

The Lower San Pedro River—Hydrology and Flow Restoration for Biodiversity Conservation

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Abstract—The lower San Pedro River, downstream from Benson, is a nearly unfragmented habitat containing perennial flow reaches that support riparian vegetation that serve as “stepping stones” for migratory species. The Nature Conservancy has purchased farm properties and retired agricultural pumping along the lower river, based largely on results from hydrologic analyses indicating that increased water availability for riparian vegetation will result from retiring agricultural pumping at key locations. A long-term commitment to hydrologic and ecological monitoring provides data that the Conservancy uses to inform property management, guide habitat restoration, and measure success of the agricultural retirement strategy.

Introduction

The San Pedro River originates in the Sky Islands and desert grasslands of southeastern Arizona and northern Sonora, Mexico, and extends approximately 140 miles north to join the Gila River at Winkelman, Arizona. The San Pedro River watershed has been divided into two hydrologic cataloging units in the United States—the upper San Pedro and the lower San Pedro (Seaber et al. 1987). The Lower San Pedro, comprising an area of about 1,980 square-miles and containing about 76 miles of river, begins at “The Narrows,” which consists of a bedrock constriction in the valley 12 miles north from Benson. The lower San Pedro River basin is shown in figure 1.

The San Pedro River is a migratory corridor of international importance for neotropical birds, bats, and insect pollinators (Kreuper 1996) and is considered one of the best remaining occurrences of Sonoran cottonwood-willow riparian forest, one of the rarest woodland types in North America (Noss et al. 1995; Stromberg et al. 1996). Compared to the upper San Pedro, the lower San Pedro basin is considerably less populated and has received less research attention; however, the lower San Pedro is an equally important terrain, with numerous reaches of high quality, cottonwood-willow riparian habitat that serve as “stepping stones” for migratory bird species (Skagen et al. 1998). The lower San Pedro River and its tributaries serve as important corridors linking the Rincon-Catalina Mountain complex to the west with the Galiuro Mountains to the east, as well as serving as a north-south corridor linking these mountain ranges with ranges to the north and south.

San Pedro River Hydrology

The lower San Pedro River flows north in the San Pedro trough, an elongated structural depression bounded on the southwest by the Catalina core complex and associated uplands lying farther north and bounded on the northeast by the faulted range fronts of the relatively undeformed Galiuro and Dripping Spring Mountains (Dickinson 1991). The San Pedro trough

contains basin-fill deposits (Quiburis Formation) that overlie a complexly corrugated paleotopography of internal tilt blocks forming the substratum of the trough floor (Dickinson 2003). Inset into the basin-fill deposits along the San Pedro River is the recent floodplain alluvium, comprised of unconsolidated, chiefly course-grained sediments that immediately underlie and adjoin, and are in direct hydraulic communication with, the stream.

The San Pedro River was formerly perennial or nearly perennial throughout much of its length (Brown et al 1981; Tellman et al. 1997). Current and formerly perennial reaches are shown in figure 1. In the lower San Pedro River, at least 50 miles of perennial flow has been lost (digital analysis of Brown et al. 1981), chiefly as a result of human activities that have changed the river in numerous ways. Lost perennial flow has eliminated riparian habitat in many areas; reduced perennial flow has degraded riparian habitat, resulting in an increase in the population of non-native species, such as tamarisk, at the expense of cottonwood-willow riparian forest.

Locations of perennial flow reaches in the San Pedro River are controlled chiefly by the underlying paleotopography. Where tilted fault blocks have produced low-permeability bedrock at shallow depths below the river, the overlying higher-permeability basin-fill deposits are thinned; these bedrock constrictions force groundwater in the alluvial aquifer to discharge to the river. The presence of fine-grained facies in the basin-fill deposits may also control locations of perennial flow. Fine-grained layers act as a confining unit, restricting the connection between the deeper regional aquifer (basin-fill deposits aquifer) and the shallow aquifer/river system. Vertical upward groundwater flow may occur through sand and gravel deposits at the edge of the fine-grained layers, allowing discharge from alluvial aquifers to the river and forming perennial reaches.

Mining and agriculture are the chief water uses in the lower San Pedro River basin; water use in 1990 totaled about 40,000 acre-feet. Groundwater pumping from the recent alluvium aquifer most directly diminishes streamflow. Pumping from the basin-fill deposits aquifer may indirectly diminish streamflow

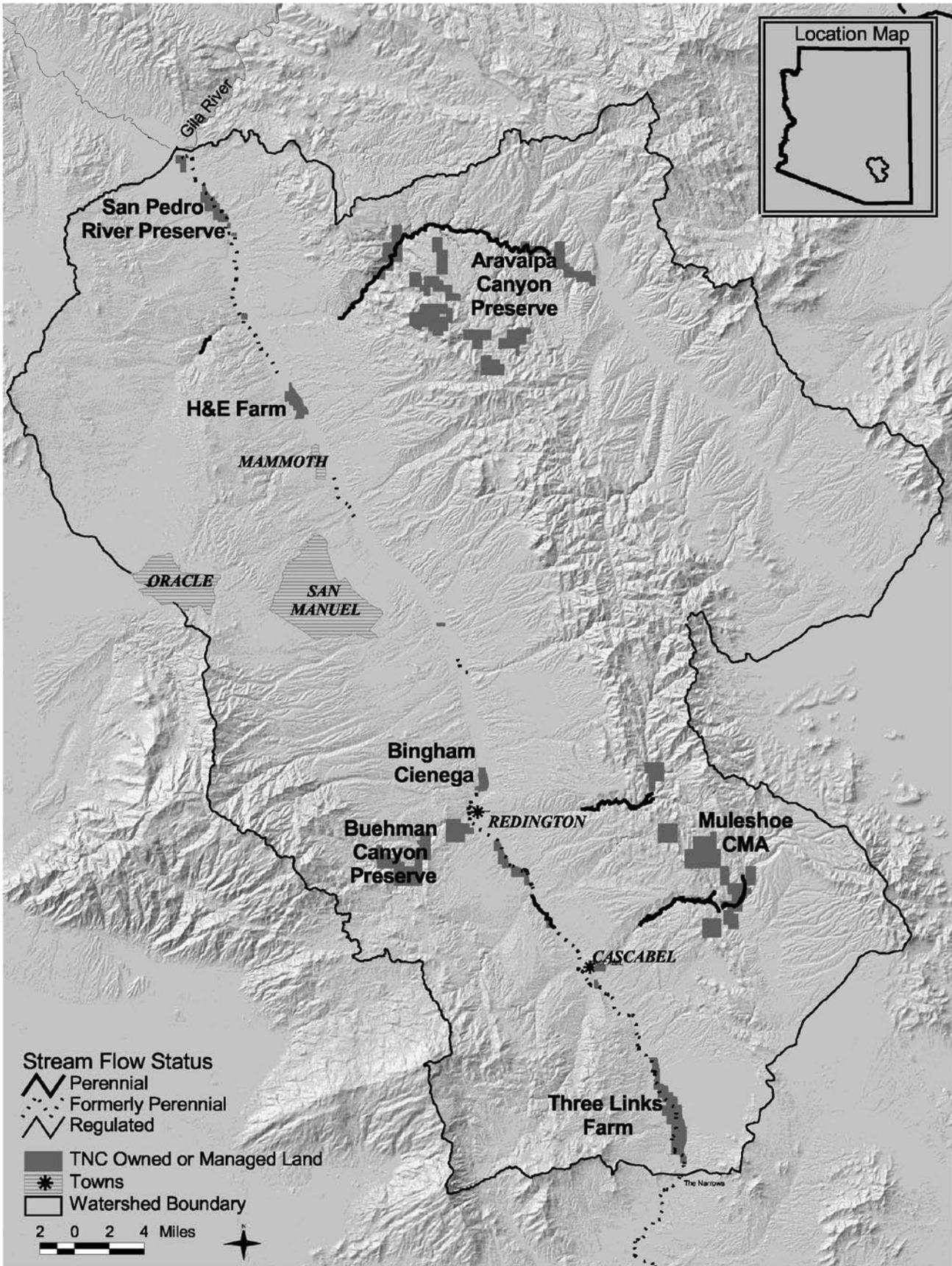


Figure 1—The Lower San Pedro River Basin.

through interception of groundwater that would have otherwise discharged to the recent alluvium and hence to the stream. Groundwater pumping leads to groundwater level decline and decreased perennial flow, which cause degradation of riparian and aquatic ecosystems. Recent research shows major reduction of streamside emergents as streams are converted from perennial to intermittent; even small increases in the degree of streamflow intermittency cause reductions in plant species richness and shift species composition from wetland species to more drought tolerant species such as bermuda grass (Julie Stromberg, Arizona State University, personal communication, April 14, 2004).

The Nature Conservancy's Flow Management Approach

The Nature Conservancy actively promotes biodiversity conservation throughout the San Pedro River basin by engaging agency and community partners in effective working relationships that foster conservation. As part of the overall conservation toolbox, the Conservancy may purchase land in key areas to meet conservation goals in that area. For the lower San Pedro River, a major conservation goal is increased water supply for riparian vegetation and a corresponding improvement in extent and quality of riparian habitat. To this end, the Conservancy has purchased three major farms totaling 3,545 acres along the lower San Pedro River; more than 8,000 acre-feet per year of agricultural groundwater pumping has been retired on these three farms.

The flow management approach can be described in four broad steps: (1) conduct hydrologic analyses, including groundwater-surface water modeling, to simulate impact to groundwater levels and surface water flow from various agricultural pumping retirement scenarios; (2) based on results from hydrologic analyses, purchase property and retire agricultural pumping at key locations; (3) following property acquisition, conduct monitoring to provide data for delineating baseline conditions and trends in ecosystem parameters; and (4) utilize data from monitoring to refine management actions and, ultimately, to gage success of the property acquisition-agricultural pumping retirement strategy.

Existing models are used, where available, for conduct of hydrologic analyses. Because an appropriate-scale groundwater model did not exist for the San Pedro River downstream from Redington, the Conservancy provided partial funding to support a University of Arizona graduate student to develop a model for this area. The model is nearly complete and will be used to analyze hydrologic response to various water management scenarios on the lower San Pedro River.

Hydrologic Monitoring and Results

The Nature Conservancy conducts hydrologic monitoring at a number of locations in the lower San Pedro River basin, including sites along the river as well as sites in several tributaries. Results from monitoring at the three largest properties

on the river—the San Pedro River Preserve, H&E Farm, and Three Links Farm—are summarized below.

San Pedro River Preserve

In 1996, the Conservancy obtained a grant from the U.S. Bureau of Reclamation to acquire the 820-acre San Pedro River Preserve on the San Pedro River near Duddleyville (figure 1). The property was formerly used for agriculture and aquaculture, with annual groundwater pumping of about 2,500 acre-feet per year (AFA), the majority of which was retired. The riparian corridor was fenced to exclude cattle and off-road vehicle (ORV) use. Hydrologic studies were conducted and a groundwater model was constructed to delineate impact to groundwater levels and river flows from various habitat restoration scenarios. Data indicated less impact to river flows from conversion of old ag fields to native grasses as compared to conversion to mesquite bosque. These data guided restoration design.

Preserve staff conduct monthly measurement of groundwater levels, surface water flow, and precipitation. Water levels from selected wells are shown in figure 2; data indicate that water in the stream and in the recent alluvium are in direct hydraulic communication, as witnessed by the rise in groundwater levels following the flood of October 2000. Groundwater levels fluctuate seasonally, reflecting climatic cycles and changes in riparian vegetation water use. Overall, groundwater levels have declined 1.5 to 2 feet since measurement began in August 1998 (figure 2), a period of severe drought. Despite drought-induced groundwater level and streamflow decline, riparian vegetation has thrived, based on field observations. Riparian-floodplain transects have been established and repeat surveys will provide data to document trends in riparian vegetation and channel geomorphologic condition.

H&E Farm

Groundwater level data, extent of surface flow, and geologic data available for the area from Mammoth to the Aravaipa Creek confluence were analyzed to predict results from various agricultural retirement scenarios. Results of analysis justified the purchase in 2001 of the 528-acre H&E Farm, with corresponding retirement of about 2,100 AFA of groundwater pumping. The riparian corridor was fenced to exclude cattle and ORV use. The expected benefit is extended perennial flow upstream from Aravaipa Crossing.

Preserve staff conduct monthly groundwater level measurements and measure precipitation; streamflow is currently ephemeral adjacent to H&E Farm and hence is not measured. Water levels from four shallow monitor wells installed in the floodplain are shown in figure 3, which also shows streamflow at the Redington gage. Data indicate that water level in the recent alluvium aquifer is responsive to river flows, with an immediate rise in water level following a flow event, followed by a decaying water level trend until the next flow event. Precipitation has been far below normal since property acquisition; few flow events have occurred and groundwater levels have overall declined. Riparian-floodplain transects

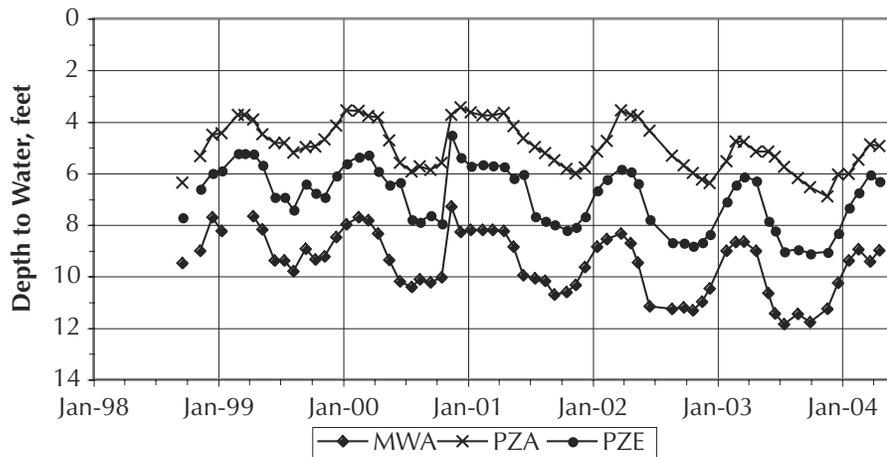


Figure 2—Depth to water in selected monitor wells at the San Pedro River Preserve.

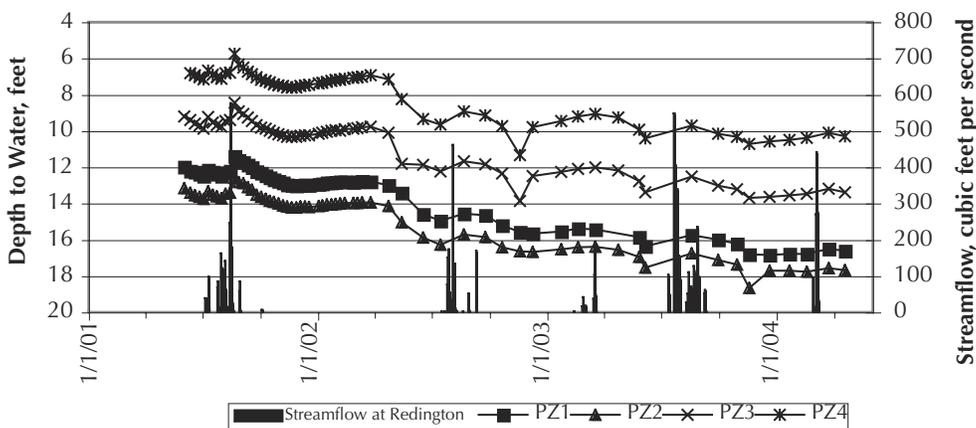


Figure 3—Depth to water in selected monitor wells at H&E Farm and streamflow at Redington.

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Three Links Farm

In 1998, The Nature Conservancy contracted a consulting hydrologist to resurrect an existing groundwater-surface water model (Jahnke 1994) for the purpose of analyzing hydrologic system response to specific agricultural retirement scenarios along the lower San Pedro River (Lombard 1998). The modeled domain extended from Fairbanks to Redington. Results of modeling justified the purchase, in 2003, of Three Links Farm, with corresponding retirement of nearly 3,500 AFA of groundwater pumping. The riparian corridor is being fenced to exclude cattle and ORV use. Based on model results, the expected benefit is increased extent of perennial flow in 14 miles of the San Pedro River, in the reach from Three Links to Cascabel.

Conservancy staff measure streamflow and depth to water in monitor wells quarterly; precipitation at the site is recorded. Results from groundwater and streamflow monitoring are shown in figure 4. Although the record is short, results indicate

that water levels vary on a seasonal basis and water levels overall have remained fairly steady. The stream gains flow as it moves from Station 1 (most upstream) to Station 3, then loses flow to Station 4 (most downstream).

Hydrologic analysis at Three Links Farm indicates substantially more hydrologic connectivity through “The Narrows” than formerly documented, which has implications to management of properties downstream from The Narrows in view of the expected increase in municipal water use upstream from The Narrows.

Summary and Conclusions

The lower San Pedro River has received much less research and public attention than the upper San Pedro River. However, the lower San Pedro is an equally important terrain. The lower San Pedro basin is an institutionally less complex region than the upper and may offer more traction for biodiversity conservation. Hydrologic connection exists between the upper San Pedro basin and the lower San Pedro basin, both in terms of flood flows and in terms of groundwater underflow through The Narrows.

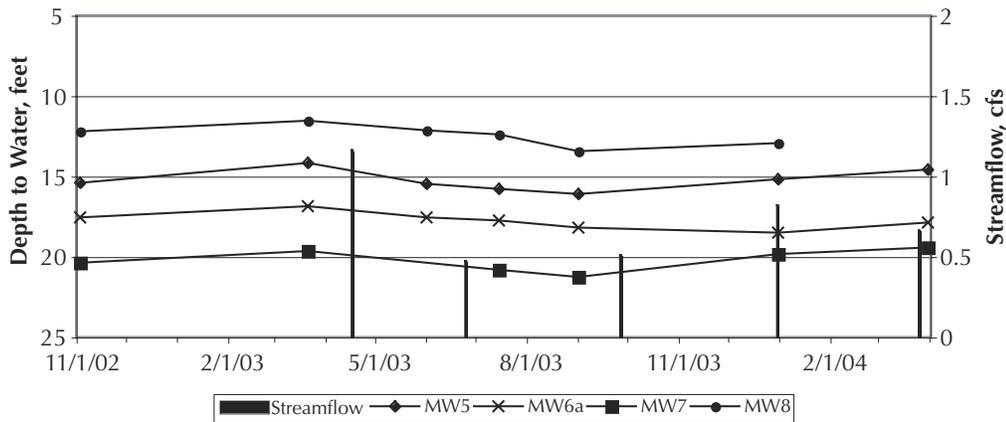


Figure 4—Depth to water in selected monitor wells and streamflow at Three Links Farm.

The Nature Conservancy employs a flow management approach to biodiversity conservation on the lower San Pedro River, with the goal of improving the water supply for riparian vegetation and returning flow to formerly perennial reaches of the river. Purchase of farms in the lower San Pedro River by the Conservancy has resulted in retirement of about 8,200 AFA of groundwater pumping. In addition, closure of the San Manuel mine has eliminated about 20,000 acre-feet of groundwater pumping. Therefore, more than half of the cultural groundwater use has been eliminated, with expected benefits for the river and riparian system.

Hydrologic monitoring and analysis of hydrologic data, both published and unpublished, contributes to: (1) selecting properties for acquisition; (2) restoration design and implementation; (3) delineating trends in ecosystem parameters; (4) documenting and reducing threats to conservation targets; (5) measuring success of a selected strategy; and (6) refining management actions accordingly.

Hydrologic components are key to restoration in riparian and wetland systems. Results from hydrologic monitoring at properties on the lower San Pedro River reflect the severe drought that has been occurring. Data from San Pedro River Preserve and Three Links Farm indicate that where hydrologic conditions support near-surface water, removal of stresses such as pumping for agricultural irrigation and cattle grazing in the riparian corridor provide system resilience for buffering against drought.

Groundwater systems respond slowly to human actions and response is often over-printed by natural climatic variation. Understanding the intricate interactions between surface water, groundwater, and riparian-aquatic systems is integral to appropriately managing these complex systems. Such understanding comes from a long-term commitment to hydrologic and ecological monitoring—collection of high quality data at consistent time intervals for an adequate length of time—prior to judging the success of a selected conservation or restoration strategy.

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