WATER RESOURCES BULLETIN
VOL. 30, NO. 3 AMERICAN WATER RESOURCES ASSOCIATION JUNE 1994

RECHARGE ESTIMATES USING A GEOMORPHIC/DISTRIBUTED-PARAMETER SIMULATION APPROACH, AMARGOSA RIVER BASIN[1]

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ABSTRACT: Average-annual volumes of runoff, evapotranspiration, channel loss, upland (interchannel) recharge, and total recharge were estimated for watersheds of 53 channel sites in the Amargosa River basin above Shoshone, California. Estimates were based on a water-balance approach combining field techniques for determining streamflow with distributed-parameter simulation models to calculate transmission losses of ephemeral streamflow and upland recharge resulting from high-magnitude, low-frequency precipitation events. Application of the water-balance models to the Amargosa River basin, Nevada and California, including part of the Nevada Test Site, suggests that about 20.5 million cubic meters of water recharges the ground-water reservoir above Shoshone annually. About 1.6 percent of precipitation becomes recharge basinwide. About 90 percent of the recharge is by transmission loss in channels, and the remainder occurs when infrequent storms yield sufficient precipitation that soil water percolates beyond the rooting zone and reaches the zone of saturation from interchannel areas. Highest rates of recharge are in headwaters of the Amargosa River and Fortymile Wash; the least recharge occurs in areas of relatively low precipitation in the lowermost Amargosa River watershed. (KEY TERMS: distributed-parameter simulation; recharge; transmission loss; water balance.)

INTRODUCTION

The Amargosa River drains a mostly arid to semiarid area of about 20,000 km^2 (square kilometers) in southern Nevada and southeastern California (Figure 1). The upper Amargosa River basin (Figure 2) includes Yucca Mountain and parts of the Nevada Test Site (NTS), from where runoff flows generally south before curling west and then north to terminate in Death Valley from its southern end (Figure 1).

As part of site characterization for possible storage of high-level radioactive wastes at Yucca Mountain, the U. S. Geological Survey, in cooperation with the U. S. Department of Energy, is conducting studies of the hydrology of a region that includes a large part of the NTS. Emphasized in these studies is the hydrology of the Yucca Mountain area and downstream parts of the Amargosa River drainage basin. A principal result of the effort will be the refinement of a finite-element model simulating the present ground-water flow system that includes the Amargosa River basin (Czarnecki and Waddell, 1984; Czarnecki, 1985). The model has been used to simulate possibly larger former ground-water fluxes in the basin that resulted from wetter climatic conditions, thereby permitting the prediction of changes in streamflow, ground-water levels, and ground-water flow if long-term climate change occurs. Reliable predictive capability is essential to anticipate the effects that changing climate might have on a potential nuclear-waste repository and on the subsurface transport of contaminants if release to the ground-water system were to occur.

The study described here is in support of the basin-scale-modeling effort, and has the objective of providing estimates of mean rates of ground-water recharge in the Amargosa River basin above Shoshone, California (Figures 1, 2). Recharge, like evapotranspiration, is generally an unmeasured or poorly measured component of the hydrologic budget in arid and semiarid areas. Rates of recharge in the Amargosa River basin are small relative to evapotranspiration (for example, see Tyler, 1987). Thus, estimates of recharge as a residual in hydrologic-budget studies can have substantial error if estimates of evapotranspiration or other major components of the water balance

[1]Paper No. 94026 of the *Water Resources Bulletin*. **Discussions are open until February 1, 1995.**

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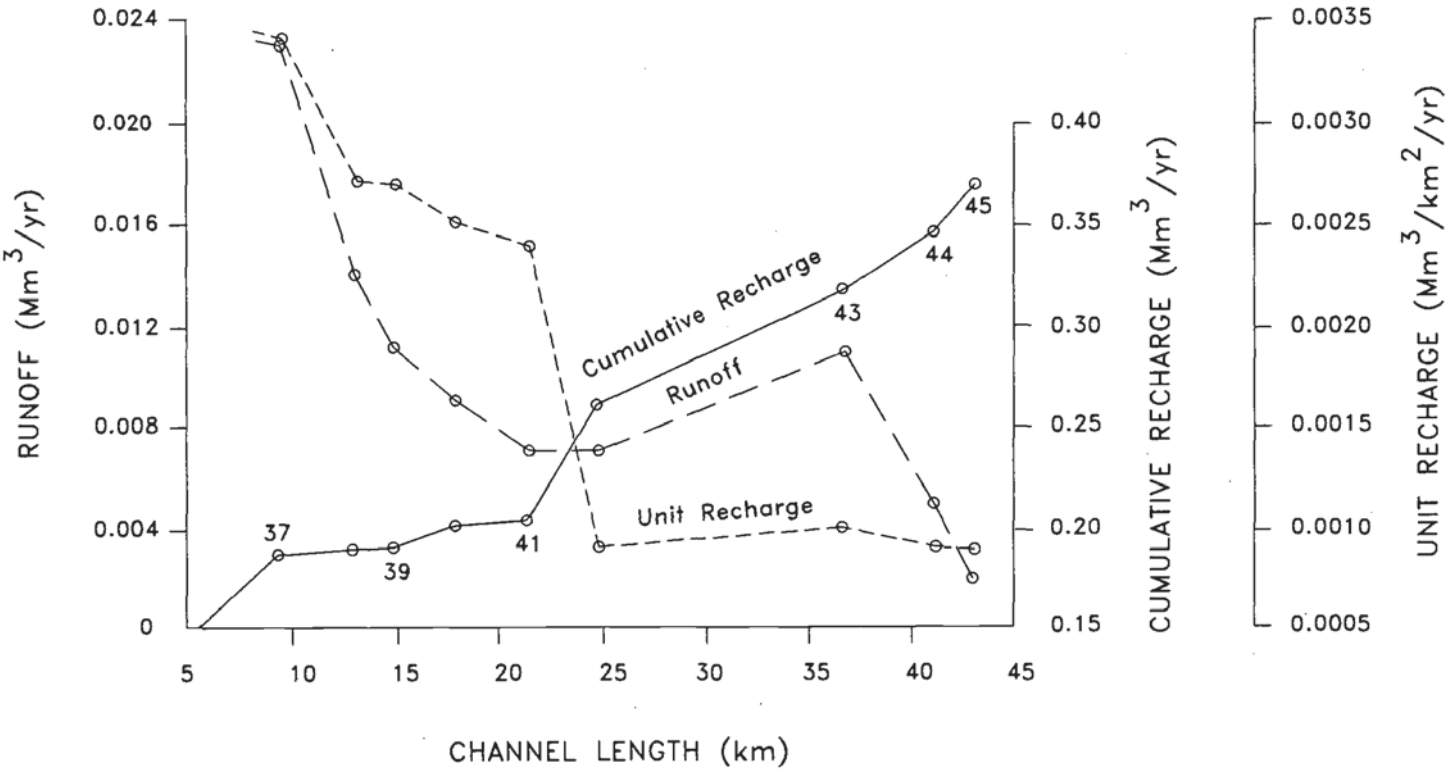

Figure 5. Graph Showing Changes in Estimated Average Annual Runoff, Cumulative Recharge, and Unit Recharge with Channel Length of Topopah Wash, Nevada (numbers correspond to selected site numbers of Tables 1 and 2).

SUMMARY OF RESULTS

Water-balance calculations, based on field observations, a distributed-parameter runoff-simulation model, and a modification of a field-scale model for interchannel runoff and recharge, suggest that average-annual ground-water recharge in the Amargosa River basin upstream from Shoshone, California, is about 20.5 Mm^3. If average-annual precipitation on the basin is about 180 mm, about 1.6 percent of precipitation recharges the ground-water reservoir. Nearly 90 percent of the estimated recharge occurs by transmission loss of channelized streamflow; the remainder is the result of water percolating through the plant-rooting zone of upland and interchannel areas during and after low-frequency precipitation events.

Figure 6 is a bar graph representing recharge in the Amargosa River basin for subbasins and major tributary basins. Recharge in secondary tributary basins, for Beatty, Yucca, and Drillhole Washes, is indicated by subbasin insets. As shown by Table 2 and suggested by Figure 6, recharge rates in the NTS/Amargosa River area are highest in the uppermost parts of the watershed where precipitation and the potential for runoff to channels are greatest. Estimates of unit recharge are lowest in low-relief parts of the lower NTS/Amargosa River area where precipitation is lowest and computed rates of ET are high. Above Beatty, Nevada, for example, about 3 percent of precipitation is computed as recharge, whereas less than 0.5 percent of precipitation that falls in the Amargosa River watershed below Amargosa Farms (site 45) recharges the ground-water reservoir.

Calculated recharge for the NTS/Amargosa River area (Table 2) includes estimates specific to the major tributaries of Fortymile Wash and Topopah Wash. As modeled, the watersheds of these two channels account for 11 percent and 4 percent, respectively, of the NTS/Amargosa River drainage area. Estimated recharge in the Fortymile Wash basin is about 20 percent of the recharge for the entire area, reflecting relatively high runoff rates in the headwater areas of Pahute Mesa. The Topopah Wash watershed, which heads in Shoshone Mountain, accounts for 1.7 percent of the estimated recharge in the NTS/Amargosa River area. Contributions to recharge in the NTS/Amargosa River area from other tributary basins, as indicated by estimates for sites 46, 47, and 48 (table 2), are relatively minor.