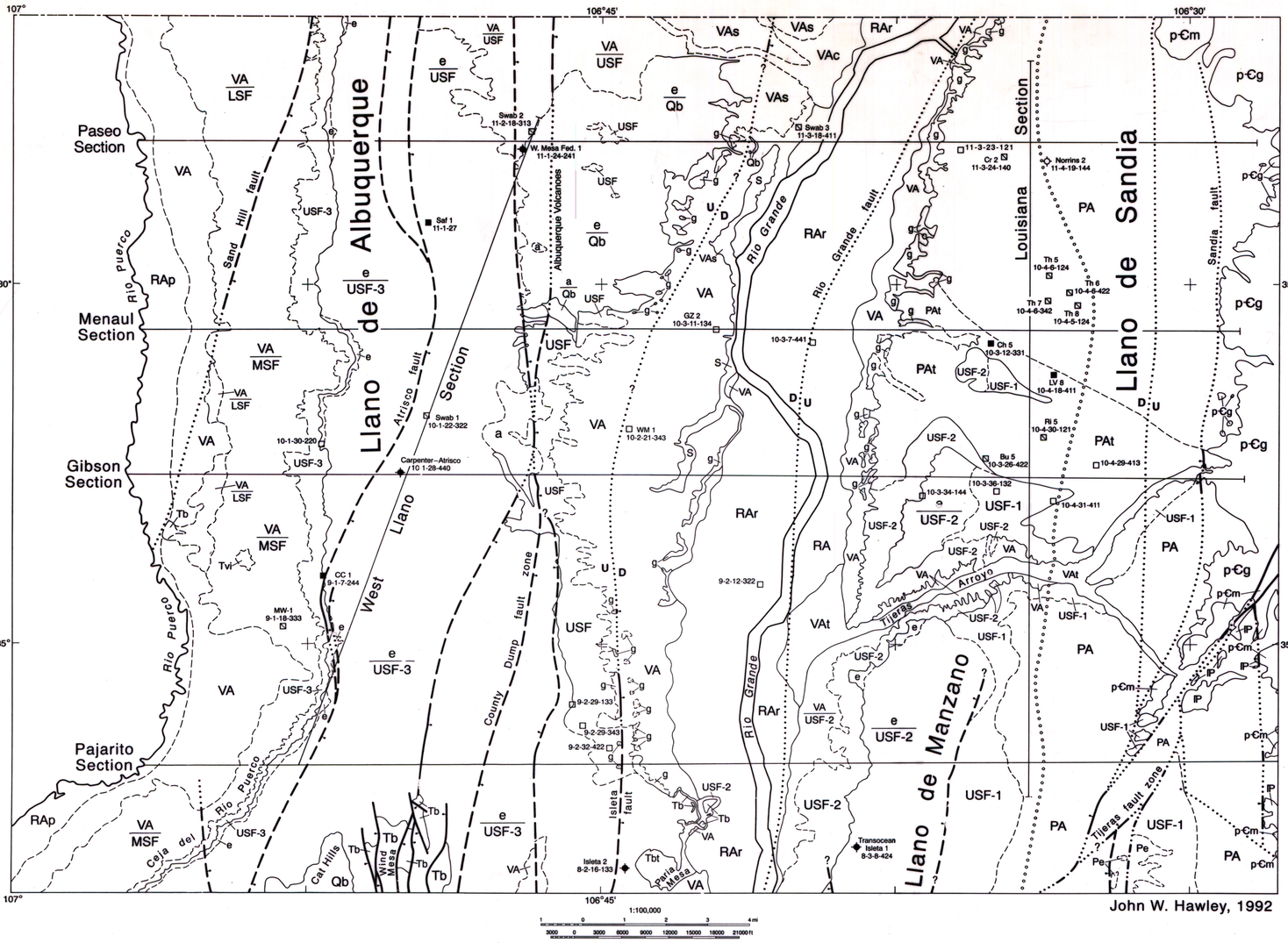

Plate 1. Hydrogeologic Map of the Albuquerque Metropolitan Area, northern Albuquerque Basin, New Mexico

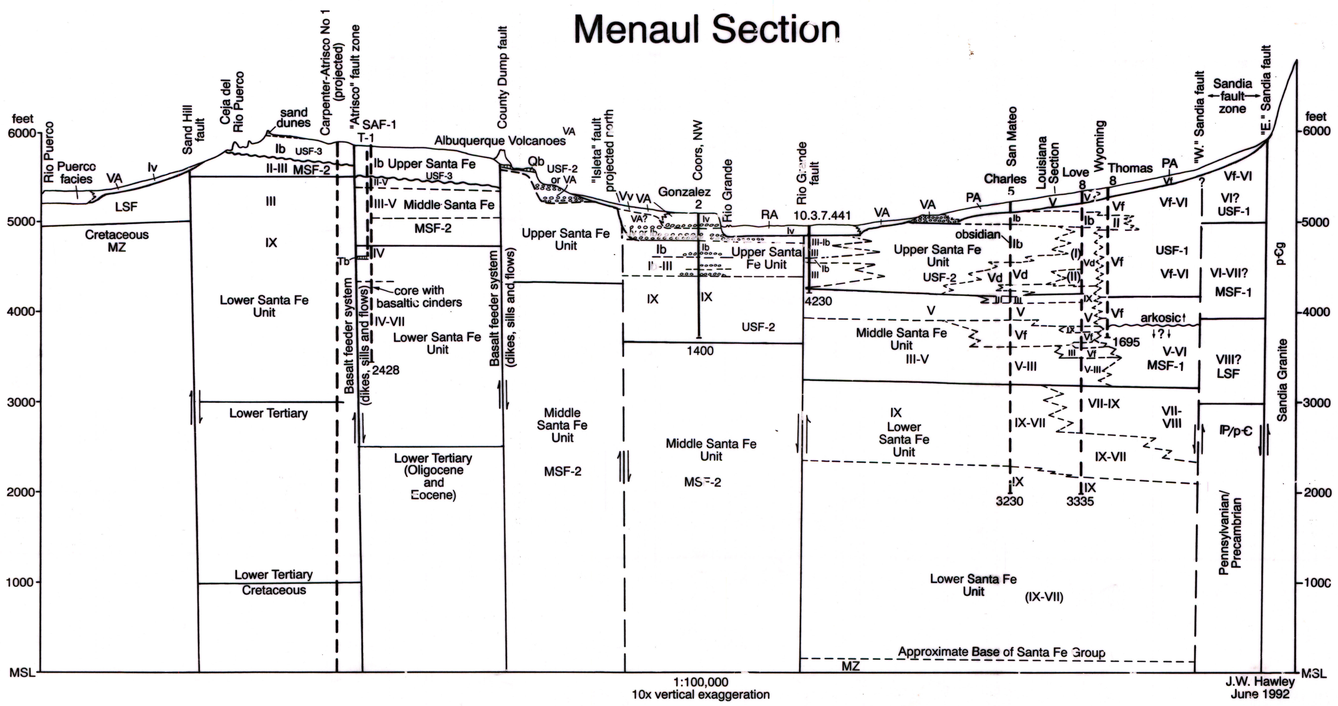

Plate 3. Menaul Hydrogeologic Section

HYDROGEOLOGIC MAP OF THE ALBUQUERQUE METROPOLITAN AREA AND MENAUL SECTION

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Key to hydrostratigraphic units in the Albuquerque Basin

Unit	Description	Age
RA RAr RAp	River alluvium; channel and floodplain deposits of inner Rio Grande (RAr) and Puerco (RAp) valleys; as much as 120 ft thick. Map unit "Qf" of Kelley (1977). Forms upper part of the "shallow aquifer". Hydrogeologic (lithofacies) subdivision Iv*.	Holocene to late Pleistocene
VA VAc VAt VAs	Valley-border alluvium; tributary-arroyo (and thin eolian) deposits in areas bordering inner Rio Grande and Puerco valleys, with locally extensive river-terrace deposits, as much as 200 ft thick. Fan, terrace and channel deposits of Calabacillas and Tijeras Arroyos are, respectively, designated VAc and VAt. VAs indicates older valley fill near Calabacillas Arroyo. Map units "Qa" and "Qt" of Kelley (1977), and "Edith, Menaul, and Los Duranes" (terrace alluvium) units of Lambert et al. (1982). Includes hydrogeologic (lithofacies) subdivision Iv, II, and Vv. Most of unit is in the vadose (unsaturated) zone.	Holocene to middle Pleistocene
PA PAt	Piedmont-slope alluvium; coarse-grained alluvium, mainly deposited as coalescent fans extending basinward from mountain fronts on the eastern and southwestern margins of the basin; as much as 150 ft thick; includes surficial deposits mantling piedmont erosion surfaces (including rock pediments). PAt designates deposits of ancestral Tijeras Arroyo system in the depression between I-40 and the SE Central-Ridgecrest Blvd. area (Lambert et al., 1982). Map units "Qfs" and "Qp" of Kelley (1977), and hydrogeologic (lithofacies) subdivisions Vf, Vd, and VI. Most of unit is in vadose zone.	Holocene to middle Pleistocene
SF	Santa Fe Group--undivided; fill of intermontaine basins of the Rio Grande rift in New Mexico and adjacent parts of Colorado, Texas, and Chihuahua (Mexico). Includes alluvial, eolian and lacustrine deposits; and interbedded extrusive volcanic rocks (basalts to silicic tuffs). In the Albuquerque Basin, the Santa Fe is as much as 15,000 ft thick. It is mapped both as a formation (member subdivisions) by Kelley (1977), and as a group (formation and member subdivisions) by Hawley (1978), Machette (1978a,b), and Lozinsky and Tedford (1991). The upper part of the group unit forms the major aquifer in the Albuquerque Basin (and elsewhere in basins of the Rio Grande rift), and is subdivided into three hydrostratigraphic units:	early Pleistocene to late Oligocene, mostly Pliocene and Miocene
USF USF-1 USF-2 USF-3	Upper Santa Fe unit; coarse- to fine-grained deposits of ancestral Rio Grande and Puerco systems that intertongue mountainward with piedmont-alluvial (fan) deposits; volcanic rocks (including basalt, andesite and rhyolite flow and pyroclastic units) and thin, sandy eolian sediments are locally present. The unit is as much as 1200 ft thick. Subunit USF-1 comprises coarse-grained, alluvial-fan and pediment-veneer facies extending westward from the bases of the Sandia, Manzanita, and Manzano uplifts. USF-2 includes deposits of the ancestral Rio Grande and interbedded fine-grained sediments in the structural depression between the Rio Grande and County Dump fault zones in the river-valley area. Alluvial and minor eolian deposits capping the Llano de Albuquerque (West Mesa) between the Rio Grande and Puerco Valleys form subunit USF-3. Unit includes Ceja Member of Kelley (1977), and Sierra Ladrones Formation of Machette (1978a,b) and Lozinsky and Tedford (1991). Forms lower part of "shallow aquifer" below river-floodplain areas, and upper part of basin-fill aquifer in western part of NE and SE Albuquerque well fields. Includes hydrogeologic (lithofacies) subdivisions Ib, II, III, V, Vd, VI, VII, and IX. Unit is in vadose zone west of the Rio Grande Valley.	early Pleistocene to late Miocene, mainly Pliocene
MSF MSF-1 MSF-2	Middle Santa Fe unit; alluvial, eolian, and playa-lake (minor in northern basin area) basin-fill facies; coarse-grained alluvial-fan deposits intertongue basinward with sandy to fine-grained basin-floor facies, which include local braided-stream and playa-lake facies; basaltic volcanics are also locally present. The unit is as much as 10,000 ft thick in the Isleta Pueblo area of the Rio Grande Valley. Subunit MSF-1 comprises piedmont alluvial deposits derived from early-stage Sandia, Manzanita, and Manzano uplifts including the ancestral Tijeras Canyon drainage basin. MSF-2 comprises sandy to fine-grained basin-floor sediments that intertongue westward and northward with coarser grained deposits derived from the Colorado Plateau and southern Rocky Mountain provinces and Rio Grande rift basins to the northeast. Includes upper part of Popotosa Formation of Machette (1978a,b) and Lozinsky and Tedford (1991) in southern Albuquerque Basin, Cochiti Formation of Manley (1978), and "middle red" formation (member) of Lambert (1968) and Kelley (1977). Forms major part of basin-fill aquifer system in much of the northern part of basin. Includes hydrogeologic (lithofacies) subdivisions II, III, IV, V, Vd, Vf, VI, VII, VIII, and IX.	late to middle Miocene
LSF	Lower Santa Fe unit; alluvial, eolian, and playa-lake basin-fill facies; sandy to fine-grained basin-floor sediments, which include thick dune sands and gypsiferous sandy mudstones; grades to conglomeratic sandstones and mudstone toward the basin margins (early-stage piedmont alluvial deposits). The unit is as much as 3500 ft thick in the central basin areas, where it is thousands of feet below sea level. Includes lower part of Popotosa Formation of Machette (1978a,b) and Lozinsky and Tedford (1991) in southern Albuquerque (Belen) Basin; and Zia (sand) Formation of Galusha (1966) and Kelley (1977) in northern part of basin. At present, is not known to form a major part of the Albuquerque Basin aquifer system. Eolian (Zia) and facies could be at least a local (future) source of groundwater in the far northwestern part of the basin (west and northwest of Rio Rancho). Includes hydrogeologic (lithofacies) subdivisions IV, VII, VIII, IX, and X.	middle Miocene to late Oligocene

Faults

- High-angle normal fault (map view), dashed where inferred, dotted where buried; bar and ball or "D" on downthrown side
- High-angle normal fault (cross section view), dashed where inferred; direction of relative motion shown by arrows
- Other faults and shear zones dominated by strike slip displacements

Other Symbols

- Approximate eastern limit of ancestral Rio Grande deposits (USF-2) in subsurface
- Water wells with drill cutting and core analyses
- Water wells with drill cutting analyses
- Water wells with driller's log analyses
- Oil Test Wells with drill cutting analyses
- Oil Test Well with driller's log analyses

Explanation of other lithologic symbols used in conjunction with hydrostratigraphic units on map and cross sections.

a	Thin, discontinuous alluvial deposits on older basin fill and basalts of the Llano de Albuquerque area between the Rio Grande and Puerco Valleys.
e	Sandy eolian deposits forming nearly continuous cover on stable summits of high tablelands (mesas) flanking the Rio Grande Valley. Underlying unit (Upper Santa Fe or basalt flow) is identified by superposition of symbols (e.g. e/USF or e/Qb). Symbol alone denotes thick dune deposits on escarpment rims, particularly at the west edge of the Llano de Albuquerque (Ceja del Rio Puerco).
g	Channel gravel deposits associated with remnants of river-terraces bordering the inner valley of the Rio Grande. Includes outcrops of Edith, Menaul, and upper buff (?) "gravels" of Lambert (1968). Pebble to cobble gravels are commonly underlain by pumiceous USF-2 beds at the edge of the inner valley (east of Edith Blvd.).
s	Sandy to silty fluvial deposits associated with river-terrace remnants west of the Rio Grande. Includes Los Duranes Formation of Lambert (1968; Lambert et al., 1982).
	Upper Cenozoic volcanics and igneous intrusives interbedded with, capping, and penetrating basin and valley fill
Qb	Younger basaltic volcanics of the Albuquerque and Cat Hills fields: extensive lava flows, with localized vent units such as cinder cones and lava domes, and possible feeder dikes and sills in subsurface; late middle Pleistocene.
Tb	Older basaltic volcanics of the Wind Mesa and Isleta fields, extensive lava flows, with localized vent units; includes possible sills and/or buried flows west of the Albuquerque volcanoes; Pliocene.
Tbt	Basaltic tuffs and associated lavas and fluvial sediments of the Isleta (Paria Mesa) center; Pliocene.
Tvi	Silicic to basaltic intrusive and volcanic rocks penetrated in deep wells west of the County Dump--Albuquerque Volcanoes fault zone; includes possible intrusives from the Cerro Colorado center (quartz-latite and trachyte); late Miocene (?) and Pliocene.
	* **Bedrock units**
	Lower and middle Tertiary sedimentary rocks undivided; primarily sandstones and mudstones; includes "unit of Isleta #2" of Lozinsky (1988), and possibly Galisteo and Espinaso Formation correlatives.
Mz	Mesozoic rocks-undivided; primarily upper Cretaceous sandstones or shales beneath the Puerco Valley and western Llano de Albuquerque area, and possible Triassic sandstones and mudstones west of the Hubbell fault zone and south of Tijeras Arroyo east of the Rio Grande.
Pe	Permian rocks-undivided; sandstones, mudstones, and minor limestones of the Abo and Yeso Formations exposed along the Hubbell fault zone.
P	Pennsylvanian rocks-undivided; limestones, sandstones and shales of the Madera Group and the Sandia Formation in the Tijeras fault zone and Manzanita foothill area south of Tijeras Canyon.
p€ p€g p€m	Precambrian rocks-undivided; igneous intrusive and metamorphic rocks of the Sandia and Manzanita uplifts; p€g—Sandia granite and local bodies of metamorphic rocks north of the Tijeras fault zone; p€m—metamorphic rocks (greenstone, quartzite, schist, gneiss and metavolcanics) south of the Tijeras fault.
	* Primarily hydrogeologic boundary units with low hydraulic conductivities. However, solution-enlarged joints and fractures in Paleozoic carbonate rocks (Pennsylvanian and Permian) may be highly conductive, and fault zones such as the Tijeras "shear" zone may be characterized by local areas of high permeability.

Lithofacies subdivisions of basin- and valley-fill hydrogeologic units and their occurrence in lithostratigraphic and hydrostratigraphic units in the Albuquerque Basin

Subdivision Descriptions

I Sand and gravel, river-valley and basin-floor fluvial facies; channel and floodplain deposits of the Rio Grande and Rio Puerco underlying 1) the modern river-valley floor—facies Iv, 2) river-terrace surfaces—deposits primarily in the vadose zone, and 3) ancient relict or buried basin-floor fluvial plains—facies Ib. Gravel is characterized by sub-rounded to well-rounded pebbles and small cobbles of resistant rock types (mainly igneous and metamorphic) derived in part from extra-basin source areas.

Iv. Sand and pebble to cobble gravel, with thin, organic-rich silty sand to silty clay lenses in Rio Grande Valley; as much as 50 ft of silt-clay in upper part of deposit in Puerco Valley; indurated zones of carbonate cementation rare or absent; as much as 120 ft thick.

Ib. Sand and pebble gravel (>85%), with thin discontinuous beds and lenses of sandstone, silty sand, and silty clay (<15%); extensive basin-floor fluvial facies; usually noniundurated, but with local zones that are cemented with calcite (common), and other minerals (uncommon) including silicate clays, iron-manganese oxides, gypsum, silica, and zeolites; 200 to 400 ft thick in central basin areas.

II Sand, with discontinuous beds and lenses of pebbly sand, silty sand, sandstone, silty clay, and mudstone; extensive basin-floor fluvial facies and local eolian deposits; gravel composition as in facies I; usually noniundurated, but local cemented zones; clean sand and pebbly-sand bodies make up an estimated 65–85 percent of unit; as much as to 1000 ft thick in central basin areas.

III Interbedded sand, silty sand, silty clay, and sandstone; with minor lenses of pebbly sand and conglomeratic sandstone; basin-floor alluvial and playa-lake facies; clay mineralogy of silty clay beds as in unit IX; usually noniundurated, but with local cemented zones as in facies Ib and II; secondary carbonate and gypsum segregations locally present in silty clay beds; common sheet-like to broadly-lenticular strata 10 to 40ft thick; clean sand layers make up an estimated 35 to 65 percent of unit; as much as 2000ft thick in central basin areas.

IV Sand to silty sand, with lenses or discontinuous beds of sandstone, silty clay, and mudstone; eolian and alluvial facies primarily deposited on basin floors and contiguous piedmont slopes; noniundurated to partly indurated, with cementing agents including calcite (common), silicate clays, iron-manganese oxides, gypsum, and zeolites (uncommon); clean fine to medium sand makes up an estimated 35 to 65 percent of unit; as much as 2000ft thick exposed near western edge of basin.

V Gravelly sand-silt-clay mixtures (loamy sands to sandy clay loams) interbedded with lenticular to sheet-like bodies of sand, gravel, and silty clay; distal to medial piedmont-slope alluvial facies (mainly coalescent fan: Vf and Vd), also alluvial deposits along valley borders associated with fans and terraces major arroyo systems (Vv); with minor component of eolian sands and silts; gravel primarily in the granule, pebble, and small cobble size range; clast composition reflects the lithologic character of the local source-bedrock terranes; usually noniundurated, but with discontinuous zones cemented with calcite, upper part of unit in the vadose zone. Symbol "V" designates undifferentiated unit Vf and Vd:

Vf. Gravelly sand-silt-clay mixtures interstratified with discontinuous beds of sand, gravel and silty clay; alluvial and debris-flow deposits of coalescent piedmont fans associated with smaller, steep mountain-front watersheds, such as the Domingo Baca–Pino–Oso–Embudo basins of the Sandia Mountains; elongate (downslope) lenticular bodies of clean sand and gravel make up about 25 to 35 percent of the unit; as much as 1000ft thick.

Vd. Sand and gravel interstratified with discontinuous beds and lenses of gravelly to non-gravelly sand-silt-clay mixtures. Primarily deposits of large, distributary (braided-stream) channels on low-gradient alluvial fans, such as the Tijeras and Abo Canyon fans, that apex at the mouths of large watersheds (>50 mi²) in mountain ranges and high plateaus flanking the Albuquerque Basin; sheet-like to broadly lenticular bodies of clean sand and gravel deposits associated with fan-distributary channel complexes make up an estimated 35 to 65 percent of the unit; as much as 1000 ft thick.

Vv. Gravelly sand-silt-clay mixtures interbedded with lenticular to sheet-like bodies of sand and gravel and silty clay. Arroyo fan and terrace deposits that border the inner valleys of the Rio Grande, Rio Puerco, Jemez Rivers and major tributary arroyos; lenticular bodies of clean sand and gravel deposits make up 35 to 65 percent of the unit; as much as 150ft thick.

VI Coarse gravelly sand-silt-clay mixtures (loamy sand and sandy loams to loams) interstratified with lenses of sand and gravel; proximal to medial piedmont-slope alluvial facies—fan and coalescent fan deposits; gravel primarily in the pebble to cobble range (up to 10 inches); clast composition reflects lithologic character of source bedrock terranes; usually noniundurated, but with discontinuous layers that are cemented with calcite; clean sand and gravel lenses make an estimated 15 to 35 percent of unit; as much as 1000ft thick.

VII Conglomeratic sandstone, silty sandstone, and mudstone with lenses and discontinuous beds of conglomerate, sand, gravel, and gravelly sand-silt-clay mixtures (as in unit V); distal to medial piedmont-slope alluvial facies, with minor component of eolian sediments; coarse clast sizes and composition as in unit V; moderately-well to poorly indurated; cementing agents include calcite (common) and silicate clays, iron-manganese oxides, silica and zeolites (uncommon); clean weakly-cemented sand and gravel beds make up an estimated 10 to 25 percent of unit; as much as 1000ft thick.

VIII Coarse conglomeratic sandstone and silty-sandstone, fanglomerate, and minor lenses of sand and gravel; proximal to medial piedmont-slope alluvial facies—and coalescent fan deposits; coarse clast sizes and compositions as in unit VI; moderately to well indurated; cementing agents as in unit VII; clean, weakly-cemented sand and gravel lenses make up an estimated 5 to 15 percent of unit, as much as 1000ft thick.

IX Silty clay interbedded with thin silty sand, sandstone, and mudstone beds; basin-floor playa-lake and alluvial-flat facies; clay mineral assemblage includes calcium smectite, mixed layer illite-smectite illite, and kaolinite; secondary deposits of calcite, gypsum, sodium-magnesium-sulfate salts, and zeolites are locally present; weakly-cemented fine to medium sand and silty sand makes up an estimated 5 to 10 percent of unit; as much as 3000ft exposed in southwestern basin areas.

X Mudstone and claystone interstratified with thin sandstone and silty sandstone beds; basin-floor playa-lake and alluvial-flat facies; clay mineral and non-clay secondary mineral assemblages as in facies IX; weakly cemented fine to medium sand and silty sand makes up an estimated 0 to 5 percent of unit; not exposed in central and northern basin areas; thickness unknown, but may exceed 2000ft.

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