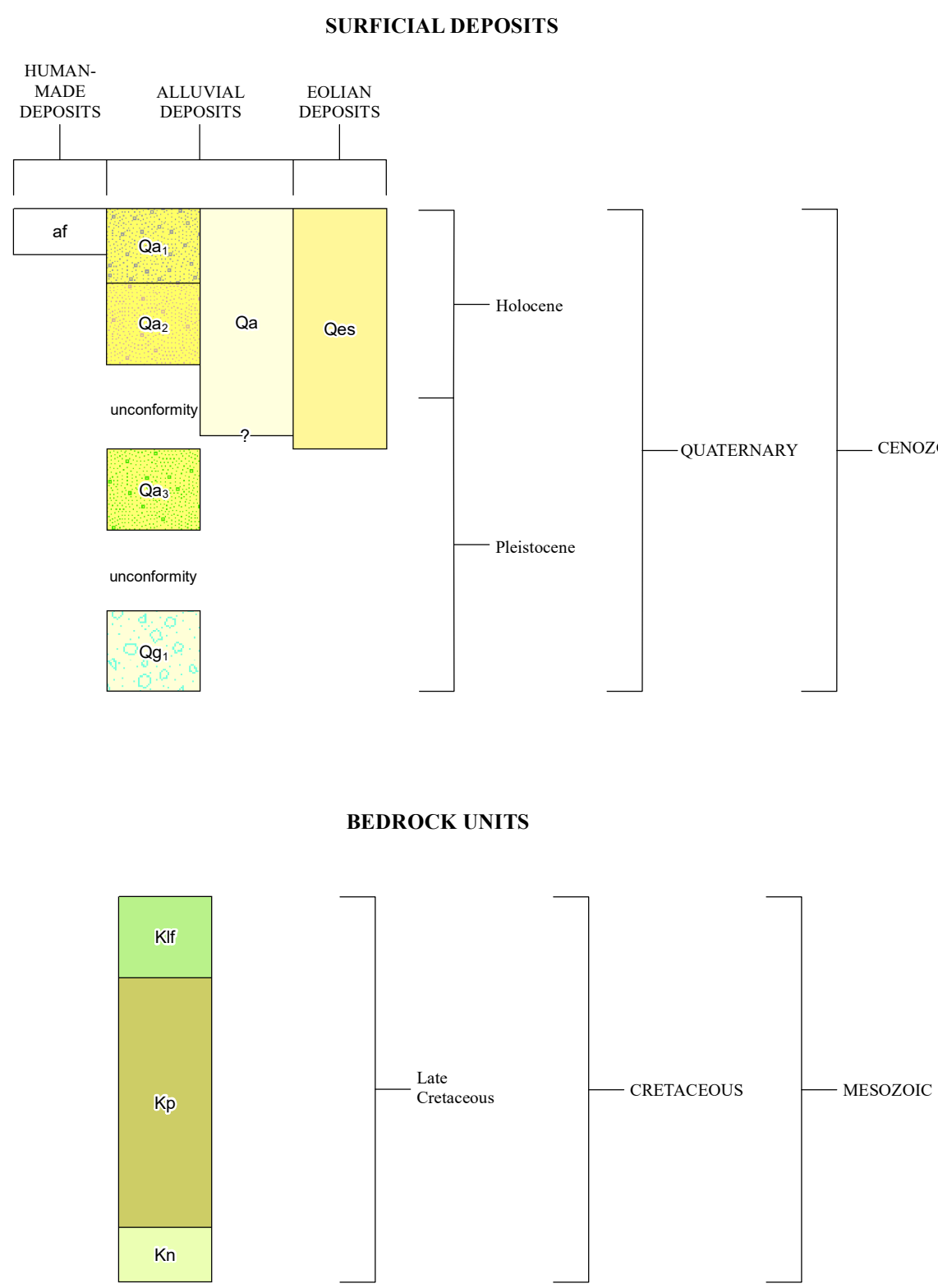
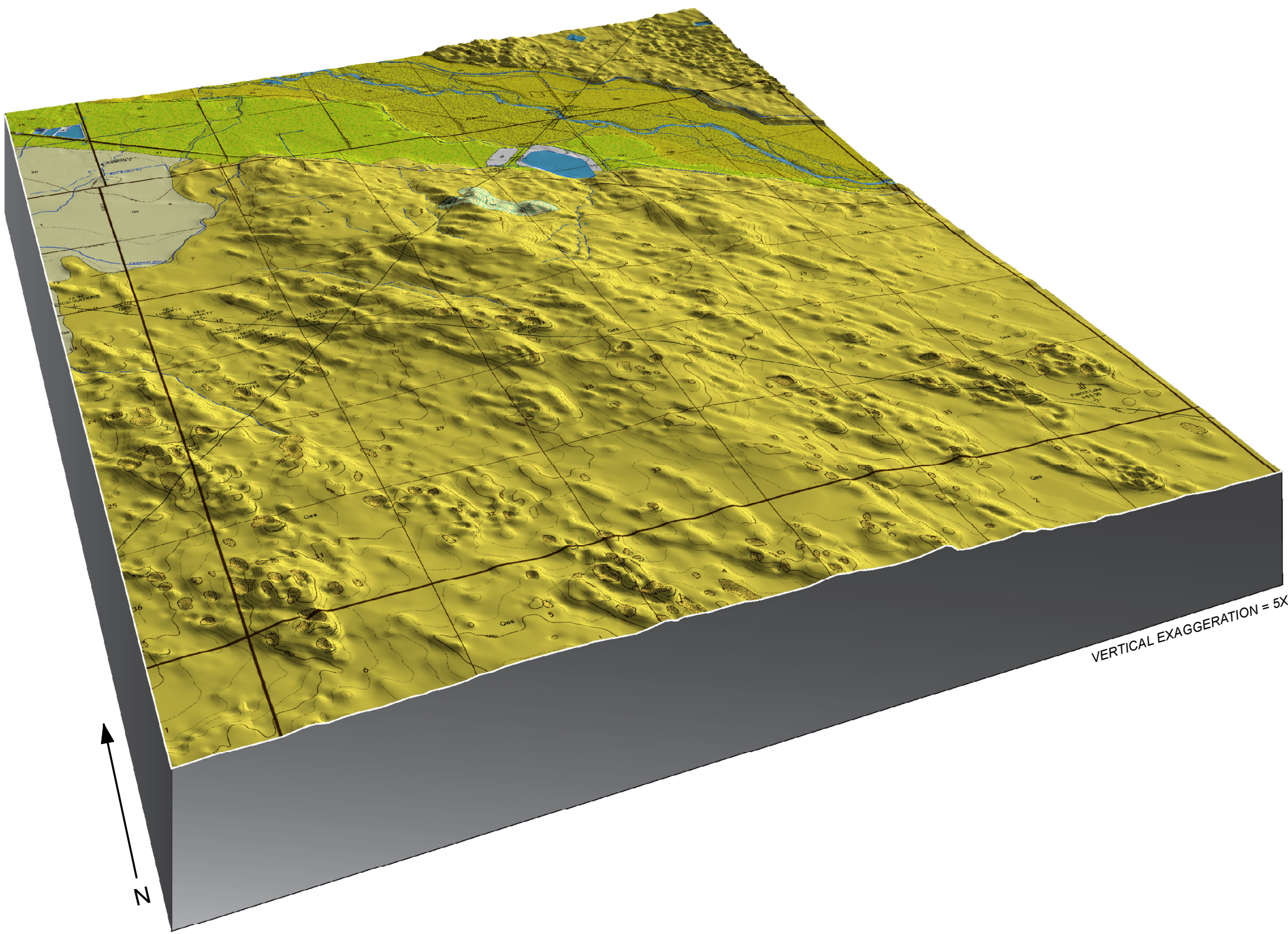


CORRELATION OF MAP UNITS



3-D OBLIQUE



GEOLOGIC HISTORY, GROUNDWATER RESOURCES, AND MINERAL RESOURCES

The Hardin quadrangle lies in northeastern Colorado, approximately 76 km northeast of metropolitan Denver and approximately 22 km southeast of Greeley. The quadrangle is located within the Colorado Piedmont section of the Great Plains physiographic province, an area in eastern Colorado where Neogene rocks were removed by erosion. The Colorado Piedmont is bounded by the Front Range foothills to the west, the High Plains to the east and north, and the Raton Basin to the south (Fenneman, 1931; Madole, 1991; Leonard, 2002; Smith and others, 2016). Two regionally extensive unconformities may define the onset of Piedmont deformation and uplift in eastern Colorado: a late Eocene unconformity concurrent with the end of the Laramide orogeny, and an early Miocene unconformity that separates the Ogallala Formation from older strata below (Epis and Chapin, 1975; Leonard, 2002). In eastern Colorado, Late Cretaceous (100-66 Ma) marine sediments were deposited during transpressive and regressive episodes of the Western Interior Seaway (WIS), a large epicritic sea that existed during the Late Cretaceous. The beginning of the Laramide orogeny at ~70 Ma (Weimer, 1996) is roughly contemporaneous with the final regression of the WIS in eastern Colorado. This final regressive pulse of the WIS is responsible for the deposition of the Niobrara Formation, Pierre Shale, Fox Hills Sandstone, and Laramie Formation. These bedrock units commonly underlie unconsolidated sedimentary material east of Greeley. As the Laramide orogeny progressed, sediments eroded off of the uplifting Rocky Mountains, filling the downwarped foreland basin from west to east with detrital sediment. This sedimentary basin, known as the Denver Basin, is a strongly asymmetric structural basin, with steeply dipping strata along its western flank and gently dipping strata along its eastern flank (Weimer, 1996; Dechesne and others, 2011).

Bedrock is not exposed in the Hardin quadrangle. In the central part of the quadrangle (E ½ sec. 9 and W ½ sec. 10, T. 4 N. R. 63 W), Middle (781 ka-126 ka) to Late (126 ka-11 ka) Pleistocene gravel (Qg₁) mantles a high area. This is an example of topographic inversion because these gravel clasts are more resistant to erosion than the surrounding sedimentary material. Typically, the only evidence of a Qg₁ deposit in the landscape is the presence of gravel clasts exposed in a matrix of eolian sediment.

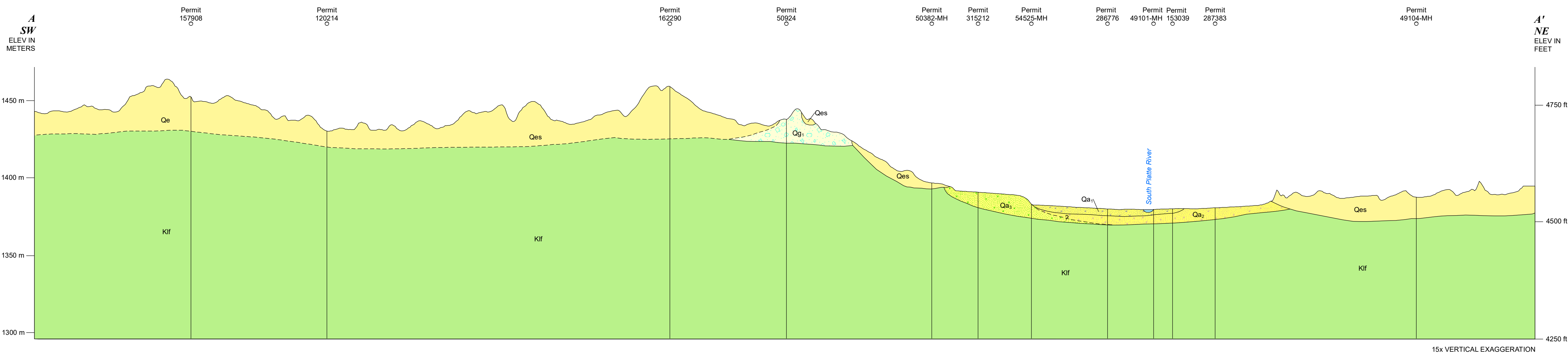
Eolian sand blankets approximately 78 percent of the quadrangle. Eolian sand in northeastern Colorado was largely deposited during the Late Pleistocene, but less extensive deposition has continued periodically during the Holocene (11.7 ka-present) (Forman and others, 1998; Muhs and others, 1996; Muhs and others, 1999; Madole, 2005; Kellogg and others, 2008; Cole and Braddock, 2009; Madole, 2016; Keller and others, 2017; Workman and others, 2018; Palkovic and others, 2018; Palkovic and others, 2019). Specifically, during the Pinedale glaciation, Madole (2016) posited that strong northwesterly winds were largely responsible for the vast eolian deposition in the northern Front Range. This hypothesis is supported by abundant northwest-southeast trending linear dune crests south of the South Platte River in the Hardin quadrangle. Additionally, many eolian deflation (blowout) features and dune crests are visible on lidar imagery north and south of the South Platte River, and are shown on the geologic map. Today, eolian deposits cover most of the Middle and Upper Pleistocene alluvial gravels in the Greeley area, with only the highest (oldest) gravels are exposed in the map area.

The South Platte River bisects the northern part of the Hardin quadrangle from west to east. After widespread eolian deposition occurred, the South Platte River and its tributaries incised and deposited alluvium (Qa₁, Qa₂, and Qa₃) from the Late Pleistocene to present (Madole and Shroba, 1979; Nelson and others, 1979; Madole, 1986; Madole 1991; Kellogg and others, 2008; Cole and Braddock, 2009; Keller and others, 2017; Palkovic and others, 2018; Workman and others, 2018; Palkovic and others, 2019). Units Qa₁ and Qa₂ are hydraulically connected to the South Platte River, influencing the static water level in those units. In unit Qe, groundwater may be much deeper below the ground surface. Static water levels from DWR boreholes (at the time of drilling) in unit Qe range from 6 to 40 m below ground surface, with a mean water level of 23 m below ground surface for wells spudded in eolian sediment south of the South Platte River surface (Division of Water Resources, 2019). On the quadrangle, unit Qe is an extensive source of sand, correlative with unit E3 of Schwachow and others (1974).

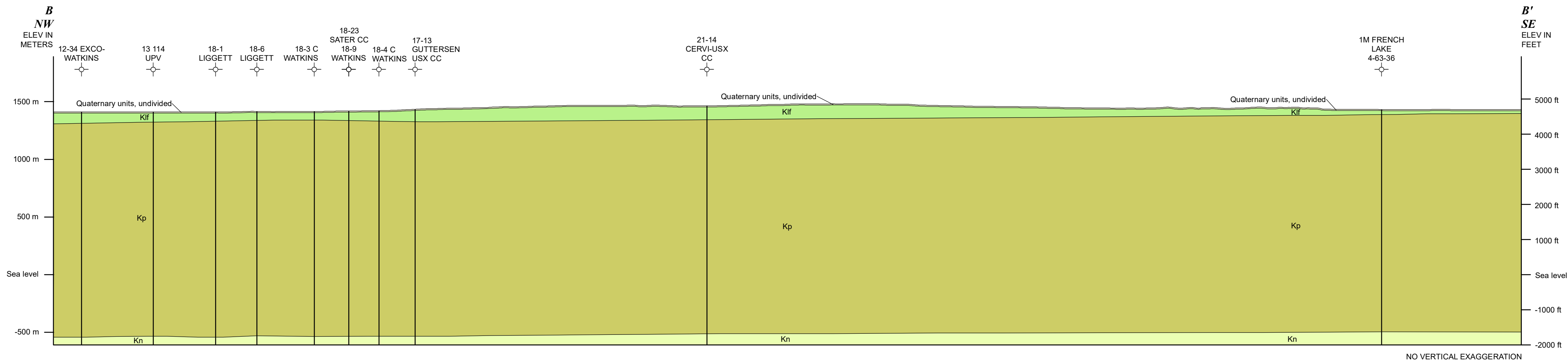
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CROSS SECTION A-A'



CROSS SECTION B-B'



GEOLOGIC MAP OF THE HARDIN QUADRANGLE, WELD COUNTY, COLORADO CORRELATION OF MAP UNITS, 3-D OBLIQUE, GEOLOGIC HISTORY, GROUNDWATER AND MINERAL RESOURCES, AND CROSS SECTIONS

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2021