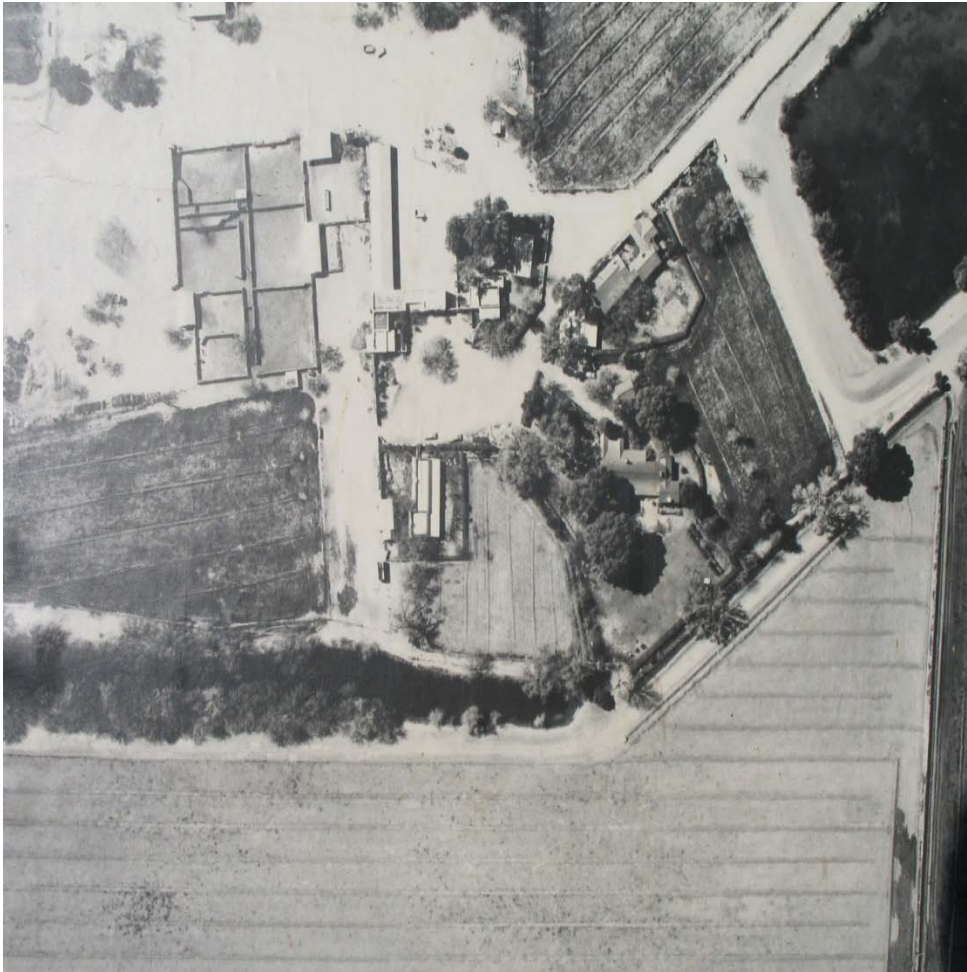


Hydrologic Evaluation of the Canoa Ranch along the Upper Santa Cruz River

BY

Frank Postillion,
Chief Hydrologist
David Scalero,
Principal
Hydrologist
&
Mark Krieski
Engineering
Manager



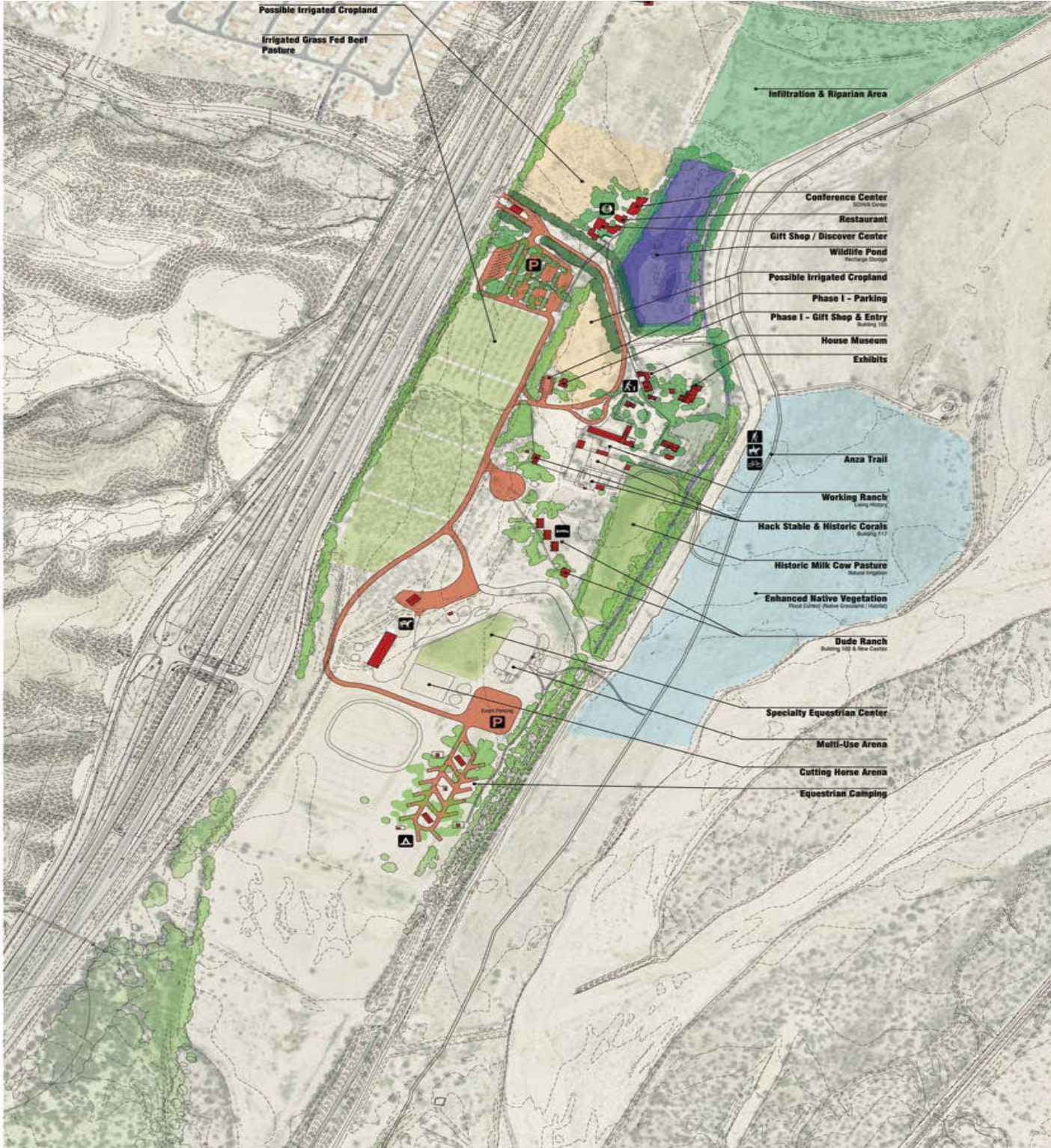
Pima County Regional
FLOOD CONTROL
DISTRICT



Canoa Ranch Restoration



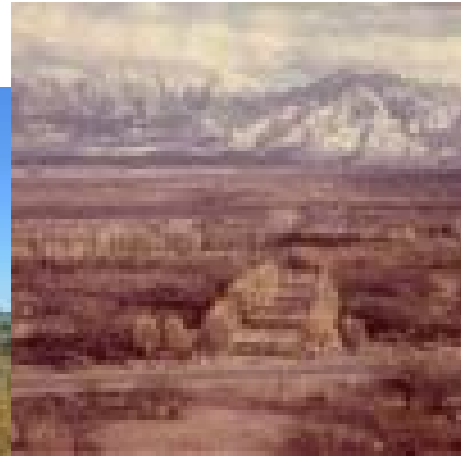
Restoration Plan



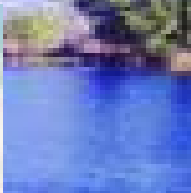
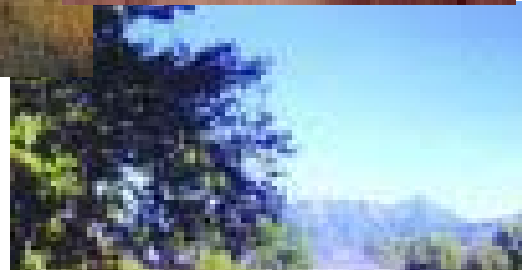
Canoa Ranch Along Santa Cruz River



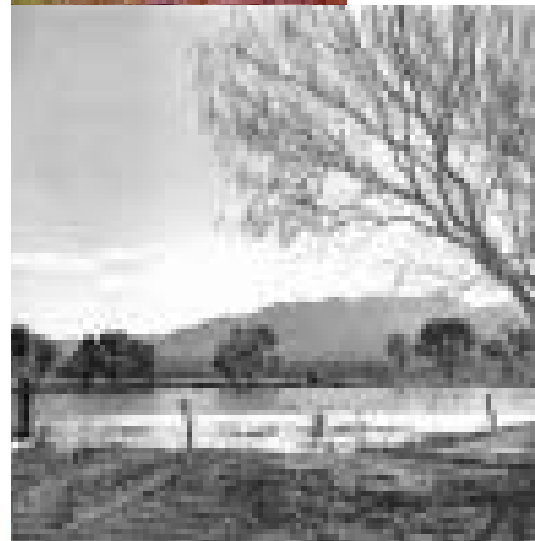
Historic Canoa Ranch Pond



Historic Photo of Canoa Ranch pond, circa 1951
Photo courtesy of Deezie Manning-Catron

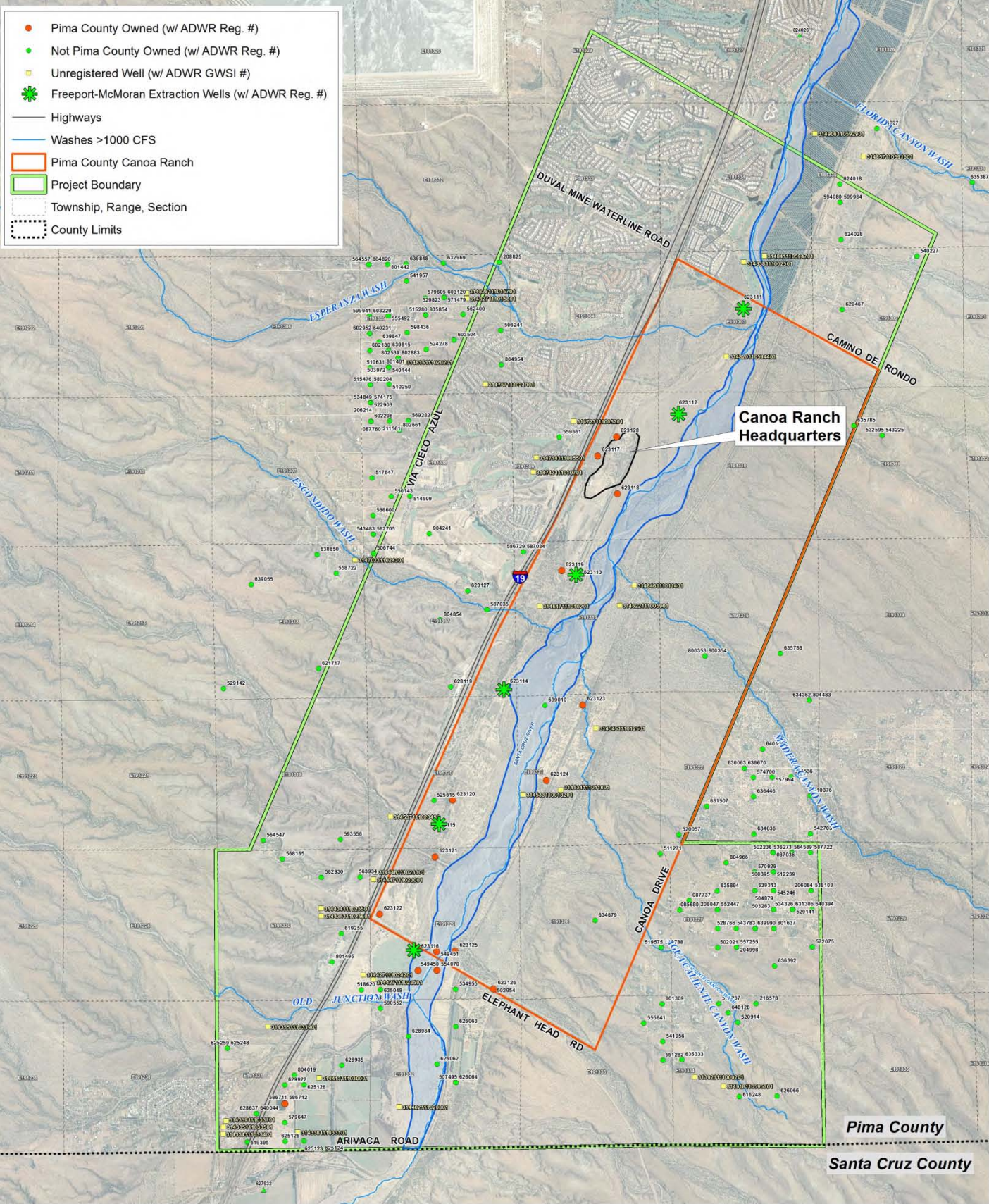


Historic photo of Canoa Ranch Canal, ca. 1925
Photo courtesy of Diana Hadley



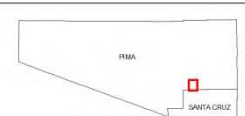
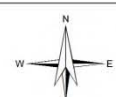
Old Wells for Monitoring





Canoa Ranch Hydrologic Study Figure 2-2 Water Wells in Study Area (not all wells field verified)

1 inch = 1,000 feet



Date: 1/31/2013



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Data Sources

- ADWR's Groundwater Site Inventory (GWSI)
- Pima County (NRP&R, RWRD & RFCD)
- FICO
- Freeport McMoran
- December 2010-March 2011 data used for DTW and Water Elevations
- Data from previous years used when needed as a supplement

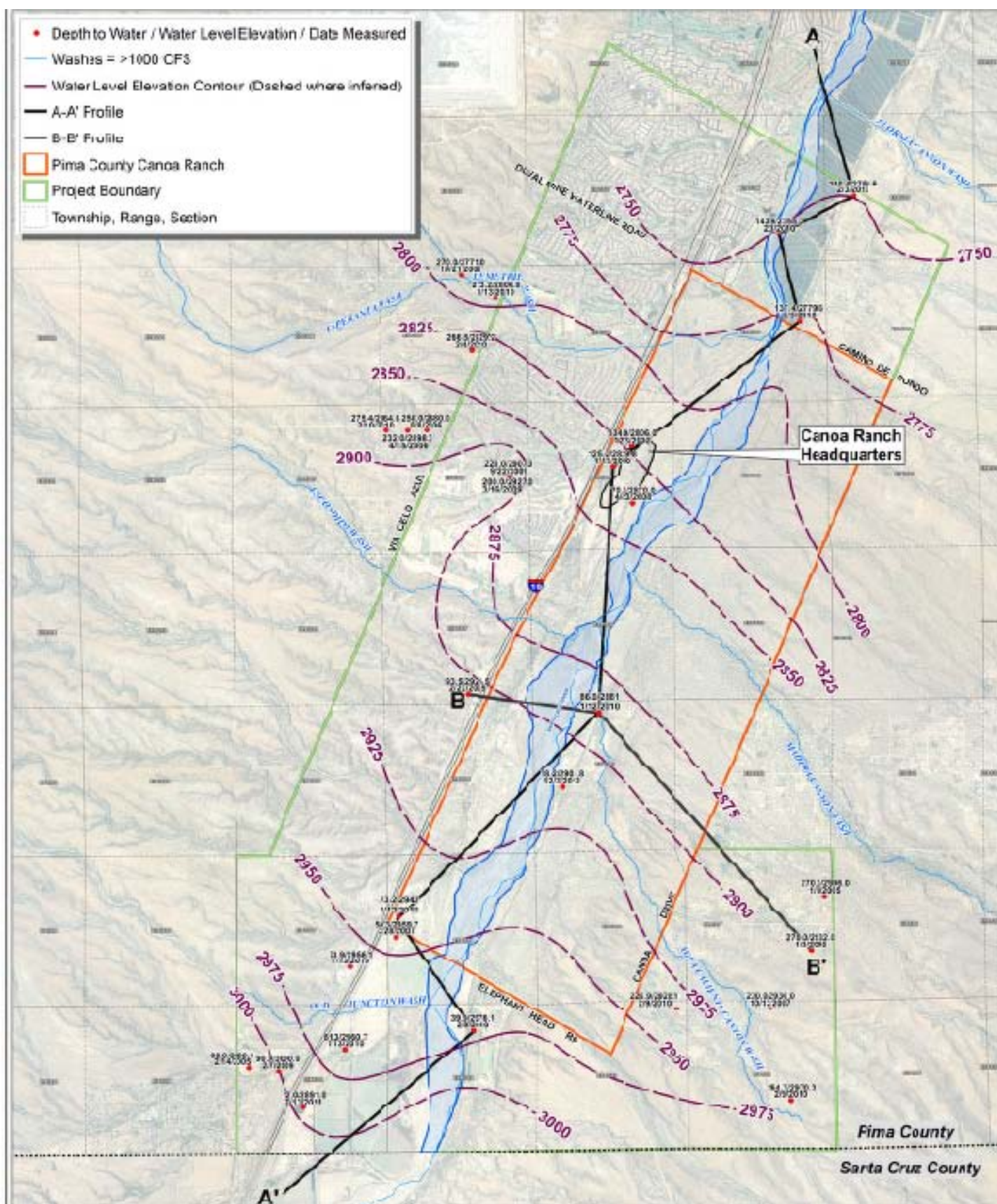
Subsurface Geology

- Alluvial Deposits
 - Sands & Gravels
 - 30 to 50 feet thick
 - Highly Permeable (rapid recharge of water)
- Fort Lowell Formation
 - Sand, Clayey Sand, Gravel & Sandy-Gravelly Clay
 - ~130 to 150 feet thick
 - Highly Permeable (rapid recharge of water)
- Tinaja Beds
 - Unconsolidated/Semi-consolidated Sands, Clay & Clayey Sand and Gravel
 - 600 to 800 feet thick
 - Primary water bearing unit (water supply)

Subsurface Geology

- Pantano Formation
 - Silty/Pebbly Sandstone, Mudstone & Gypsiferous Mudstone to moderately Cemented Gravel
 - Unproductive for water supply
- Santa Rita and Sierrita Bedrock
 - Fractured Gneiss and Granite
 - Some volcanics
 - As shallow as 400 feet bls near pediments
 - Unproductive water yield for larger municipal and industrial wells
 - Will yield some water for domestics

Water Level Elevations



Current Water Table

- Groundwater movement
 - Northwesterly near Elephant Head Rd.
 - Northeasterly near Ranch Headquarters
- Groundwater Gradient
 - 40 feet/mile in southern portion
 - 27 feet/mile near Elephant Head Rd.
 - 100 feet/mile at Ranch HQ north
- Water levels shallowest at Elephant Head Road and South

Figure 3-2: Longitudinal Profile A - A'

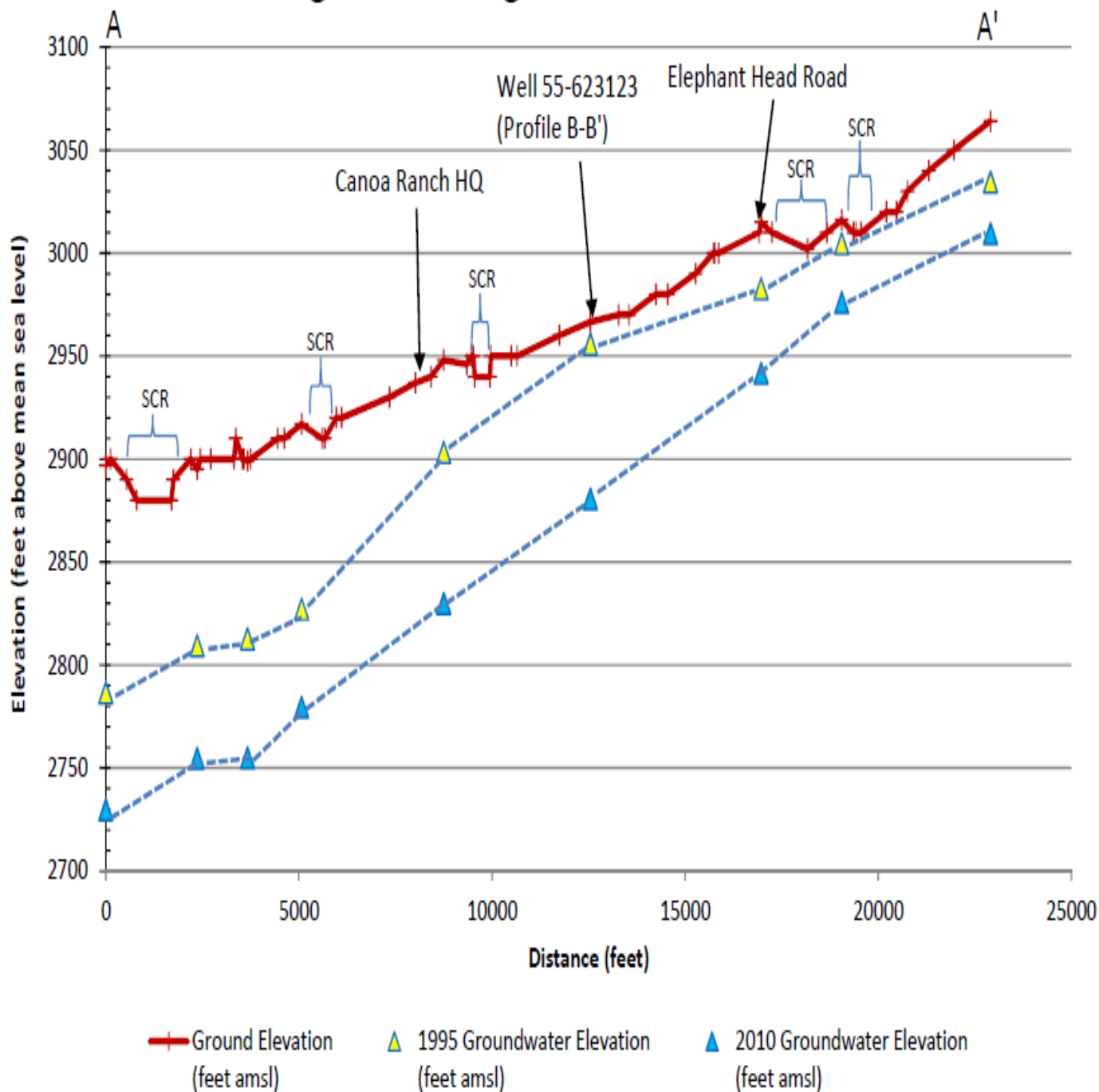
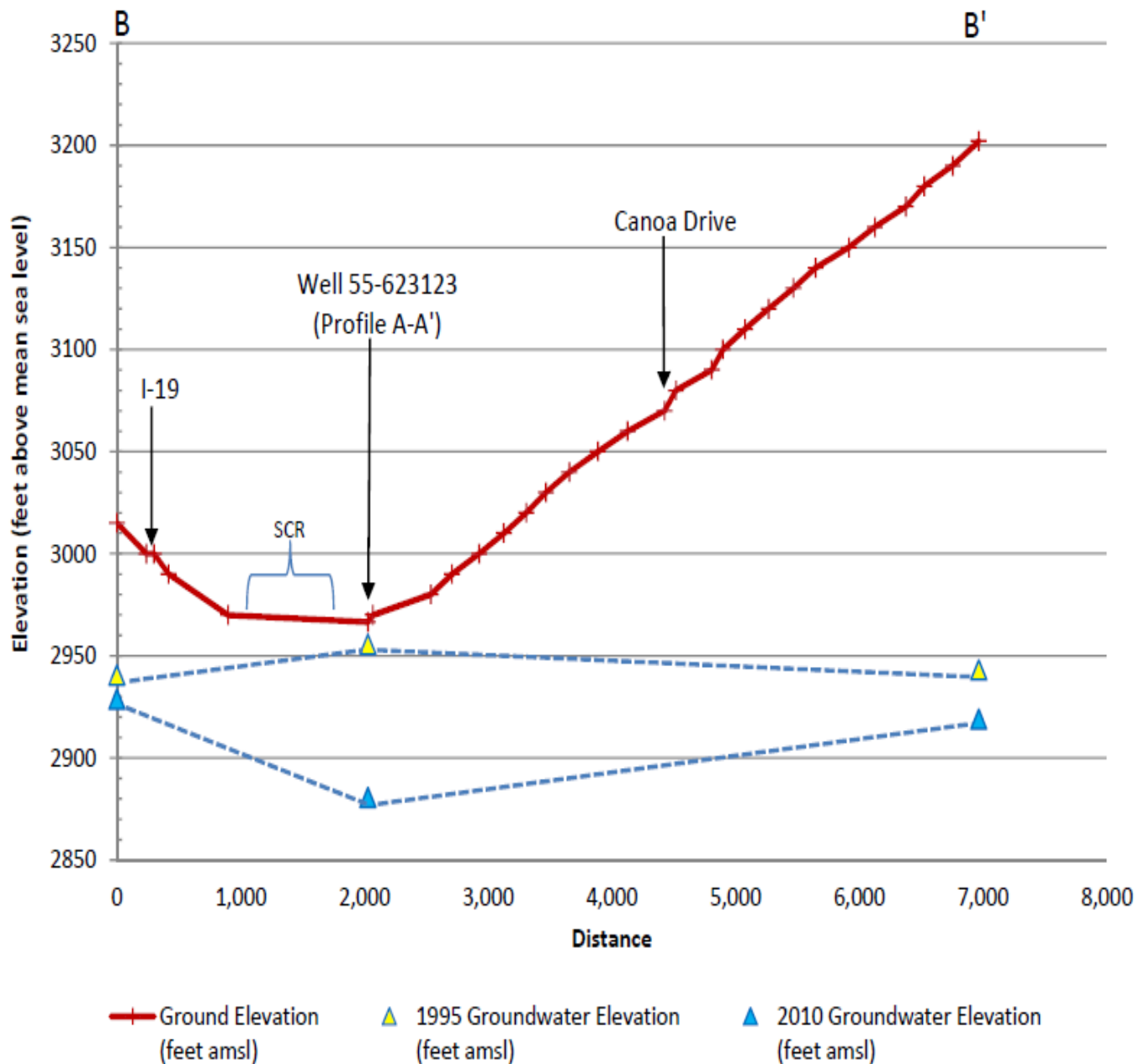


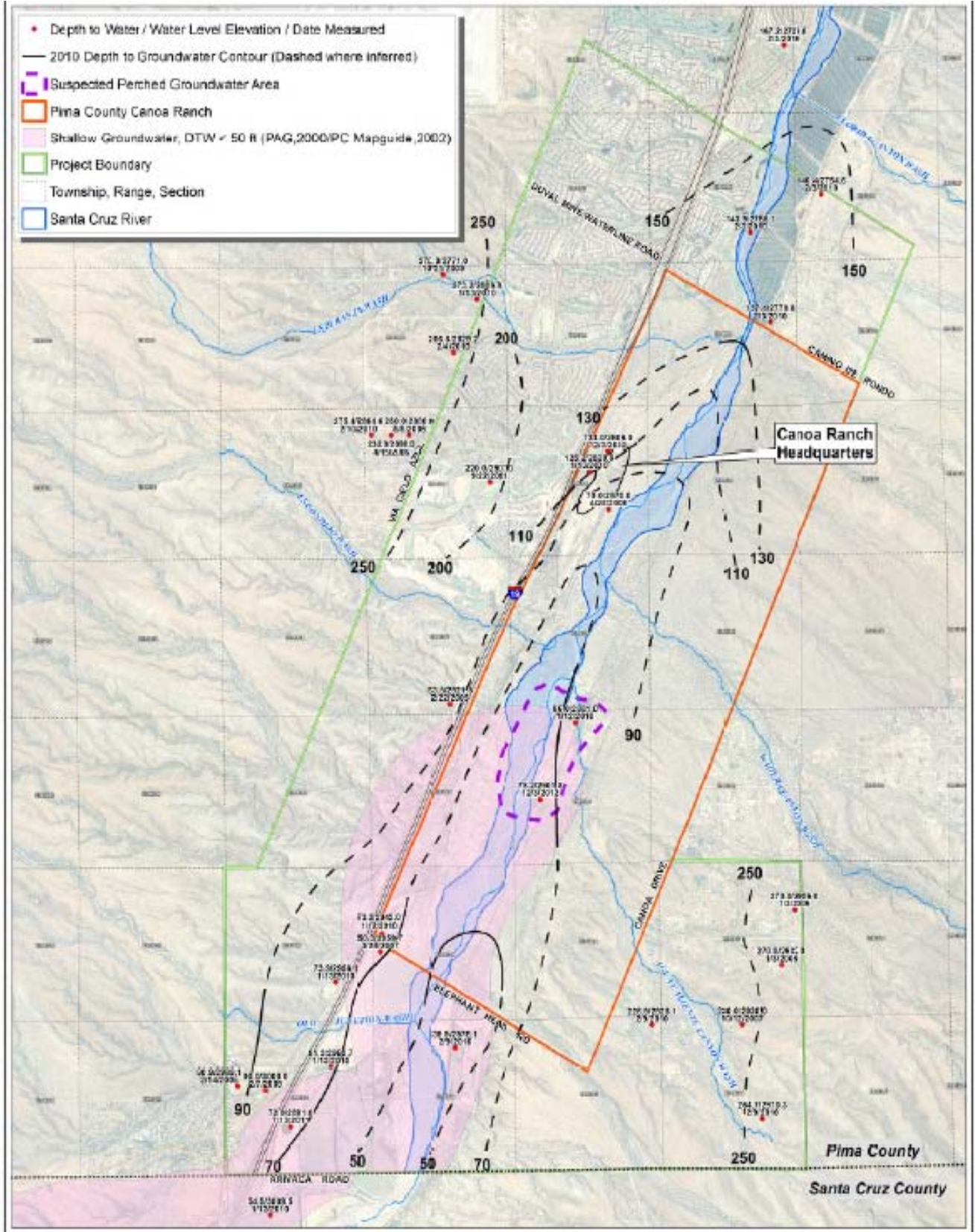
Figure 3-3: Canoa Ranch Profile B - B'



Depth to Groundwater and Declines

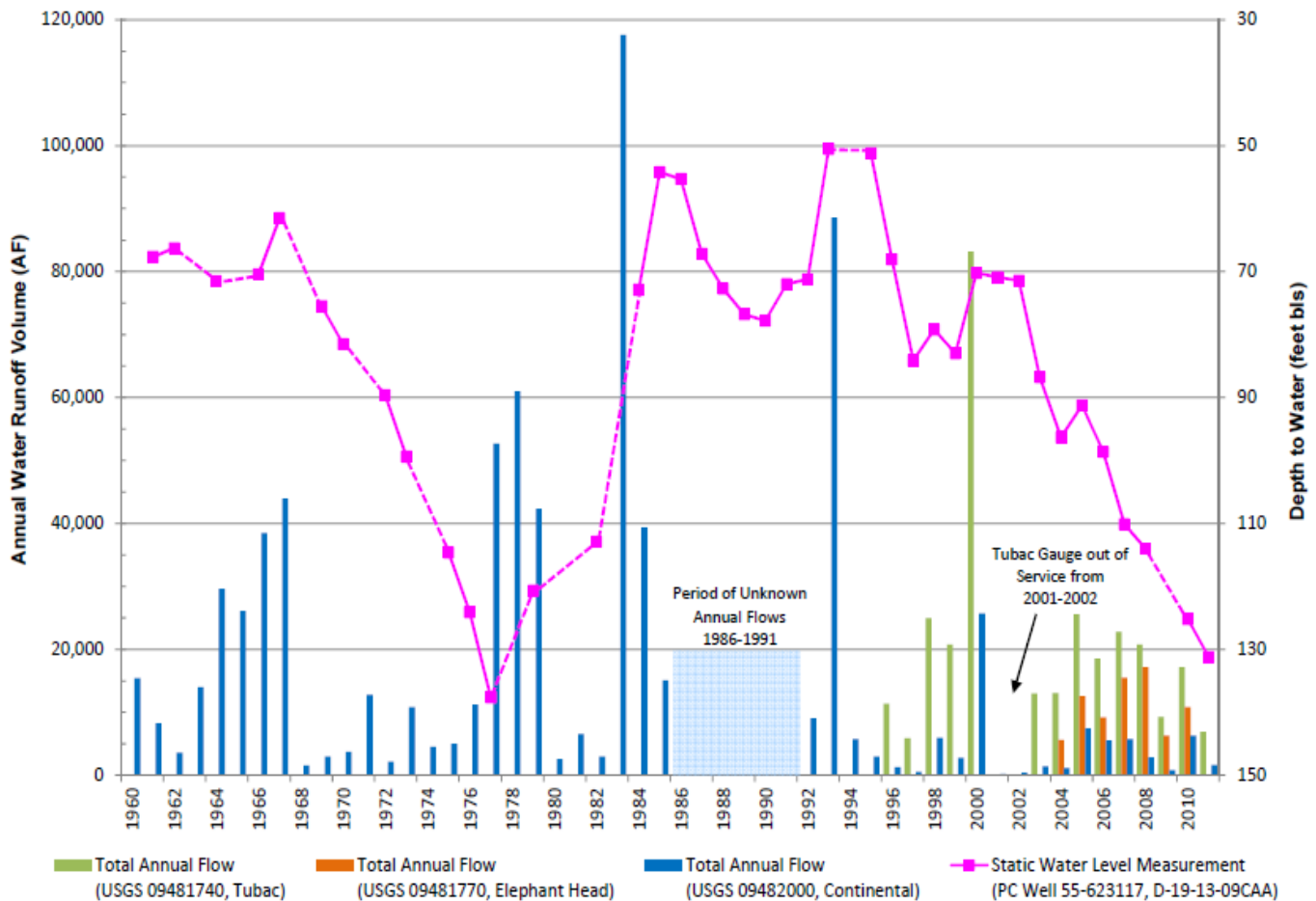
- 50 ft. and less near Elephant Head Road
- Perched water possible about 1 mile N of Elephant Head Rd.
- 70-90 feet bls near Ranch HQ
- Declines large over last 16-17 years. 5 ft/yr at Ranch Wells and 3 ft/yr overall
- Last 33 years little overall net change due to large floods in 1978, 1983 and 1993. But dramatic fall 1968-1978; large rise 1978-1994; and dramatic fall 1994-2012

Depth To Water



Effects of Stream-flow recharge on Water Levels

Annual Runoff Volume vs. Depth to Water
in a Well at the Canoa Ranch Headquarters Entrance
(Pima County Well 55-623117, D-19-13-09CAA)



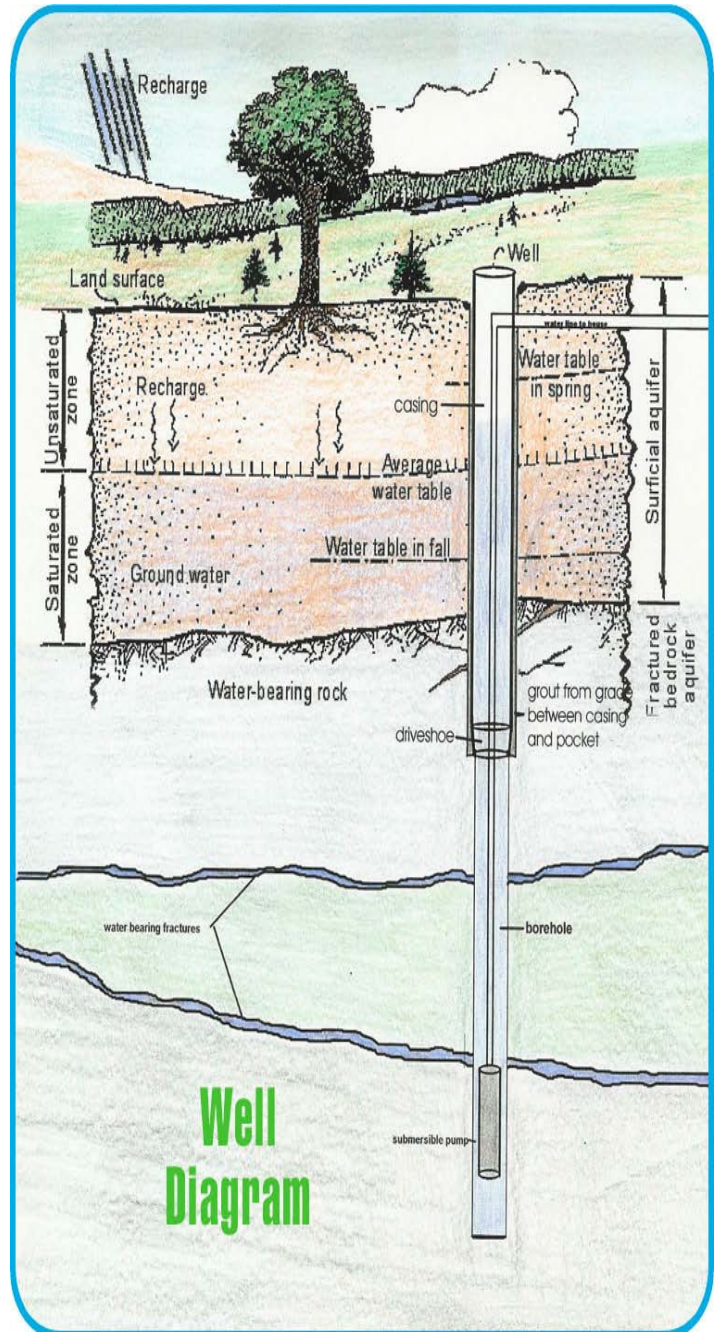
Historic Effluent and Storm-flow Recharge

- Effluent Recharge north of Elephant Head Rd. 720 AF/mi/yr 2005-09
- Effluent Recharge 425 AF/mi/yr from Tubac to Elephant Head Road
- Storm-flow recharge rates Tubac-Continental Bridge about 250 AF/mi/yr 1996-2011, except 2000
- Year 2000- 3,040 AF/mi/yr Tubac to Continental Bridge



Pumping

- 1984 -2010 total pumping average of 19,600 AF/yr
- 1984-2010 pumping average of 16,270 AF/yr from Mining Wells
- Future Canoa Ranch mine pumping to be reduced significantly

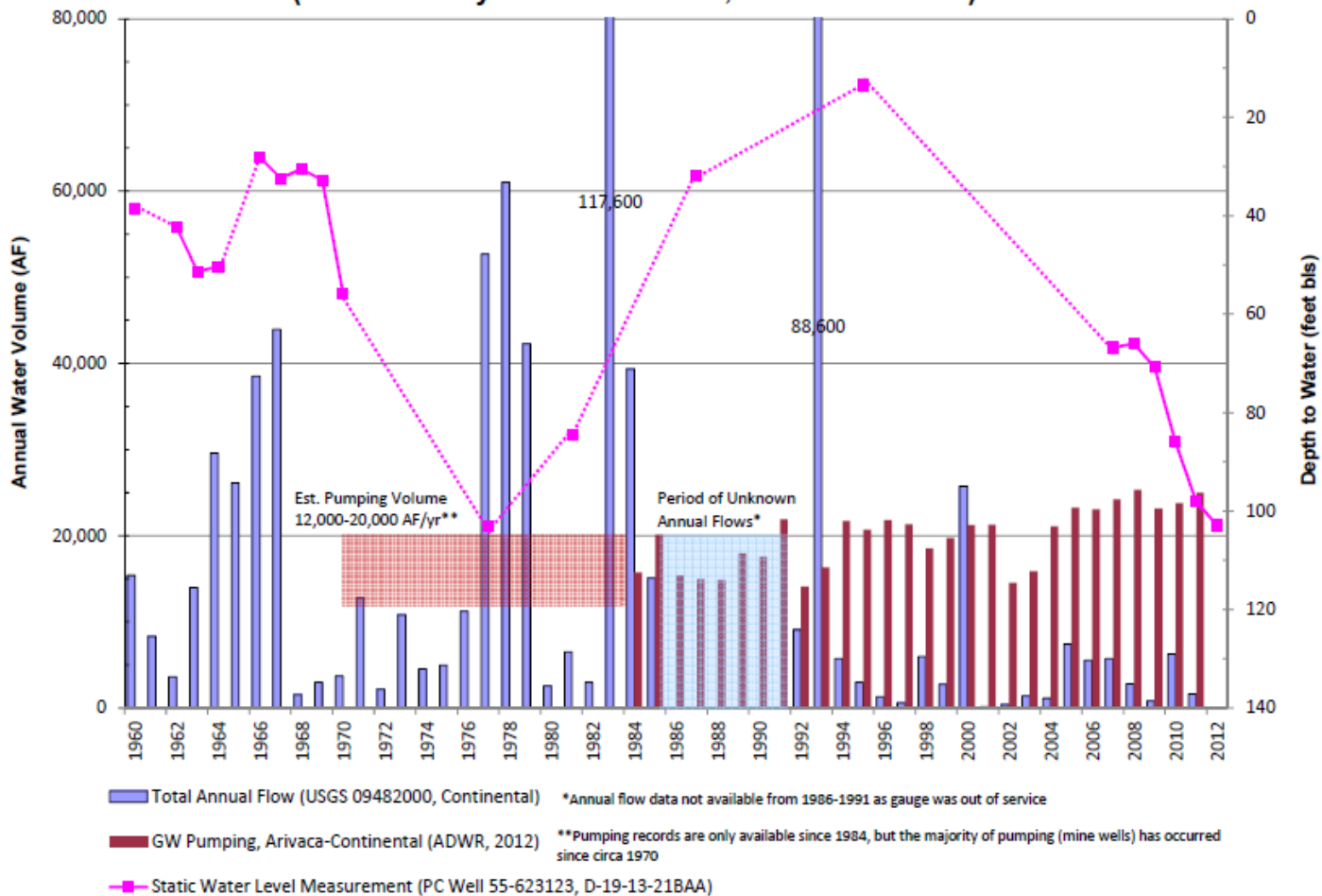


Water Balance

- Highest groundwater fluctuation occurs at wells closest to SCR
- Water level recovery of 10-35 feet w/in one year of large floods recorded in 1978, 1983, 1993 and even 2000
- WL recovery not sustained over time due to lesser flood flows and ongoing pumping
- Water Balance indicates significant loss of water storage over last 16 years

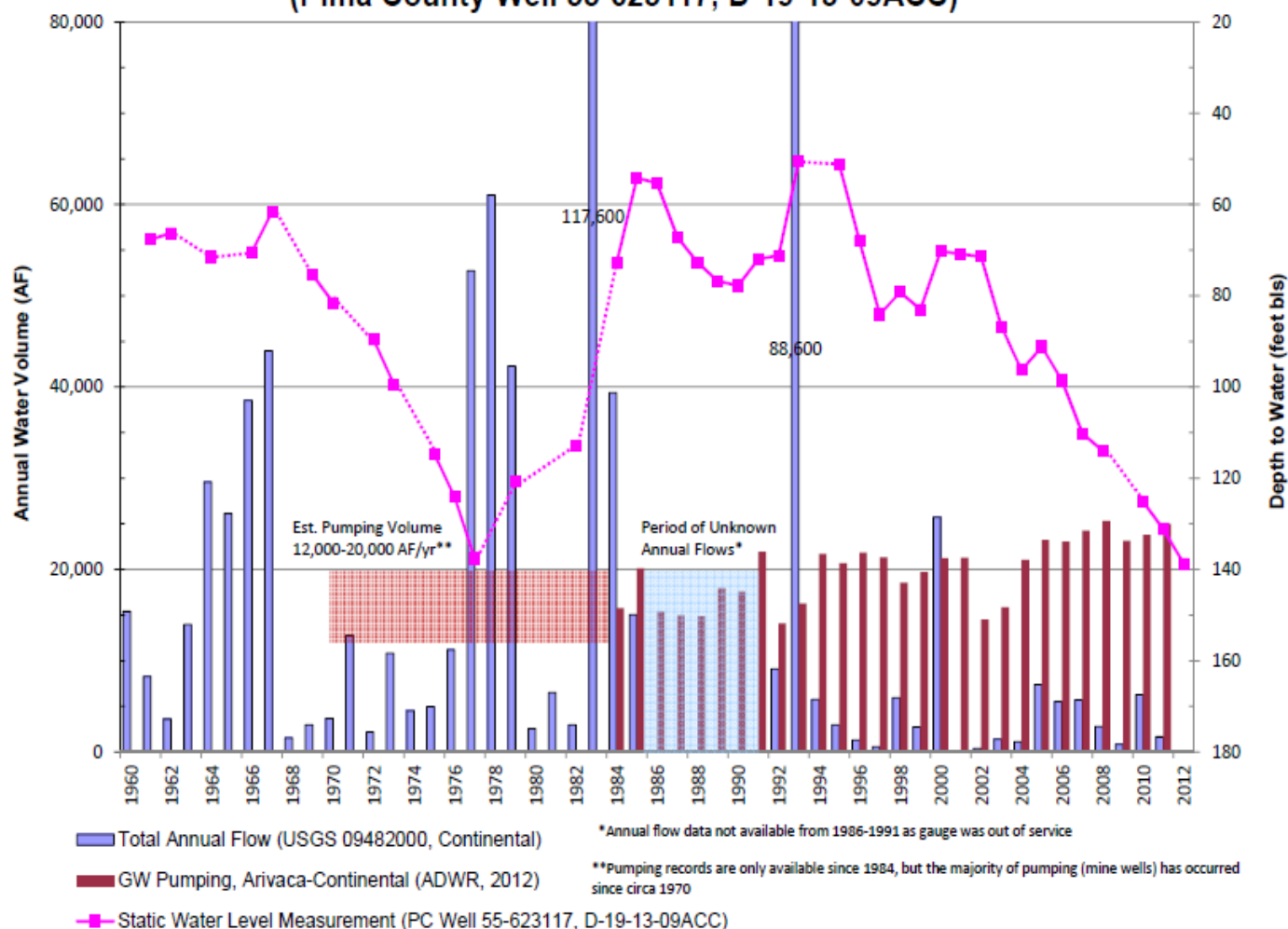
Water Balance

**Annual Runoff Volume at Continental Bridge vs. Depth to Water in a Well near SCR, 1.5 miles South of Canoa Ranch Headquarters
(Pima County Well 55-623123, D-19-13-21BAA)**



Water Balance

**Annual Runoff Volume at Continental Bridge vs. Depth to Water in a Well Near the Entrance to Canoa Ranch
(Pima County Well 55-623117, D-19-13-09ACC)**



Future Scenarios-What will our future local climate forecast? Will large mine pumping reductions help? Nogales Effluent doubtful in this reach?

Rainfall Data for Three Climatic Periods in the Canoa Ranch Vicinity

Date Range	Average Annual Rainfall at Green Valley NCDC Coop #23668 (inches)	Average Annual Rainfall at SRER NCDC Coop #27593 & ALERT #6390 (Florida Canyon Station) (inches)	Average Annual Rainfall at Elephant Head Butte ALERT #6350 (inches)	Average Annual Rainfall at Elephant Head Road ALERT #6060 (inches)	Average Annual Rainfall at Tumacacori NCDC Coop #28865 (inches)
1962-1977	----	20.78	----	----	14.81
1978-1994	----	26.31	----	----	19.13
1995-2011	12.50 ^a	19.04 ^b	11.85	9.20	14.54

	Planned Sierrita Mine Pumping (AF/yr)					
	2013	2014 to 2020	2021 to 2025	2026 to 2030	2031 to 2035	2036 to 2042
Total Mitigation Order Pumping	8,969	23,145	22,175	20,867	20,141	17,240
Total Canoa Well-field Pumping	17,726	3,450	4,420	5,728	6,154	9,355
Total Sierrita Pumping	26,595	26,595	26,595	26,595	26,595	26,595

Source: Beck, 2013



Downstream discharge from the NIWWTF to diminish 3-5 MGD (Alisos); and improved WQ enhances upstream GW recharge . Photo-Elephant Head Bridge 3/2013

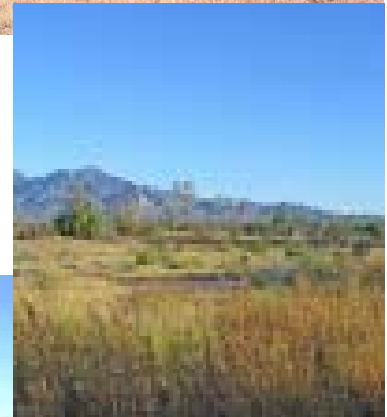
Recommendations

- Evaluate Recharge Opportunities in Canoa Ranch Area to sustain riparian corridor and stabilize water levels
- Identify range of overall recharge/pumping conditions necessary to maintain adequate shallow water levels along the SCR



Recommendations

- Investigate suspected perched groundwater area to understand relationship between the shallow GW zone and the enhanced riparian environment
- Evaluate diversion of treated effluent from the Arivaca WWTF to the historic pond at Canoa Ranch HQ for multi-purpose recharge and riparian restoration



Recommendations

- Further evaluate constructed multi-purpose recharge of CAP water in the northern portion of Canoa Ranch, from the headquarters area to the north property line to maintain and/or recover water levels in this part of the ranch
- Update current ADWR Upper Santa Cruz Basin model using data from 2013 water level monitoring program and this report. Perform sensitivity analyses and spatial mining pumping scenarios