Hydrogeologic Processes in a Transitional Tropical Forest

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Introduction

In the volcanic regions of central Costa Rica, runoff and groundwater discharge provide water to large streams and reservoirs that are used for agriculture and human consumption. Little is known about the movement of groundwater through the subsurface and what kind of interactions take place between the water and earth. In this study, we focus on the response of aquifers with precipitation and how water quality changes throughout the watershed.

Site Description

- Texas A&M Soltis Center, San Isidro de Peñas Blancas, Alajuela, Costa Rica
- Eastern side of Cordillera Tilarán
- 460 meters above sea level

Figure 1: Google Earth image of site

- Estimated 2.2 to 2.6 hectares in secondary transitional tropical forest
- Subsurface soil composed of clay with saprolitic tuff at depth, basaltic bedrock
- Groundwater seeps common throughout watershed, most notably at soil/bedrock interfaces

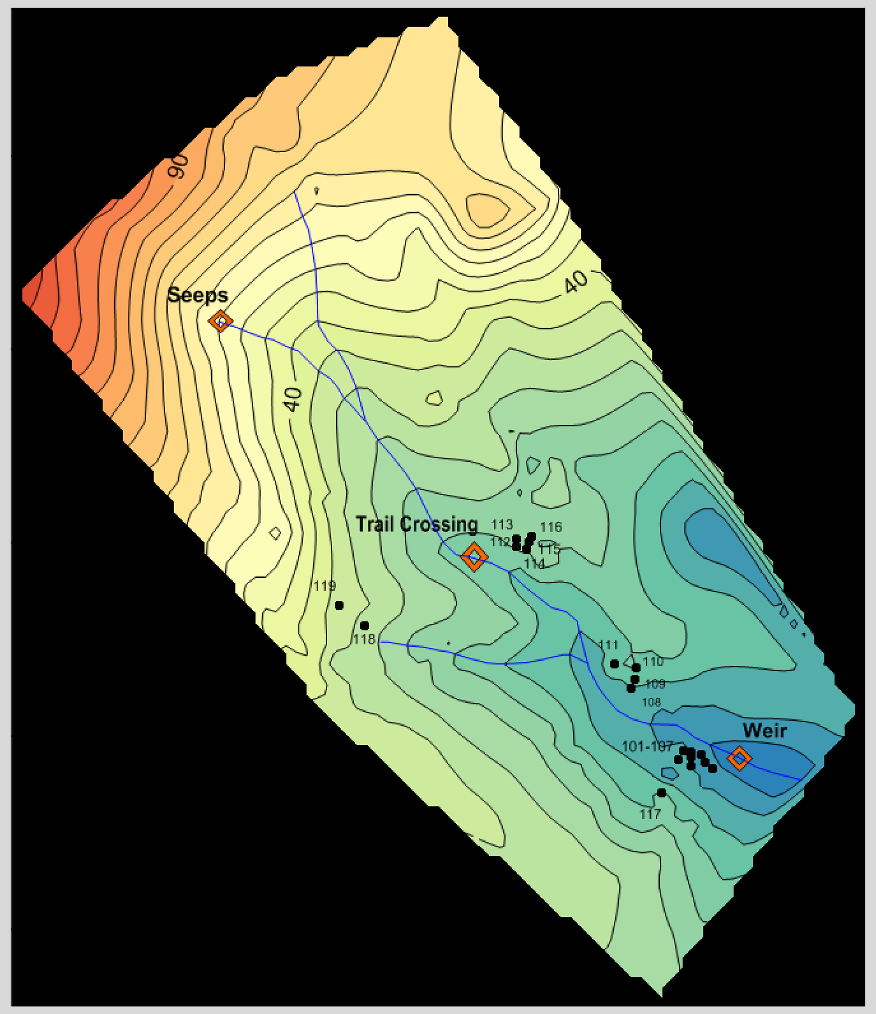


Figure 2: Map of watershed with piezometers and water testing locations

Methods

Water Table

- 15 piezometers installed at four different locations
- Augured boreholes into Subsurface, inserted Piezometers, and backfilled with sand, clay and concrete
- Water levels recorded daily and analyzed in Surfer 11.5

Figure 3: Drilling borehole for piezometer

Hydraulic Conductivity (*K*)

- Falling-head slug tests at three different wells (#104,#110,#116)
- Change in head recorded manually, plotted semi-log
- Analyzed using Hvorslev Method

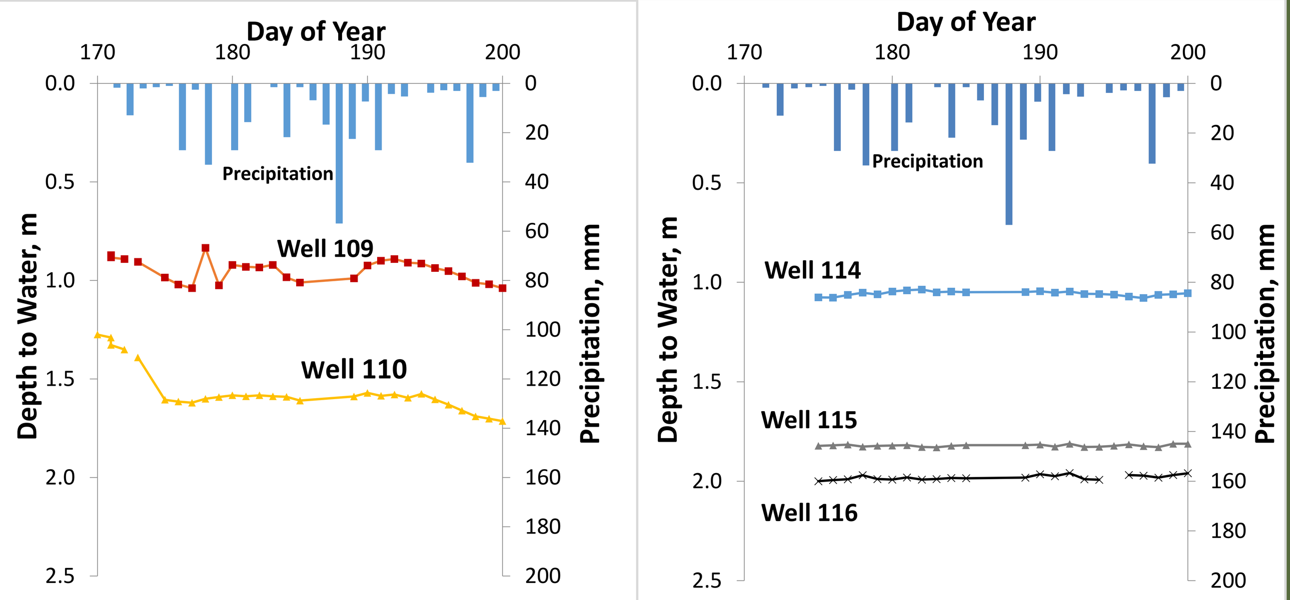
$$K = \frac{r^2 \ln(\frac{L_e}{R})}{2 L_e t_{37}}$$

Water Chemistry

- Electrical conductivity and temperature measured with YSI-85
- Five locations along streams, three within watershed (Figure 2)

Figure 4: Testing for temperature and conductivity

Results and Discussion



Figures 5 and 6: Depth to Groundwater for Upstream Series (left) and Trail Series (right)

- Upstream Series shows fluctuations in water level by upwards of 40 centimeters over experiment time while Trail Series changes by only several centimeters
- Trail piezometer boreholes were drilled until basalt was exposed, which may indicate that bedrock aquitard keeps water table regulated
- Upstream piezometers are located among many large trees. Root growth may play a factor in forming preferential flowpaths for groundwater, causing more dramatic water level changes

Results and Discussion Continued

Well	t_{37} (seconds)	Hydraulic Conductivity (m/s)
110	960	9.6E-07
104	690	1.3E-06
116	500	1.8E-06

Figure : Table of hydraulic conductivities calculated from slug tests

- Average K= 1.3 x 10^{-6} m/s
- All wells screened into orange clay, with some partially completed in erratic saprolitic tuff
- Literature values of *K* are typically lower, but fractures, saprolitic erratics, and bioturbation may create macropores, increasing conductivity.

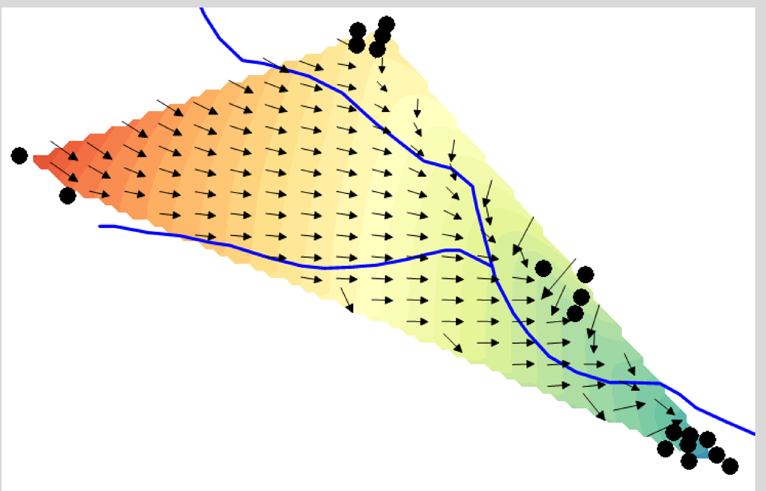


Figure 8: Computer generated flow vectors and gradient lines, Day 182

Gradient of water table at Upstream transect (108,109,110)= 0.56 m/m

$$v = \frac{Ki}{n}$$

- Groundwater velocity at Upstream transect calculated to be 1.4 x 10^{-6} m/s
- Water level contours point upstream, indicates gaining stream
- As groundwater levels change, flow direction and magnitude do not visibly vary

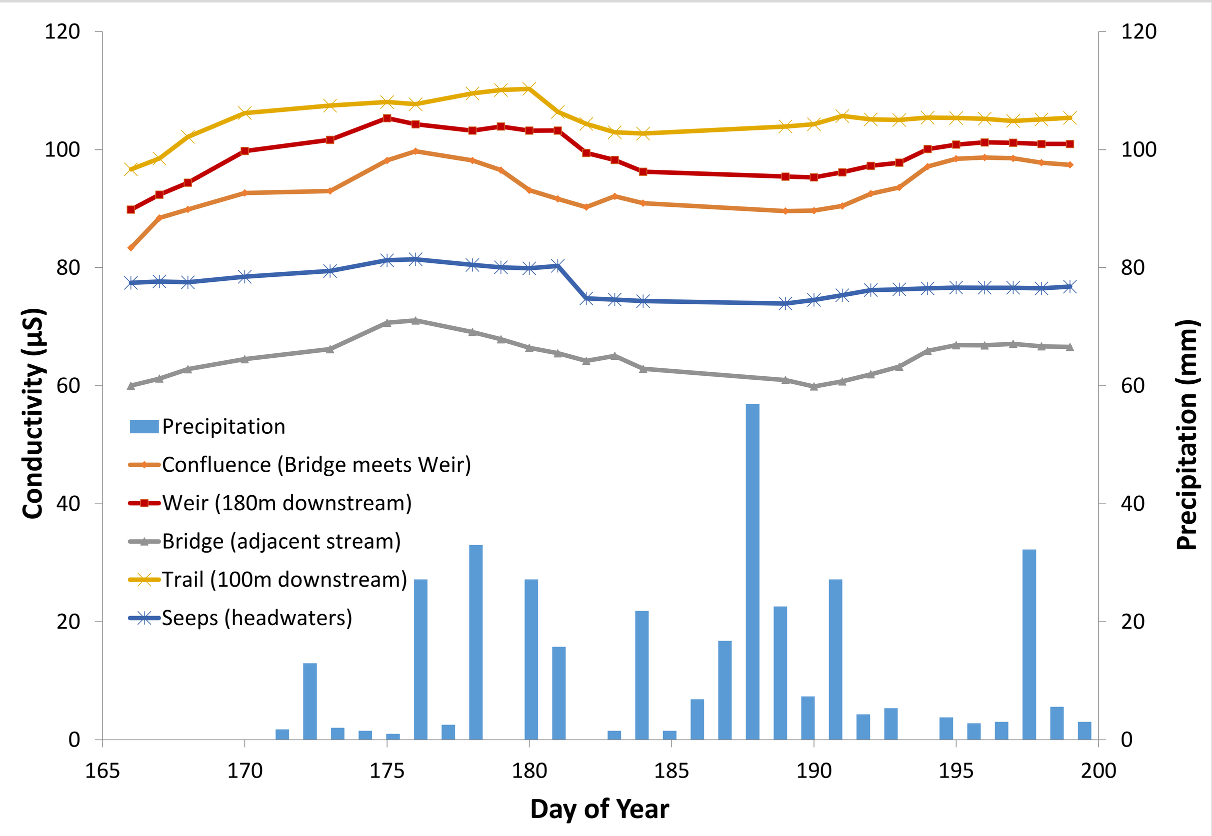


Figure 9: Three-Day Moving Average of Electrical Conductivity

- Electrical conductivity varied by 30-40 µS between seeps and trail (100 m)
- Conductivity of precipitation 2-10 µS
- High EC at trail location could be due to high presence of groundwater seeps or frequent stirring of sediment due to human activity

Results and Discussion Continued

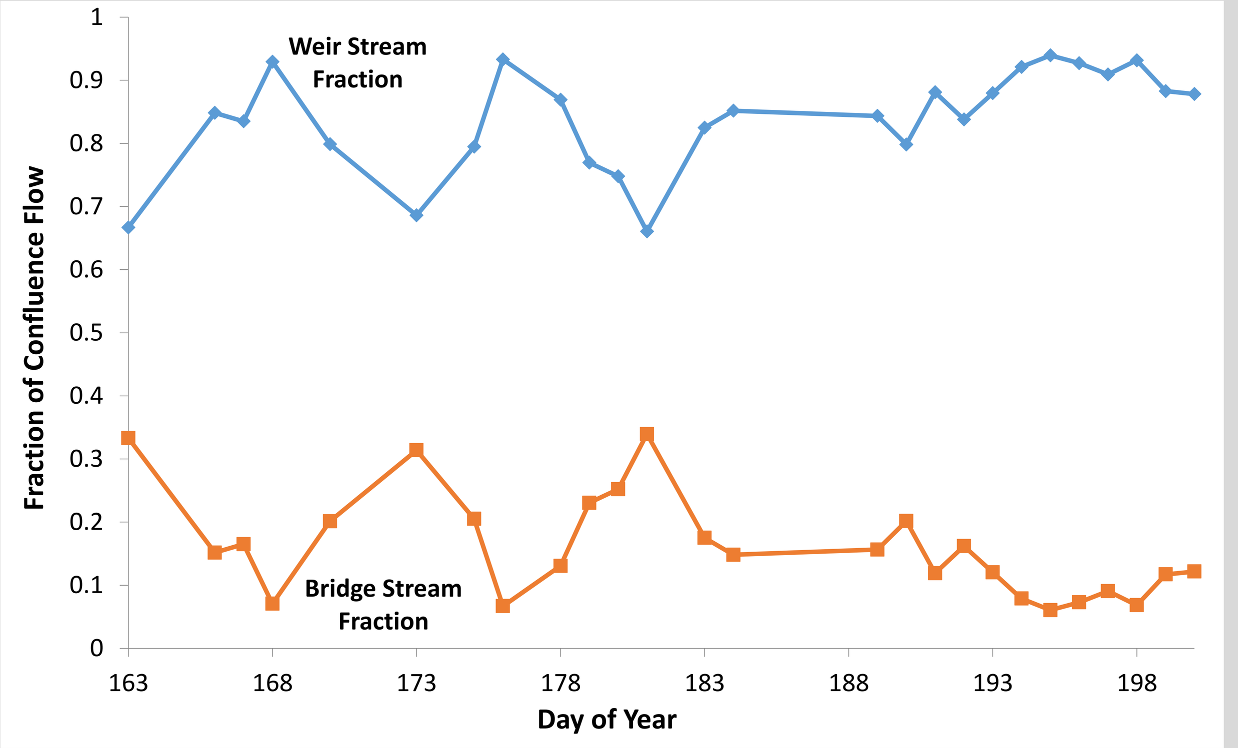


Figure 10: Fraction of flow at Stream Confluence based on electrical conductivity

- Confluence testing point located where Weir stream and adjacent Bridge stream connect
- Flow contributions at confluence are calculated using conductivity data from both streams and the confluence itself
- Flow fractions have no correlation with precipitation events, signifying that base flow is the main contribution to stream water
- Confluence testing point is subject to sediment mixing from humans

Future Research Goals

- More piezometers will be installed throughout the watershed to evenly characterize groundwater contours
- Stream samples from testing locations and groundwater samples from piezometers will be run through an ICP Mass Spectrometer and tested for heavy metals (lead, mercury, arsenic) that may have adverse effects on overall water quality for humans
- Fluorescent tracer fluids will be injected into ground and tracked for movement at groundwater seeps, notably those at bedrock interfaces

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