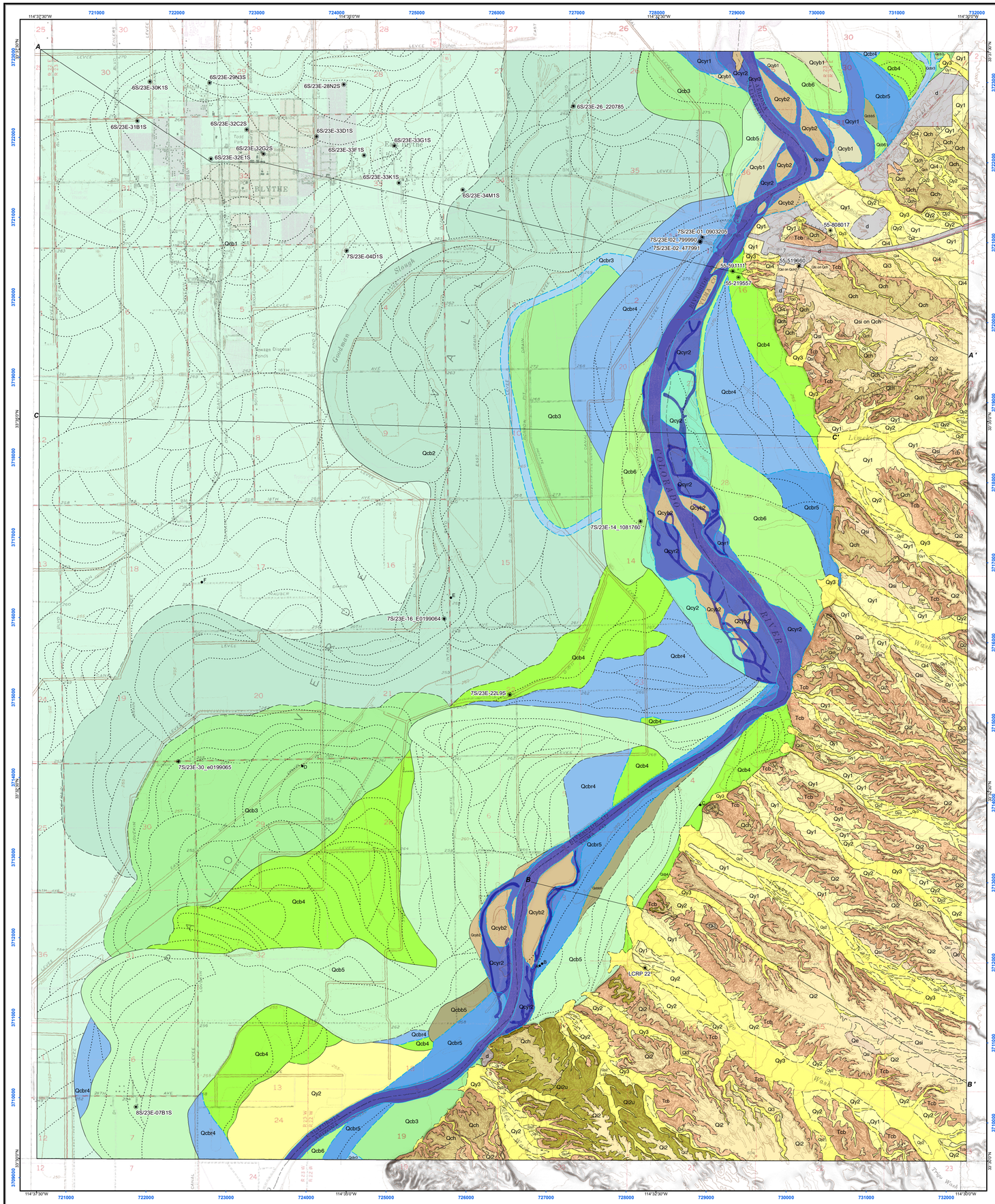

Geologic Map of the Blythe 7 ½' Quadrangle, La Paz County, Arizona and Riverside County, CA

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Arizona Geological Survey

Digital Geologic Map 124 (DGM-124)

version 1.0 - sheet 1 of 2

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Introduction

The Blythe 7 ½' Quadrangle straddles the Colorado River, including the City of Blythe, California and areas to the south, in western Arizona and eastern California. The map encompasses much of the lateral extent of the Holocene river floodplain, which is almost entirely in California, and the lower piedmont east of the river in Arizona. This mapping complements previous mapping efforts in this area (Spencer et al., 2015; Gootee et al., 2016a; 2016b). Development of this map was a collaborative effort between the Arizona Geological Survey (AZGS) and the U.S. Geological Survey (USGS). Geologic mapping in Arizona was done by Gootee and Pearthree under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992, and was jointly funded by the AZGS and the USGS under STATEMAP assistance award # G16AC00294. Detailed mapping in California was done by Block and House using historical aerial photographs and topographic maps that predate construction of large dams upstream on the river, and subsequent pervasive anthropogenic floodplain alterations, as part of the USGS LOCO Project funded under the FEDMAP program. All mapping was compiled digitally using ESRI ArcGIS software.

References cited are listed in the accompanying text document.

Map Unit Descriptions

Miscellaneous Units

d — **Disturbed ground** - Developed areas of Ehrenburg, Interstate 10 and other areas modified by human activity so that original geologic characteristics are obscure.

Qe — **Eolian sand dune deposits** - Quartz-rich sand deposits forming relatively small dunes and associated sand sheets. Lesser amounts of silt and clay are associated with more stable parts of dunes. Dunes trend generally SE and NW, and have up to 6 m relief.

Qsi — **Sand sheet deposits** - Laterally extensive sand deposits, with minor gravel, silt, and clay. Includes small, low dunes less than 3 to 4 m in height. Percent coverage of sand is variable, but typically is >50 percent. Includes areas of gravel lag and eroded alluvial fan deposits underlying map unit Qi2.

Piedmont Alluvium

Qy_3 — **Deposits of active channels, low terraces and bars** - Piedmont gravel, sand and silt deposits located along active drainages, including channels, adjacent gravel bars and low terraces, and broader distributary multi-channel expansion reaches. Qy3 deposits are poorly-sorted and unconsolidated. Gravel clasts are not varnished unless reworked from older deposits, and soil development is minimal. Vegetation consists of desert trees including palo verde, ironwood, and mesquite.

Qy_2 — **Deposits of low fan terraces and active alluvial fans** - Gravel, sand, and silt deposits forming low terraces and small alluvial fans, located primarily along the flanks of active washes inset into Pleistocene alluvial deposits. Some Qy2 deposits comprise extensive low relief alluvial terraces in broad valley reaches. These deposits are unconsolidated to very weakly consolidated sediments, poorly sorted with sub-rounded to sub-angular pebble to cobble bars on the surface and beds and lenses in cross section. Topographically low areas commonly are covered by thin mantles of silt and clay. Soil development is minimal. Vegetation includes desert trees and shrubs. Single deposit on floodplain likely from tributary drainage down Mohave Wash. Cadastral map of 1874 shows "swamp and overflowed land" with channel dissecting northwest half of mapped deposit west of the river. In 1902 and 1917 the river is west of the mapped deposit. Earliest aerial photo (1930) shows distinct fan-like form.

Qy_1 — **Deposits of low terraces and young relict alluvial fans** - Gravel, sand, silt and clay deposits forming relict alluvial fans and terraces along larger piedmont drainages. Qy1 deposits are composed of silt to pebbles in swales, and lightly to moderately varnished pebbles to small boulders in bars. These deposits are generally located on the margins of incised valleys away from the more active parts of the drainage systems, and typically are 1-2m above adjacent active washes, and partially overlie Pleistocene and Pliocene deposits in some areas. Vegetation includes sparse, relatively small desert riparian trees, shrubs including creosote and cacti.

Qi_4 — **Youngest intermediate alluvial fan and terrace deposits** - Gravelly deposits in low terraces and relict alluvial fans along larger piedmont drainages. Deposits consist of pebbles, cobble, small boulders, sand, silt, and clay. Moderate varnish on clasts, weak to moderate undulating desert pavements, but not as tight as Qi3. Soil development includes very slight reddening and visible carbonate accumulations. Vegetation is sparse and concentrated along slightly incised small drainageways.

Qi_3 — **Intermediate alluvial fan and terrace deposits** - Very poorly sorted deposits including pebbles, cobbles, sand, with minor silt and clay, and locally bouldery, forming laterally extensive relict alluvial fans and terraces. Surfaces are typically 1-5 m above adjacent Holocene deposits and vary from undulating to very smooth. Desert pavements are moderately to strongly developed and rock varnish is quite dark. Locally, multiple levels of surfaces are grouped together, and some latest Pleistocene (Qi4) deposits are included in this unit. Soil development is moderate, with slight reddening, minor clay accumulation, calcic horizon development of stage II-III. Qi3 surfaces are graded to the highest level of late Pleistocene Chemehuevi Formation deposits or younger inset river surfaces.

Qi_{3u} — **Intermediate deposits beneath Chemehuevi deposits** - Intermediate to young fan deposits composed of locally-derived gravel and sand. This unit is younger than high-standing Qi2 deposits and pre-dates unit Qch river terrace deposits but are interfingered with older Qch deposits. We interpret Qi2u to be generally coeval with the main Chemehuevi aggradation event, although it may be older than Qch in some localities.

Qi_2 — **Older intermediate alluvial fan and terrace deposits** - Poorly sorted pebbles, cobbles, sand, some boulders, and minor silt and clay associated with moderately dissected remnant terraces ~5-20 m above active washes. Highest Qch deposits around 135 m overly Qi2 lag surface remnants, followed by Qi2 deposits capping highest Qch deposits. Rock varnish and pavement development is variable, quite strong on well-preserved surfaces and moderate to weak on more eroded surfaces. Soils are obviously reddened beneath pavements, and carbonate rinds are moderately thick.Vegetation is sparse; bushes and small trees are concentrated along small drainages.

Qi_1 — **Oldest intermediate alluvial fan and terrace deposits** - Poorly sorted pebbles, cobbles, sand, and minor silt and clay identified in one polygon in the southern portion of the map and associated with extensively dissected remnant terraces ~30-35 m above active washes. This deposit may also be related to the Palo Verde Alluvium of House and others (2018). Also shown in cross section BB'.

Colorado River Deposits

Channel Deposits of the Modern, Regulated Colorado River

$Qcyr_3$ — **Active channel deposits** - Deposits under the active Colorado River channel which is now mostly confined by rip-rap and artificial levees. Includes mostly water, subaqueous sand bars, and possible fine-gravelly bedforms. 'Active' channel is up to 0.35 km wide in short, unconfined reach a few km north of the quad. In that short reach the channel has a variable meander wavelength of about 1.3 to about 3 km. This interval includes the construction of most regulatory structures on the river (dams, diversions, channelization, some wetland remediation). Partly equivalent to Qycr (active Colorado River channel deposits) of Gootee and others (2016), fw (flowing water) of Malmon and others (2009), and Qcrc (active river channel deposits) of Pearthree and House (2005).

$Qcyb_3$ — **Active channel bars and emergent bars** - Mid-channel bars in active channel. Composed of sand and possibly minor amounts of fine gravel. May include coarser sediments in proximity to junctions with tributary washes.

$Qcyr_2$ — **Youngest inactive channel deposits** - Relative stratigraphic age is restricted to date of aerial photography and shows location of wetted channel of Colorado River in 1948 that has not been overprinted by subsequent channel migration. Poorly-sorted, sub-rounded, fine- to medium-grained, light yellowish-brown sand with ~20% coarser grained lithic component.

$Qcyb_2$ — **Youngest channel bars and emergent bars** - Mid-channel bars or bank-attached bars of 1948 channel. Composed of sand and possibly minor amounts of fine gravel. May include coarser sediments in proximity to junctions with tributary washes.

Qcy_2 — **Youngest alluvial deposits** - Point bar deposits of 1938 channel or marginal bar of 1948 channel. Active backwater channels currently occupy the 1948 mainstem channel and related sand bar deposits. Determined from 1948 aerial photos and 2014 satellite imagery. This interval includes some construction of regulatory structures on the river (Parker Dam, temporary weir in Palo Verde Valley). Not visited in field.

$Qcyr_1$ — **Younger inactive channel deposits** - Relative stratigraphic age is restricted to date of aerial photography and shows location of wetted channel of Colorado River in 1938 that has not been overprinted by subsequent channel migration. Unit interpreted as part of the early response of the river to stringent regulation of water and sediment upstream by Hoover Dam. Partly equivalent to Qyar (historical (pre-regulation) Colorado River channel deposits) of Gootee and others (2016), Qc3ch (post-Hoover Dam channel deposits (1935-1953)) of Malmon and others (2009), and Qcr2 (historical floodplain deposits) of Pearthree and House (2005).

$Qcyb_1$ — **Younger channel bars and emergent bars** - Mid-channel bars or bank-attached bars of 1938 channel. Composed of sand and possibly minor amounts of fine gravel. May include coarser sediments in proximity to junctions with tributary washes.

Blythe Alluvium

Qcb_6 — **Alluvial deposits of the early Modern era** - This unit includes Colorado River deposits emplaced during the interval between 1930 and 1938, excluding the active 1938 channel. This time period includes the construction and completion of Hoover Dam in 1935 and the filling of Lake Mead between 1935 and 1941. This distinction of Qcb6 from unit Qcr1 (river terrace deposits of Pearthree and House, 2005) assumes that the active channel in the 1938 aerial photographs has incised into the youngest pre-dam deposits. Mapping of these deposits is based on interpretation of the 1930 and 1938 aerial photographs. Qcb6 surfaces are about 3 meters above the active river channel.

$Qcbr_5$ — **Young historical channel deposits** - Wetted Colorado River channel in 1930 (June 24). In 1930 aerial photos, active channel appears barren of vegetation. Channel width varies significantly from as much as 1.8 km in broad expansion reaches with large expansion bars to less than 700' where the river impinges on banks formed in older deposits and where it passes under the old Ehrenberg Bridge. Remnants of this unit include point bar deposits on river right to ~3 m above modern channel of poorly-sorted, sub-rounded, fine- to medium-grained, quartz-rich pale brown pebbly sand with quartz, chert, and granite clasts and containing abundant Corbicula. Above point bar deposits ~1 m of mostly cobble-sized granitic clasts. Partly equivalent to Qc2ch (pre-Hoover Dam channel deposits (prehistoric through 1935) of Malmon and others (2009) and Qymr (Colorado River meander-belt deposits) and Qysr (Colorado River splay deposits) of Gootee and others (2016).

$Qcbb_5$ — **Young historical bars and emergent bars** - Mid-channel bars or bank-attached bars of 1930 channel. Composed of sand and possibly minor amounts of fine gravel. May include coarser sediments in proximity to junctions with tributary washes.

Qcb_5 — **Young historical alluvial deposits** - Channel and floodplain alluvium deposited between 1917 and 1930. Cuts 1874 and 1902 channels as well as unit Qcb4. Deposits include sediments and morphological features of a sequence of relatively large floods between 1917 and 1929. This includes high-flow channel tracts, bars, and crevasse splays.

$Qcbr_4$ — **Intermediate historical channel deposits** - Information regarding the wetted channel in 1917 is unavailable. Age range and eastern extent of channel deposits is constrained by 1917 cadastral survey of Arizona channel bank and 1930 aerial photographs. Its western extent is inferred from interpretation of 1902 topographic map. This same interval corresponds to a series of 8 floods in excess of 100,000 ft3/s (2,832 m3/s). Consequently, unit includes composite channel deposits from the interval of 1917-1930. Poorly-sorted, sub-rounded, yellowish-brown very fine-grained sand, with ~35% lithic component. Abundant woody debris.

Qcb_4 — **Intermediate historical alluvial deposits** - Channel and floodplain alluvium deposited between 1902 and 1917. Cuts 1874 and 1902 channels. Extent and character inferred from 1930 imagery. Composite unit containing multiple cross-cutting channels that are likely to reflect a series of large floods between 1907-1917. This characteristic is indicated with form lines. Includes meanders, crevasse splays, and dissected, high-albedo sand bodies with sparse vegetation. Shallow mud cracks on surface.

$Qcbr_3$ — **Old historical channel deposits** - Relative stratigraphic age is restricted to date of topographic map and shows location of wetted channel of Colorado River in 1902 that has not been overprinted by subsequent channel migration. Partly equivalent to Qc2ch (pre-Hoover Dam channel deposits) of Malmon and others (2009). Not visited in field.

Qcb_3 — **Old historical alluvial deposits** - Alluvium reworked from 1858 and 1874 channel and floodplain (survey map only shows river margin in California), overprinted by 1902 channel and topography. Very likely that this unit reflects erosive and depositional effects of a large flood in 1884 that was estimated at 300,000 ft3/s (8,495 m3/s) at Topock (Smith and Heckler, 1955). Channel bifurcation of 1902 roughly follows 1874 channel. Uppermost meter from 1874 meander in south-central portion of map is poorly-sorted, rounded, brown very fine-grained quartz-rich sand and silt. Abundant Corbicula and minor woody debris. Vegetation includes tamarisk and arrowweed. Partly equivalent to Qy3r (youngest Colorado River terrace deposits) of Gootee and others (2016).

Qcb_2 — **Older historical alluvial deposits** - Maximum age based on interpretation of Egglofstein's floodplain map made on the 1858 Ives Expedition (Ives, 1861); minimum age based on cadastral survey of west bank of the river in 1874. Unit is likely to include Colorado River deposits and morphological features formed by large flood in 1862 (Wheeler, 1876). The western channel boundary was mapped in the BLM cadastral survey (1874) and includes well-defined segments of meandering channels. This unit is the oldest clearly discernible meander-belt segment in the map. Goodman Slough (named on a subsequent map in 1902) is a prime example of a well-preserved channel segment. It is approximately 0.3 km wide and forms a broadly arcing meander segment that supports a meander wavelength of up to ~5 km (Sections 4 and 9 R22W, T7S). Its outer (western) bank defines the contact between units Qcb1 and Qcb2. Goodman Slough follows disconnected and unnamed sloughs of 1874 survey. Cottonwood groves and low willow swamps occupied land between Goodman Slough and 1874 channel, 2.5 km to the east, along with numerous small sloughs. It is currently dry and contains sand with centimeter-thick mud cracks on undisturbed ground surface. Approximate 1 m exposed section with 20 cm gravel cap containing volcanic and leucogranitic clasts. Gravel overlies a 10-15 cm bed of poorly-sorted, sub-rounded, fine-grained, ripple cross-laminated brown sand. Indistinct bounding surfaces separate largely massive, structureless sand bodies below. Root structures half meter below ground surface. Shell hash in bottommost bed. One outstandingly large flood is reported to have occurred between the date of the Ives Expedition and the cadastral survey in 1874, one of approximately 400,000 ft3/s (11,327 m3/s) in 1862. Flood events approaching this scale would have a significant effect on the Colorado River channel and floodplain.

Qcb_1 — **Oldest alluvial deposits** - Prehistorical Colorado River deposits. Minimum age set by (1858) mapping by Egglofstein (in Ives, 1861).Associated with a complex, amalgamated and palimpsest pattern of multiple cross-cutting meandering channel belts and possible interspersed braided channel tracts. The associated floodplain surface extends beyond the west edge of the map to the floodplain margin where it abuts the bluffs of Palo Verde Mesa. The map was published in 1861 based on work done on the 1858 Ives Expedition. It is likely that the flood of 1861-62, reported as 400,000 ft3/s (11,327 m3/s) at Topock (see footnote 9 in pamphlet) had a significant geomorphic effect on this part of the floodplain. The 1874 cadastral survey map shows Blythe townsite as sand hills and knolls bordered by mesquite on this surface. Although the network of visible channel patterns from the earliest aerial photography (1930) likely reflects original Colorado River topography, overbank flow during large floods and potential groundwater seepage in the intervening years have probably modified the faintly discernible flow patterns. Banks of unlined canals along cultivated land contain wash load of poorly-sorted, sub-rounded, very-fine-grained, yellowish-brown sand in accessible upper meter. Only map unit not traversed by Colorado River in available historical data. Partly equivalent to Qc1fp (prehistoric floodplain deposits) of Malmon and others (2009).Prehistorical Colorado River deposits. Minimum age set by (1858) mapping by Egglofstein (in Ives, 1861). Associated with a complex, amalgamated and palimpsest pattern of multiple cross-cutting meandering channel belts and possible interspersed braided channel tracts. The associated floodplain surface extends beyond the west edge of the map to the floodplain margin where it abuts the bluffs of Palo Verde Mesa. The map was published in 1861 based on work done on the 1858 Ives Expedition. It is likely that the flood of 1861-62, reported as 400,000 ft3/s (11,327 m3/s) at Topock (see footnote 9 in pamphlet) had a significant geomorphic effect on this part of the floodplain. The 1874 cadastral survey map shows Blythe townsite as sand hills and knolls bordered by mesquite on this surface. Although the network of visible channel patterns from the earliest aerial photography (1930) likely reflects original Colorado River topography, overbank flow during large floods and potential groundwater seepage in the intervening years have probably modified the faintly discernible flow patterns. Banks of unlined canals along cultivated land contain wash load of poorly-sorted, sub-rounded, very-fine-grained, yellowish-brown sand in accessible upper meter. Only map unit not traversed by Colorado River in available historical data. Partly equivalent to Qc1fp (prehistoric floodplain deposits) of Malmon and others (2009).

Ancestral Colorado River Deposits

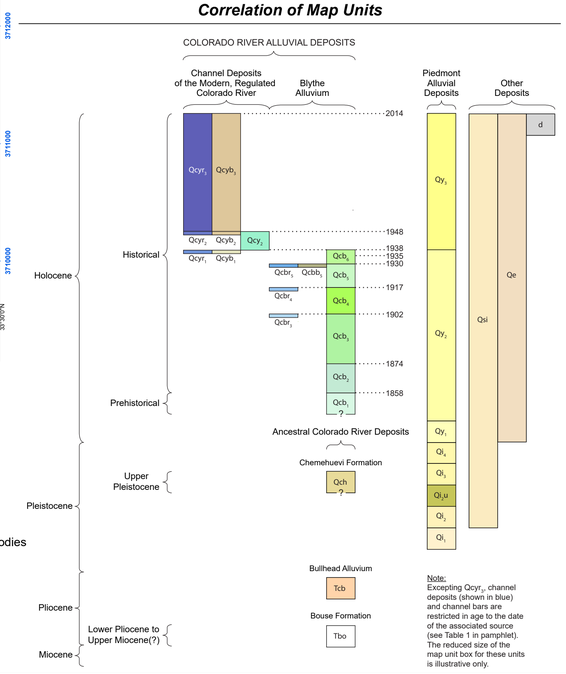
Qch — **Chemehuevi Formation** - Deposits of fluvial mud, sand, and gravel on eroded piedmont deposits along the eastern margin of the map. Sediments are often found abutting a well-developed fluvial scarp. Overlying gravel terraces may be part of the younger suite of Riverside terrace sediments of House (2016) and House and others (2018). Qch deposits onlap eroded Tcb and older Qi tributary deposits (Qi2u) and are locally interfingered with (Qi3). Younger elements of Qi3 bevel Qch and are graded to river terraces that formed after the maximum Chemehuevi aggradation. Latest Pleistocene and younger deposits are at or near the floors of modern valleys, and thus were graded to the river when it had incised close to or below its modern elevation. Qch deposits consist primarily of well-sorted, fine to medium quartz-rich sand. Qch deposits also have channel forms filled with sand-supported Colorado River channel pebble and pea gravel, although do not appear laterally extensive or traceable. Bedded and massive mud and silt are however common and laterally continuous for miles along the riverside between tributary mouths. Tributary sand and mud are also interbedded with Qch further up tributaries as a cut-fill relationship, found above the youngest Qi3 deposits, but inset below earliest Qi2 deposits.

Tcb — **Bullhead Alluvium** - Thick intervals of generally unconsolidated quartz-rich sand and exotic well-rounded gravel of the Pliocene Bullhead Alluvium (Howard and others, 2015) were deposited in the valleys of the lower Colorado following its integration with the sea (House and others, 2005; Howard and others, 2015). Tcb deposits are almost always sand-supported with floating exotic pea, pebble and cobbles, some as large as 8 in long dimension. Planar, trough and low-angle channel bedforms are common as well as massive channel sand. Less common are red, brown and green silt and mud beds interpreted to be overbank deposits. Rip-up clasts of mudstone are characteristically silicified, either partially or completely to limonitic oxide mineralization, and Tcb exhibits patchy and discontinuous carbonate cementation. Tcb also contains locally abundant petrified woods. Sand-rich deposits of a rapidly aggrading, likely complexly braided early Colorado River culminated in ~200 m thick up to ~50 km wide alluvial fill that raised the grade of the lower Colorado River 200-300 m (Howard and others, 2015; Pearthree and House, 2014). In areas surrounding the Blythe 7.5' quadrangle, Bullhead deposits are exposed along eastern margin of the modern floodplain at elevations between ~100-225 m asl, and the unit is known from well logs in the Blythe area to extend below modern sea level. The Bullhead aggradation pulse is constrained between 4.8 and 3.3 Ma in the Colorado River extensional corridor but is assumed to mostly span the period from ca. 4.5 to 3.5 Ma (Howard and others, 2015). The Blythe quadrangle contains only the lower to middle part of the Bullhead aggradational sequence, but there are excellent exposures along river bluffs and incised tributary valleys.

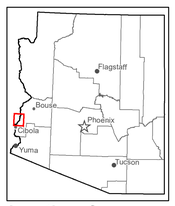
Tbo — **Bouse Formation (only present in subsurface)** - Thick, basin-filling sequence of interbedded fluvial sand and mud overlying relatively thin carbonate and travertine tufa (Metzger, 1968). Siliciclastic deposits are likely subaqueous pro-delta sediments of the Colorado River associated with the transition of the valley from a deep aquatic basin to a repository for Colorado River sediments during early phase of river integration. Siliciclastic Bouse Formation deposits are known from well logs to extend to more than 160 m below sea level in the Blythe quadrangle (Metzger and others, 1973), shown in well log LCRP-22 in section BB'.

In the Blythe Basin, Colorado-River-derived Bouse deposits are less than 5.24 Ma (Crow and others, 2019) and at least 4.9 Ma, based on the presence of the Lawlor Tuff interbedded in Bouse carbonate at high elevation in the basin (Sarna-Wojcicki and others, 2011; Harvey, 2014). Water trapped in the Blythe Basin spilled through the Chocolate Mountain divide and the river became fully integrated with the Gulf of California between 4.8 and 4.6 Ma (Crow et al., 2019).

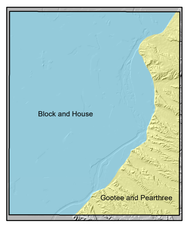
Correlation of Map Units



Note: Excepting $Qcyr_3$, channel deposits (shown in blue) and channel bars are restricted in age to the date of the associated source (see Table 1 in pamphlet). The reduced size of the map unit box for these units is illustrative only.



Location of map area



SCALE 1:24,000

1 0.5 0 1 Miles

1 0.5 0 1 Kilometers

0 1000 2000 3000 4000 5000 Feet

CONTOUR INTERVAL 20 FEET

Topographic base map derived from the Blythe 7.5' USGS topographic quadrangle map originally with NAD27 datum. Reprojected to UTM NAD83 datum (zone 11) using iGage All Topo Maps V9. UTM NAD 83 grid and lat-lon markers produced using ESRI ArcMap v. 10.4.

TRUE NORTH
MAGNETIC NORTH
11°
Approximate mean declination, 2019

Line and symbol legend

- Contact, accurate
- Contact, approximate
- Incised scarp
- Historical channel boundary
- Active channel boundary
- Backwater or isolated water bodies of the Colorado River
- Abandoned channel or meander scroll trace
- A——A' Cross section
- Well ID
- Stratigraphic locality

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