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Road Map to a Water Budget

Harney Basin Study Advisory Committee
18 January 2018

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U.S. Department of the Interior
U.S. Geological Survey

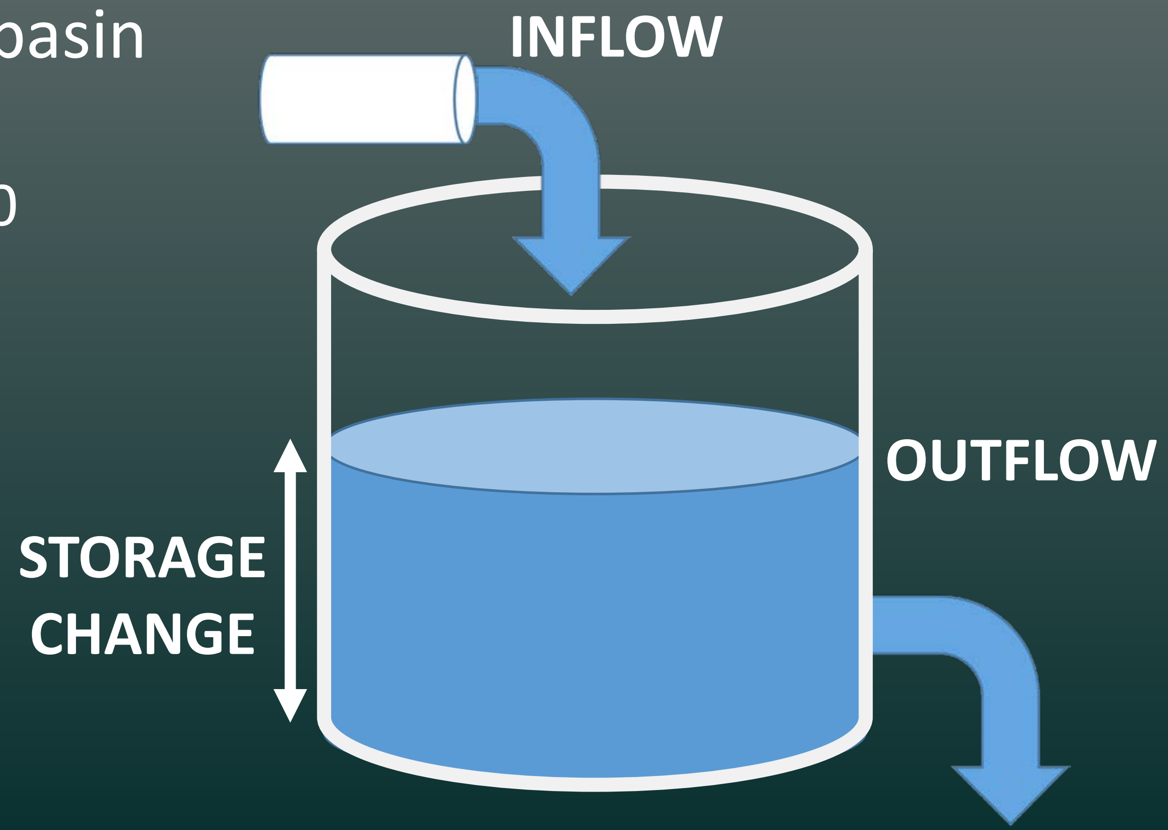
Basin Water Budget

↓INFLOW = ↑OUTFLOW ± CHANGE IN STORAGE

Steady-state closed basin

- Inflow = Outflow
- Storage change = 0

(no water-level decline)



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Water Budget Road Map

STORAGE CHANGE

- Groundwater-level change
- Lake-volume change

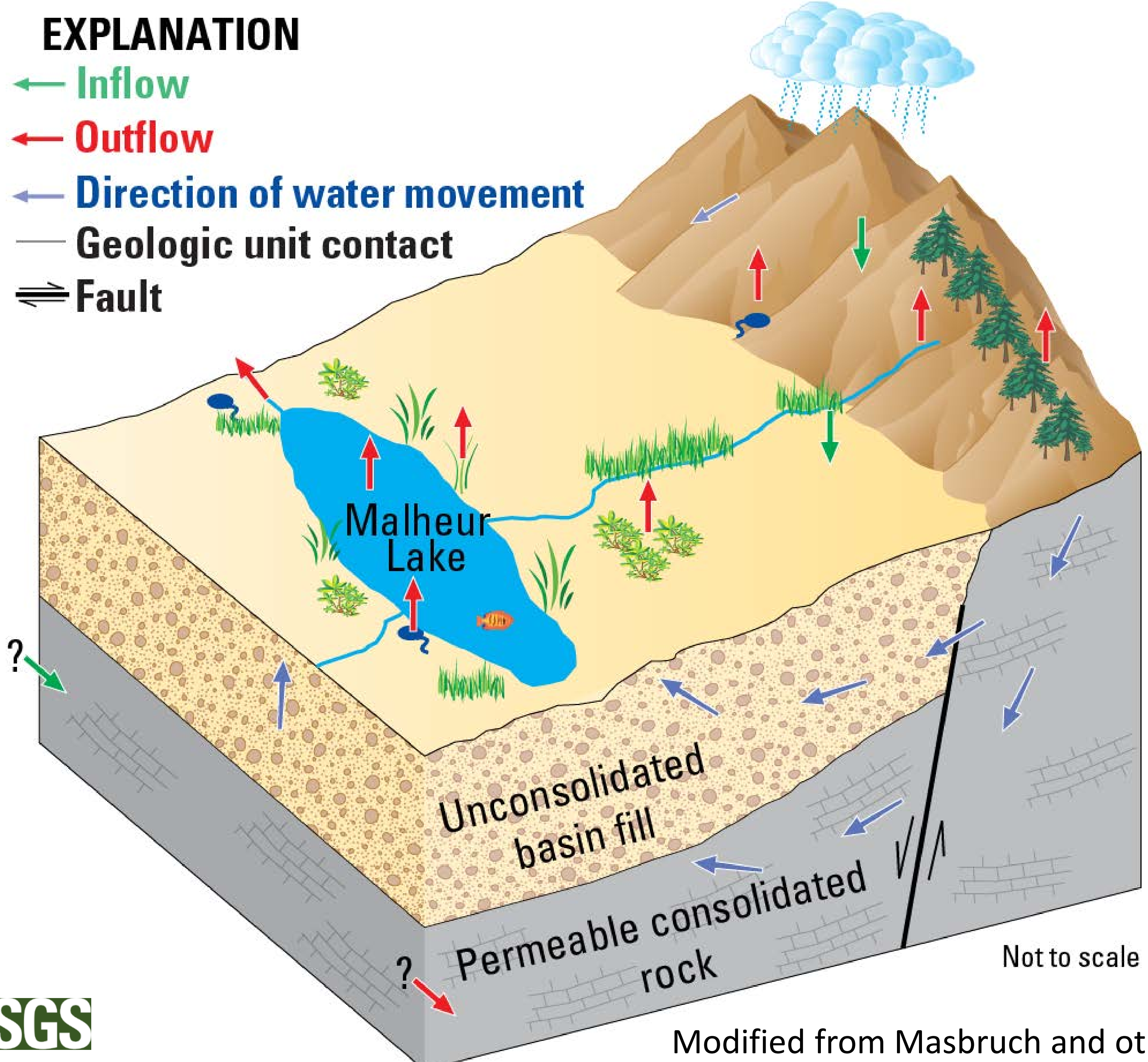
INFLOW

- Precipitation – primary
- Irrigation – secondary
- Interbasin flow?

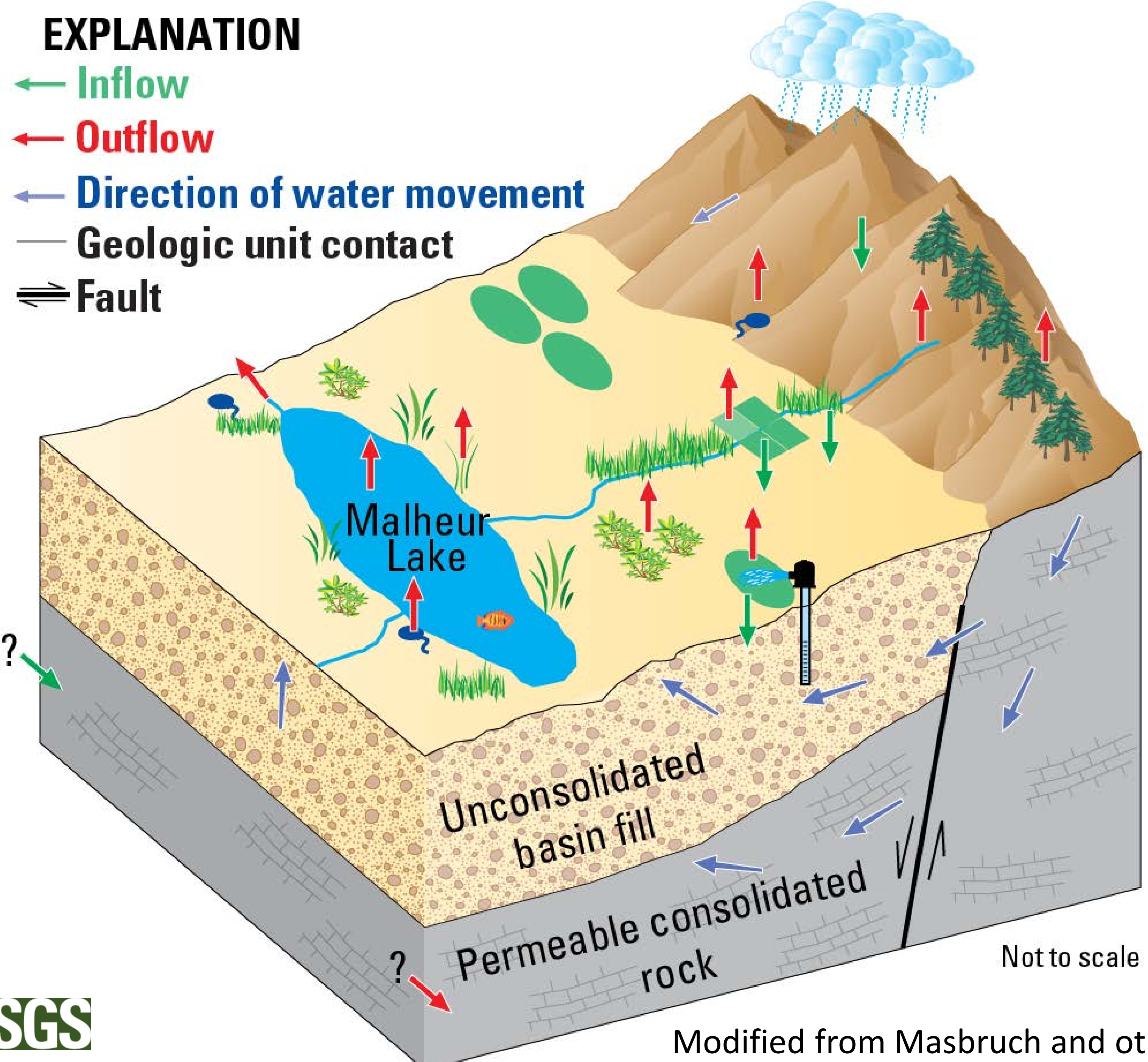
OUTFLOW

- Evapotranspiration (ET)
  - Natural
  - Irrigation
- Spring discharge
- Interbasin flow?
- Other consumptive use
  - Domestic
  - Agricultural

Image source: openclipart.org



Modified from Masbruch and others (2010)



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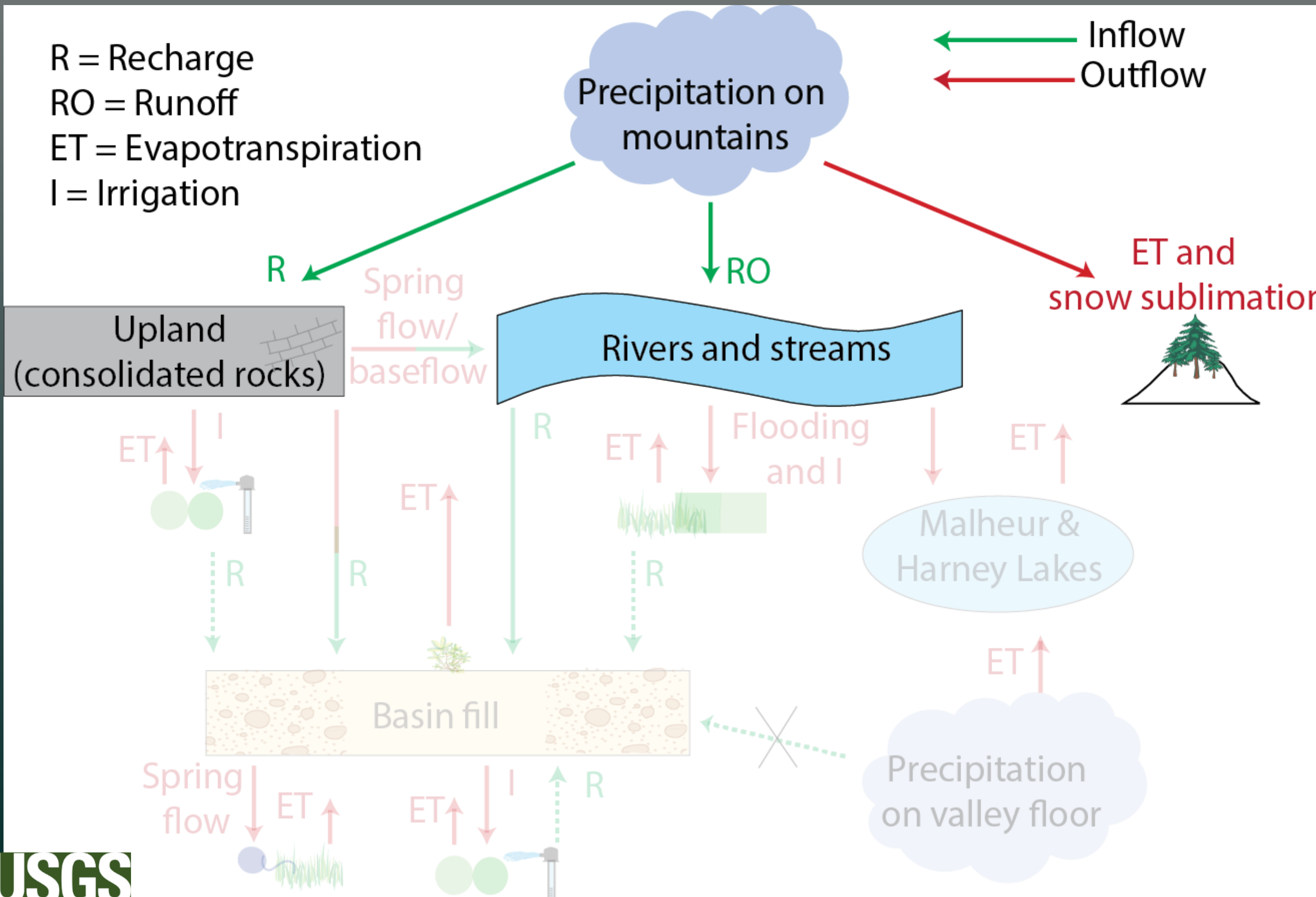
Inflow – Primary Mechanisms



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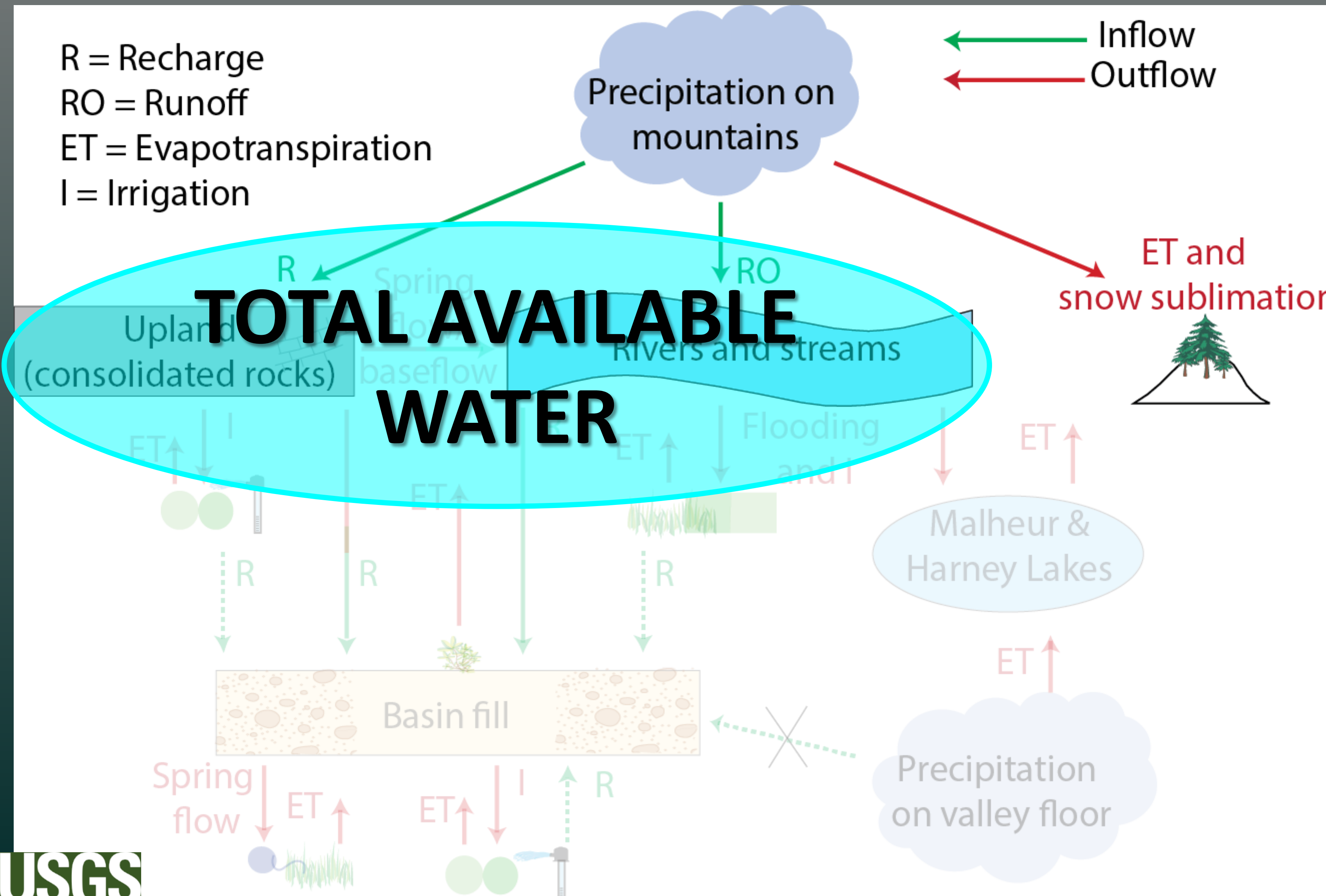


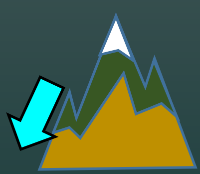
Recharge – Two Approaches

Empirical method[1]

Precipitation

× Great Basin recharge coefficient

= Runoff

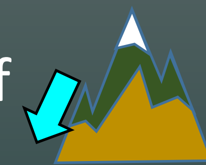


\+ Upland recharge

Soil Water Balance (SWB)[2] method

Precipitation

− Runoff



− ET

= Upland recharge

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[1]Modified Maxey-Eakin approach (Epstein and others, 2010)

[2]Westenbroek and others (2010)

Precipitation image from openclipart.org

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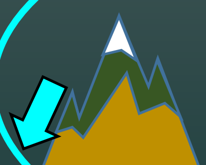


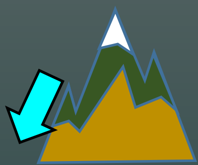
\+ Upland recharge

Total available water

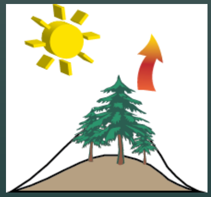
Soil Water Balance (SWB)[2] method

Precipitation

– Runoff



– ET



= Upland recharge

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Precipitation image from openclipart.org

Recharge – Two Approaches

Empirical method

- Simple
- Developed for the Great Basin
- Uses data from Harney Basin and across the Great Basin
- Single estimate represents the long-term average

SWB method

- Complex
  - Multiple datasets
  - Based on physical processes
- Uses data from Harney Basin
- Temporal component provides short- and long-term estimates

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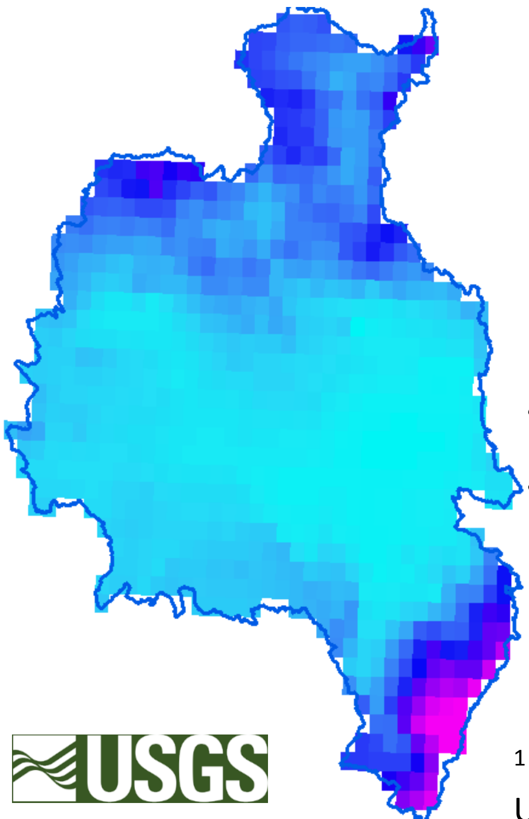
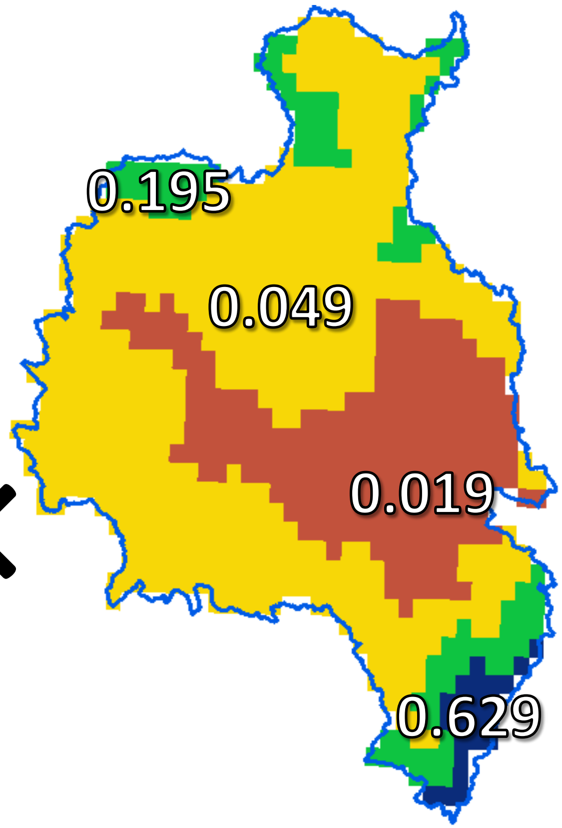
Recharge – Empirical Method

30-yr average precipitation 1961-1990[1]



×

Coefficient[2]



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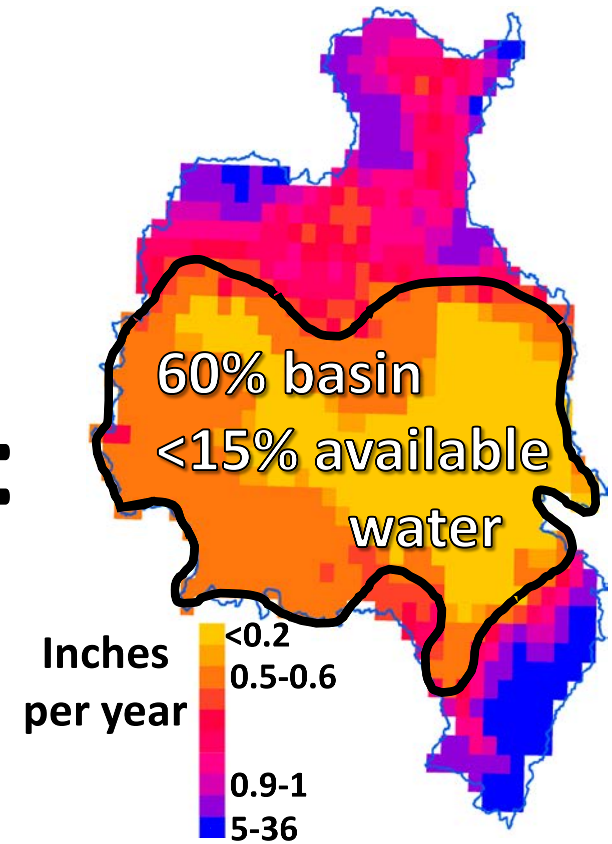
Total available water[3]



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[1]PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu

[2]Epstein and others (2010)

[3]Unpublished data subject to revision

Recharge – Two Approaches

Empirical method

Precipitation × Great Basin recharge coefficient

= Runoff + Upland recharge

Total available water

Soil Water Balance (SWB) method

Precipitation

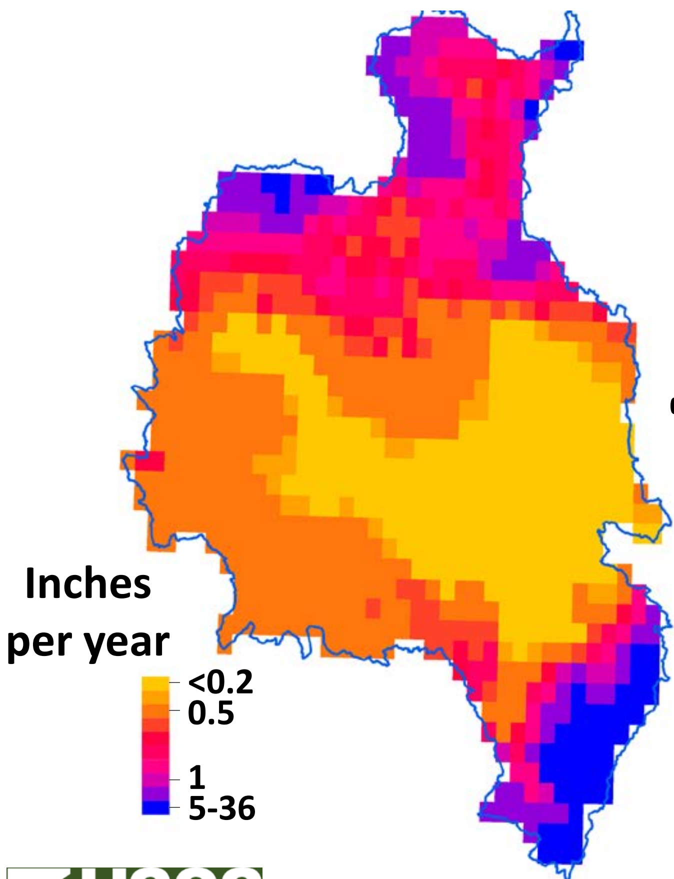
− Runoff

− ET

= Upland recharge

Recharge – Empirical Method

Total available water[1]



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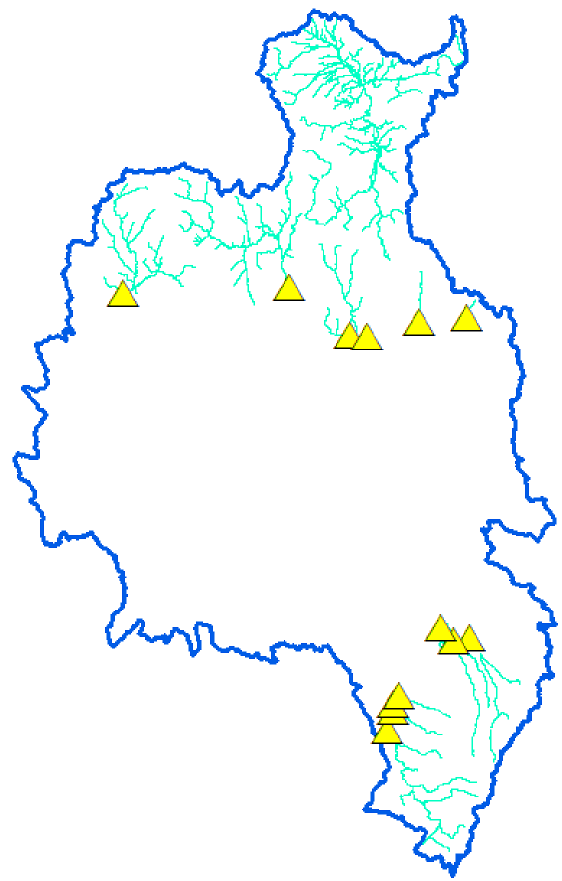
Runoff estimated from upland stream gages in Harney Basin



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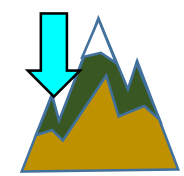
Upland recharge



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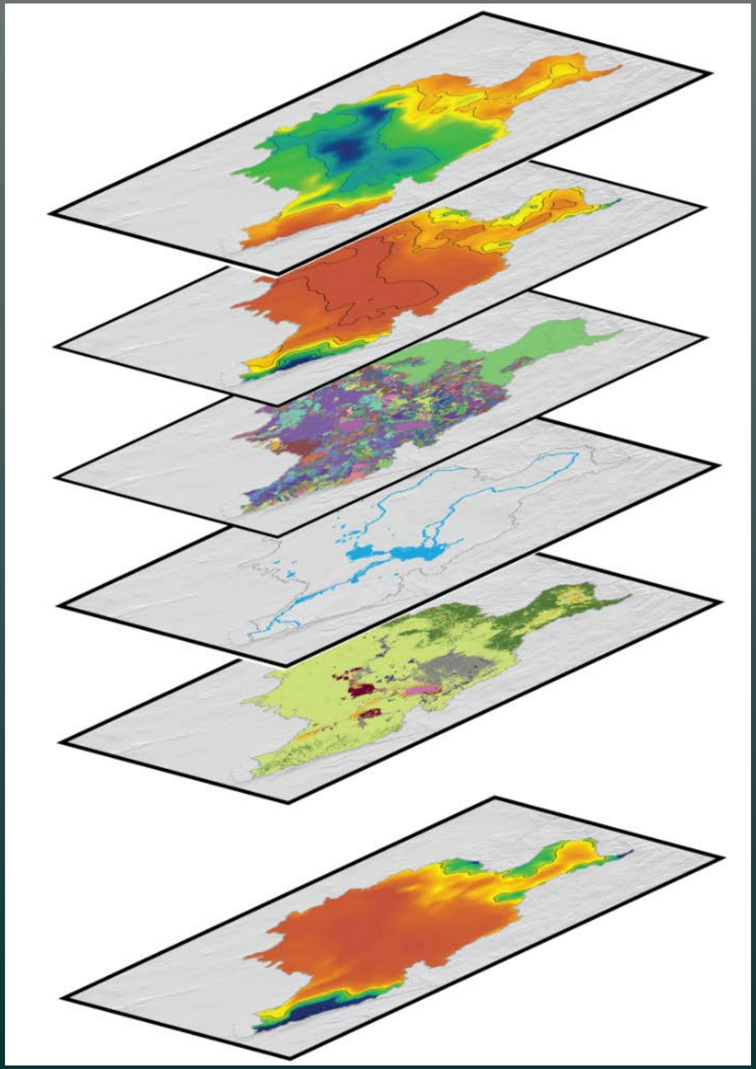


Precipitation[1]

Evapotranspiration

Soils[1]

Runoff

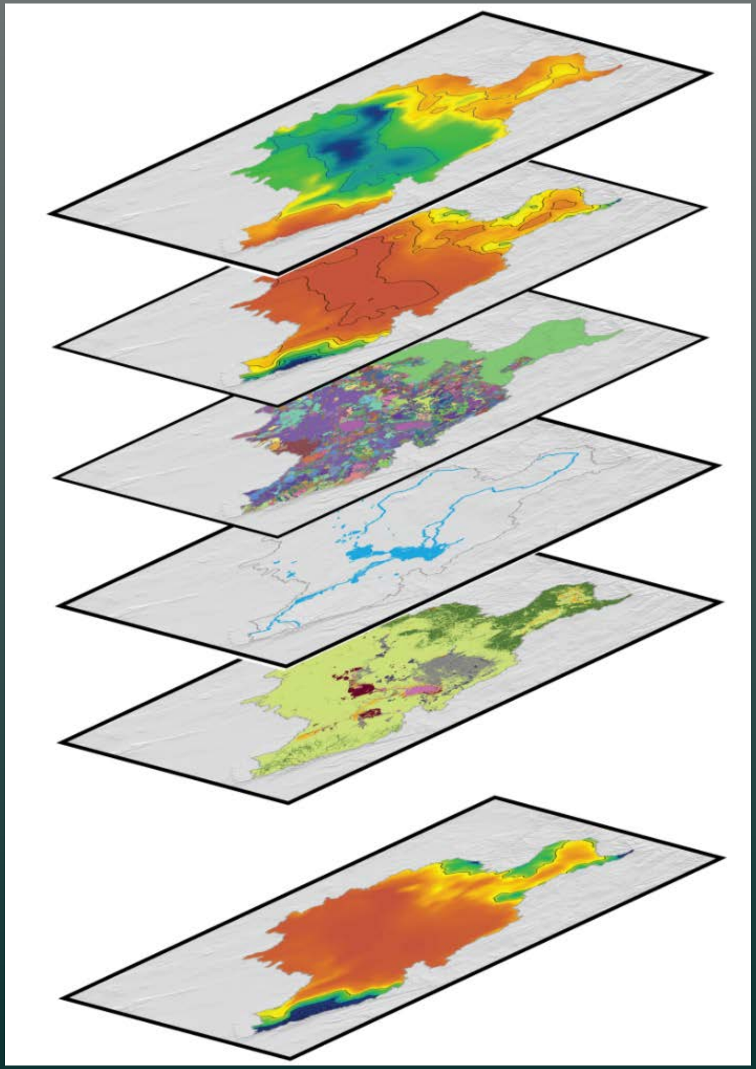
Land use[1]

↓

Upland recharge

[1]published datasets

Recharge – SWB Method



Precipitation[1]

Evapotranspiration

Soils[1]

Runoff

Land use[1]

↓

Upland recharge

[1]published datasets

SWB – Runoff Estimation

Based on long-term stream-gage measurements in Harney Basin

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SWB – ET Estimation

Potential ET[1]

Solar radiation

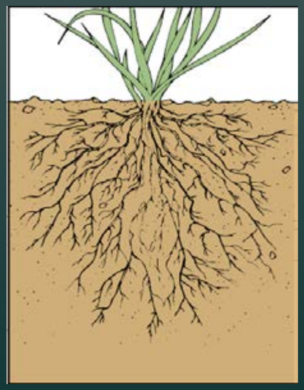
Temperature

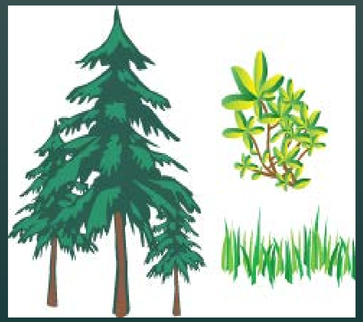
ET limiting factors

Precipitation

Soil: moisture, depth, type

Vegetation type





[1]Hargraves and Samani (1985)
Precipitation, sun, and thermometer images from openclipart.org
Soil-root picture from jcruz661.wikispaces.com

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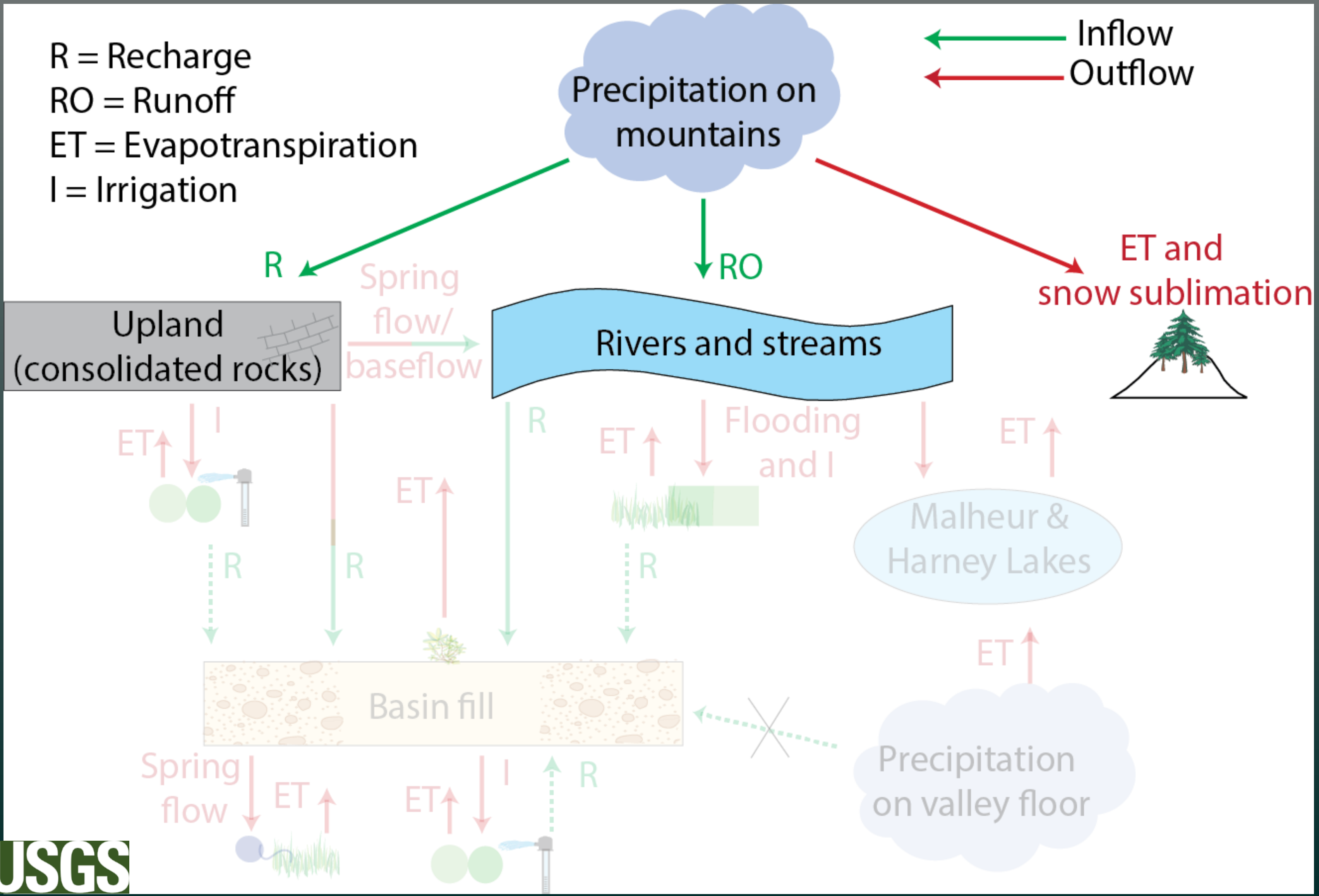

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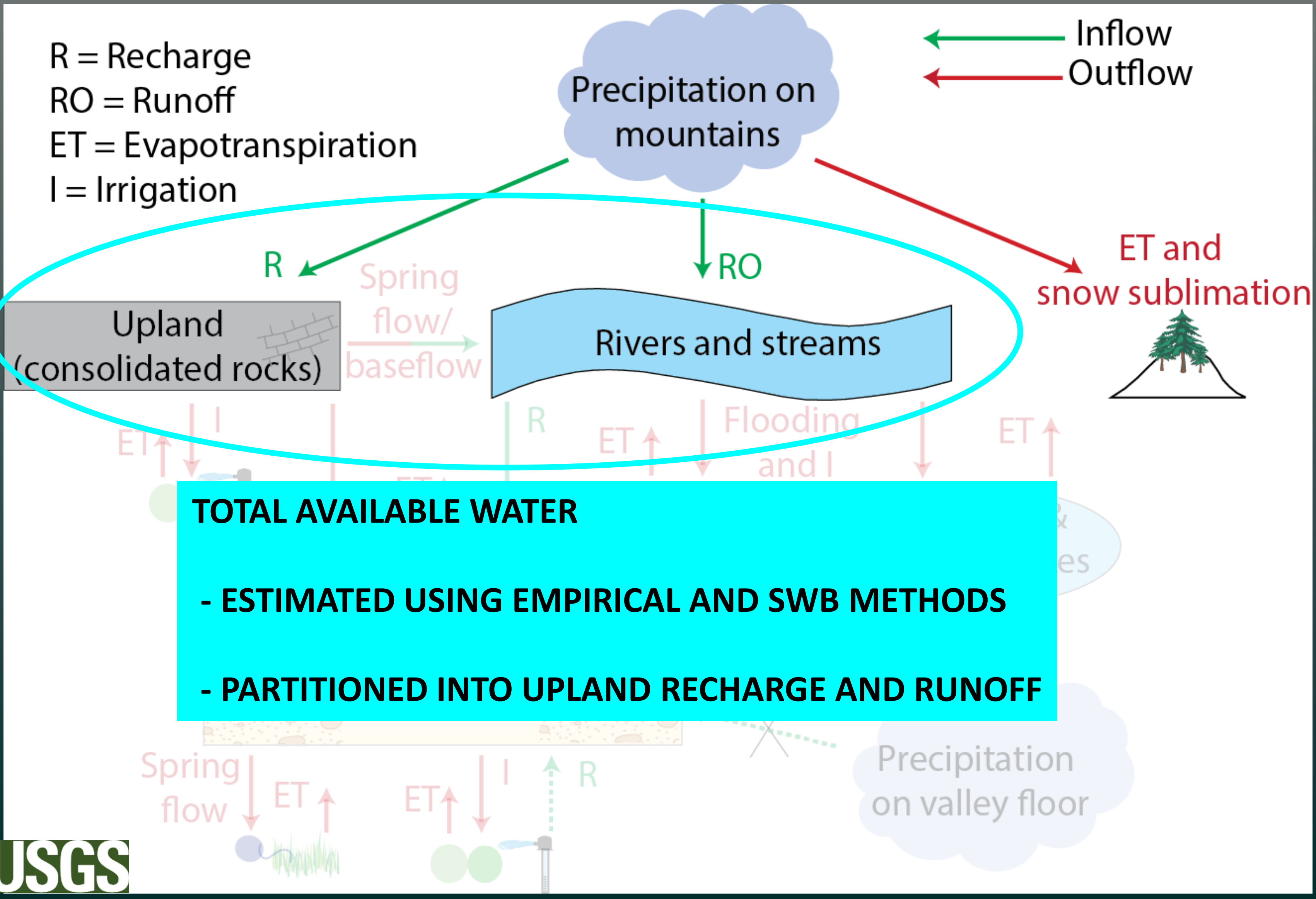
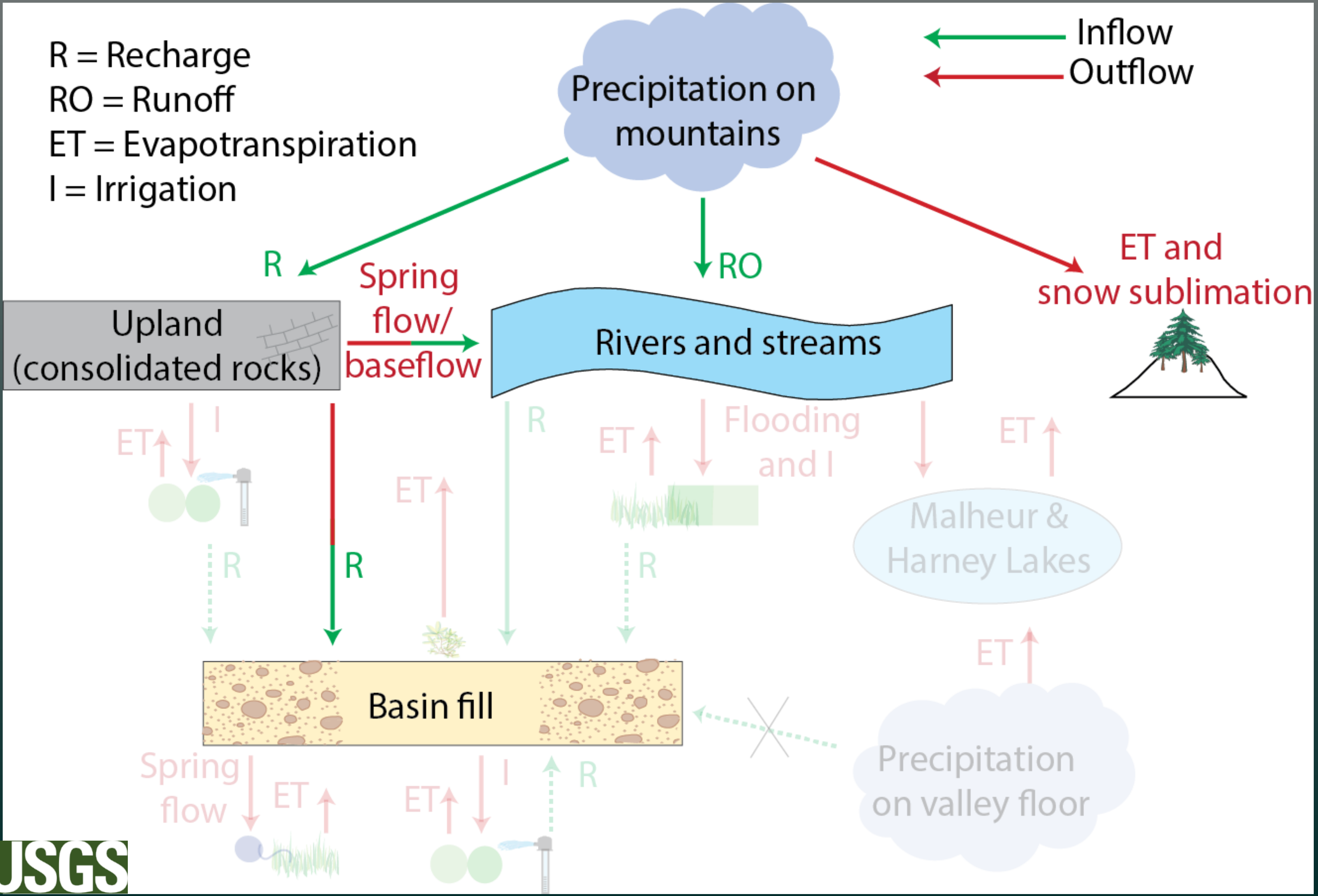


TOTAL AVAILABLE WATER

- ESTIMATED USING EMPIRICAL AND SWB METHODS

- PARTITIONED INTO UPLAND RECHARGE AND RUNOFF

Inflow – Primary Mechanisms



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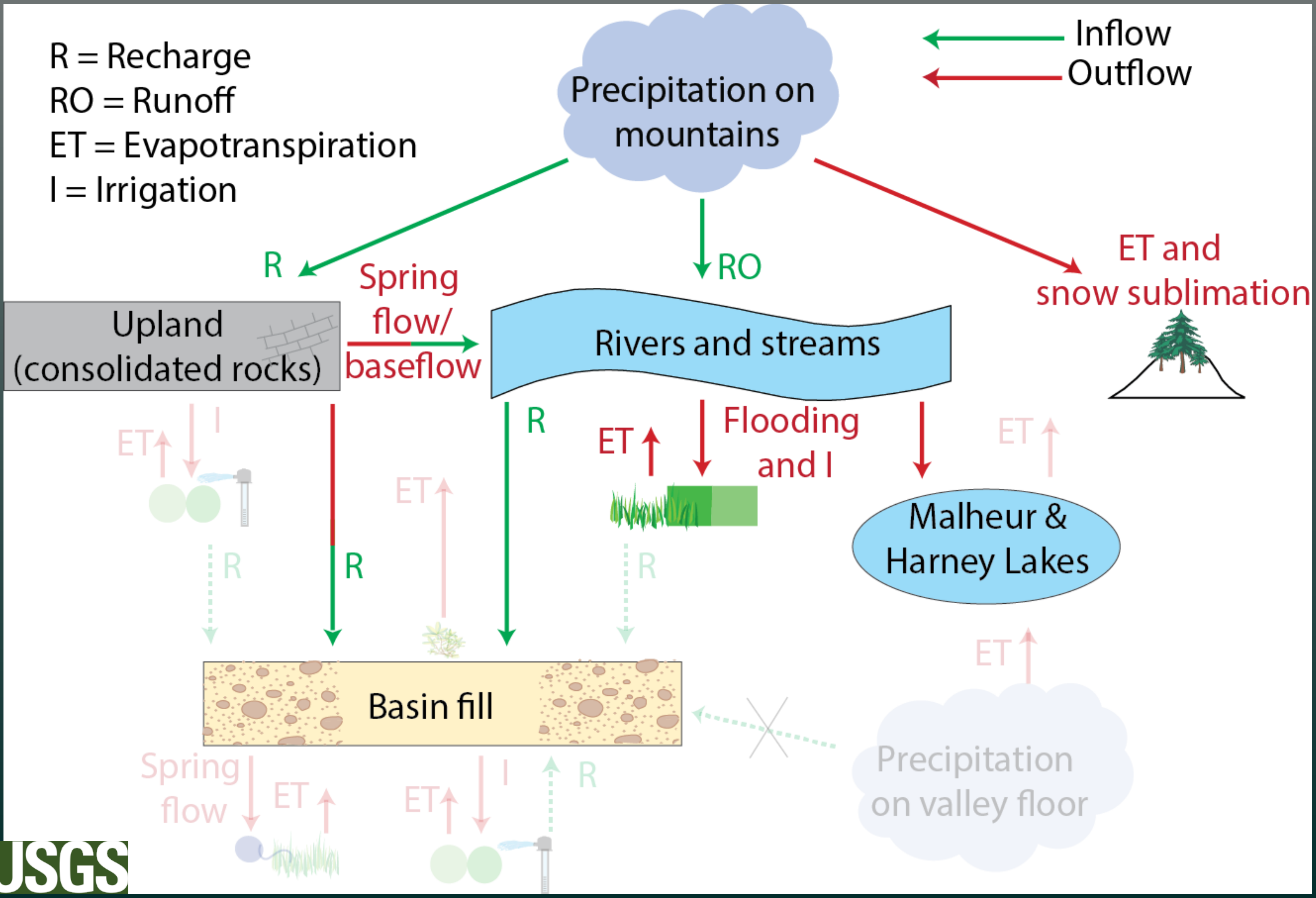

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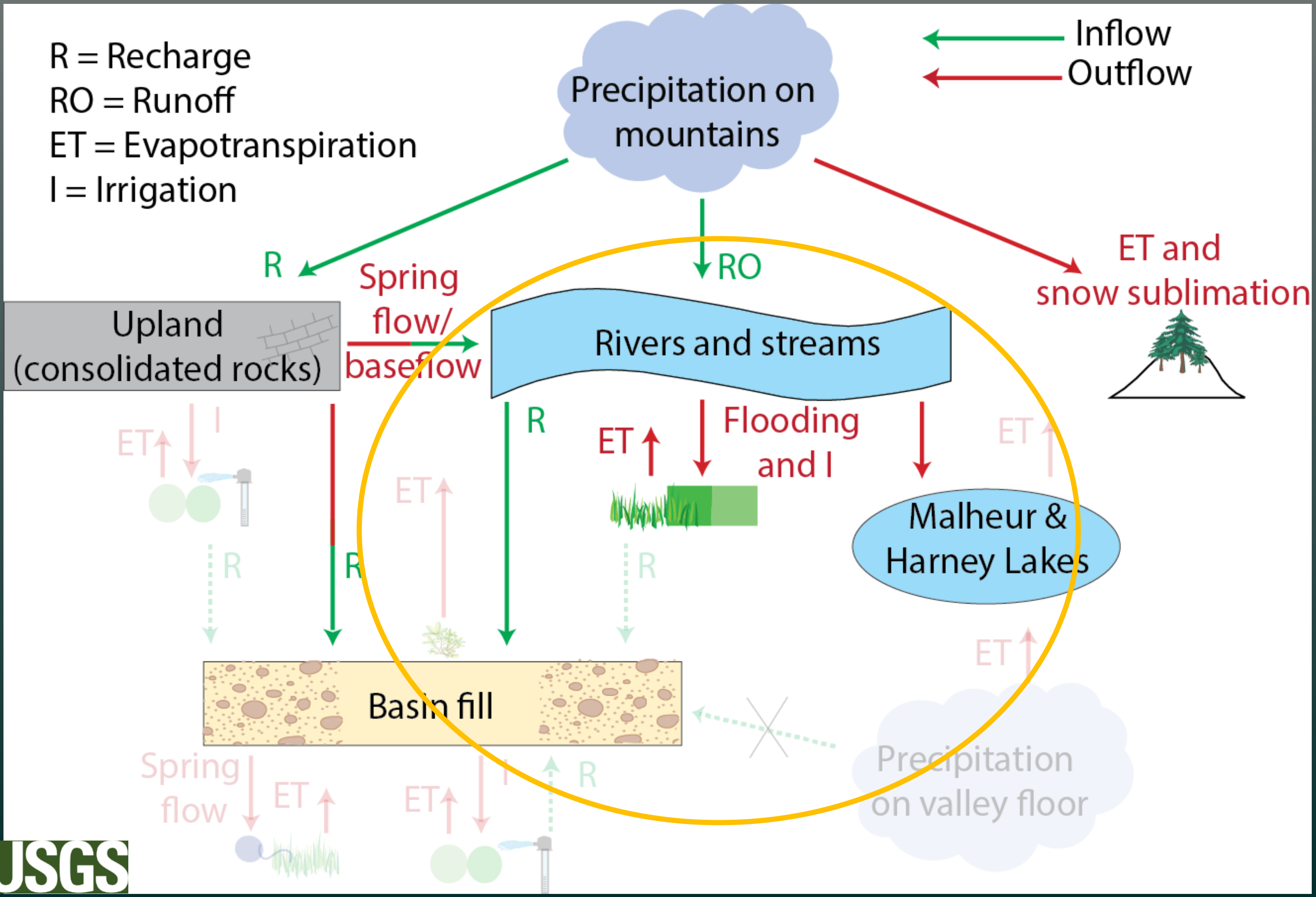

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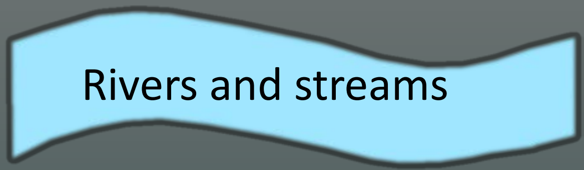
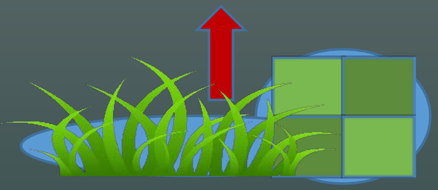
Streamflow Partitioning

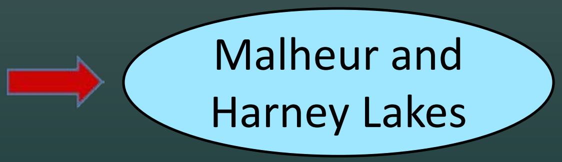
Streamflow



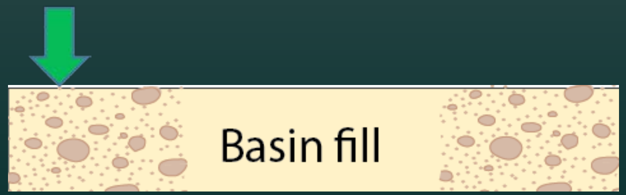
– ET from surface-water flooding and irrigation



– Streamflow to lakes



Basin-fill recharge



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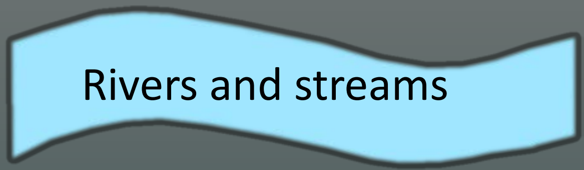

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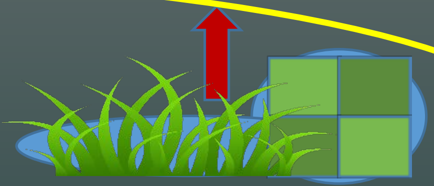

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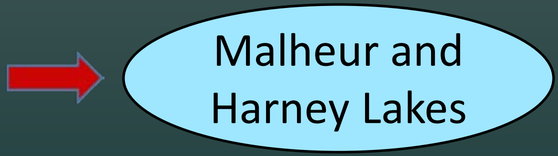

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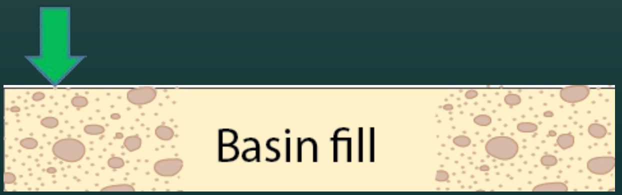

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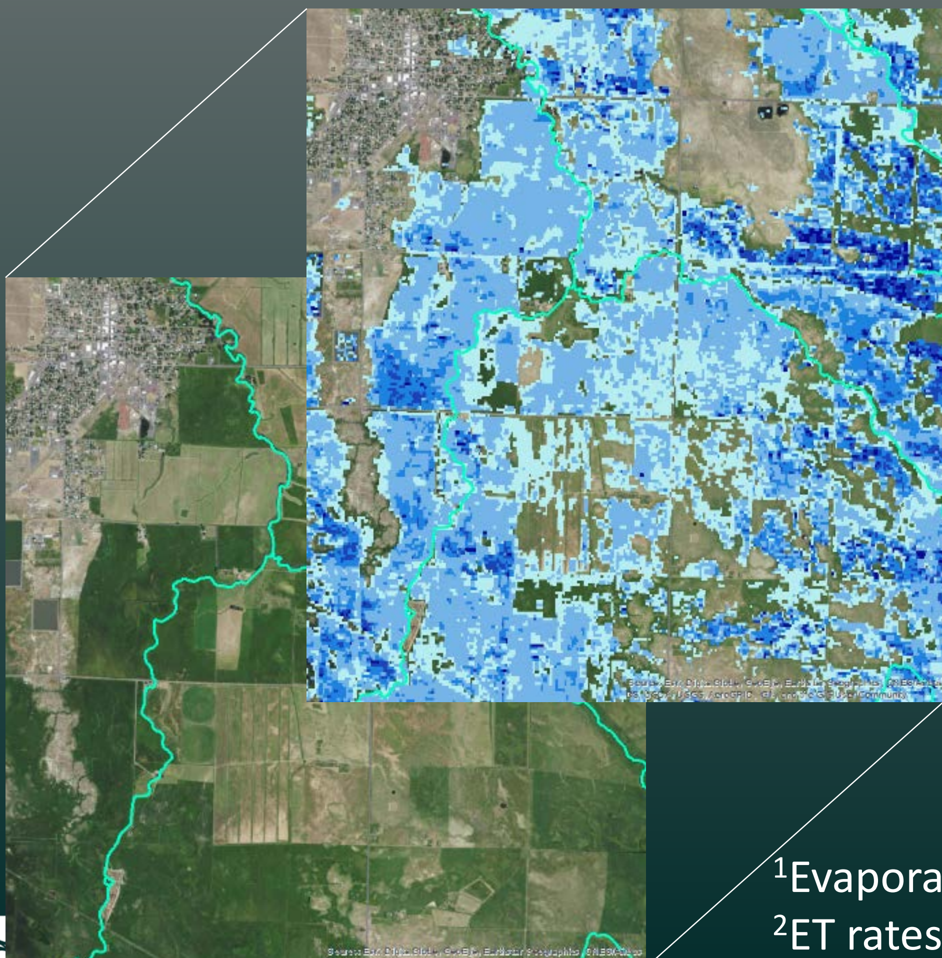
ET from Surface-Water Flooding and Irrigation

Map flooded areas using Landsat images



Evaporation of open water during inundation[1]

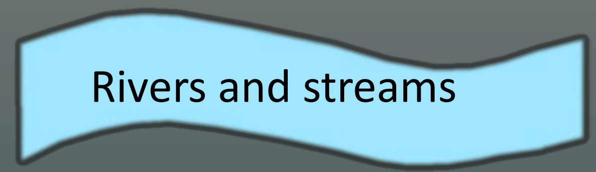
ET from flooded or irrigated vegetation and soil[2]

[1]Evaporation rates from published datasets

[2]ET rates from published datasets and satellite imagery

Streamflow Partitioning

Streamflow



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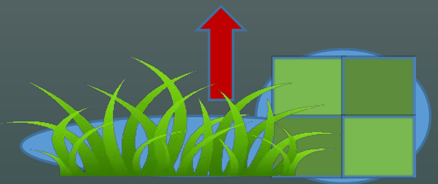

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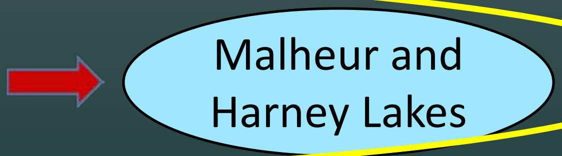

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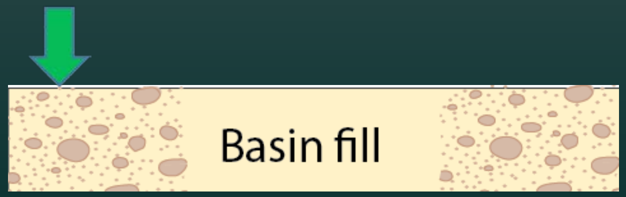

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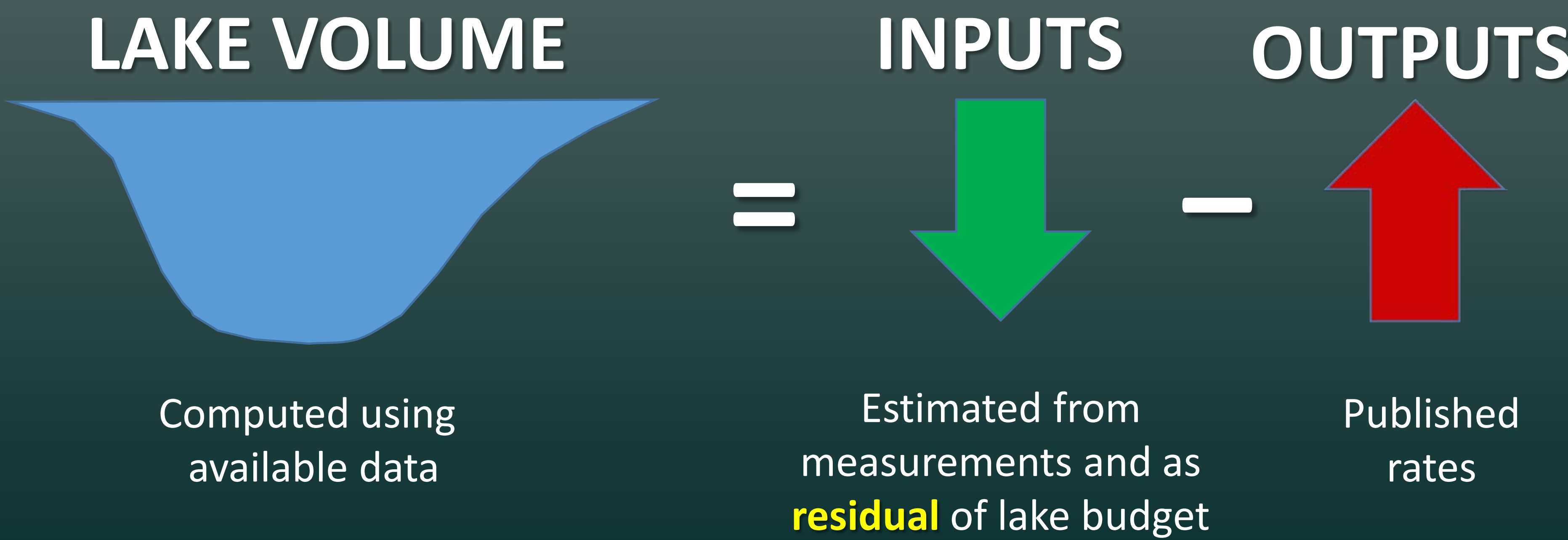
Streamflow to the Lakes

- Difficult to measure
- Estimated as a residual to lake water budgets



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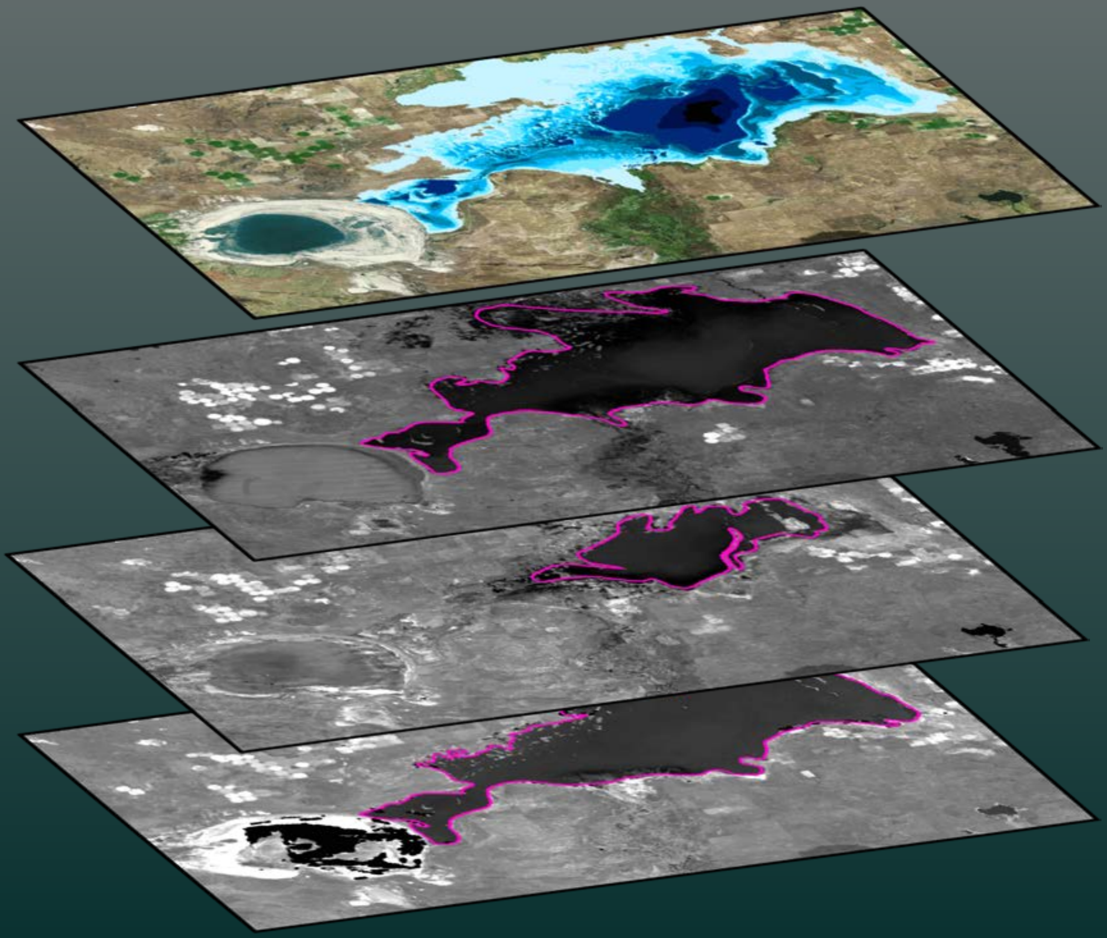
Streamflow to the Lakes – Lake Volume



LiDAR-based bathymetry (USFWS)

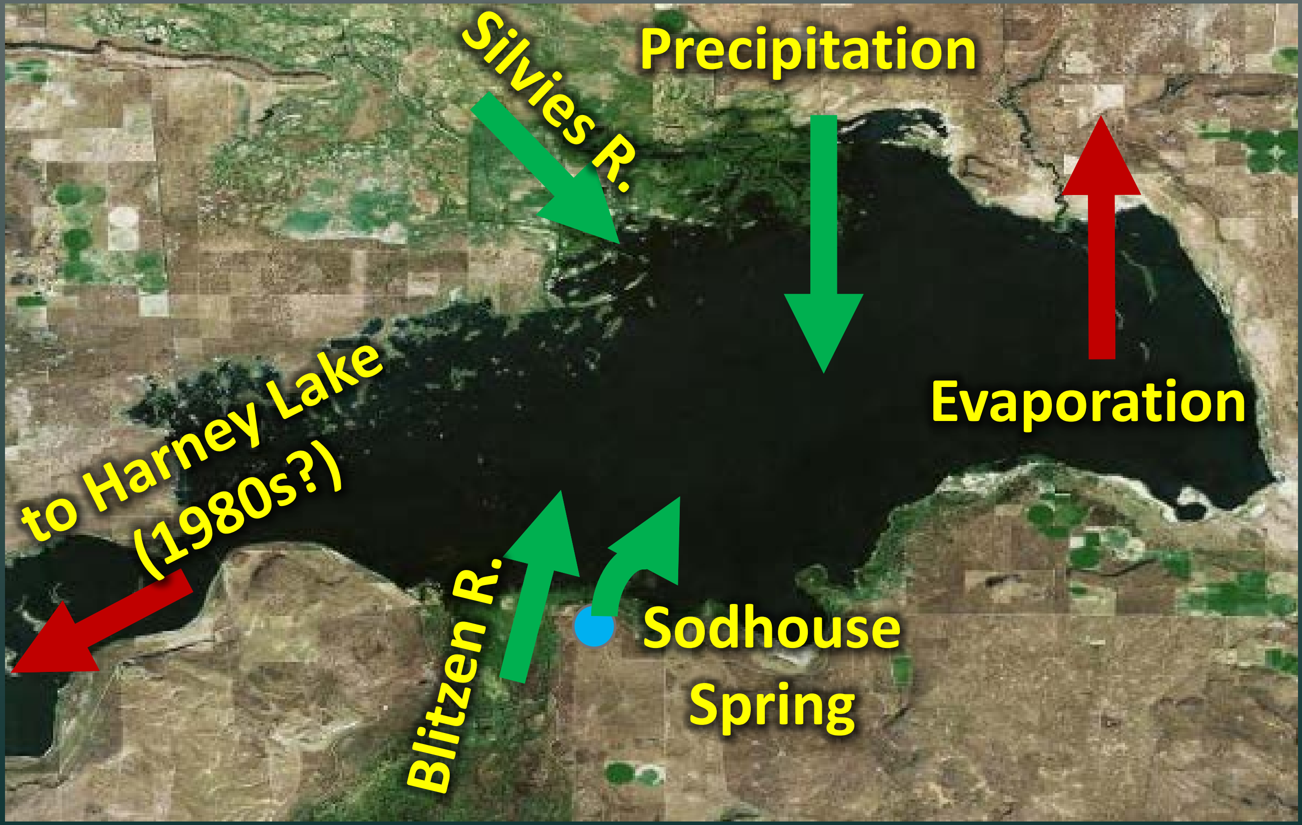
Lake area time series from satellite imagery (USFWS, USGS)

↓

Lake volume time series

Streamflow to the Lakes – Inputs and Outputs

Malheur Lake Example



Precipitation and evaporation: published datasets

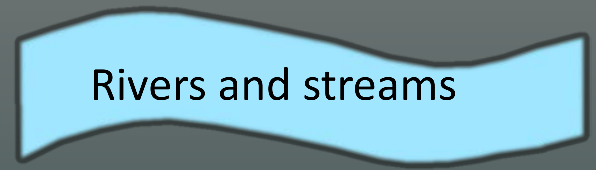
Blitzen: 1937-1977, 2001-present

Sodhouse spring: discrete measurements (1900s, 1930s, 1970s, 1980)

Silvies: 1972-1977

Streamflow Partitioning

Streamflow



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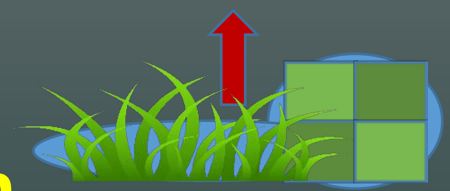

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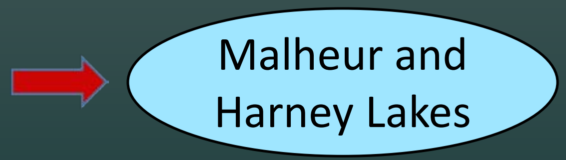

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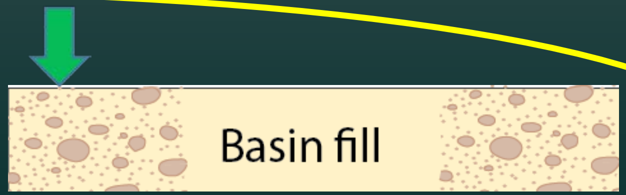

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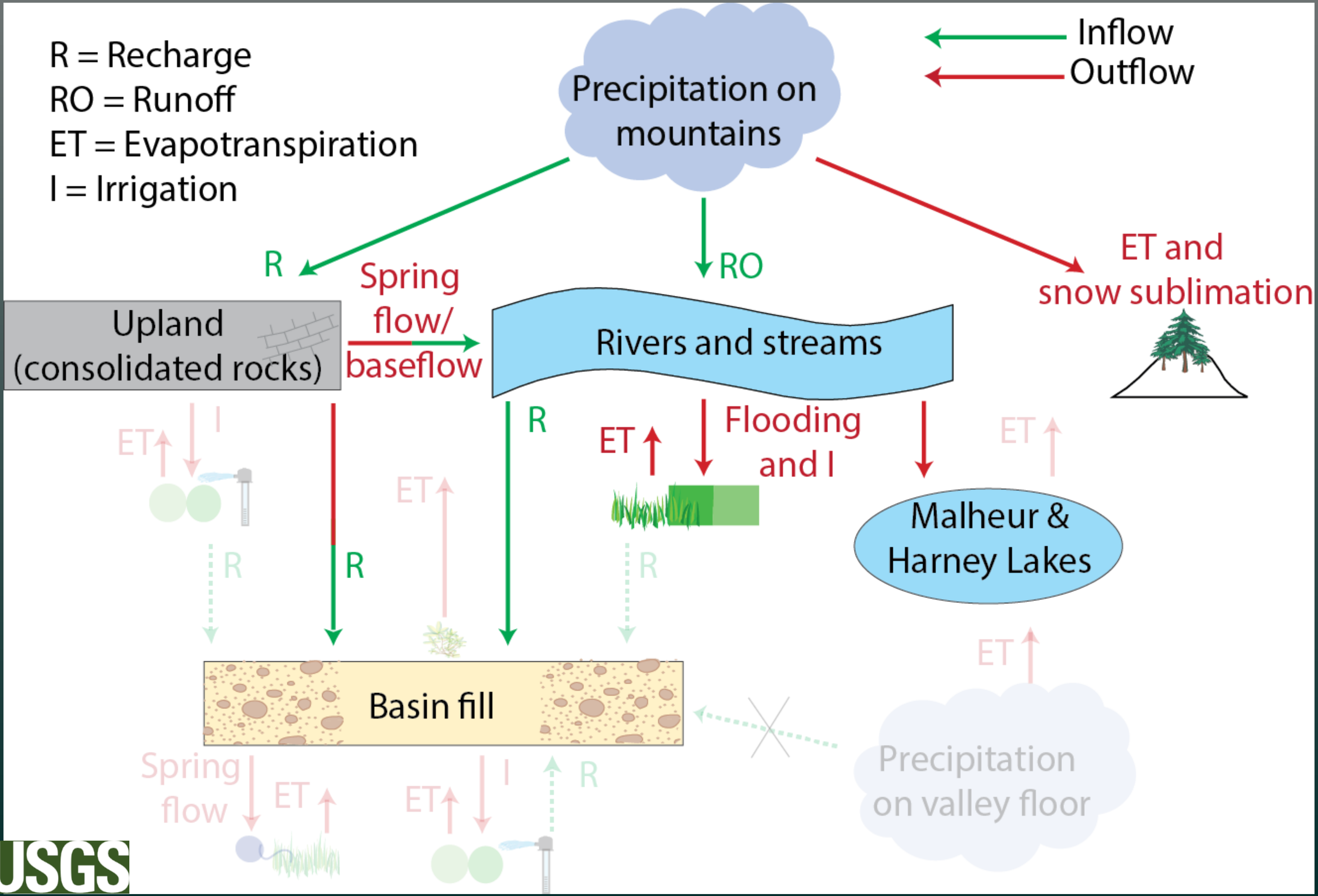
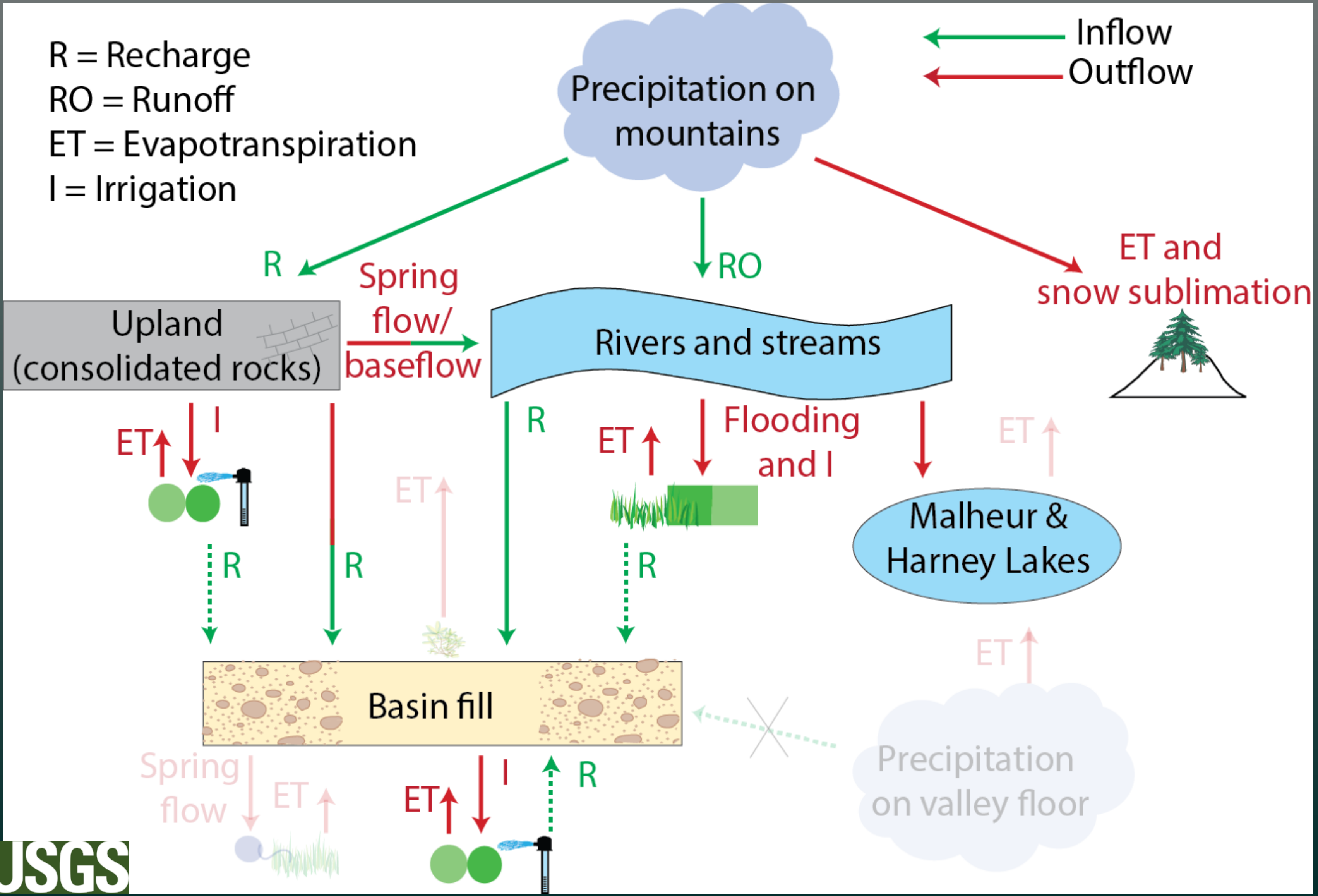


Inflow – Primary and Secondary Mechanisms



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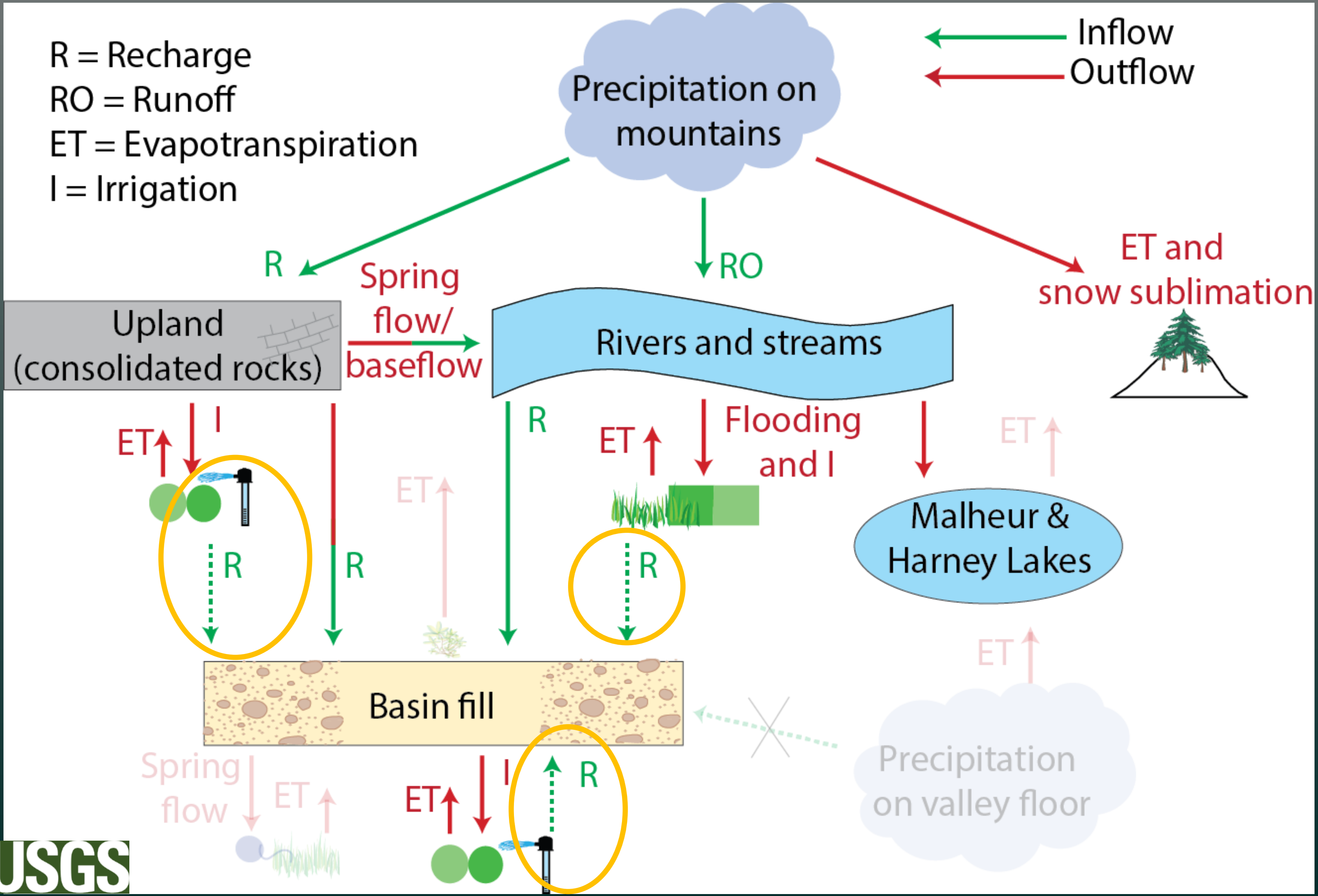

Inflow and Outflow

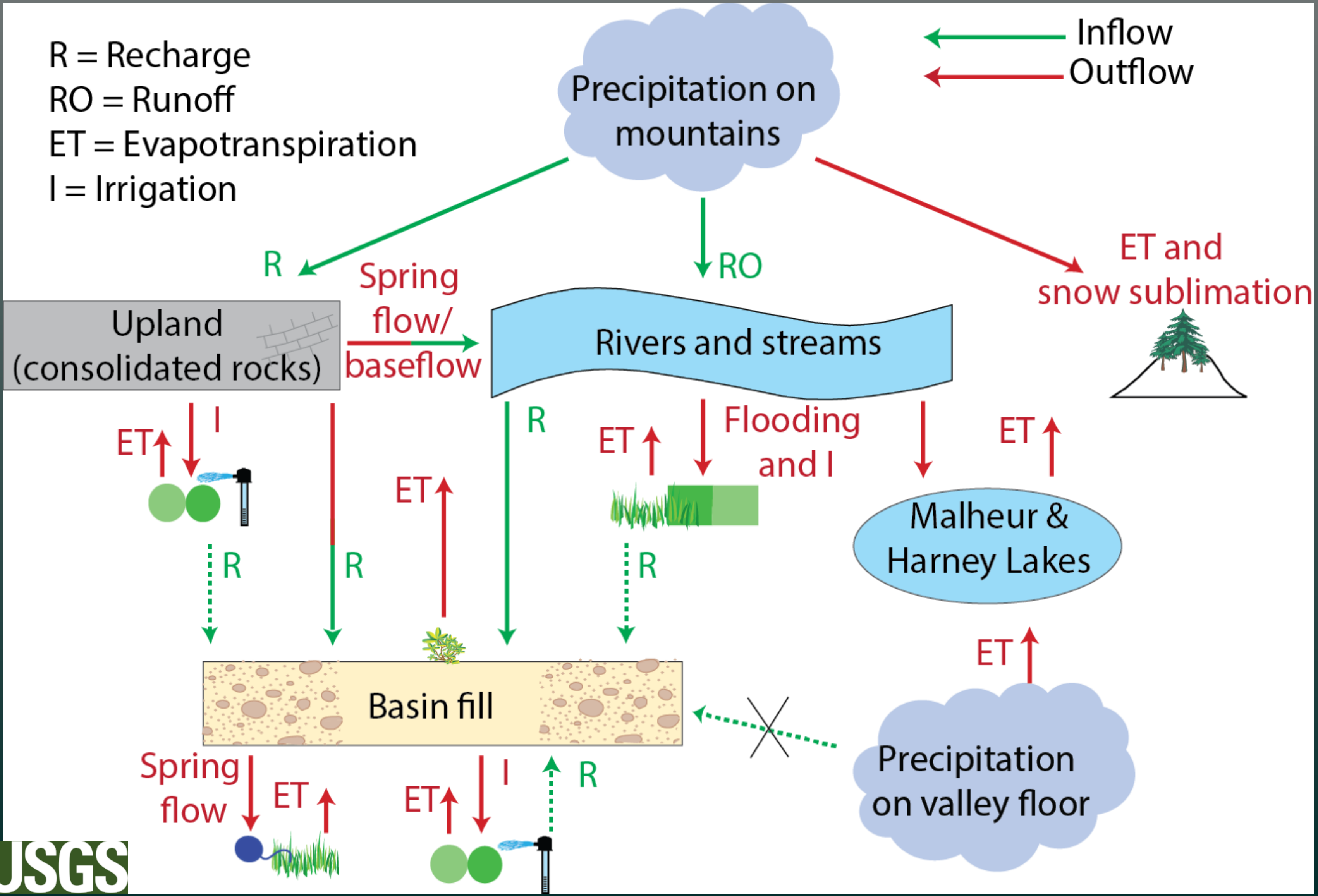

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Image source: openclipart.org

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Image source: openclipart.org

Upcoming 2018 SAC Meetings

- Estimating additional water-budget components
  - Outflow
    - ET from natural and irrigated areas
    - Spring discharge
    - Interbasin flow?
  - Storage change from groundwater levels
- Preliminary estimates when available

USGS

References

Epstein, B.J., Pohll, G.M., Huntington, J., and Carrol, R.W.H., 2010, Development and uncertainty analysis of an empirical recharge prediction model for Nevada's Desert Basins: Journal of Nevada Water Resources Association, v. 5, no. 1, 79 p.

Masbruch, M.D., Heilweil, V.M., Buto, S.G., Brooks, L.D., Susong, D.D., Flint, A.L., Flint, L.E., and Gardner, P.M., 2011, Chapter D: Estimated groundwater budgets, *in* Heilweil, V.M., and Brooks, L.E., eds., Conceptual model of the Great Basin carbonate and alluvial aquifer system: U.S. Geological Survey Scientific Investigations Report 2010-5193, 191 p. Available online at: https://pubs.usgs.gov/sir/2010/5193/PDF/GreatBasinChapterD.pdf.

PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, retrieved December 2017.

Westenbroek, S.M., Kelson, V.A., Dripps, W.R., Hunt, R.J., and Bradbury,K.R., 2010, SWB—A modified Thornthwaite-Mather Soil-Water-Balance code for estimating groundwater recharge: U.S. Geological Survey Techniques and Methods 6–A31, 60 p. Available online at: https://pubs.usgs.gov/tm/tm6-a31/.

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