unit Qa is not a potential source of aggregate and is prone to flooding during intense or protracted rainstorm events. The distribution of unit Qa along the eastern drainages was estimated using lidar imagery due to the lack of exposure and subsurface information (e.g., drill logs) in this area.

Qa_1

Alluvium one (Upper Holocene) — Unit Qa_1 occupies the active channel of the South Platte River and underlies terraces that are less than 1 m above stream level. Point bars in the active South Platte River channel consist of lag deposits with gray (10YR 6/1), poorly sorted, loose, coarse to very coarse sand and gravel at the surface. Clasts are subangular to rounded and, in areas, granule- to cobble-sized (up to ~25 cm and average ~7 cm in diameter); gravel composes ~60% of the surfaces of gravel bars. Beneath the lag deposit, the sand and gravel deposits are loose, gray (10YR 6/1), poorly sorted, coarse to very coarse sand and granule- to cobble-sized gravel, with less cobbles and more pebbles than exposed on the surface of the deposit. Unit contains thin (< 5 cm) interbedded gray (2.5YR 5/1) clayey lenses locally. Clasts are subangular to subround. The proportions of sand and gravel vary. In test pits along the South Platte River, ~60% to 70% sand and ~30% to 40% gravel occurs to a depth of ~0.5 m. Sand composition is dominantly quartz; feldspar, which commonly gives the sand a pinkish hue; and opaque minerals. Sand composition is typically ~60% to 70% quartz with ~20% to 30% feldspar and ~5% to 15% opaque minerals. Gravel deposits typically contain abundant granitic and metamorphic (e.g., schist, gneiss, quartzite) clasts with less volcanic and rare sedimentary rock clasts. Gravel consisting of vein quartz is also common. This unit may be a limited source of aggregate and (or) fill material and is prone to flooding and bank collapse during major rainfall events.

Qa_2

Alluvium two (Holocene to Upper Pleistocene) — Pale-brown (10YR 6/3) to light brownish-gray (2.5Y 6/2), laminated (< 1 cm thick), humic, loose, micaceous, very fine- to fine-grained sand and silt with trace clay. The base of the unit locally contains gravel (loose, sandy with pebbles and cobbles). Unit Qa_2 occupies most of the floodplain of the South Platte River and has been disturbed by mining, reclamation, and urban and agricultural development. Unit occurs ~2 m to 2.5 m above the present river level and is ~0.5 m to 3 m thick (Schwochow, 1972; Post-Piney Creek Alluvium).

The unit is likely correlative with the Piney Creek Alluvium in the Denver area as described by Hunt (1954) by virtue of height above stream level, soil profile characteristics, physical properties, and radiometric dates. Hunt (1954) reported a radiocarbon age of 1,110 ± 70 14C years before present (yr BP) on the basis of carbon-14 dates (14C) from organic-rich sediment near the top of the Piney Creek Alluvium at its type locality. This age is in accord with two bulk 14C ages of 1,360 and 1,380 ± 30 14C yr BP (Beta Analytic) reported by Keller and others (2019) within unit Qa_2 immediately above the contact with the underlying Qa_3 in the Gowanda quadrangle. Berry and others (2015) reported calibrated (cal) 14C ages of 11.90 ± 0.28 cal thousands of years (ka) BP and 11.95 ± 0.24 cal ka BP from a sample collected near the base of the Piney Creek Alluvium in the Masters quadrangle near Fort Morgan, CO (R.F. Madole, written commun., 2016). Hunt's age assignment for his Piney Creek Alluvium at its type locality along Piney Creek was based on archeological data including the presence of Plains Woodland artifacts; the site he radiometrically dated and ultimately assigned an age to the Piney Creek Alluvium was based on the 14C age of charcoal at a Plains Woodland site >32 km to the north-northwest of its type locality. These ages only indicate that Piney Creek Alluvium was deposited prior to the time that Plains Woodland people occupied these two localities. This unit is not a source of aggregate and is typically treated as overburden during quarrying. Unit Qa_2 is subject to occasional flooding and bank collapse during major rainfall events.

Qa_3

Alluvium three (Upper Pleistocene) — No undisturbed exposures of unit Qa_3 were observed on the Brighton quadrangle. The following description is from an exposure within the Albert Frei and Sons Hatchery quarry located approximately 2.8 km to the southwest of the Brighton quadrangle at the northwest corner of the intersection of Brighton Road and E. 88th Avenue (9001 Monaco Street). The exposure was along the eastern portion of the pit ~10 m west of the western edge of Monaco Street. This unit has been referred to as the Broadway Alluvium in previous publications (see Trimble and Machette, 1979; Kellogg and others, 2008).

At the Hatchery quarry, unit Qa_3 is ~3 m thick and includes interbedded sand, gravel, and sandy silt or silty sand as described below. The deposit consists of light-tan (10YR 8/2) to grayish-tan (10YR 7/1), poorly sorted, fine to very coarse sand and gravel with interbedded, low angle, cross-bedded sand beds. Clasts are subround to subangular and consist dominantly of pebbles with cobbles up to 8 cm in diameter. Sand composition is predominantly composed of granitic detritus and contains abundant quartz, pink and white feldspar, opaque minerals, and muscovite. Gravel clasts are chiefly granitic and metamorphic with some volcanic, sedimentary, vein quartz, and minor amounts of other rock types. In exposures, undulatory soft-sediment deformation was observed. Reddish-brown iron oxides occur in two ~15 cm zones and two calcic soil horizons occur near the top and bottom of the deposit. Bk soil horizons (Stage I-II) occur at ~3.4 m and 2.8 m below ground surface. A ~1 m to 1.5 m thick, light-tan (10YR 7/6) sandy silt or silty sand layer occurs at the bottom of the sand and gravel layers that contains 40% to 50% silt in places, very fine to trace coarse sand (dominantly very fine sand), trace clay, mica, with trace subround to subangular pebbles.

Optically stimulated luminescence and thermal-transfer OSL (TT-OSL) samples BR-OSL-1, BR-OSL-2, BR-OSL-3, and BR-OSL-4 were collected from alluvium on the east wall of the Hatchery quarry over a ~1.5 m interval, from 2.75 m to 14.30 m below ground surface. The samples range in age from 13,465 ± 550 single aliquot regenerative (SAR)-OSL yrs to >179,100 SAR-OSL yrs and span Marine Isotope Stage (MIS) 1 through 6 (Table 1, Plate 2). Sample BR-OSL-6 was obtained from alluvium ~1.2 m above the contact with the underlying Denver Formation (~10 m below ground surface) within the Martin Marietta Riverbend pit (located ~4 km north of the northern Brighton quadrangle boundary at 12979 E Crown Prince Blvd., Brighton, CO) and yielded an age estimate of 18,555 ± 1,225 SAR-OSL yrs (MIS 2).

Unit Qa_3 is a source of aggregate and has been mined extensively in the Brighton quadrangle. Geotechnical borings that penetrate unit Qa_3 near the intersection of 120th Avenue and Highway 85, east of the South Platte River and in the Brighton quadrangle, indicate that the thickness of Qa_3 and older underlying sands and gravels are ~8.5 m to 12 m thick, with a layer of sandy clay observed at a depth between ~3 m and 4 m, deposited on Denver Formation (Fox and Associates, 1974). Within the Brighton city limits, at the intersection of North 5th Avenue and Walnut Street, borings indicate that Qa_3 and underlying sand and gravel are at least 12 m thick (Kumar and Associates, 1997). Currently, Qa_3 is mined to the north and south of the Brighton quadrangle.

Qg_2

Gravel deposit two (Middle Pleistocene) — Yellowish-brown (10YR 5/4) to light-gray (10YR 7/2), poorly sorted, very fine to very coarse (dominantly coarse) sand and gravel with trace silt. Sand is subangular to subround and is composed dominantly of quartz, feldspar, and opaque minerals. Gravel content ranges between ~30% and 50% and includes subround to subangular granules and cobbles up to 25 cm in diameter. The composition of clasts based on the identification of one hundred clasts is: granitic (40%), quartzite (28%), vein quartz (11%), gneiss (6%), volcanic (5%), metamorphic (5%), sedimentary (2%), iron-oxide concretions (2%), and chert (1%). The deposit also contains abundant clasts of petrified wood likely derived from the underlying Denver Formation or reworked from older alluvium in the region. The unit contains a weakly to moderately developed Bk horizon (Stage II-II+ carbonate development (Birkeland, 1999; Machette, 1985)) from the ground surface to ~0.7 m depth and contains cobbles and gravel completely coated with calcium carbonate rinds up to 2 mm thick on the clast bottoms. Gravel clasts below this horizon have < 1 mm-thick calcium carbonate rinds on the bottom of the clasts. Sample BR-OSL-8 was collected from this unit within a sandy layer below the surface calcic soil horizon at a depth of ~66 cm and yielded a minimum age estimate of >96,700 SAR-OSL yrs (MIS 5). This unit is not a source of aggregate but may be a local source of fill material.

This unit is the oldest identified surficial deposit in the quadrangle and caps the hills west of the South Platte River valley where it overlies the Denver Formation. Schwochow (1972, page 31) reports that over 5 m of this alluvium (his Verdos Alluvium) is exposed at Barr Lake. Other authors (Turner, 1973; Trimble and Machette, 1979) report the occurrence at Barr Lake; however, Qg_2 was not observed near Barr Lake during this investigation. Unit Qg_2 (and perhaps other Pleistocene gravels) may be present within the South Platte River paleovalley that is depicted in the southeastern part of cross-section A-A' (Plate 2).

A diagnostic feature of this unit (referred to as the Verdos Alluvium in Schwochow (1972); Trimble and Machette (1985); Kellogg and others (2008)) is the local presence of a volcanic ash bed correlated with the Lava Creek B tephra, erupted from the Yellowstone Plateau volcanic field at ~631 ka (Matthews and others, 2015). The ash was observed at the base of the unit by Schwochow (1972) within the Brighton quadrangle at Barr Lake (he provides no details on its diagnostic features). This volcanic ash bed was not observed during this investigation and in surrounding quadrangles as reported by Turner (1973, page 9). At its type location in the Littleton quadrangle (Scott, 1962), the Verdos Alluvium is deposited upon the Lava Creek B ash (previously known as the "Pearlette" ash). Samples of the basal ash at the Verdos Alluvium type section were obtained by CGS geologists in 2018 and subsequently dated at 641.9 ka +/- 28 ka using the 40Ar/39Ar method (D. Miggins, written commun., 2018, Oregon State University); at this location, the pediment gravel post-dates the deposition of the ash and therefore must be younger than 641 ka.

Kellogg and others (2008) considered the age of older deposits of the Verdos Alluvium to be about 610 to 675 ka. Their age estimate was based upon the presence of the Lava Creek B tephra at the base, within, and at the top of the alluvium. Kellogg and others (2008) estimate the age of younger Verdos Alluvium deposits as 410 to 475 ka. Riihimaki and others (2006) estimate Verdos Alluvium age as several hundred thousand years. Berry and others (2019) documented the presence of the ash in Verdos Alluvium at sites along the South Platte River northeast of Fort Morgan; although at many sites the ash is probably reworked.

Qg

Gravels of the South Platte River paleovalley (Pleistocene?) — Shown only on cross section A-A' (Plate 2). Gravel deposits within a paleovalley of the former South Platte River. Maximum thickness of 17 m on the basis of water-well driller's logs.

EOLIAN DEPOSITS

Qes

Eolian sand (Holocene) — Light-tan (7.5YR 5/3 to 7.5YR 7/3), loose to semi-compacted, massive, well to moderately sorted, very fine to medium grained sand with trace coarse to very coarse sand, silt, and clay observed mostly east of the South Platte River. Unit Qes covers over one-half of the quadrangle and consists of silty sand with some deposits containing > 20% silt. Sand is subround to subangular, weakly cemented with calcium carbonate locally, and is composed dominantly of quartz with varying percentages of feldspar, opaque minerals, and mica. Unit Qes may grade horizontally into deposits of sandy silt, silty sand, and clayey sand. In some exposures, a 0.2-m-thick zone of secondary calcium carbonate (possible Bk soil horizons) occurs within silt-rich deposits. As reported by Turner (1973, page 12), there are at least two facies within this unit. The upper facies is composed primarily of sand-sized grains and low amplitude, longitudinal and parabolic dune forms indicating wind transport from the northwest. The lower facies is predominantly silty loess with weak to no internal structure. A TT-OSL sample, BR-OSL-7, was collected from an artificial exposure of very fine to medium sand within a mottled zone of calcium carbonate at a depth of 1.8 m below ground surface. The sample yielded a minimum age estimate of >76,400 SAR-OSL yrs (MIS 4).

Several building excavations located in the south, east, and northeastern portions of the quadrangle contained thin (1-2 m) deposits of interbedded silty sand and sandy silt with secondary calcium carbonate zones (possible Bk soil horizons) overlying eroded Denver Formation. Geotechnical borings from the southeastern corner of the quadrangle contained silty sand and clayey sand to depths up to ~6 m (Kumar and Associates, 2008). Additional geotechnical borings near the intersection of 120th Avenue and Highway 85, east of the South Platte River, reported as much as ~3 m of sand (clayey and silty) locally (Fox and Associates, 1974). Turner (1973, page 12) indicates that these deposits rarely exceed ~10.5 m in thickness. Locally, such as near the southwest corner of Buckley Road and East 128 Avenue and adjacent to Barr Lake, unit Qes may be absent. At the location stated above, one geotechnical boring records thin (~0.3 m) sandy clay underlain by up to 6 m of clay, which may indicate the presence of shallow eroded Denver Formation (High Plains Engineering, 2004). The unit may be a source of borrow material and may be prone to hydrocompaction and erosion.

Qs

Eolian sediment (Holocene) — Light grayish-brown (10YR 5/2), very fine to medium silty sand with trace medium to coarse sand, pebbles, and clay. Sand grains are subangular to rounded and composed dominantly of quartz with varying content of feldspar and mica. Schwochow (1972) reports that the silt and clay content can vary from 13% to 65% based on sieve analysis. Dune features were not observed on this deposit and there are significant amounts of silt and clay in this unit locally. The unit is ~1-3 m thick as reported by Turner (1973). When wet, unit Qs may expand and adversely impact existing and future buildings and infrastructure.

MASS-WASTING DEPOSITS

Qcs

Colluvium and sheetwash deposits, undivided (Holocene to Upper Pleistocene) — Occurs on the slopes of hills west of the South Platte River. Unit consists of a heterogeneous mixture of sand and gravel eroded from unit Qg_2 as well as fragments of claystone and sandstone fragments eroded from the Denver Formation. Unit consists of loose, poorly sorted, fine to very coarse, subangular to subround sand, and granule- to cobble-sized gravel, all likely derived from unit Qg_2 deposits and Denver Formation bedrock. Gravel is subangular to subround. Sand and gravel clast composition is similar to Qg_2 deposits. Unit is clayey locally where claystone from the Denver Formation has been eroded and transported downslope. Unit contains reddish-brown iron oxide-stained sandstone fragments. Gravel typically has discontinuous calcium carbonate rinds up to 2 mm thick. Maximum thickness is ~1 m to 2 m. Unit Qcs locally may contain landslide deposits of limited extent (beyond map scale) that were identified from hillshaded lidar imagery. Some of these landslides were mapped by previous authors but due to difficulties with property access, these deposits were not verified in the field and are not shown separately on the map. Turner (1973) mapped and described a few landslides along the eastern bluffs on the western side of the South Platte River in the Brighton quadrangle. As reported by Turner (1973, page 13), "The failure surfaces are located within poorly indurated bedrock. Those observed were of the rotational type and were generally slope circle failures with one probable toe circle type failure. In all cases failure can be ascribed to excessive saturation of the bedrock." It is unknown if these landslides are still active and some appear to have been graded over by earth-moving equipment. Any building activities associated with this area, especially within the hills and along the bluffs to the west of the South Platte River, should include an assessment of potential geological hazards especially with regards to landslides associated with the Denver Formation and any overlying younger map units (also see the description for the KPd).

BEDROCK GEOLOGY

KPd

Denver Formation (Paleocene to Upper Cretaceous) — Olive-gray (5Y 4/1) and brownish-gray (5Y 6/2) claystone, siltstone, and light-brown (10YR 7/6 to 10YR 8/4) to yellowish-brown (2.5Y 8/4) interbedded sandstone. Claystone is blocky when dry, sandy locally, and typically has brown iron-oxide coatings on fractures and abundant secondary, 1- to 3-mm-wide gypsum and calcite veins. Gypsum typically occurs as 1 mm to 3 mm diameter milky white subhedral crystals in 5- to 6-cm-wide clusters along veinlets. Traces of dark-grey to black organic material also occur on some fracture planes near the ground surface. Sandstone is weakly to moderately indurated, thinly laminated (< 1 mm) locally, and fine to very fine grained, trace silt and clay, with ~60% to 80% quartz, feldspar, and trace mica. Locally, sandstone is extensively eroded and has orange-brown iron-oxide staining coating grains and on fracture surfaces; calcite veinlets (1 mm to 2 mm wide) occur locally. Dinosaur bones indicating a Late Cretaceous age were collected from within the Denver Formation (Schwochow, 1972) less than ~1.5 km from the western quadrangle boundary. Two detrital zircon samples were collected while mapping the Brighton quadrangle (Table 1, Plate 2). Analysis of the zircon ages from sample BRDZ1, collected from an exposure of blackish-gray sandstone within the Hatchery quarry (see unit Qa3 description for quarry location), yielded a youngest population age of 67.1 ± 1.4 Ma (n=31; Mean Squared Weighted Deviate (MSWD) = 0.91; youngest single grain of 60.2 ± 4.1 Ma). This weakly indurated sandstone consists of approximately 39% angular to subround quartz, 32% chlorite or possibly ferrocarpholite, and 15% feldspar (dominantly potassium feldspar) with minor amounts of calcite (9%) and biotite (2%) based on thin section analysis. Sample BRDZ3 was collected in the northwestern quadrant of the quadrangle from an outcrop of yellowish-brown, very fine- to fine-grained arenitic sandstone and yielded a youngest age population of 76.4 ± 1.7 Ma (n=9; MSWD=0.75; youngest single grain of 72.8 ± 2.7 Ma). The uncertainties of maximum depositional ages associated with the detrital zircon ages are reported at 95% confidence. Obradovich (2002) reported a date of 65.7 +/- 0.4 Ma from sanidine grains in a volcanic ash interbedded within Denver Formation (D1 sequence of Raynolds (2002)) lignite beds at Denver International Airport located ~18 km to the southwest of the eastern Brighton quadrangle boundary. Sharman and others (2018) reported detrital zircon ages for Denver Formation (D1 sequence of Raynolds (2002)) samples collected from the Castle Pines core, ~150 km south of the Brighton quadrangle, that ranged from 66.8 to 72.6 (error varies, see Table 2 in Sharman and others (2018)) Ma for the youngest single grains.

Denver Formation is exposed along the western bluffs of the South Platte River and in the northeast portion of the quadrangle. Exposures of the Denver Formation were also observed in most residential building excavations throughout the quadrangle where it is typically overlain by eolian sand or sandy silt and (or) a soil horizon. The paleosurface of the Denver Formation is typically undulatory and the rocks are weathered with abundant fractures and iron oxide stains locally. The overlying soil horizons typically consist of a ~0.3-m-thick A horizon and a ~2-m-thick Bk horizon (Stage II-II+) with calcium carbonate nodules, filaments, and clast coatings. In an excavation located in the northwest corner of the quadrangle, an eroded 0.6-m-thick sandstone bed fills a paleochannel in the underlying claystone and is overlain by lenses of matrix-supported paleodebris-flow deposits (of probable Cretaceous age) containing subround to angular 17- to 20-cm-diameter clasts of sandstone, quartzite, and igneous rocks. Thin (~0.3 m) conglomeratic beds were also observed locally and contained up to ~8 cm subround clasts of igneous rocks, quartzite, and weathered sandstone. One exposure of Denver Formation within a ditch in the northeast corner of the quadrangle consists of brownish-gray (10YR 8/1), weakly to moderately indurated, calcite-cemented, medium- to fine-grained sandstone with subround to subangular grains, trace very coarse sand, ~60 to 65% quartz, ~25 to 35% feldspar and opaque minerals, and pebbles up to 12 mm. Exposed thickness of the Denver Formation within the quadrangle is approximately 40 m and estimated total thickness is ~305 m in the Brighton quadrangle (Dechesne and others, 2011).

The Denver Formation may locally contain swelling and expansive claystone, which could adversely impact building foundations and infrastructure. Soils derived from the Denver Formation are also prone to shrink/swell. The bluffs to the west of the South Platte River locally contain slope-failure surfaces and landslide deposits within the Denver Formation which may adversely impact past and future building and infrastructure development (Turner, 1973). (Also see the description for unit Qcs).

KPda

Denver Formation (Paleocene and Upper Cretaceous) and Arapahoe Conglomerate (Upper Cretaceous), undivided — Shown only on cross section A-A' (Plate 2). The unit is exposed in the nearby Lafayette quadrangle (Machette, 1977). Within that quadrangle, it is described as olive-gray to bluish-gray claystone and siltstone and light-gray to light orange-brown sandstone and granule conglomerate. Conglomerate is composed of claystone fragments and (or) sedimentary and igneous rock fragments. Sandstone is predominantly quartz, feldspar, and mica. May contain local subbituminous coal beds. Crossbedding and cut-and-fill channels are visible in excavated exposures. Thickness is ~120 m in the Lafayette quadrangle.

The Arapahoe Conglomerate consists of coarse-grained alluvial fan and fluvial deposits and is considered to be composed of sediments derived from the erosional unroofing of the Front Range during the Late Cretaceous.

Kl

Laramie Formation (Upper Cretaceous) — Shown only on cross section A-A' (Plate 2). Typically light-gray to yellow-gray sandstone with interbedded beds of claystone and siltstone. Coal beds are common in the unit. Unit conformably overlies Fox Hills Sandstone (Upper Cretaceous) and unconformably underlies Arapahoe Conglomerate (Upper Cretaceous). Thickness in the Brighton quadrangle is approximately 110 to 138 m based on oil and gas well logs (Dechesne and others, 2011; plate 10).

MAP SYMBOLS

Contact — Approximately located

High-angle vertical displacement fault of Weimer (1996) — Existence certain, location concealed, ball and bar on downthrown side

High-angle vertical displacement fault of Weimer (1996) — Existence certain, location concealed, relative motion unknown

113682 **Water well** (Division of Water Resources permit number shown on map and cross section)

BR_OSL-7 **Optically Stimulated Luminescence sample**

BRDZ3 **Detrital zircon sample**

A — A' **Alignment of cross section**

High-angle vertical displacement fault of Weimer (1996) — Existence certain, location concealed (shown on cross section only)

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