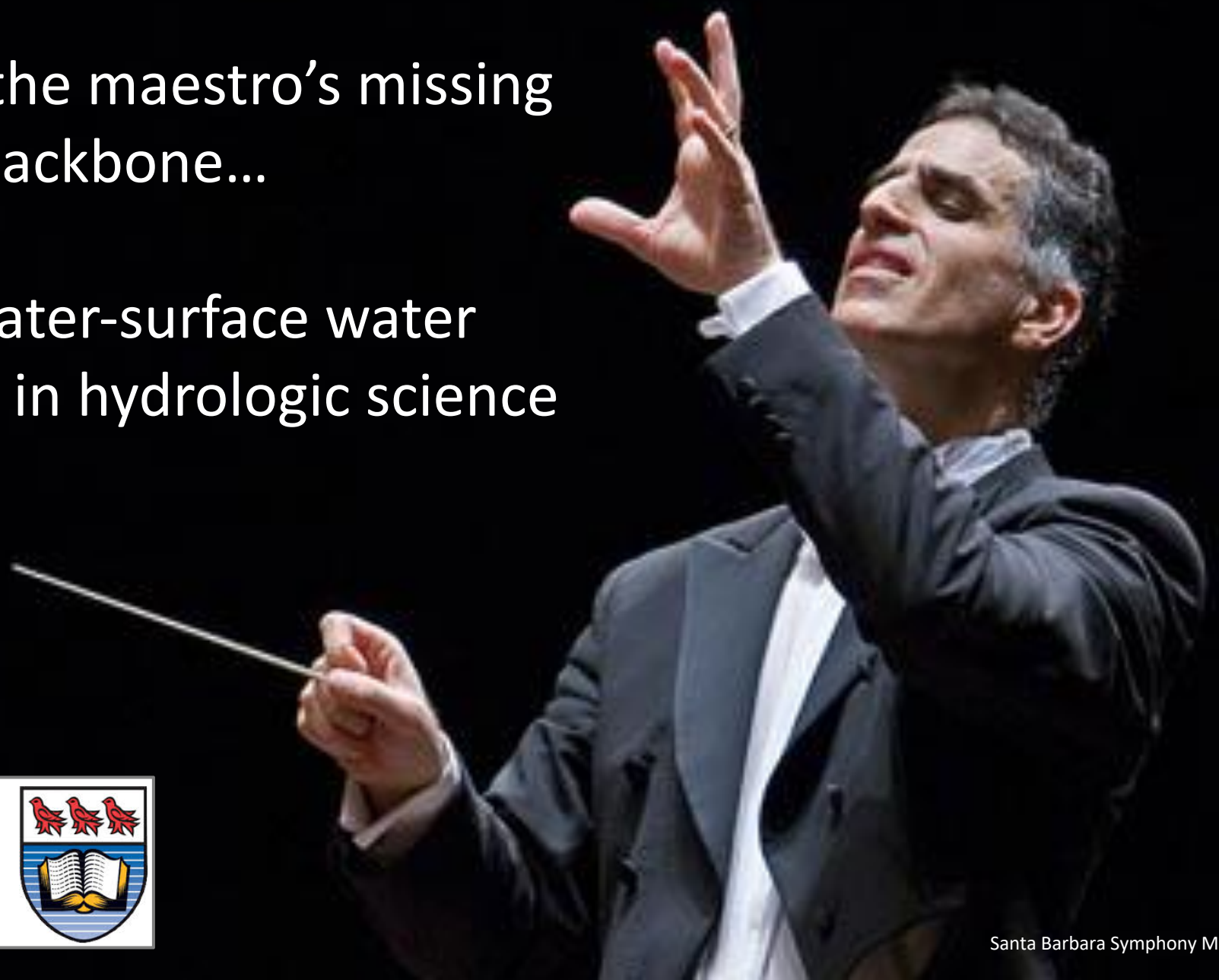
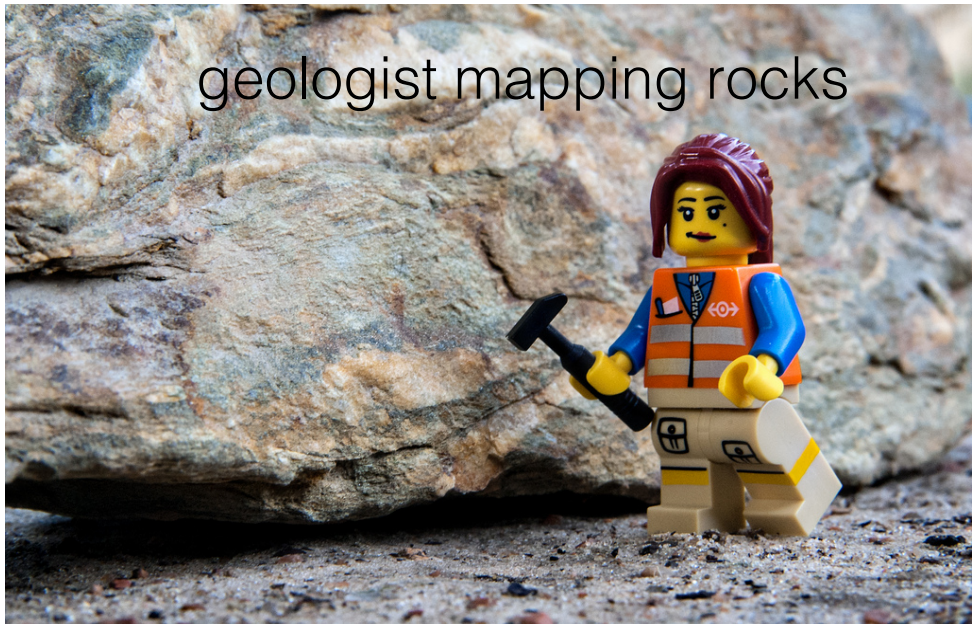
the case of the maestro's missing backbone…

groundwater-surface water connectivity in hydrologic science

Tom Gleeson
University of Victoria

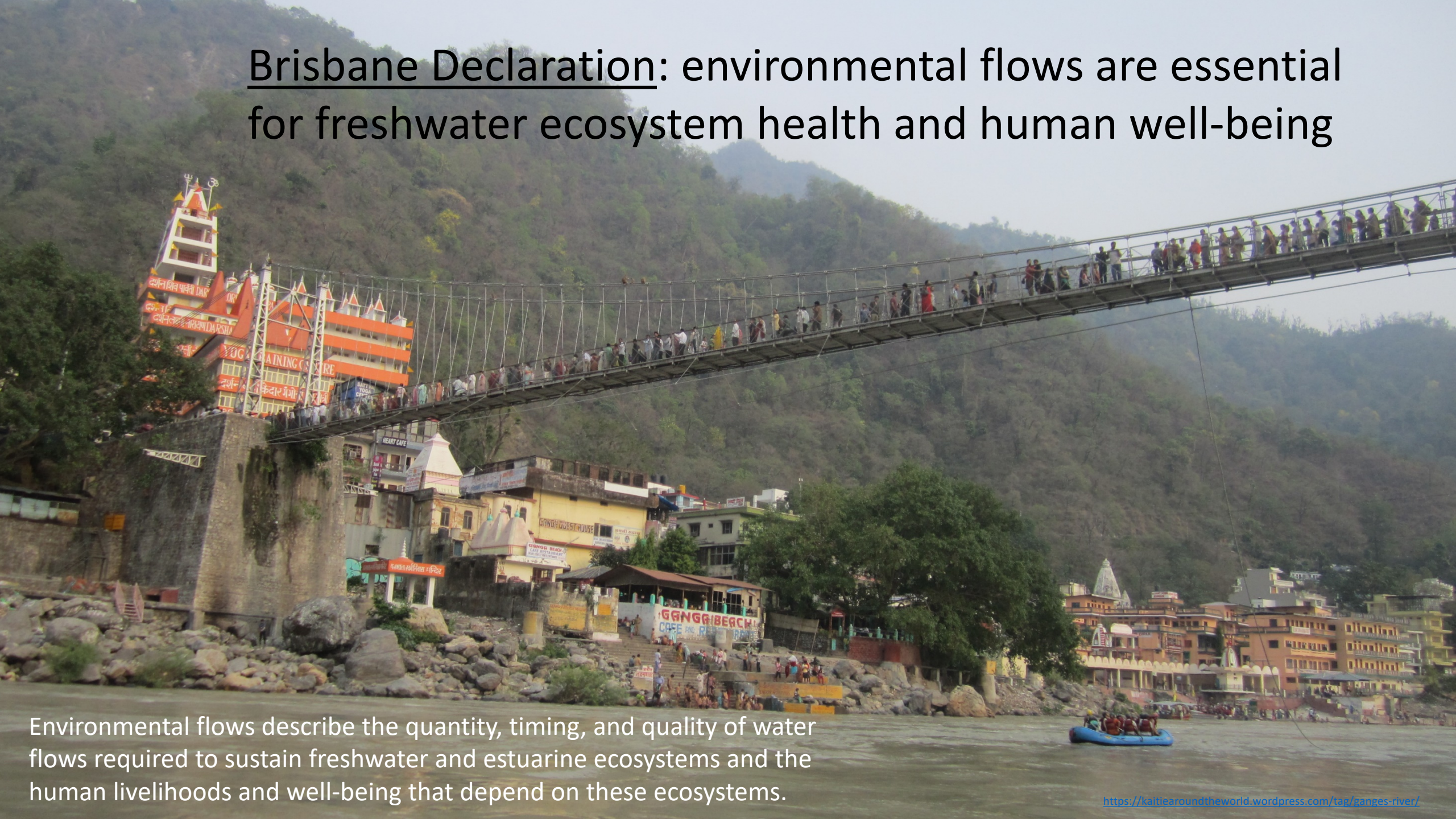


Santa Barbara Symphony Maestro Nir Kabaretti



https://www.flickr.com/photos/rattleandhum/10844562216
https://www.snagajob.com/resources/data-analyst-job-interview-questions/
https://girlsintogeoscience.wordpress.com/2017/03/29/profile-brighid-o-dochartaigh/

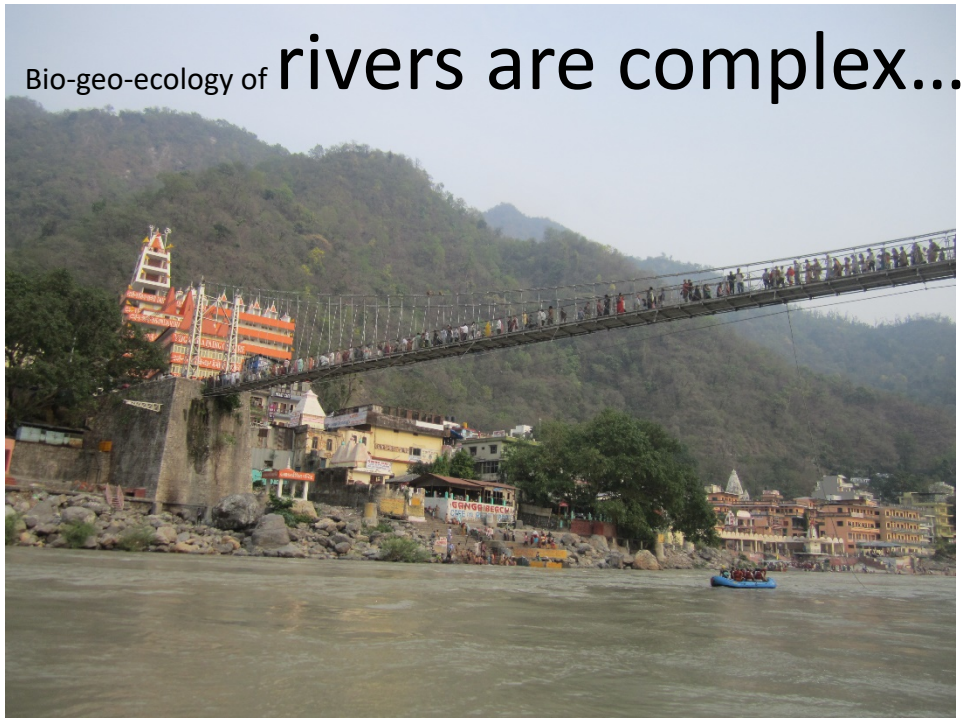
Brisbane Declaration: environmental flows are essential for freshwater ecosystem health and human well-being



Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems.

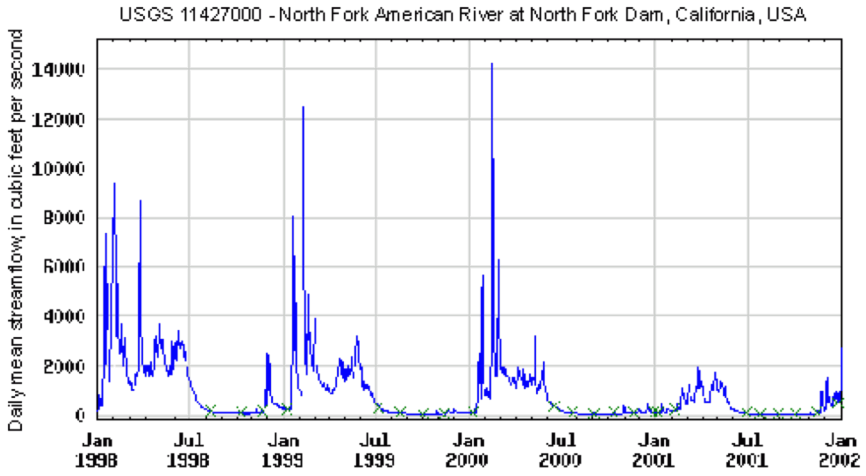
https://kaitiearoundtheworld.wordpress.com/tag/ganges-river/

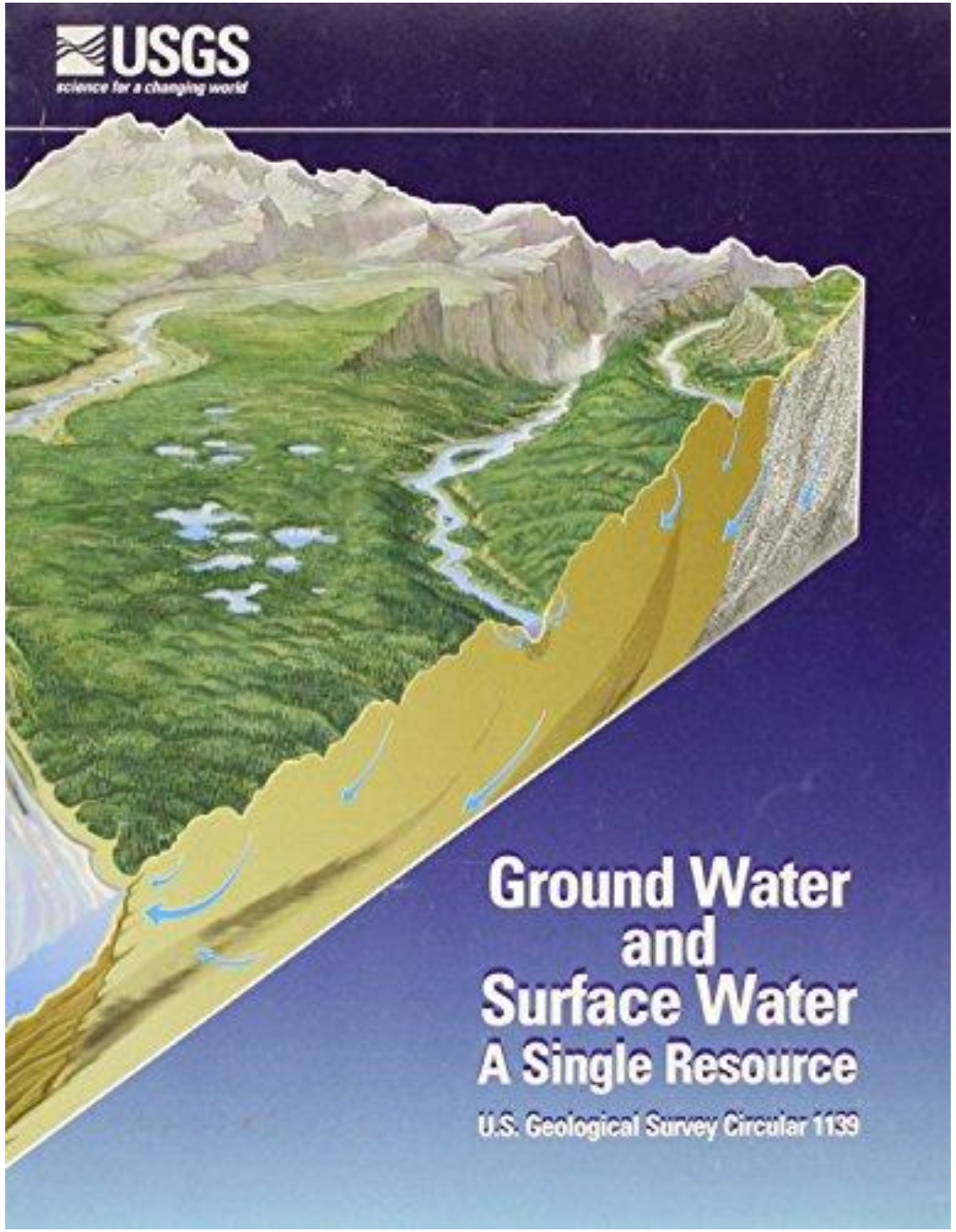
Bio-geo-ecology of rivers are complex…



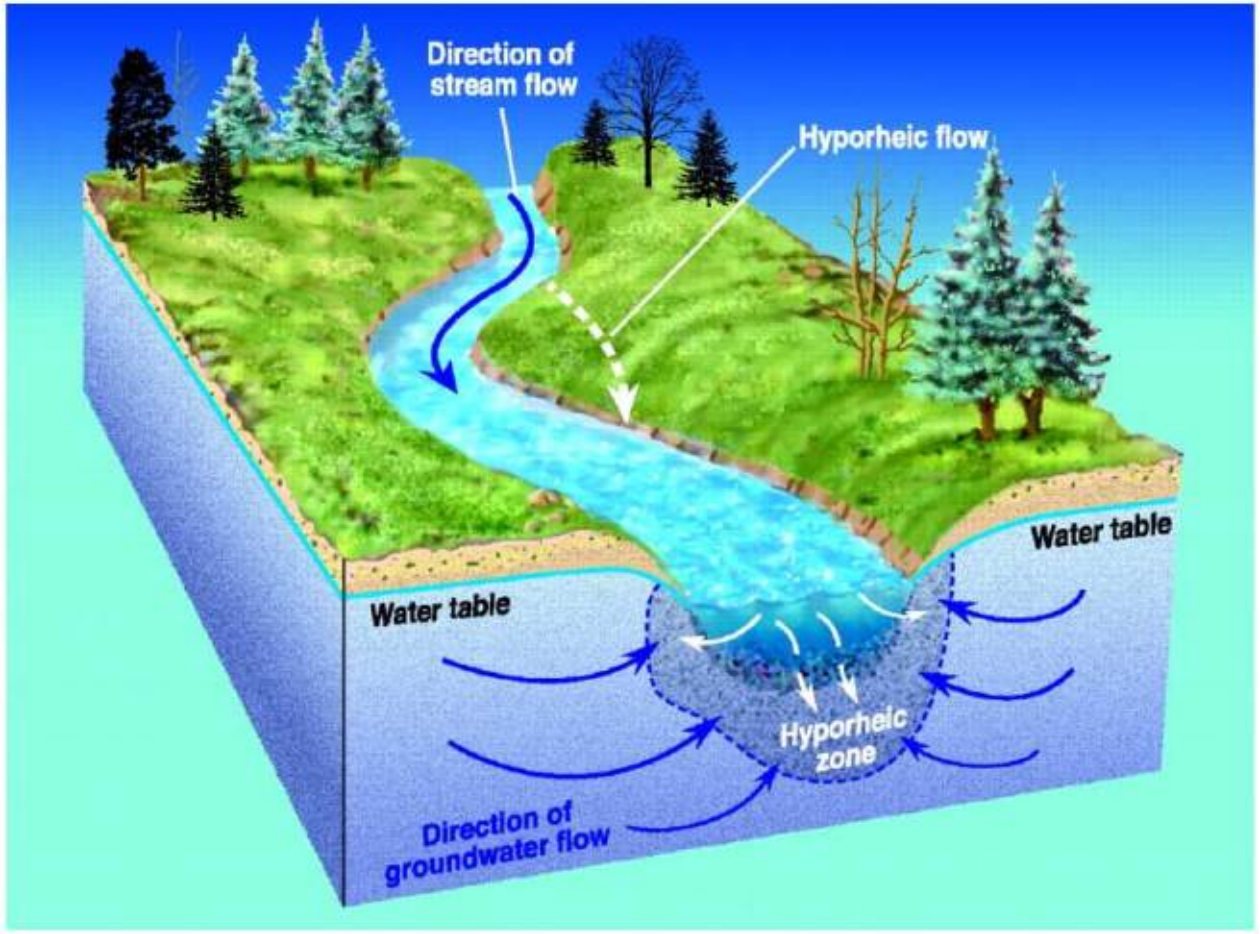
like orchestras!

Streamflow is ‘master variable’ or ‘maestro’ of orchestra….





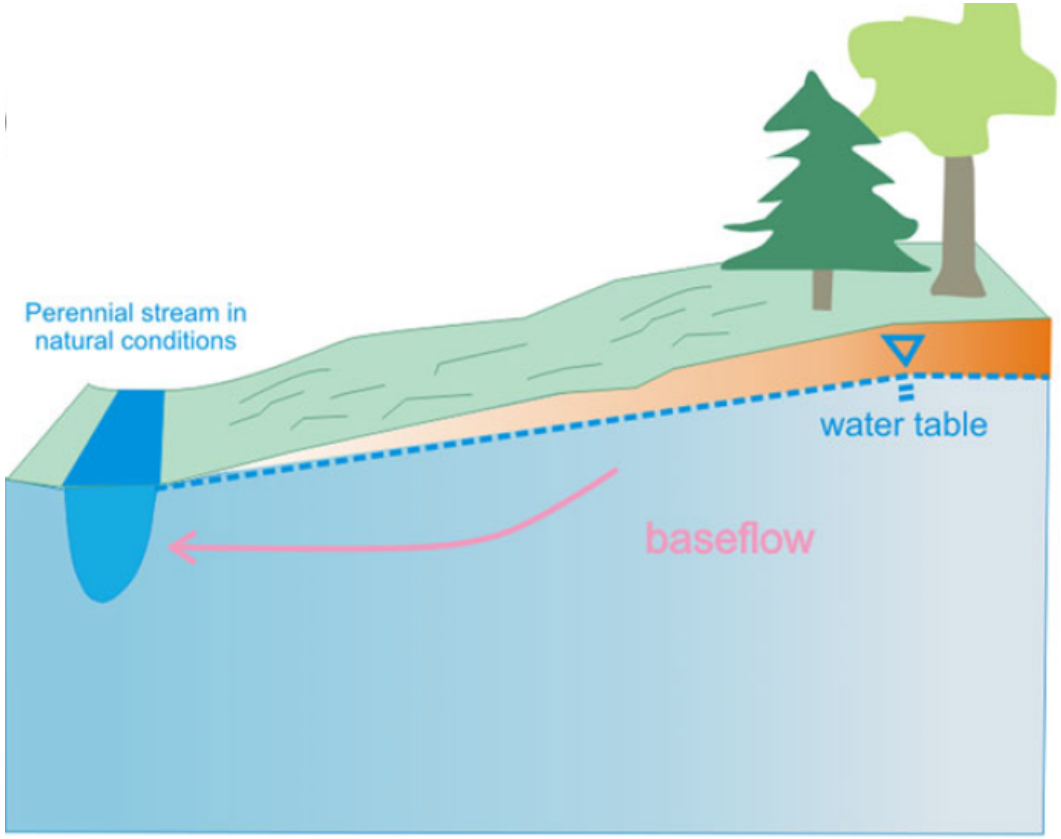
Groundwater and surface water are connected!

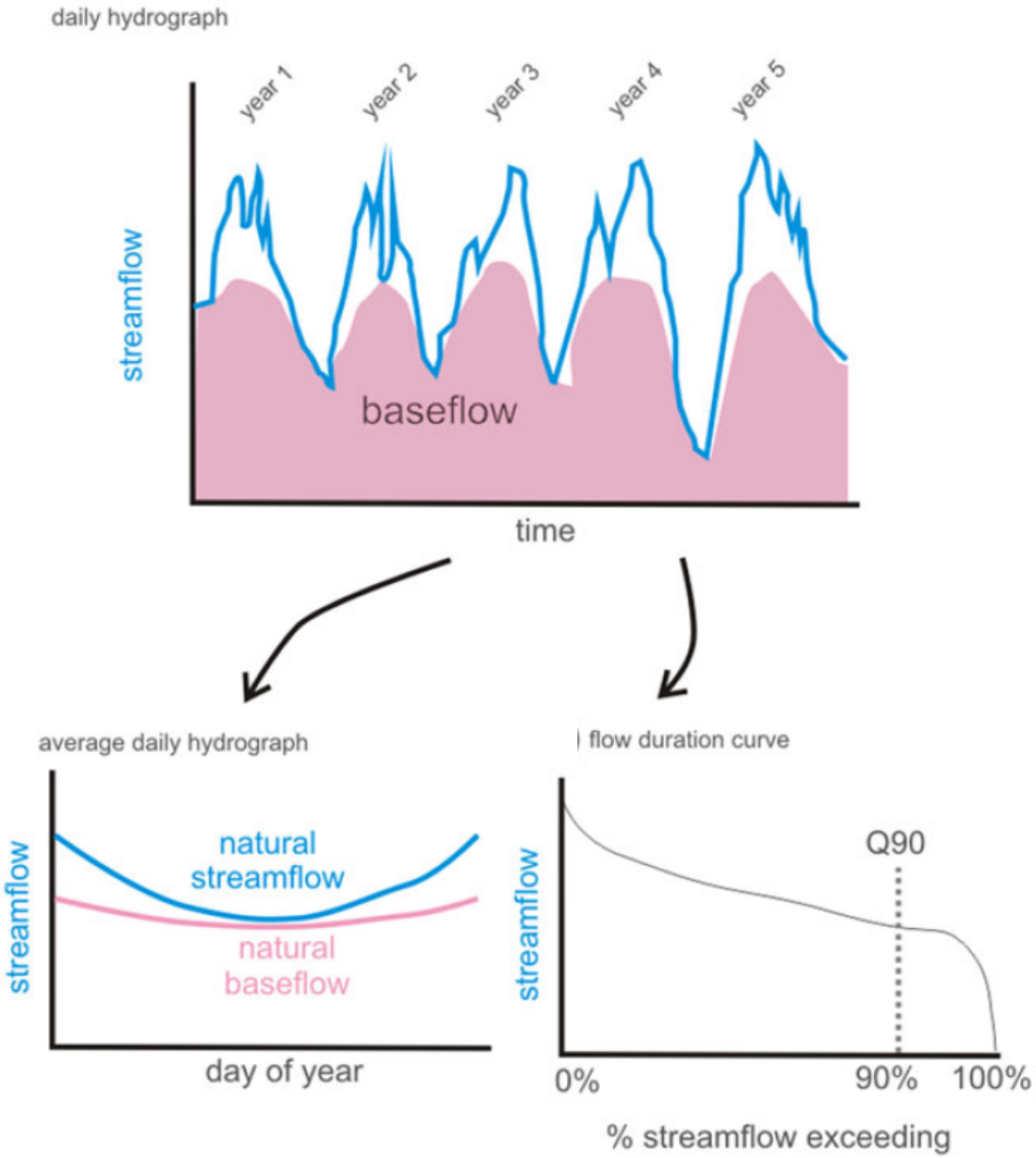


If streamflow is the ‘maestro’ of environmental flows…

the maestro has no backbone if we do not explicitly account for groundwater

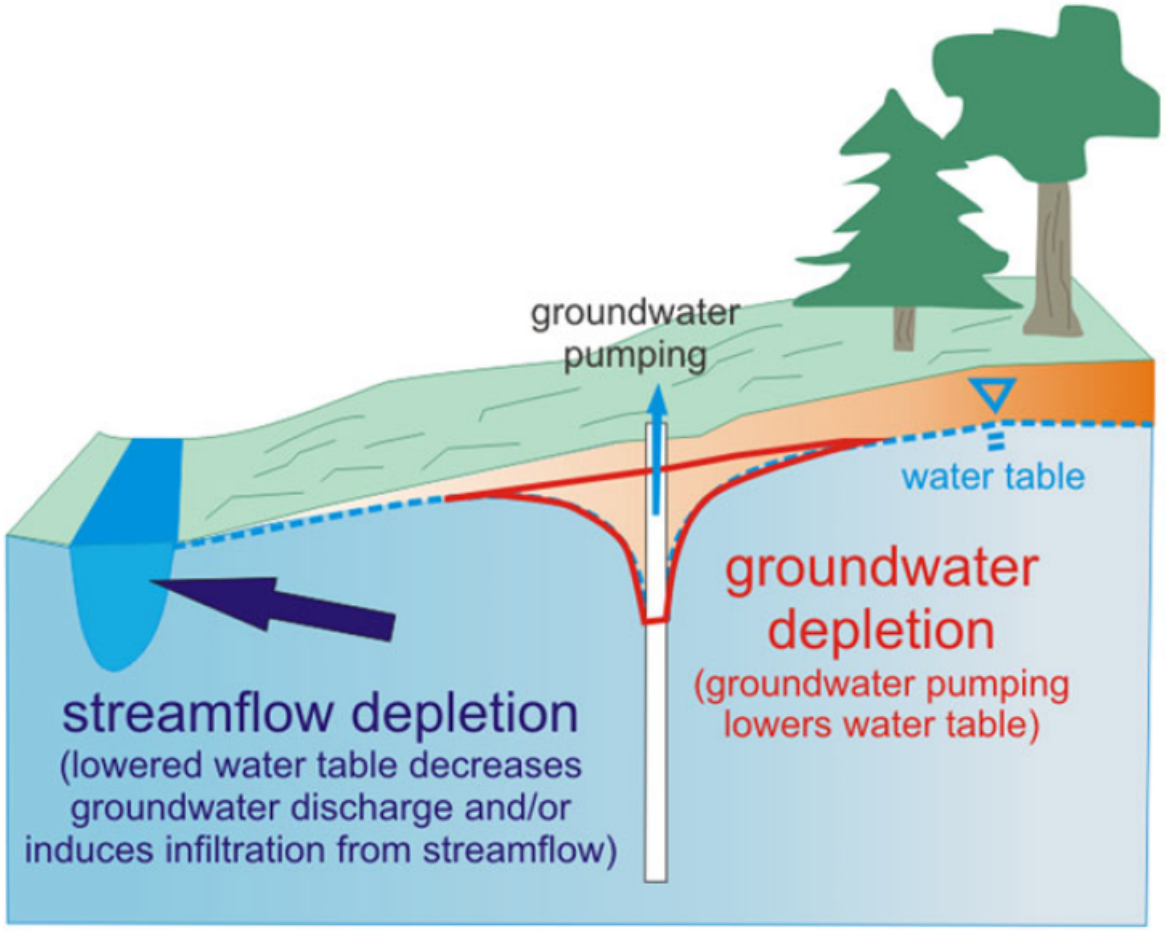
Groundwater as a the maestro's backbone

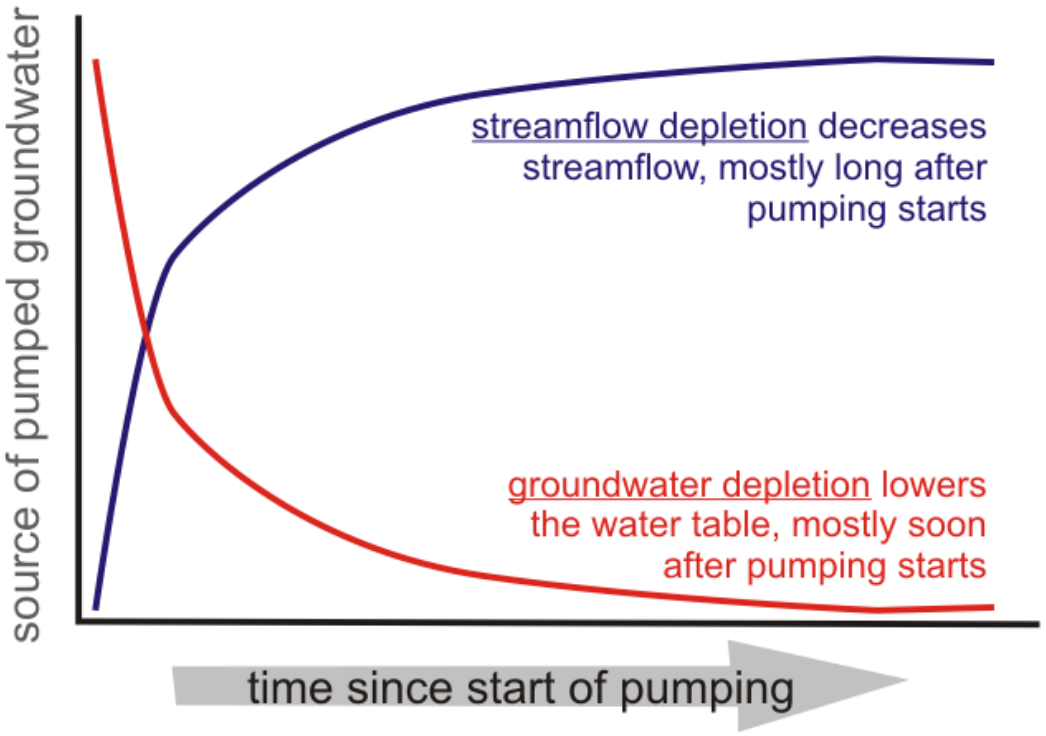




Gleeson and Richter 2018 from Konikow, Leake, Alley etc.

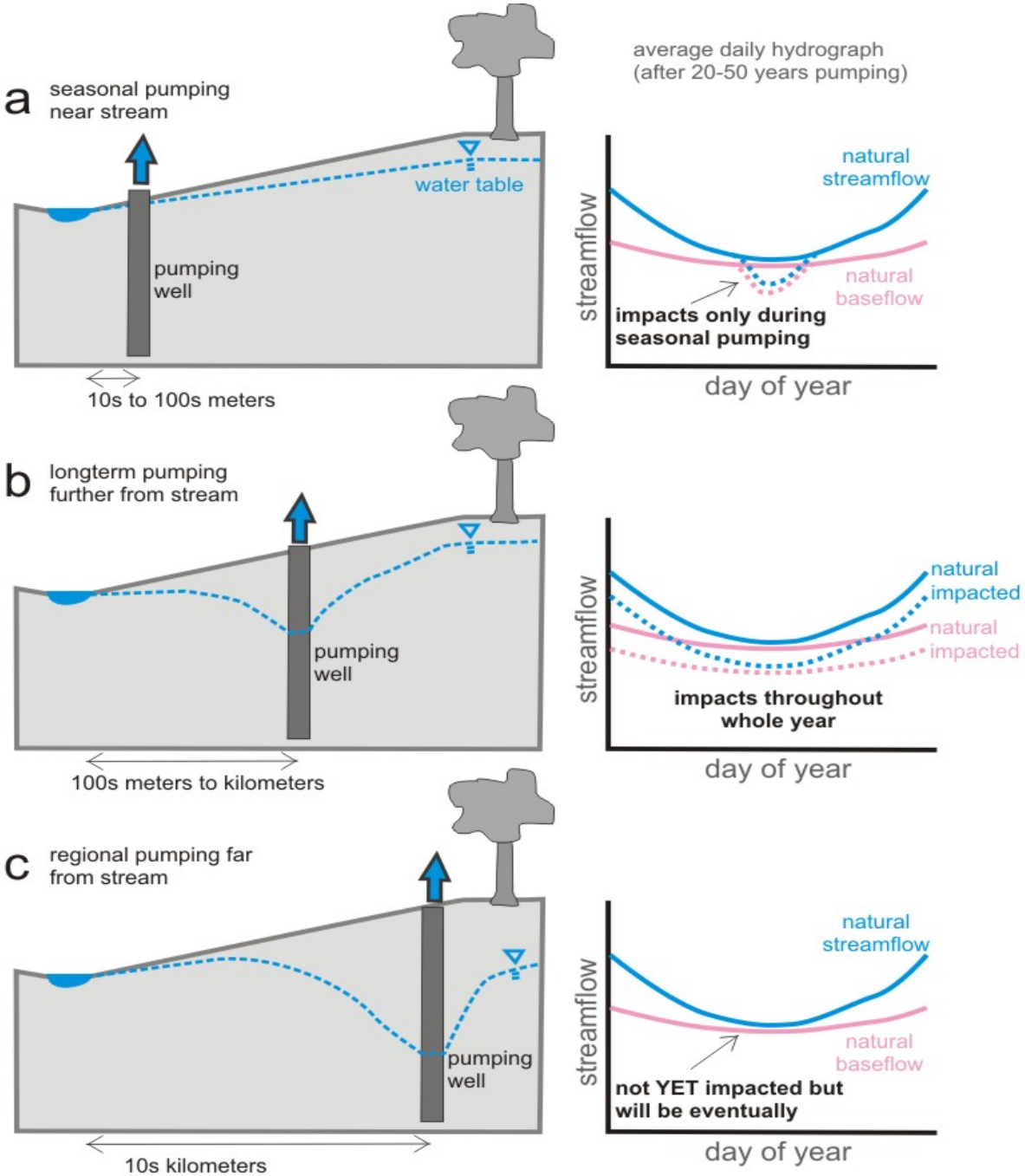
How the maestro's backbone gets broken…





Gleeson and Richter 2018 from Konikow, Leake, Alley etc.

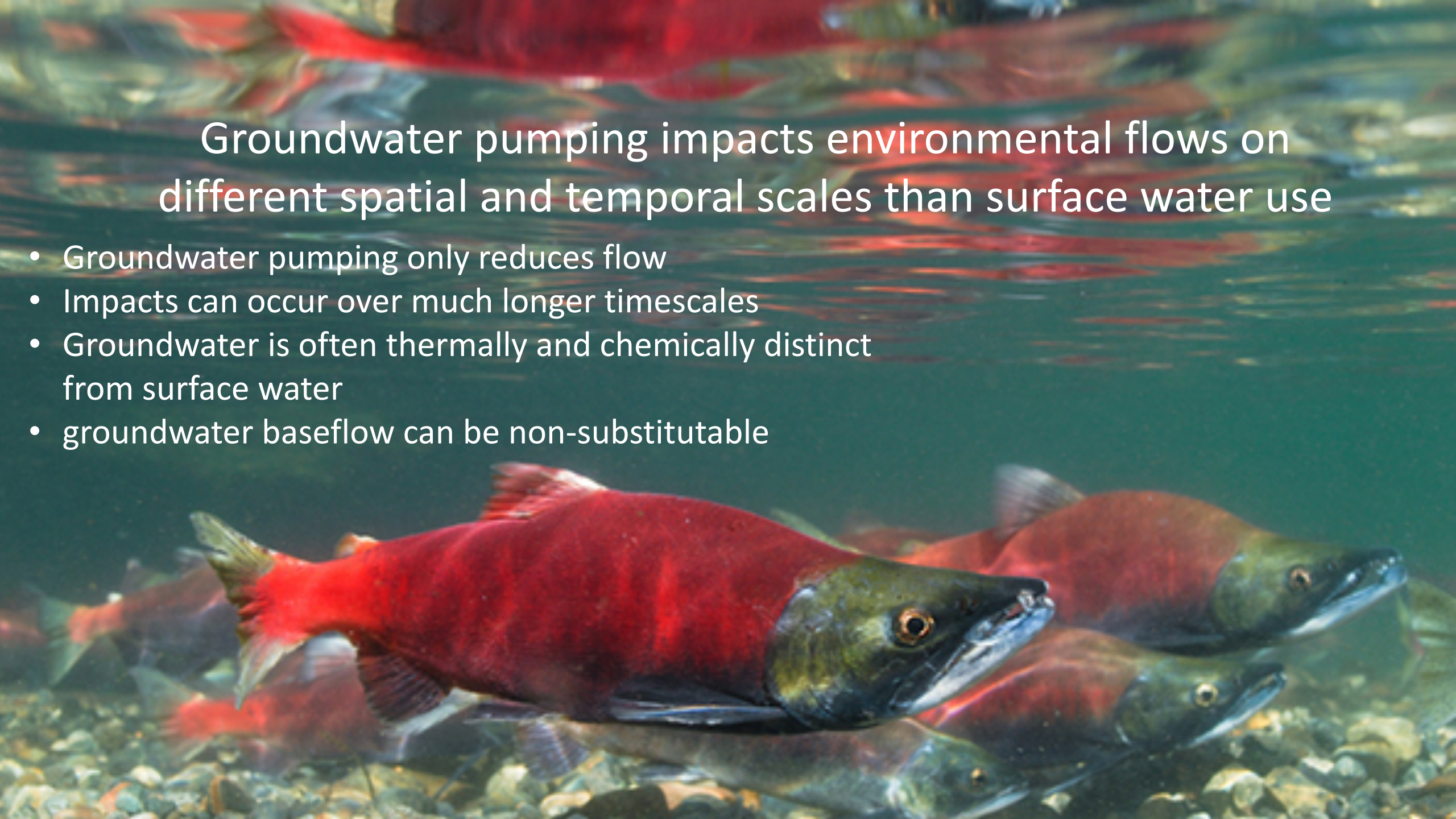
Breaking the backbone happens on different time scales…



Gleeson and Richter 2018 from Konikow, Leake, Alley etc.

Groundwater pumping impacts environmental flows on different spatial and temporal scales than surface water use

- Groundwater pumping only reduces flow
- Impacts can occur over much longer timescales
- Groundwater is often thermally and chemically distinct from surface water
- groundwater baseflow can be non-substitutable



So in my humble opinion…

Good water policy considering hydrologic connectivity would:

1) **Quantify and consider the contribution of groundwater to environmental flows;**

2) **Recognize the sometimes non-substitutable contribution of groundwater to environmental flows;**

3) **Incorporate the potential long-term (decades or centuries) impacts of groundwater pumping**

In your opinion…What are the three most important elements of good water policy considering hydrologic connectivity?

Since this is a workshop about tools…what is a tool?

1) a device or implement, especially one held in the hand, used to carry out a particular function (Collins dictionary)

2) a guy with a hugely over-inflated ego, who in an attempt to get un-due attention for himself, will act like a jackass, because, in his deluded state, he will think it's going to make him look cool, or make others want to be like him (Urban dictionary).

3) an intellectual/technical equation/method/algorithm/model that can be used in water management (Tom's rough definition)

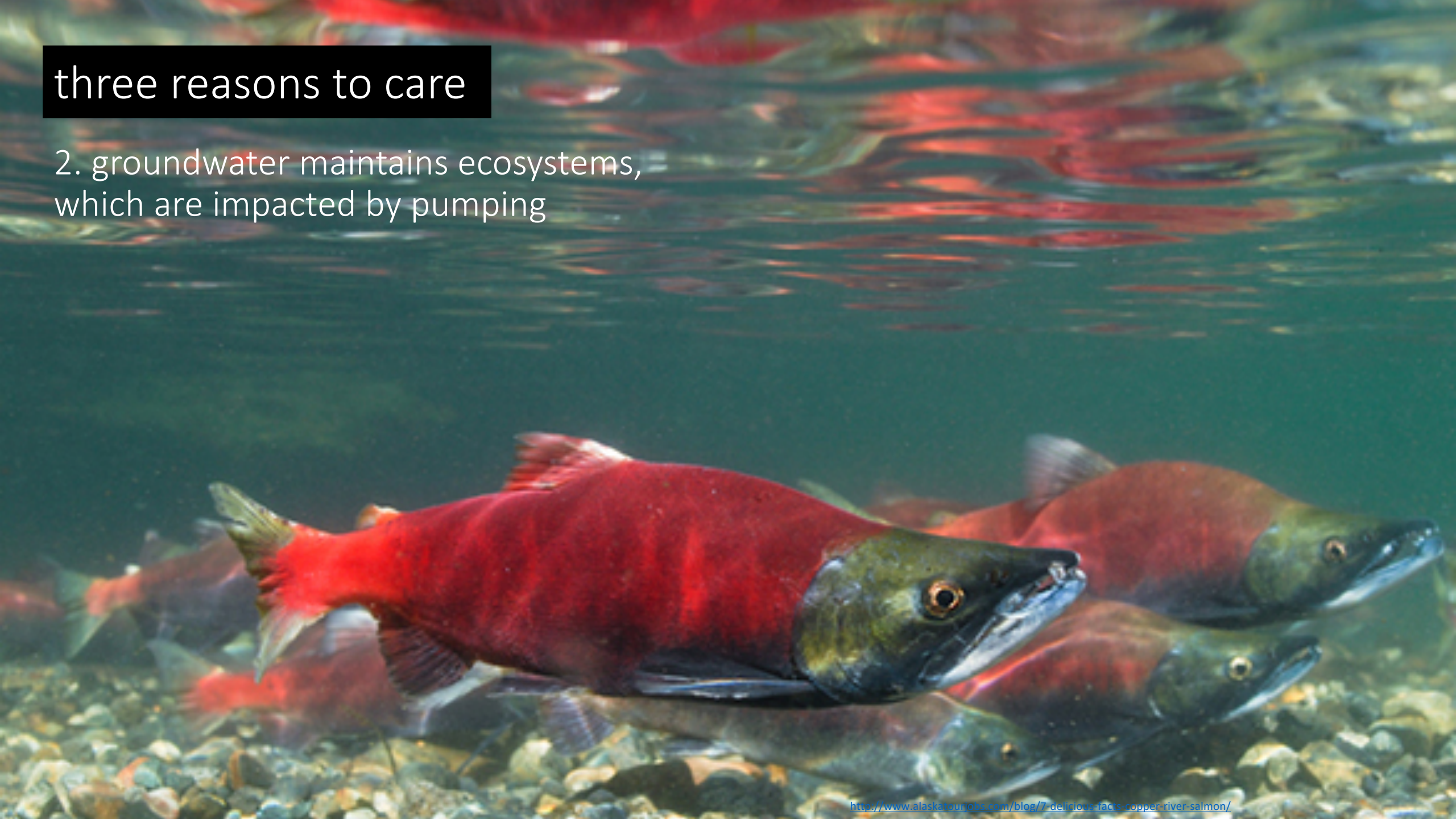
In your opinion…what tools could be useful for managing water given hydrologic connectivity?

three reasons to care

1. groundwater is a critical and strategic resource

three reasons to care

2. groundwater maintains ecosystems, which are impacted by pumping

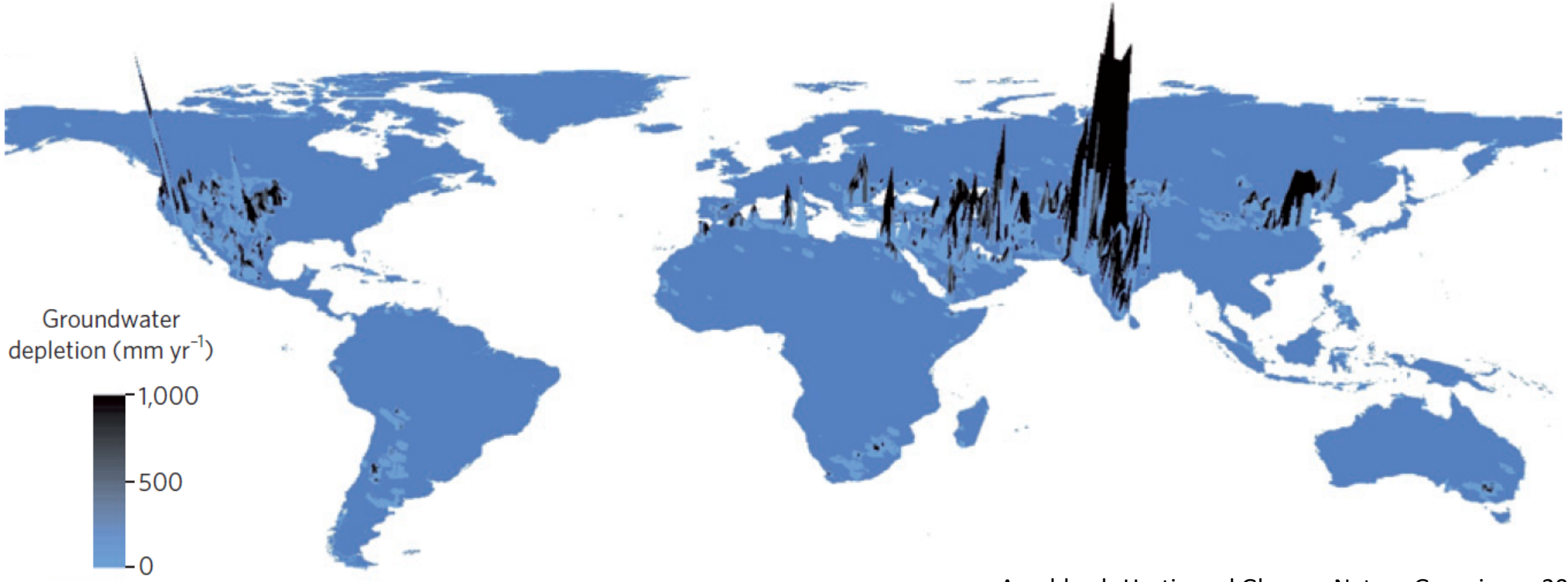


http://www.alaskatourjobs.com/blog/7-delicious-facts-copper-river-salmon/

three reasons to care

3. groundwater sustainability is threatened globally

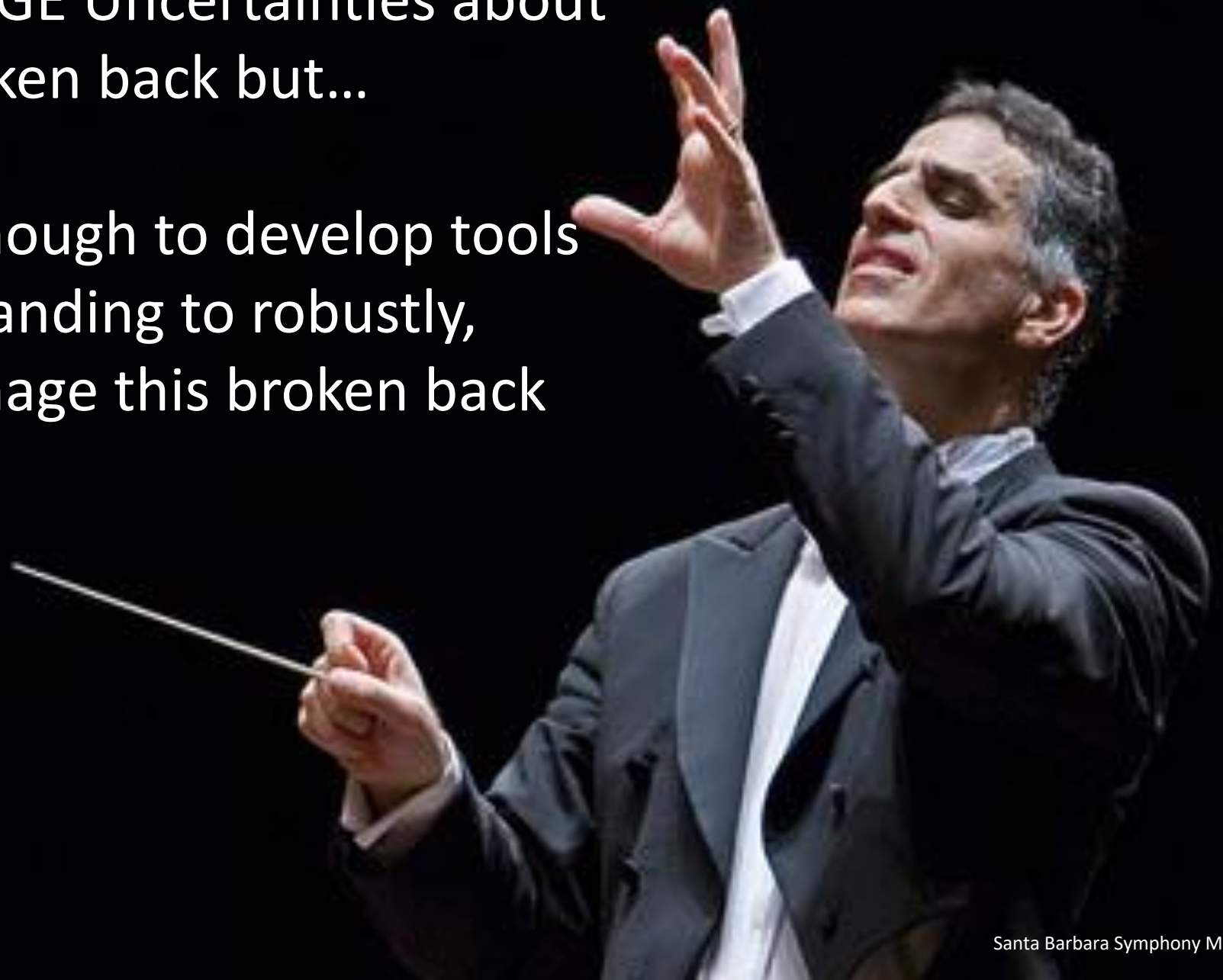
Can California be a global leader?



Aeschbach-Hertig and Gleeson Nature Geoscience 2012

Yes, there are HUGE Uncertainties about This Broken back but…

we also know enough to develop tools and understanding to robustly, adaptively manage this broken back



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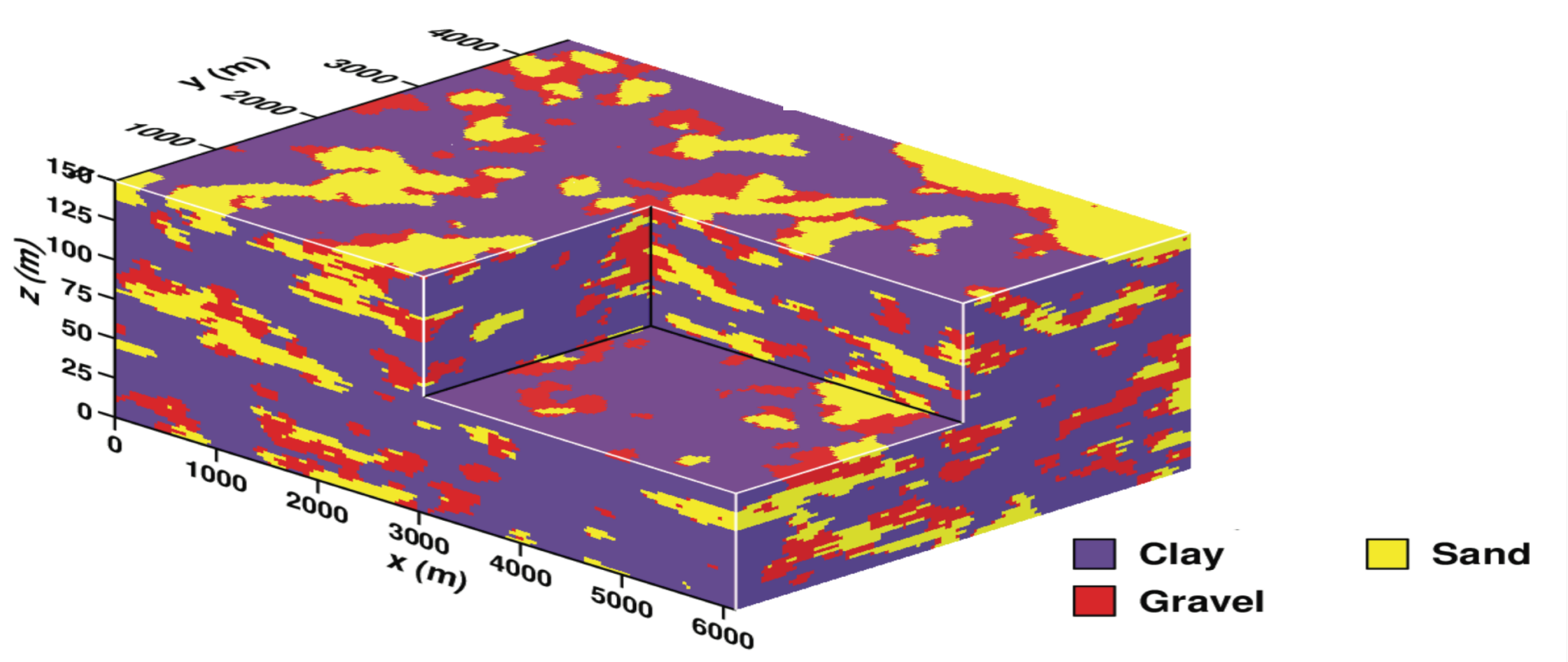
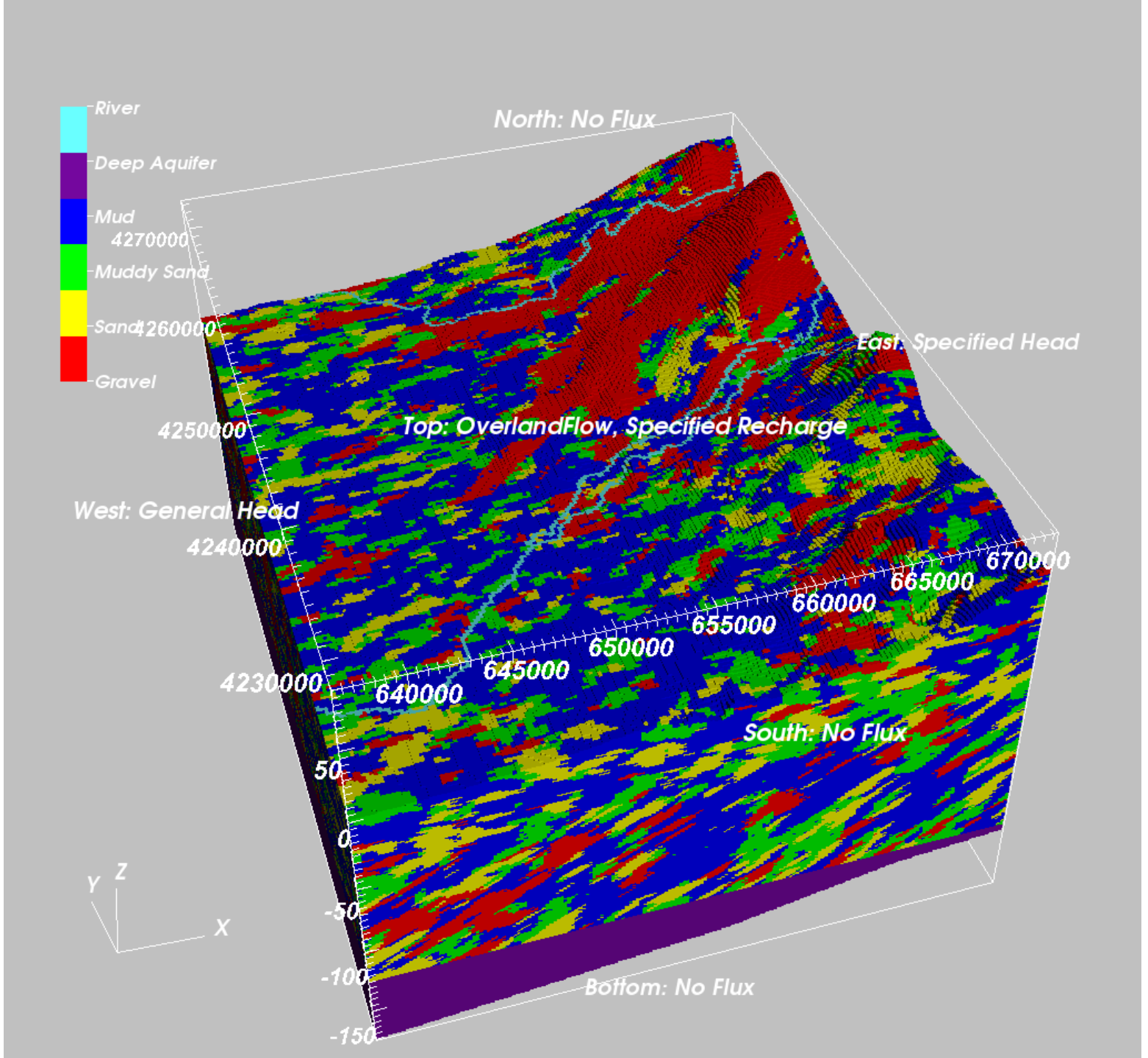
Key Points

- Aquifers are commonly, mostly *not* comprised of aquifer materials.
- Heterogeneity results in spatial complexity, but connectivity simplifies matters at the GSA scale.
- Models can capture large scale interaction through appropriate calibration and data.
- But be mindful of local variability.

Woodland Area Aquifer System Network (Stephen Maples, HYD 273)

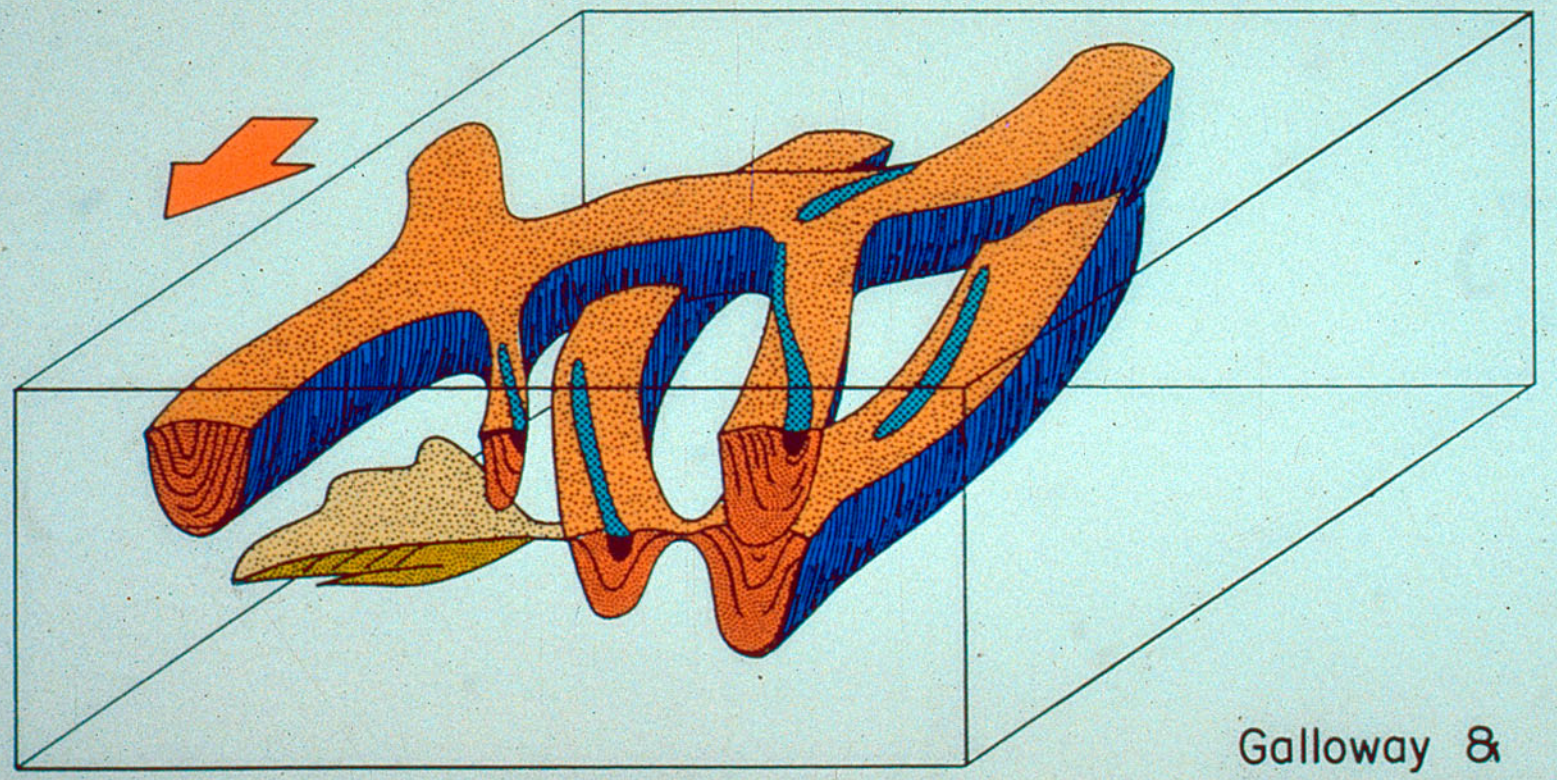


Sacramento County Subsurface, UC Water Security and Sustainability Research Initiative



Connectivity of High-K (Aquifer) Facies Generally Good

FACIES ARCHITECTURE



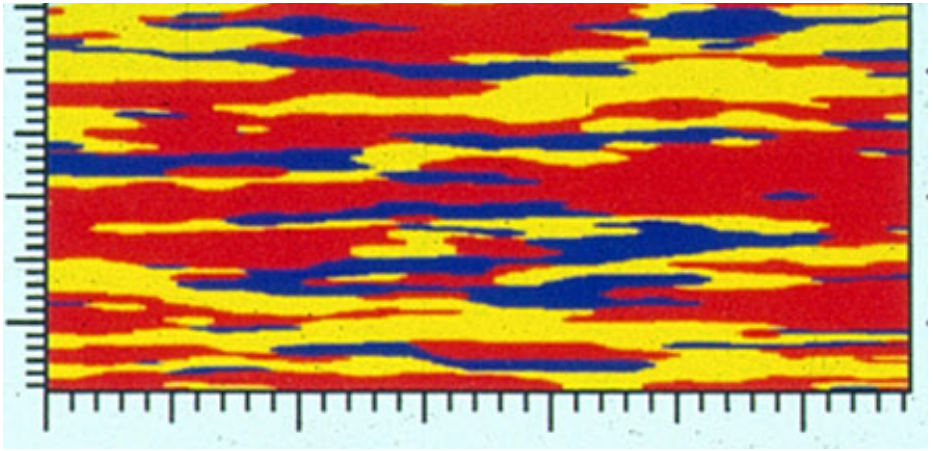
Galloway &
Hobday 1983

Suspended-load channel

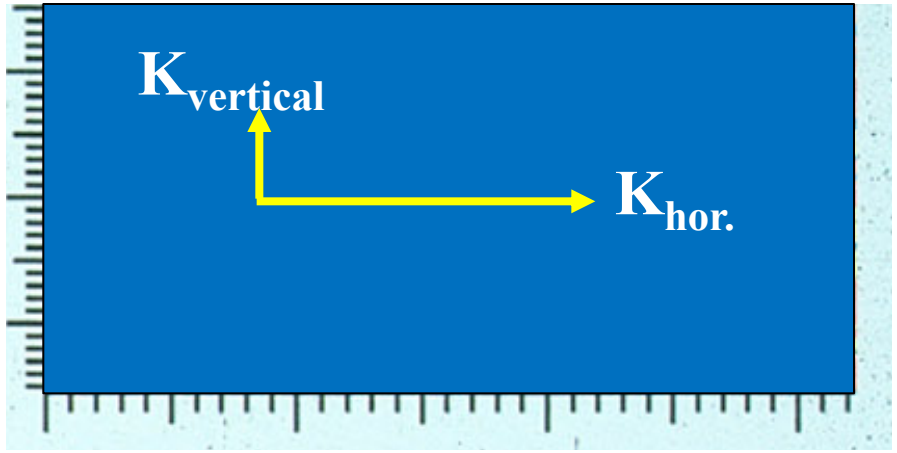
Bureau of Economic Geology QA-2480

Representing Heterogeneity With Homogeneous, Anisotropic Equivalent

Heterogeneous



Homogeneous, Anisotropic



- $K_{hor.}$ from well tests and conventional model calibration.
- $K_{vert.}$ from vertical h gradient data and calibration (Fogg, 1986)