Hydrogeological Functioning of a Floodplain

CRC 1253 CAMPOS Catchments as Reactors

Simon Martin[1], S. Klingler[1], C. Leven[1], P. Dietrich[1,2], O. A. Cirpka[1]

[1] Universität Tübingen, [2] Helmholtz Center for Environmental Research – UFZ, Leipzig

Contact: Simon Martin
simon.martin@uni-tuebingen.de

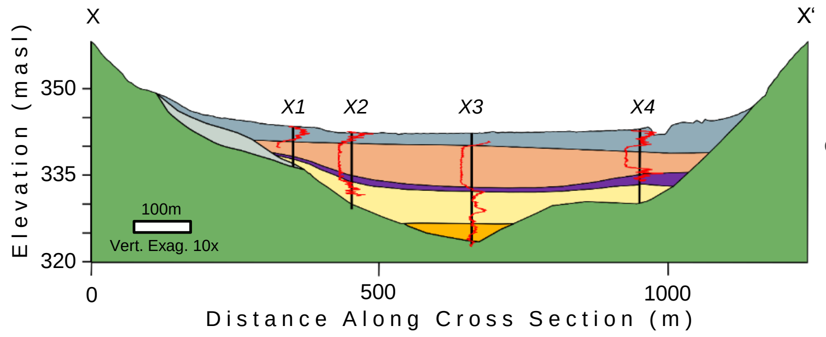
Motivation

Subsurface heterogeneity is ubiquitous in sedimentary floodplains, however when presented as environmental filters, floodplains are often conceptually simplified.

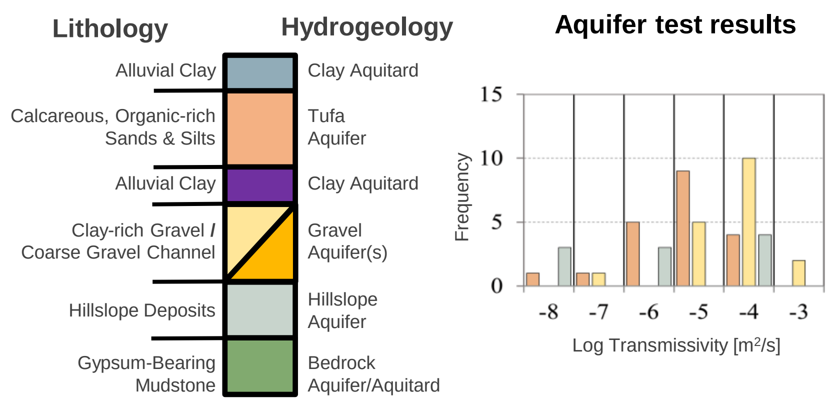
Hypothesis: Internal subsurface structure controls the hydrogeologic function of floodplains

Hydrogeologic Setting

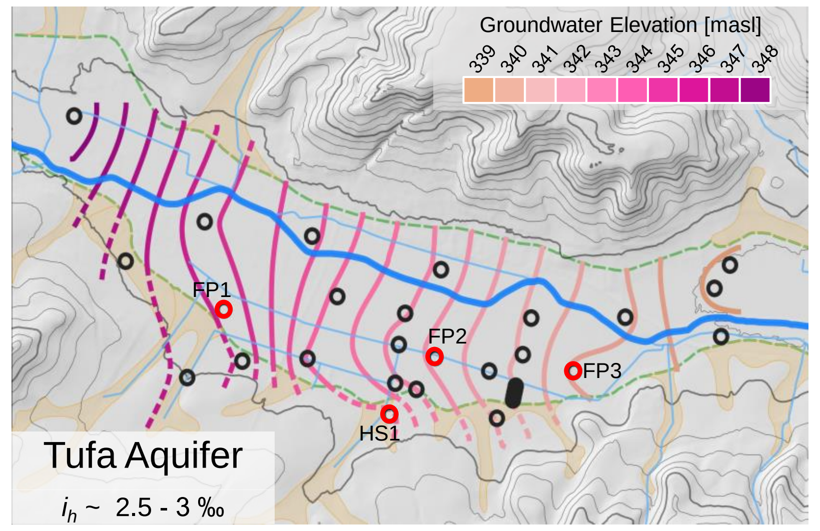
Geologic Modelling and Hydrostratigraphy

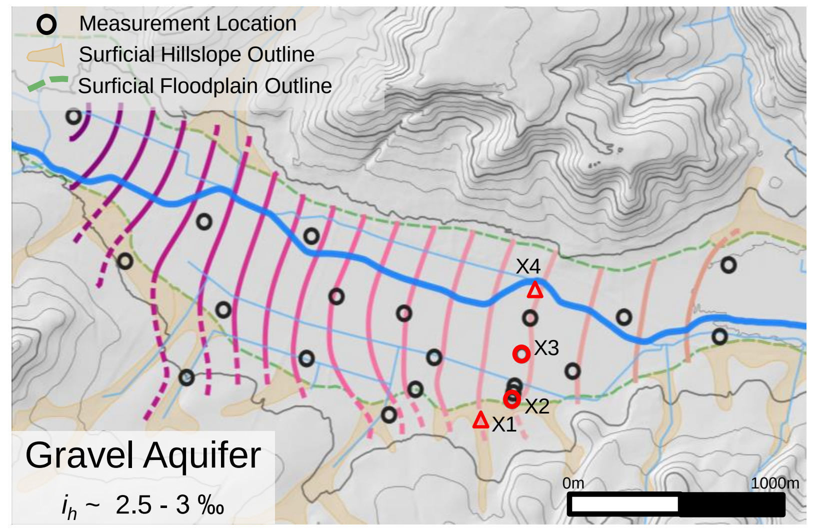


Cross-valley cross-section from geologic model.
Measurement locations found on groundwater flow map



Groundwater Flow





General along valley flow with cross-valley groundwater flow near hillslopes and drainage channels

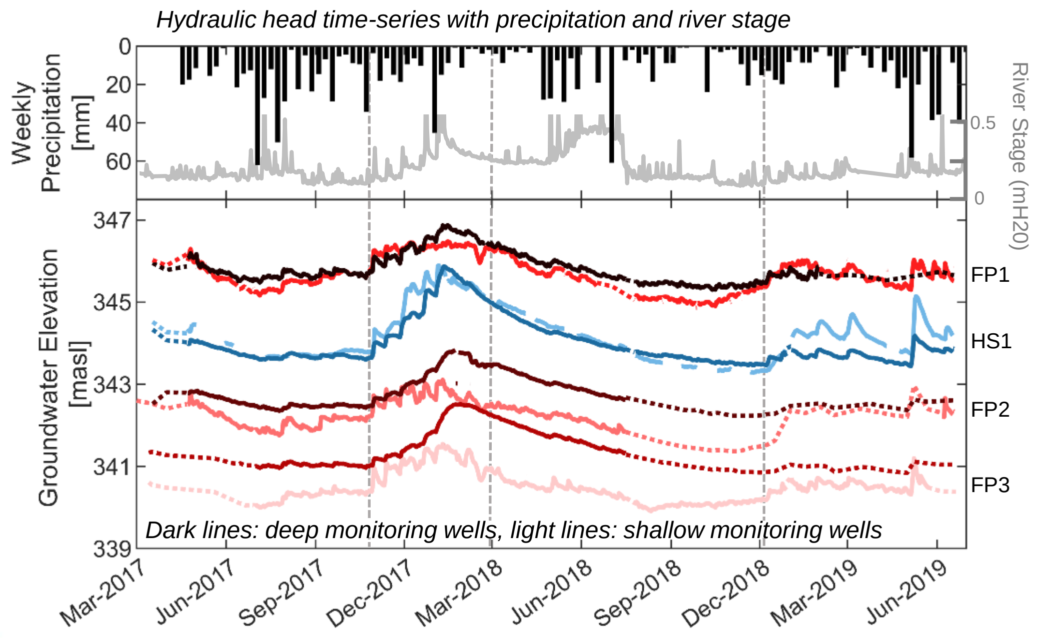
General along valley flow with minimal cross-valley groundwater flow

Groundwater Fluctuations

Tufa and Hillslope aquifers: highly responsive to rainfall events

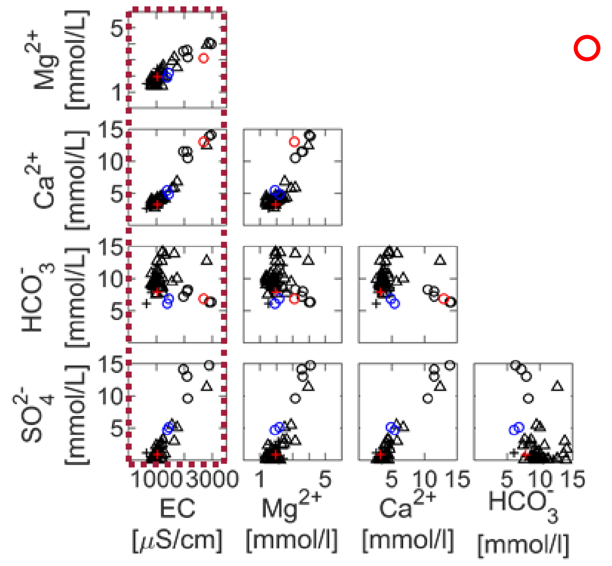
Gravel aquifer: responsive to rainfall during wet season (winter months)

Artesian conditions in winter 2017 / 2018 and extreme dry conditions in late summer / fall 2018



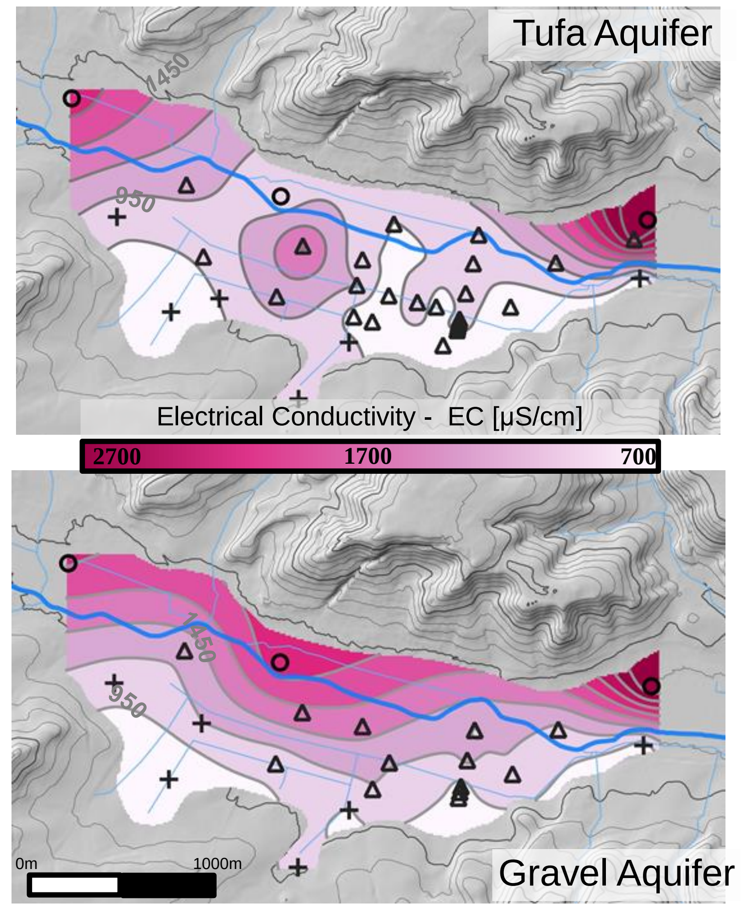
Hydrogeochemistry

Regional Hydrochemistry

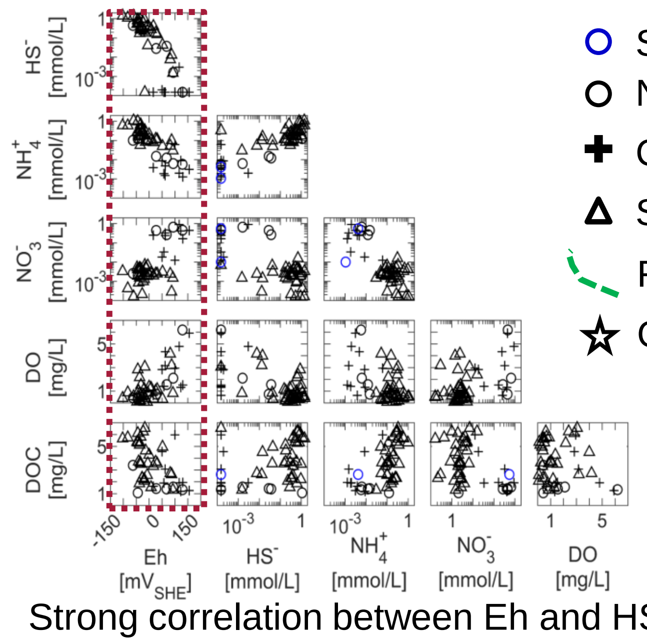


Strong correlations between EC, Ca^{2+}, Mg^{2+} and SO_4^{2-}
→ indicative of gypsum dissolution

Strong cross-valley EC gradients in both aquifer systems
→ highest EC near the northern tributary valleys
→ north spring clusters with northern floodplain groundwater

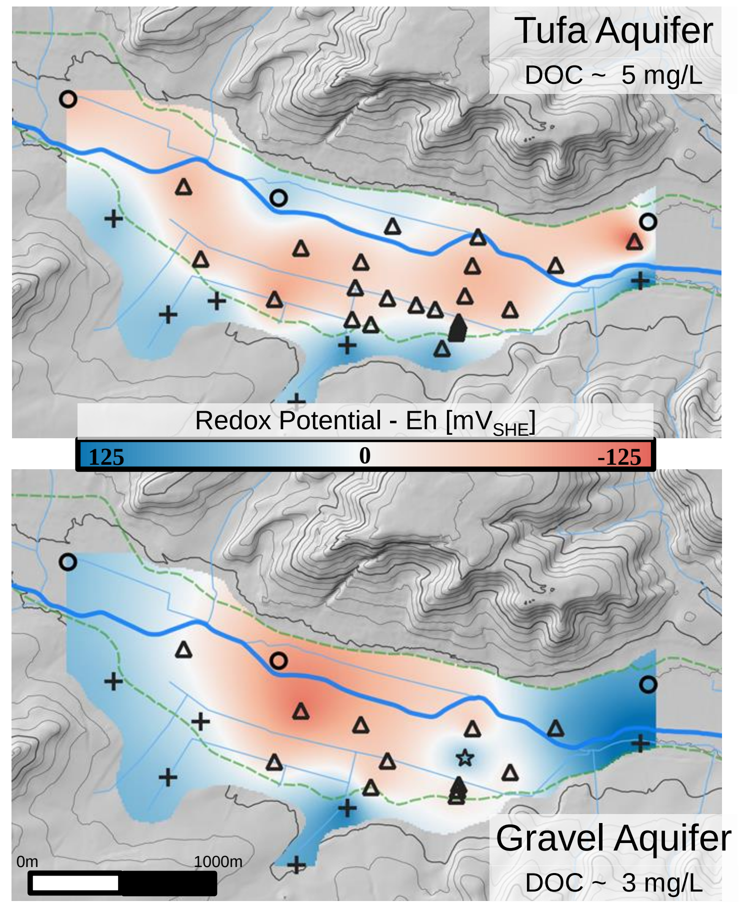


Regional Redox Patterns

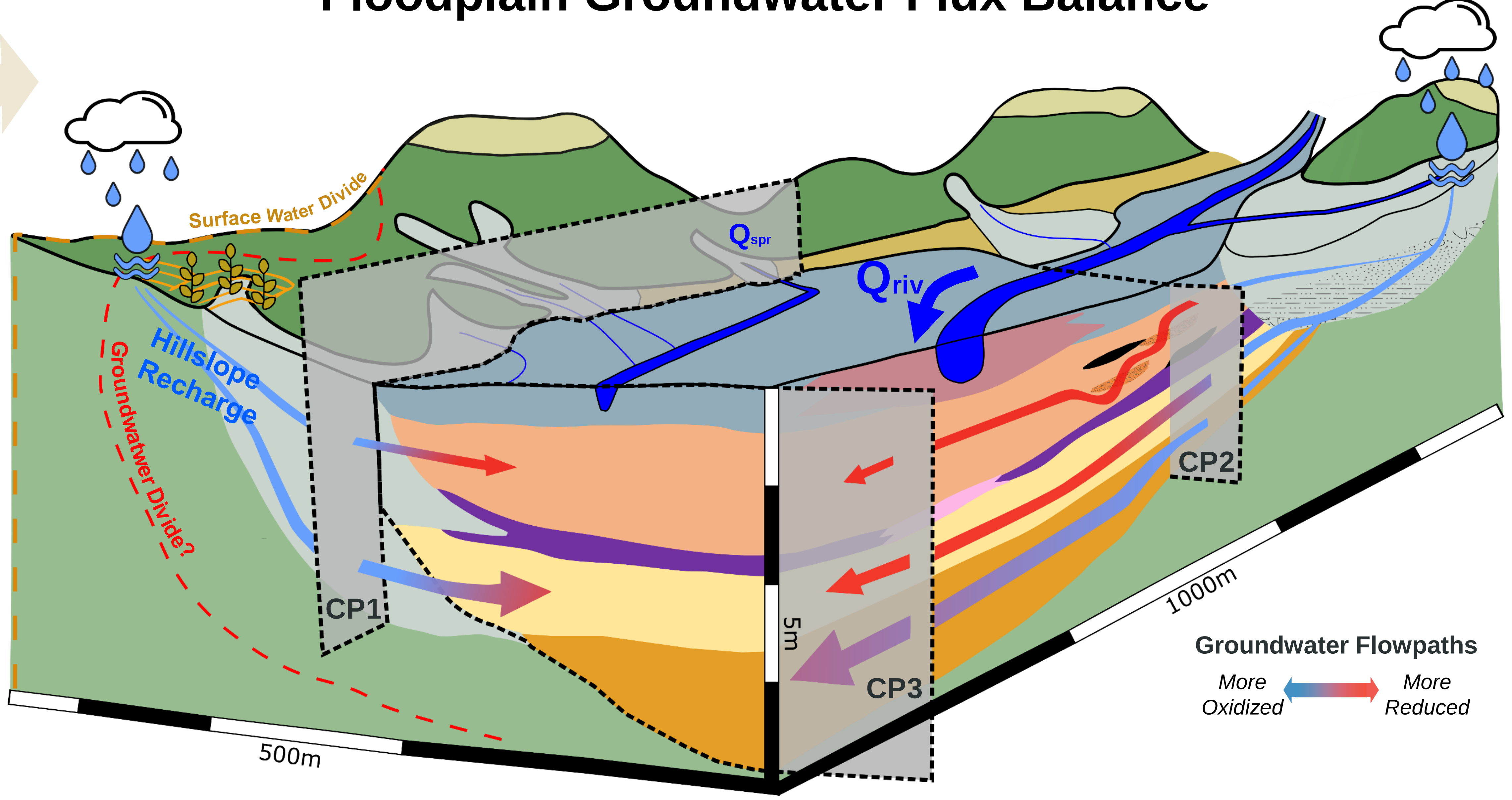


Strong correlation between Eh and HS^-
→ indicative of SO_4^{2-} reduction

Cross-valley Eh gradient in both aquifers and along-valley gradient in *Gravel aquifer*
→ groundwater flow bypass in clean gravel channel



Floodplain Groundwater Flux Balance



Combining interpolated hydraulic head data and floodplain thickness (geologic model), total water and solute fluxes are evaluated across control planes (CP)

CP1: cross-valley flux through hillslope sediment into floodplain
CP2: 2eam along-valley flux through floodplain aquifers
CP3: downstream along-valley flux through floodplain aquifers

Aquifer	Aquifer Transmissivity [m²/s]	Control Plane	Long-Term Average Water Flux [L/s]	Peak Water Flux [L/s]	Sulfur Load [kg/yr]	Nitrogen Load [kg/yr]
***Scenario 1**: geometric means of aquifer transmissivities*						
Hillslope	7.6×10^{-5}	CP1	0.12	0.20	24.2	3.42
Tufa	1.7×10^{-5}	CP2	0.02	0.025	65.3	1.29
		CP3	0.04	0.05	26.7	3.13
Gravel	1.3×10^{-4}	CP2	0.06	0.065	190	1.92
		CP3	0.16	0.165	111	10.8
***Scenario 2**: high transmissivity features included*						
Hillslope /Hillslope Hollows	$7.6\times10^{-5}/1.5\times10^{-4}$	CP1	0.59	0.96	68	9.64
Tufa	6.7×10^{-5}	CP2	0.07	0.10	199	3.93
		CP3	0.14	0.21	81.3	9.51
Gravel / Gravel Channel	$1.0\times10^{-4}/1.2\times10^{-3}$	CP2	0.42	0.45	2607	12.1
		CP3	0.80	0.86	902	10.9
Hydrological Fluxes		Q_{spr}	1	3		
		HS Recharge	3.5	16		
		Q_{riv}	1×10^3	1×10^4		

Hydraulics:

- ➢ In both scenarios, on-average, floodplain groundwater system can accommodate hillslope groundwater
- ➢ Dynamics of peak hillslope groundwater fluxes necessitate another release valve → hillslope spring (Q_{spr})

Fate of solutes:

- ➢ Clean gravel channel acts as a flow bypass from the more reduced floodplain setting
- ➢ Require an improved description of nitrogen & sulfur cycling to explain NO_3^- / NH_4^+ & SO_4^{2-} / HS^- patterns

River water quality:

- ➢ Groundwater and spring fluxes <<<< river base flow

EBERHARD KARLS UNIVERSITÄT TÜBINGEN — UFZ HELMHOLTZ Centre for Environmental Research — DFG

This work was supported by the Collaborative Research Center 1253 CAMPOS (Project 3: Flood-plain Hydrology), funded by the German Research Foundation (DFG, GA SFB 1253/1 2017).