Visible and Invisible Rivers: Hydraulic Continuity in the Methow Valley

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Introduction to USGS

U.S. Geological Survey (USGS) is an science agency in the U.S. Department of the Interior that works in the Methow River basin

- *monitors streamflow at 7 sites*
- *conducts investigations of water quality, groundwater, and fish*
- *develops hydrologic models*

Most projects are conducted in cooperation with local, state, federal, and tribal agencies.

USGS monitors water quality in Andrews Creek as part of its Hydrologic Benchmark program.

USGS does not manage water or other natural resources, regulate water use, or make policies affecting the management or regulation of water.

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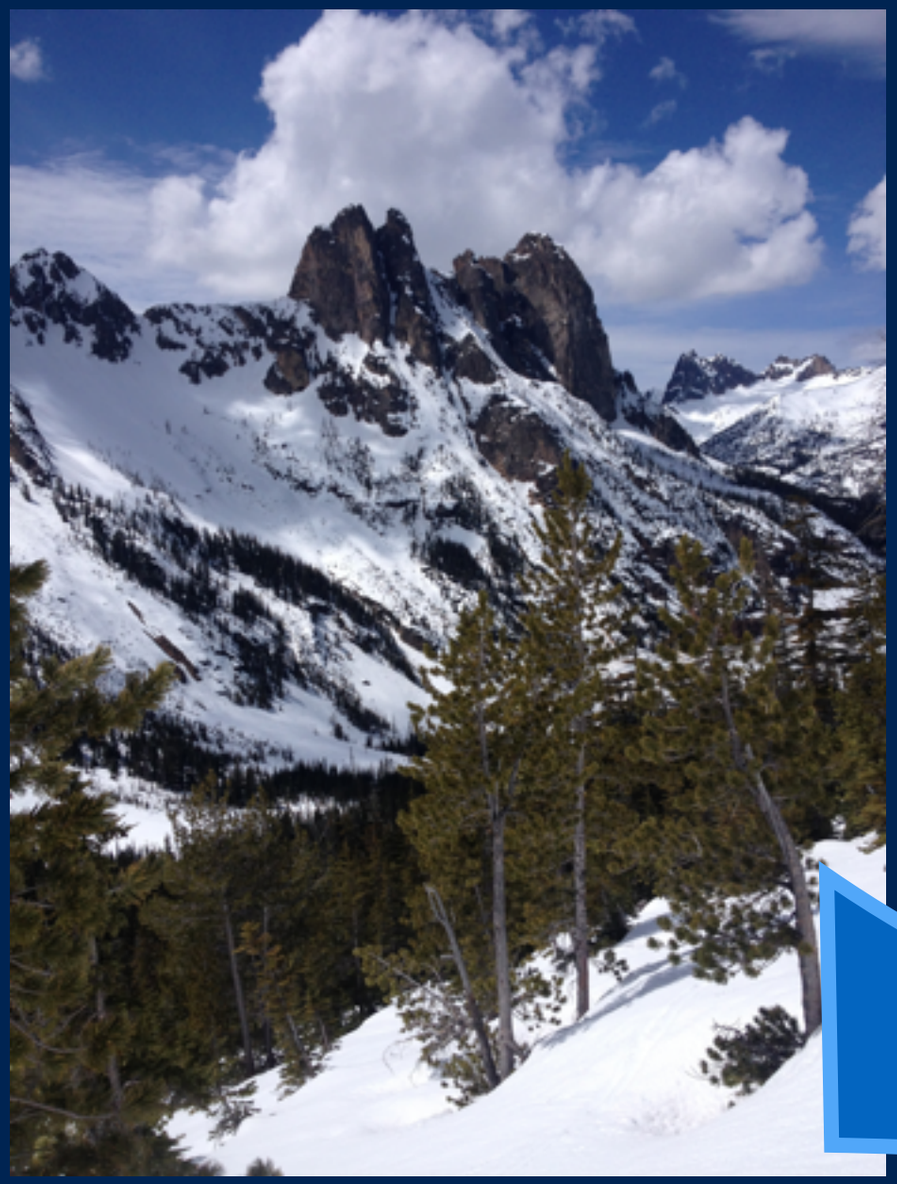
Hydraulic Continuity



Hydraulic continuity is the connection between the amount/movement of water in two locations.

The connection can be instantaneous or lagged in time, but requires a flow path.

The water cycle indicates many aspects of hydraulic continuity.

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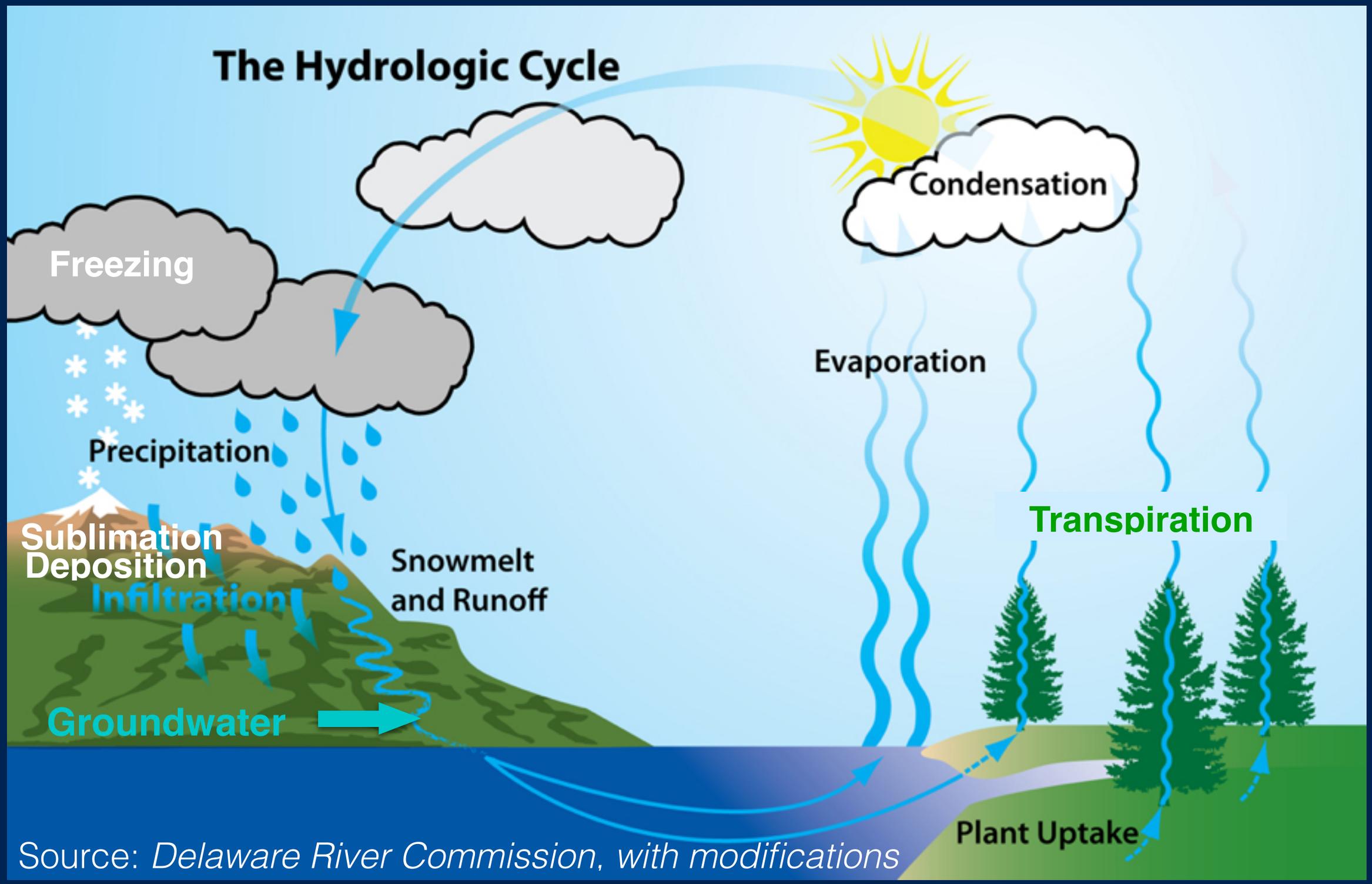

Source: *Delaware River Commission, with modifications*

Examples of Hydraulic Continuity from the Water Cycle

Snowpack melts and flow down (overland and through soil) into a stream.

Streamflow rises in the spring and recharges groundwater (river stage is higher than groundwater level)

Groundwater flows into a river channel during late summer (groundwater level is higher than river water level).

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Hydraulics

Water will flow from a higher energy location to a lower energy location as long as there are no impermeable barriers: **energy gradient + flow path**

Surface water flows down river channels from higher elevations to lower elevations.

Groundwater flows through aquifers from higher pressure to lower pressure.

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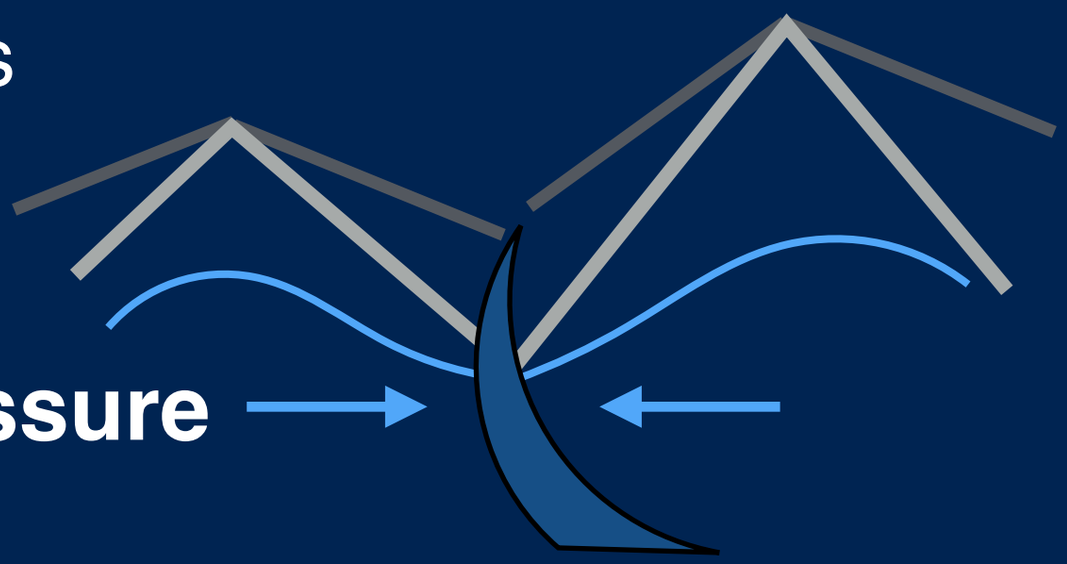
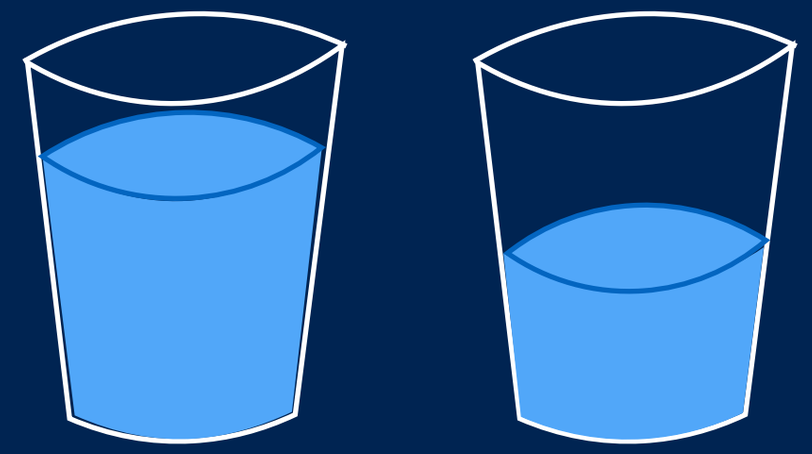


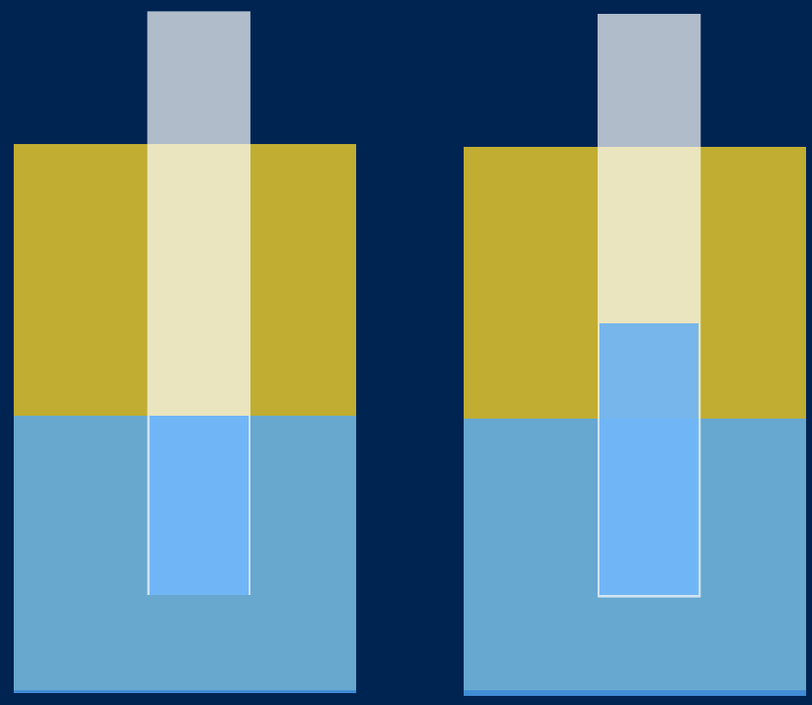
Water flows when there is an energy gradient + flow path

Energy of water is equal to its elevation + pressure.



Water level in a open well indicates the pressure lower in the aquifer.

Where does the water have high energy?



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The water cycle shows how different forms of water are connected.

Measuring or estimating the amount of water in each form can be used to create a water budget

A water budget can help assess the continuity (connection) of water in different places.

WATER BUDGET
+Inflows
-Outflows
Change in Storage

can be calculated for any area and time period

Main Components of the Annual Water Budget for the Methow River basin

WATER BUDGET
+Inflows
-Outflows
Change in Storage

A water budget for the whole basin can be expressed in terms of water depths that represent average conditions. Each term varies across the basin.

INFLOW:
Precipitation ~ 1 m/year (4 ft) for the Methow River basin

OUTFLOWS:
Streamflow ~ 0.3 m/year

Evapo-transpiration ~ 0.7 m/yr
hard to measure, so it is usually calculated as precipitation - streamflow

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Where are snow and groundwater in the water budget?

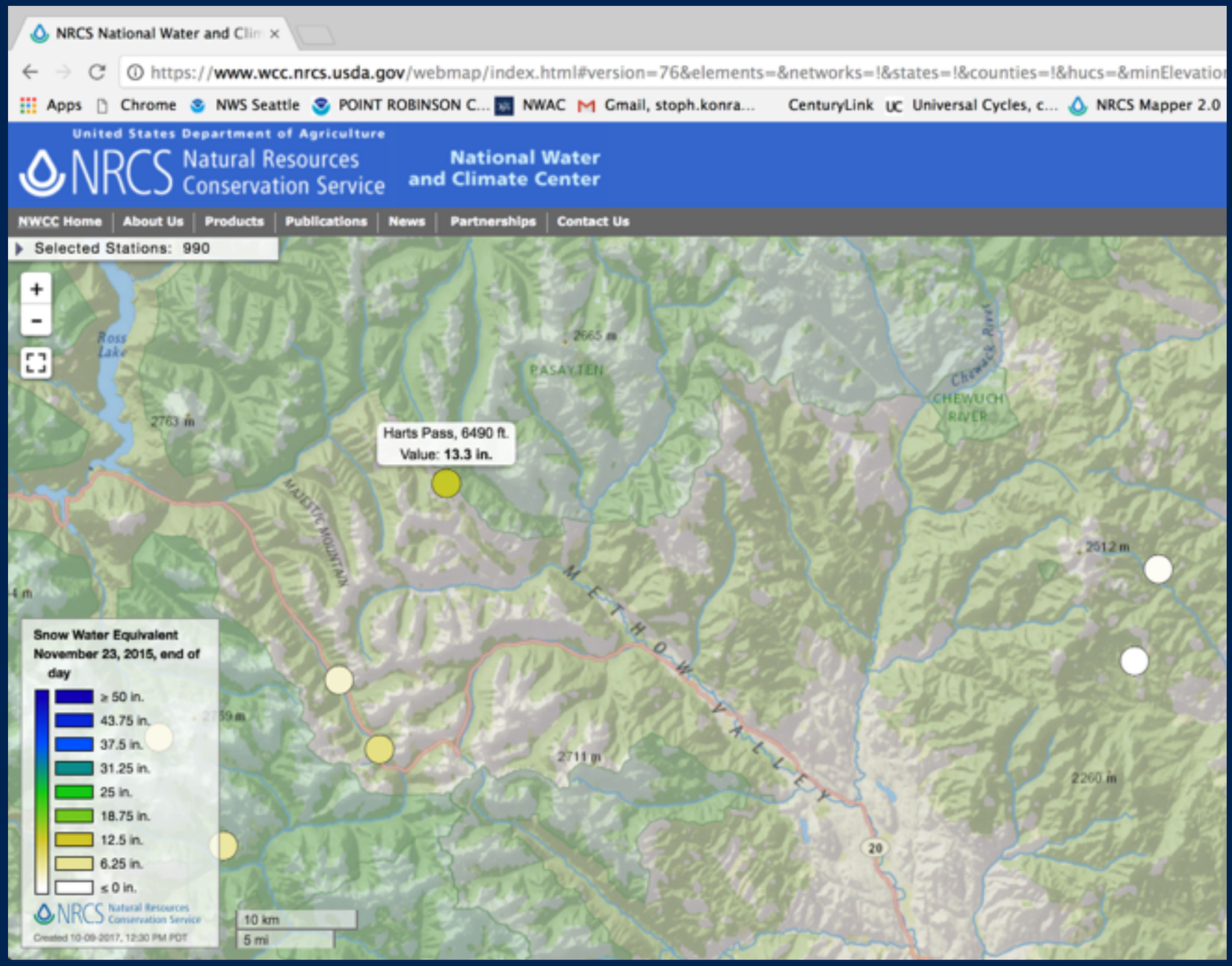
For an annual water budget, groundwater is usually a small portion of outflow from a basin and net change in groundwater is assumed to be zero. Annual water budgets are typically constructed for 1 October - 30 September, so snow is included in precipitation, but there is little change in snowpack storage.

For seasonal water budgets, snowpack and groundwater storage can be large terms for a seasonal water budget.

Sources of Water: Snow and Rain

Precipitation is monitored at a few locations around the Methow River Basin.

Strong gradients in amount from southeast to northwest and low elevation to high elevation



www.wcc.nrcs.usda.gov/webmap/index.html

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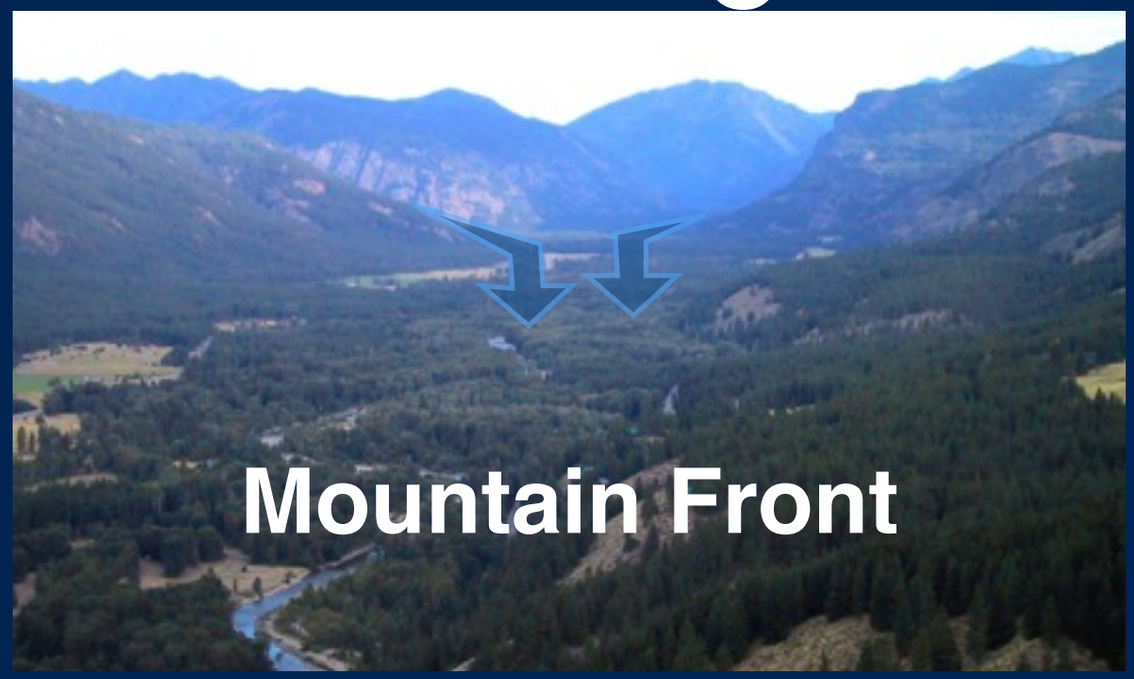
Groundwater Recharge

Infiltration of snowmelt through soil

Groundwater Recharge



Losses of streamflow from rivers and streams on during high flow (indirectly from snowmelt).

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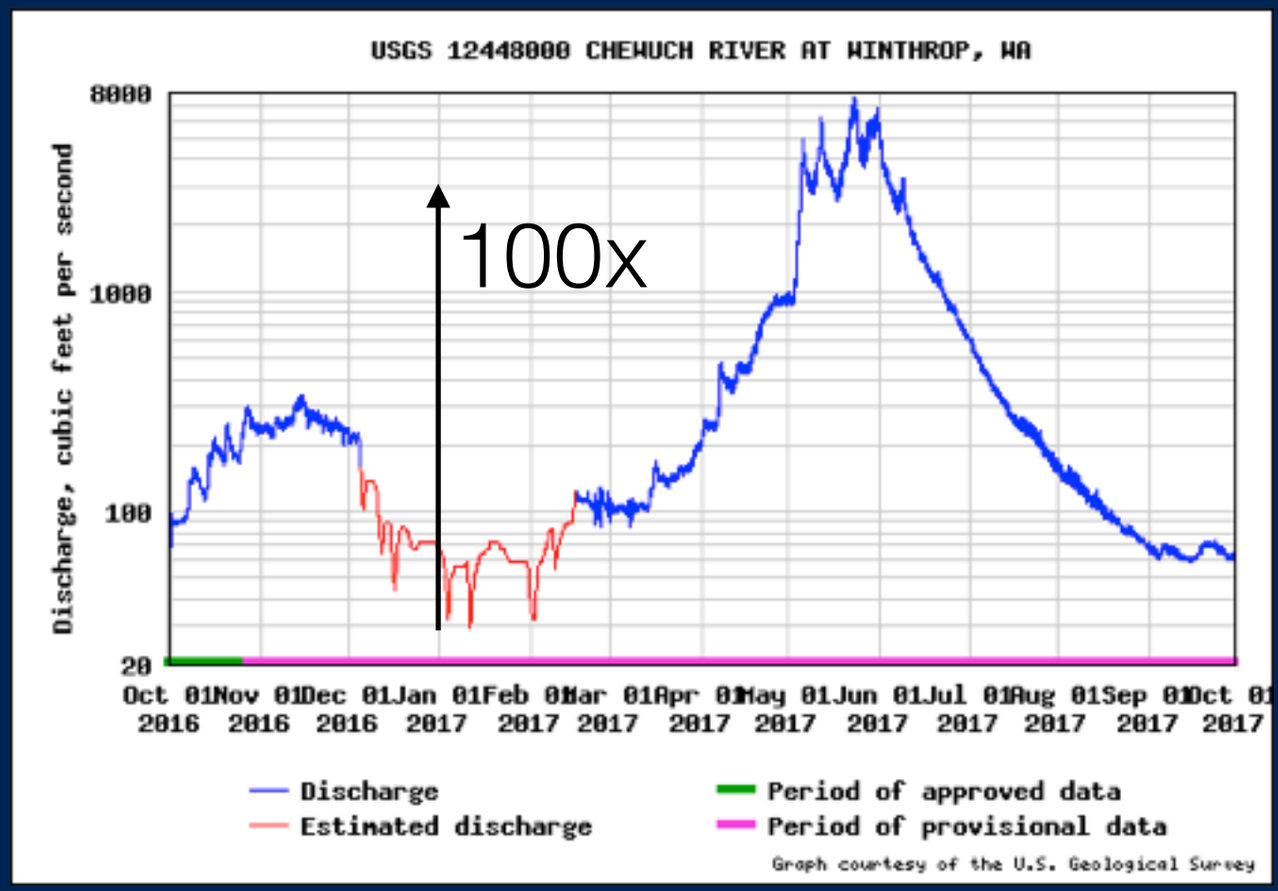
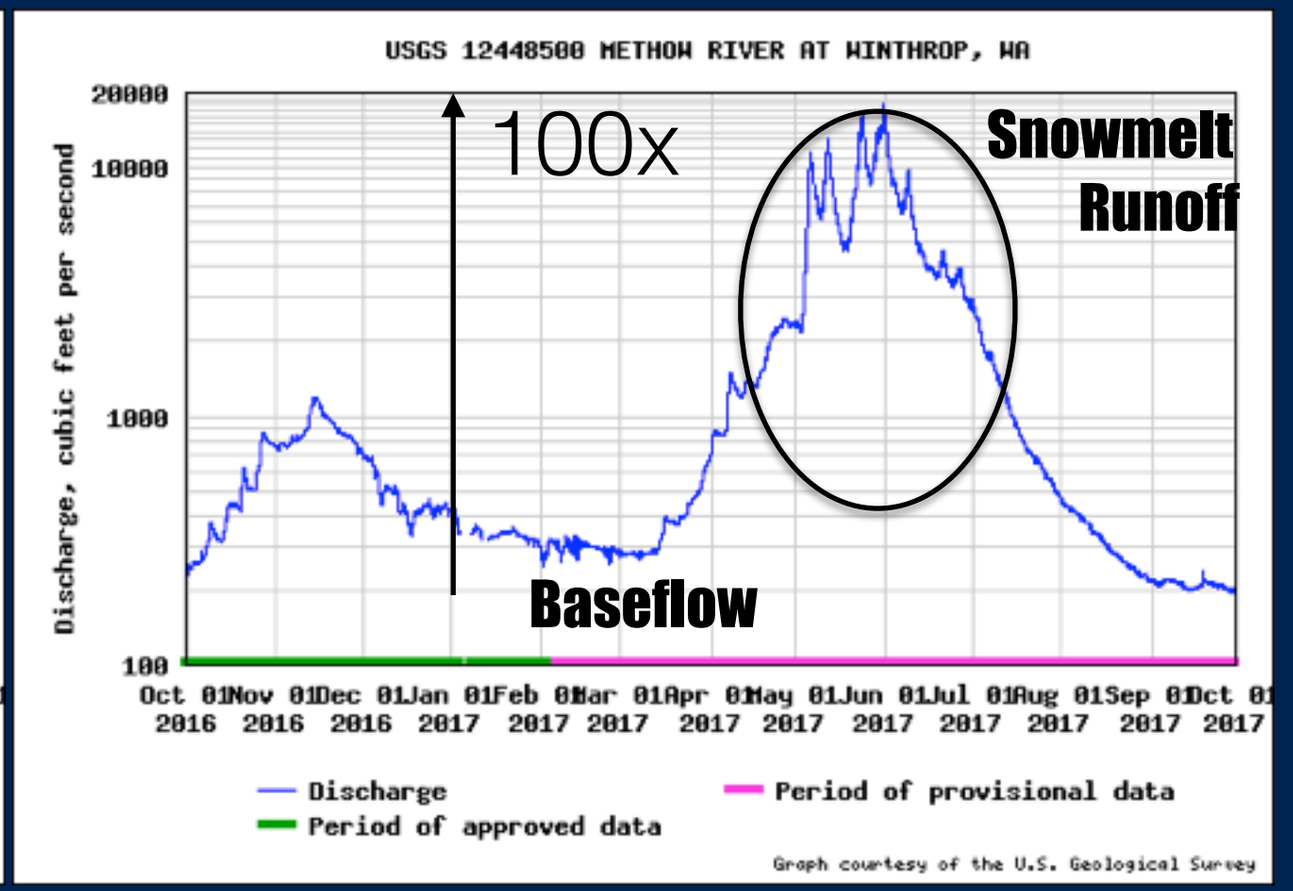
Streamflow





Streamflow is mostly runoff during snowmelt from April through July:
90% of annual flow in Chewuch River and
75% of annual flow in Methow River at Winthrop

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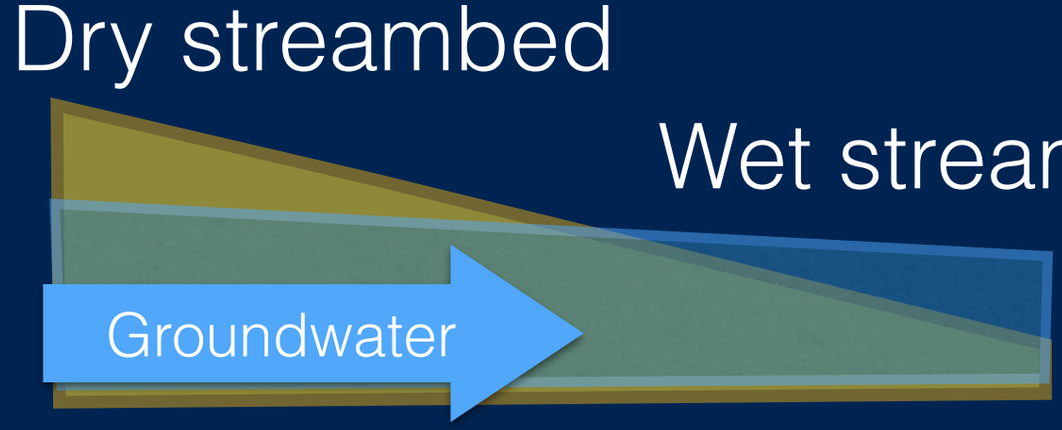
Base Flow



Base flow is the steady portion of streamflow generated by groundwater discharge.

Base flow depends on the groundwater level relative to the bottom of the river channel.

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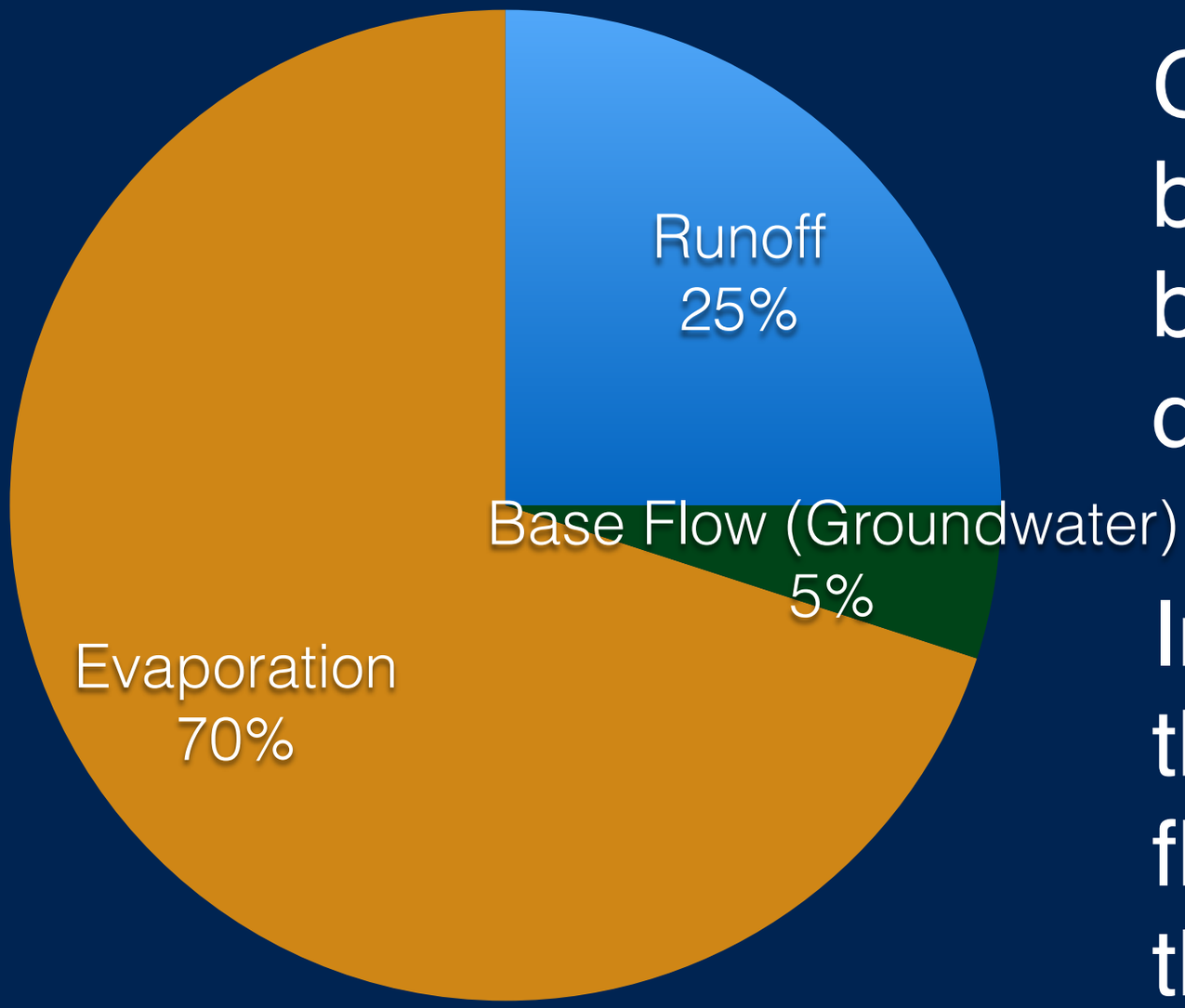
Base Flow

During summer and winter low-flow periods, the Methow River receives ~ 3 cubic meters per second (100 cubic feet per second) from groundwater as it flows through the Big Valley.

Where is groundwater flow in the annual water budget?



Groundwater flow can be estimated from base flow (streamflow during dry periods).

In this case, most of the groundwater is flowing out of the basin through the river.

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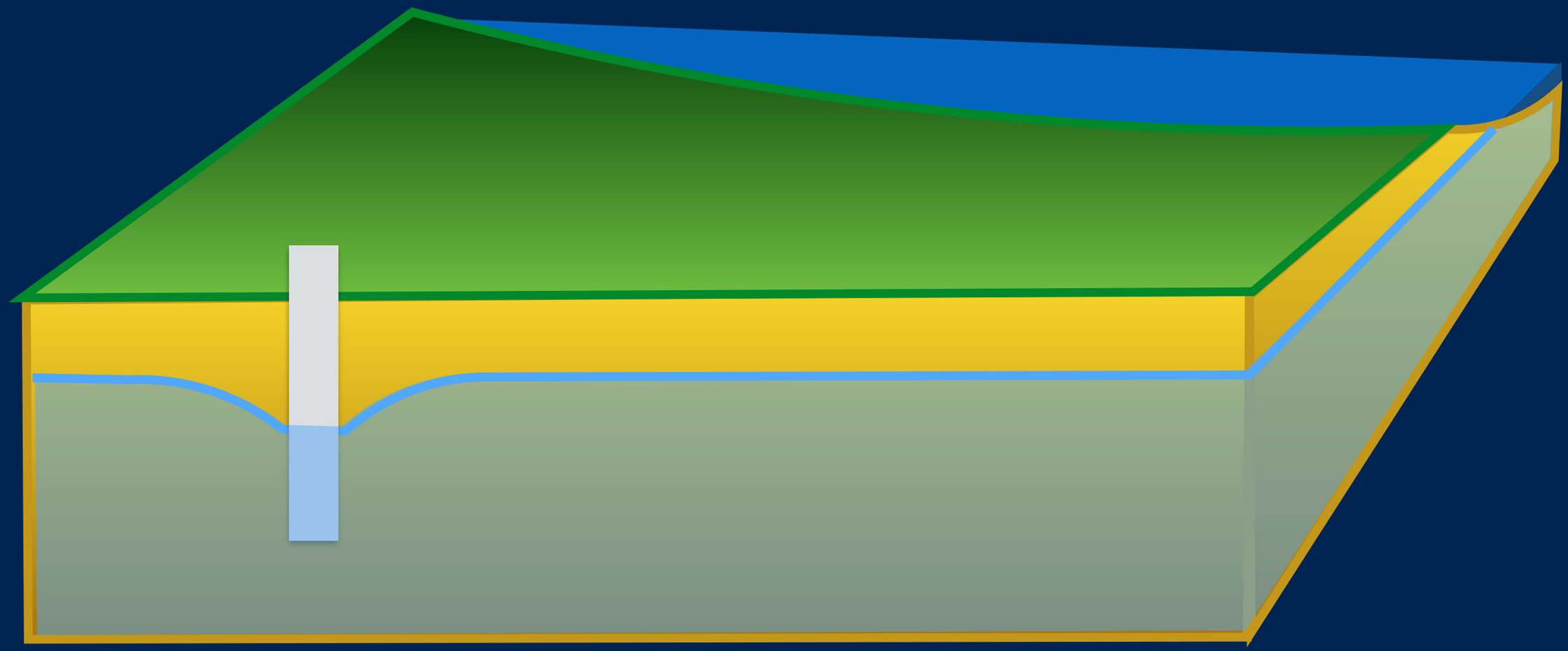
Groundwater



Groundwater is an important resource in the Methow valley, but its connections with other water resources are not visible.

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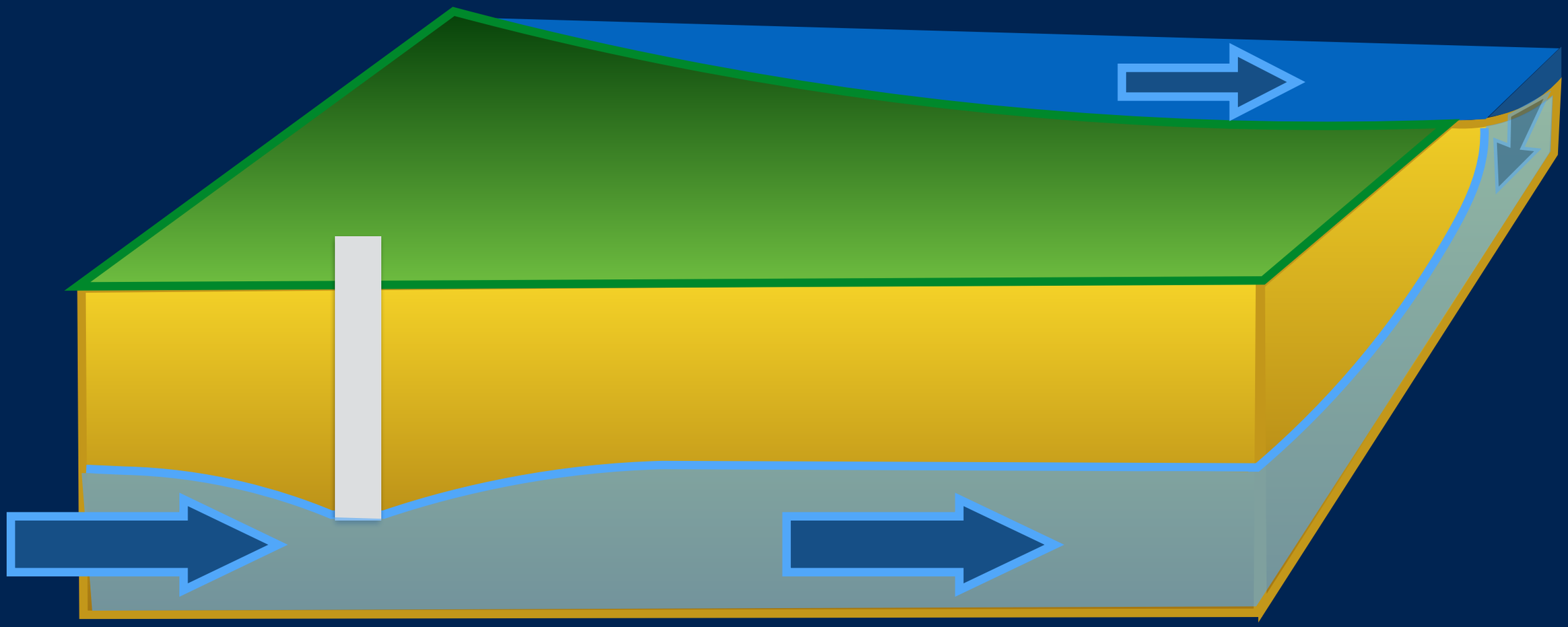
Hydraulic Continuity of Groundwater and Surface Water in the Spring



High flows in rivers and streams during snowmelt recharges groundwater.

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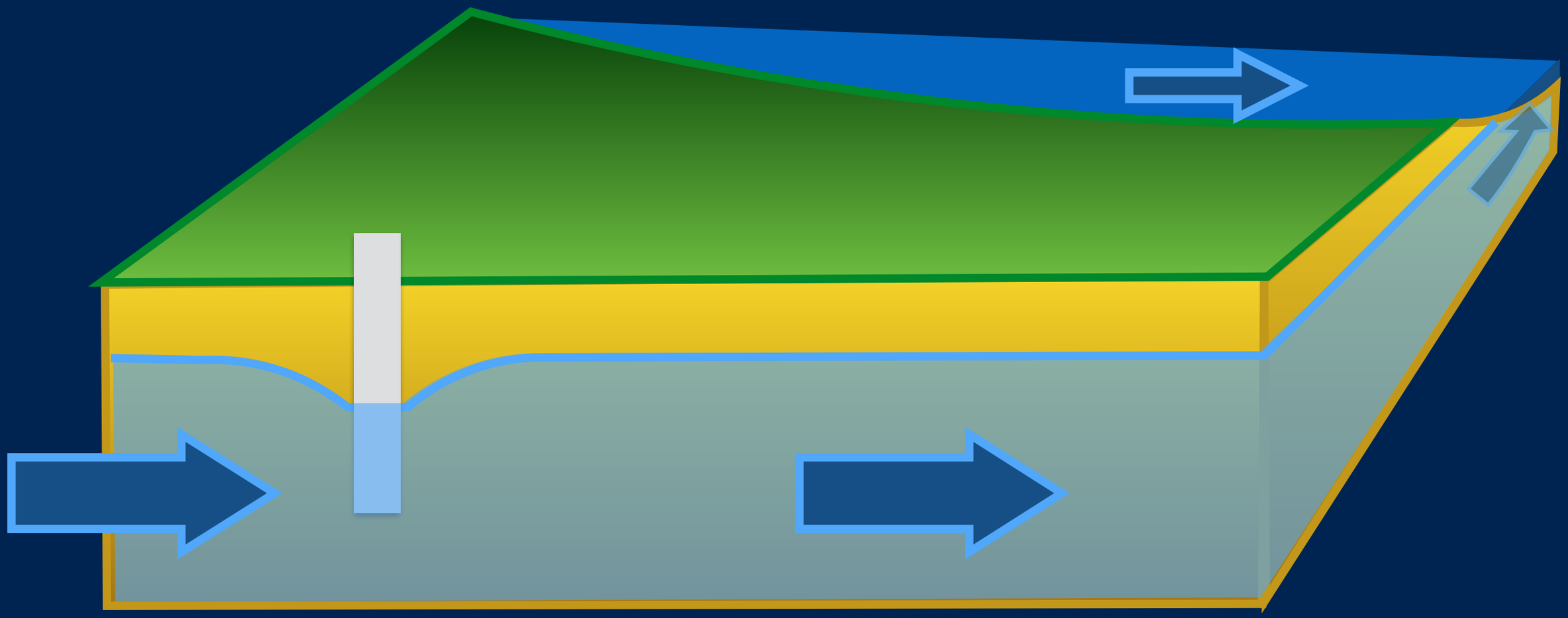
Hydraulic Continuity of Groundwater and Surface Water in the Summer



Groundwater flows into rivers and streams when streamflow is lower.

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Implications of Hydraulic Continuity

Consumptive water use (and conveyance for non-consumptive uses) reduce water pressure, levels, or flow rates in connected surface and groundwater.

The impacts can be localized, temporary, and to small to measure.

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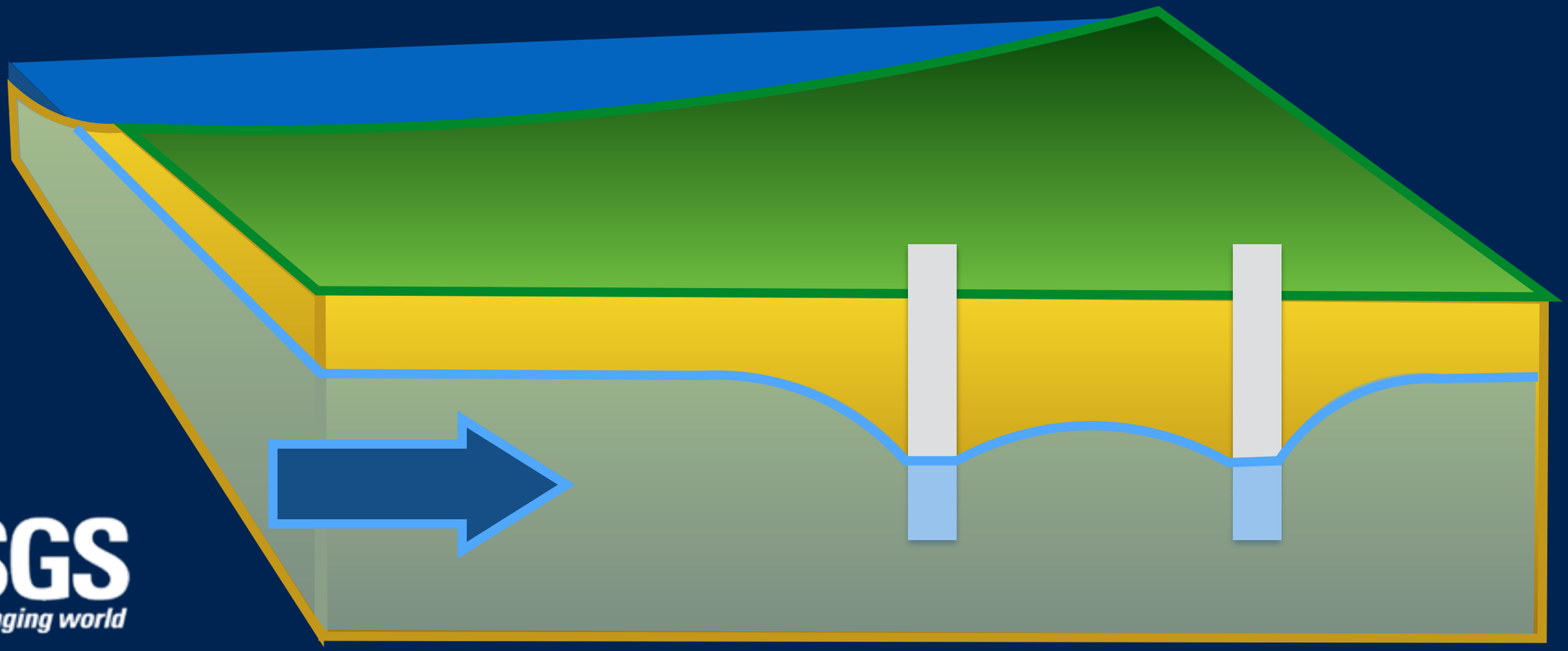
Hydraulic Continuity of Two Wells in Close Proximity

Pumping groundwater lowers the pressure or water level in the surrounding aquifer. The extent depends on the rate and duration of pumping and the transmissivity of the aquifer (how much water is flowing through the aquifer).



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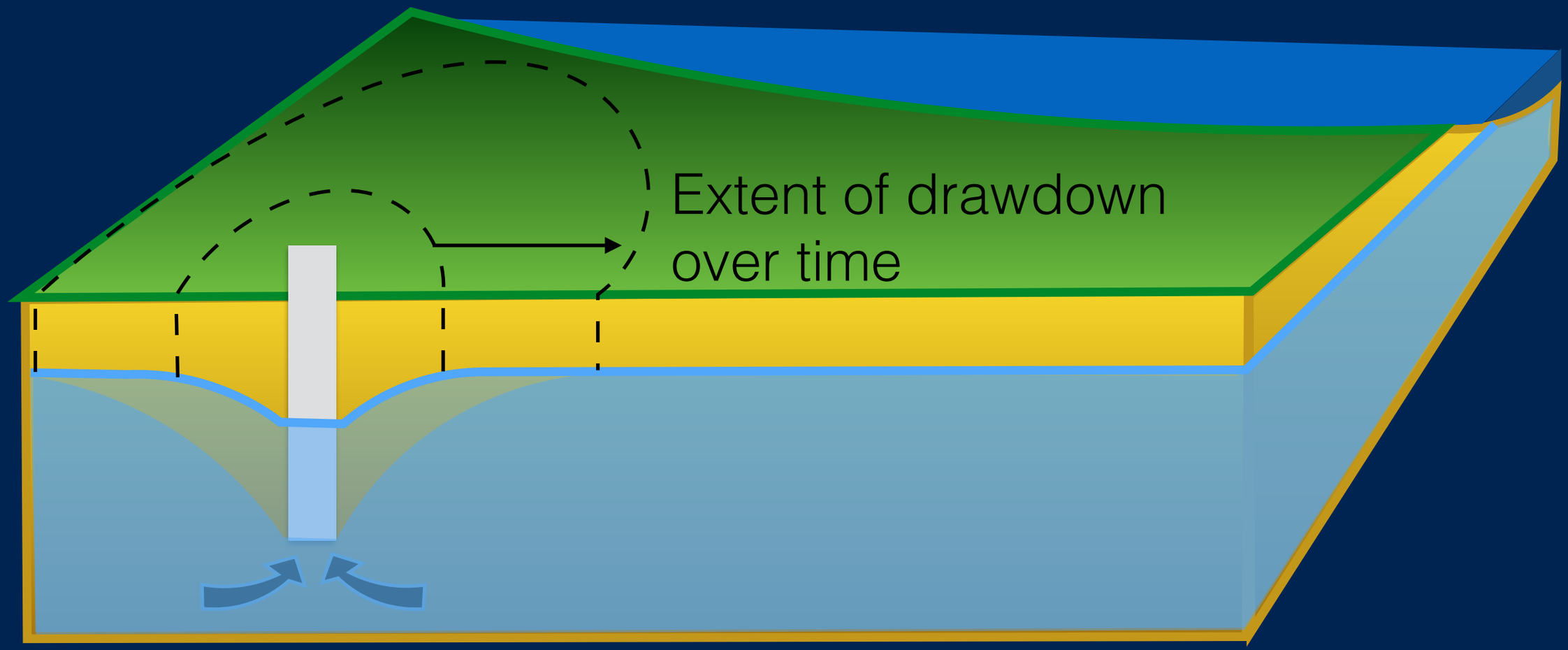
Timing of Impacts



The impact of pumping on groundwater level expands over time. The expansion will slow but the water withdrawn can still affect flow rates in neighboring groundwater and streams.

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How can we assess/anticipate impacts of water use?

We can expect an impact from water use where there is hydraulic continuity and the use changes the water level (or pressure) or the flow rate through a river, stream, or aquifer. Under these conditions, there will be a "*de minimus*" impact

The location of impacts can change seasonally (e.g., because of different flow paths).

Need to know the flow path(s) and the change in water level or flow rate to quantify the impact.

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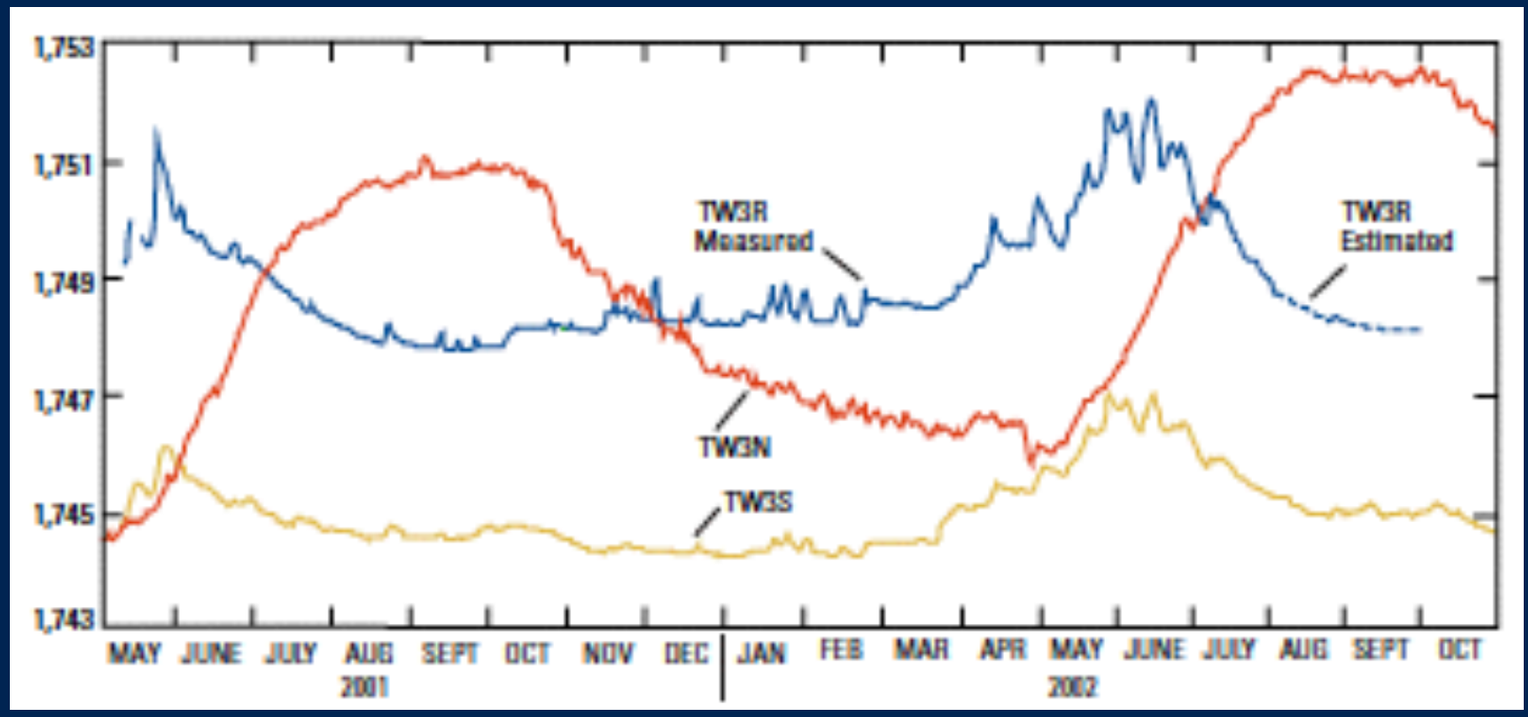
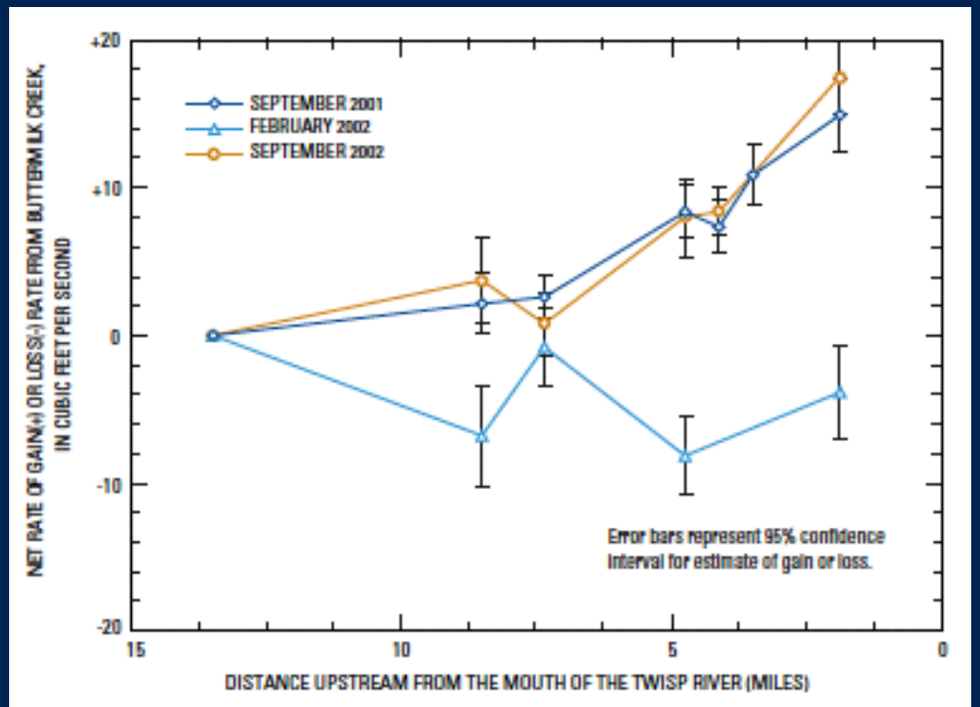
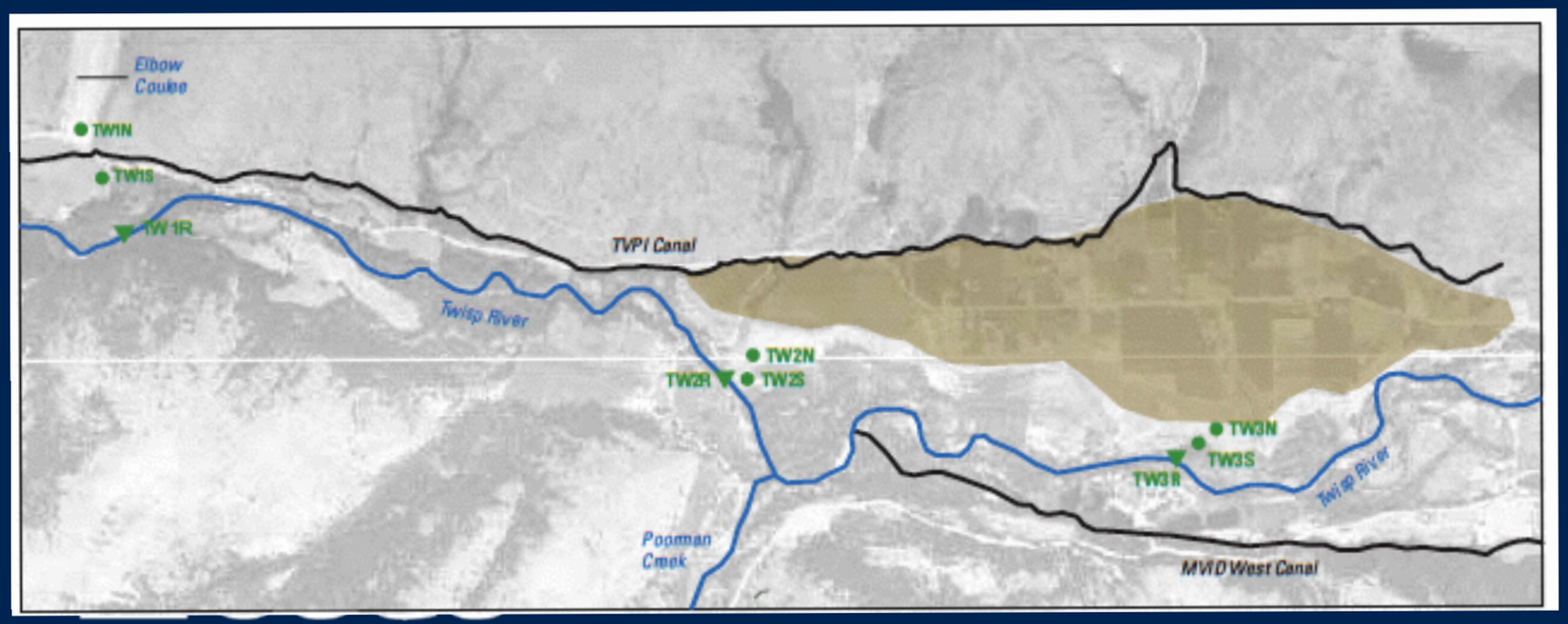
Example of Quantifying Hydraulic Continuity: Irrigation in the Twisp River Valley







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As much as 15 cfs returned to the river through groundwater during irrigation season, no impact by winter

Summary

Hydraulic Continuity is the connection between water at two locations. A flow path between the locations is necessary for hydraulic continuity.

Water use at one location can affect use at another location when there is hydraulic continuity between the locations and the uses affect water levels or flow rates.

Quantify the impacts requires mapping flow paths and estimating changes in water levels and flow rates. This is not simple when it involves groundwater, rivers, and water uses that are dynamic (change season to season).

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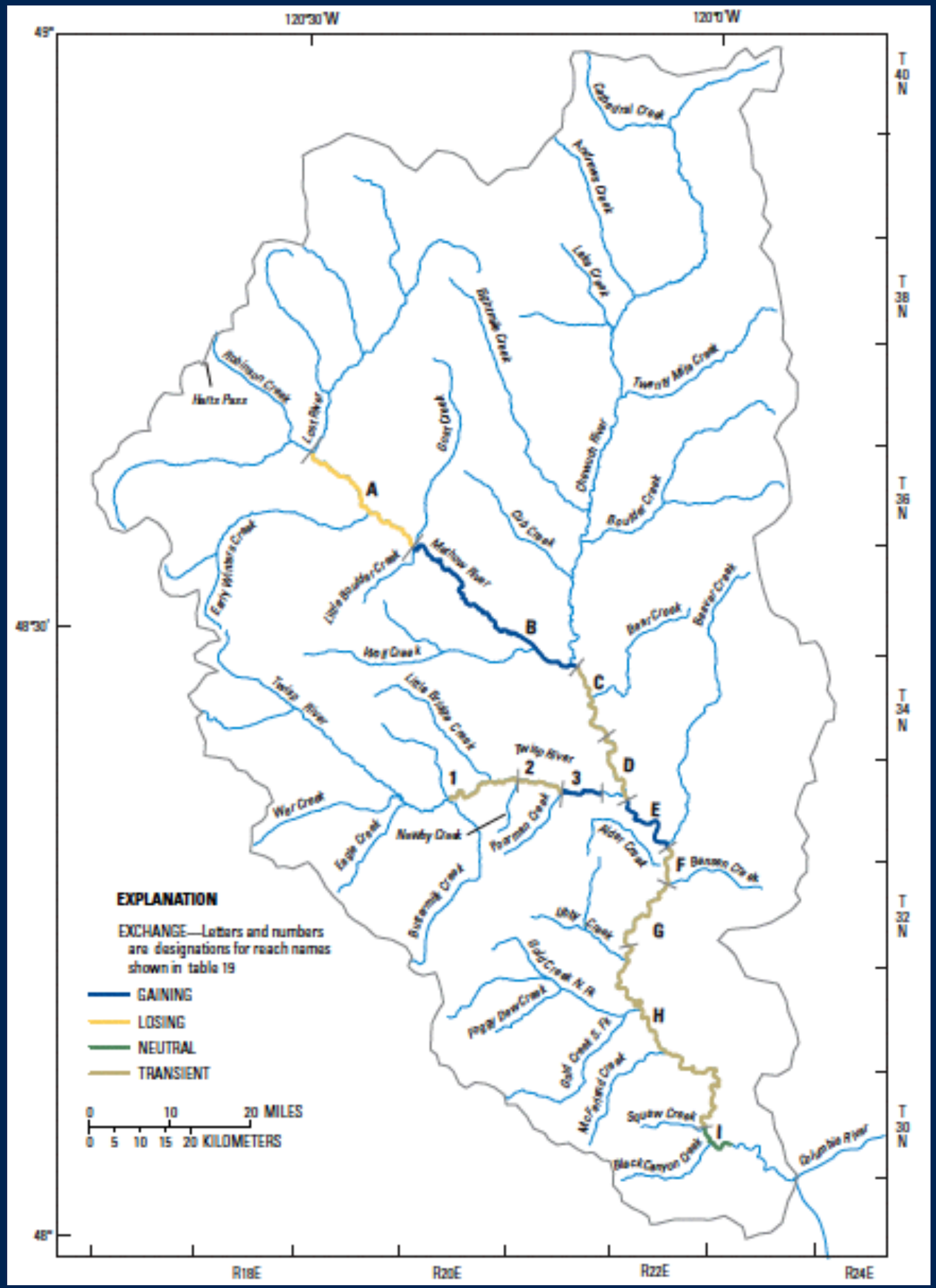
Gains and Losses of Streamflow



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