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LEGAL
DEPT OF WATER RESOURCES

IN THE SUPERIOR COURT OF THE STATE OF ARIZONA
IN AND FOR THE COUNTY OF MARICOPA

IN RE: THE GENERAL ADJUDICATION OF ALL RIGHTS TO USE WATER IN THE GILA RIVER SYSTEM AND SOURCE,

NO. W-1 (SALT)
NO. W-2 (VERDE)
NO. W-3 (UPPER GILA)
NO. W-4 (SAN PEDRO)

No. Contested Case No. W1-103

OBJECTION TO SUBFLOW ZONE DELINEATION REPORT FOR THE SAN PEDRO RIVER WATERSHED DATED JUNE 30, 2009

(Assigned to The Honorable Eddward P. Ballinger, Jr.)

1. This objection is filed on behalf of The Nature Conservancy which is a claimant in the Gila River adjudication and is entitled to file an objection in this matter because it holds Statements of Claimant for water rights in the San Pedro River Watershed listed on **Exhibit 1** attached hereto.

2. The Nature Conservancy requests that the Court direct the Arizona Department of Water Resources ("ADWR") to revise its 2009 subflow zone delineation based on additional physical features that, taken as a whole, will more accurately correspond to the stable geologic unit of the saturated floodplain Holocene alluvium. ADWR relied on surficial exposure of floodplain Holocene alluvium, with setbacks applied, as being exclusively indicative of the subflow zone. ADWR's reliance on surface exposures of floodplain Holocene alluvium, together with application of setbacks, results in numerous locations where there are gaps in the subflow zone along the river, or where

the present river channel lies outside the ADWR delineated subflow zone. The expert report of The Nature Conservancy's staff hydrologist, Jeanmarie A. Haney, attached hereto as **Exhibit 2**, details the basis for The Nature Conservancy's objection herein.

3. The original copy of this objection is being sent by first class mail for receipt no later than December 28, 2009 to:

Clerk of the Superior Court
Maricopa County, Attn: Water Case
601 W. Jackson Street
Phoenix, Arizona 85003

4. Also, copies of this objection are being sent by first class mail to each person on the attached mailing list, which includes the judge and Special Master assigned to this matter.

DATED this 21st day of December, 2009.

LEWIS AND ROCA LLP

By Linda C. McNulty
Linda C. McNulty
Attorneys for The Nature Conservancy

GILA RIVER ADJUDICATION
COURT APPROVED MAILING LIST

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EXHIBIT 1

to The Nature Conservancy's
Objection to Subflow Zone Delineation Report
for the San Pedro River Watershed dated June 30, 2009

Statements of Claimant for water rights in the San Pedro River Watershed held by The Nature Conservancy:

39	333	39	5500	39	5598
39	334	39	5503	39	5599
39	335	39	5505	39	5600
39	336	39	5506	39	5601
39	989	39	5507	39	5990
39	990	39	5508	39	5991
39	991	39	5509	39	5992
39	992	39	5510	39	5993
39	2116	39	5511	39	5994
39	2217	39	5512	39	5995
39	2219	39	5513	39	6084
39	2220	39	5514	39	6085
39	2221	39	5515	39	6086
39	2222	39	5516	39	6087
39	2225	39	5517	39	6088
39	2640	39	5518	39	6089
39	2642	39	5519	39	6090
39	2645	39	5520	39	6091
39	2647	39	5521	39	6092
39	2648	39	5522	39	6093
39	2649	39	5524	39	6094
39	2650	39	5527	39	6095
39	2651	39	5528	39	6096
39	3653	39	5529	39	6097
39	3655	39	5534	39	6098
39	3657	39	5535	39	6115
39	3658	39	5536	39	6116
39	3669	39	5548	39	6525
39	3693	39	5549	39	11371
39	3958	39	5550	39	11584
39	4150	39	5574	39	11585
39	5486	39	5576	39	11588
39	5487	39	5577	39	12016
39	5488	39	5578	39	12017
39	5489	39	5579	39	12018
39	5492	39	5586	39	14131
39	5493	39	5587	39	14132
39	5494	39	5592	39	14133
39	5497	39	5593	39	14134
39	5498	39	5594	39	14486
39	5499	39	5595		

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EXHIBIT 2
to The Nature Conservancy's
Objection to Subflow Zone Delineation Report
for the San Pedro River Watershed dated June 30, 2009

[See attached]

Exhibit 2

Report of Jeanmarie A. Haney

Qualifications

I am an employee of The Nature Conservancy ("Conservancy"), based in Tucson, Arizona. The statements contained in this report are made based upon my own personal knowledge and work performed by me or by contractors to The Nature Conservancy and from knowledge gained from review of published and unpublished reports and data. I am a Registered Professional Geologist in the state of Arizona (#30437) and I have 13 years of work experience as a groundwater hydrologist in the state of Arizona. In that capacity, I have conducted aquifer pumping tests and analyzed results; conducted water quality testing and analyzed results; supervised exploratory borehole drilling and monitor and production well installation and testing; and conducted geologic mapping and hydrogeologic characterization throughout the southwestern U.S. and in Baja Sur, Mexico, and in northern Chile. I have an additional 8 years of work experience as a conservation hydrologist with The Nature Conservancy in Arizona. In that capacity, I oversee hydrologic monitoring on Conservancy preserves in Arizona and analyze results; conduct analyses of hydrologic data and conduct stream channel and watershed analyses; provide hydrologic technical assistance to site program managers; and analyze potential ecological impacts from human-imposed flow alterations. I have completed review and analysis the Arizona Department of Water Resource's San Pedro River subflow zone delineation report (ADWR 2009). I provide my professional conclusions and comments in this report.

ADWR Hydrologic and Geologic Analysis

The Arizona Department of Water Resources (ADWR) provides a concise summary of court decisions and criteria for delineating the subflow (ADWR 2009; Chapters 1 and 2) and a thorough and accurate description of hydrologic conditions in the San Pedro River watershed (ADWR 2009; Chapter 3). ADWR identified stream reaches with predevelopment perennial or intermittent streamflow and concluded that the San Pedro River was perennial or intermittent from the International Border to its confluence with the Gila River (ADWR 2009; Chapter 3). I agree with this conclusion and with the extent of predevelopment perennial or intermittent conditions determined by ADWR on Aravaipa Creek and Babocomari River. I commend ADWR staff for their thorough and comprehensive work on this subject.

Geologic Mapping by the Arizona Geological Survey

The Arizona Geological Survey (AZGS) did an exemplary job in mapping surficial geology adjacent to the San Pedro River and Babocomari and Aravaipa Creeks (AZGS 2009). Their methods and results are well documented.

ADWR Extent of Floodplain Holocene Alluvium and Setbacks for "Side Recharge"

As directed by the adjudication court and consistent with Judge Ballinger's September 28, 2005 Subflow Order ("2005 Subflow Order"), ADWR defines the subflow zone as the lateral extent of the saturated floodplain Holocene alluvium. ADWR applied procedures outlined in the 2005 Subflow Order to delineate the subflow zone, categorizing the procedures as hydrologic, geologic, and hydrogeologic criteria. Also, ADWR followed the procedures described in Chapter 2 of ADWR's 2002 Subflow Report (ADWR 2002) to determine the lateral extent of the floodplain Holocene alluvium; and the saturated portion of the floodplain Holocene alluvium, to the extent that they were consistent with the 2005 Subflow Order.

While acknowledging that tributaries have recently deposited alluvium on top of the floodplain **(Figure 1)**, ADWR excludes all surficial exposures of tributary Holocene alluvium from the floodplain Holocene alluvium boundary, based upon their interpretation of Judge Goodfarb's June 30, 1994 Subflow Order ("1994 Subflow Order"). ADWR asserts that subsurface mapping to delineate the extent to which tributary Holocene alluvium overlies floodplain Holocene alluvium would be impractical and beyond the scope of their report (ADWR 2009). While I agree that subsurface mapping is not practicable within the time frames of the adjudication proceedings, I believe some of the techniques discussed below can provide a reasonably simple means to delineate the subflow zone to more accurately correspond to the saturated floodplain Holocene alluvium. It is clear that ADWR's delineation excluding all surficial exposures of tributary Holocene alluvium from the subflow zone does not meet the criteria for correlation to the stable geologic unit as set forth in the 1994 and 2005 Subflow Orders. The word "stable" occurs numerous times in these orders, originating with Judge Goodfarb's 1994 Order, ...the floodplain Holocene alluvium "is the only stable geologic unit which is beneath and adjacent to most rivers and streams..." (Goodfarb 1994, p.56). The subflow zone as delineated by ADWR does not correspond to the stable geologic unit for two primary reasons: active channel migration will cause the river to leave the subflow zone and tributary deposits are transitional and easily eroded by active channel migration and high flows.

Based on ADWR's interpretation of geologic mapping conducted by the Arizona Geological Survey, ADWR drew the boundary for the floodplain Holocene alluvium along the San Pedro River (ADWR 2009). To map the subflow zone, ADWR adjusted the lateral extent of floodplain Holocene alluvium using 100- and 200-foot setbacks to account for "side recharge from saturated basin fill and tributary alluvium", in strict compliance with the 1994 Subflow Order.

ADWR drew the boundary of the floodplain Holocene alluvium and the subflow zone based on data available to them and based on strict compliance with their interpretation of directions from the adjudication court. However, examination of site specific data from properties owned/managed by The Nature Conservancy -- including geologic and soil maps, groundwater levels, borehole geologic-driller's logs, soil map units, and extent of riparian vegetation -- supports delineation of a wider subflow zone that will more accurately correspond to the central, overarching mandates of the adjudication court. Based on these data and directions from the adjudication court (1994 Subflow Order; 2005 Subflow Order), I delineate the Haney2009 subflow zone on three properties owned by The Nature Conservancy. I assert that the Haney2009 subflow zone meets the intent of the court to designate the subflow zone as the aerial extent of the stable saturated floodplain Holocene alluvium and the location where groundwater flow direction and gradient is essentially in the same direction as the surface flow of the river. I present hydrologic, geologic, and hydrogeologic data from three properties owned/managed by the Conservancy and provide an interpretation of the subflow zone at these properties. I then apply that interpretation to basin-wide analysis of the subflow zone.

J. Haney Analysis of Subflow Zone

AZGS delineated five units comprising river alluvium of Holocene age and four units comprising piedmont (tributary) alluvium of Holocene age. In addition, AZGS identified three units of river alluvium of Pleistocene age and four units of river piedmont alluvium of Pleistocene age, as well as Tertiary-age basin-fill deposits.

The U.S. Natural Resource Conservation Service (NRCS) mapped soil units along the San Pedro River (SSURGO 2009). These deposits comprise various portions of the Holocene-age floodplain and also include alluvial fan and terrace deposits. NRCS specifies the depositional environment of each unit as inner channel, recent floodplain, floodplain, or alluvial fan. Units comprised of transient alluvial fan deposits and unstable terrace material may overlie floodplain deposits and may also extend uphill where they overlie non-floodplain materials. AZGS used published NRCS soil maps to assist in their interpretations of floodplain Holocene alluvium, especially in disturbed areas.

Geologic and soil mapping delineate the surficial extent of the floodplain Holocene alluvium. However, surficial extent does not account for the true lateral extent of the floodplain Holocene alluvium, because tributary alluvium may overlie deposits of floodplain Holocene alluvium, especially near the edge of the floodplain or where alluvium fans extend into the floodplain from tributaries. Thus, surficial extent does not account for the true lateral extent of the stable floodplain Holocene alluvium. Geologic logs and pumping tests provide information on the subsurface geology and hydrology, allowing delineation of the true lateral extent of the floodplain Holocene alluvium on a site-specific basis. The site-specific data available to the Conservancy on our properties on the lower San Pedro River can be used as a basis for refining a method to delineate a more accurate subflow zone basin-wide. Particular outcrop patterns (as mapped by AZGS), together with topographic and phreatophyte vegetation patterns, are good indicators of the edge of the Holocene-age alluvium and hence the subflow zone. Specific examples will be given below.

I analyzed data and information for three properties along the river in the lower San Pedro River subbasin: San Pedro River Preserve (SPRP), H&E Farm, and Three Links Farm **(Figure 2)**. These properties are owned and/or managed by The Nature Conservancy. In addition, I obtained data sets from ADWR, the Arizona Geological Survey (AZGS), and the Natural Resource Conservation Service (NRCS), and reviewed published literature. I spoke with professionals from the AZGS, NRCS, and ADWR and accessed records and publications and U.S. Geological Survey, AZGS, NRCS, and exhibits from Gila River adjudication.

Data and Findings at Conservancy Properties

San Pedro River Preserve: There are 31 water level monitor wells and 4 water production wells at the SPRP (**Figure 3**). Well depths range from 10 to 81 feet below land surface. Geologic logging was conducted at the time of drilling (Geosystems Analysis Inc 2000). Water levels have been measured regularly since 1998. Depth to water in monitor wells at the San Pedro River Preserve ranges from about 10 to 45 feet below land surface. The large number of water level monitor wells provides high resolution in developing groundwater level altitude contour maps. Observed groundwater level gradients indicate that groundwater underlying the entire extent of the floodplain Holocene alluvium is moving as subflow in approximately the same direction as the San Pedro River, and at about the same gradient as the riverbed throughout the year (**Figures 4 and 5**). Results from pumping tests conducted on wells W3 (55-517549), W4 (55-612036), and W5 (55-515185) indicate average aquifer transmissivity of 44,000 ft^2/day at these wells, indicating they are completed in coarse-grained saturated floodplain Holocene alluvium, which the adjudication court has defined as the stable geologic unit. Observation of outcrops at SPRP indicates that basin-fill deposits underlying the floodplain Holocene alluvium are clay-rich and thus are poorly transmissive, indicating the lower boundary of the floodplain Holocene alluvium.

Based on a search of ADWR 55 Well Registry imaged records, 27 wells in the vicinity of the SPRP have geologic (driller's) logs on file (**Table 1**). Fourteen of these wells clearly indicate a transition from coarse-grained sediments (sand and gravel, with or without clay stringers) to fine-grained sediments (clay). This lithologic transition is commonly accepted as the base of the floodplain Holocene alluvium. Ten of the 14 wells are located in surficial exposures of tributary Holocene alluvium. Examination of surficial relation of geologic units and of units encountered during drilling indicates coarse-grained floodplain Holocene alluvium underlies tributary Holocene alluvium at these locations. Thus, although surficial geology indicates these wells are located in tributary Holocene alluvium, drill logs indicate the wells are pumping from stable floodplain Holocene alluvium.

Based on examination of NRCS soil maps and discussions with NRCS soil scientist Bill Svetlik regarding the depositional environment for each soil unit of Holocene age, I conclude that there are five soil units of Holocene age in the vicinity of the SPRP. Together with surficial geologic mapping from the AZGS, these units delineate the extent of floodplain Holocene alluvium.

Based on hydrogeologic information, I conclude: 1) the thickness of the floodplain alluvium ranges from approximately 80 to 90 feet in the vicinity of the SPRP; 2) the floodplain Holocene alluvium extends beneath, and maintains a nearly constant thickness beneath, tributary Holocene alluvium, extending to the break in topographic slope, after which tributary Holocene alluvium overlies older, non-alluvial deposits; 3) groundwater leakage from the alluvial basin-fill deposits aquifer into the flood-plain alluvium aquifer is not significant; there is no indication of "side recharge" from tributary Holocene alluvium or from basin-fill deposits; and 4) the large value for transmissivity indicates that the wells are pumping from coarse-grained floodplain Holocene alluvium.

Using the cited data and references, I prepared **Figure 6**, which shows my interpretation of the subflow zone on the San Pedro River Preserve (Haney Subflow Zone). Geologic logs, AZGS geologic mapping units, NRCS soil units, topography, and hydrogeologic data obtained during investigations and regular monitoring at the San Pedro River Preserve are the chief criteria on which I delineated the Haney Subflow Zone. Figure 6 also shows the ADWR Subflow Zone, which includes setbacks for "side recharge" and which does not include areas overlain by deposits of tributary Holocene alluvium.

H&E Farm: There are 13 water level monitor wells at H&E Farm (**Figure 7**). Well depths range from 75 to 150 feet below land surface. Water levels have been measured monthly since 2001. Depth to water in monitor wells at H&E Farm ranges from 7 to 45 feet below land surface. Observation of outcrops at H&E Farm indicates that basin-fill deposits underlying the floodplain Holocene alluvium are clay-rich and thus are poorly transmissive, indicating the lower boundary of the floodplain Holocene alluvium.

Based on a search of ADWR 55 Well Registry imaged records, 11 wells in the vicinity of the H&E Farm have geologic (driller's) logs on file (**Table 2**). Four of these wells clearly indicate a transition from coarse-grained sediments (sand and gravel, with or without clay stringers) to fine-grained sediments (clay). This lithologic transition is commonly accepted as the base of the floodplain alluvium. Two of the four wells are located in surficial exposures of tributary Holocene alluvium. Examination of surficial relation of geologic units and of units encountered during drilling indicates coarse-grained floodplain Holocene alluvium underlies tributary Holocene alluvium at these locations. Thus, although surficial geology indicates these wells are located in tributary Holocene alluvium, drill logs indicate the wells are pumping from stable floodplain Holocene alluvium.

Based on hydrogeologic information, I conclude: 1) the thickness of the floodplain Holocene alluvium ranges from approximately 80 to 90 feet in the vicinity of the H&E Farm and 2) the floodplain Holocene alluvium extends beneath, and maintains a nearly consistent thickness beneath, tributary Holocene alluvium, extending to the break in topographic slope, after which tributary Holocene alluvium overlies older, non-alluvial deposits.

Using the cited data and references, I prepared **Figure 8**, which shows my interpretation of the subflow zone at H&E Farm (Haney Subflow Zone). Geologic logs, AZGS geologic mapping units, NRCS soil units, topography, and hydrogeologic data obtained during investigations and regular monitoring at the H&E Farm are the chief criteria on which I delineated the Haney Subflow Zone. Figure 8 also shows the ADWR Subflow Zone, which includes setbacks for "side recharge" and which does not include areas overlain by deposits of tributary Holocene alluvium.

Three Links Farm: There are 19 water level monitor wells at Three Links Farm (**Figure 9**); depths range from 62 to 135 feet. Water levels have been measured regularly since 2003. Depth to water in monitor wells at Three Links Farm ranges from 11 to 52 feet below land surface. Results from pumping tests conducted on Well 6 indicate that the average aquifer transmissivity is 40,000 ft^2/day. Observation of outcrops at SPRP indicates that basin-fill deposits underlying the Holocene alluvium are clay-rich and thus are poorly transmissive.

Based on a search of ADWR 55 Well Registry imaged records, 13 wells in the vicinity of this site have geologic (driller's) logs on file (**Table 3**). Six of these wells clearly indicate a transition from coarse-grained sediments (sand and gravel, with or without clay stringers) to fine-grained sediments (clay). This lithologic transition is commonly accepted as the base of the floodplain alluvium. Three of the six wells are located in surficial exposures of tributary Holocene alluvium. Examination of surficial relation of geologic units and of units encountered during drilling indicates coarse-grained floodplain Holocene alluvium underlies tributary Holocene alluvium at these locations. Thus, although surficial geology indicates these wells are located in tributary Holocene alluvium, drill logs indicate the wells are pumping from stable floodplain Holocene alluvium.

I have examined the soil units on the NRCS draft map and spoken with the NRCS soil scientist regarding soil units of Holocene age. Based on this information, I conclude that there are 13 soil units of Holocene age in the area of the Three Links Farm. Together with surficial geologic mapping from the AZGS, these units provide an indication of the extent of floodplain Holocene alluvium.

Based on hydrogeologic information, I conclude: 1) the thickness of the floodplain Holocene alluvium ranges from approximately 50 to 100 feet in the vicinity of the Three Links Farm; 2) the floodplain Holocene alluvium extends beneath, and maintains a nearly consistent thickness beneath, tributary Holocene alluvium, extending to the break in topographic slope, after which tributary Holocene alluvium overlies older, non-alluvial deposits; and 3) the large value for transmissivity indicates that the wells are pumping from coarse-grained, poorly indurated floodplain alluvium.

Using the cited data and references, I prepared **Figure 10**, which shows my interpretation of the subflow zone on Three Links Farm (Haney Subflow Zone). Geologic logs, AZGS geologic mapping units, NRCS soil units, topography, and hydrogeologic data obtained during investigations and regular monitoring at the San Pedro River Preserve are the chief criteria on which I delineated the Haney Subflow Zone. Figure 10 also shows the ADWR Subflow Zone, which includes setbacks for "side recharge" and which does not include areas overlain by deposits of tributary Holocene alluvium.

Summary of Findings from Site Specific Analysis

The three Conservancy properties examined herein, distributed along 80 miles of the river, reflect consistent physical relationships in the floodplain Holocene alluvium. Data from geologic and drillers logs from wells on and near the three Conservancy properties described in this report indicates that the floodplain Holocene alluvium is on the order of 100 feet thick and extends beneath the thin veneer of surficial tributary alluvium to near the break in slope at the edge of the historic floodplain. Groundwater level altitude contour maps for the San Pedro River Preserve (based on a high density grid of water level monitor wells) show that direction of groundwater movement is parallel to and at nearly the same gradient as the river. Results from pumping tests indicate that highly transmissive materials underlie the properties.

These data indicate that "side recharge", if occurring at all, is so reduced as to have no significant effect on the flow direction of groundwater in the floodplain alluvium. At the three locations examined, flow direction, water level elevations, and hydraulic gradients in the Subflow Zone I have delineated are substantially the same as flow directions, water level elevations, and gradient in the river. It is expected that these conditions would be representative for many locations along the river in the San Pedro basin.

Regional Observations

ADWR used surficial exposures of floodplain Holocene alluvium, with setbacks applied, to draw the subflow zone. However, by not including subsurface extent of the floodplain Holocene alluvium, ADWR has delineated a subflow zone that does not meet the criteria and central intent set forth by the adjudication court for delineating a subflow zone that corresponds to the floodplain Holocene alluvium as the stable geologic unit. The combination of considering only surface exposures of floodplain Holocene alluvium, together with application of setbacks, results in numerous locations where there are gaps in the subflow zone along the river, or where the present river channel lies outside the ADWR delineated subflow zone. **Figures 11 and 12** show such examples in the vicinity of the San Pedro River Preserve and the Three Links Farm. These anomalies demonstrate that additional analysis of geologic and hydrologic features of the San Pedro River Basin is needed to delineate the full extent of the subflow zone.

In Appendix D-4 of the subflow report (ADWR 2009), ADWR recognized the challenges that are inherent with their current subflow zone, and suggests a method for "smoothing" the outer edge of the subflow zone while still aligning with the court's direction that the floodplain Holocene alluvium comprises the subflow zone. Thus, ADWR is aware that adjustments are needed. ADWR suggests using a perimeter to length ratio for units of tributary alluvium, and including those units in the subflow zone if the P:L ratio is larger than 2.5. Although this approach more closely mirrors the physical system, it does not account for the geologic pattern seen in the physical system. The outcrop pattern of pre-Holocene (Pleistocene and older basin-fill) units provides clear guidance for the edge of the subsurface floodplain Holocene alluvium. The outcrop pattern of these units, together with the topographic break, are strong indicators of the edge of the floodplain Holocene alluvium, the stable geologic unit. This approach is illustrated in **Figure 13**, where the Haney subflow zone is drawn inward from the outcrops of basin-fill materials. Revision of ADWR's Subflow Zone would be more accurate based on the geology and hydrology of the system, rather than on an arbitrary ratio.

The Nature Conservancy suggests that the adjudication court direct ADWR to revise its subflow zone delineation. I recommend that ADWR use much of the data and conclusions from the 2009 subflow report, but utilize additional physical features for revising the irregular boundaries produced by the strict adherence to surficial outcrops as subflow zone boundary indicators. The basis for revision of ADWR's delineation could consist of interpretation of outcrop patterns as shown on AZGS geologic maps and would not require analysis of drill logs or new drilling to examine subsurface materials. In addition to subsurface interpretation of geologic outcrop pattern as mapped by AZGS, evidence that could be integratively examined to delineate a smoother subflow zone boundary that corresponds to the stable geologic unit include soil units as mapped by Natural Resource Conservation Service; pattern of phreatophytes–type and density; surface topography; readily available site-specific data; and nature and spatial pattern of connecting tributary aquifers versus basin-fill deposits.

Examination and subsurface interpretation of geologic maps provided by the AZGS along with patterns of phreatophyte vegetation and topography provide a sound physical basis for delineating the lateral extent of floodplain Holocene alluvium beneath deposits of tributary alluvium. The appropriateness of such delineation can be supported by examining site-specific data such as those available on The Nature Conservancy's properties in the lower San Pedro River basin.

References

Arizona Department of Water Resources, 2009. Subflow Zone Delineation Report for the San Pedro River Watershed, June 2009 and GIS data sets.

Arizona Department of Water Resources, 2005. Subflow Technical Report, San Pedro River Watershed, Arizona Department of Water Resources.

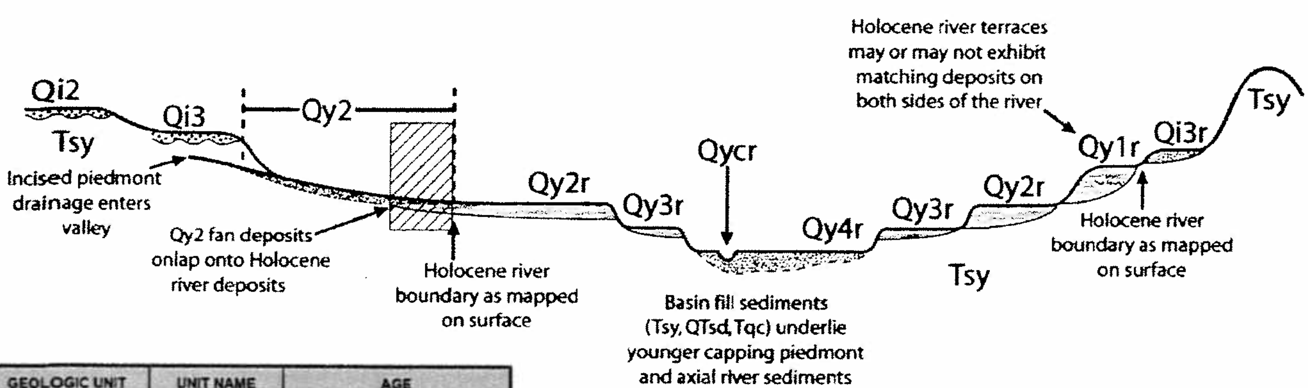
Arizona Geological Survey, 2009. Mapping of Holocene River Alluvium along the San Pedro River, Aravaipa Creek, and Babocomari River, Southeastern Arizona, J.P. Cook, A. Youberg, P.A. Pearthree, J.A. Onken, B.J. MacFarlane, D.E. Haddad, E.R. Bigio and A.L. Kowler. Digital Map DM-RM-1E

Geosystems Analysis Inc 2000. San Pedro River Preserve Hydrogeologic Summary Report. Consultant's report written for The Nature Conservancy, February 9, 2000.

Judge Goodfarb Order dated June 30, 1994, Case Nos W-1, W-2, W-3, W-4, In re the General Adjudication of All Rights to Use Water in the Gila River System and Source, Superior Court of Arizona, Maricopa County

SSURGO 2009. Soil Survey Geographic database for Eastern Pinal and Southern Gila Counties, Arizona, AZ661. http://soildatamart.nrcs.usda.gov/ accessed May 2009

Judge Ballinger Order dated September 28, 2005, Case Nos W-1, W-2, W-3, W-4 (Consolidated) Contested Case No. W1-103, In re the General Adjudication of All Rights to Use Water in the Gila River System and Source, Superior Court of Arizona, Maricopa County. Order Re: Report of the Special Master on the ADWR's Subflow Technical Report, San Pedro River Watershed and Motion for Approval of Report.



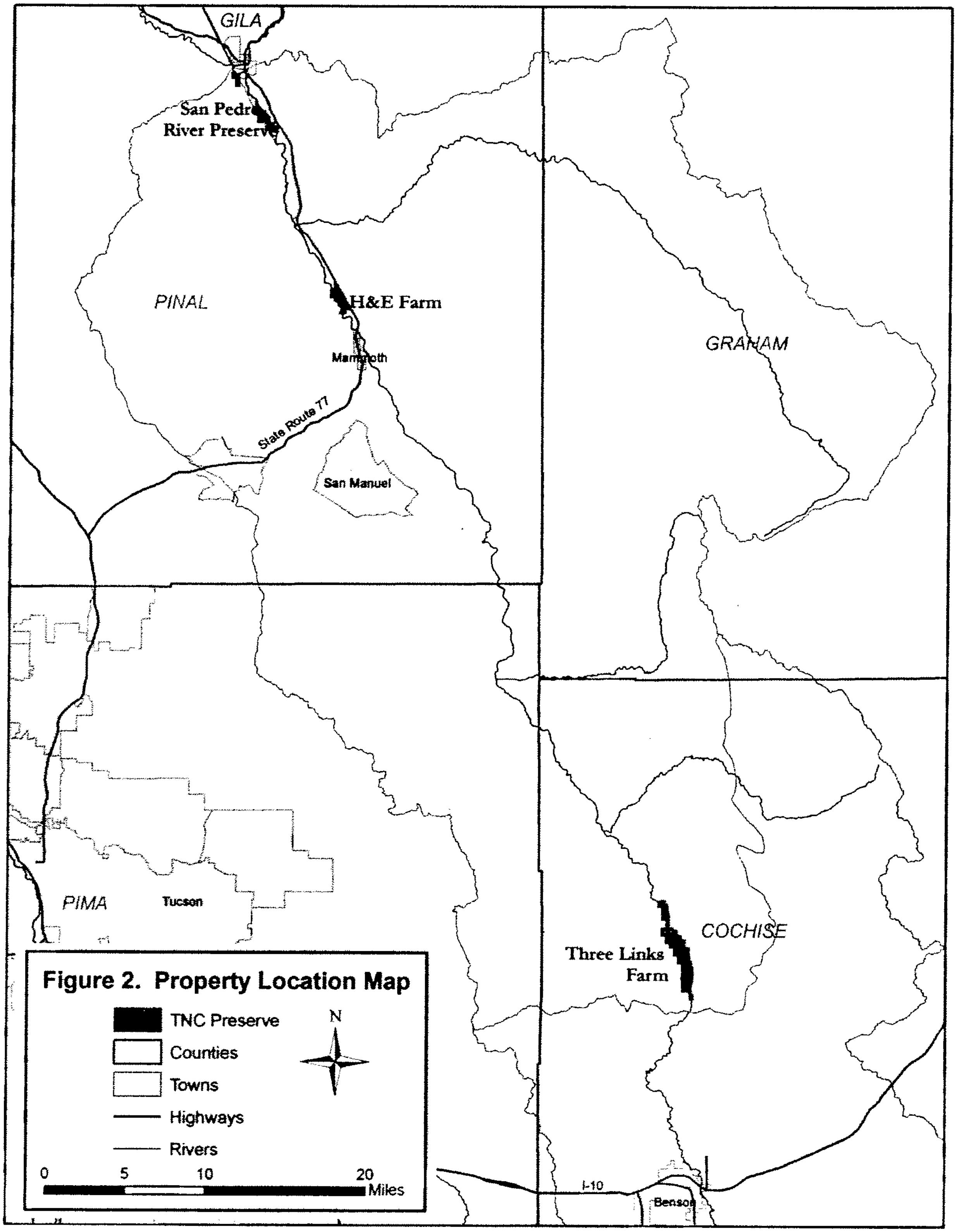
GEOLOGIC UNIT	UNIT NAME	AGE
Active/Modern Channel Deposits	Qycr	Holocene (10,000 years ago to present)
Stream Terraces	Qy4r (youngest)	Holocene
	Qy3r	
	Qy2r	
	Qy1r	
	Qi3r (oldest)	Pleistocene (2 million to 10,000 years ago)
Piedmont Deposits (Tributary Alluvium and Younger Basin Fill)	Qy2 (youngest)	Holocene
	Qi3	Pleistocene
	Qi2 (oldest)	
Older Basin Fill	QTsd (youngest)	Tertiary (2 million years ago and before)
	Tqc	
	Tsy (oldest)	

Source: AZGS (2009)

Figure 4-1
Generalized Cross Section of Stream Terraces and Piedmont Deposits Flanking the San Pedro River

Subflow Zone Delineation Report for the San Pedro River Watershed

Figure 1. From ADWR 2009 subflow report. Red crosshatched box is added and shows zone where tributary alluvium occurs as a thin layer over floodplain Holocene alluvium.


GILA
San Pedro
River Preserve
PINAL
H&E Farm
Mammoth
State Route 77
San Manuel
GRAHAM
PIMA
Tucson
COCHISE
Three Links
Farm
I-10
Benson
Figure 2. Property Location Map
TNC Preserve
Counties
Towns
Highways
Rivers
N
0
5
10
20
Miles

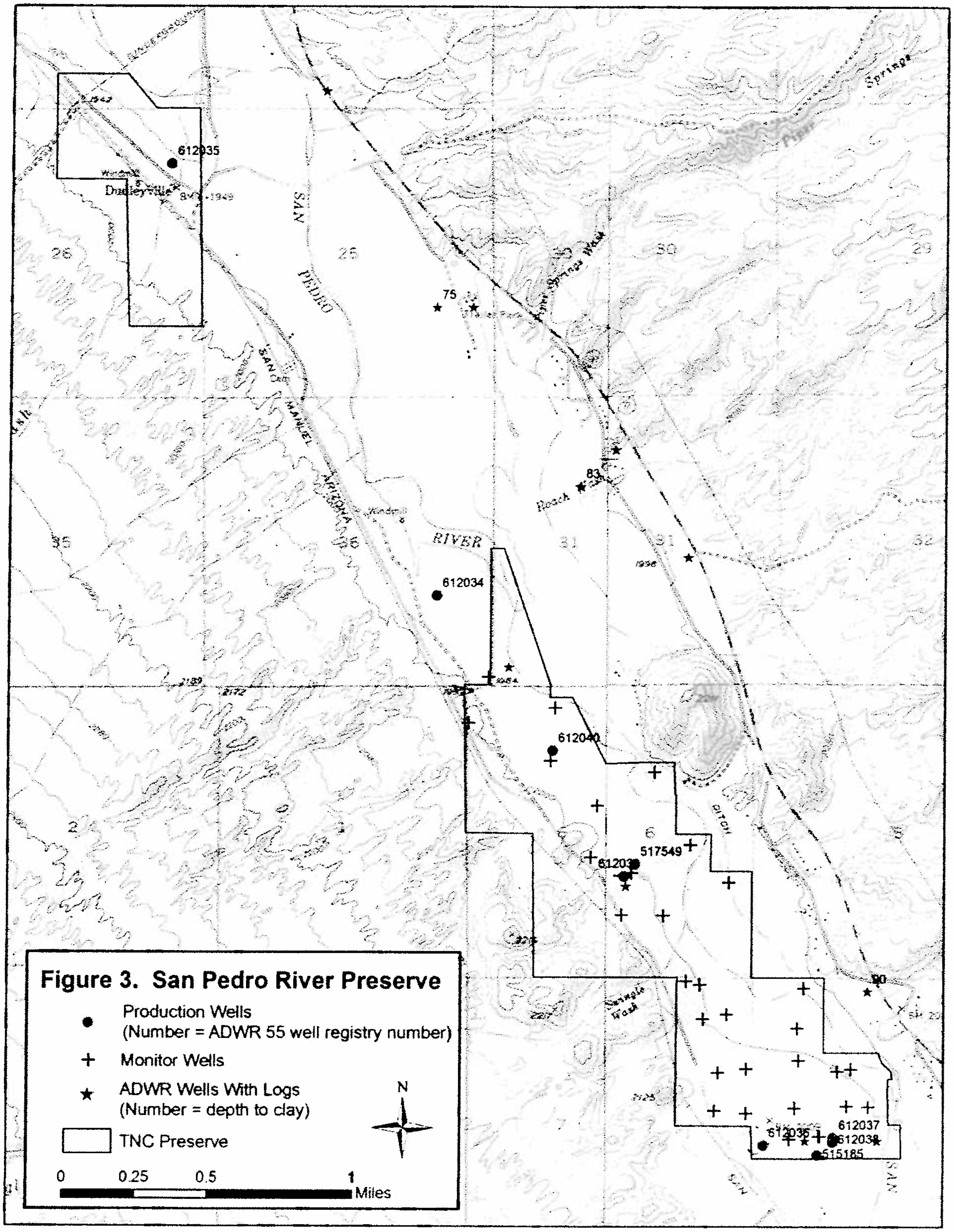


Figure 3. San Pedro River Preserve
Production Wells
(Number = ADWR 55 well registry number)
Monitor Wells
ADWR Wells With Logs
(Number = depth to clay)
TNC Preserve
N
0
0.25
0.5
1
Miles
612035
612034
612040
517549
612037
515185
75
83
90
SAN PEDRO
RIVER
ARIZONA
DITCH
Dudleyville
25
26
30
29
35
36
31
32
6
2

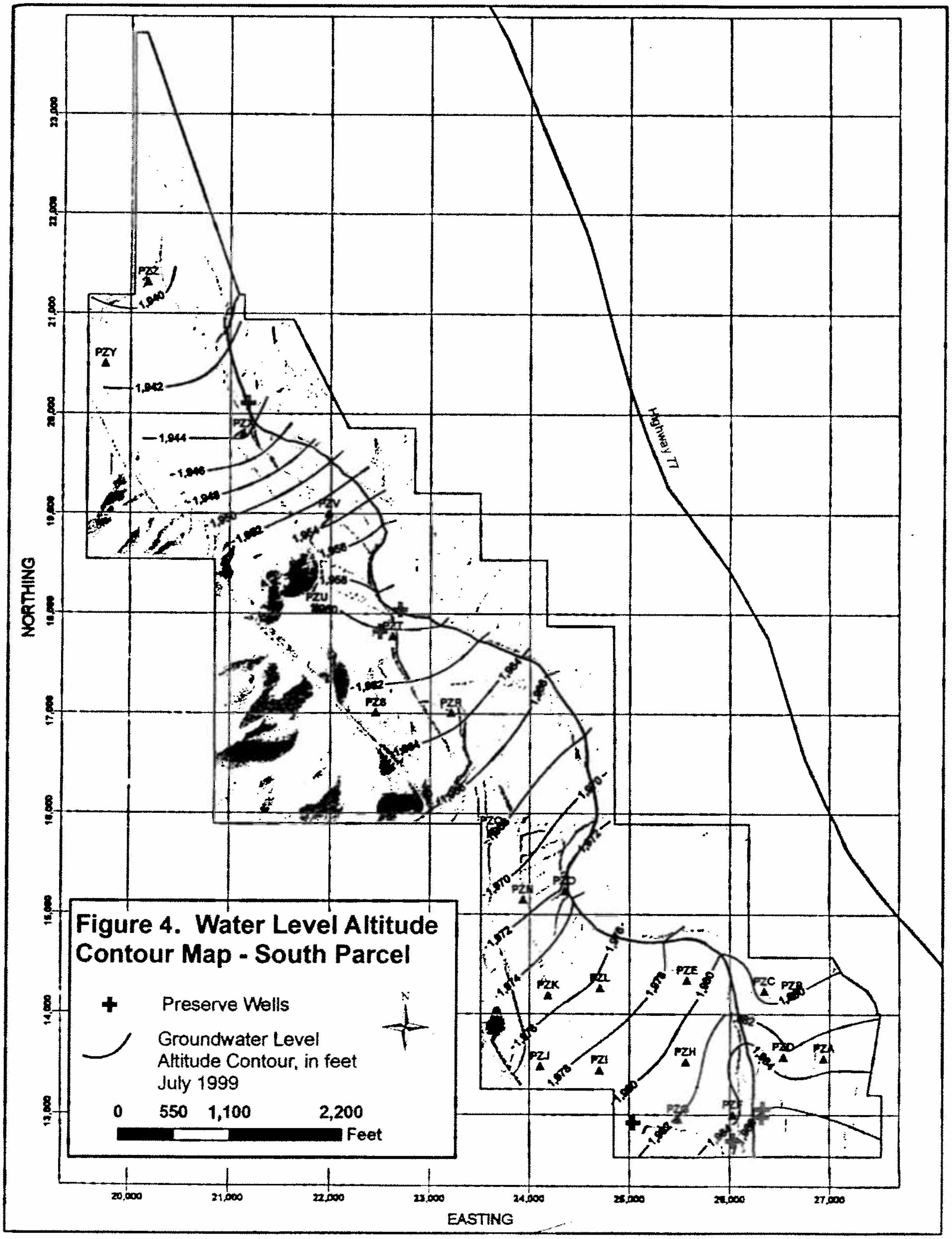


Figure 4. Water Level Altitude Contour Map - South Parcel
Preserve Wells
Groundwater Level Altitude Contour, in feet July 1999
0 550 1,100 2,200
Feet
NORTHING
EASTING
Highway 77
PZZ
PZY
PZV
PZU
PZT
PZS
PZR
PZQ
PZN
PZK
PZL
PZE
PZC
PZJ
PZI
PZH
PZD
PZA
1,940
1,942
1,944
1,946
1,948
1,950
1,952
1,954
1,956
1,970
1,972
1,974
1,976
1,978
1,980
20,000
21,000
22,000
23,000
24,000
25,000
26,000
27,000

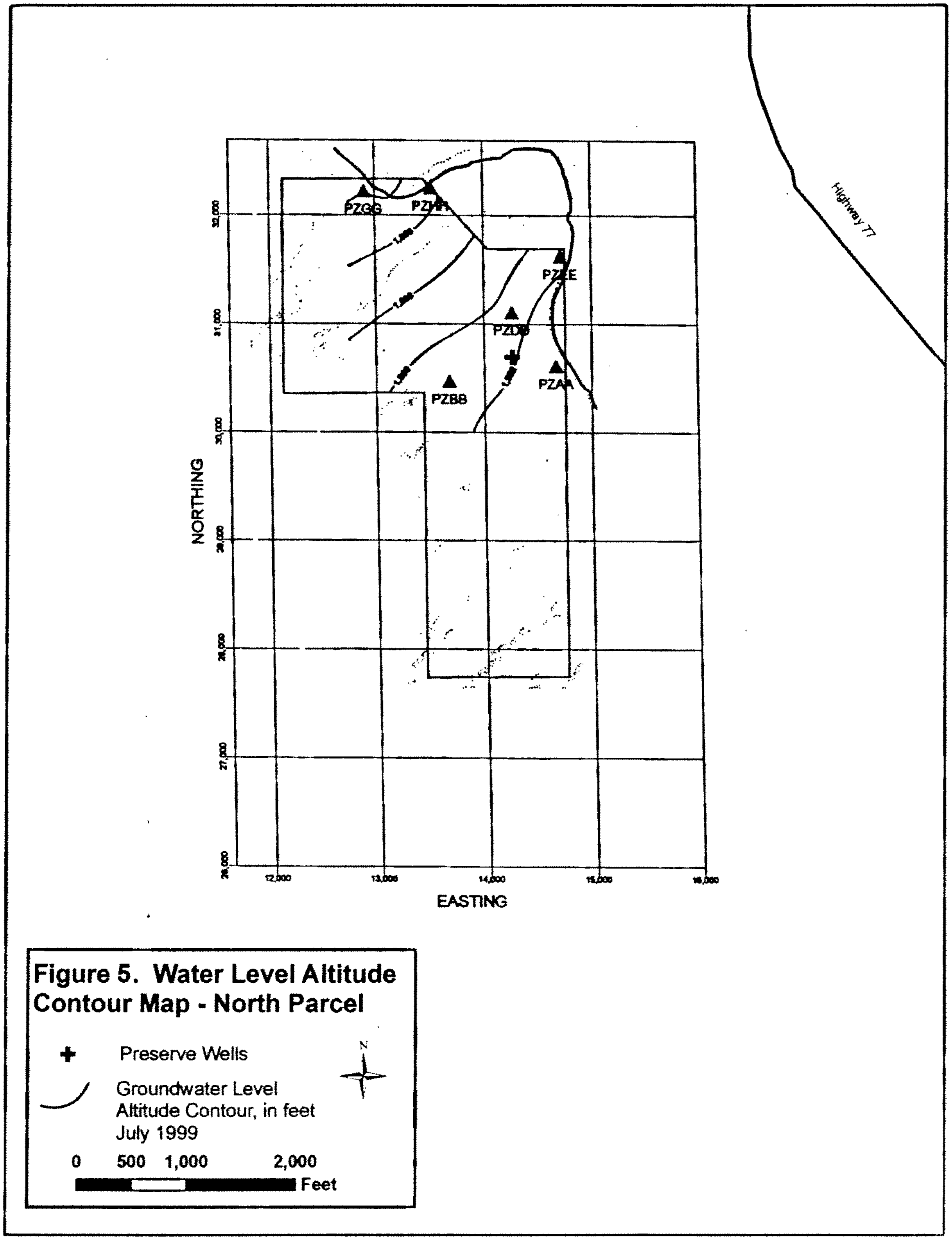
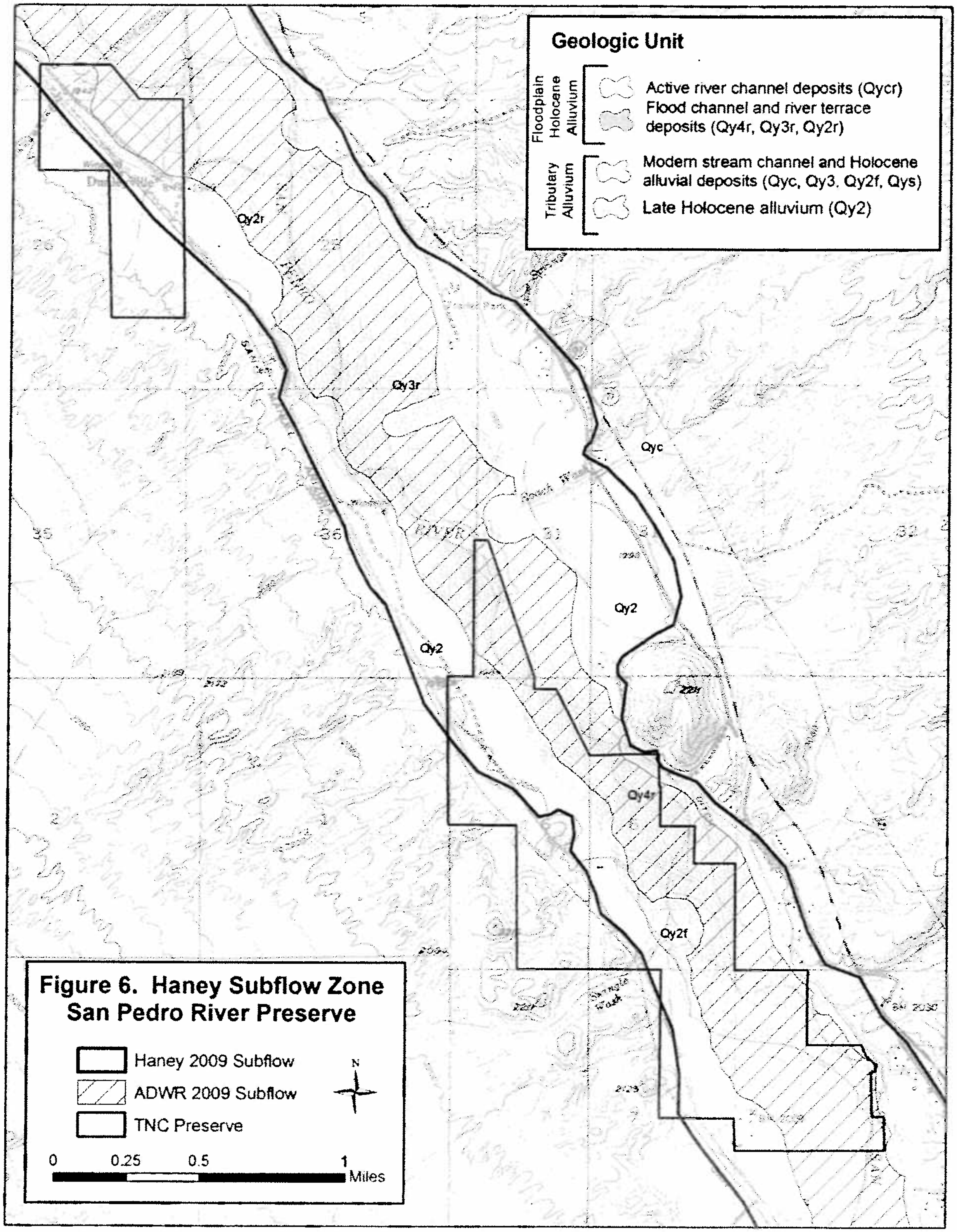


Figure 5. Water Level Altitude Contour Map - North Parcel


Geologic Unit
Floodplain Holocene Alluvium
Active river channel deposits (Qycr)
Flood channel and river terrace deposits (Qy4r, Qy3r, Qy2r)
Tributary Alluvium
Modern stream channel and Holocene alluvial deposits (Qyc, Qy3, Qy2f, Qys)
Late Holocene alluvium (Qy2)
Qy2r
Qy3r
Qyc
Qy2
Qy2
Qy4r
Qy2f
Figure 6. Haney Subflow Zone
San Pedro River Preserve
Haney 2009 Subflow
ADWR 2009 Subflow
TNC Preserve
N
0
0.25
0.5
1
Miles

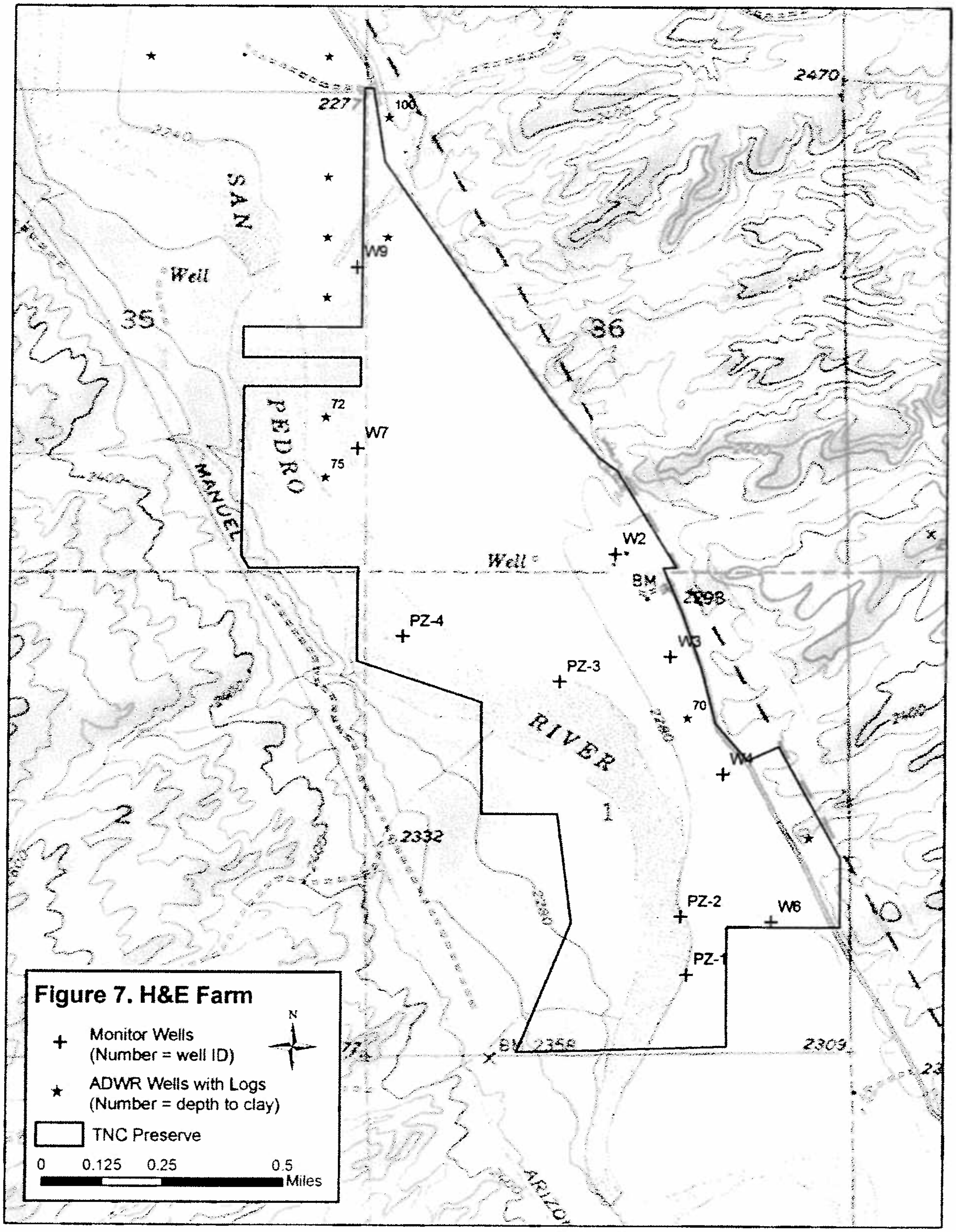
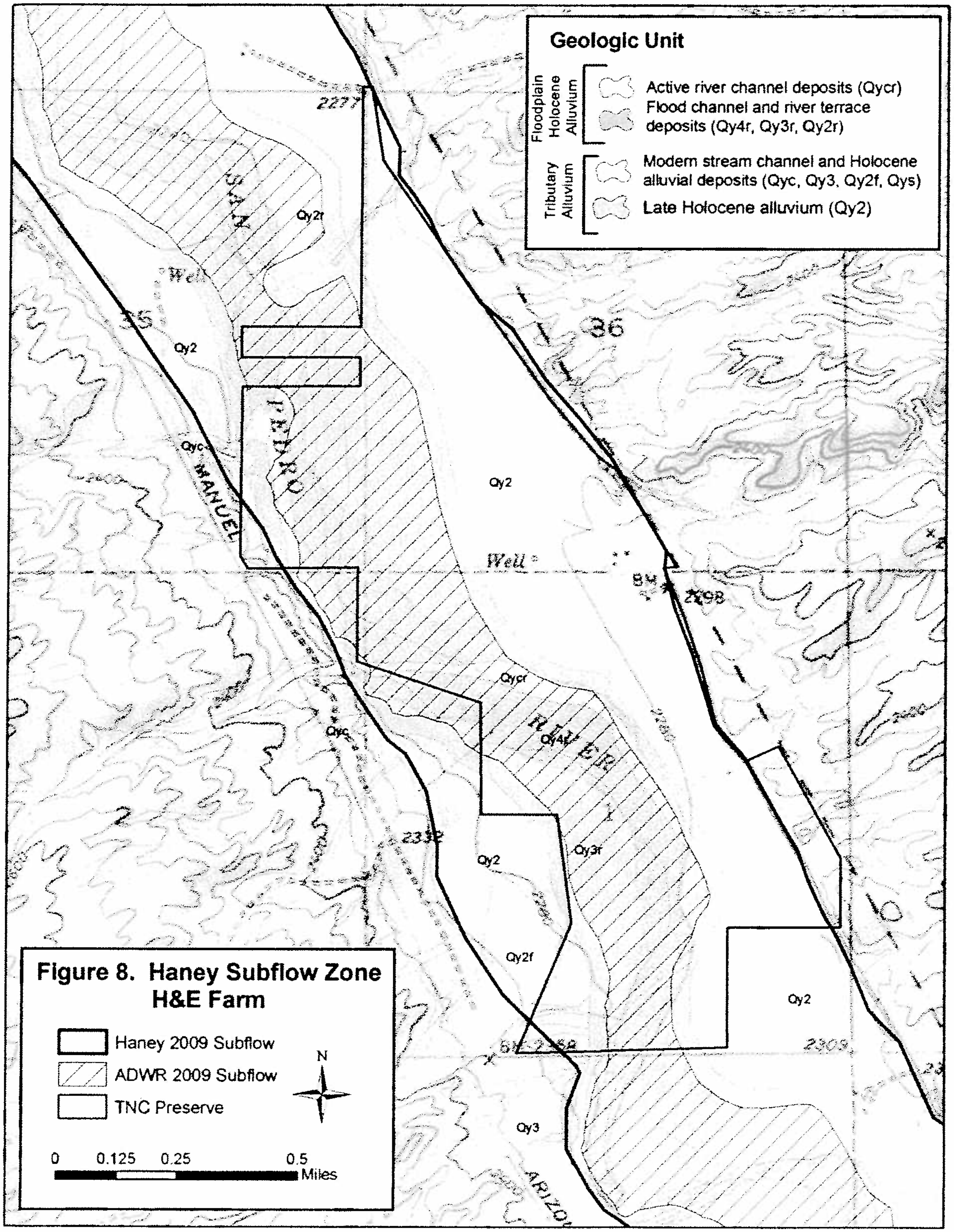


Figure 7. H&E Farm
Monitor Wells
(Number = well ID)
ADWR Wells with Logs
(Number = depth to clay)
TNC Preserve
0 0.125 0.25 0.5
Miles
N
SAN
PEDRO
RIVER
MANUEL
Well
Well
35
36
2
2470
2332
2309
2358
W9
W7
W2
W3
W4
W6
PZ-1
PZ-2
PZ-3
PZ-4
BM
72
75
70
100


Geologic Unit
Floodplain Holocene Alluvium
Active river channel deposits (Qycr)
Flood channel and river terrace deposits (Qy4r, Qy3r, Qy2r)
Tributary Alluvium
Modern stream channel and Holocene alluvial deposits (Qyc, Qy3, Qy2f, Qys)
Late Holocene alluvium (Qy2)
Figure 8. Haney Subflow Zone H&E Farm
Haney 2009 Subflow
ADWR 2009 Subflow
TNC Preserve
N
0 0.125 0.25 0.5 Miles
SAN PEDRO RIVER
MANUEL
Qy2r
Qy2
Qyc
Qycr
Qy4r
Qy3r
Qy2f
Qy3
Well
36
2298
2332
2309
ARIZO

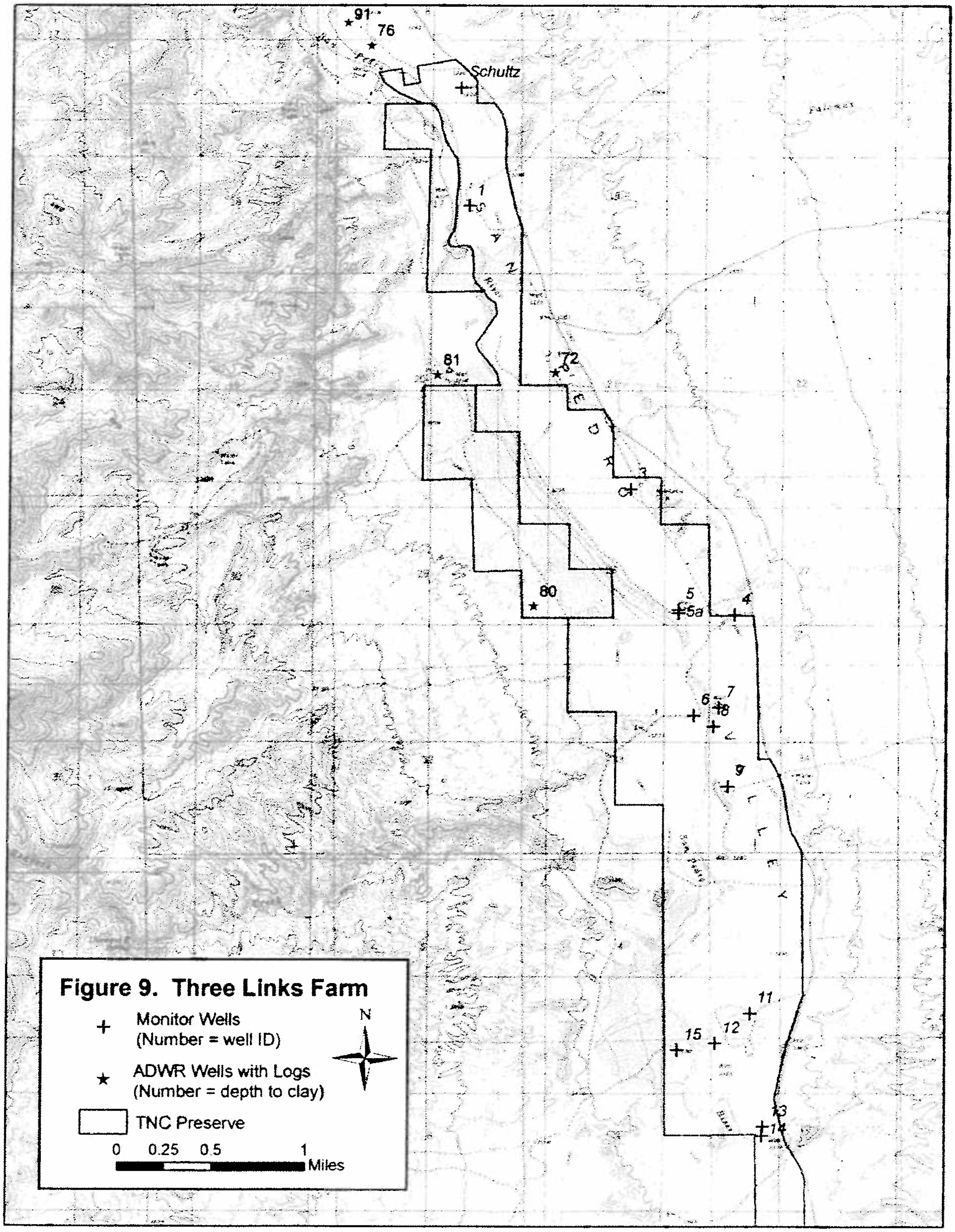


Figure 9. Three Links Farm
Monitor Wells
(Number = well ID)
ADWR Wells with Logs
(Number = depth to clay)
TNC Preserve
0 0.25 0.5 1
Miles
N
Schultz
91
76
1
2
81
72
3
80
5
5a
4
6
7
8
9
11
12
15
13
14

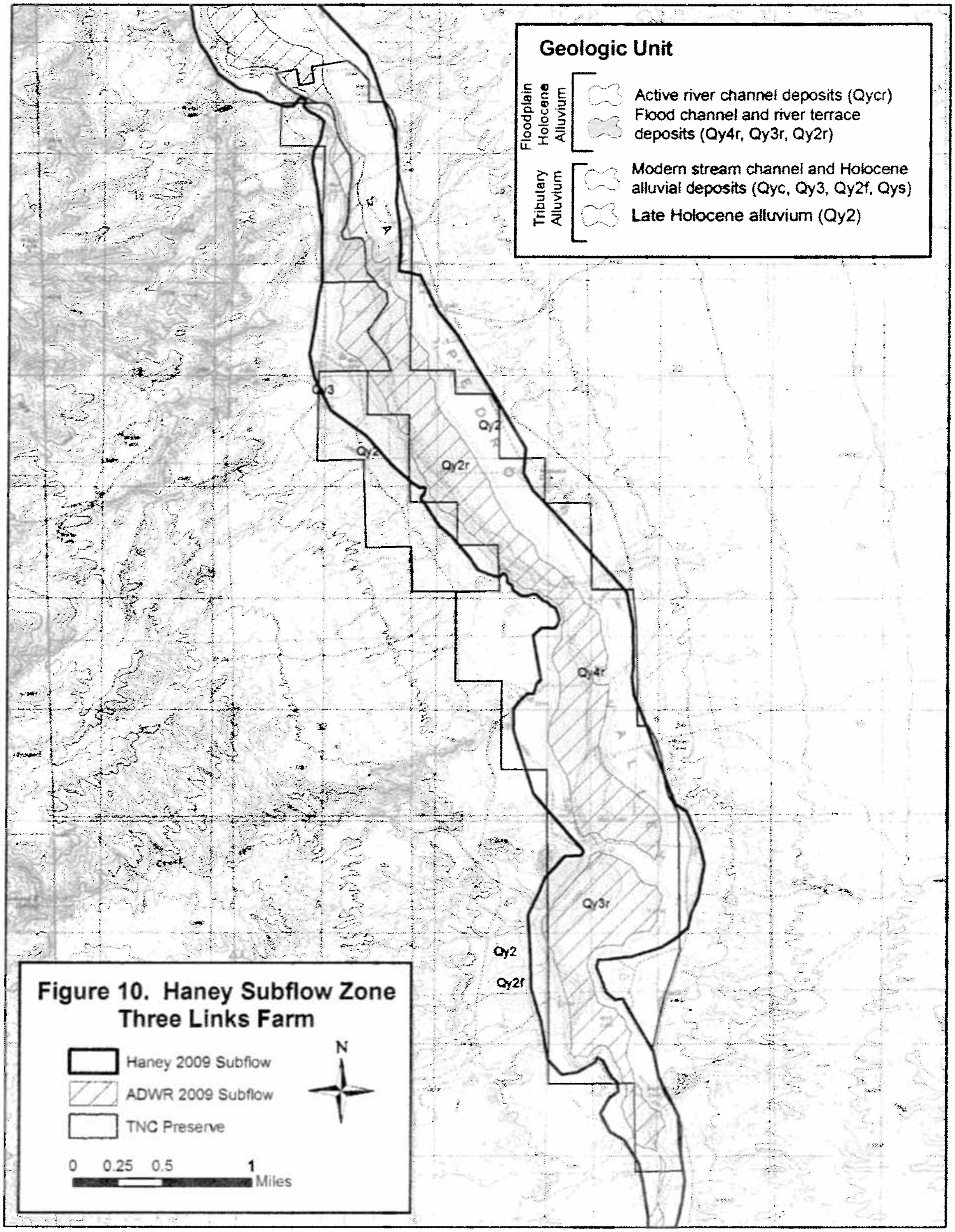
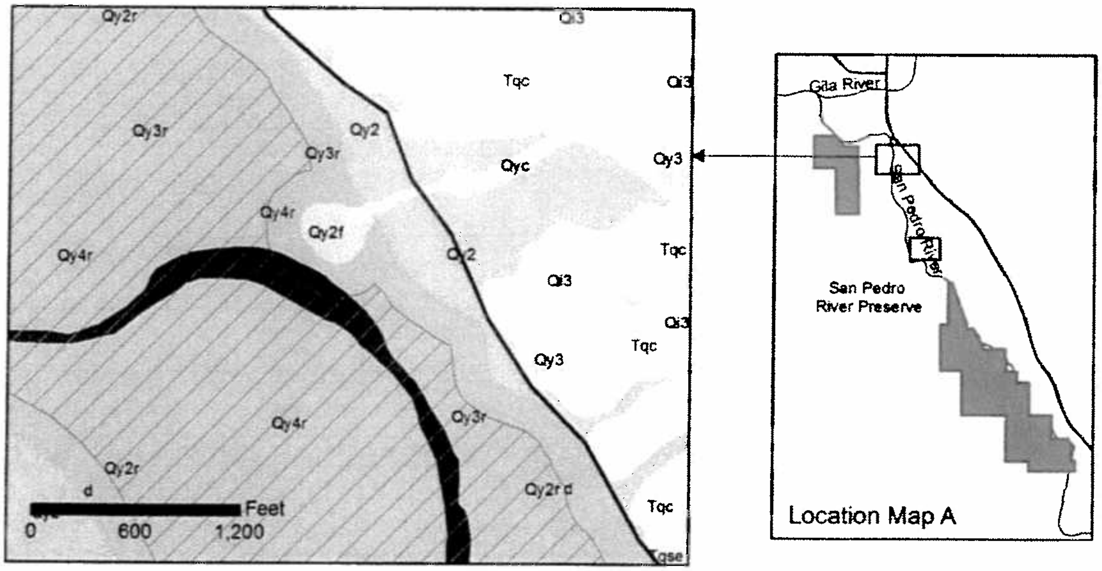
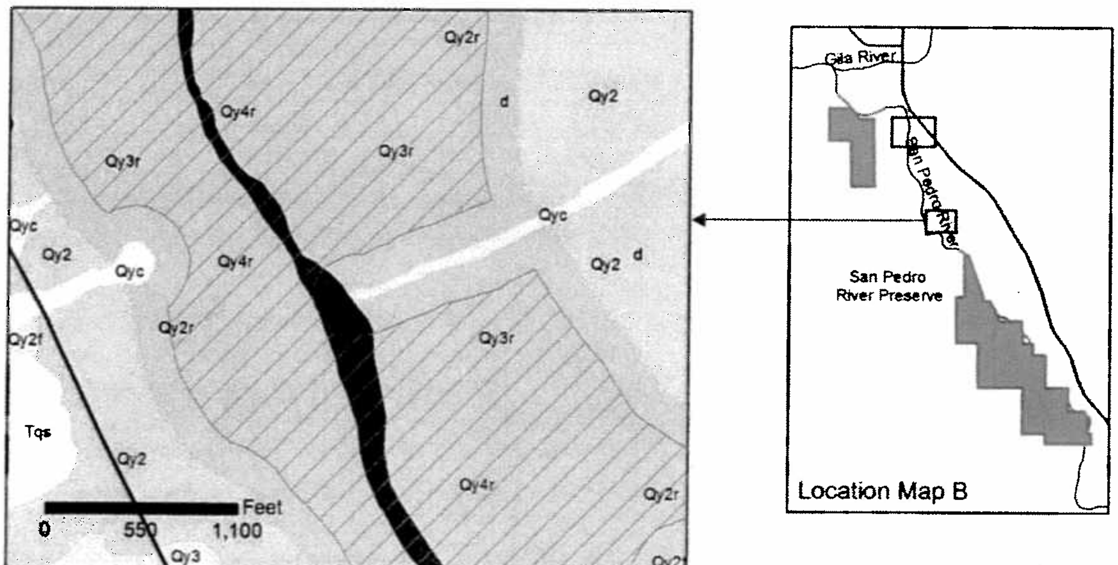


Figure 10. Haney Subflow Zone Three Links Farm



A. ADWR subflow zone excludes tributary alluvial fan (Qy2f). Portion of active channel outside subflow zone. Migration of active channel to northeast, as fan debirs is removed, will place more of the river outside ADWR subflow zone.



B. ADWR subflow zone excludes the full width of the active channel, because a small finger of tributary alluvium (Qyc) overlies the floodplain Holocene alluvium.

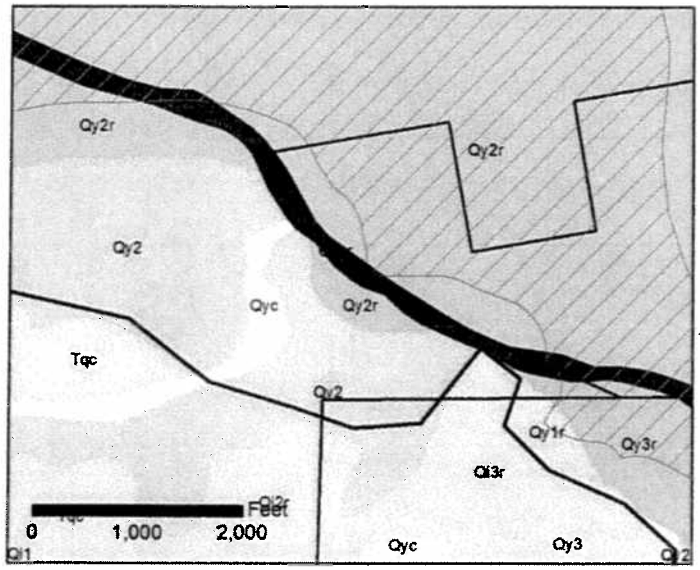
Geologic Units

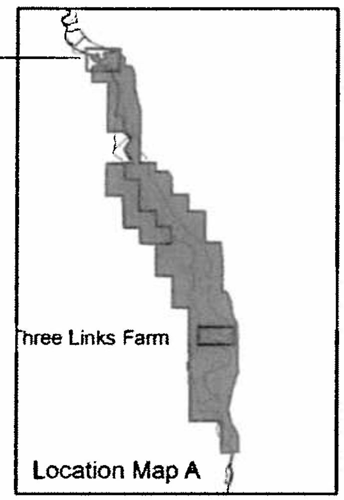
Floodplain Holocene Alluvium
- Active river channel deposits (Qycr)
- Flood channel and river terrace deposits (Qy4r, Qy3r, Qy2r)

Tributary Alluvium
- Modern stream channel deposits (Qyc)
- Holocene alluvial deposits (Qy3, Qy2f, Qys)
- Late Holocene alluvium (Qy2)

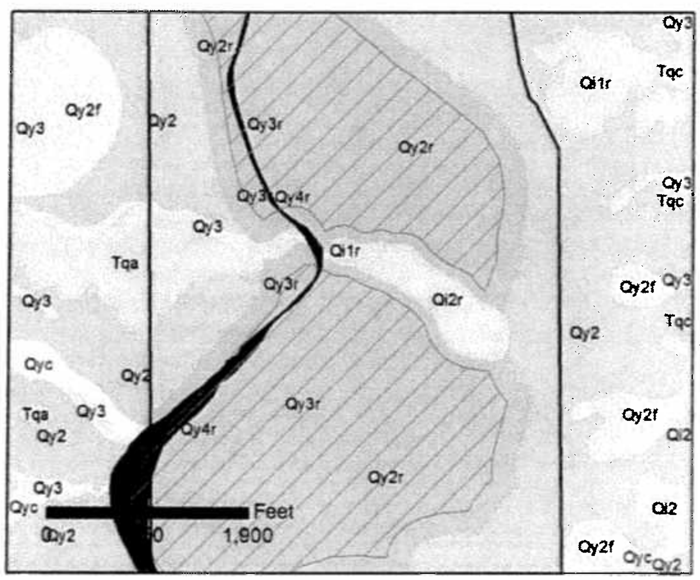
Figure 11. Examples: ADWR Subflow Zone Excludes Active Channel

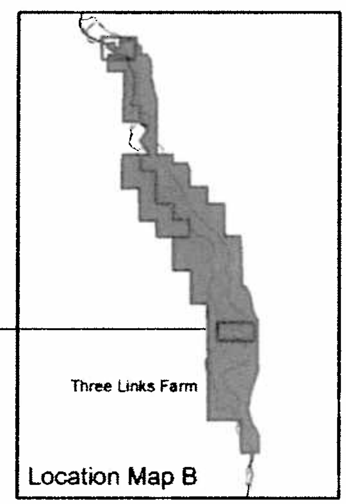
ADWR 2009 Subflow — Haney 2009 Subflow





A. ADWR subflow zone excludes portions of the river and active channel, due to setback from edge of surficial exposure of floodplain Holocene alluvium.





B. ADWR subflow zone excludes the river and active channel.

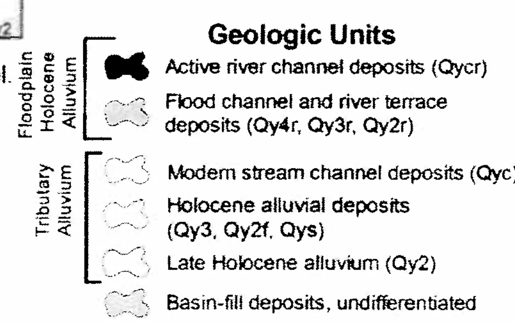
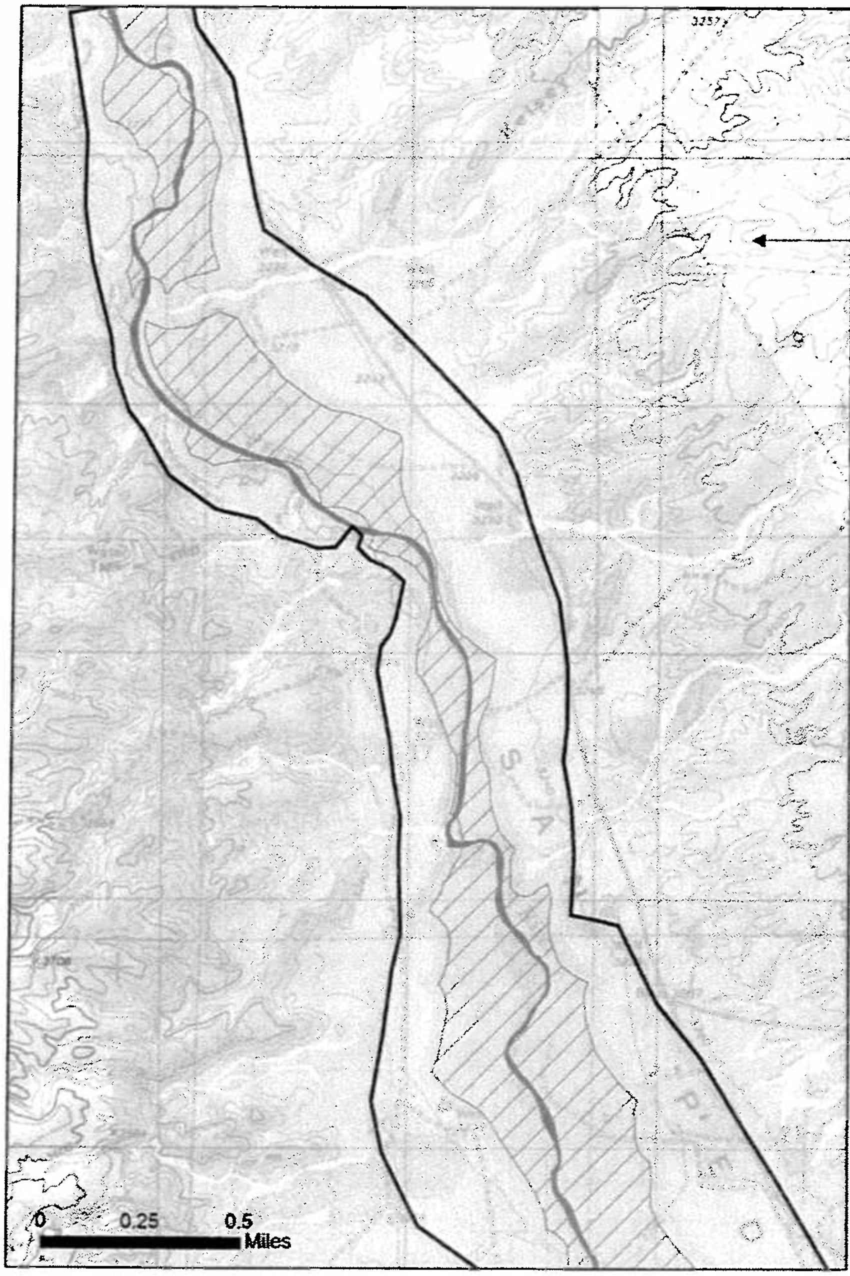


Figure 12. Examples: ADWR Subflow Zone Excludes Active Channel

ADWR 2009 Subflow

Haney 2009 Subflow



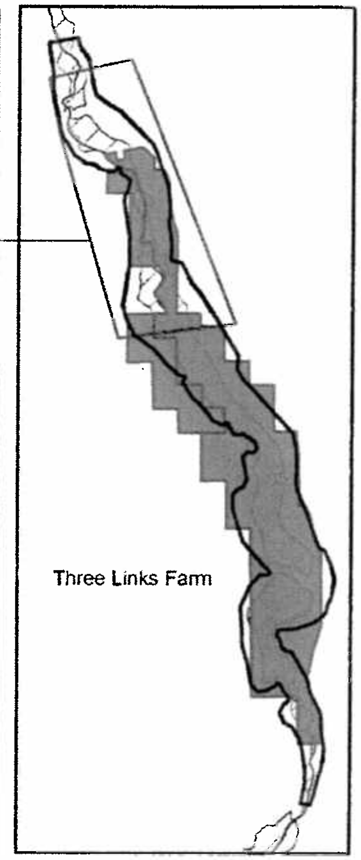


Illustration of using geologic outcrops to assist in delineating subsurface extent of floodplain Holocene alluvium. Pre-Holocene age materials taken together with topographic breaks assist in determining the subsuface extent of the floodplain Holocene alluvium.

Figure 13. Using Geologic Outcrop Pattern to Map Subsurface Extent of Floodplain Holocene Alluvium

ADWR 2009 Subflow

Haney 2009 Subflow

N

Geologic Units

Floodplain Holocene Alluvium
- Active river channel deposits (Qycr)
- Flood channel and river terrace deposits (Qy4r, Qy3r, Qy2r)

Tributary Alluvium
- Modern stream channel deposits (Qyc)
- Holocene alluvial deposits (Qy3, Qy2f, Qys)
- Late Holocene alluvium (Qy2)

Basin-fill deposits, undifferentiated

Table 1: Well Logs in the Vicinity of San Pedro River Preserve

Reg No	From	To	Description	Collared in
504927	0	18	Sand & gravel	Qy2r
	18	22	Hard rock layer	
	22	25	Sand & gravel-water	
	28	28	Clay	
	28	48	Sand & gravel	
	48	54	Quick sand & water	
	54	65	Hard white rock	
540663	0	18	Gravel	Qy2r
	18	137	Conglomerate consolidated	
	137	147	Unconsolidated gravel-water	
506187	0	240	Sand-clay-gravel	Tqc-Qy2
506463	0	15	Overburden	Qy2r
	15	75	Sand & gravel	
	75	80	**Clay**	
586161	0	45	Loose sand	
	45	60	Gray & white rock 1/4-1"	Qy2
535727	0	54	sand and gravel water	Tqse/Qy2
	54	64	sand and gravel	
	64	178	sand and gravel	
644307	0	2	Topsoil	Qy2
	2	23	Caliche, cemented	
	23	80	Clay	
	80	83	Sand gravel water	
	83	100	**Clay**	
518322	67	68	first water - sand and gravel	Qy2
	123		water - sand and gravel	
569983	0	3	Brn silt & clay	Qy4r
	3	6	Brn silty clayey sand & gravel	
	6	9	Brn sand	
	9	12	Brn sand & gravel w/cobbles	
	12	15	Brn gravelly sand	
	15	20	Brn silty clayey sand & gravel	
			TD-20 ft.	
			Water-10 ft	
517549	0	10	Hard clay	Qy4r/Qy2
	10	80	Gravel and small boulders	

			First water-10 feet	
588864	0	6	Topsoil (Potato dirt)	Qy2
	6	47	Sand comglomerate some clay	
	47	90	Gravel,rounded, lot of sand	
	90	100	**Clay**	
542796	0	5	Sand and boulders	Qy2/Tqm
	5	20	Boulders and clay	
	20	400	Clay and gravels	
570118	0	81	Sand gravel cobbles	Qy2r
515185	0	10	Clay or caliche	
	10	60	Sand and gravel	
	60	67	Conglomerate, 2/3 rock, 1/3 clay	
502627	0	15	Top soil	Qy2
	15	20	Sand & gravel	
	20	75	Clay	
	75	90	Gravel & sand, small water	
	90	135	Clay	
	135	165	Sand, gravel, large rock, water	
	165	180	Clay	
			Water strata 135 to 165 ft	
528815	60	70	Sand and gravel	Qy2
	70	100	**Clay**	
534764	0	8	Brown gravel	Qy2
	8	38	Brown gravel & clay	
	38	57	Firm hard packed gravel, water	
	57	80	Brown sand clay and gravel	
	80	89	Boulders and gravel	
	89	91	**Red Clay**	
502289	0	15	Silt	Qy4r
	15	35	Sand gravel & clay	
	35	55	Silt	
	55	65	Gravel	
	65	86	Sandy clay	
	86	---	**Red clay**	
508378	0	35	Soil and gravel	Qy2
	35	100	**Clay streaked sand**	
530492	0	4	Top soil	Qy2
	4	10	clay	
	10	15	clay, sand and rock mix	
	15	20	clay	

	20	23	sandy loam, ponding water	
	23	30	clay	
	30	36	clay sandy	
	36	38	sand stringer, first water	
	38	45	clay	
	45	47	very hard red caliche, 2nd water	
	47	52	caliche? mixed w/clay	
	52	62	river sand coarse	
	62	72	large gravel	
	72	77	large boulders	
	77	80	**dark red clay**	
508496	0	20	Soil	Tqm
	20	50	Clay and boulders	
	50	73	Gravel	
	73	102	**Clay**	
534899	0	43	Brown sandy clay	Qy2/Qy2f
	43	55	Brown clay and gravel	
	55	74	Brown sandy gravel	
	74	80	**Brown clay**	
521131	65	100	Sand & gravel,streaks of clay	Qy2/Qy2f
541858	0	20	Sandy clay	
	20	50	Clay gravel; water at 45 feet	
	50	60	Gravel	
	60	140	**Clay**	
552142	0	27	Silt, clay, and gravel	Qy2
	27	45	Gravel and clay	
	45	70	Gravel and sand	
	70	80	**(Red) Sandy clay**	
542060	0	50	Clay	Qy2
	50	63	Gravel, sand, and water	
	63	100	**Clay**	
565875	0	20	Brown clay	Qy2
	20	40	Sand	
	40	62	Sand, gravel, & cobbles	
	62	85	**Brown clay**	

Table 2: Well Logs in the Vicinity of the H&E Farm

Reg No	From	To	Description		Collared in
527192	0	20	8" PVC cemented in place		Qy2
	20	140	sandy clay		
	140	160	sandy clay with streaks of sand		
523699	0	25	dirt & clay		Qy3r
	25	75	sand & gravel	1st water 35'	
	75	77	**clay**	**static 18'**	
523698	0	25	dirt & clay		Qy3r
	25	72	sand & gravel	1st water 35'	
	72	75	**clay**	**static 14'**	
523696	0	10	surface soil		Qy2r
	10	70	sand		
	70	100	gravel & water		
523695	0	10	surface soil		Qy2r
	10	65	sand		
	65	100	gravel and water		
522331	0	6	loam		Qy3r
	6	20	gravel		
	20	70	clay		
	70	78	sand & gravel		
522142	0	50	clay		Qy2
	50	30	sand & gravel		
	60	95	clay with large rocks		
	95	180	some sand & gravel		
503079	0	12	top soil		Qy2
	12	30	sand & gravel		
	30	35	gravel with some clay		
	35	36	water first encountered		
	36	70	grave, river boulders, & water		
	70	75	**clay**		
501673	0	8	top soil		Qy2
	8	20	sand & gravel		

	20	30	clay	
	30	40	sand	
	40	65	gravel to large rock water 44'	
	65	70	clay	
	70	100	gravel & water	
	100	110	**clay**	
534685	0	6	silt	Qy2r
	6	10	silty fine sand	
	10	12	coarse sand	
	12	35	gravelly coarse sand; water at 14'	
573355	0	20	loose gravel	Qy2
	20	195	gravel & shale	

Table 3: Well Logs in the Vicinity of the Three Links Farm

Reg No	From	To	Description		Collared in
910588	0	50	Sandy brown clay		Qy2r
	50	95	Decomposed granite		
906973	0	170	Weathered granite		Qi1r
906970	0	168	Weathered granite		Qy2
598659	0	30	brown dirt		Qyc
	30	60	brown clay		
	60	110	sand and course gravel		
	110	142	**brown sandy clay**		
582635	0	26	dirt and clay		Qy2r
	26	310	conglomeration		
	310	405	clay and gravel		
	405	430	sand and gravel		
546954	0	35	silty clay		Qy2r
	35	114	sandy gravel		
520298	0	3	soil		Qy2r
	3	26	sandy clay		
	26	76	gravel	1st water 51'	
	76	79	**clay**		
	79	112	sandy clay-streaks of sand		
	112	115	**clay**		
520105	0	3	soil		Qy2
	3	28	sand clay		
	28	81	gravel & sand	1st water 46'	
	81	93	**clay**		
	93	98	sand clay		
	98	103	clay		
518817	0	28	sand & sandy clay		Qy2
	28	113	clay		
	113	117	sand	1st water	
	117	200	clay		

502244	0	20	red clay		Qy2
	20	60	clay conglomerate		
	60	80	clay with sand streaks		
	80	152	**clay congl, layers sand & gravel**		
502111	0	5	soil		Qy2
	5	12	sand & boulders		
	12	30	clay		
	30	50	gravel & rock		
	50	72	sand-gravel-water		
	72	204	**red clay**		
502022	0	2	sand		Qy2
	2	15	hard sand & boulders		
	15	28	hard sand & boulders		
	28	40	clay & gravel		
	40	50	hard sand & boulders		
			clay	1st water	
	50	111	50'		
	111	117	conglomerate (hard)		
	117	165	clay		
502003	0	6	soil		Qy2r
	6	28	red clay		
	28	40	sandy clay		
	40	46	sand	1st water	
	46	85	sandy clay		
	85	91	gravel - water		
	91	120	**red clay**		