Predevelopment interconnection of surface and ground water along Big Chino Wash

(A stream with surface-ground water connection under natural conditions)

By

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April 12, 2010

I wonder what the valley floor was like before upstream diversion/storage and local pumping and associated lowering of the underlying groundwater.

The planform pattern of Big Chino Wash provides information on past streamflow characteristics that created the floor of Big Chino Valley. The valley floor, and thus the bed and bank of the wash channel, is composed of sediment transported by the wash. The shape of the alluvial channel is uniquely produced by the type of streamflow. For example, a pattern of meandering stream channels, when viewed from above, is uniquely produced by perennial or intermittent flow that is interconnection with underlying groundwater. In Arizona, the resulting saturated floodplain Holocene alluvium is defined as the subflow zone. Appropriable water includes surface water and subsurface water of the subflow zone. Thus, the present geomorphology of Big Chino Wash contains information of past streamflow and groundwater conditions that is useful to water managers, river engineers and hydrologists.

Big Chino Wash heads in Bill Williams Mountain to the east and the Juniper Mountains to the west. The watershed is the headwaters of the Verde River. According to Woodhouse and others (2002) "The major streams in the upper part of the Verde River watershed are the Verde River (perennial below its confluence with Granite Creek); Big Chino Wash (ephemeral); Williamson Valley Wash, Walnut Creek, and Granite Creek (all with perennial flow in their upper reaches and ephemeral farther downstream); and Pine Creek and Partridge Creek (intermittent)." Although presently an ephemeral stream there is considerable evidence the Big Chino Wash was perennial/intermittent before anglo settlers impacted the area with upstream storage and diversions and with local groundwater extraction.

To envision how the discharge from base runoff formed the meandering channel, imagine placing a water hose discharging at constant rate in a freshly tilled garden. Eventually, a small channel will form and reach an equilibrium geometry. At the larger scale of Big Chino Wash, consider the rather steady or persistent releasing of groundwater at springs that combines to produce base runoff discharge on the wide alluvial Big Chino Valley. Experience has shown that the persistent nature of base runoff is the *channel-forming discharge* of meandering channels with sediment and slope characteristics like those of Big Chino Wash.

PRIOR EVIDENCE OF A SURFACE - GROUND WATER CONNECTION

Wirt (2005) presented considerable "evidence that some reaches of Big Chino Wash may have been intermittent or perennial prior to agricultural development" and also there was evidence that suggested the base runoff and underlying groundwater had been interconnected under pre-development conditions. Wirt, however, found little hydrologic information available prior to 1946 and thus was inconclusive whether flow in Big Chino Wash had been perennial/intermittent or ephemeral. Because of study constraints, Wirt's analysis stopped short of (1) postdicting the type of base runoff from the appearance, slope and sediment characteristics of the stream channel and valley floor and (2) answering the questions about irrigation diversion dams along the valley such as *Were the several diversions for irrigation along Big Chino Wash for ephemeral flow?*

PURPOSE AND SCOPE

This report and analysis are a continuation of Wirt's examination of the possibility that the predevelopment flow in Big Chino Wash was interconnected with the underlying groundwater. This analysis is based on (1) my observations, knowledge and expertise concerning hydrology, hydraulics and fluvial processes, in general, and the application of this knowledge to the Big Chino Wash in central Arizona, in particular, (2) topographic maps, aerial photographs and published reports by the U. S. Geological Survey and other Federal agencies and (3) pier reviewed literature published in many scientific journals.

The Big Chino Valley along the primary study area between Partridge and Walnut Creeks is roughly 1/2 to 1 mile wide and slopes gently to the southeast. The present (2010) meandering channel of Big Chino Wash has alternating bends with irregular spacing and amplitude along the valley trend. Several irrigation diversion dams crossed both the channel and the valley.

The question-- *Was the groundwater in the valley bottomland hydraulically connected to the main stem channel*? is answered using (1) information gleaned from aerial photographs of 1940 that show many irrigation diversion dams along big Chino Valley and flow in the channel of Big Chino wash and canals and (2) postdiction of the type of streamflow (perennial, intermittent or ephemeral) that produced the meandering channel of the wash. In other words-- What does the mere presence of the diversion dams with canals along the valley floor tell us about the interconnection of the surface water and ground water? Also, are the spatial characteristics and differences of the channel meanders (Figure 1 and Photograph A) related to past perennial, intermittent or ephemeral streamflow? And if so, can the nature of the predevelopment streamflow be postdicted using channel morphology?

The Arizona definition of subflow used by ADWR for the recent San Pedro River study and mentioned in the recent Arizona Superior Court decision on the Big Chino pipeline are briefly discussed.

Geomorphologic principles using published physical characteristics of the Lynx soil of the valley floor are used. A short reach of the meandering channel of Big Chino Wash is closely examined (Reach A-B, Photograph A).

While climate change has potential to affect the hydrology of the Big Chino watershed, it is beyond the scope of this analysis.

A glossary of a few terms is at the back of the report.

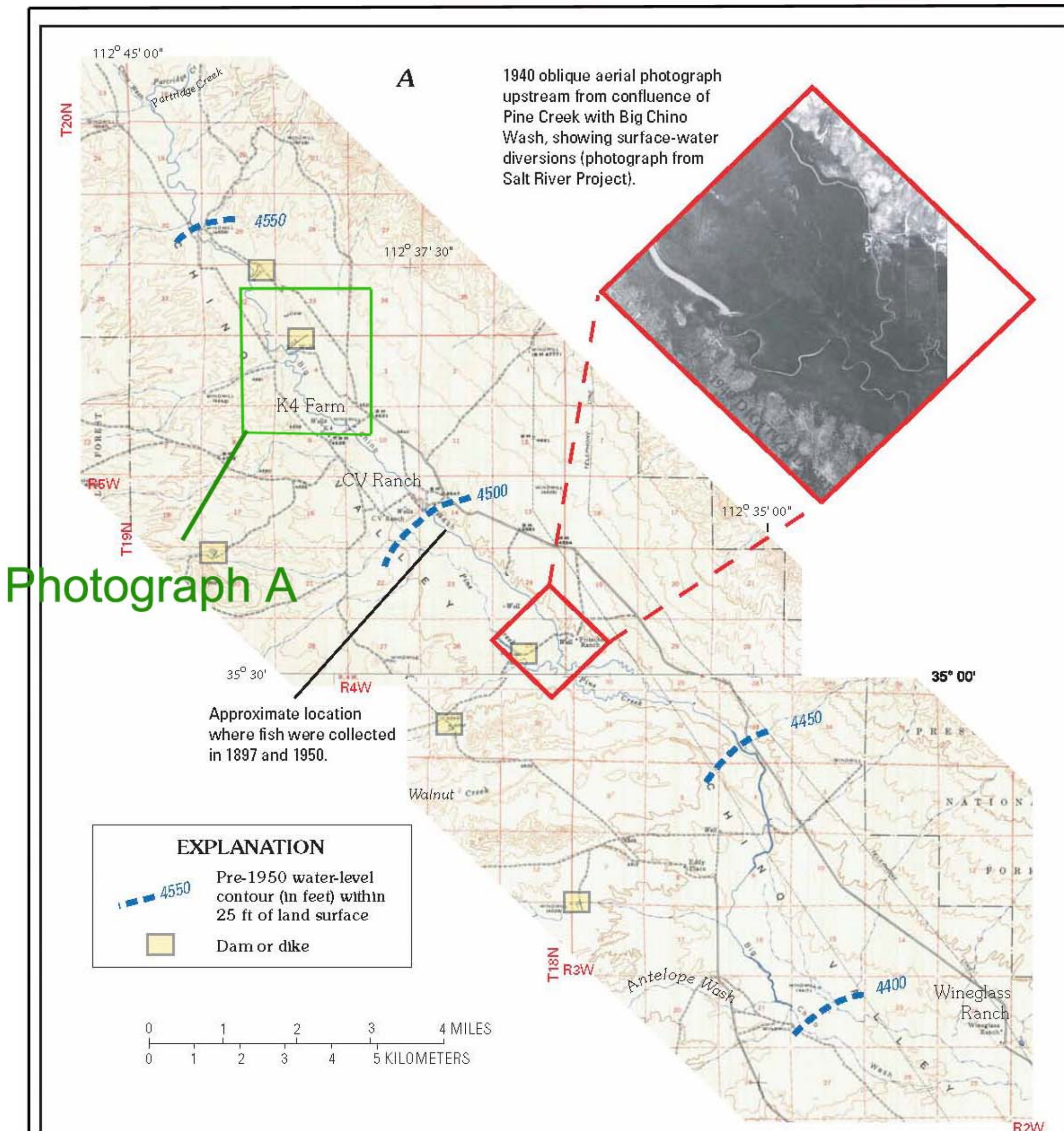
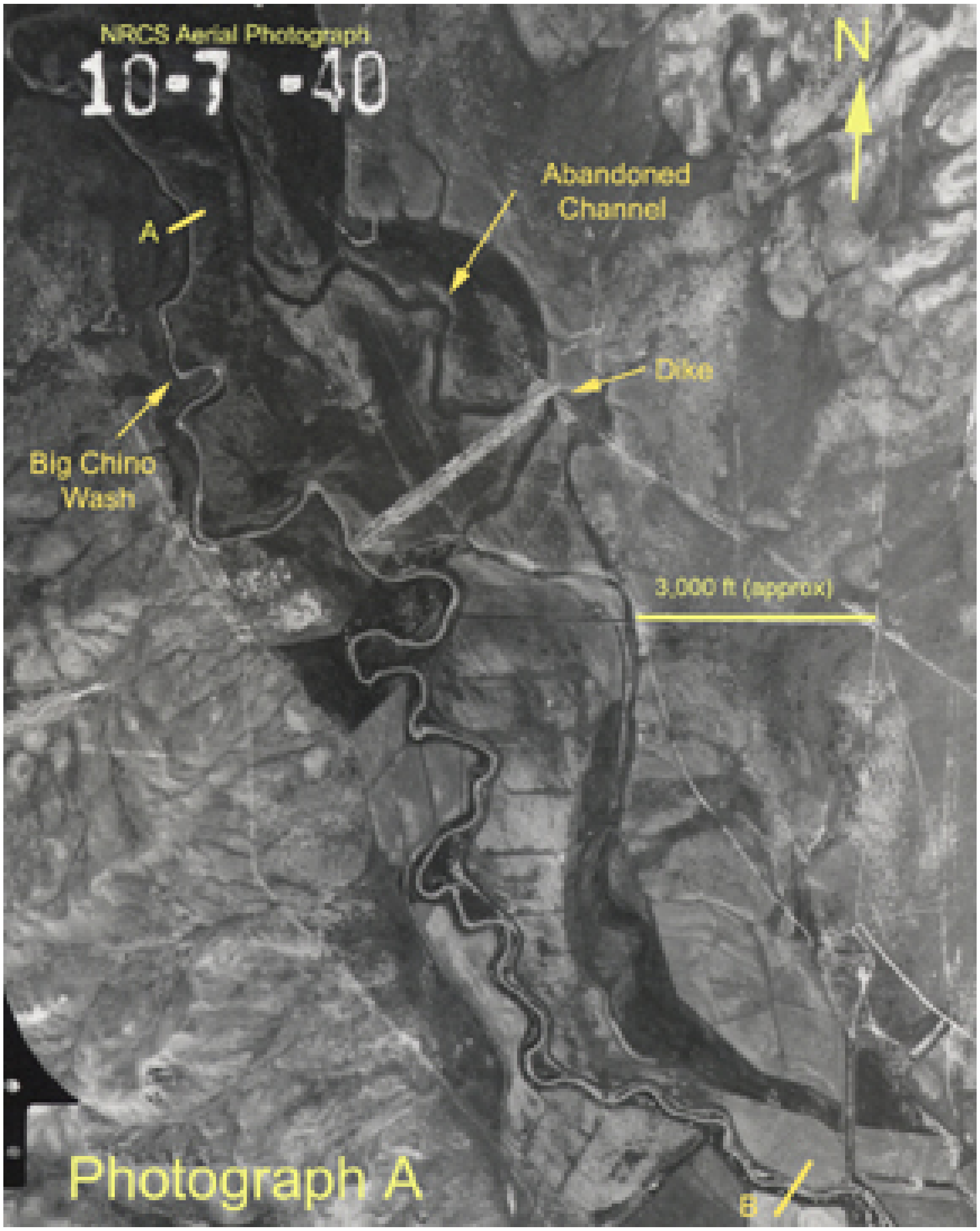


Figure A10. Pre-1950 ground-water conditions inferred from 1947 U.S. Geological Survey topographic maps, indicating shallow water table in parts of Big and Little Chino Valleys. A, intermittent reach of upper Big Chino Wash between Partridge Creek and Wineglass Ranch (1947 Pichacho Buttes and Simmons quadrangles; 1:62,500 scale). Inset shows 1940 aerial photograph of Pine Creek and Big Chino Wash with cienaga; B, (facing page).

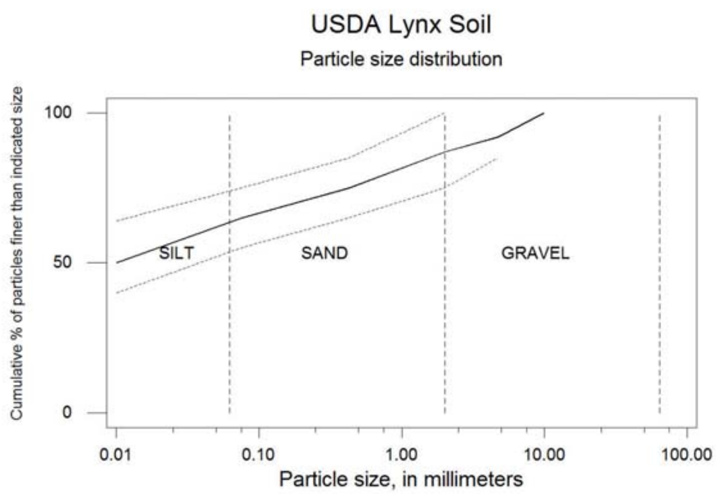
Figure 1. Topographic map of Big Chino Wash from Wirt (2005).


NRCS Aerial Photograph
10-7 -40
N
Abandoned
Channel
A
Dike
Big Chino
Wash
3,000 ft (approx)
Photograph A
B

HOLOCENE ALLUVIUM (SEDIMENT AND SOIL)

Big Chino Wash is an axial or base level stream where tributaries that head in adjacent mountains form alluvial fans on the valley floor. Much of the channel is incised in Holocene deposits of silt and clay that reside in a gently sloping wide valley bounded by the fault-block mountains. The resulting valley floor is Lynx soil (Wendt, 1977) that is a mix of silt and clay and the locally incoming coarser silt and sand that forms the alluvial fans.

The slightly sticky and sometimes plastic dark brown soil is typically loam, silt loam, clay loam, and sandy clay loam with some weak thick platy structure. Along the nearly level bottom lands the Lynx soil is clay loam. At tributary streams there is a mixing of coarse incoming sediment and the finer sediments in Big Chino Wash. The rather uniform particle size distribution, as shown below, is typical of streams with rather steady flow (perennial) as opposed to the wide range of particle size associated with ephemeral streams.



PREDEVELOPMENT

Before development by anglos, the base runoff in Big Chino Wash and some of the mountain and lower lying tributaries was created as precipitation became groundwater and eventually exited to the stream channel from tributary areas such as Pine, Partridge and Walnut Creeks. Along many places of the tributary channels runoff was lost to infiltration as the general groundwater was far below the channel beds. In other areas such as some of Partridge Creek the runoff was perched by impermeable rock above the underlying water table. Winter snowmelt in the surrounding mountains intermittently flowed along Big Chino Wash. Big Chino Wash was, and is, exotic because of its wet origins and it flows through a semi-arid Big Chino Valley.

The natural flow in Big Chino Wash was governed largely by the climate of the watershed. The distribution of high flows was governed by the physiography and plant cover of the watershed. The distribution of low persistent flows (base runoff) was controlled chiefly by the geology of the watershed and the availability of discharging groundwater. Base runoff in the study reach was the composite of ground water drainage from many parts of the watershed. Much of the base runoff was from limestone aquifers.

The channel of the Big Chino Wash apparently migrated within the confines of the floodplain in response to floods that eroded sand and gravel bars and deposited new ones. The size and shape were related to the stream discharge and sediment in the valley floor. Floods would alter the channel geometry but the base runoff would reform or heal the channel. The stream constructed its own geometry with the resulting narrow and deep meandering channel.

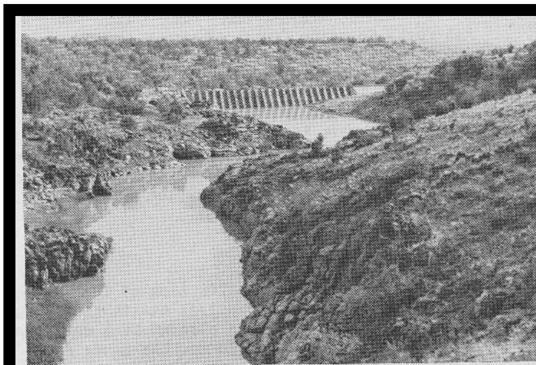
The has been considerable development of the water resources of the Big Chino Valley and watershed. There are many stock tanks, permanent storage reservoirs, large diversion dams, windmills, wells and the such all over the watershed. The water table under Big Chino Valley has lowered from groundwater extraction by humans. There is excellent photographic evidence that farmers developed dikes and ditches to divert perennial or intermittent flow along Big Chino Wash.

DEVELOPMENT

Diversion and regulation since roughly 1870, the approximate time when anglos felt safe to settle the area, have altered the discharge and sediment characteristics and changed the once perennial/intermittent stream to an ephemeral wash. There presently is no base flow to reform the low-water channel following changes of geometry from floods and melting snow. As with the dewatering of many base level streams in the southwest, such as the Santa Cruz and Gila Rivers, the meandering channel is becoming a braided channel.

Watershed

There are many examples of the impact anglos have had on streamflow of streams in Arizona and the Big Chino Wash is no exception. Simply break out the USGS topographic maps and you'll see Meath Dam, Sawtooth Tank, Concrete Dam, Antelope Dam, Red Hat Tank and many other named and unnamed impoundments. One of the most interesting and seldom mentioned is Ash Fork Steel Dam on Johnson Canyon in the headwaters of Partridge Creek.



ASH FORK STEEL DAM, ASH FORK, ARIZONA

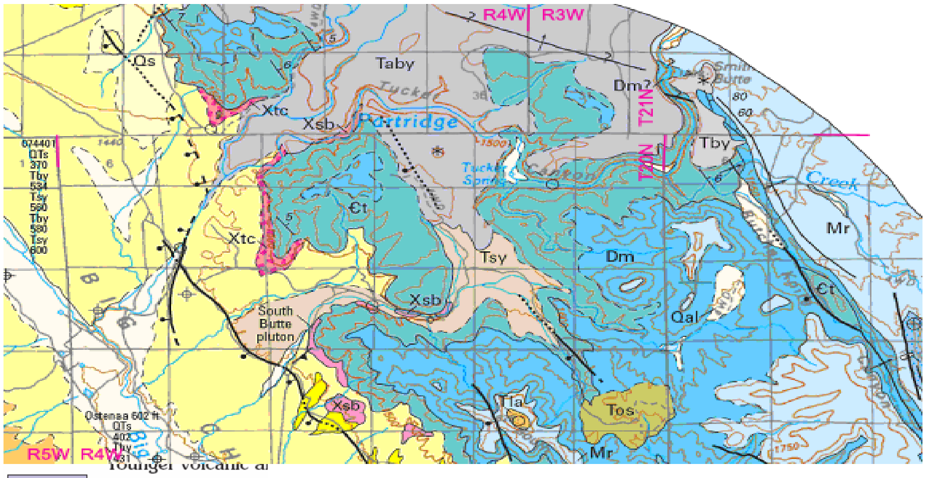
The maximum height of Ash Fork Steel Dam is 46 feet. Including masonry abutments at each end, its length is 300 feet. It has no spillway and was designed to permit a flow of up to six feet of water over its entire crest. The reservoir impounded has a volume of 36 million gallons. It has been well maintained through the years by the Santa Fe Railway, the original builder and still the present owner. Its water, that was potential base runoff for the Big Chino Stream, is now used for livestock watering by local stockmen.

Based on the geohydrology and the author's field observations, there was persistent base runoff in lower Partridge Creek and in Big Chino Wash below the confluence of Partridge Creek. While there's little chance of perennial flow along the entire length of Partridge Creek because of high infiltration along the channel that is perched far above the underlying general groundwater (comm. with Don Bills (USGS) and Ed Wolfe (USGS retired)), there was, and are, periods of persistent snowmelt runoff along the length of the watercourse. Combined base runoff and snowmelt runoff produced perennial/intermittent flow at the mouth of Partridge Creek. A short distance downstream of the alluvial fan at the mouth of Partridge Creek is the incised meandering channel of Big Chino Wash that was formed by perennial/intermittent flow. Streamflow at any one time might have consisted of water from one or both sources.

The following geologic map (Ed DeWitt's map) and the USGS color IR photograph to the left indicates there was perched (above the regional groundwater) dry-weather flow along Partridge Creek in July 2000. The geologic map shows that the reach of Partridge Creek in Tucker Canyon is floored by either Cambrian Tapeats Sandstone or Precambrian granite except for a couple of reaches in which the canyon crosses basalt (Taby) that locally buries the Tapeats or the granite (Ed Wolfe, written comm). Although neither the Tapeats nor the granite is likely to be highly transmissive, the spring occurs where a small patch of mapped alluvium rests on the Tapeats Sandstone. The streambed along this reach is on or near relatively impermeable “basement”. Thus, there is little opportunity along this reach for loss of surface water by infiltration. The color IR on the left clearly shows transpiring riparian vegetation (red line) along Partridge Creek throughout Tucker Canyon that corresponds to the impermeable streambed.

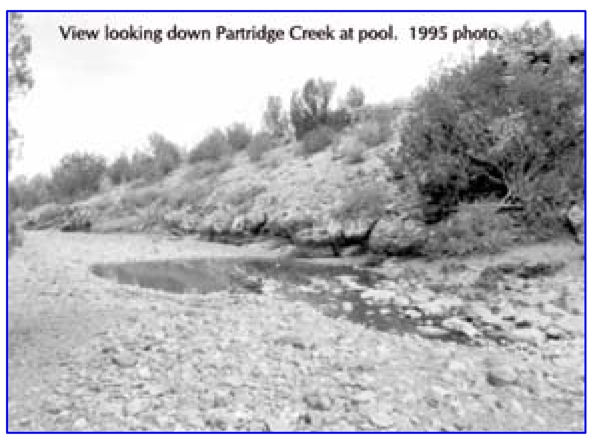
The red color on the above color infra red photo also suggests dry weather flow to the confluence with Big Chino Wash where a large area of transpiring grasses at the confluence with Partridge Creek is shown. The faint red along Big Chino Wash to near the farming area suggests surface or near surface water supplying the transpiring vegetation. The area was larger and marshy (oozing with water) when the author hiked into the area during the winter of the mid 1960s while performing field investigations for the USGS.

Geology of lower Partridge Creek watershed from DeWitt and others (2008).

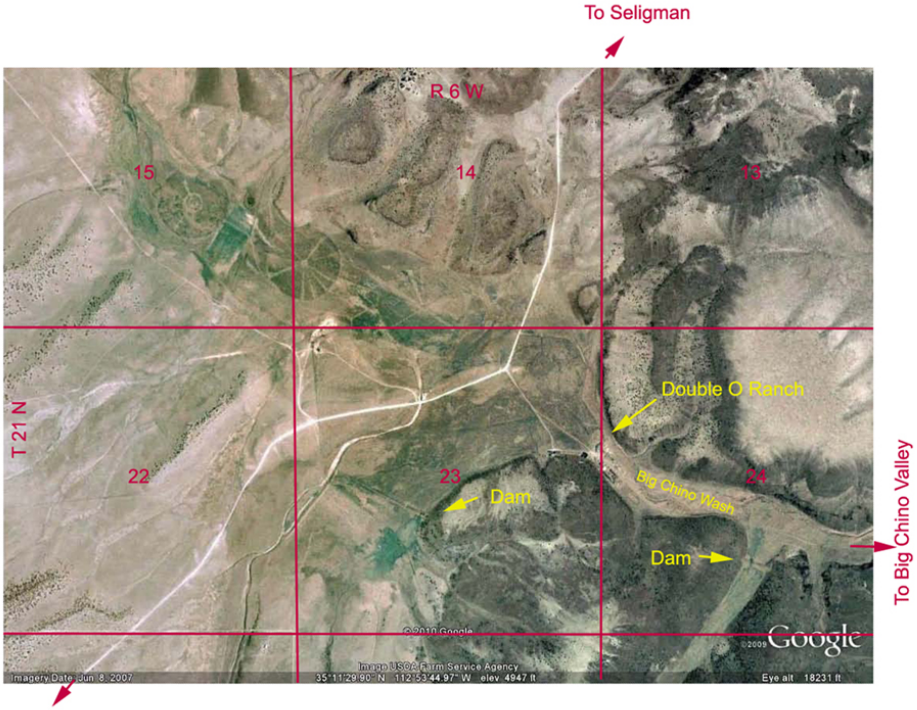


Taby	Alkali basalt
Ptc	Toroweap Formation and Coconino Sandstone (Lower Permian)
Psh	Schnebly Hill Formation (Lower Permian)
Ph	Hermit Formation (Lower Permian)
Pshh	Schnebly Hill and Hermit Formations, undivided (Lower Permian)
IPs	Supai Formation (Lower Permian to Upper Mississippian (or Upper Pennsylvanian of Blakey))
PIPss	Schnebly Hill, Hermit, and Supai Formations, undivided (Lower Permian and Upper Pennsylvanian)
Mr	Redwall Limestone (Mississippian)
Dm	Martin Formation (Upper and Middle? Devonian)
MDrm	Redwall Limestone and Martin Formation, undivided (Mississippian through Middle? Devonian)
D€mt	Martin Formation and Tapeats Sandstone, undivided (Upper Devonian through Lower Cambrian)
€b	Bright Angel Shale (Middle Cambrian)

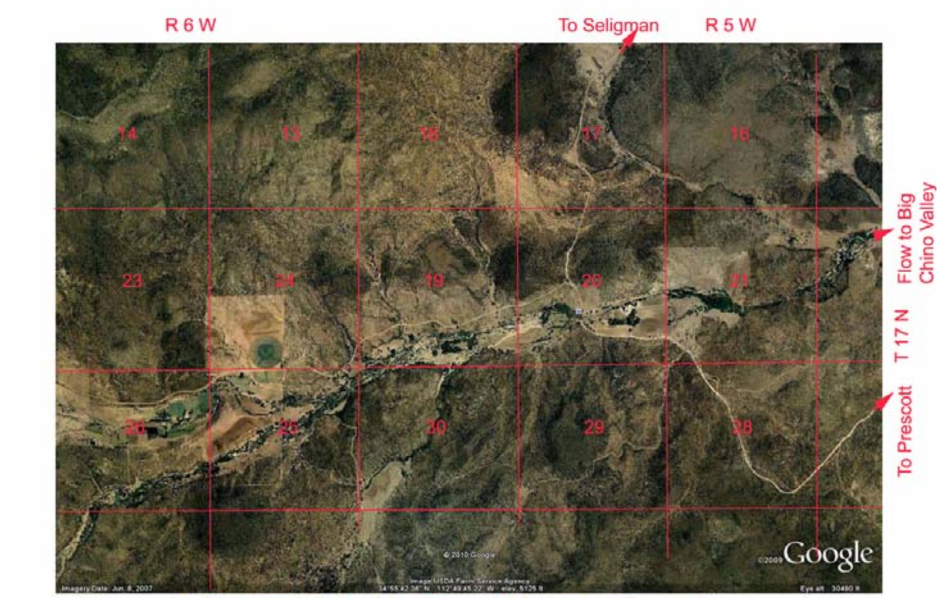
Indian habitation along the ridge of Tucker Canyon above pools of Partridge Creek shown in the scene to the right is evidence of persistent flow.



Two examples of irrigation in the watershed above Big Chino Valley are shown in the following aerial photographs. A few hundred acres of land irrigated by groundwater pumping and base flow diversion along both Big Chino Wash and Walnut Creek are shown in the two photographs.



Irrigated land along Big Chino Wash
upstream from Big Chino Valley



Irrigated land along Walnut Creek
upstream of Big Chino Valley

Valley Floor

Wirt discussed the fact Big Chino Wash is represented by a solid or double blue line between Partridge Creek and Antelope Wash (west of Wineglass Ranch), indicating either perennial or intermittent conditions (fig. 1). Wirt said these maps, that are based on 1946 aerial photographs, are inconclusive because the aerial photography and field checking may have occurred during a wetter timeframe. However, a second set of photographs of the NRCS taken on Nov. 7, 1940 also show flow in Big Chino Wash for the reach shown in Figure 1. Furthermore, several irrigation diversion dams, or dikes, along the valley floor are shown in Figure 1 and also on the NRCS photographs of Nov. 7, 1940. For example, the photographs of one dam show water in an irrigation ditch leading from the dam of the left side of the valley to a field near Wineglass Ranch.

Diversion Dams

Were the farmers along the valley floor diverting perennial, intermittent or ephemeral flow? Several of the embankments (low dams) were constructed across the valley floor at right angles to the land slope using valley floor material. There were small capacity diversions to small ditches that conveyed water to fields with little storage behind the dams. Other earth dams extended across the channel and simply diverted low flow to ditches. Generally, it appears low persistent flows were simply diverted to fields and high flows breached the structures.

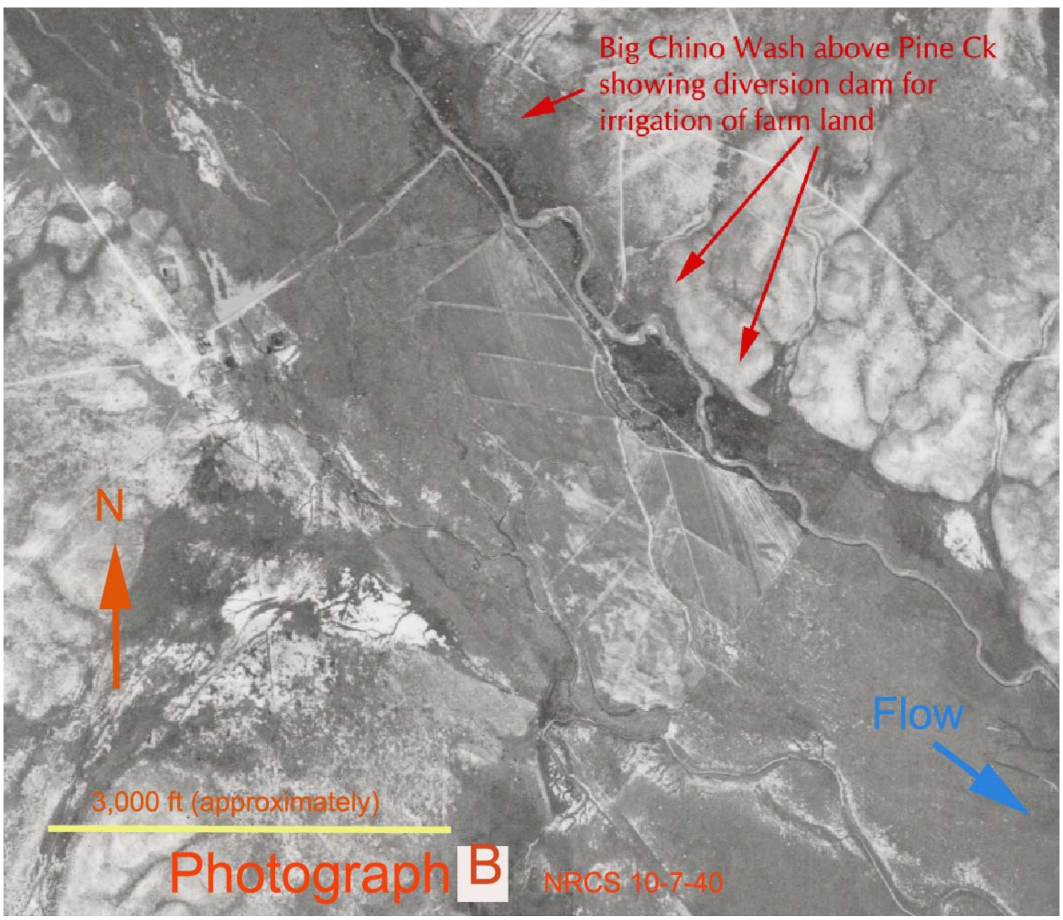
It's important to note that floodwater farming along ephemeral streams is a common practice in arid areas of the world. For example, American Indians have practiced floodwater farming along ephemeral watercourses in the southwest for many years (Bryan, 1929). Areas such as alluvial fans that are likely to be flooded are seeded (by making a hole with a planting stick and inserting a seed). Floodwater diversion from ephemeral streams has also been used for farming in other arid and semi-arid region of the world (Kerem and others, 2002). Elementary diversion works along normally dry river beds are used to deflect sporadic water to pre-prepared fields. Masonary diversion works along the banks of normally dry rivers are also used in some regions. Generally speaking there is more seeding than harvesting as success is dependent on sporadic debris-laden floods.

The mere presence of several wide-low irrigation diversion dams with relatively small canals along the valley floor is compelling evidence there was perennial/intermittent base flow along Big Chino Wash before and into the 1940s. Melting snow may have produced some usable persistent flow for irrigation diversion but snowmelt runoff was seldom available when water was most needed for growing crops. Several earth embankment irrigation systems are shown on the NRCS 1940 aerial photographs of October 7, 1940.

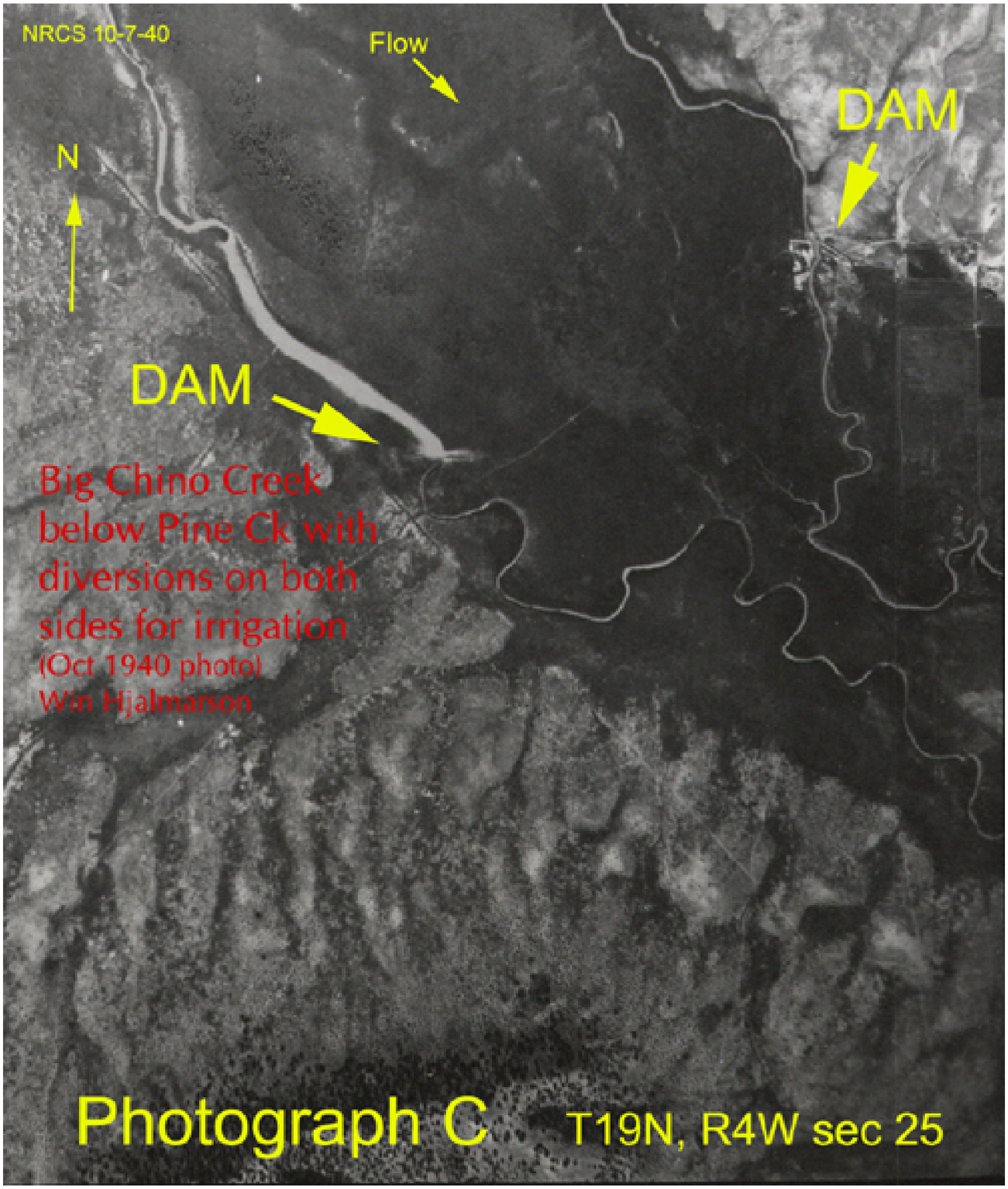
Consider the dams and dikes shown in photographs A,B and C as follows.

The meandering channel of Big Chino Wash shown in Photograph A is on the right bank side (Viewed looking downstream) of the valley floor that is the dark area in Photograph. The center of the photograph is at T19N, R4W, sec4 and flow is from top to bottom). This is a classic appearing meandering channel formed by perennial flow on the wide-flat floor of Big Chino Valley downstream of Partridge Creek and upstream of Pine Creek. An abandoned meandering channel of the wash is along the left bank side of the valley floor. The cultivated field below the dike was irrigated by perennial or intermittent flow in Big Chino Wash diverted at the dike.

Diversion of streamflow at a second dike is shown in Photograph B. The center of the photograph is at T19N, R4W, sec15.



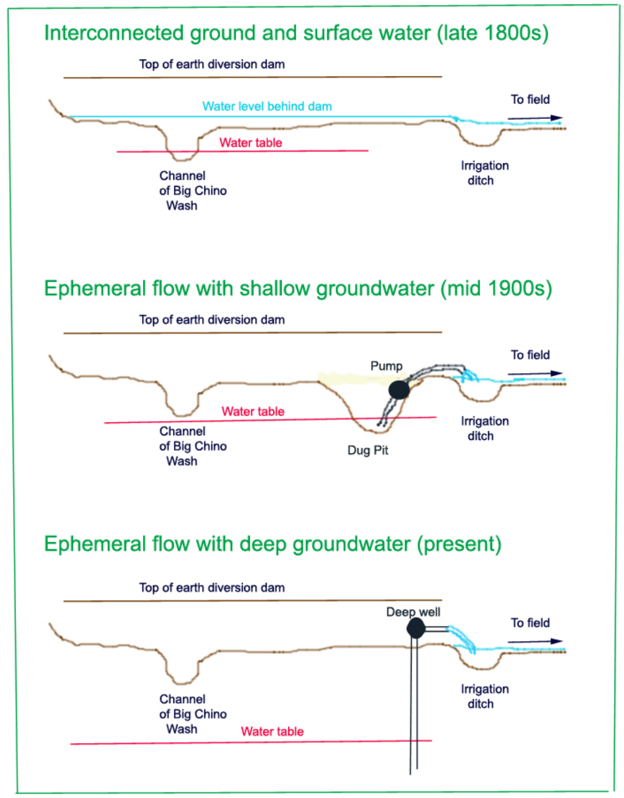
Photograph C depicts irrigation diversion dams on both sides of the valley floor. The dam on the left-bank side in on Big Chino Wash and the dam on the right is on a channel leading from Pine Creek. Farm land is visible along the left bank side of the valley.



Shallow pumps

In the mid 1960s the author was performing field duties for the USGS and observed a low lift centrifugal pump installation on the upstream side of an earthen dike in Big Chino Valley. The installation is roughly depicted in the center sketch of the following three cross-section sketches of Big Chino Valley. The suction line was in a dug pit (a shallow well) on the upstream side of the dike or earth dam. It appeared that the pit was dug by a bulldozer to get to the underlying ground-water as the level was dropping from human extraction by deep wells and upstream human diversion.

The general response of crop irrigation practices in Big Chino Valley to the declining water table is depicted in the three simple sketches to the right.



Deep Wells

The introduction of turbine pumps following World War II enabled groundwater to be extracted from greater depths and greatly expanded its use. What was left of the base flow along the Big Chino Stream was under serious attack. In an early account of lower Big Chino Valley, the Bureau of Reclamation (1946, Chino Valley project, Arizona: U.S. Department of Interior, Project Planning Report No. 3-8b.9-0, April 1946, Appendix C) described the relation of streams in the Verde River headwaters as follows: “the head of the Verde, formed by the junction of Chino Creek (*Big Chino Wash?*) and Williamson Valley Wash, is fed by permanent ground water.” Although perennial flow of the Verde River began at the mouth of Williamson Valley Wash as late as 1946, a few years later there was no base flow in Big Chino Wash between the mouth of Williamson Valley Wash and Sullivan Lake. Eventually all of the base flow in Big Chino Wash was gone.

GEOMORPHOLOGY

Streams with natural alluvial channels like the Big Chino have constructed their own geometries. The amount of flow is the principal control of channel size and the sediment characteristics largely determine channel shape. The general slope of the valley and the climate are also important factors. Channels formed in nearly level valleys that are composed of moderately permeable deep clay loam soils like the Big Chino above Pine Creek, typically are rather stable. Thus, signatures of past streamflow remains for aerial viewing and interpretation until history turns them to dust

It's become rather common knowledge among river engineers and geomorphologists that "Channel pattern is used to describe the plan view of a reach of river as seen from above as in an airplane, and includes meandering, braiding, or relatively straight channels."(Leopold and Wolman, 1957). There are several planform predictors of a meandering-braiding threshold that have been published (See for example Schumm (1985) and U. S. Corps of Engineers (1990)). There are also several channel geometry and material predictors for alluvial channels like Big Chino Wash (See for example Osterkamp (1980), Osterkamp and Headman (1982), Schumm (1960),(1968)). Numerous examples of ephemeral (non-wetland waters) stream morphology, such as channel planforms, are shown by Lichvar and McColley (2008). Lastly, elaborate planform and channel geometry predictors have been developed for hydrologic and environmental studies of perennial and ephemeral streams where a meandering pattern is distinctive of perennial streams (Rosgen, 1994 and 1996), (Bull, 1997) and (U. S. Corps of Engineers, 2001).

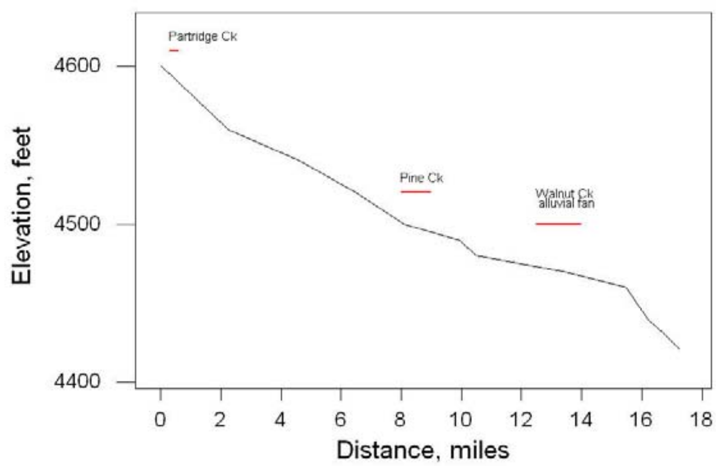
Big Chino Wash

The meandering channel has, or had under natural conditions, a rather uniform width (width-depth ratio generally <10) with a wide floodplain that is a storage zone for water, sediment and dissolved load (terminology from Schumm (1977) and the Glossary) from headwater and adjacent streams. The mature Big Chino Valley has gentle slopes and a flood plain (composed of Lynx soil) where the stream channel has meandered across the width of the flood plain (Figure 1).

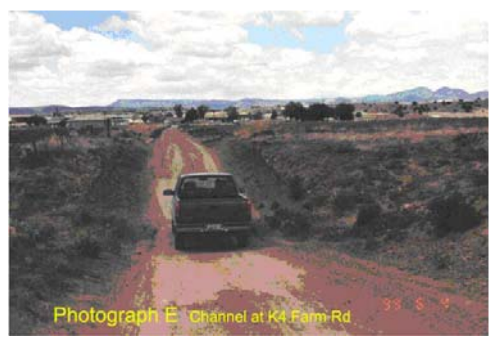
The slope, sediment and cross-section shape of Big Chino Wash varies along the valley. The meandering of the single channel also changes (sinuosity increases) where sediments are finer and the valley slope is less. The changing meanders are obvious in photographs A, B and C and in Figure 1. Where sediments are courser and valley slope is greater (at and below tributary alluvial fans) the amount of meandering of the main channel is less.

Much of the valley has gentle slopes of about 0.2% (see following profile) with significant floodplain sedimentation and cohesive banks (U.S. Soil Conservation Service Soil Survey Report for Western Part of Yavapai County,1976). Sediment deposited by tributary flow locally disrupted the channel stability and sinuous shape. Overall, the morphology classically shows the presence of perennial flow in a channel formed in Holocene sediments of the valley floor (Photographs D, E and F).

Profile of channel along Big Chino Valley
(approximate- from USGS 7.5 min topo maps)



Photograph D


Photograph E Channel at K4 Farm Rd


Photograph F Channel of wash at K4 road

The wide and rather flat floodplain (Photograph D) suggests the sediment input is from the wash. The alluvial fan areas clearly show the side-valley tributaries are important sediment source areas.

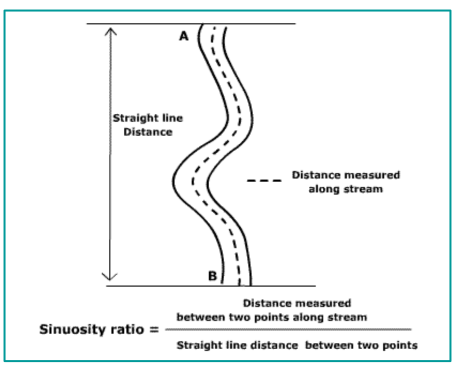
The three major tributary streams with significant alluvial fans in the valley floor, in downstream order, follow:

1. **Partridge Creek** that heads in the Bill Williams Mountain area to the northeast. The active alluvial fan at the mouth of Partridge Creek is the upper end of this study.
2. **Pine Creek** that heads in the Juniper Mountains to the west.
3. **Walnut Creek** that heads in the Juniper Mountains to the west.

Much of the floodplain soil, that is typically greater than 5 ft deep, probably was above the water table. However, given the wide rather low-permeable floodplain, bottom of the soil may have been close to saturation because of the capillary fringe effect.

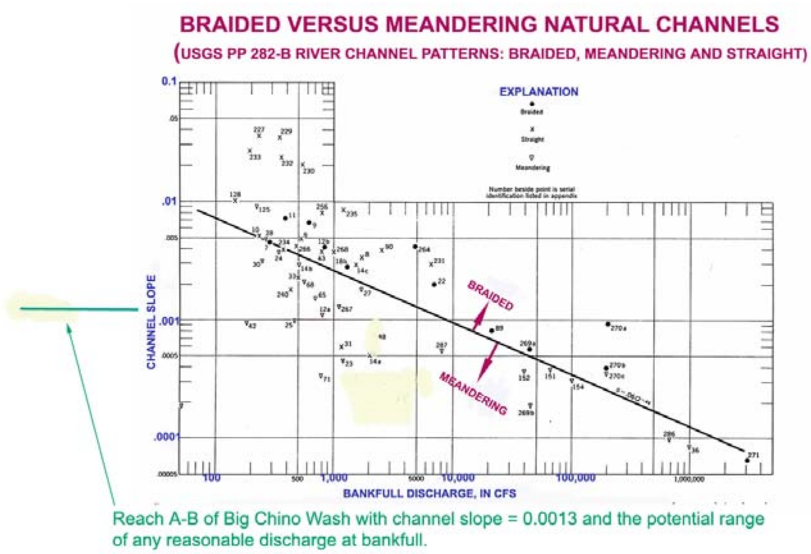
Reach A-B of Big Chino Wash

A reach of the meandering channel between Partridge and Pine Creeks is closely examined for this analysis (Profile and Reach A-B, Photograph A). The sinuosity (Ratio of the channel or thalweg to the down-valley distance (Leopold and Wolman, 1957, p. 53 and shown below) of the channel is 1.6 with a slope of about 0.13 percent. The abandoned channel of prior flow along the left (looking down the valley) side of the valley has a similar sinuosity and slope.



A sinuosity of 1.6 clearly is indicative of perennial flow for alluvial streams like Big Chino Wash. Many geomorphologists agree a lower limit for persistent base flow is 1.3 while Leopold and Wolman (1957) suggested that a sinuosity of 1.5 marks the lower boundary for true meandering of perennial streams.

An example of the general association distinguishing between meanders and braided channels on the basis of channel slope and discharge is shown below (Leopold and Wolman, 1957). Although *off the graph* below, Big Chino Wash clearly was a meandering stream.



As mentioned previously, Rosgen (1994 and NRCS, 2007) has developed and elaborate classification system for perennial streams using planform, channel geometry and other characteristics. Big Chino Wash is a Type E "Rosgen" stream with a narrow and deep channel (low width/depth ratio) but has a very wide and well developed floodplain.

It's important to note the postdiction of the type of streamflow is dependent on several factors that include the channel pattern (meandering, straight or braided), the distribution and size of the channel sediment, the cross-sectional geometry of the channel and slope of the channel. The combination of these factors points to the particular type of flow that produced the particular stream channel. For example, in the absence of other information, a meandering channel with a sinuosity of more than 1.3 is a good stand alone indicator that perennial flow produced that particular channel. However, where the channel of Big Chino wash has a slope of only 0.0013, is incised in a wide-flat alluvial valley composed mostly of clayey silt, the width to depth ratio of the channel is less than 10, and the sinuosity ratio is 1.6 then it becomes highly likely the producing streamflow was perennial.

DISCUSSION OF RELATED INFORMATION

Additional information related to the subject is presented and/or briefly discussed in this section of the report. Part of the posdiction of flow type included a comparison of morphology of Big Chino Wash and ephemeral streams. Thus, a note about ephemeral streams. Also, there was something fishy worth revisiting (Wirt, 2005). Lastly, this report would be incomplete without mention of subflow and the Arizona Supreme Court ruling on the Big Chino pipeline.

Ephemeral streams

Ephemeral stream channels in Arizona typically are subject to rapid change of width and depth by floodwater. Channels typically are braided or rather straight while the channel of Big Chino Wash has a winding channel. Many other physical characteristics of ephemeral stream channels that are unlike those of Big Chino Wash in the study area are given in many scientific reports including the following:

Bull, W. B., 1997, Discontinuous ephemeral streams: Geomorphology, pp 227-276.

Hjalmarson, H. W, 1997, Piedmont flood hazard assessment for Flood Plain Management for Maricopa County, Arizona, USER'S MANUAL, Flood Control District of Maricopa County 178 p. and Appendixes.

Lichvar, R. W. and McColley, S. M., 2008, A Field Guide to the Identification of the Ordinary High Water Mark (OHWM) in the Arid West Region of the Western United States-A Delineation Manual, ERDC/CRREL TR-08-12: U.S. Army Engineer Research and Development Center, 72p.

Schumm, S.A. 1961. Effect of sediment characteristics on erosion and deposition in ephemeral-stream channels. USGS Professional Paper 352C.

The meandering channel of Big Chino Wash has classic characteristics of channels formed by persistent flow (perennial or intermittent) that clearly are unlike characteristics of ephemeral channels in the southwest US.

Something's fishy

The following is worth considering for this analysis. According to Wirt (2005):

"Evidence that there were pools capable of withstanding droughts, however, is provided by biologists who collected fish in the vicinity of CV Ranch. Several native fish species were taken from upper Big Chino Wash in 1897 (Gilbert and Scofield, 1898) and again in 1950 (Winn and Miller, 1954). Species identified in

1897 included Roundtail Chub *(Gila Robusta intermedia),* Spikedace *(Meda fulgida),* Speckled dace, *(Rhinichthys osculus*) and loach minnow *(Tiaroga cobitis).* Roundtail chub and Sonora sucker *(Catostomus insignis)* were identified in 1950. Weedman and others (1996) describe the collection site as 2 mi southeast of K4 Farm, which is near the meandering confluence of Big Chino Wash with Pine Creek."

Subflow

Because the waters of Big Chino Wash were interconnected with underlying groundwater, then are the wells in Big Chino Valley drawing surface water? If so, might they need a water right in order to use surface water? Consider the following:

<u>Judge Shedden's decision (exerpts)</u>

> In the Matter of the Decision of Director to Grant the City of Prescott's Application for Modification of its Designation as Having an Assured Water Supply Designation No. 86-401501.0001, Thomas Shedden Administrative Law Judge 10 29 2009
>
> APPLICABLE WATER LAW
> 24. No subflow zone has been determined or mapped for the Verde River watershed. It is the judiciary that must determine the boundaries of the subflow zone. Consequently, the mere presence of saturated floodplain Holocene alluvium in the watershed can carry no substantial weight in this proceeding.
>
> CONCLUSIONS OF LAW- PROCEDURAL MATTERS:
> 2. One who asserts that underground water is a part of a stream's subflow must prove that fact by clear and convincing evidence

<u>ADWR</u>

> "The Department (ADWR), therefore, recommends that the entire lateral extent of the floodplain Holocene alluvium be assumed to be saturated for the purpose of delineating the jurisdictional subflow zone. This recommendation is consistent with the inclusion of predevelopment perennial streams in the Department's methodology for delineating the jurisdictional subflow zone as requested by the court. By definition, floodplain Holocene alluvium was saturated at some point in predevelopment time." (ADWR, 2002, p.17)

Also, "After consideration of flow direction, water level elevation, the gradation of water levels over a stream reach, the chemical composition if available, and lack of hydraulic pressure from tributary aquifer and basin fill recharge which is perpendicular to stream and "subflow" direction, the Court finds the most accurate of all the markers is the edge of the Holocene alluvium." (ADWR, 2002, p.17).

ADWR, Mar. 29, 2002, SUB FLOW TECHNICAL REPORT - SAN PEDRO RIVER WATERSHED: Arizona Department of Water Resources, 49p.

Steve Ayers

According to Camp Verde Bugle newspaper reported Steve Ayres:

The statutes regarding surface water define the term as “water of all sources, flowing in streams…or in the definite underground channels…” This underground channel is often referred to as the subflow of the stream. The lateral extent of the subflow of a stream has recently been clarified by the Arizona Supreme Court as the “saturated Holocene alluvium.”

Generally, that means the loose gravel and sand that lies beneath and adjacent to a stream, that has been laid down during the Holocene period---the last 10,000 years or so. That means that the water in the subflow zone is subject to the surface water statues, or prior appropriation by SRP or any other surface water claimant.

The issue of subflow has been an important legal question ever since the 1931 Southwest Cotton case and is a situation that SRP wants clarified. And although SRP believes many of the surface water claims in the Verde Valley will be upheld in court, they still see problems with some of them.

CONCLUSION

There was perennial/intermittent flow with surface water and ground water interconnection along Big Chino Wash before anglo development.

GLOSSARY (Mostly from Langbein and Iseri)

Bank. The margins of a channel. Banks are called right or left as viewed facing in the direction of flow.

Base flow. See Base runoff.

Base runoff. Sustained or fair weather runoff. In most streams, base runoff is composed largely of groundwater effluent. (Langbein and others, 1947, p. 6.) The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the logical term. (See also Ground-water runoff and Direct runoff.)

Braiding of river channels. Successive division and rejoining (of river flow) with accompanying islands is the important characteristic denoted by the synonymous terms, braided or anatomizing stream. A braided stream is composed of anabranches.

Direct runoff. The runoff entering stream channels promptly after rainfall or snowmelt. Superposed on base runoff, it forms the bulk of the hydrograph of a flood.

Ground-water runoff. That part of the runoff which has passed into the ground, has become ground water, and has been discharged into a stream channel as spring or seepage water. See also Base runoff and Direct runoff.

Meander. The winding of a stream channel.

Runoff. That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels.

Streamflow. The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term “streamflow” is more general than runoff, as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Water table. The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body.

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