

MONITORING BANK STORAGE IN THE
SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA, ARIZONA

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1. INTRODUCTION

This paper describes the instrumentation, data collection and preliminary results for monitoring bank storage at the Lewis Springs site within the San Pedro Riparian National Conservation Area (SPRNCA), located in southeastern Arizona (see Figure 2 in Goodrich et al., 1.1, this issue). Bank storage is a critical variable for accurately modeling the water budget in semi-arid riparian systems, but is particularly difficult to assess and quantify. It is especially essential for understanding ground-water/surface-water interactions.

2. INSTRUMENTATION

In order to monitor and measure bank storage in the SPRNCA, an intensive network of vadose zone monitoring equipment was installed: ten water content reflectometry (WCR) probes, eight thermocouples, and three nests of four tensiometers each were installed on either side of the San Pedro River at Lewis Springs (see Figure 1). The WCR probes were installed in trenches which were subsequently backfilled. The location of these trenches, and the location of this instrumentation transect in general, may be identified as the trench sites in Figure 4 of Maddock et al. (this issue).

The tensiometers and WCR probes were installed at the water table interface and in the capillary fringe to monitor diurnal, seasonal and flood-event-induced fluctuations in soil moisture and soil matric potential within the cottonwood-willow forest gallery (i.e near-stream riparian biome). A submersible pressure transducer was installed in the river along this intensively instrumented transect to measure stream stage elevation data and provide stream stage fluctuations which correspond to the soil moisture and soil matric potential data.

The tensiometers were fitted with pressure transducers, and along with the WCR probes and thermocouples, were wired to a datalogger to collect measurements every 30 minutes. The thermocouples were installed to monitor soil

temperature adjacent to the WCR probes, as the WCR probes are temperature-sensitive. Additionally, six neutron probe access tubes (NPATs) were installed on either side of the San Pedro River at Lewis Springs, in two different transects to collect manual measurements of soil moisture to supplement the automated datalogger information. The locations of these NPATs are identified in Figure 4 of Maddock et al. (this issue).

Only select WCR probe soil moisture data and select tensiometer matric potential data are available for presentation at this time.

3. PRELIMINARY RESULTS

Preliminary data showing bank storage response to diurnal fluctuations and Arizona's 1997 monsoon flood-events are presented. Select WCR probe soil moisture data and tensiometer matric potential data show both immediate and delayed responses to increases in stream stage. The data for two high-flow events are shown: a 38 cm stream stage increase on Julian Day 219 (August 7, 1997), and a 90 cm stream stage increase on Julian Day 221 (August 9, 1997).

Figure 2 shows changes in soil moisture measured using WCR probes. These probes were selected from the west trench (see Figure 1). Diurnal fluctuations as well as an immediate response to an increase in stream stage are evident. Although the stream stage decreases sharply within 24 hours, the riverbank maintains a higher soil moisture for several days.

The strong diurnal fluctuations exhibited by the WCR probes may reflect the evapotranspiration cycles of the cottonwood and willow trees in the SPRNCA. However, the apparently diurnal pattern may also be an artifact of the probes' sensitivity to temperature. The data from the adjacent thermocouples have not yet been used to normalize the soil moisture data to 20° C. Additionally, the probes have not yet been calibrated for the soils in which they are installed; a standard polynomial provided by the

manufacturer was used in the interim to discern relative soil moisture differences.

Figure 3 shows fluctuations in soil matric potential measured using select tensiometer data from nests D, E and F located on the east bank of the San Pedro River (see Figure 1). Diurnal fluctuations are evident, but are considerably more subtle than those measured with the WCR probes. At least two factors may account for these differences. First, the pressure transducers associated with the tensiometers are calibrated to account for non-isothermal conditions using the method described by Lacher (1996). While both WCR probes and tensiometers' pressure transducers are installed below the ground surface to minimize temperature fluctuations, temperature may still affect the calibration of both instruments (Lacher, 1996 and Warrick et al., *submitted* 1997). Accordingly, temperature may still affect these instruments. However, the instruments' proximity to different plant roots may reflect variation in evapotranspiration of the vegetation in the cottonwood-willow forest gallery of the SPRNCA.

The response of the tensiometers to increases in stream stage appears slower than the WCR probes, but the two graphs cannot be compared directly because they represent data from opposing river banks. However, it can be noted from Figure 3 that the 6.0 feet-deep tensiometers (6.0 D and E) - regardless of their lateral proximity to the river - respond more quickly to the rises in river stage than the tensiometers at 6.5 feet depth (6.5 D and F). This may be a function of soil texture, which was recorded during the installation process, but has not yet been factored into the interpretation of the results. Note that tensiometer 6.0 D showed a response to the increased stream stage prior to 6.0 E, which is further from the river by approximately 1.5 meters. A similar response can be noted in tensiometers 6.5 D and 6.5 F, respectively.

4. SUMMARY

The response of soil moisture and soil matric potential to increases in stream stage indicate a prolonged increase in bank storage following a high flow event that increases the stream stage by as little as 90 cm. Additionally, the apparent diurnal response of soil moisture and matric potential provide information about the evapotranspiration patterns in the cottonwood-willow forest gallery. Additional soil moisture data, matric potential data and hydraulic head data, collected in coordination with high flow events, will

provide crucial information on the evapotranspiration cycles of the cottonwood and willow tree species within the SPRNCA. This data will be used to improve models which consider bank storage as an important variable in the hydrologic cycle.

5. ACKNOWLEDGMENTS

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6. REFERENCES

- Goodrich, D.C. et al. 1997. An overview of the 1997 activities of the Semi-Arid Land Surface-Atmosphere (SALSA) program (1.1, this issue).
- Lacher, L. J. 1996. Recharge characteristics of an effluent dominated stream near Tucson, Arizona. Ph.D. Dissertation, Dept. Of Hydrology and Water Resources, Univ. Of Arizona, 229 p.
- Maddock, T., R.D. Mac Nish, D.C. Goodrich, D.G. Williams, W.J. Shuttleworth, B.A. Goff, R.L. Scott, M.S. Moran, D.I. Cooper, L.E. Hips, A.G. Chebouni. 1997. The overview of atmospheric and surface water coupling to regional groundwater models in semi-arid basins. (1.10, this issue).
- Warrick, A., P.J. Wierenga, M.H. Young, and S.A. Musil. *Submitted* August 1997. Diurnal fluctuations of tensiometric readings due to surface temperature changes. *Water Resources Research*.

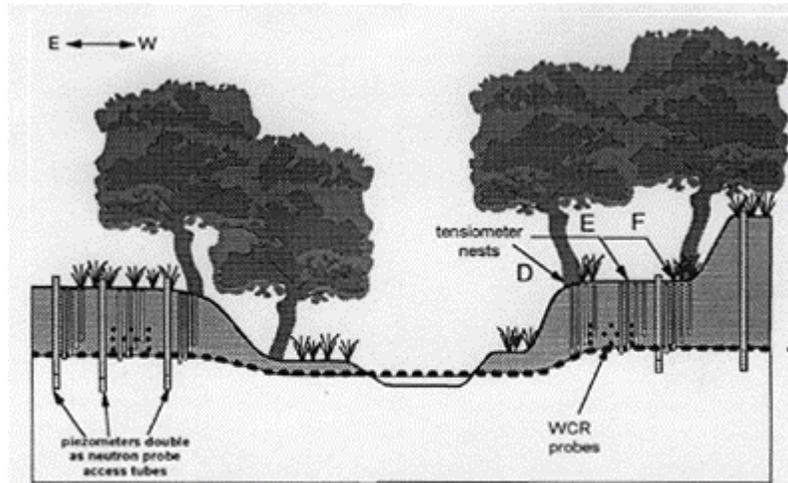


Figure 1. Schematic diagram of instrumentation for monitoring bank storage at the Lewis Springs reach of the San Pedro River, AZ

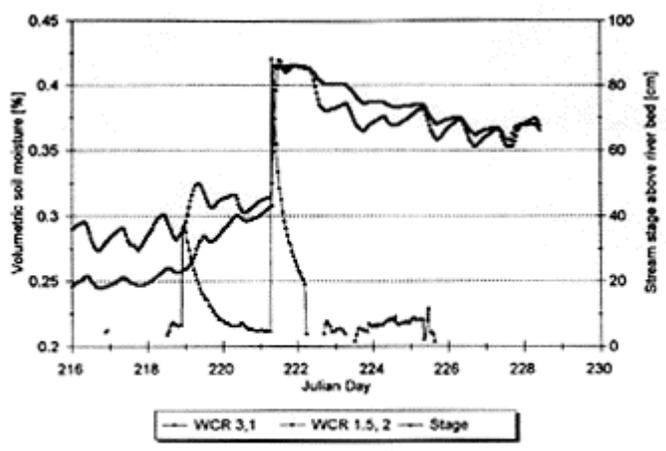


Figure 2. Response of WCR soil moisture probes to stream stage.

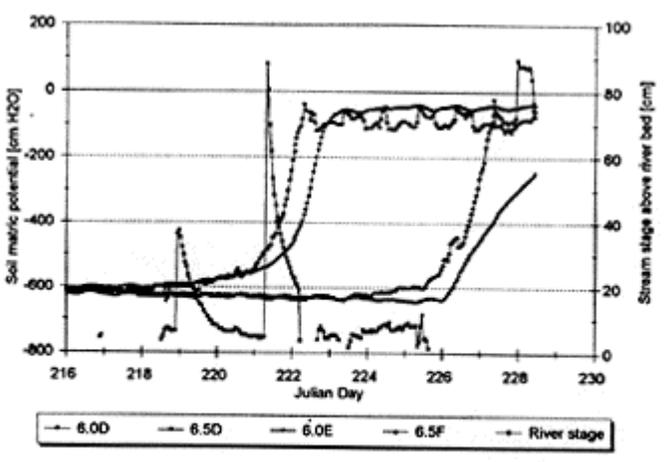


Figure 3. Response of soil matric potential to stream stage.