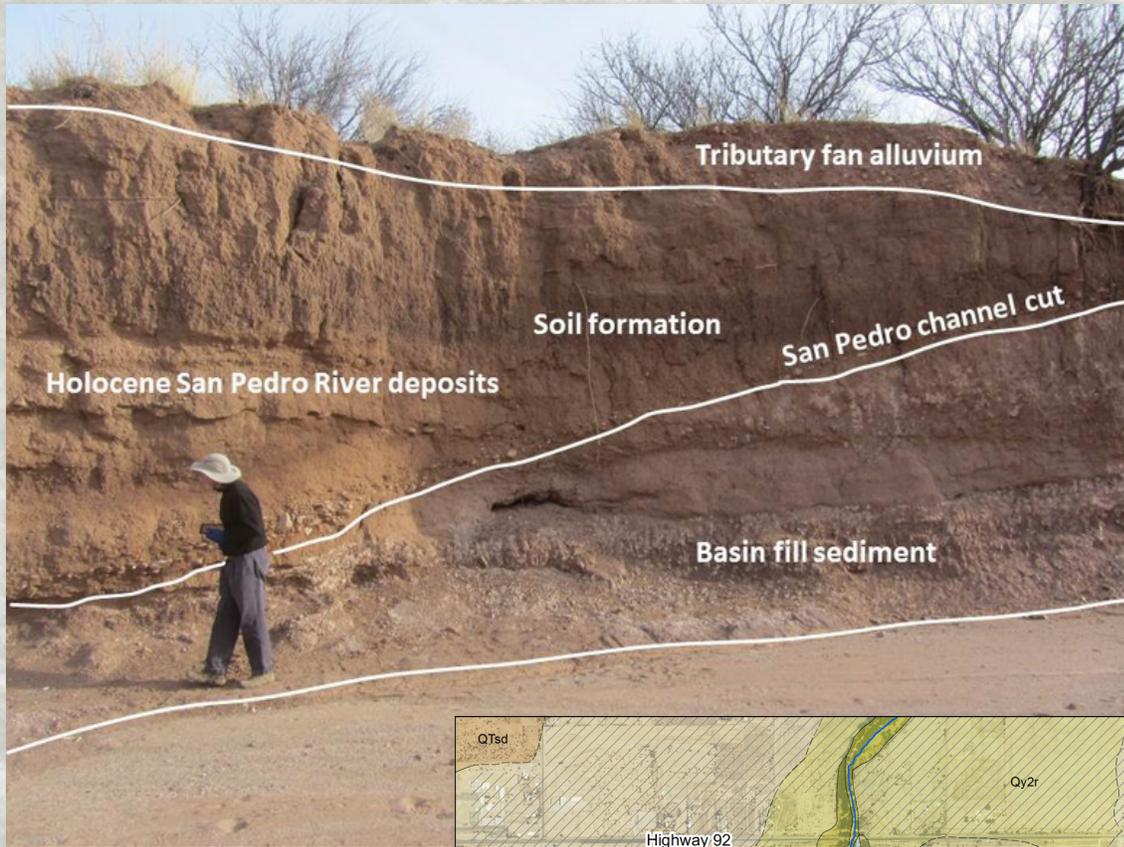


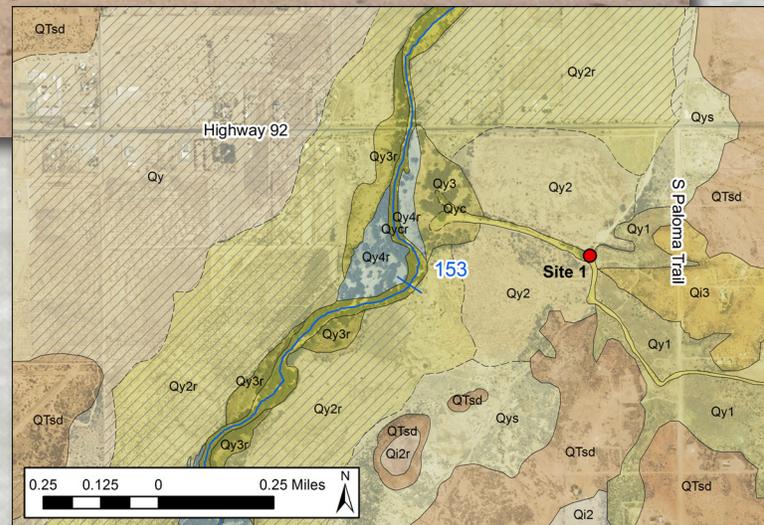
Site Investigation of Tributary Drainages to the San Pedro River, Arizona

Joseph P. Cook

Arizona Geological Survey



Palominas Arroyo, San Pedro River - mile marker 153 E



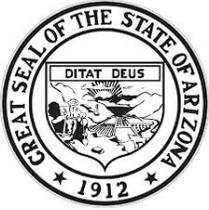
OPEN-FILE REPORT OFR-15-02

August 2017

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Arizona Geological Survey

P.A. Pearthree, State Geologist and Director

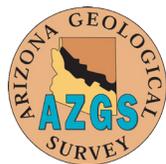
Manuscript approved for publication in August 2017
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Recommended Citation: Cook, J.P., 2017, Site Investigation of Tributary Drainages to the San Pedro River, Arizona. Arizona Geological Survey Open-File Report (OFR) 15-02, 83 p.



Site Investigation of Tributary Drainages to the San Pedro River

Introduction

In late 2013 the Arizona Geological Survey (AZGS) partnered with the Arizona Department of Water Resources (ADWR) to investigate sedimentary relationships at numerous sites along the San Pedro River in southeastern Arizona. This project supplemented previous work along the San Pedro River. In 2007, AZGS conducted surficial geologic mapping along the San Pedro River, Aravaipa Creek, and the Babocomari River. These maps and a report are available in AZGS DM-RM-1.2. The goal of the 2013 project was to conduct site investigations along the San Pedro River to determine whether sedimentary relationships between San Pedro River and tributary alluvium are accurately represented by their mapped location on the surface. This document includes a brief summary and description of sites along the San Pedro River visited by AZGS geologists in late 2013 and early 2014.

AZGS and ADWR compiled a list of thirty-nine (39) candidate sites along the San Pedro River from near the U.S./Mexico border to near the confluence with the Gila River at Winkelman, AZ. Sites were chosen based on distribution along the San Pedro River and location within tributary alluvial deposits at the surface. Exposures at each site were sought out to determine if relationships between tributary and river alluvium were evident and whether observations of buried deposits matched contacts shown on surficial geologic maps. Most sites are located in incised arroyos tributary to the San Pedro River but some include channel bank exposures along the San Pedro River. Of these 39 sites, eight (8) were inaccessible due to private property or other access issues, and nine (9) were not incised deeply enough to provide exposures of sedimentary relationships between Holocene river and tributary alluvium.

Exposures at twenty-two (22) sites demonstrated overlapping and/or interfingering alluvial relationships. Of these 22 sites, five (5) exposures were located along the San Pedro River and seventeen (17) were located within tributary channels. Of the 17 sites located in incised tributary channels four (4) showed deposits consistent with either Holocene San Pedro River floodplain deposition or tributary reworking of fine grained basin fill alluvium. One was disturbed by human activity and the remaining twelve (12) appear to provide direct evidence that Holocene San Pedro alluvium extends farther away from the modern river channel in the subsurface than is depicted on AZGS surficial geologic maps.

Site locations are described using approximate ADWR-supplied river mile and directional information (i.e. SPR 69.5E denotes a site located on the east side of the San Pedro River at approximately river mile 69.5). River miles begin at the San Pedro-Gila confluence at Winkelman and increase upstream. Photos taken at sites have been geotagged and site

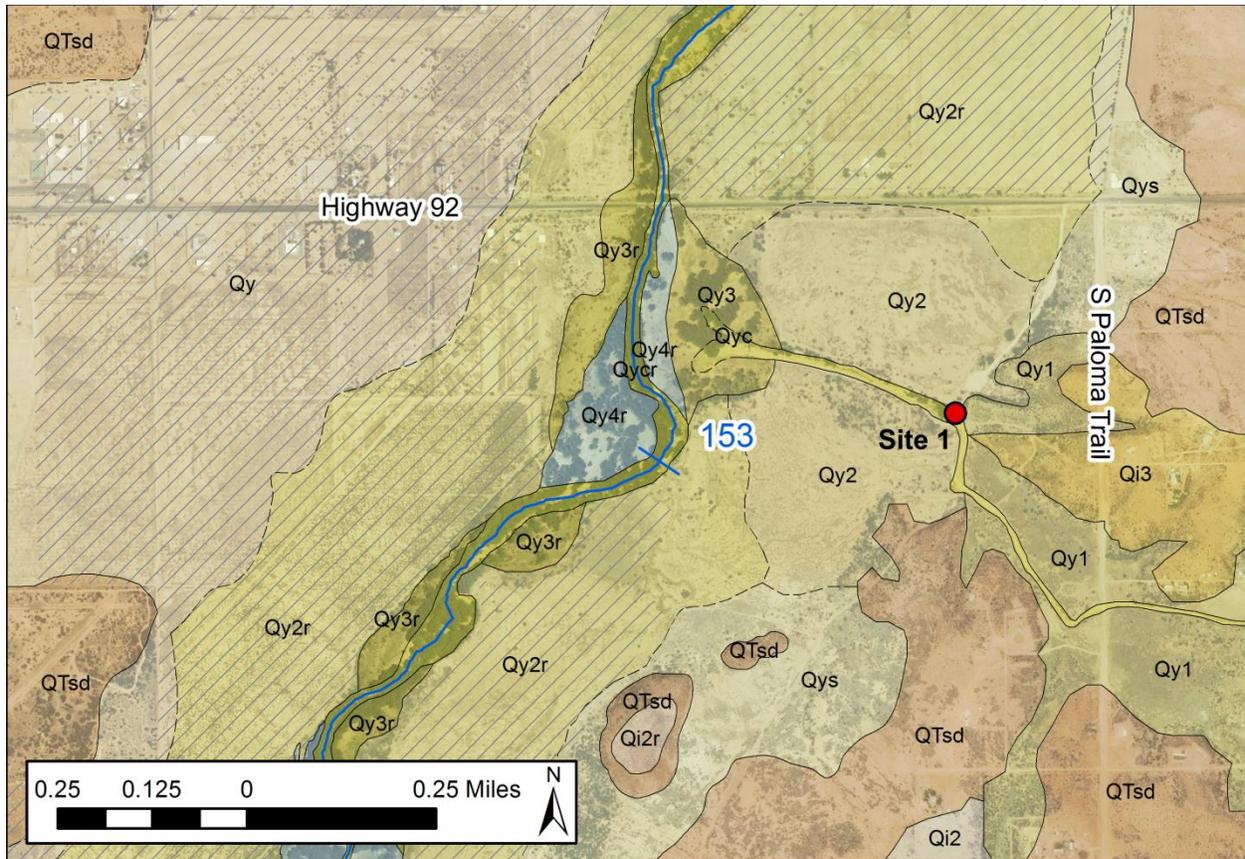
locations are depicted as red dots on figures in this document. Information regarding routes used to access each location is included for each site. If observations were made at a site, a brief description of the exposed sediment is provided followed by a stratigraphic interpretation of the exposed sedimentary relationships.

All surficial geologic map figures included in this report include geologic contacts and map units derived from AZGS DM-RM-1.2 (Cook et al., 2009) overlain on 2013, 1 meter resolution National Agricultural Imagery Program (NAIP) aerial imagery (USDA-FSA-APFO, 2013). Geologic unit descriptions for surficial and bedrock units appearing in figures are available in AZGS DM-RM-1.2.

Site 1

Potential exposure within Palominas Arroyo

San Pedro River mile marker 153 east



Site Location and Description

Palominas Arroyo exits confinement from rolling basin fill (QTsd) hills to the east, flowing west toward the San Pedro River at river mile 153 south (upstream) of Highway 92. A thin, broad, nearly semicircular fan (Qy2) was deposited prior to historical incision of Palominas Arroyo driven by the downcutting of the San Pedro River. Arroyo walls exceed 15-20 ft tall in places. Recent archaeological studies in Palominas Arroyo (Ballenger, 2010) suggest all sediment exposed in arroyo walls was deposited in the Holocene. San Pedro River gravels and channel sediments are exposed at site 1 where Palominas Arroyo bends to the west.

Because this location corresponds with the topographic surface expression of nearby basin fill deposits which predate the Holocene San Pedro River it is likely this exposure offers the best known example of otherwise buried Holocene San Pedro channel deposits adjacent to basin fill bluffs outside the modern channel.

Site Access

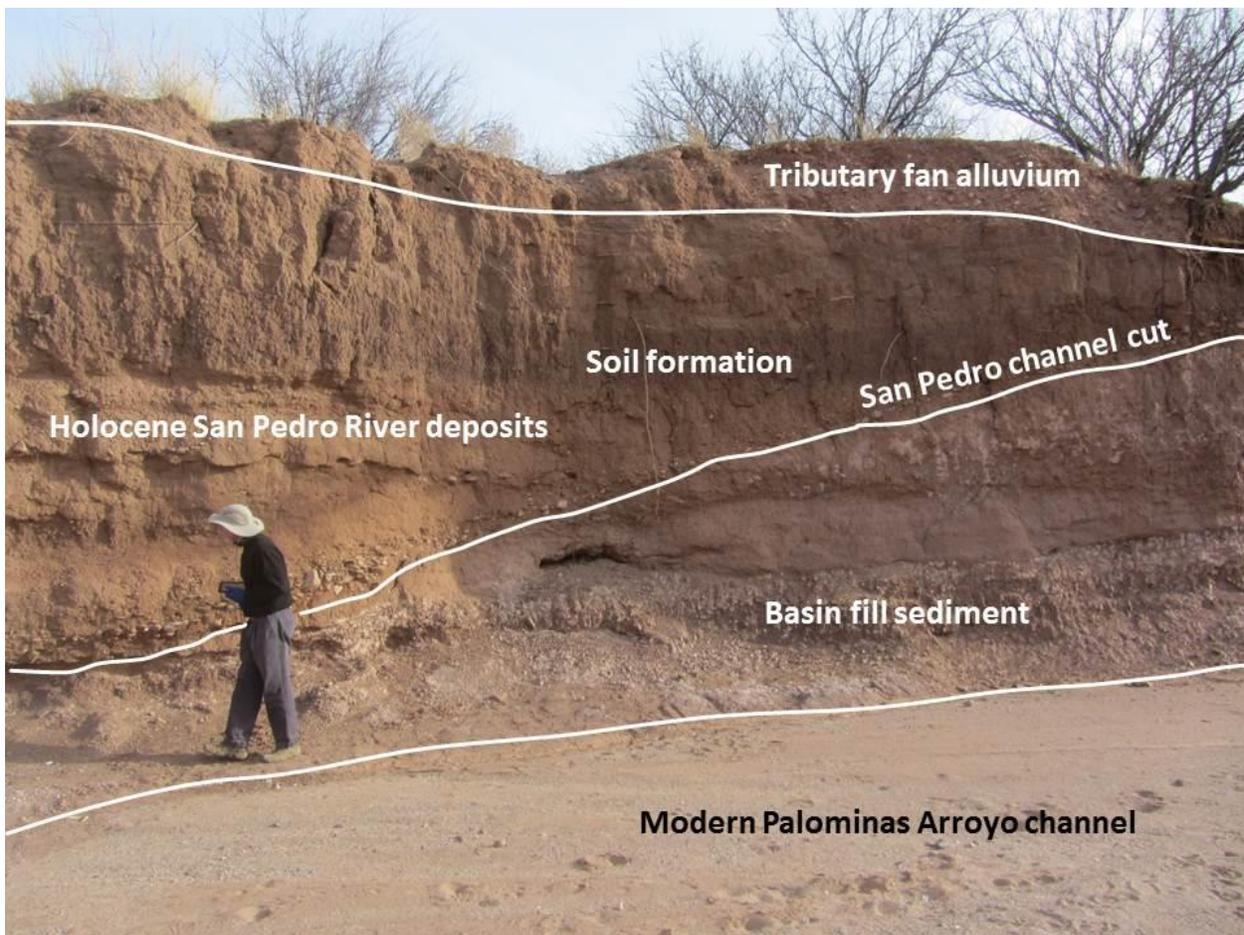
Palominas Arroyo is accessible where it crosses S Paloma Trail and from a San Pedro Riparian National Conservation Area (SPRNCA) parking lot just northeast of the red dot in the figure above. Observations regarding this site are presented on the following pages.

Site 1

Photo SPR153E_A

Exposure within Palominas Arroyo

San Pedro River mile marker 153 east

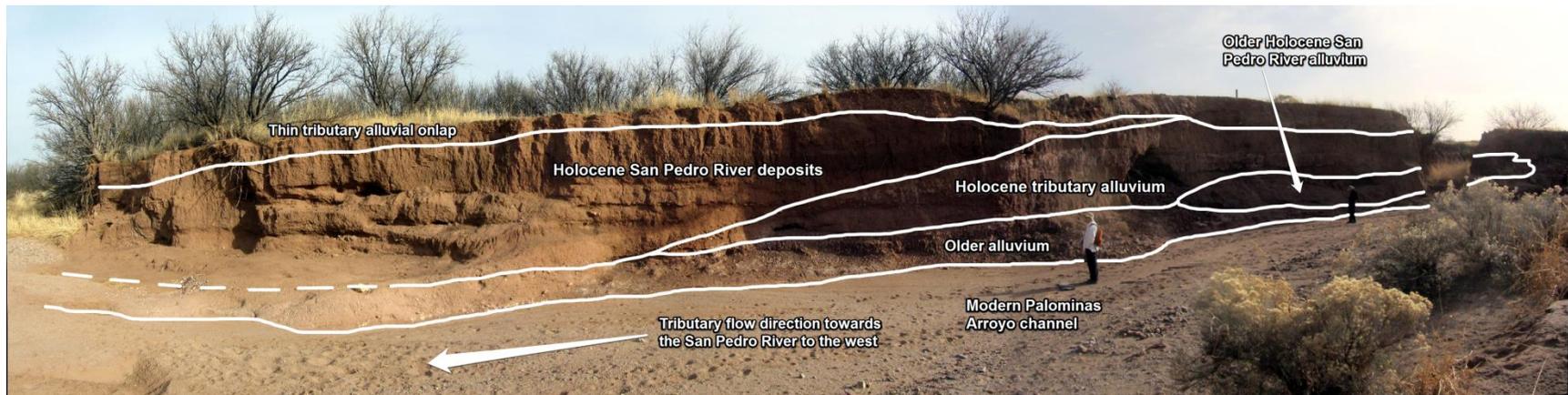


Site 1

Photo SPR153E_B

Exposure within Palominas Arroyo

San Pedro River mile marker 153 east



Description of Tributary Arroyo Exposures

A coarse, poorly sorted sand and angular to sub-angular gravel layer is present at the top of the Palominas Arroyo exposure. This base of this layer is in sharp erosional contact with underlying well-sorted, consolidated, fine to medium sand. Alternating layers of unconsolidated coarse sand with interbedded pebbles and gravel, fine reddened consolidated silts with thin clay films on blocky soil structure faces, and thin sub-rounded cobble beds are deposited above a broad erosional contact lined with rounded cobbles. The cobble-lined erosional unconformity cuts fine sandy to silty beds with abundant, well-cemented carbonate nodules up to several inches in diameter, moderately well-sorted, consolidated to poorly consolidated sandy deposits, and a second fine-grained, well-consolidated calcium carbonate nodule-rich deposit exposed at the base of the arroyo wall. The panoramic photo includes a broader view of cross cutting, erosional, and depositional sedimentary relationships exposed in the northern wall of Palominas Arroyo. Extensive beds of poorly to moderately sorted sand and gravel deposits overlie thick lenses of well-rounded and lithologically diverse pebbles and small cobbles.

Two distinct beds of carbonate nodule-rich sandy to silty alluvium are exposed in arroyo walls as far upstream as an abrupt incised tributary arroyo channel cut.

Stratigraphic Interpretation

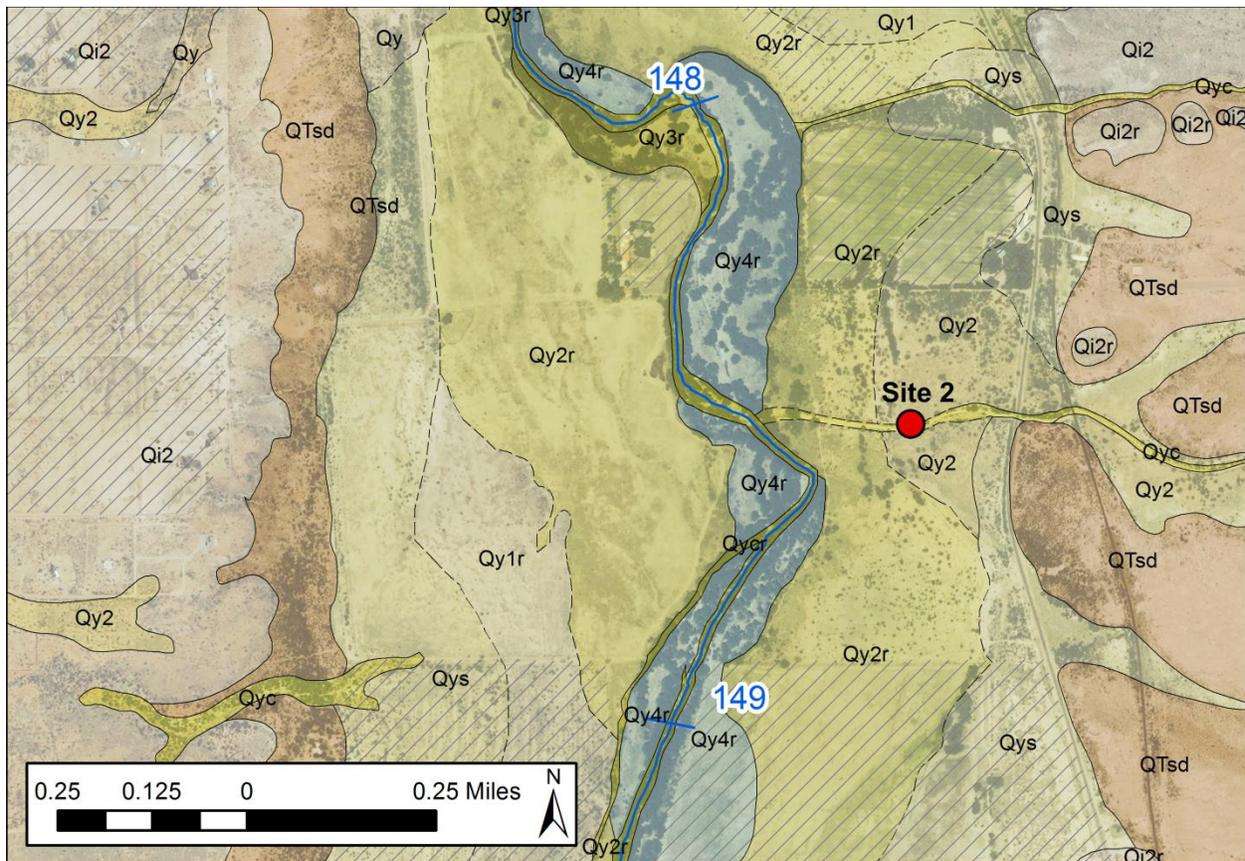
The prominent sloping, cobble-lined, erosional unconformity exposed in the arroyo wall is interpreted as the base of a large paleochannel of the San Pedro River. Deposits immediately above this contact are interpreted as San Pedro River deposits. The finer grained portion of the San Pedro deposit is characterized by well-sorted, medium to dark brown fine grained sandy beds, buried soils, and laminated fine sandy interbeds. Following deposition of river alluvium by the San Pedro, a thin cover of tributary fan alluvium was deposited on top. This deposit consists of lighter brown, poorly sorted sand and gravel including angular to sub-angular clasts. This thin fan cover extends far to the west, nearly to the modern San Pedro River channel. Well-cemented layers exhibiting multiple horizons of calcium carbonate nodule formation are cut by the San Pedro channel. These indurated layers may be a topographic high of underlying basin fill deposits or an older, possibly Pleistocene, tributary or river deposit. Isolated lenses of well-rounded pebbles and cobbles within more poorly sorted, angular clast-bearing alluvium below the upper carbonate-rich layer indicate interfingering deposition of San Pedro River and tributary alluvium occurred here in the past. Because these pebble and cobble lenses are stratigraphically below the upper carbonate nodule-rich layer which is cut by a large San Pedro paleochannel they must be older than the prominent paleochannel. San Pedro Channel deposits pinch out immediately upstream of this location; therefore these deposits appear to represent the maximum lateral extent of Holocene San Pedro River deposits exposed at the surface in Palominas Arroyo. It seems clear the Holocene San Pedro eroded into older deposits as far from the modern channel as the topographic expression of basin fill bluffs lining the east side of the modern San Pedro trough. Today the river is incised into its own Holocene floodplain deposits but earlier in the Holocene the active channel carved a path through basin fill alluvium at this location. Recent archaeological studies (Ballenger, 2010) indicate all exposed sediment in Palominas Arroyo may be Holocene in age.

Holocene San Pedro deposits exposed in Palominas Arroyo are located as much as 2,200 ft outside mapped Holocene river deposits on AZGS surficial maps.

Site 2

Potential exposure within Spring Creek

San Pedro River mile marker 148.5 east



Site Location and Description

Spring Creek enters the San Pedro River from the east at river mile 148.5. The arroyo was not well incised, exposing only the uppermost few feet of tributary alluvium. No exposures of underlying sedimentary relationships were observed. *No observations were made at this location due to lack of exposure.*

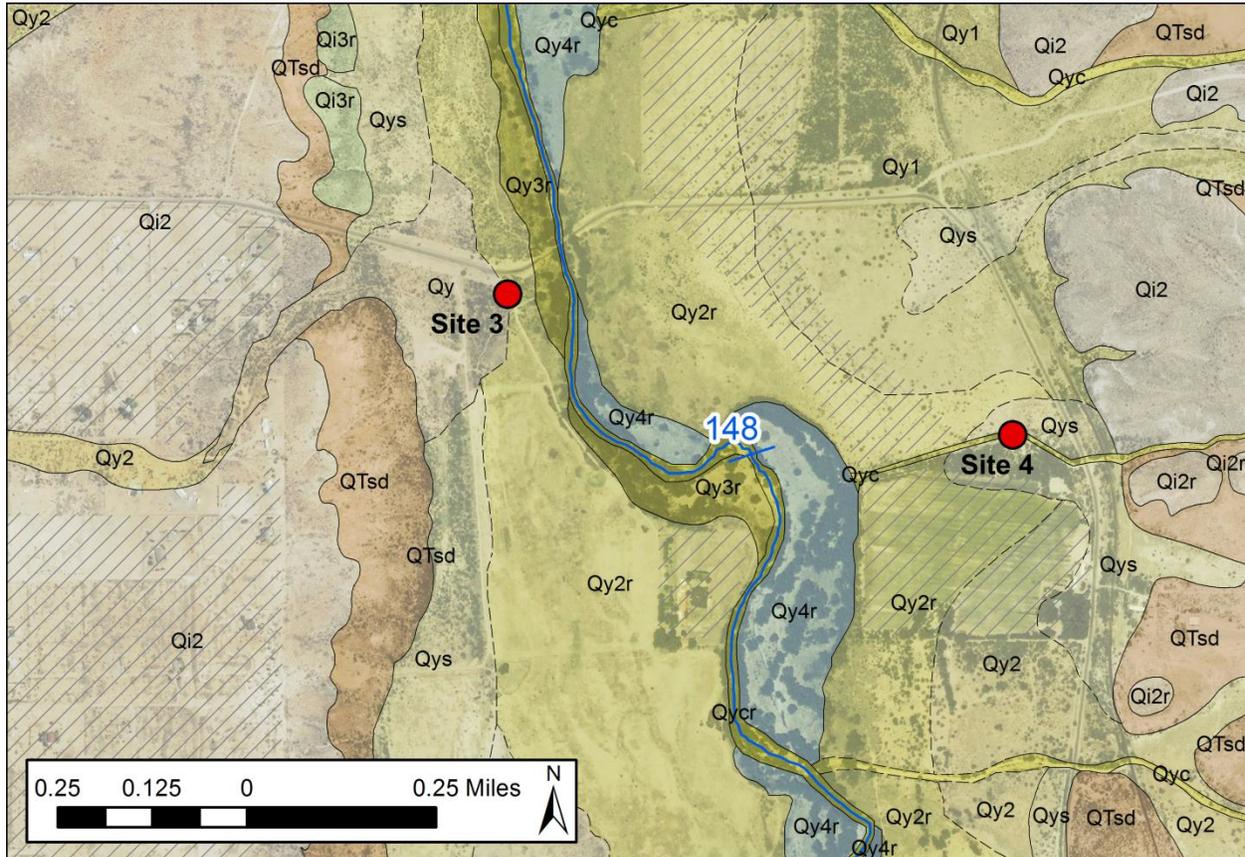
Site Access

Spring Creek was accessed from where the arroyo passes beneath S Hereford Rd. The arroyo was traversed from the road to the San Pedro River but no suitable exposures were encountered.

Site 3 and 4

Potential exposure at the base of a Holocene tributary fan near the E Hereford Rd bridge and within an unnamed arroyo

San Pedro River mile marker 148 west (site 3) and east (site 4)



Site Location and Description

The arroyo entering the San Pedro River from the east side and the broad fan deposited nearly to the San Pedro at E Hereford Rd on the west side near river mile 148 did not provide good exposures of underlying sedimentary relationships. The arroyo was not well incised and the broad fan was largely unincised and covered by thick vegetation near the river. *No observations were made at these locations due to lack of exposure.*

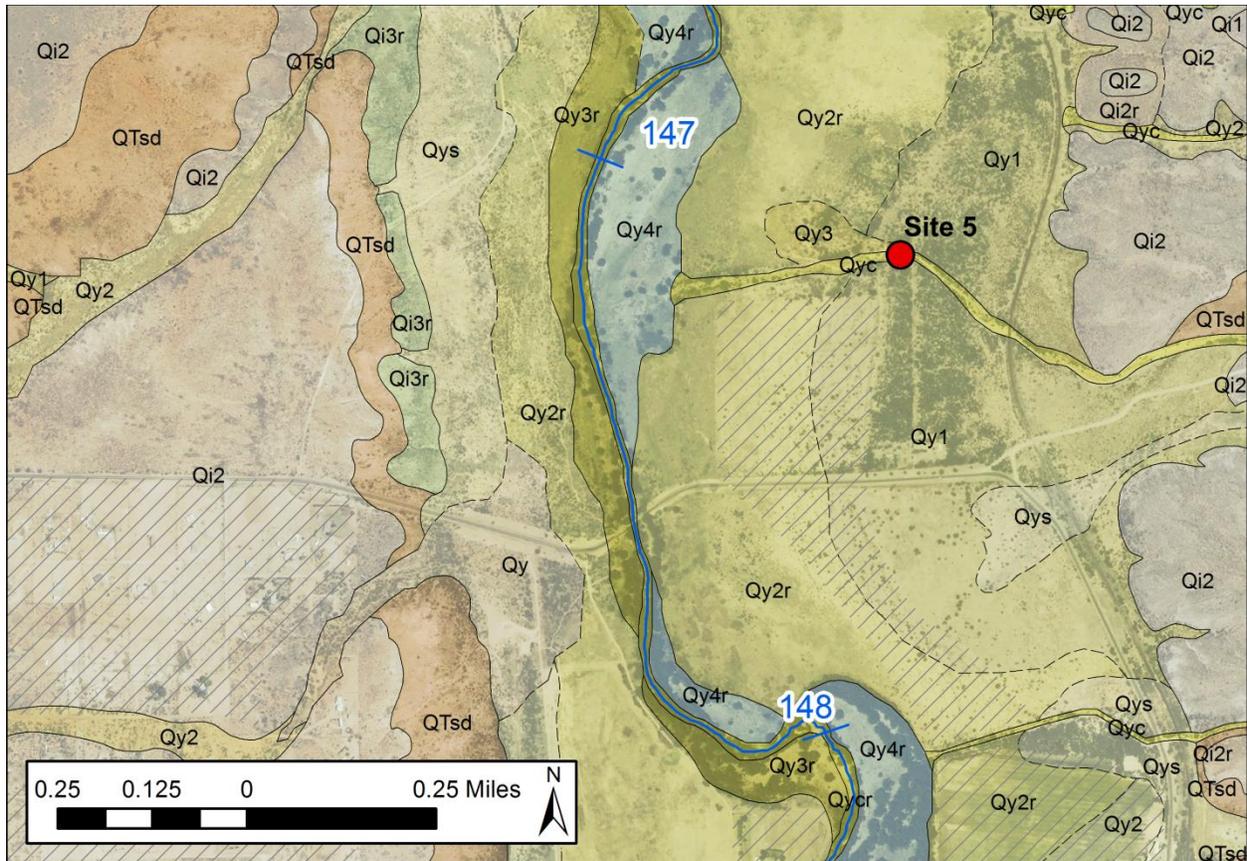
Site Access

The unnamed arroyo on the east side of the San Pedro was accessed from S Hereford Rd and traversed beyond the mapped tributary fan boundary. The base of the tributary fan near the E Hereford Rd bridge was accessed from a parking area immediately south of the road near the bridge. No suitable exposures were encountered at either location.

Site 5

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 147 east



Site Location and Description

The arroyo entering the San Pedro River from the east side near river mile 147 was not well incised and offered no exposure of more deeply buried sedimentary relationships. *No observations were made at this location due to lack of exposure.*

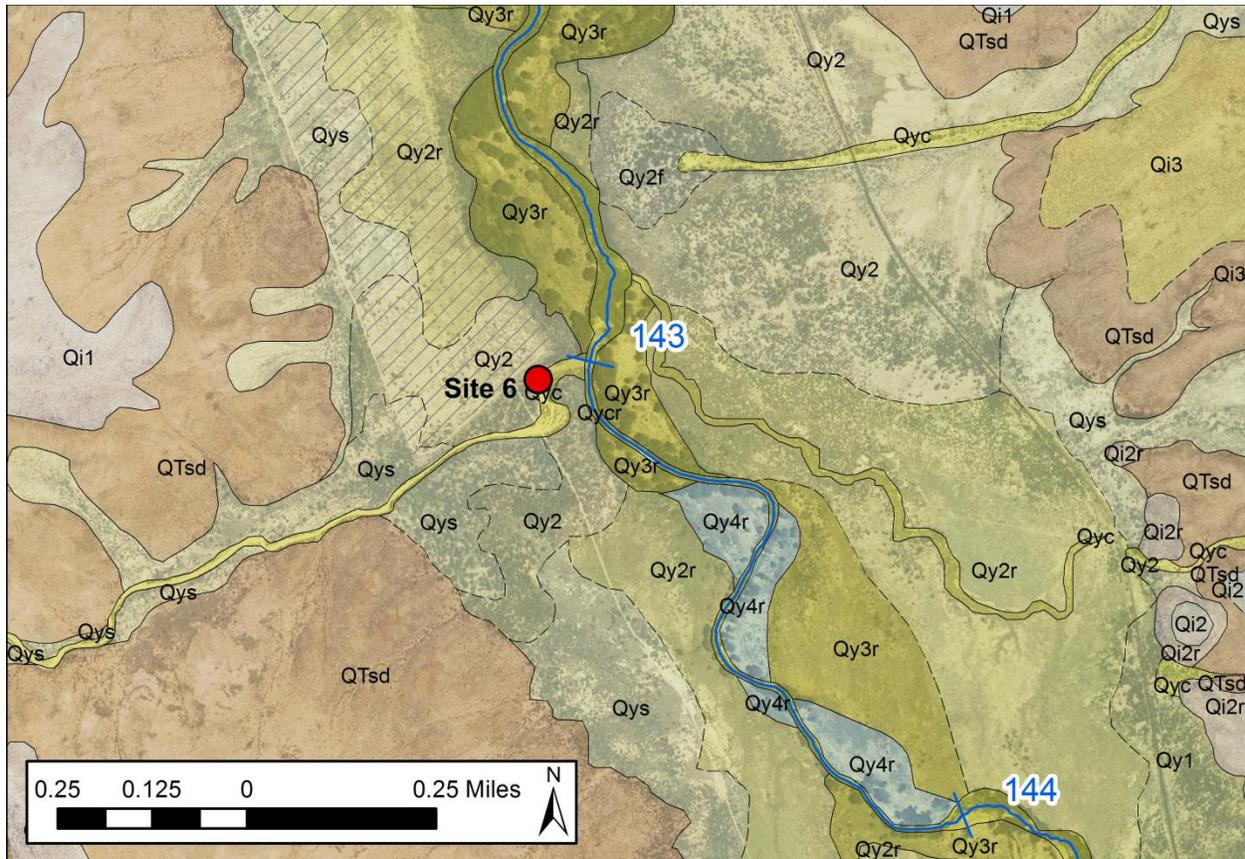
Site Access

This arroyo was accessed from the historic railroad bed running north-south along the east side of the San Pedro River at this location.

Site 6

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 143 west



Site Location and Description

This site is located within SPRNCA boundaries. Small incised arroyos exiting well-eroded basin fill (QTsd) deposits along the west side of the San Pedro River have deposited broad splays of tributary (Qy2 and Qys) alluvium dominantly composed of reworked basin fill sediment. The arroyos is sufficiently incised at site 6 to expose an interfingering depositional relationship between Holocene tributary (Qy2 and Qys deposits) and San Pedro floodplain (Qy2r deposits) alluvium.

Site Access

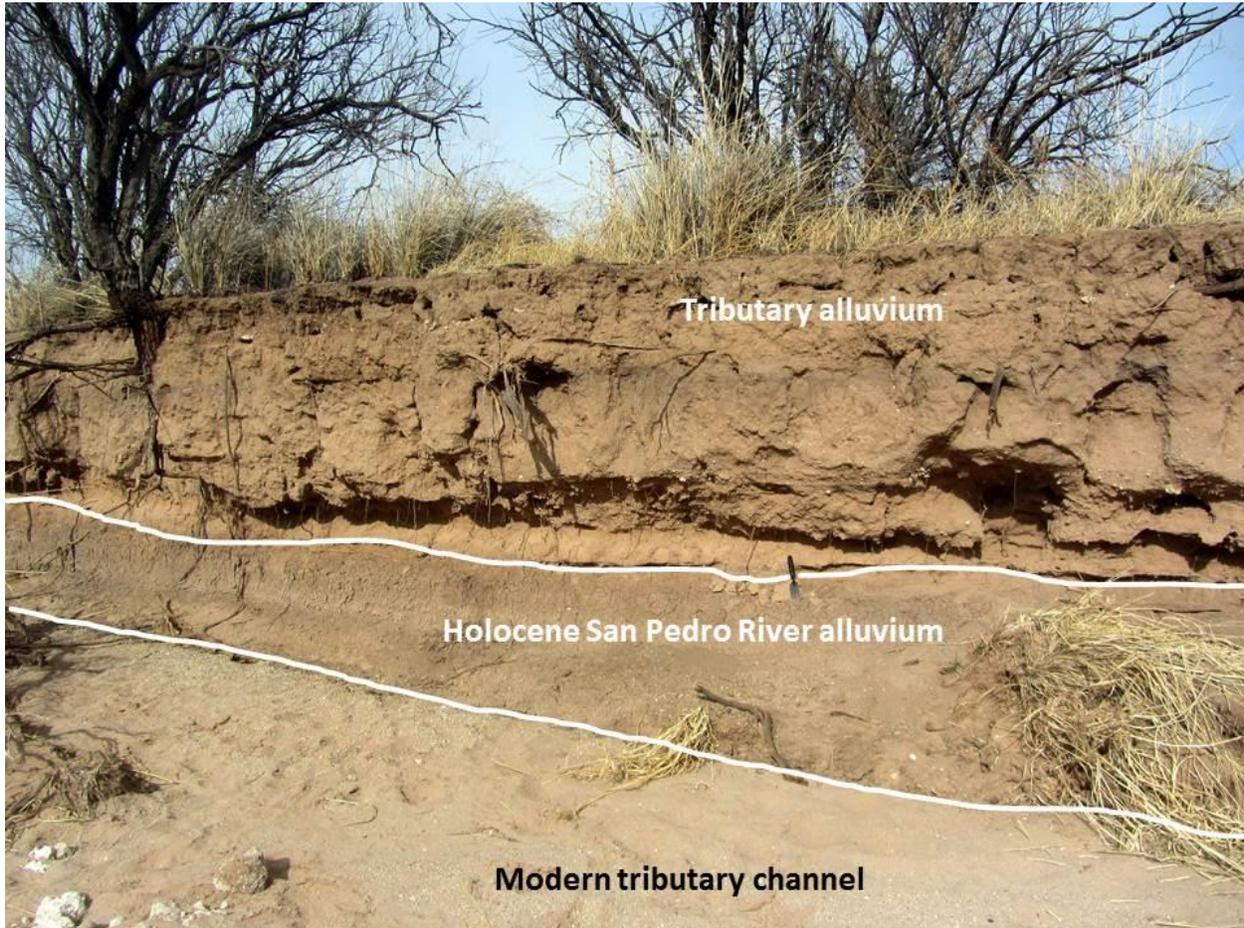
This arroyo was accessed from a former ranch road on the west side of the river within the SPRNCA now called the San Pedro Trail. Observations regarding this site are presented on the following pages.

Site 6

Photo SPR143W

Exposure within an unnamed tributary channel

San Pedro River mile marker 143 west



Description of Tributary Arroyo Exposures

Note trowel located right of center at contact for scale. Light brown, poorly sorted sandy to pebbly Holocene alluvium overlies well-sorted, medium brown, consolidated, fine sandy to silty deposits exhibiting a banded appearance (soil development). Upper alluvium contains abundant calcium carbonate nodules identical to those found in basin fill hills to the west. Some of these nodules are evident in the lower left corner of the photo in the modern tributary channel.

Stratigraphic Interpretation

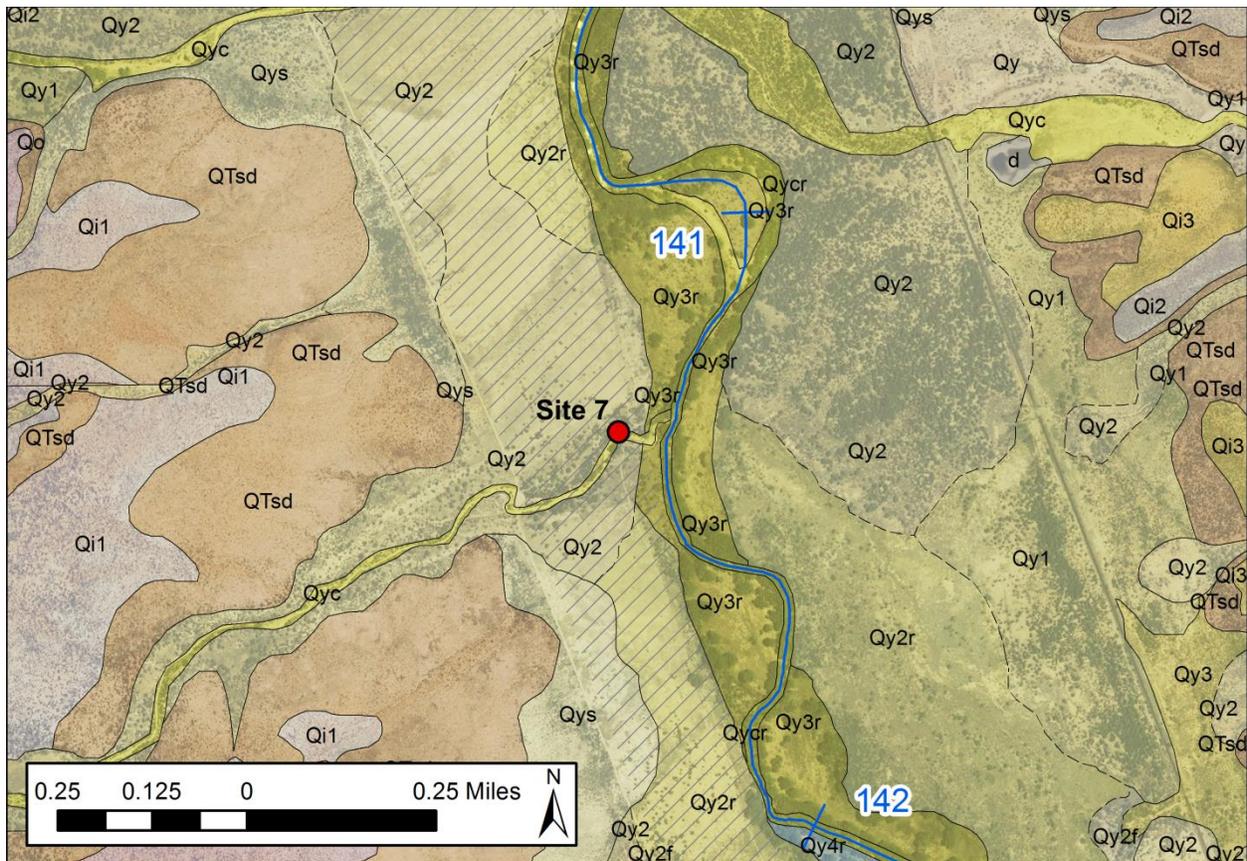
The poorly sorted alluvium containing calcium carbonate nodules is interpreted as tributary alluvium composed mainly of reworked basin fill sediment. This deposit overlies a much better sorted, fine-grained deposit consistent with floodplain deposition by the San Pedro River.

These exposures of fine grained floodplain alluvium are located up to 300 ft outside the mapped boundary of Holocene river alluvium on AZGS surficial maps. These fine-grained San Pedro deposits become buried a short distance upstream and are no longer exposed in the arroyo wall so the maximum lateral extent of these deposits is not visible.

Site 7

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 141.5 west



Site Location and Description

This site is located within SPRNCA boundaries. Small incised arroyos exiting well-eroded basin fill (QTsd) deposits along the west side of the San Pedro River have deposited broad splays of tributary (Qy2 and Qys) alluvium dominantly composed of reworked basin fill sediment. The arroyo at site 7 is sufficiently incised to expose an interfingering depositional relationship between Holocene tributary (Qy2 and Qys deposits) and San Pedro floodplain (Qy2r deposits) alluvium.

Site Access

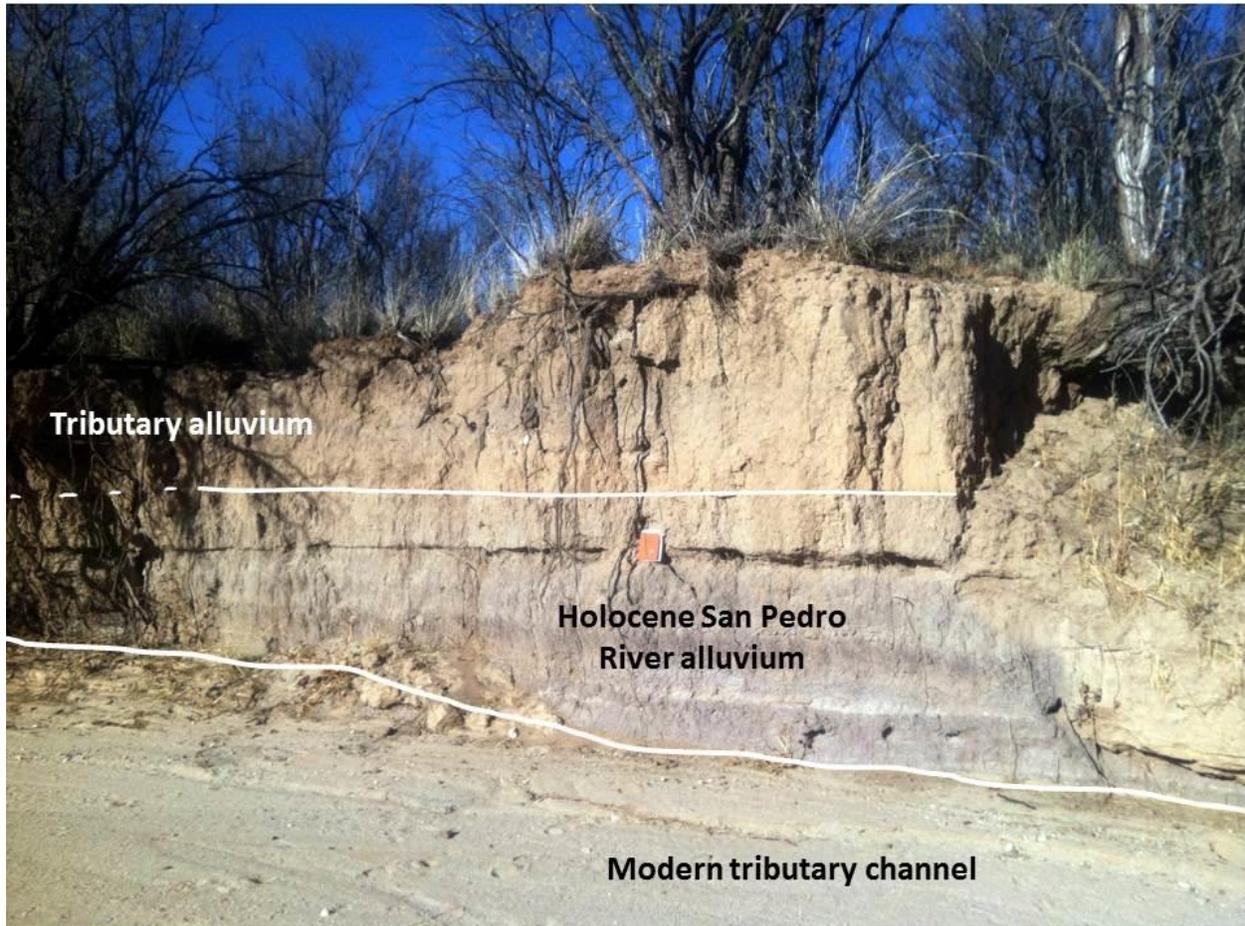
This arroyo was accessed from a former ranch road on the west side of the river within the SPRNCA now called the San Pedro Trail. Observations regarding this site are presented on the following pages.

Site 7

Photo SPR141.5W

Exposure within an unnamed tributary channel

San Pedro River mile marker 141.5 west



Description of Tributary Arroyo Exposures

Poorly sorted sandy to gravelly, latest Holocene to historical deposits overlie well-sorted, fine sand to silt dominated deposits. The upper poorly sorted alluvium exhibits angular to sub angular clasts and an abundance of calcium carbonate nodules identical to those found in well-eroded basin fill deposits to the west (upstream of this portion of the tributary channel). The underlying alluvium is much finer grained, consisting of silt to fine sand and exhibits soil development.

Stratigraphic Interpretation

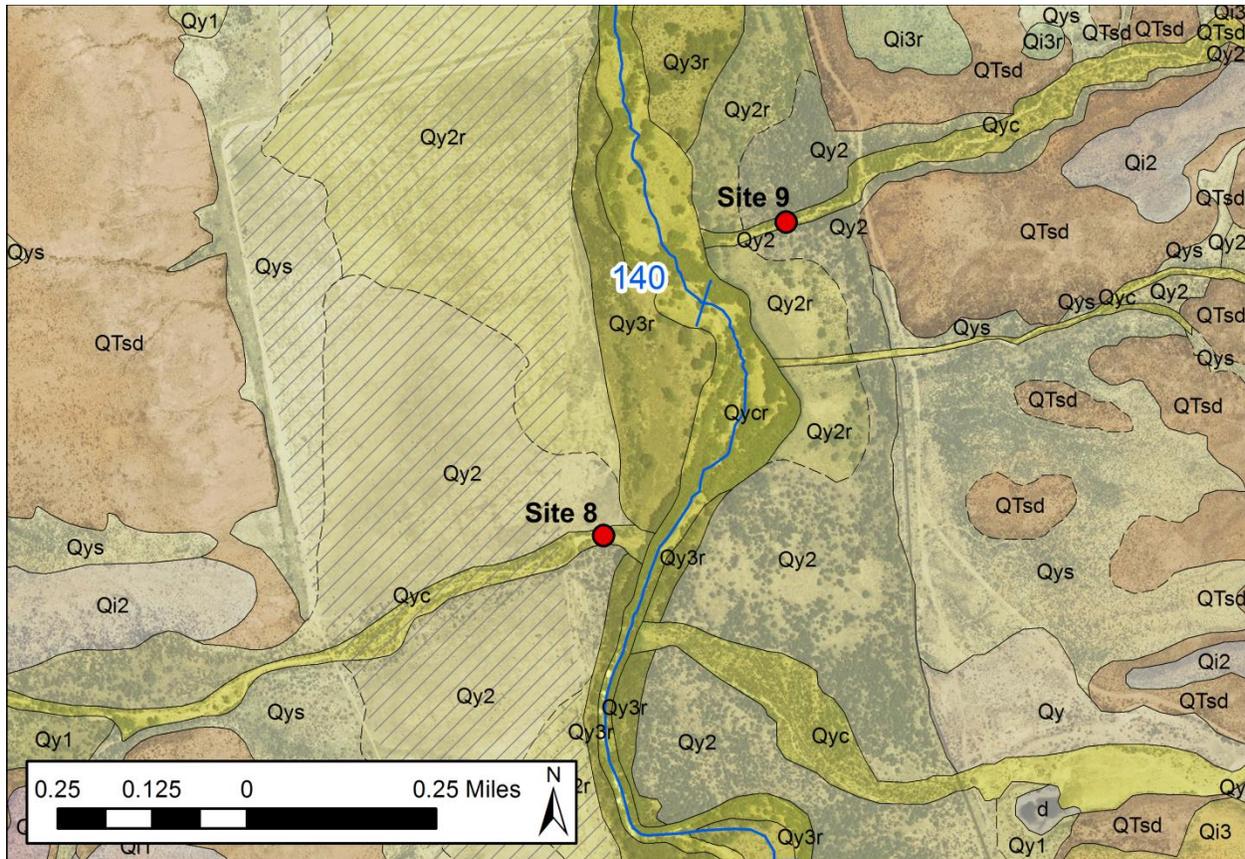
The poorly sorted alluvium containing angular clasts and abundant calcium carbonate nodules is interpreted to be tributary alluvium dominantly composed of reworked basin fill sediment. These tributary deposits overlie a much better sorted, fine-grained deposit consistent with floodplain deposition by the San Pedro River. The gray soil layers in the floodplain alluvium are apparent in other exposures of San Pedro floodplain and channel deposits to the south (site 6) and may reflect a period of regional landscape stability along the San Pedro River prior to burial by progradation of tributary alluvial fans.

These exposures of fine grained floodplain alluvium are located up to 175 ft outside the mapped boundary of Holocene river alluvium on AZGS surficial maps. These fine-grained San Pedro deposits become buried a short distance upstream and are no longer exposed in the arroyo wall so the maximum lateral extent of these deposits is not visible.

Site 8 and 9

Potential exposure within unnamed tributary channels

San Pedro River mile marker 140 west (site 8) and 140.5 east (site9)



Site Location and Description

Small incised arroyos enter the San Pedro River from both sides near river mile 140. Incision along the west side arroyo (site 8) was insufficient to expose sedimentary relationships between tributary drainage and San Pedro River alluvium. The only means of access to the arroyo on the east side (site 9) was miles of old railroad bed inaccessible to vehicles. *No observations were made at either of these locations due to lack of exposure and difficulty of access.*

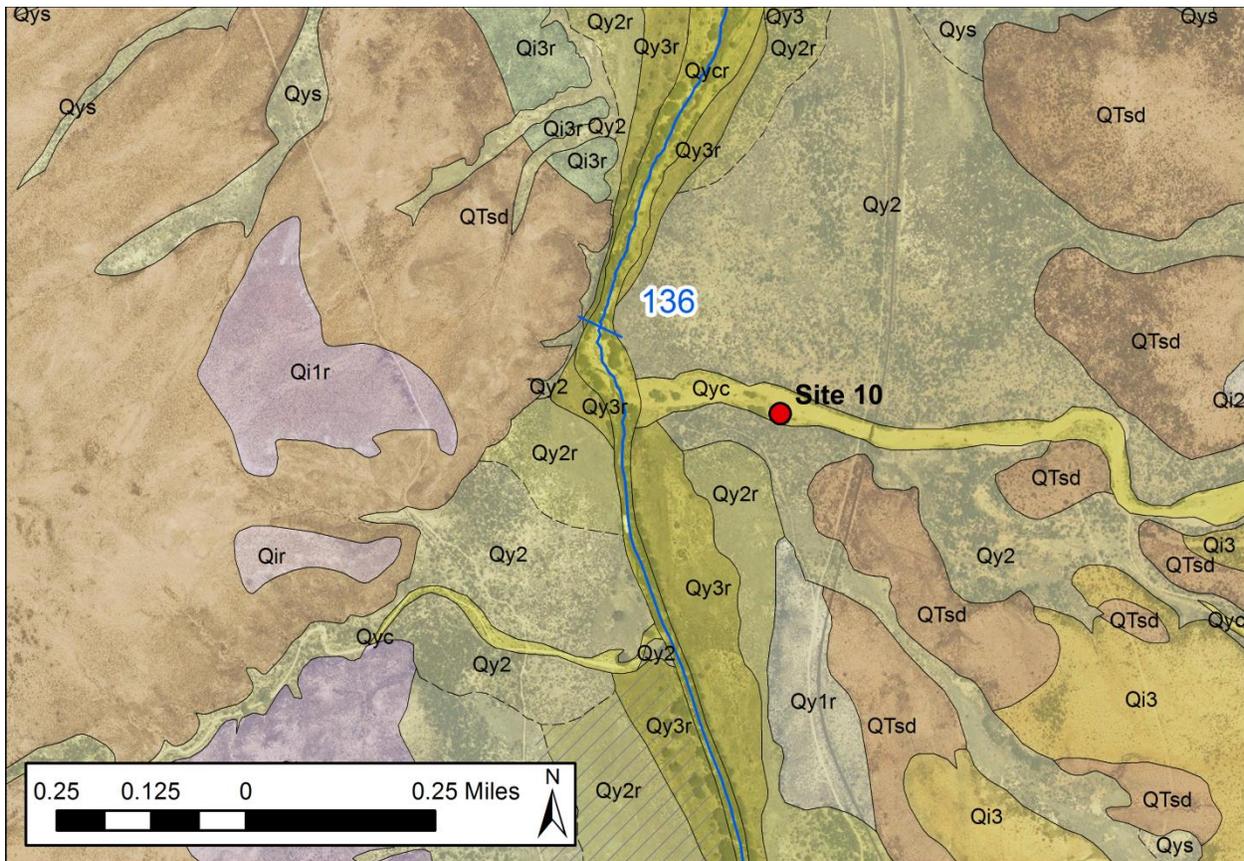
Site Access

This arroyo on the west side of the San Pedro at mile 140.5 (site 8) was accessed from a former ranch road on the west side of the river within the SPRNCA now called the San Pedro Trail. The arroyo on the east side of the San Pedro at mile 140 (site 9) was not accessed due to remoteness and difficulty of access along the east side of the river at this location.

Site 10

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 136 east



Site Location and Description

A large incised tributary drainage joins the San Pedro River from the east near river mile 136. Incision along the arroyo was insufficient to expose sedimentary relationships between tributary and river deposits. Only tributary deposits are exposed in arroyo walls. *No observations were made at this location due to lack of exposure.*

Site Access

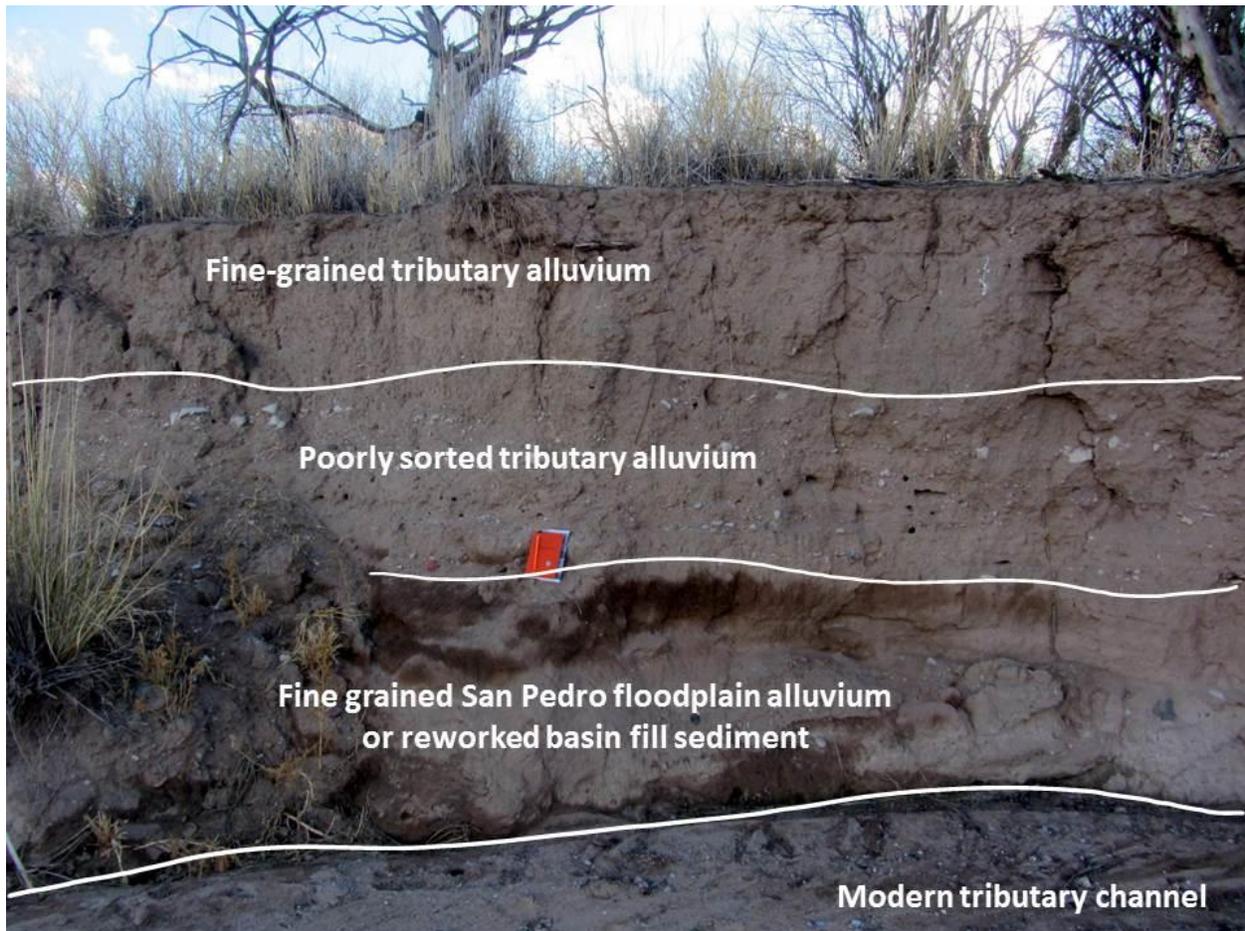
This arroyo was accessed from the historic railroad bed running north-south along the east side of the San Pedro River at this location.

Site 11

Photo SPR121.5E

Exposure within Walnut Gulch

San Pedro River mile marker 121.5 east



Description of Tributary Arroyo Exposures

Incision along lower Walnut Gulch has exposed alternating beds of poorly sorted, angular to sub angular clast-bearing alluvium and finer-grained, well-sorted, sandy to silty alluvium. Erosion of tributary channel walls at outside channel bends and recent bank collapse has provided excellent exposures of alluvial deposits at this location.

Stratigraphic Interpretation

The poorly sorted beds strongly resemble modern tributary channel bedload in Walnut Gulch. For this reason these deposits are interpreted to be derived from deposition by Walnut Gulch. The well-sorted, finer-grained beds resemble deposits commonly

associated with Holocene San Pedro River floodplain deposition. It is also possible that the fine grained beds may be attributed to reworking of fine grained basin fill alluvium by Walnut Gulch.

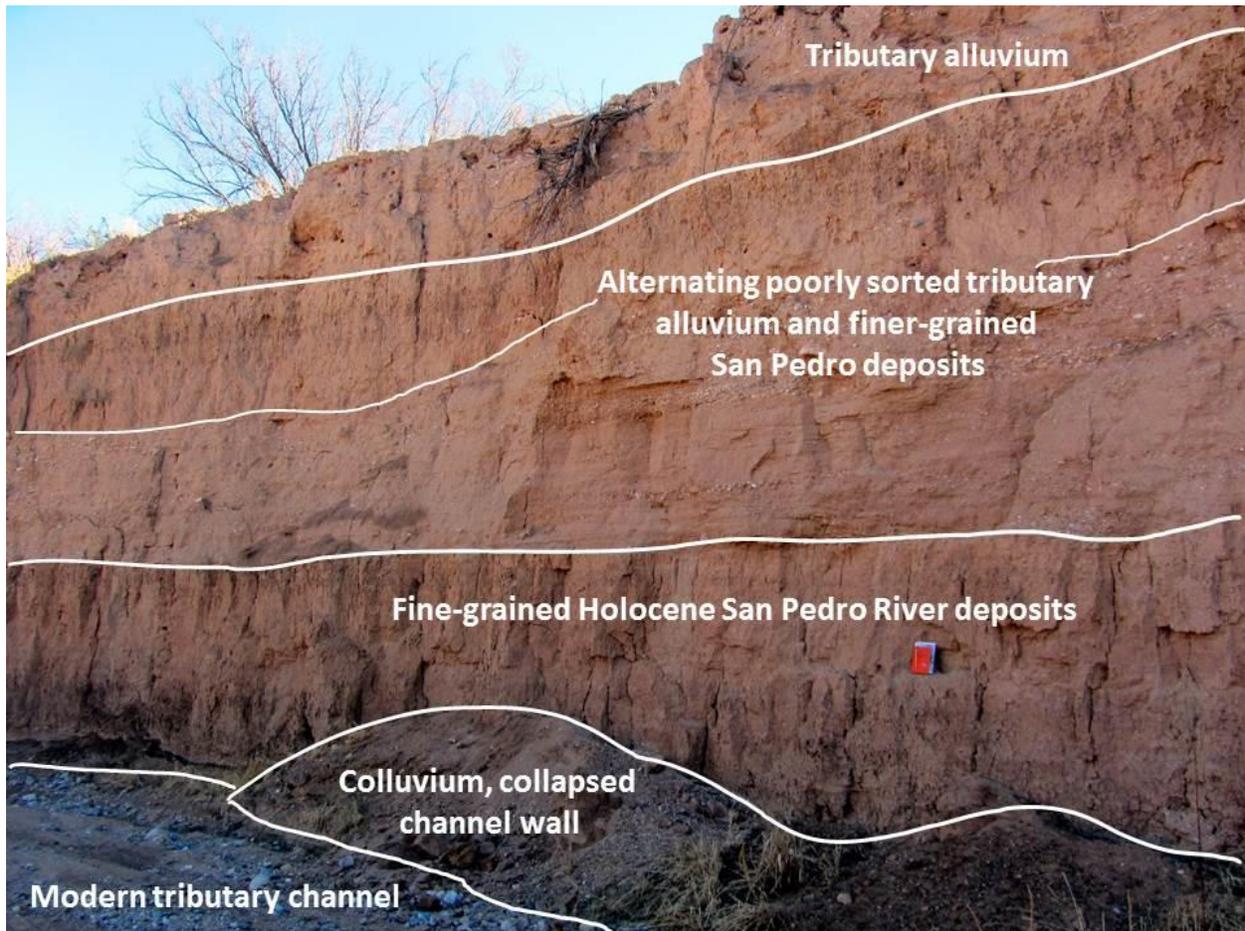
Because either mode of deposition could result in fine-grained deposition at this location, the origin of the fine grained layers cannot be conclusively determined based on field examination of these exposures.

Site 13

Photo SPR112W

Exposure within California Wash

San Pedro River mile marker 112 west



Description of Tributary Arroyo Exposures

Vertical channel walls of California Wash expose alternating beds of poorly sorted sandy to gravelly laminar and cross bedded sediment and well-sorted fine grained alluvium. The exposed sequence is aggradational but the base of some deposits exhibit erosion into underlying deposits. Mild to moderate buried soils are present in the finer grained deposits indicating a period of landscape stability. Elsewhere in California Wash possible archaeological material (a buried hearth) includes charcoal that could be used for age constraint of the deposit.

Stratigraphic Interpretation

The poorly sorted beds containing angular to sub angular clasts are interpreted to be tributary alluvial deposits while the well-sorted, fine-grained alluvium strongly resembles floodplain deposits exposed in the channel walls of the San Pedro to the east. The uppermost layer at the top of the sequence exhibits little to no soil development and appears to have been deposited recently, probably in historical times prior to widespread incision along the San Pedro River. Deposits exposed along California Wash record alternating deposition of Holocene tributary and San Pedro River alluvium prior to deposition of young prograding tributary fan alluvium at the surface (uppermost unit).

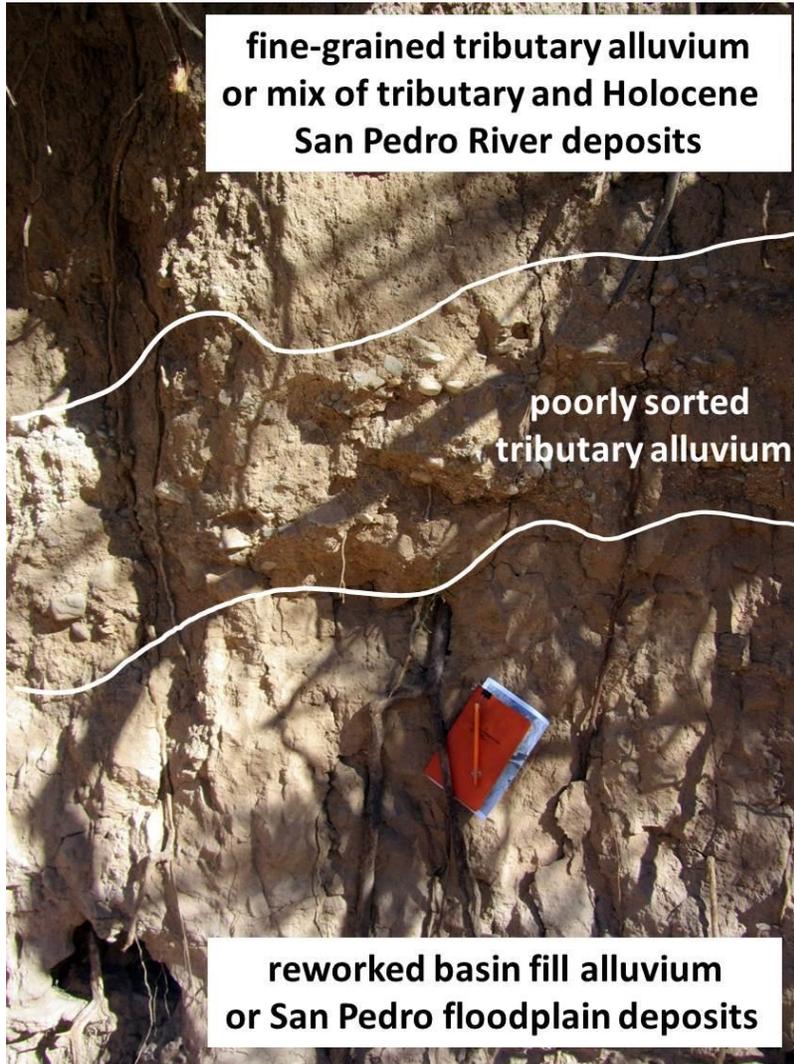
These exposures of Holocene San Pedro River alluvium are located up to 275 ft outside mapped deposits of Holocene river alluvium on AZGS surficial geologic maps.

Site 14

Photo SPR112E

Exposure within Clifford Wash

San Pedro River mile marker 112 east



Description of Tributary Arroyo Exposures

A moderately well-sorted, fine to medium-grained, sandy to pebbly deposit overlies coarse sandy, poorly sorted deposits with abundant angular pebble and small cobble clasts. These deposits overlie a fine-grained, massive deposit of medium to fine sand exposed at the base of the channel wall. An undulating erosional contact is evident between each layer in the exposure.

Stratigraphic Interpretation

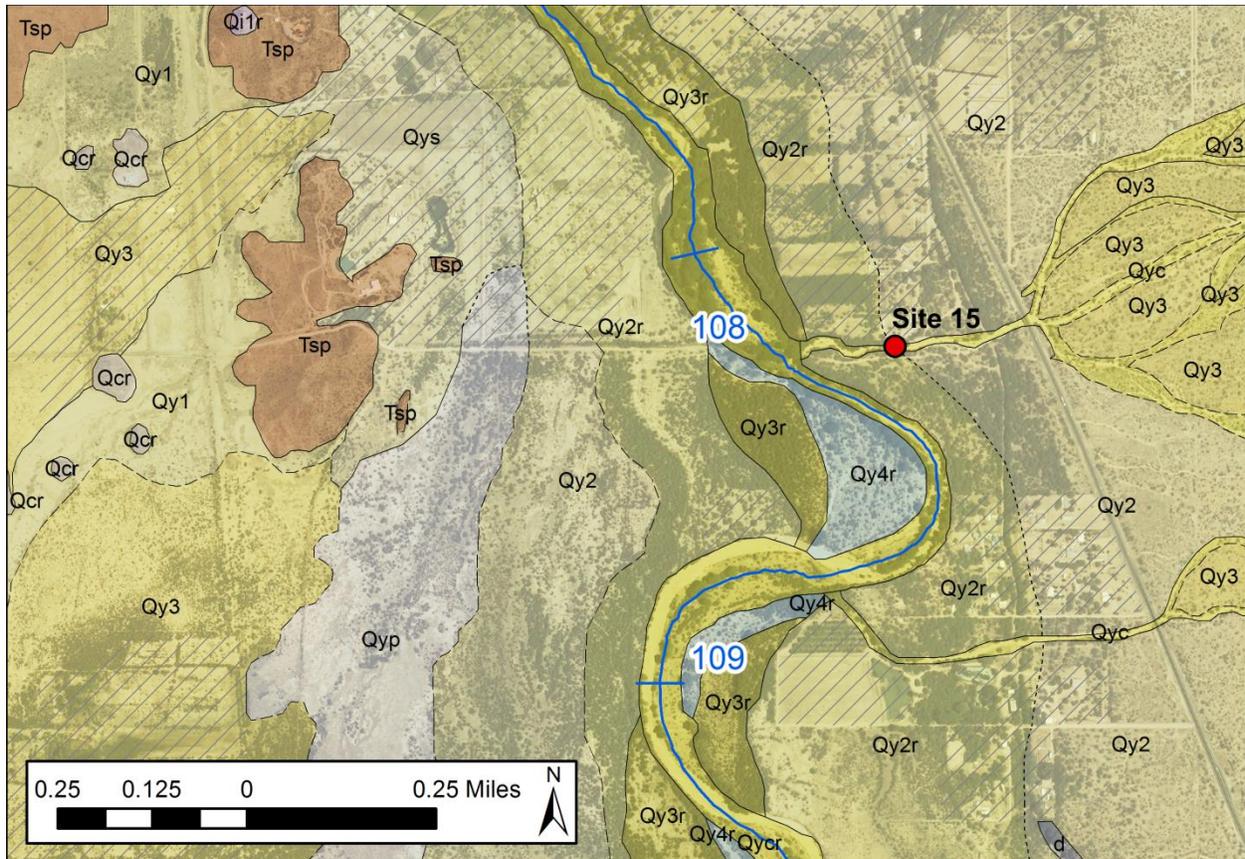
The upper moderately well-sorted deposits could be a mix of tributary (poorly sorted) and low energy river floodplain (well-sorted) alluvium or they could be attributed to lower energy deposition in a large distributary fan environment such as Clifford Wash. The middle deposits are interpreted as clearly deposited by a tributary drainage based on the presence of many angular and sub angular clasts and a close resemblance to the modern bedload of Clifford Wash. The lower, well-sorted, fine-grained alluvium resembles deposits commonly associated with Holocene San Pedro River floodplain deposition. It is also possible that the fine grained beds may be attributed to reworking of fine grained basin fill alluvium by Clifford Wash. Well-eroded basin fill hills are located upstream along Clifford Wash to the east.

Because either mode of deposition could result in fine-grained deposition at this location, the origin of the fine grained layers cannot be conclusively determined based on field examination of these exposures.

Site 15

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 108 east



Site Location and Description

A narrow arroyo joins the San Pedro from the east near river mile 108 south of St David, AZ. The arroyo incises through broad, low-relief tributary alluvial (Qy2) fans and Holocene (Qy2r) San Pedro deposits. Historically, agricultural fields straddled the boundary between tributary and river alluvium, obscuring the contact at the surface. Some of these fields are still cultivated today. Exposures of sedimentary relationships are present in the northern wall of the arroyo at site 15 in the figure above.

Site Access

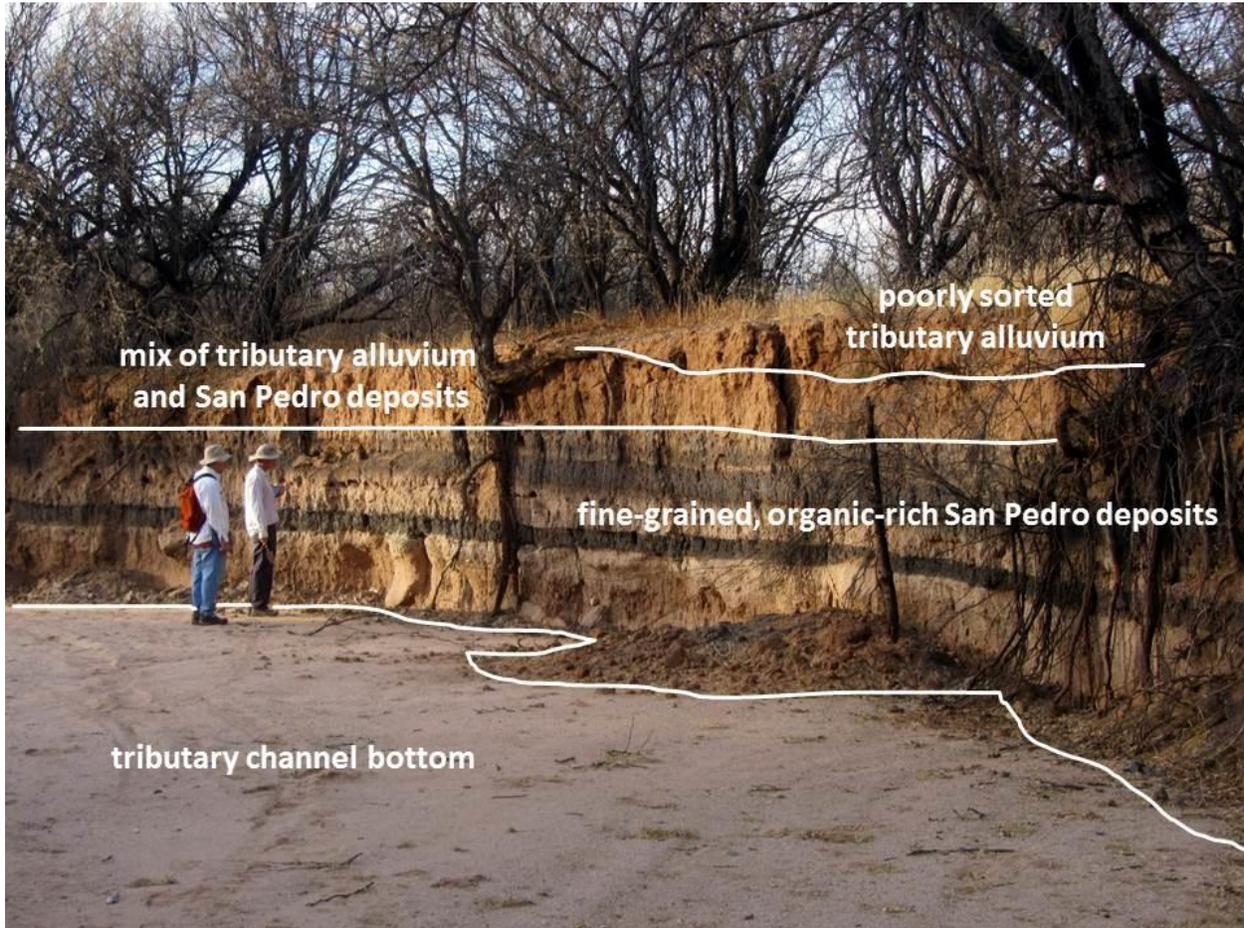
Site 15 is accessible by crossing the San Pedro River from the west by Escalante Crossing Rd or from the east by E Judd St. Observations regarding this site are presented on the following pages.

Site 15

Photo SPR108E

Exposure within an unnamed tributary channel

San Pedro River mile marker 108 east



Description of Tributary Arroyo Exposures

Exposures along the north channel wall at site 15 consist of fine-grained, moderately well-sorted alluvium with dark gray to black, organic-rich interbeds overlain by predominantly fine sandy alluvium with coarse sandy to pebbly interbeds. These deposits, in turn, are overlain by a thinning deposit of poorly sorted sandy to pebbly alluvium with angular to sub angular clasts. A wavy erosional contact into underlying sands is present at the base of the poorly sorted uppermost layer. A near vertical channel wall with fresh bank collapse provides excellent exposures of these alluvial units.

Stratigraphic Interpretation

The dark, organic-rich, banded fine-grained deposits are interpreted as low energy cienega-like San Pedro River alluvium. Springs were known to sustain wetlands in this area in the past. These dark layers could represent slow aggradation of organic-rich, swampy sediment prior to historical incision along this portion of the San Pedro River. Some of the dark banded layers appear to include angular sand and pebbles which may indicate mixing of tributary and San Pedro alluvium at the time of deposition. This location is very near the incised modern San Pedro channel yet the banded appearance is stratigraphically above the exposed channel walls so deposition of the organic-rich beds occurred prior to historical downcutting along the San Pedro. These deposits are overlain by more recent medium brown river alluvium and a mix of tributary deposits which becomes more apparent upstream along the incised tributary. The uppermost deposit that pinches out as it nears the San Pedro is interpreted as a thinning tributary fan deposit emplaced prior to historical incision of the San Pedro and headcutting of the tributary arroyo. This exposure is located at the mapped tributary fan/Holocene San Pedro alluvial boundary on the surface.

Exposures of San Pedro deposits extend upstream in the arroyo for approximately 20-30 ft where they become buried. Upstream of this point the exposed deposits consist entirely of tributary alluvium.

Site 16

Photo SPR107E

Exposure within Slavin Wash

San Pedro River mile marker 107 east



Description of Tributary Arroyo Exposures

Poorly sorted sandy to pebbly alluvium is interbedded with well-sorted, fine-grained alluvium. Deposits are noticeably less well sorted above the marked contact in the image above (GPS for scale). This exposure is very close to the mapped surficial boundary of tributary alluvial fans on AZGS surficial geologic maps although an interfingering relationship between tributary and river alluvium appears to exist in the subsurface.

Stratigraphic Interpretation

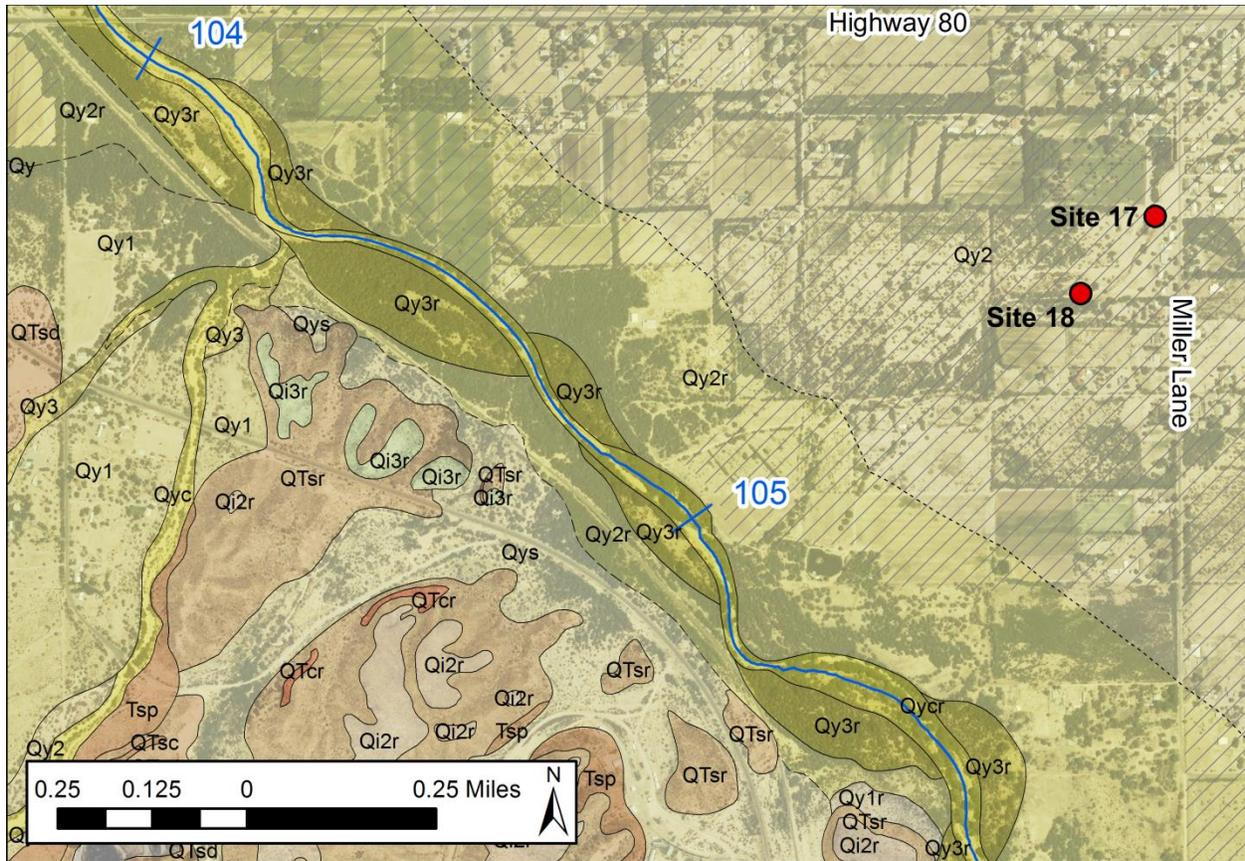
The poorly sorted sandy to pebbly alluvium is interpreted as tributary alluvium while the well-sorted fine-grained alluvium strongly resembles low energy San Pedro floodplain deposits exposed in river channel walls downstream. These well-sorted deposits could conceivably be related to distal tributary fan deposition or a combination of both tributary and river deposition.

In this location, close to the mapped boundary of the toe of tributary fans overlying fine grained Holocene San Pedro River deposits, it seems reasonable to associate the finer grained layers with dominant deposition by the San Pedro River.

Site 17 and 18

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 105 east



Site Location and Description

Broad, very low relief, largely unincised tributary (Qy2) alluvium sourced from heavily eroded basin fill bluffs to the E/NE slopes gradually toward the San Pedro River to the SW in St David, AZ. A rare incised arroyo west of Miller Lane (sites 17 and 18 in the figure above) south of Hwy 80 exposes recent historically disturbed tributary sediment as well as possible interfingering deposits of river and tributary alluvium.

Site Access

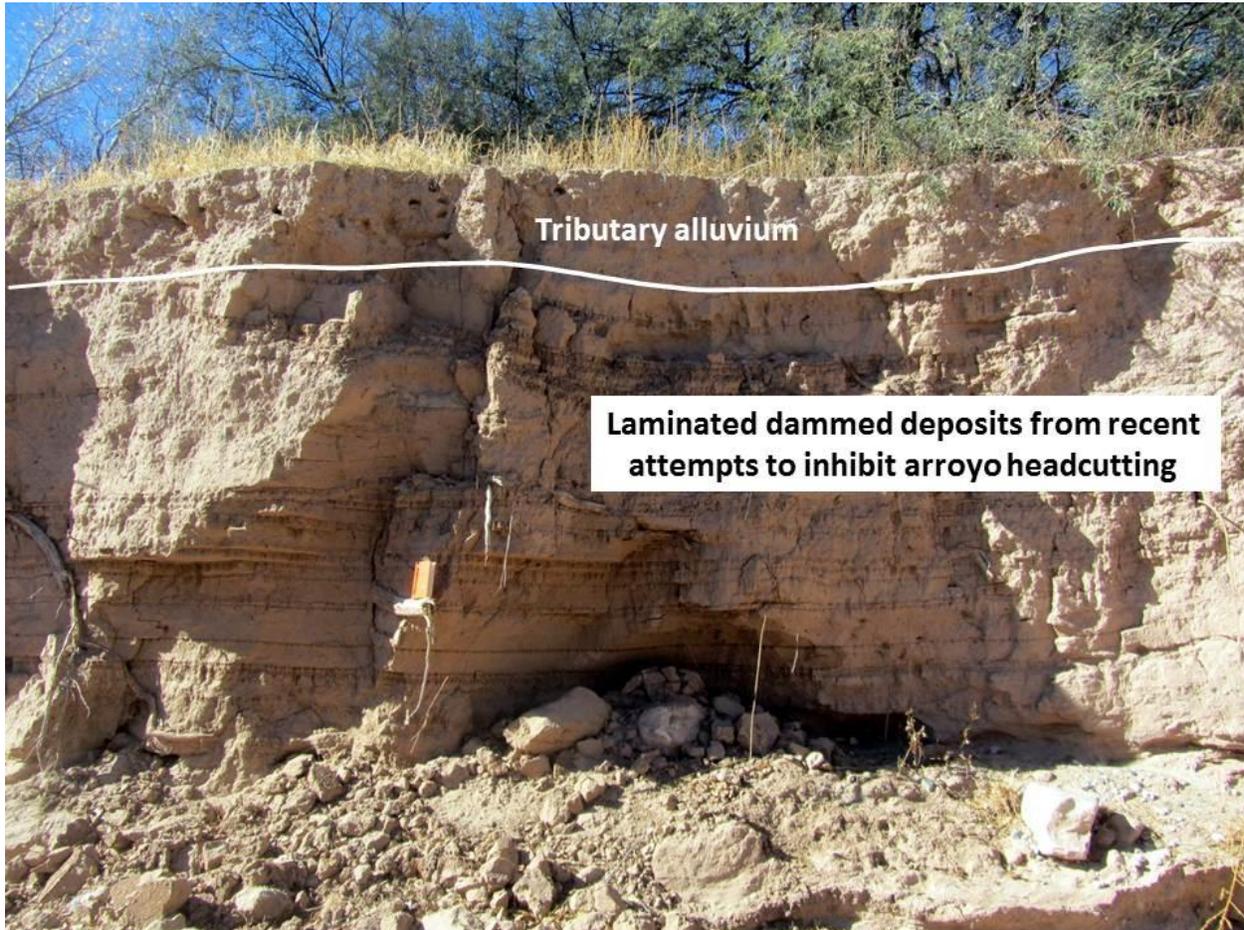
This site was accessed from an empty dirt lot adjacent to Miller Lane south of Highway 80 in St David, AZ. Observations regarding this site are presented on the following pages.

Site 17

Photo SPR105E_A

Exposure within an unnamed tributary channel

San Pedro River mile marker 105 east



Description of Tributary Arroyo Exposures

The northern arroyo wall just west of Miller Lane exposes thick deposits (field notebook for scale) of well-sorted, laminar, fine to medium sandy alluvium beneath poorly sorted sandy to gravelly deposits at the top of the arroyo wall. Thick piles of large chunks of rebar-reinforced concrete lie immediately upstream in an attempt to inhibit further erosion and property loss along the headcutting arroyo. Further headcutting of the arroyo would cut access to nearby homes and erode property very near existing homes. Conversations with residents indicate extensive effort aimed at halting further incision along this arroyo has been attempted since the 1980s including a concrete and earthen dam downstream of this exposure which has since been eroded away by the arroyo.

Stratigraphic Interpretation

The laminated beds apparent in this exposure are interpreted as a result of deposition of fine sands into standing water ponded upstream of a dam formerly spanning the arroyo downstream of this exposure. Poorly sorted sands and gravels overlying the laminar deposits are interpreted as prograding tributary alluvium atop the sand and sediment that gradually filled the area behind the dam. Once channel flow overtopped the dam it failed and was subsequently eroded away again allowing headcutting along the arroyo.

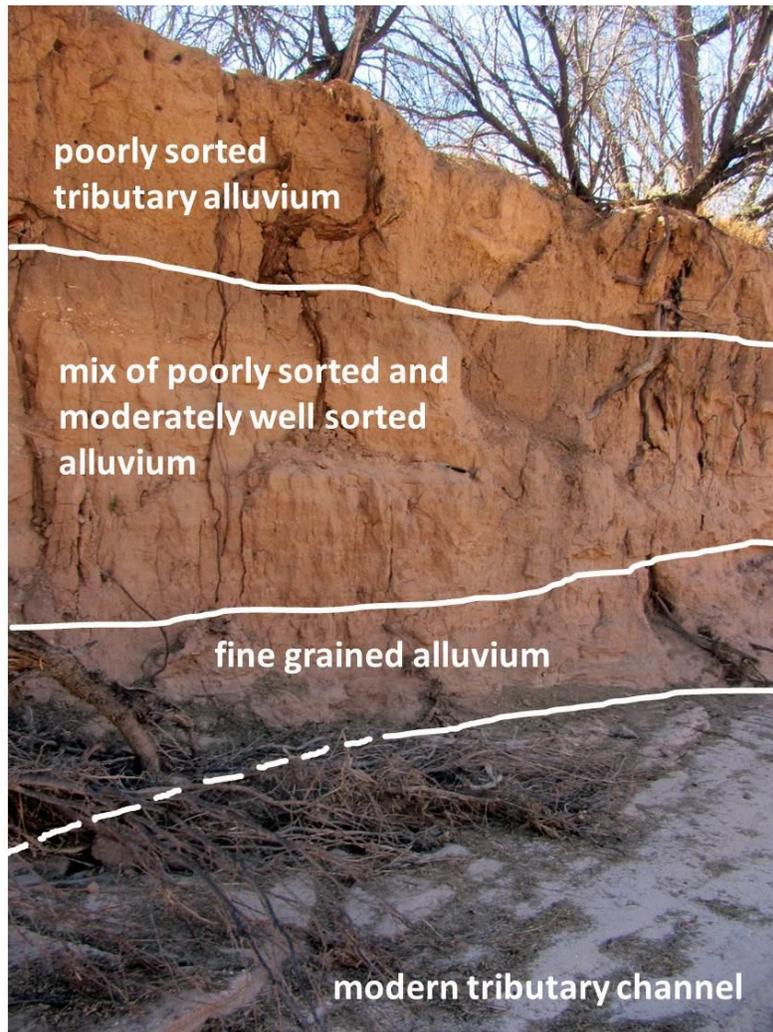
This portion of the arroyo does not provide an exposure of undisturbed tributary and river depositional relationships. Any undisturbed arroyo wall exposures are obscured by disturbed ponded sediment.

Site 18

Photo SPR105E_B

Exposure within an unnamed tributary channel

San Pedro River mile marker 105 east



Description of Tributary Arroyo Exposures

Predominantly fine grained, well-sorted alluvium is exposed at the base of the southern arroyo wall downstream from the historically disturbed portion of the arroyo. These deposits are overlain by interbedded well-sorted, fine sandy and poorly sorted sandy to angular pebbly alluvium. Atop these sediments lies very poorly sorted, medium brown, sandy to gravelly alluvium. The finer interbeds in this exposure exhibit some consolidation and blocky soil structure. Every layer tested reacts strongly to acid indicating calcium carbonate development is present throughout the exposure.

Stratigraphic Interpretation

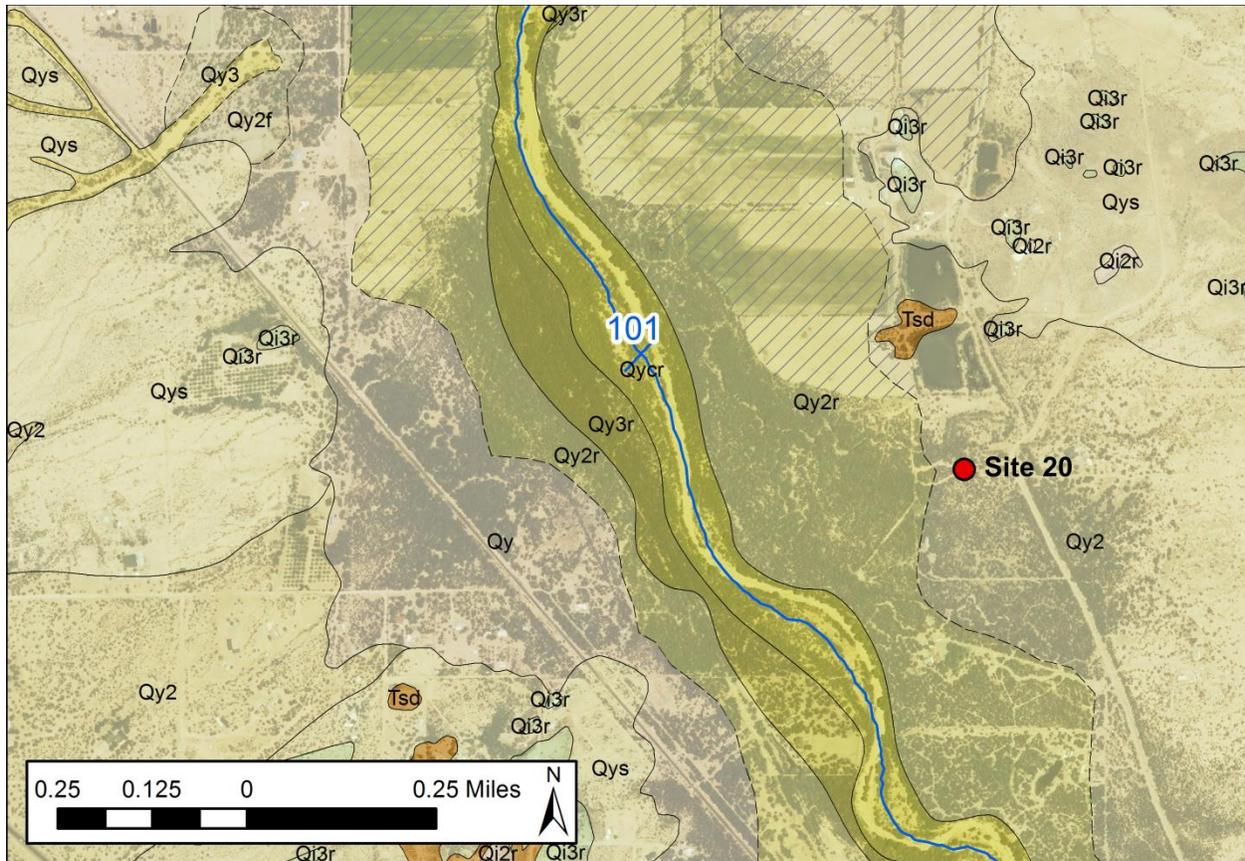
The uppermost very poorly sorted deposits are interpreted to be derived from prograding tributary alluvial fans. These deposits overlie possible interbedded deposits of tributary and river alluvium. The finer grained interbeds could also have been deposited by lower energy splays or sheetflow in a distributary alluvial fan environment. The lowermost fine-grained, well-sorted deposits resemble deposits commonly associated with Holocene San Pedro River floodplain deposition. It is also possible that the fine grained beds may be attributed to reworking of fine grained basin fill alluvium by local drainages. Well-eroded basin fill hills are located upstream along the unnamed arroyo to the east.

Because either mode of deposition could result in fine-grained deposition at this location, the origin of the fine grained layers cannot be conclusively determined based on field examination of these exposures.

Site 20

Potential exposure within an unnamed arroyo

San Pedro River mile marker 101 east



Site Location and Description

Site 20 is located in a small incised arroyo near the toe of a low relief piedmont fan extends into Holocene San Pedro (Qy2r) alluvium southeast of Benson, AZ. The distal edges of piedmont fans (Qy2 deposits) and large portions of Holocene river alluvium (Qy2r deposits) have been historically disturbed by agriculture and the boundary between river and piedmont alluvium is obscured.

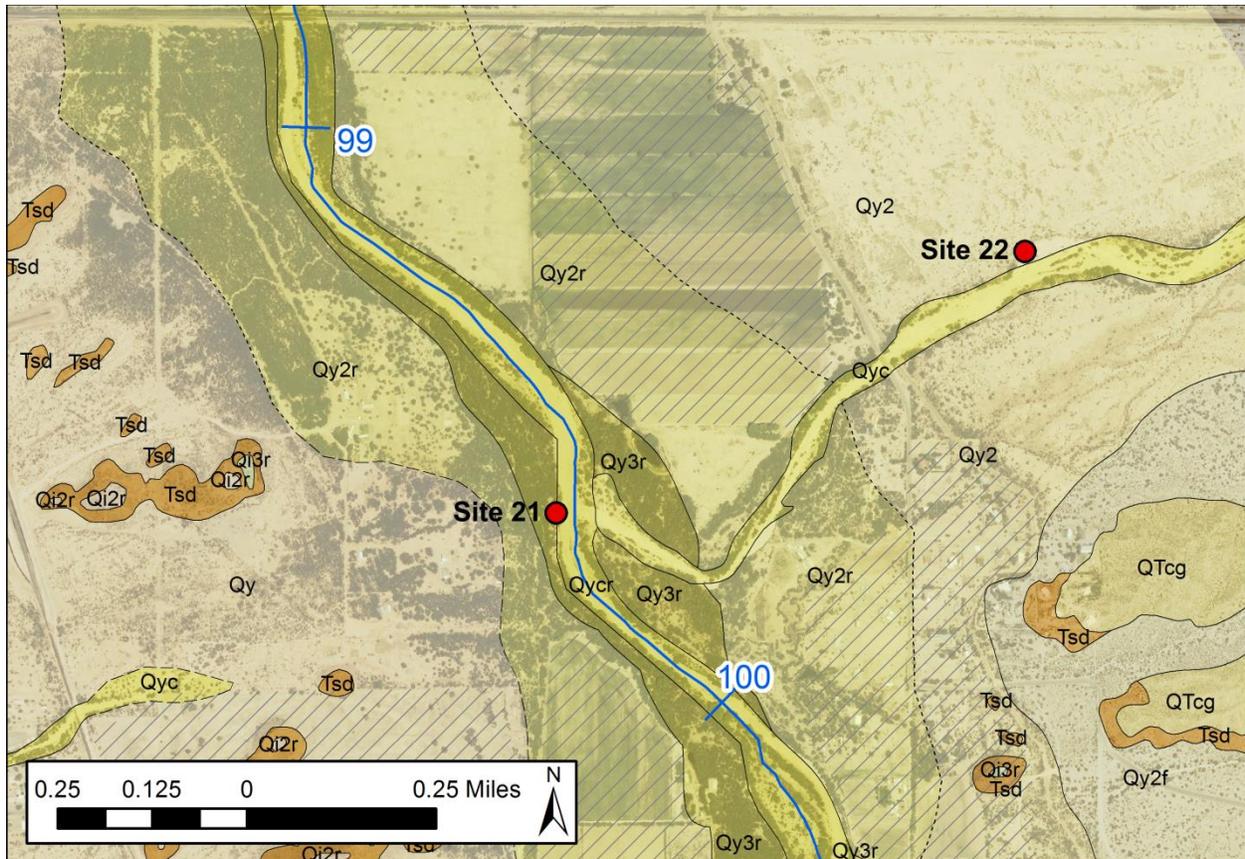
Site Access

Access to this site is blocked by no trespassing signs, locked gates, and private property from both the north and south. *No observations were made at this location due to lack of accessibility.*

Site 21

Potential exposure within the San Pedro River

San Pedro River mile marker 99.5 west



Site Location and Description

Broad, low relief fans sourced from eroding basin fill deposits (Qy2 and Qy2f deposits) stretch towards the incised San Pedro River south of I-10 near Benson, AZ. *Exposures along the incised San Pedro River at site 21 provide good examples of typical San Pedro River deposits that may be visible in the walls of incised arroyos outside the mapped extent of these deposits on AZGS surficial geologic maps.*

Site Access

The San Pedro channel at this location was accessed by traversing the unnamed tributary arroyo from the E Benson Airport Rd crossing to the east. Observations regarding this site are presented on the following pages.

Site 21

Photo SPR99.5W

Exposure within the San Pedro River

San Pedro River mile marker 99.5 west



Description of River Exposures

Alternating beds of fine grained, well-sorted San Pedro floodplain and channel deposits are visible in the west wall of the San Pedro near Benson, AZ. The youngest deposit (excluding the modern incised channel bottom) is the medium brown sandy to pebbly layer located at the top of the exposure. Below the uppermost layer lies a darker brown fine sandy layer exhibiting mild to moderate soil development. Alternating channel sands without soil development and other fine grained San Pedro alluvium compose the lower levels of this exposure. 15-20 ft of Holocene river alluvium is exposed at this location. All of these units appear to be Holocene in age and may be used to compare similar fine

grained layers exposed in incised tributary arroyos to the San Pedro River to better discern the possible extent of Holocene San Pedro floodplain alluvium in the subsurface.

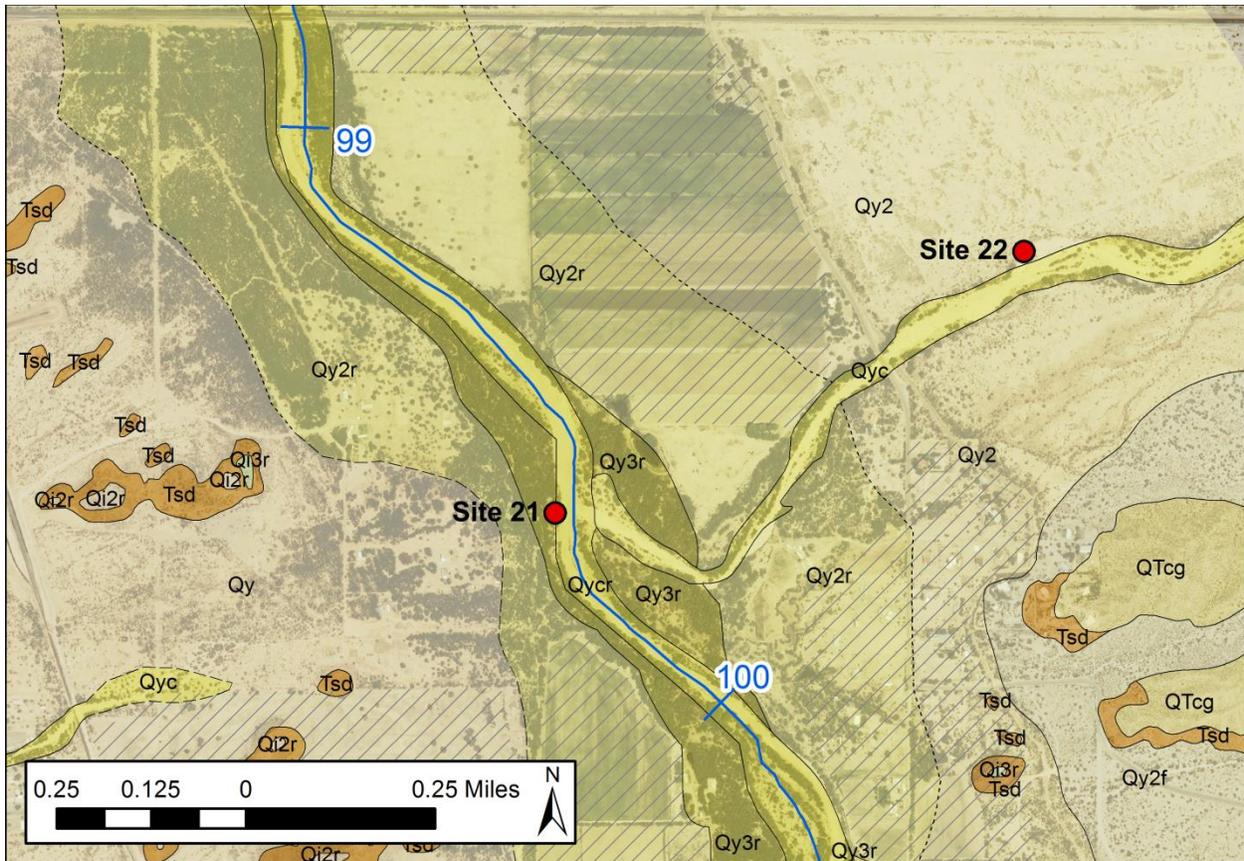
Stratigraphic Interpretation

Few erosional contacts are noted between alluvial layers exposed in the San Pedro channel wall at this location. Some coarse sandy to pebbly channel deposits appear to have been erosionally emplaced atop underlying fine grained river floodplain deposits but the erosion is minimal and the exposed stratigraphic sequence was deposited in an aggradational meandering river system. Alternating beds of fine sandy to silty and sandy to pebbly alluvium are interpreted to represent river floodplain and channel deposits, respectively. Layers exhibiting soil development are indicative of periods of depositional inactivity. Sedimentary layers with soil development must have been exposed at the surface for extended periods of time in order for soil horizons to form. Rapid, continuous aggradation of river sediment would not allow multiple soils to form in the profile. Gradual deposition of these deposits punctuated by periods of stability in the Holocene was followed by rapid incision of the San Pedro and tributary drainages in the late 1800s and early 1900s resulting in the steep channel walls still present along this portion of the San Pedro today.

Site 22

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 99.5 east



Site Location and Description

Broad, low relief fans (Qy2 and Qy2f deposits) sourced from eroding basin fill deposits stretch towards the incised San Pedro River south of I-10 near Benson, AZ. Exposures along the incised arroyo at site 22 lie at an outside bend of the tributary channel which has eroded farther into piedmont deposits since AZGS conducted mapping in this area (note wider channel evident at this location in the 2013 imagery compared to location of the channel depicted on AZGS surficial geologic maps).

Site Access

This site was accessed by driving up the tributary channel from where it crosses E Benson Airport Rd to the west. Observations regarding this site are presented on the following pages.

Site 22

Photo SPR 99.5E

Exposure within an unnamed tributary channel

San Pedro River mile marker 99.5 east



Description of Tributary Arroyo Exposures

Poorly sorted coarse sandy to gravelly deposits with angular to sub angular clasts are evident at the top of the exposed arroyo wall. These deposits erosionally overlie thicker deposits of finer grained, banded, moderately well-sorted alluvium. Modern tributary channel alluvium is dominantly sandy with pebble to cobble bars throughout the channel. Fresh bank collapse provides good exposures of sedimentary relationships at this location.

Stratigraphic Interpretation

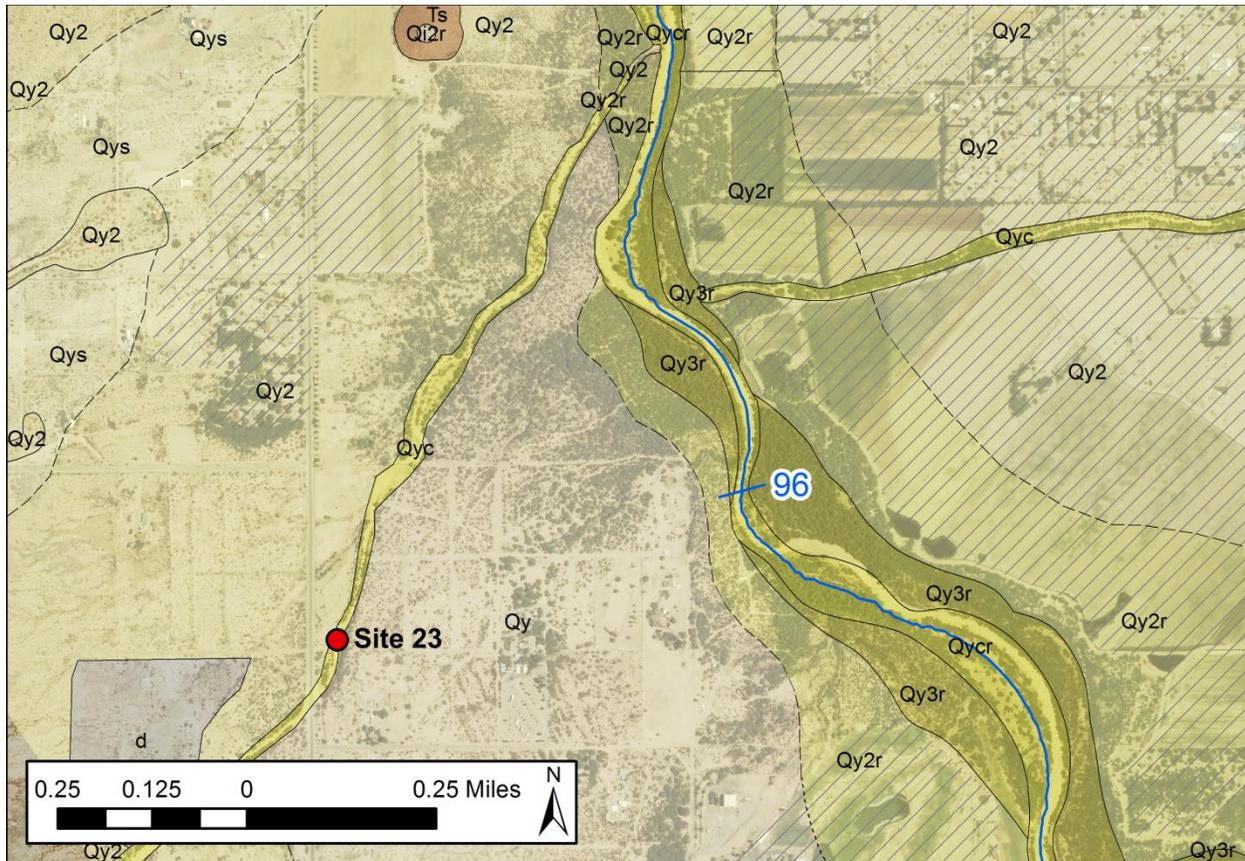
The angular clast bearing, poorly sorted alluvium exposed at the top of the arroyo wall is interpreted as young Holocene to historical prograding tributary piedmont alluvium. Angular clasts exposed in this deposit strongly resemble those present in the modern channel. The finer-grained, well-sorted, banded alluvial deposits present below the angular clast-bearing deposit may have been deposited by low energy distal fan deposition.

These deposits also resemble fine grained river floodplain deposits but the position in the landscape and proximity to tall, well-dissected basin fill bluffs to the east which provide a continuous source of fine-grained sediment suggest these deposits were more likely emplaced in a tributary channel or fan environment. Although, because either mode of deposition could result in fine-grained deposition at this location, the origin of the fine grained layers cannot be conclusively determined based on field examination of these exposures.

Site 23

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 96 west



Site Location and Description

Low relief, gently sloping tributary (Qy and Qy2) alluvium sourced from well-eroded basin fill deposits to the southwest blankets this portion of the San Pedro River Valley nearly to the modern San Pedro River channel in places. An incised arroyo crossing Ocotillo Rd exposes possible interfingering fine grained San Pedro floodplain (Qy2r) and coarser grained, poorly sorted tributary fan alluvium (site 23 in figure above).

Site Access

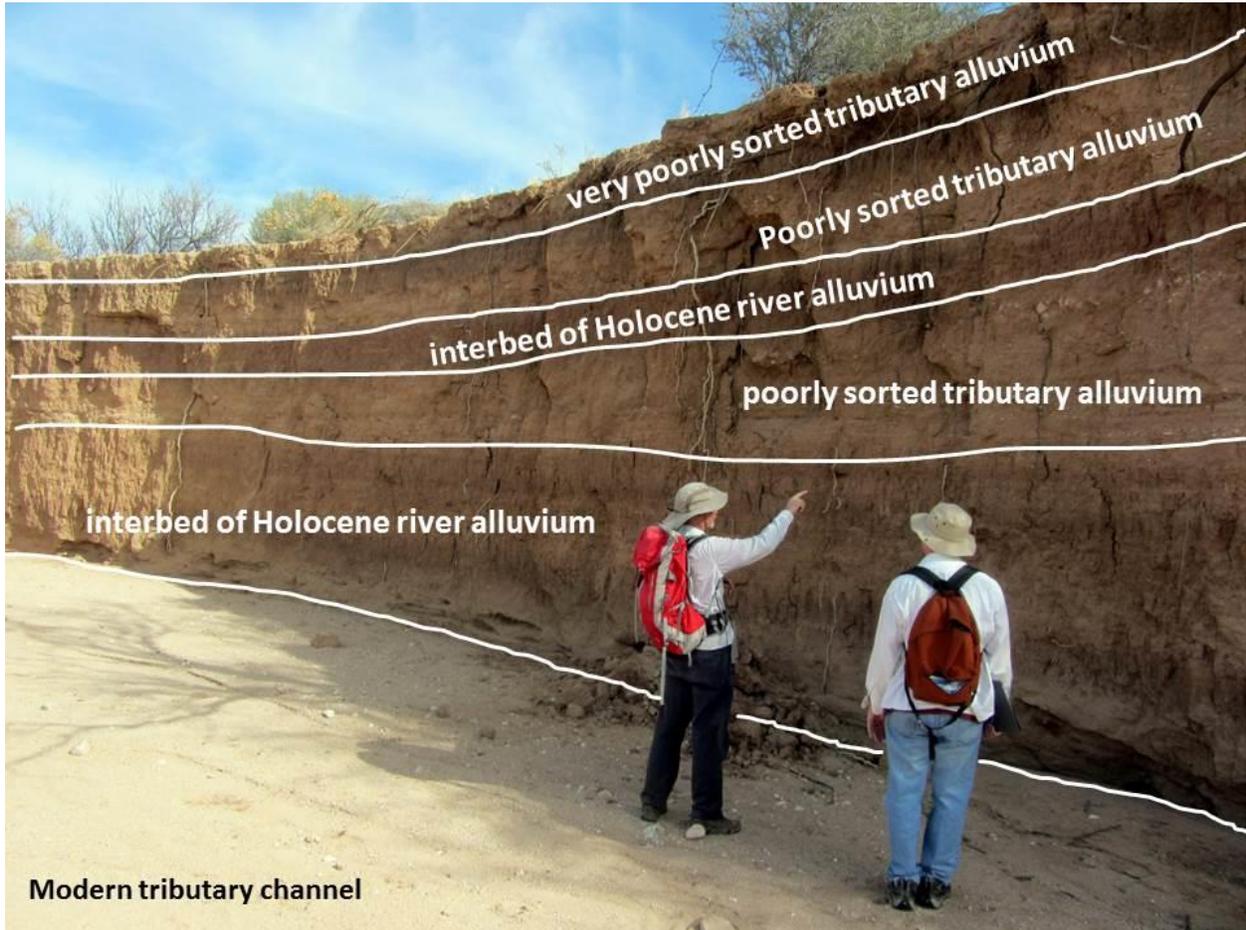
This site was accessed from N Ocotillo Rd. Observations regarding this site are presented on the following pages.

Site 23

Photo SPR96W

Exposure within an unnamed tributary channel

San Pedro River mile marker 96 west



Description of Tributary Arroyo Exposures

Very poorly sorted light brown sandy to gravelly beds with angular to sub angular clasts interfinger with finer-grained, well-sorted, darker brown interbeds. The coarser beds strongly resemble tributary fan alluvium observed throughout the arroyo and in the modern tributary channel while the finer grained interbeds resemble San Pedro River floodplain deposits exposed in a similar relationship in nearby arroyos (site 24) and in modern channel walls of the San Pedro River.

Stratigraphic Interpretation

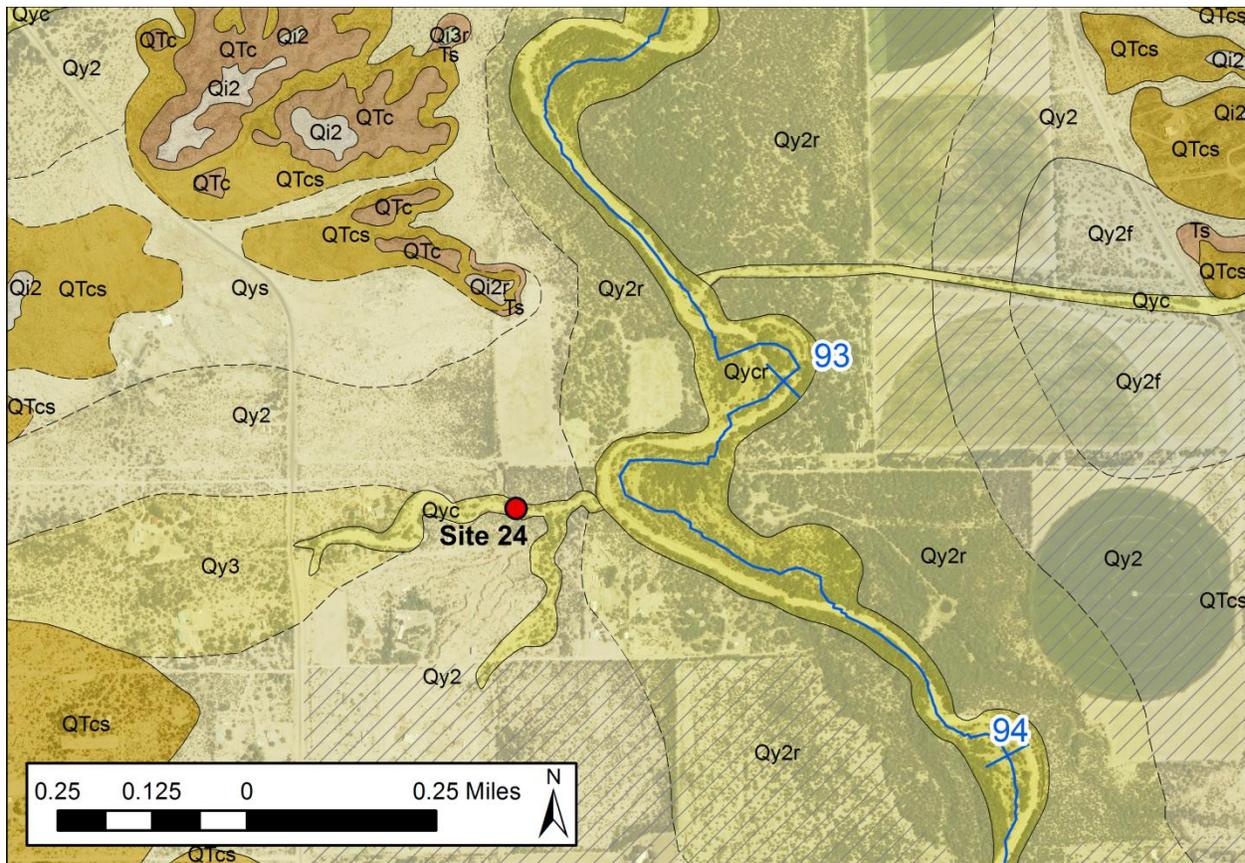
Laterally continuous exposures of multiple buried soils indicate punctuated landscape stability sufficient for soil development throughout a period of net aggradation in the Holocene. Widespread fine-grained deposition could have been achieved by broad, repeated, low energy floodplain deposition by the San Pedro. Coarser, poorly sorted tributary piedmont deposits overlying these fine-grained beds later prograded across these extensive floodplain deposits. This process repeated through time resulting in the alternating fine-coarse interbedding with soil development exposed in the arroyo today. It is possible the fine grained beds could also have been deposited by lower energy distal tributary fan progradation but the uniform particle size, excellent sorting, and laterally continuous buried soil layers seem more likely to result from widespread, low energy floodplain deposition by the San Pedro River.

Probable Holocene river floodplain deposits are exposed in this arroyo up to 2,600 ft outside the mapped surficial boundary of Holocene river alluvium on AZGS geologic maps.

Site 24

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 93.5 west



Site Location and Description

Site 24 is located in a small incised arroyo joins the San Pedro River from the west near river mile 93.5. Broad, relatively unincised piedmont (Qy2, Qys, and Qy3) alluvium stretches from isolated remnants of basin fill (QTc, QTcs) bluffs to the west and north onto Holocene river floodplain (Qy2r) deposits near this location.

Site Access

Private property blocks access to some of this arroyo system. *Incision along accessible portions of this arroyo was insufficient to provide exposures of tributary fan and San Pedro River sedimentary interaction. No observations were made at this location.*

Site 25

Photo SPR89.5W_A

Exposure within an unnamed tributary channel

San Pedro River mile marker 89.5 west



Description of Tributary Arroyo Exposures

Light brown, poorly sorted, sandy alluvium with angular to sub-angular pebble and gravel-dominated interbeds overlies more uniformly sorted, medium brown, fine sandy beds with darker brown fine sandy to silty buried soils (just below upper drawn contact in the image above) in the north arroyo wall at this location. Isolated lenses of lithologically diverse, well-rounded pebbles and cobbles are present within the fine-grained layer. A darker brown buried soil is present in the finer layer just below the overlying poorly sorted coarser sediment. The angular clasts present in the upper deposit strongly resemble those found in the modern tributary channel bottom. Discontinuous interbeds of poorly sorted alluvium interfingering with the finer-grained deposits are apparent in arroyo walls here but become

less frequent downstream, yielding to more continuous exposure of fine grained alluvium beneath a thinning cap of poorly sorted alluvium.

Stratigraphic Interpretation

The poorly sorted alluvium with angular gravels exposed at the top of the arroyo wall is interpreted as tributary channel and fan deposits. These deposits overlie finer-grained, well-sorted sandy to silty alluvium with well-rounded cobble lenses representing Holocene San Pedro floodplain and channel deposits with discontinuous tributary interbeds resulting from interfingering tributary and river deposition in the Holocene. The buried soil near the top of the fine-grained unit represents a period of landscape stability occurring prior to the latest Holocene fan progradation atop Holocene river floodplain deposits. The tributary sand and gravel cap becomes noticeably thinner nearer to the modern San Pedro channel, indicating thinning tributary fan deposition atop laterally extensive and thick Holocene San Pedro floodplain deposits.

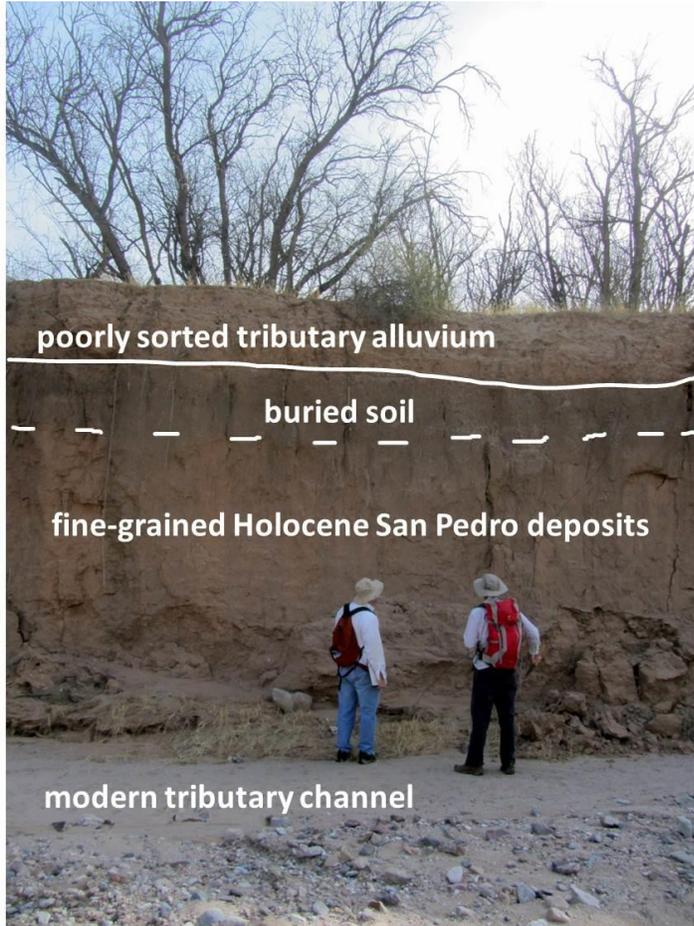
Holocene river floodplain deposits are exposed in this arroyo up to 820 ft outside the mapped surficial boundary of Holocene river alluvium on AZGS geologic maps.

Site 26

Photo SPR89.5W_B

Exposure within an unnamed tributary channel

San Pedro River mile marker 89.5 west



Description of Tributary Arroyo Exposures

Site 26 offers another view of predominantly well-sorted, fine grained, Holocene alluvium with buried soil layers beneath a thin veneer of poorly sorted alluvium. This exposure is located several hundred feet farther downstream from site 25 in the southern arroyo wall closer to the modern San Pedro River channel.

Stratigraphic Interpretation

The same interpretations described for site 25 are applicable here although fewer poorly sorted tributary channel interbeds are present within the predominantly well-sorted fine-grained river floodplain deposits. This trend indicates increasing dominance of

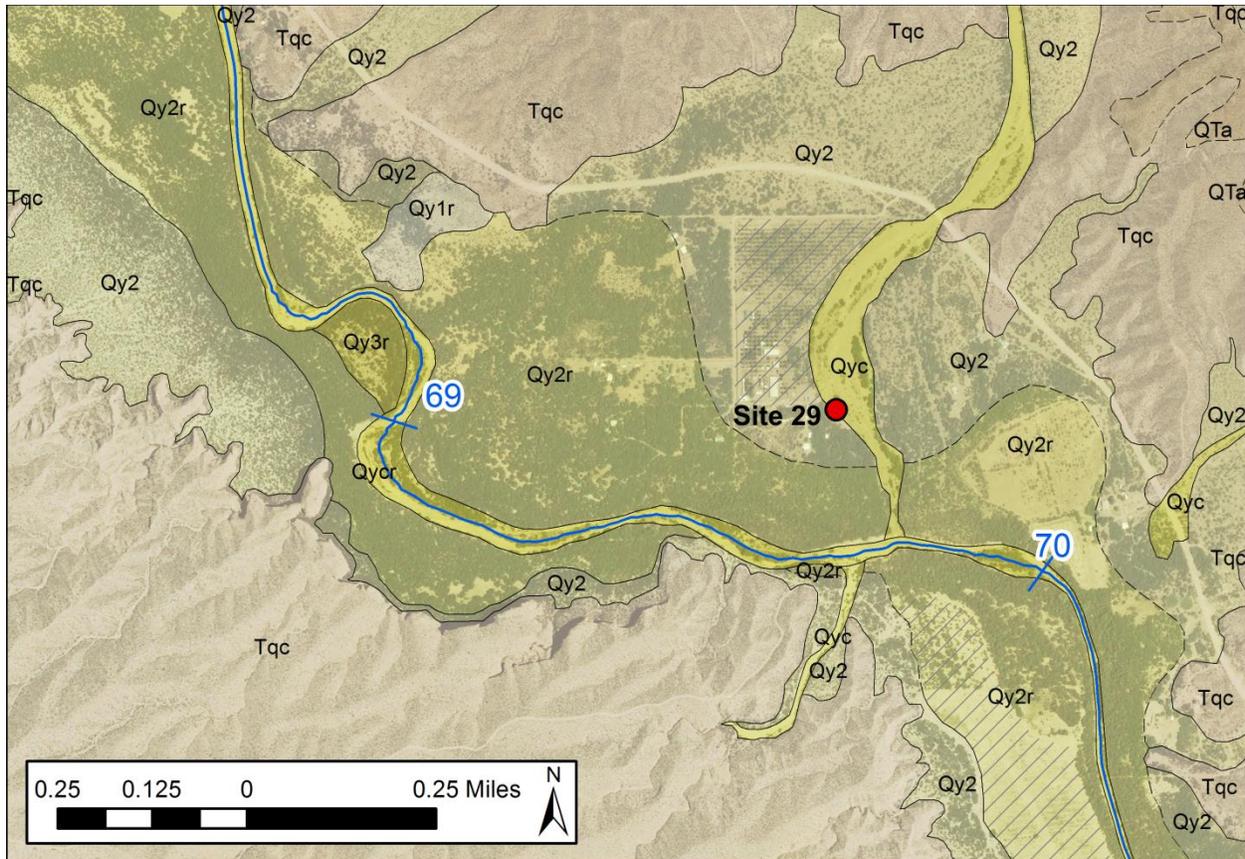
deposition by the San Pedro nearer the modern channel. Most of the tributary alluvium evident at this location is the thinning alluvial deposit at the top of the exposure. The vast majority of sediment exposed in cross section here is interpreted as Holocene river deposits while surficial mapping shows this area as Holocene tributary (Qy2) deposits.

The surface is dominated by tributary alluvium at this location which is depicted in surficial AZGS geologic mapping yet it seems clear Holocene river deposits extends farther from the river in the subsurface than the surficial maps indicate.

Site 29

Potential exposure within Teran Wash

San Pedro River mile marker 69.5 east



Site Location and Description

Lower Teran Wash has deposited a broad semi-circular alluvial fan (Qy2 deposits) where it becomes unconfined downstream of high-standing, dissected Quiburis basin fill (Tqc) bluffs. At site 29 the modern Teran Wash channel has incised through interfingering Holocene tributary fan (Qy2) and San Pedro River deposits (likely Qy2r) as it has kept pace with historical to latest Holocene base level drop of the San Pedro River to the south.

Site Access

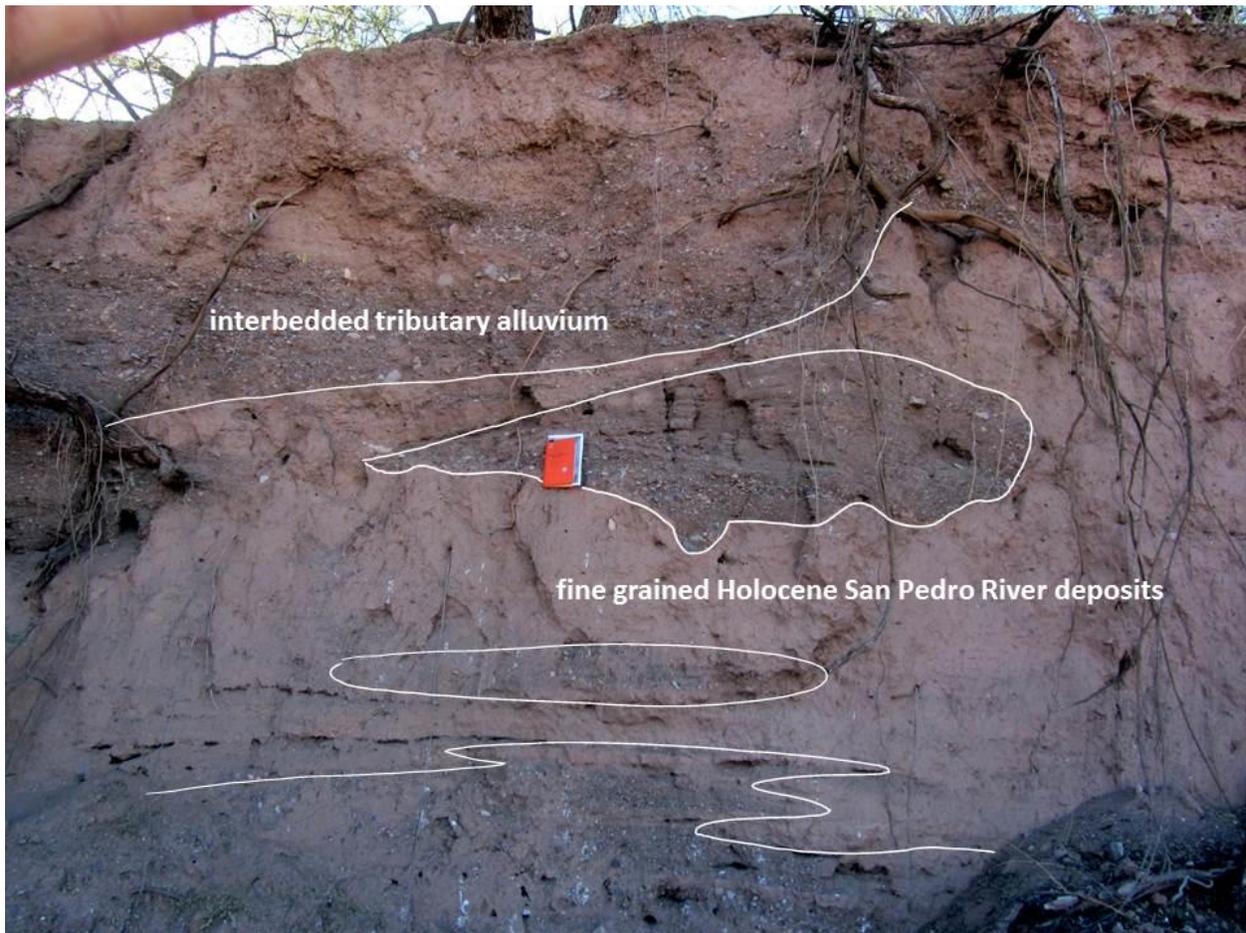
This site was accessed from the Oasis Bird Sanctuary located off N Cascabel Rd on the west bank of Teran Wash. Observations regarding this site are presented on the following pages.

Site 29

Photo SPR69.5E

Exposure within Teran Wash

San Pedro River mile marker 69.5 east



Description of Tributary Arroyo Exposures

Erosional interbeds and channel deposits of cross bedded, poorly sorted, sandy to pebbly angular alluvium are exposed within well-sorted fine sandy to silty deposits in a channel wall in an outside bend of Teran Wash north of its confluence with the San Pedro River. The poorly sorted interbeds strongly resemble modern Teran Wash bedload and the finer grained, well-sorted beds are evident in Holocene San Pedro River deposits exposed along the river throughout the area.

Stratigraphic Interpretation

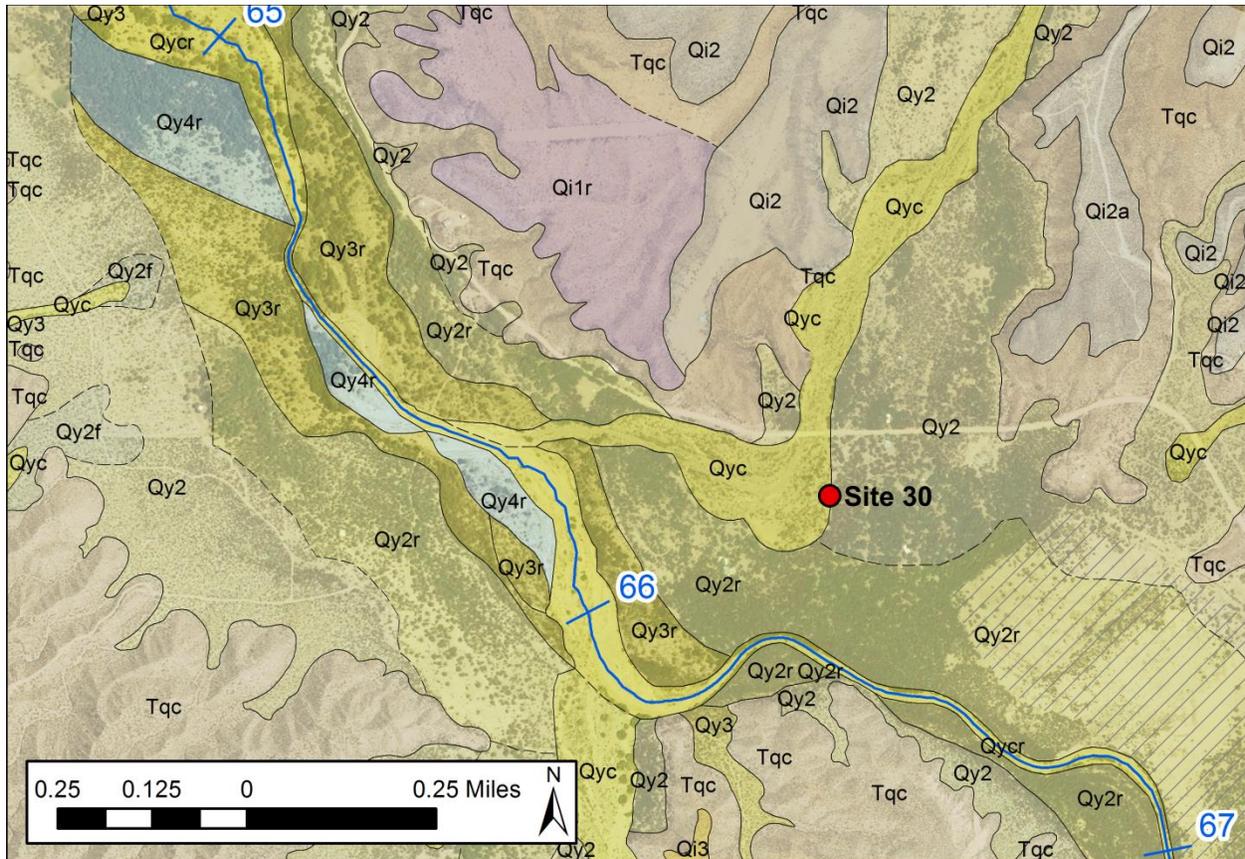
Coarse, poorly sorted alluvium matching modern Teran Wash deposits is interpreted as tributary channel alluvium. Fine grained, well-sorted alluvium strongly resembling deposits exposed in river channel walls to the west is interpreted as Latest Holocene San Pedro River floodplain and low energy channel deposits. Intricate interbedding of tributary and river deposits indicates concurrent deposition in a confluence zone between tributary and river. Today Teran Wash is incised to meet the incised San Pedro to the west but prior to basin incision it is likely the zone of confluence between these two channels was much more widespread and deposit dominance fluctuated laterally with river meandering and tributary floods.

Although AZGS surficial mapping depicts tributary fan alluvium throughout this area at the surface, this exposure exhibits interfingering and concurrent deposition of Teran Wash and San Pedro River sediment in an aggrading distal fan/river floodplain environment up to 425 ft farther from the river than depicted on AZGS maps.

Site 30

Potential exposure within Hot Springs Wash

San Pedro River mile marker 66 east



Site Location and Description

Hot Springs Wash joins the San Pedro River from the east side near river mile 66. Site 30 is located in an outside bend of Hot Springs Wash which has exposed a sequence of alternating tributary and San Pedro River deposits. Hot Springs Wash becomes unconfined upon exiting Hot Springs Canyon to the north. Unconfined flow has resulted in deposition of a broad fan at the mouth of the canyon. Since the deposition of this tributary fan, the San Pedro River and Hot Springs Wash have incised, exposing former fan and Holocene San Pedro River floodplain deposits. Exposures of the relationship between these sedimentary packages are visible along outside erosional bends of Hot Springs Wash.

Site Access

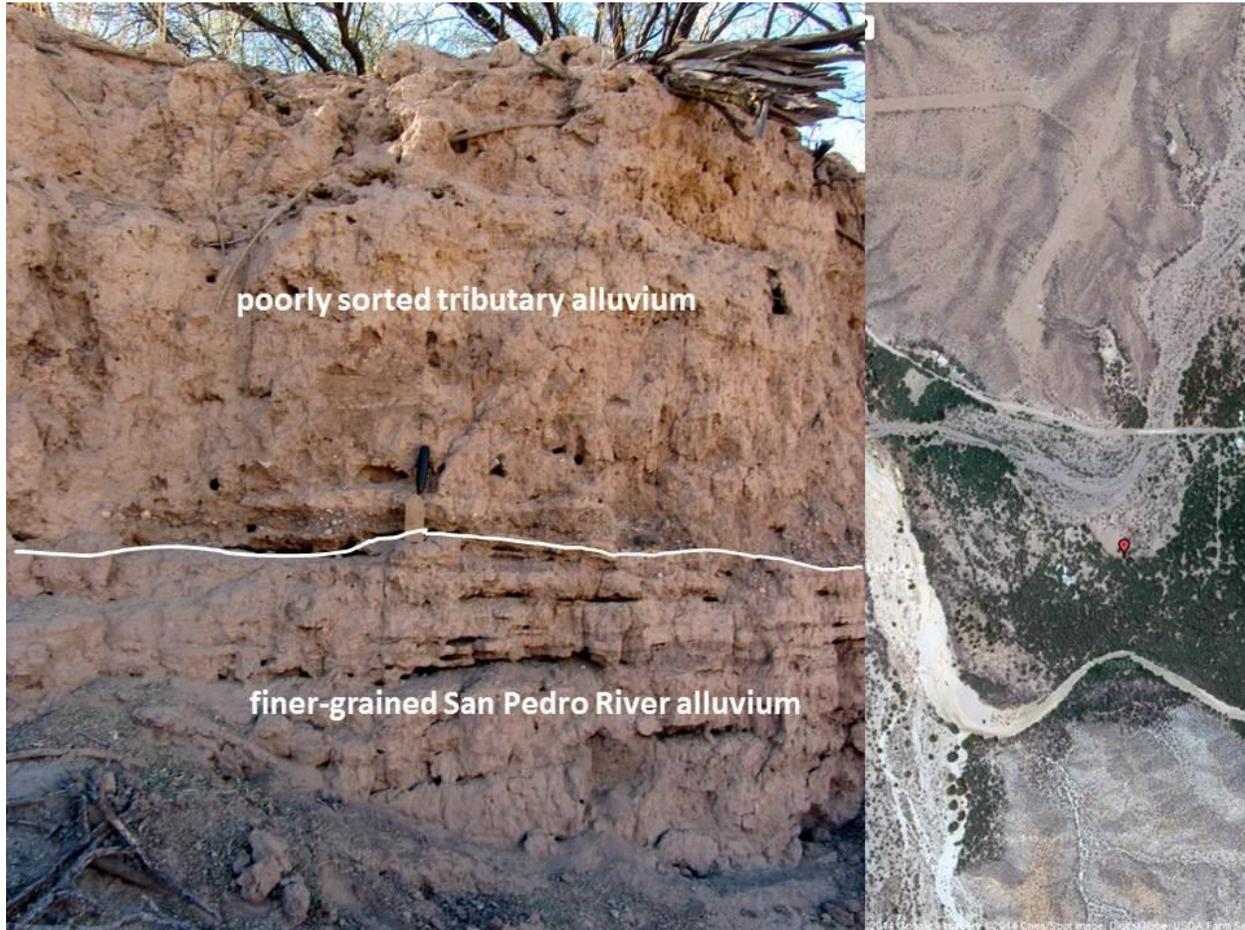
This site was accessed from the intersection of Hot Springs Wash and N Cascabel Rd. Observations regarding this site are presented on the following pages.

Site 30

Photo SPR66E

Exposure within Hot Springs Wash

San Pedro River mile marker 66 east



Description of Tributary Arroyo Exposures

The photo on the left shows poorly sorted, light to medium brown alluvium deposited on top of finer-grained, well-sorted, darker brown, fine sandy to silty alluvium. A mild erosional contact into the fine grained deposits is present at the base of the poorly sorted alluvium. The aerial photo on the right depicts the photo location within the tributary fan that has prograded out into the San Pedro River bottom. This exposure is a result of recent bank erosion along an outside bend of Hot Springs Wash. The active Hot Springs Wash channel joins the San Pedro River to the west. Portions of the tributary fan emanating from Hot Springs Canyon have been eroded away by the meandering San

Pedro River. A dynamic depositional and erosional system between the San Pedro River and Hot Springs Wash is evident at this location.

Stratigraphic Interpretation

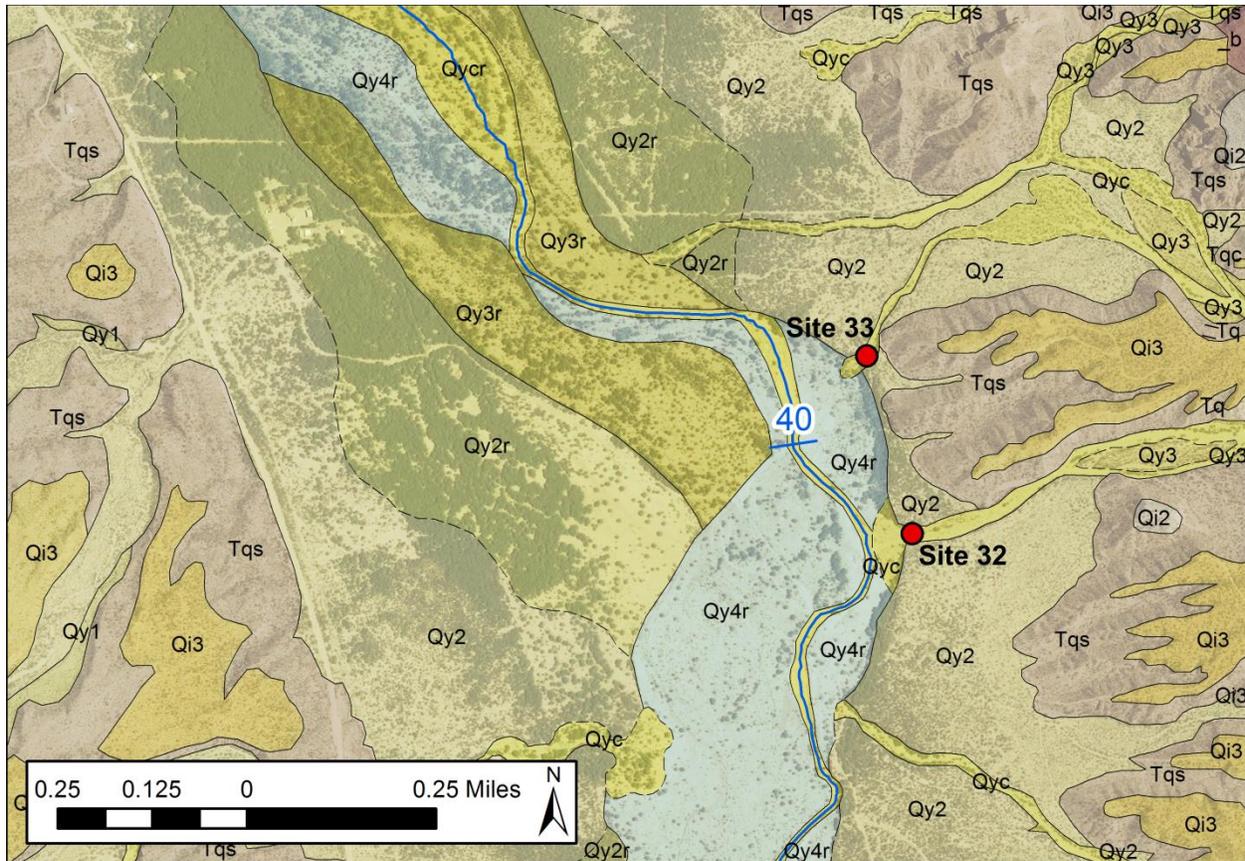
The poorly sorted sand and gravel in the upper half of the exposure is interpreted as tributary Hot Springs Wash alluvium. The well-sorted fine sandy to silty deposits overlain by the tributary alluvium is interpreted as low energy San Pedro River and floodplain deposits. The erosional contact at the base of the tributary alluvium indicates some scouring on river floodplain deposits by Hot Springs Wash occurred prior to deposition of tributary sand and gravel. Low energy river floodplain deposits would be easily erodible by higher energy, coarser tributary flow in Hot Springs Wash. The deposition and erosion cycle between Hot Springs Wash and the San Pedro River evident in the modern landscape is indicative of these same processes in the past.

Holocene river alluvium is exposed in the banks of Hot Springs Wash up to 350 ft outside the boundary depicted on AZGS surficial geologic maps.

Site 32 and 33

Potential exposures within unnamed tributary channels

San Pedro River mile marker 40 east



Site Location and Description

Sites 32 and 33 are located at the mouth of two small arroyos that join the San Pedro from the east near river mile 40. Each arroyo has incised through high-standing Quiburis basin fill (Tqs) deposits and tributary alluvium and small fans have been deposited atop Holocene to historical San Pedro River (Qy4r) deposits near the modern San Pedro River. The tip of the southern arroyo fan has been trimmed off by recent erosion along an outside meander of the active San Pedro River channel. These sites demonstrate the dynamic relationship between tributary aggradation, incision, fan progradation and erosion by a meandering San Pedro River.

Site Access

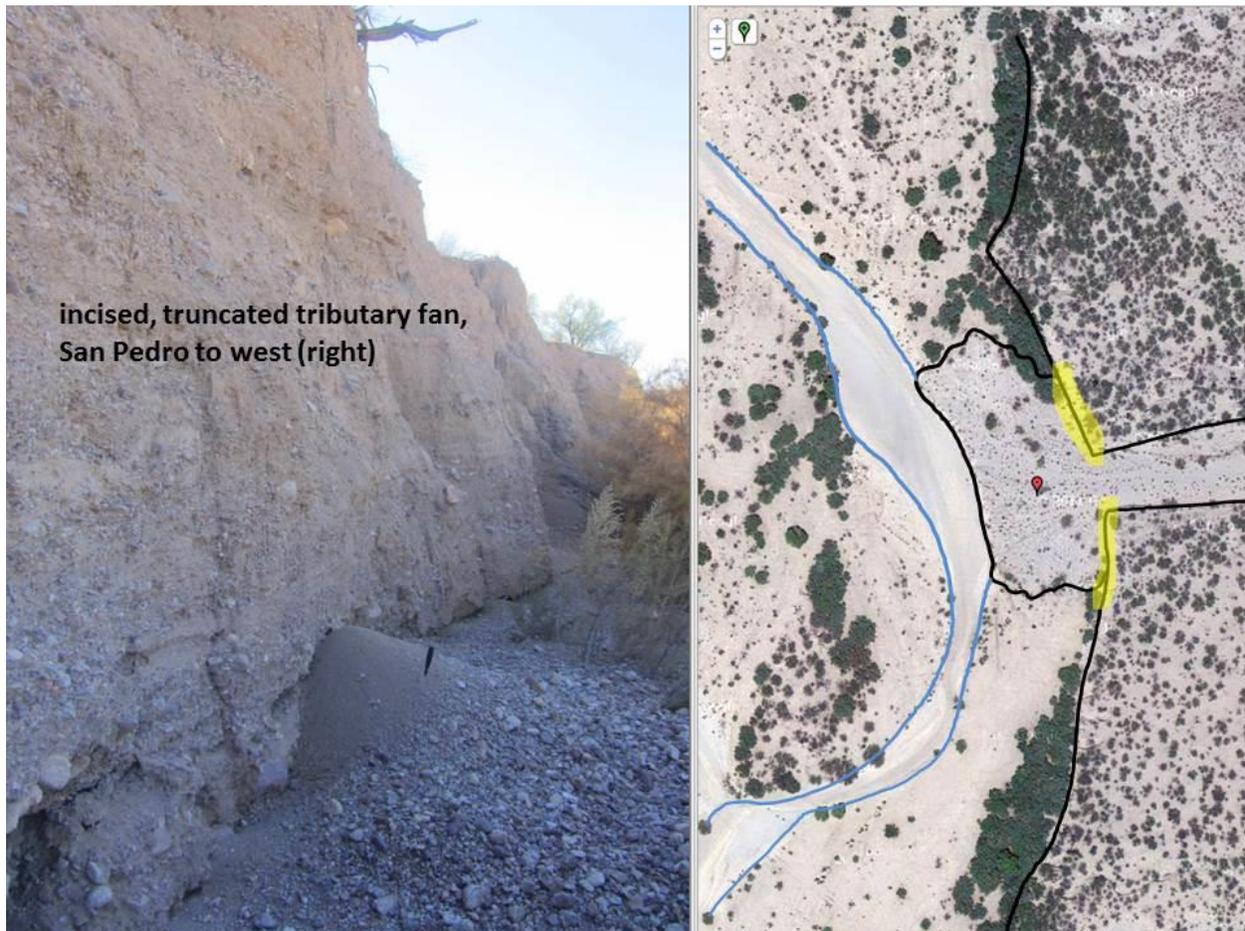
This site was accessed by crossing the San Pedro on unnamed dirt roads from S Redington Rd to the west. Observations regarding this site are presented on the following pages.

Site 32

Photo SPR40E_A

Exposure within an unnamed tributary channel

San Pedro River mile marker 40 east



Description of Tributary Arroyo Exposures

Very poorly sorted, angular to sub-angular clast dominated alluvium is exposed in tributary arroyo walls and tall (15-20 ft) San Pedro channel walls. A very young splay of coarse, very poorly sorted alluvium has spilled out from between incised arroyo walls to the modern San Pedro channel. The edge of this deposit has been trimmed away by erosion on an outside bend of the San Pedro River.

Stratigraphic Interpretation

The photo on the left depicts 15-20 feet of exposed tributary fan alluvium that has been exposed by lateral erosion of the San Pedro River. The annotated aerial photo on the right shows the general erosional trend of this exposure (yellow highlighted bluffs) which matches the general north-south orientation of the San Pedro River (active channel outlined in blue). The tributary channel in this area has incised through Holocene tributary alluvium to meet the base level of the downcutting San Pedro River. Upon exiting the confined incised tributary channel, a young tributary fan has been deposited into the modern San Pedro River channel by the tributary drainage (outlined in black). Young tributary channel alluvium overlies recent San Pedro River channel deposits between the bluffs and the modern river channel. The toe of this tributary fan has subsequently been eroded away by an outside meander of the San Pedro.

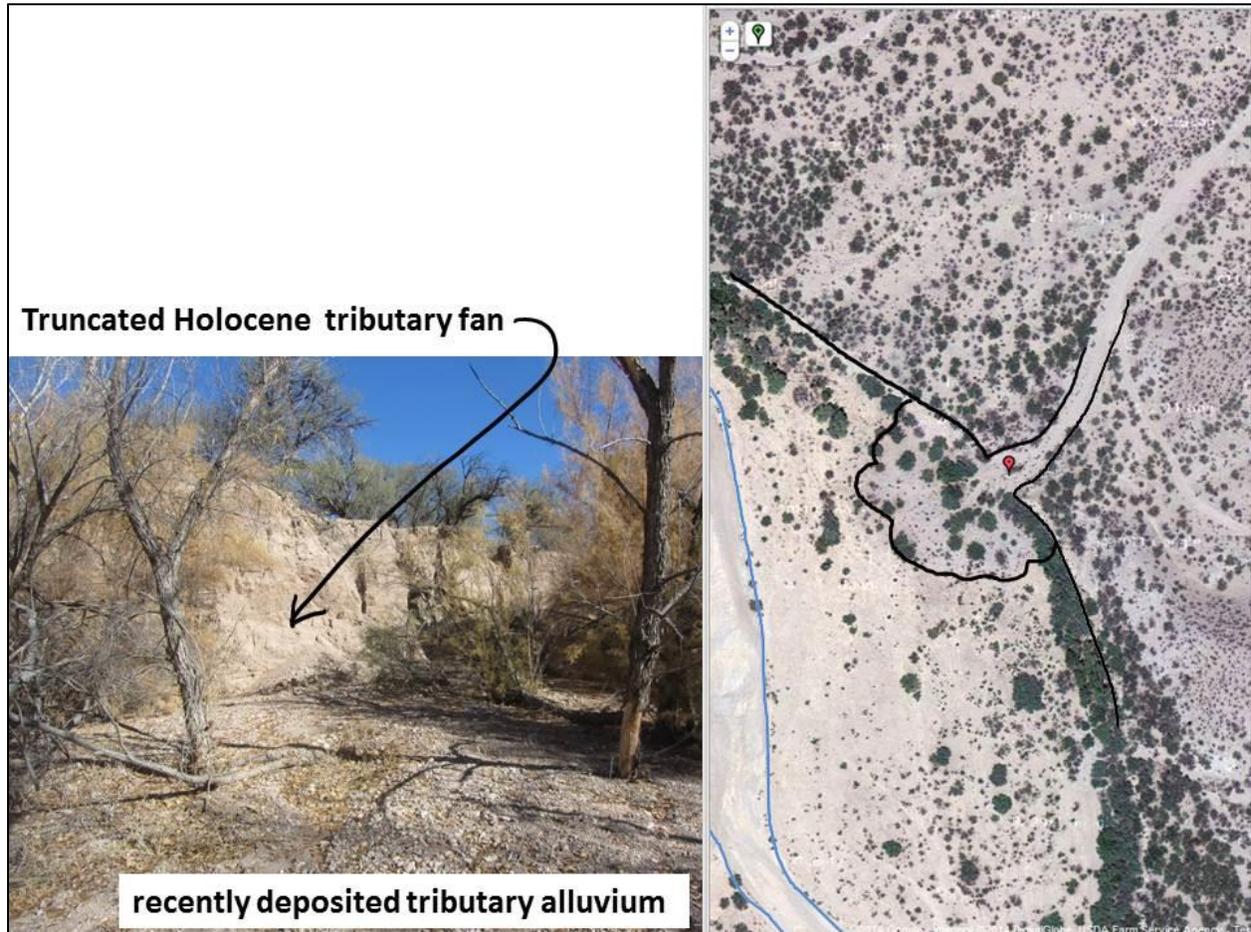
At least two generations of tributary fan progradation and erosional trimming by the San Pedro River are exposed at this location.

Site 33

Photo SPR40E_B

Exposure within an unnamed tributary channel

San Pedro River mile marker 40 east



Description of Tributary Arroyo Exposures

Very poorly sorted, angular to sub-angular clast dominated alluvium is exposed in tributary arroyo walls and tall (10-15 ft) San Pedro channel walls. A very young splay of coarse, very poorly sorted sand and gravel has spilled out from between incised arroyo walls onto historical to recent San Pedro channel deposits. The base of trees growing in this area exhibit stripped away bark and burial by very fresh, poorly sorted sand and gravel. Holocene river alluvium is deposited up to the vertical channel walls upstream and downstream of the young tributary fan deposit. The annotated aerial photo on the right depicts these relationships. The tributary channel walls, young fan deposit, and San Pedro channel walls are shown in black, the modern river channel is outlined in blue.

Stratigraphic Interpretation

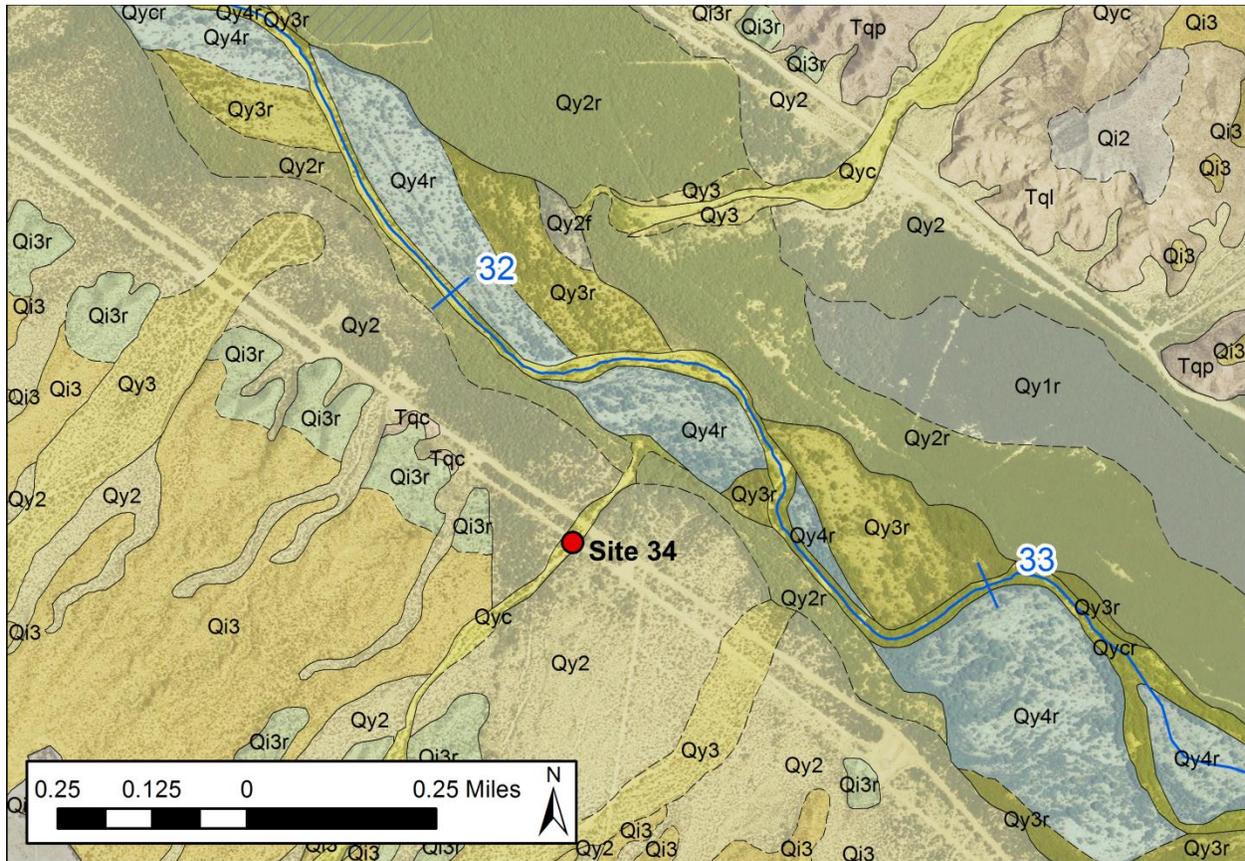
The vertical San Pedro channel walls are composed of poorly sorted alluvium which is interpreted as tributary piedmont and channel deposits. The vertical walls were eroded back to their present position by a former meander of the San Pedro River. No well-sorted beds of fine sediment that could be interpreted as river floodplain or low energy channel deposits are present in the exposure.

The young tributary fan that has spilled out onto slightly older San Pedro alluvium at this location clearly demonstrates onlapping tributary and river stratigraphic relationships but no cross section is present.

Site 34

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 32.5 west



Site Location and Description

Broad, relatively unincised, steeply sloping piedmont (Qy2) alluvium extends from the west nearly to the modern San Pedro River channel. Infrequent incised arroyos cut these deposits and deposit thin splays of tributary alluvium atop Holocene River alluvium near the San Pedro.

Site Access

Access to the site 34 in the arroyo entering the San Pedro River from the west at river mile 32.5 was achieved by hiking across the San Pedro from S River Rd on the east side of the San Pedro. Unfortunately the arroyo was relatively unincised and offered no exposures of sedimentary relationships between tributary and river deposits. *No observations were made at this location due to lack of sedimentary exposures.*

Site 35

Photo SPR32E_A

Exposure within James Wash

San Pedro River mile marker 32 east

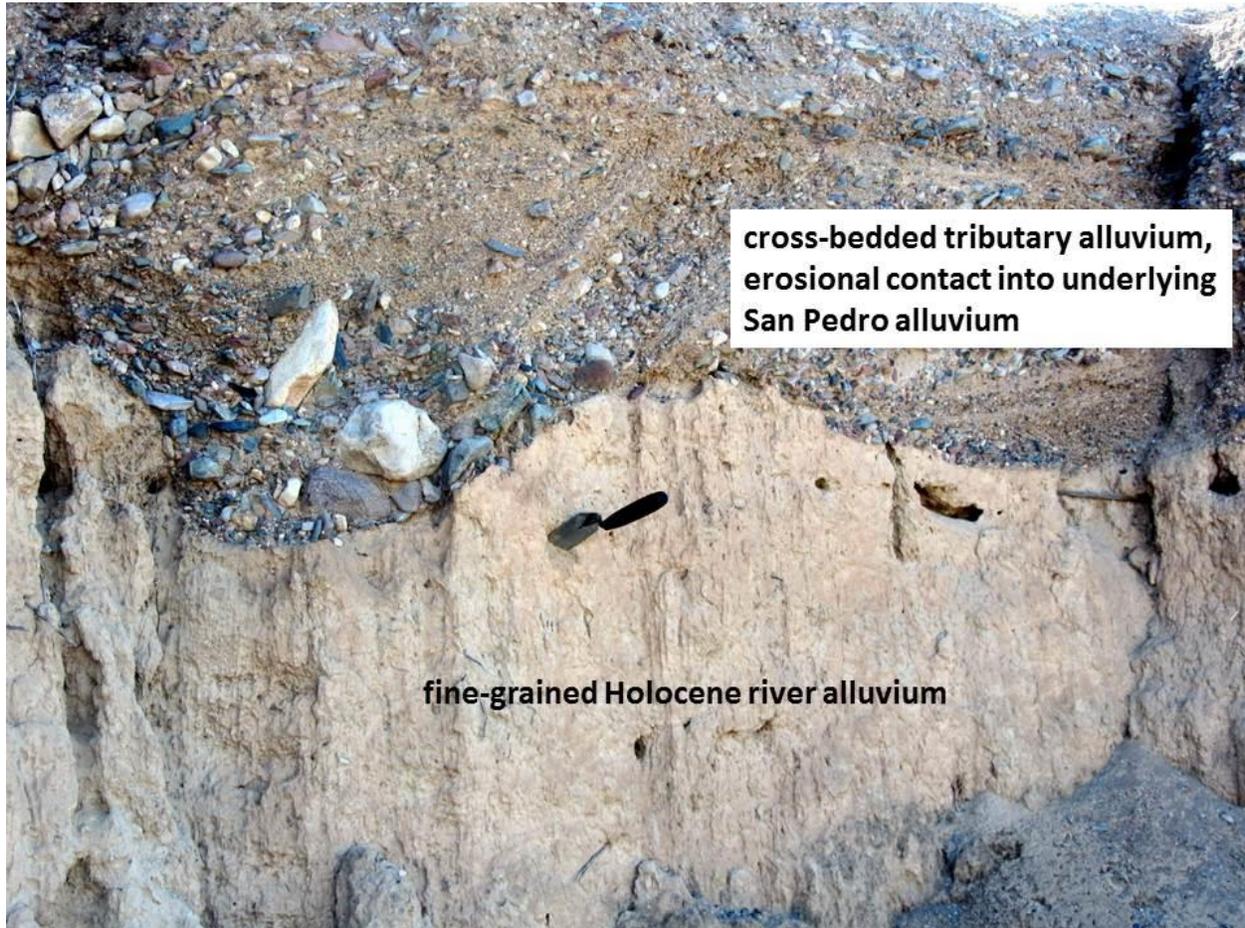


Site 35

Photo SPR32E_B

Exposure within James Wash

San Pedro River mile marker 32 east



Description of Tributary Arroyo Exposures

In the first photo (SPR32E_A), well-sorted, light brown, predominantly sandy alluvium is exposed in an interfingering depositional relationship with much coarser, pebble to cobble-dominated, sub-angular to sub-rounded, poorly sorted alluvium. The coarse clasts strongly resemble the modern channel bedload and the finer alluvium resembles exposures in the banks of the San Pedro to the west. In the second photo (SPR32E_B), taken 20-30 ft downstream, very coarse, very poorly sorted, sub rounded to sub angular alluvium erosionaly overlies much finer, well-sorted, sand-dominated alluvium. The clasts in the upper portion of this exposure strongly resemble those observed in the modern

channel of James Wash. The sandy alluvium strongly resembles exposures in the banks of the San Pedro to the west. Large crossbeds in the coarse alluvium are evident.

Stratigraphic Interpretation

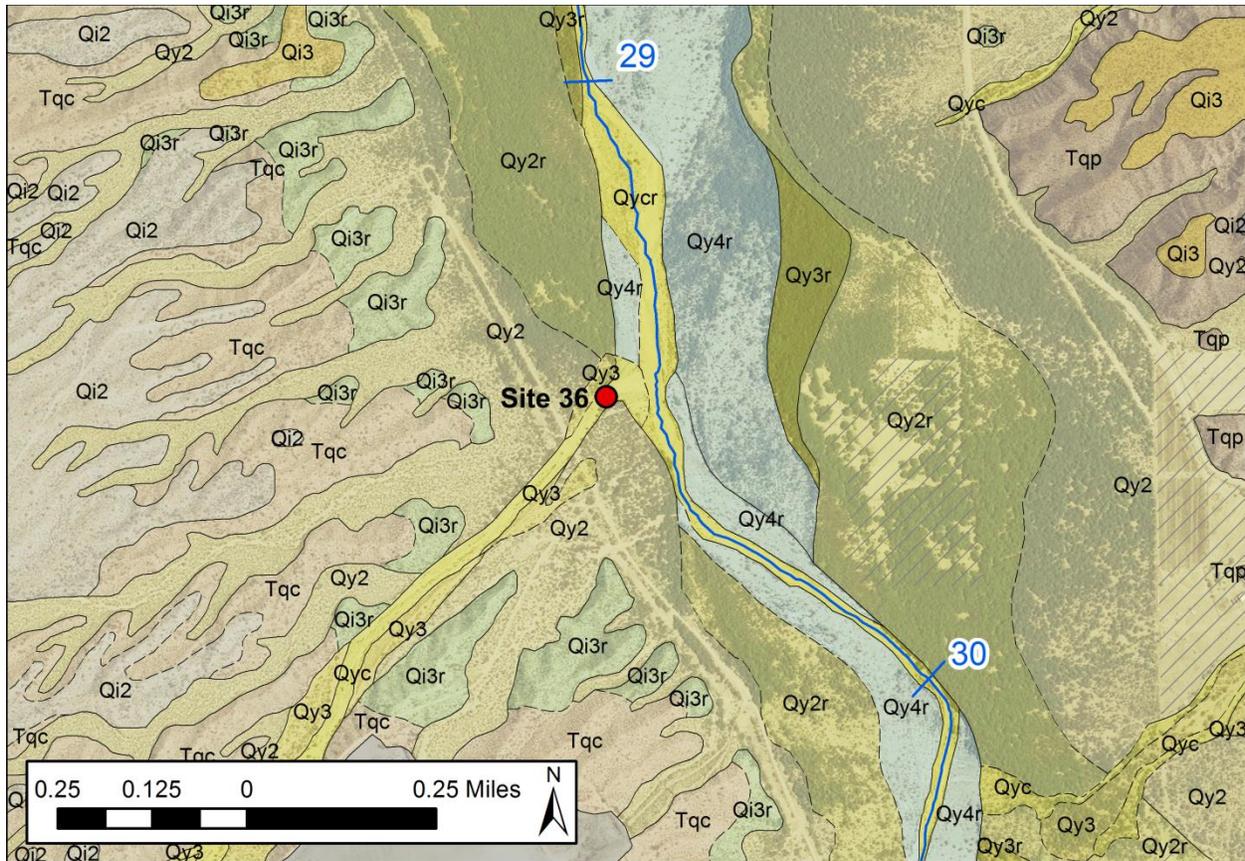
These distinctly different deposits are interpreted to have been deposited concurrently in a former confluence zone of the San Pedro River and James Wash prior to historical incision of the valley. The fine-grained, well-sorted alluvium is interpreted as San Pedro floodplain and low energy channel deposits and the very coarse, poorly sorted alluvium is interpreted as James Wash deposits. These deposits are alternately exposed in depositional and erosional sedimentary relationships. A depositional relationship between tributary and river channel sediment is characterized in photo SPR32E_A. Much like the exposure at site 29, these deposits were emplaced synchronously where James Wash joined the San Pedro in the past. Local variations in dominance of sediment from one source of deposition over the other can be explained by meandering of the San Pedro River, floods along James Wash, and limited preservation and exposure of depositional relationships. Large pebbles and cobbles exposed in James Wash deposits exhibit crossbedding and lie in erosional contact with underlying San Pedro deposits, indicating the coarser sediment was deposited by high energy flow, possibly during a flood event in the tributary channel. The fine-grained well-sorted composition of the lower deposit indicates steady, lower energy deposition such as that of a river floodplain or low energy channel. Similar fine grained deposits are encountered in Holocene to historical San Pedro River deposits to the west. This site is interpreted as exposing Holocene tributary fan and channel alluvium erosional overlying Holocene San Pedro River floodplain deposits.

Holocene river alluvium is exposed in arroyo walls of James Wash up to 600 ft outside mapped boundaries of Holocene River alluvium on AZGS surficial geologic maps.

Site 36

Potential exposure within an unnamed tributary channel

San Pedro River mile marker 29.5 west



Site Location and Description

Site 36 is located in an arroyo entering the San Pedro from the west near San Pedro River mile 29.5. Upstream, the channel exits highly dissected basin fill (Tqc) bluffs and flows across steeply sloping piedmont fans (Qy2 deposits) before depositing a small splay of young tributary sediment atop Holocene river floodplain (Qy2r and Qy4r) alluvium at the western edge of the modern San Pedro channel.

Site Access

Access to this site was very remote from the west and blocked by private property on the east. *No observations were made at this location due to difficulty of access and posted private property.*

Site Access

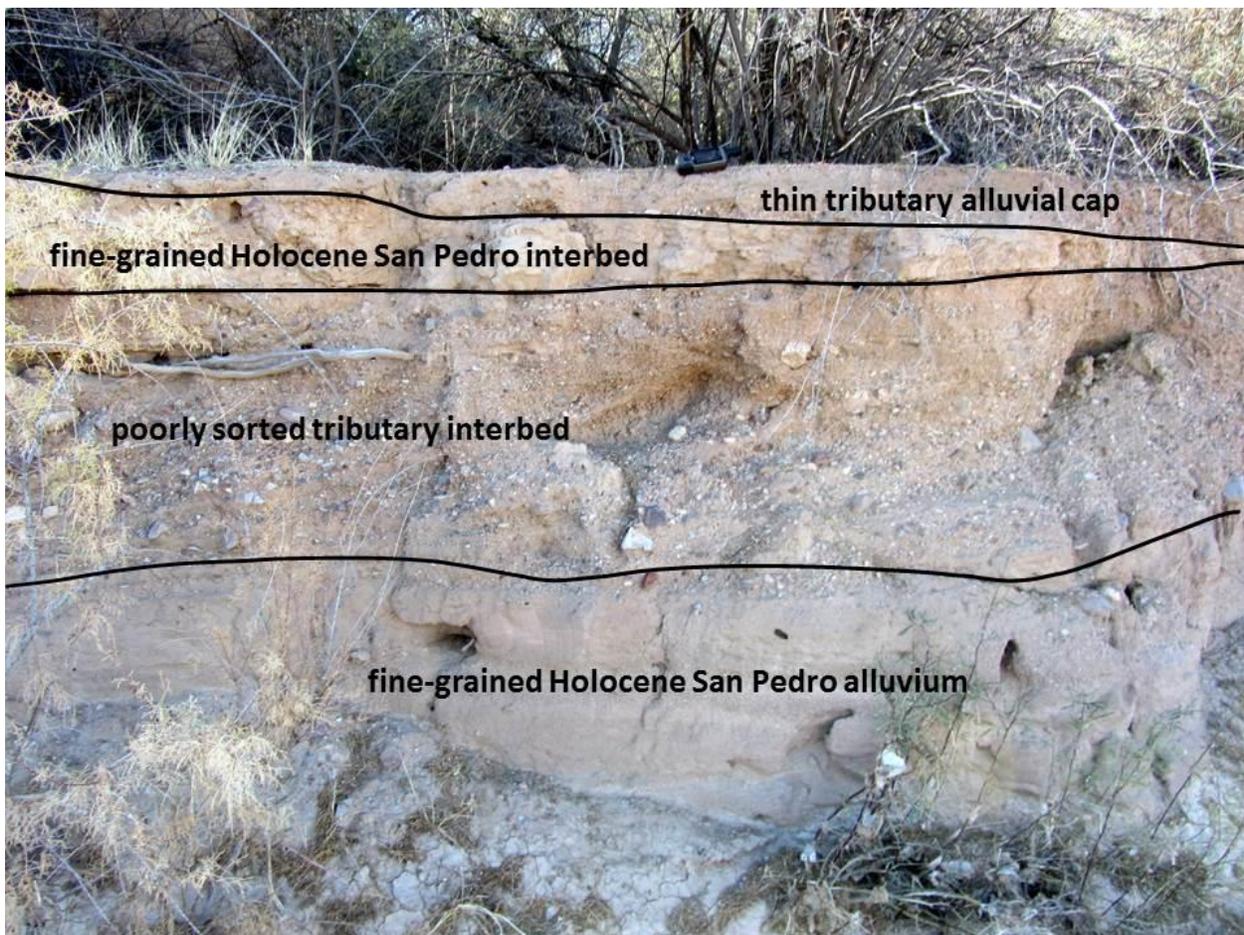
This site was accessed by driving south (upstream) in the San Pedro River bottom from E Copper Creek Rd at Mammoth, AZ to the north. Observations regarding this site are presented on the following pages.

Site 37

Photo SPR26W_A

Exposure within Mammoth Wash

San Pedro River mile marker 26 west

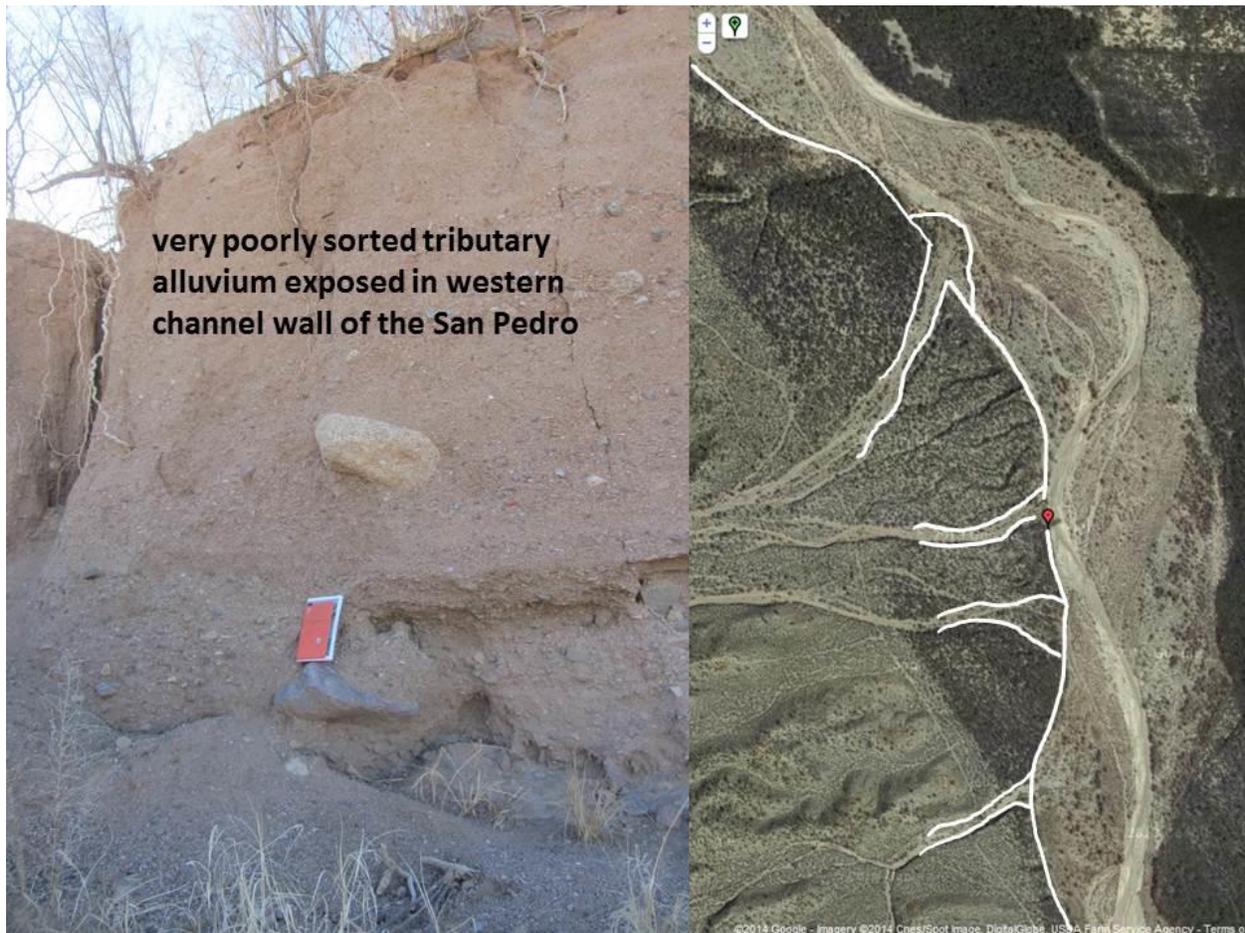


Site 37

Photo SPR26W_B

Exposure within Mammoth Wash

San Pedro River mile marker 26 west



Description of Tributary Arroyo Exposures

Photo SPR26W_A depicts alternating beds of poorly sorted, sandy to gravelly and well-sorted, fine sandy alluvium exposed in the edge of a large distributary alluvial fan emanating from Mammoth Wash. These deposits are exposed in the western channel wall of the San Pedro River a few miles south (upstream) of Mammoth, AZ. Interbedded and interfingering tributary and river deposits are present. The coarse, poorly sorted alluvium resembles bedload in distributary channels of Mammoth Wash to the west while the well-sorted sandy layers resemble fine alluvium exposed in San Pedro riverbanks ubiquitous throughout the area. In contrast, photo SPR26W_B was taken 10-20 ft away and depicts 8-10 feet of very poorly sorted sandy to bouldery (field notebook for scale)

alluvium exposed along an outside meander bend of the modern San Pedro River. No well-sorted alluvial layers are exposed at this location. An annotated overview of tributary channel deposits demonstrates alternating deposition of tributary sediment into the San Pedro river bottom and erosion of these deposits by the meandering San Pedro River. The overview figure demonstrates some tributary channels are truncated at outside meander bends of the San Pedro while others have deposited small splays of tributary sediment onto recent San Pedro channel deposits.

Stratigraphic Interpretation

The poorly sorted coarse sandy to gravelly deposits are interpreted as tributary alluvium deposited by Mammoth Wash. The finer sandy beds are interpreted as San Pedro River floodplain and low energy channel deposits. Some exposures at this site contain evidence for an interbedded relationship between these deposits while others consist entirely of tributary alluvium deposited by Mammoth Wash. Where an interbedded relationship is exposed, it is interpreted as evidence for concurrent and alternating deposition of sediment by Mammoth Wash and the San Pedro River in a confluence zone analogous to the confluence between drainages still present today. A complete lack of well-sorted San Pedro alluvium in some areas indicates portions of the Mammoth Wash fan are dominated by tributary channel deposition and fan progradation. Erosion of the tributary fan toe occurs where the active San Pedro River channel is adjacent to the fan, especially at outside erosional bends of the river. Because the active San Pedro channel shifts and meanders during flood events, different portions of the tributary fan are eroded away over time. Progradation of tributary fan alluvium occurs where the active San Pedro River channel is located away from the fan toe. Ephemeral flow during flood events in tributary fan channels delivers pulses of sediment to different areas of the distributary fan drainage network. Over time, the Mammoth Wash fan has prograded into the San Pedro River valley bottom, pushing the San Pedro River to the east.

Here we observe Mammoth Wash deposits to overlie former San Pedro River deposits but no exposures of the sedimentary relationship were found farther from the San Pedro River channel bottom. This is likely due, in part, to the unincised character of Mammoth Wash fan channels nearby.

Site Access

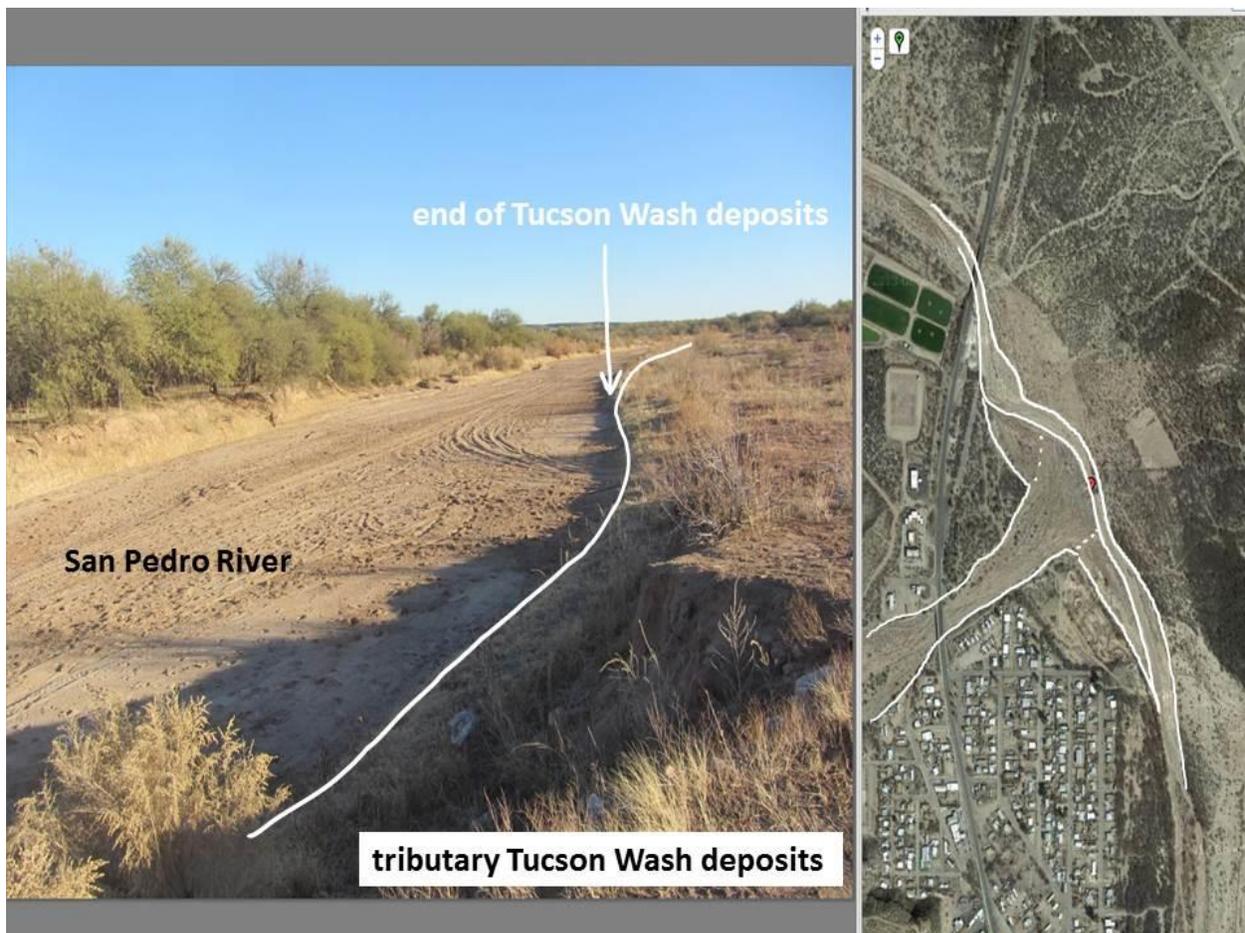
This site was accessed from Highway 77 where at the bridge spanning Tucson Wash. The wash was walked to the confluence with the San Pedro to the east. Observations regarding this site are presented on the following pages.

Site 38

Photo SPR23.5W

Exposure within Tucson Wash

San Pedro River mile marker 23.5 west



Description of Tributary Arroyo Exposures

View to the south (upstream) along the San Pedro River at the confluence of Tucson Wash. Poorly sorted sand and boulders dominate Tucson Wash deposits. San Pedro River bedload is generally finer overall than these large tributary deposits and here are

mostly composed of sand to gravel. The distal edge of alluvium recently deposited by Tucson Wash has been eroded away by the San Pedro resulting in a 3-6 ft tall bank of poorly sorted tributary sediment. No exposures of Holocene river alluvium are present at this location as the confluence zone is broad and unincised. The annotated aerial photo on the right outlines the relative positions of tributary and river deposits. Tucson Wash channel deposits project out across recent sandy San Pedro channel deposits. Homes and infrastructure in Mammoth, AZ have been constructed on former San Pedro terraces up to erosional scarps overlooking the modern river floodplain. A dynamic depositional and erosional system between the San Pedro River and Tucson Wash is evident at this location.

Stratigraphic Interpretation

Tucson Wash has deposited sediment all the way to the active San Pedro River. The distal end of these tributary deposits has subsequently been eroded away by the river. The San Pedro River has meandered back and forth across the valley bottom, alternately eroding and redistributing tributary fan and channel deposits. The modern landscape and distribution of tributary and river alluvium is a product of deposition and influence of both channel systems.

Recent Tucson Wash deposits overlie multiple generations of former San Pedro channel deposits at this location.

References

Ballenger, J.A.M, 2010, Late Quaternary Paleoenvironments and Archaeology in the San Pedro Basin, Southeastern Arizona, U.S.A.: Doctoral dissertation, University of Arizona, Tucson, AZ, 217 p.

Cook, J.P, Youberg, A., Pearthree, P.A, Onken J.A., MacFarlane, B.J., Haddad, D.E., Bigio, E.R And Kowler, A.L, 2009, Mapping Of Holocene River Alluvium Along The San Pedro River, Aravaipa Creek, And Babocomari River, Southeastern Arizona: DM-RM-1, 6 Sheets, Scale 1:24,000, With Text.

USDA-FSA Aerial Photography Field Office, 2013, NAIP 2013 Orthoimagery