# Irrigation Water Reuse Reduces Effectiveness of Modernizing Irrigation Technologies, when not Coupled with Enhanced Aquifer Recharge: Example from the Upper Snake River Basin, USA

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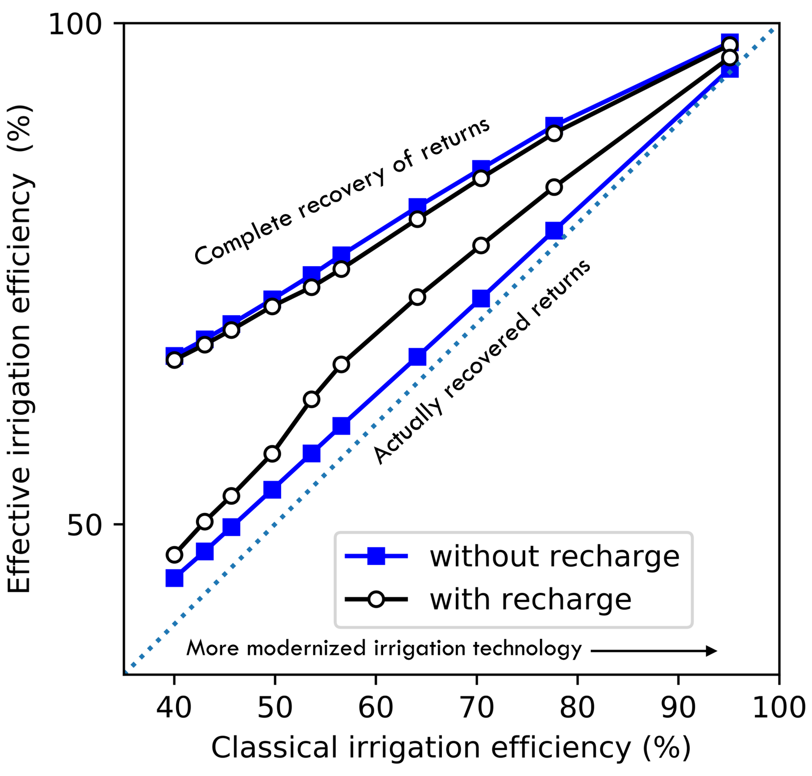
## *Knowledge Gap*

Modernizing irrigation technology and implementing Enhanced Aquifer Recharge are adaptations to reduce drawdown in stressed aquifers. *How does modernizing irrigation technology reduce the system scale **reuse** of incidental returns, and does **recharge** mitigate the loss of this "source" of water?*

*Effective Irrigation Efficiency increased more slowly than Classical Irrigation Efficiency when **simulated technologies** were modernized.*

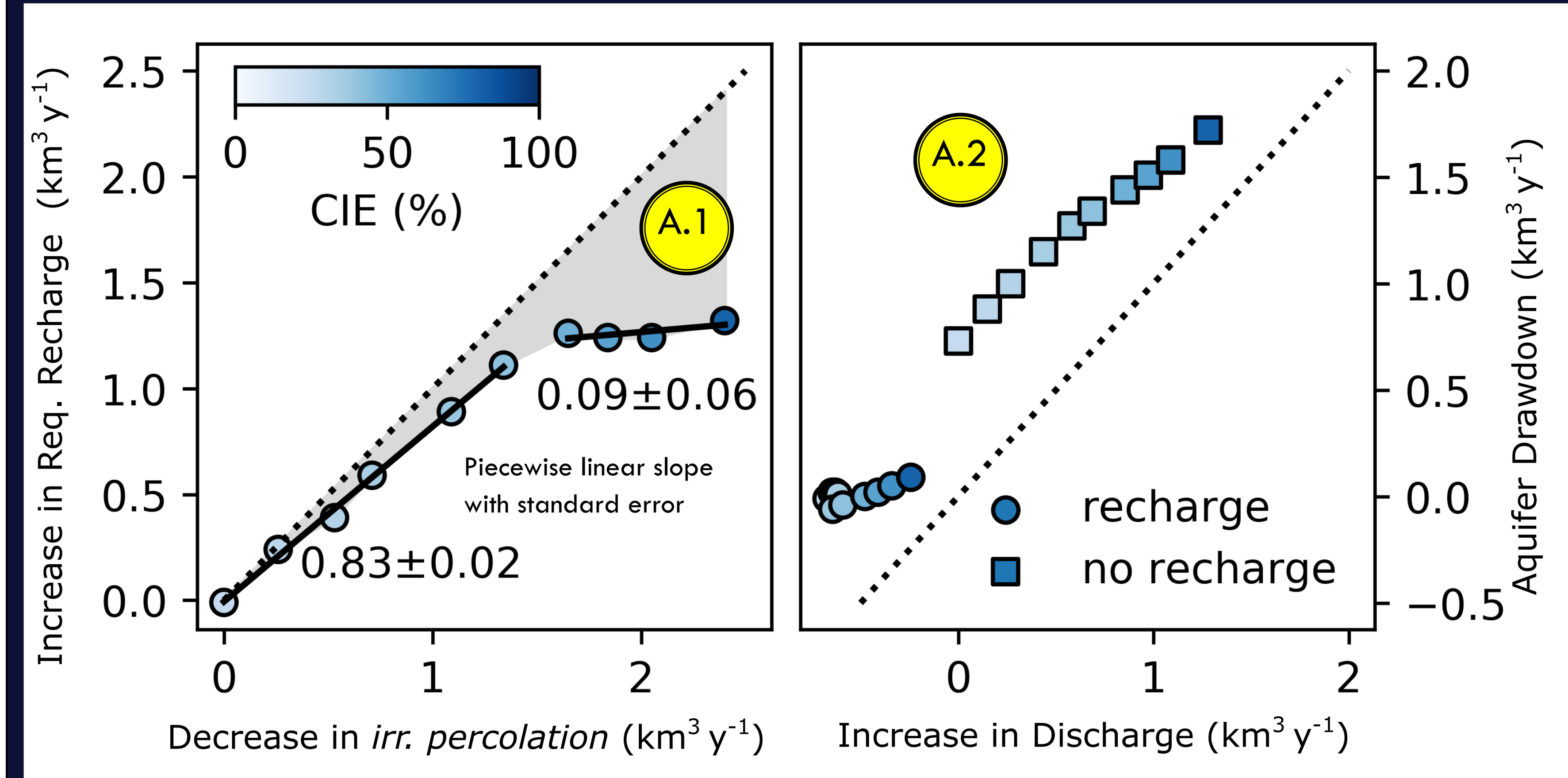
***When coupled with enhanced recharge, reuse through actual recovery increases the effectiveness of modernization.***

*Increasing recovery is the key to adaptation in conjunctively managed systems.*

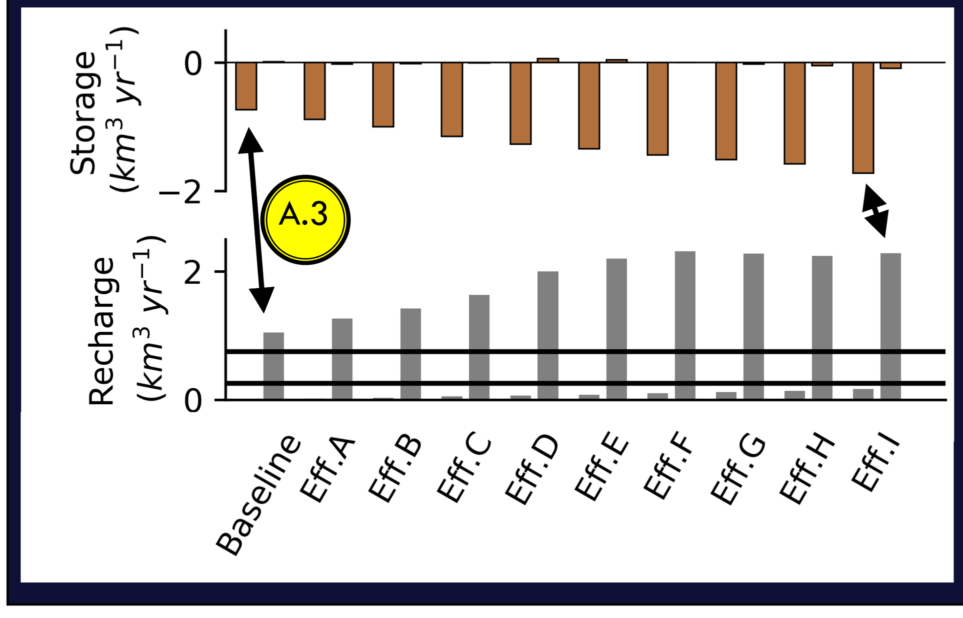



***As both adaptations increase, changes in outlet discharge more closely match aquifer drawdown (never perfectly), approaching parity between aquifer and downstream shortfalls.***

- A.1 As technology modernizes, less *recharge* is needed than incidental *returns* lost.
- A.2 Increasing irrigation efficiency yields greater drawdown than discharge gained.
- A.3 Enhanced aquifer recharge at an efficiency level exceeded drawdown without.




***Left:*** Recharge required above baseline to stabilize aquifer plotted against the reduced *irrigated percolation* from baseline. At 95% classical efficiency (CIE) the benefit overcomes baseline *recharge* requirement. ***Right:*** Aquifer drawdown is always greater than the change in outlet discharge from baseline.



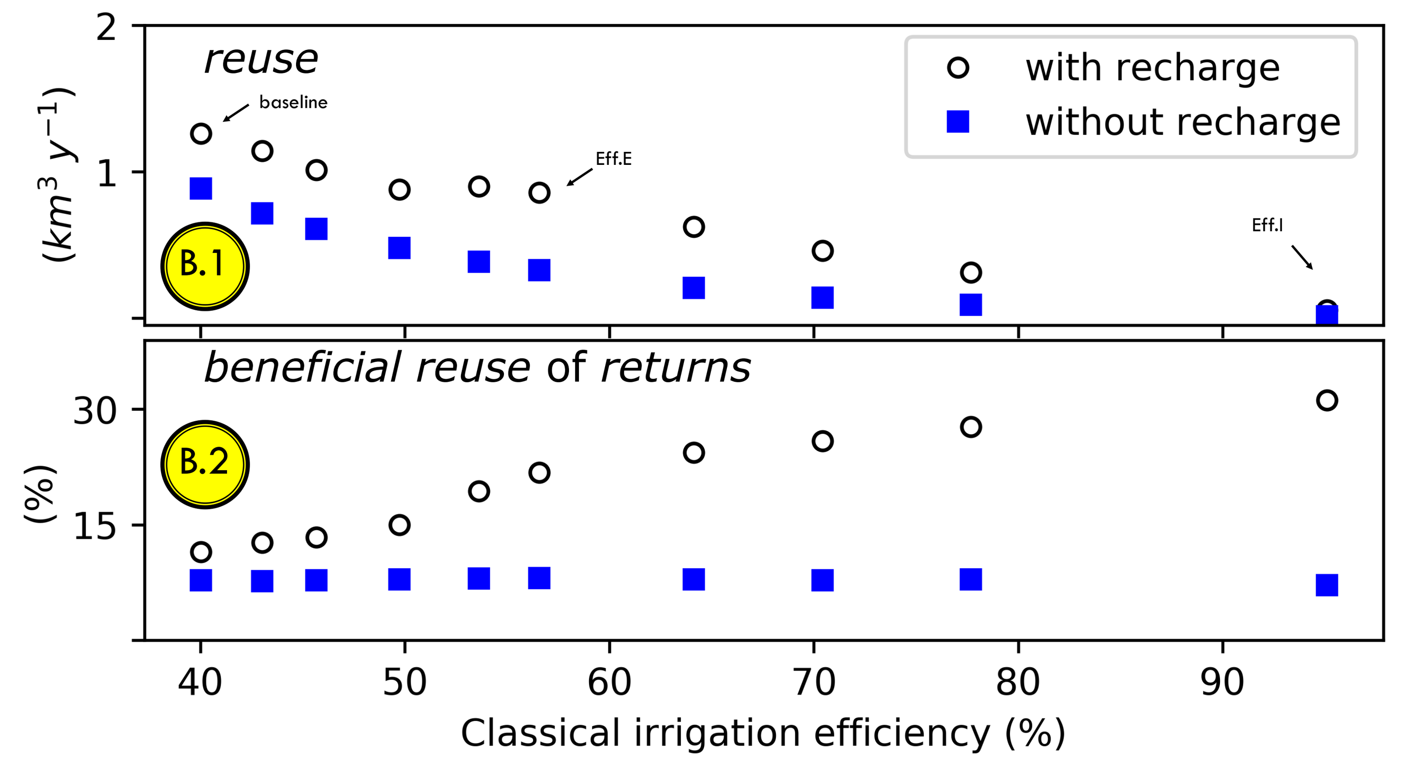

Change in aquifer storage (top) and *recharge* required for aquifer stability (bottom) for each pair of parameterizations. Stabilization is less than 10% of baseline drawdown.

Drawdown is less than *recharge* required.

Solid lines (bottom) depict the negotiated *recharge* mandate (lower), and the estimated maximum feasible *recharge* capacity (upper).

**Reuse of returns declines with increasing efficiency of irrigation technology, but recharge resulted in <u>more</u> AND <u>more effective</u> reuse.**

- B.1 Irrigation *reuse* was always greater with *recharge* represented.
- B.2 *Beneficial* consumption of *reuse* increased with *recharge*.
- ? *Reuse* was underestimated in the model.




Volume flux of *reuse* (top) and percentage of *beneficial* use from prior incidental *returns* across gradient of classical irrigation efficiency of parameterizations.

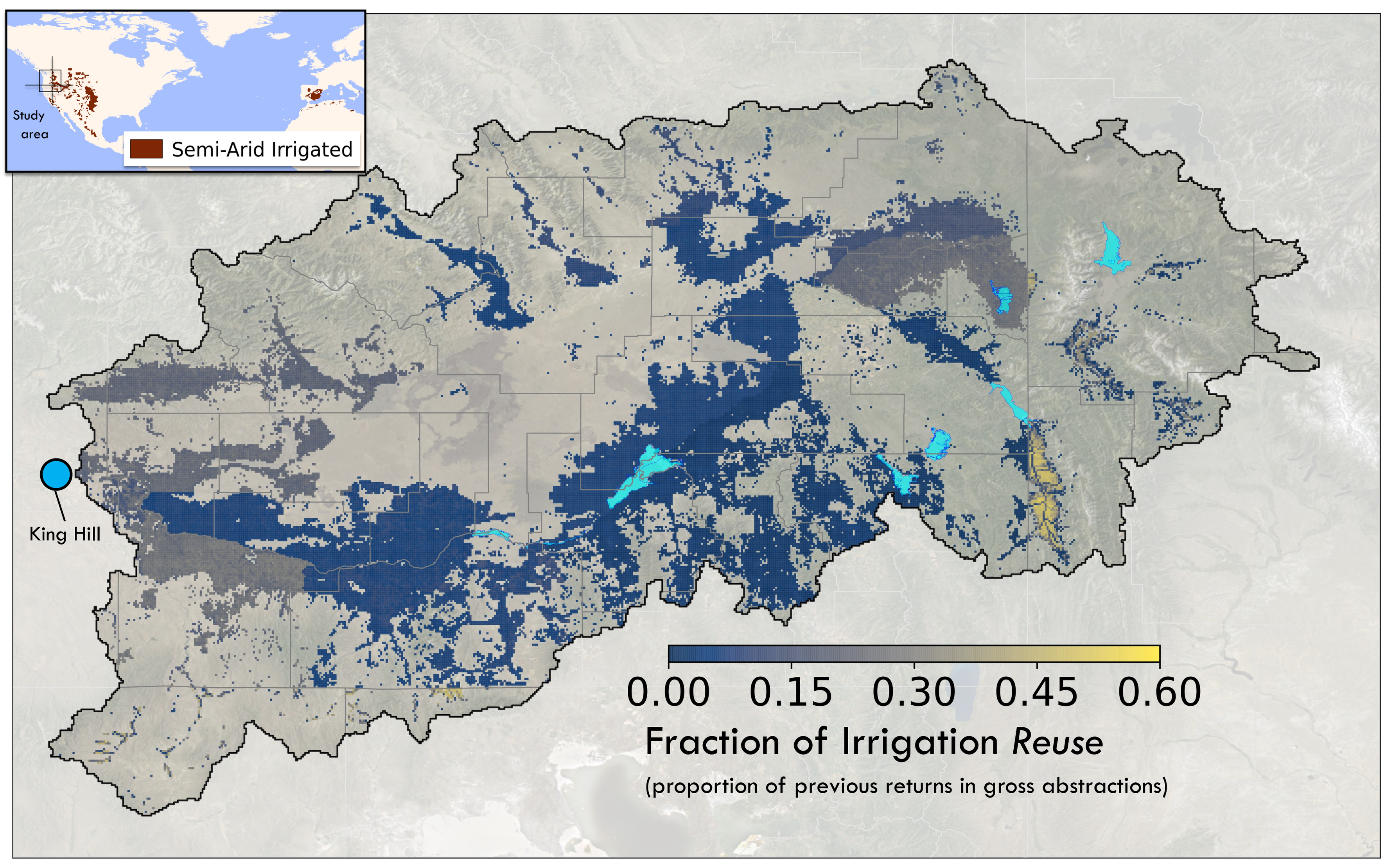
## *Terminology*

***beneficial*** Evapotranspiration of supplied irrigation water by crops (FAO56).
***irrigated percolation*** Net percolation from irrigation minus local abstractions.
***recharge*** Managed or Enhanced Aquifer Recharge.
***returns*** incidental returns/percolation. Non-consumptive loss.
***reuse*** Abstraction of prior *returns* for irrigation.
***baseline*** Flux or storage at contemporary best model estimate.

## *Model*

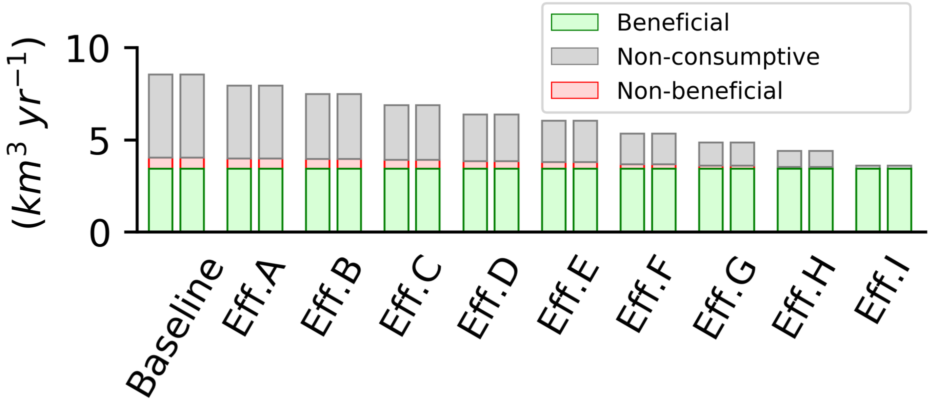
The Water Balance Model (WBM) is a rasterized, conceptual hydrologic model with explicit representations of irrigation technology, dams, and sectoral water allocations. Daily time-step. 780m resolution.

## Setting and experimental design

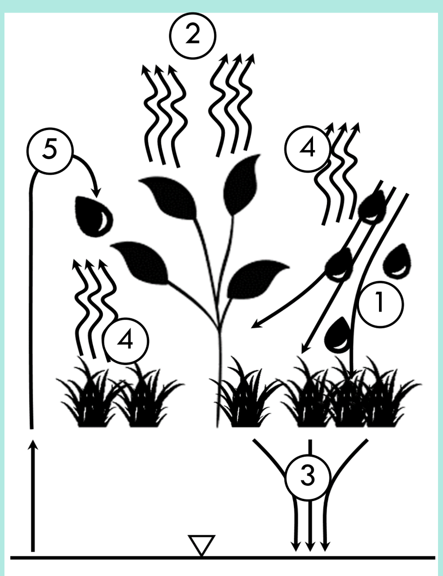



The Upper Snake River Basin (USRB) of southern Idaho is semi-arid with robust dairy and commodity crop agriculture supported by seasonal snow melt and the highly productive Eastern Snake Plain Aquifer (ESPA). Surface irrigation from 1900-1950 added storage to ESPA. Recent adjudication requires aquifer storage to remain at current head. Conjunctive management focuses on managed recharge, with continued irrigation technology modernization.

We simulated 10 parameterizations that increased irrigation technological efficiency from contemporary to extremely efficient between 2008 and 2017 with and without sufficient *recharge* to stabilize the aquifer. Aquifer stabilization by manual calibration.




## Fate of Abstractions

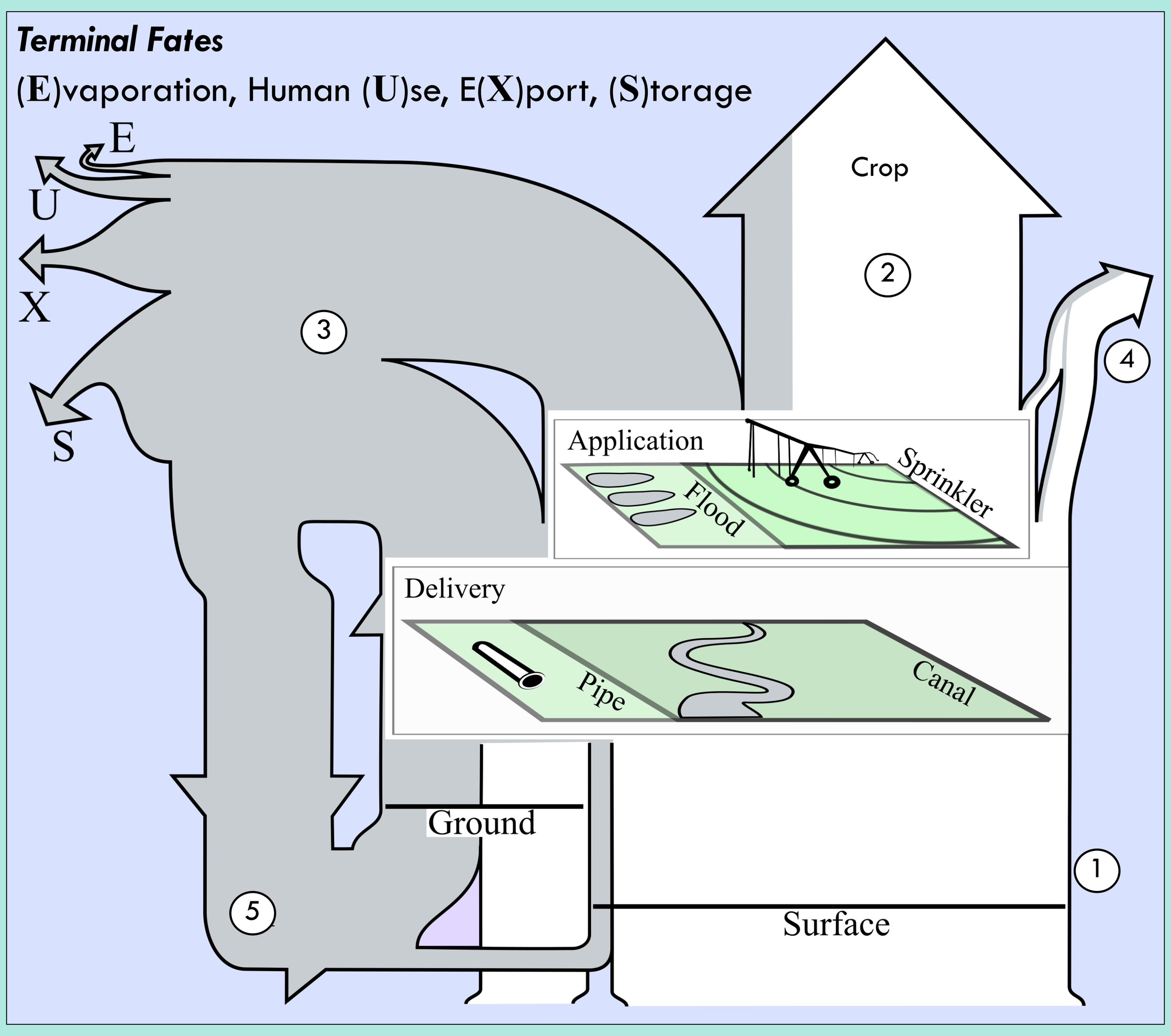


1. **Gross Irrigation** (abstraction)
2. **Beneficial** consumption
3. *Returns* (**Non-consumptive** loss) (***L***)
4. **Non-beneficial** consumption
5. **Reuse**

Aggregate fluxes normalized by gross irrigation.

### Plot-scale

WBM tracks incidental returns through each pool and flux within the model, permitting characterization of the ultimate fate of all returns. The system-scale diagram below represents fates that are proportional to each flux at baseline.




Pristine abstractions (in white), Incidental returns and reuse (in gray).
Recoverable Fraction (RF) (Simons et al. 2015) = 53% (baseline), 5% for Eff.I.
Observed recovered fraction implies 1e-4 (Eff.I) to 0.19 (baseline) cycles of reuse.

Online version of this poster available at: www.wsag.unh.edu/publications/ or scan the QR code above.

Online version includes supporting material including model structure, input data sources, validation against observations, citations.

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