Simulation of rivers, drains, and Lake Lowell

Stephen Hundt

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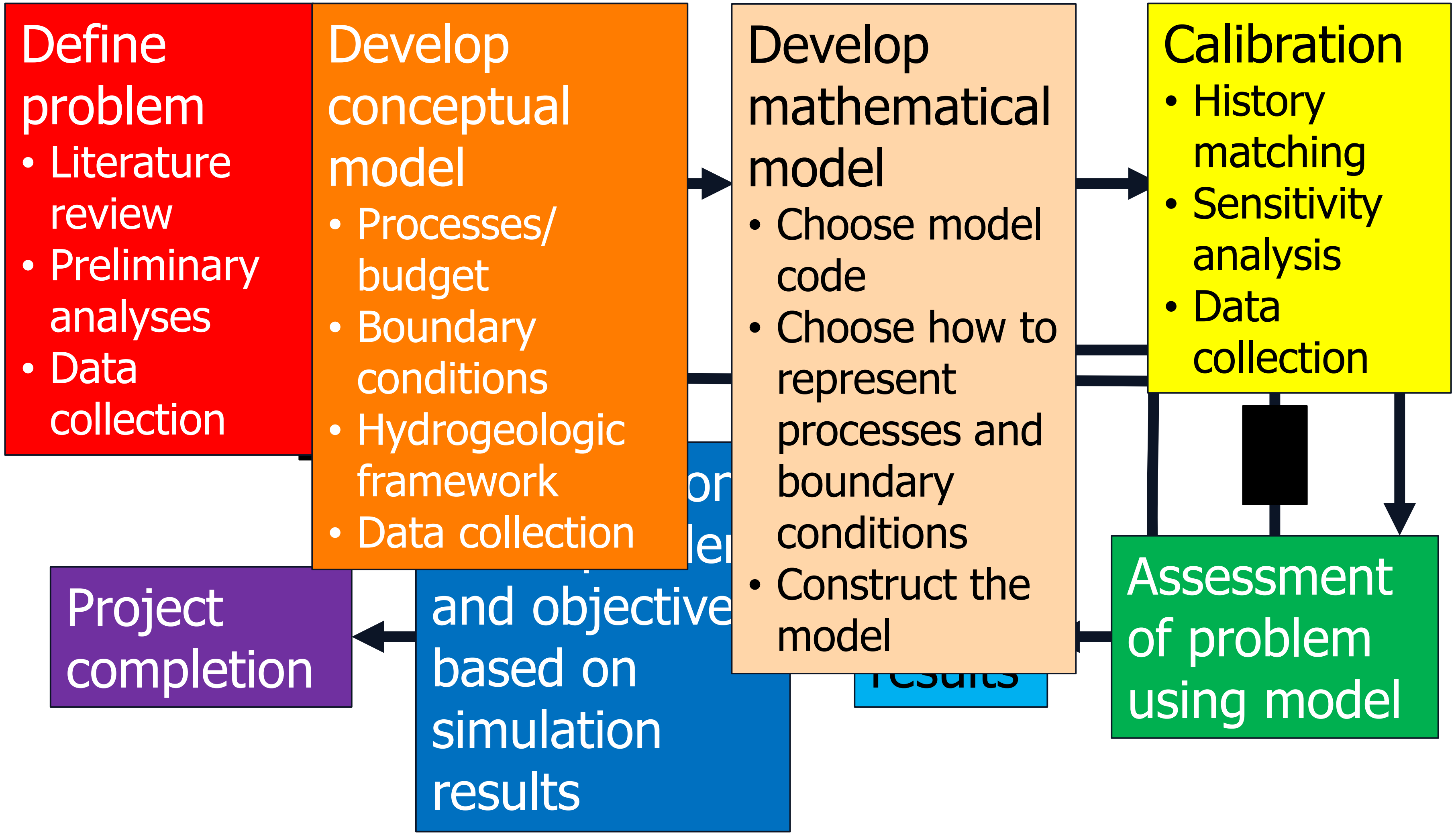
Context

Where we are

The modeling process



After Reilly (2001) TWRI 3,B8

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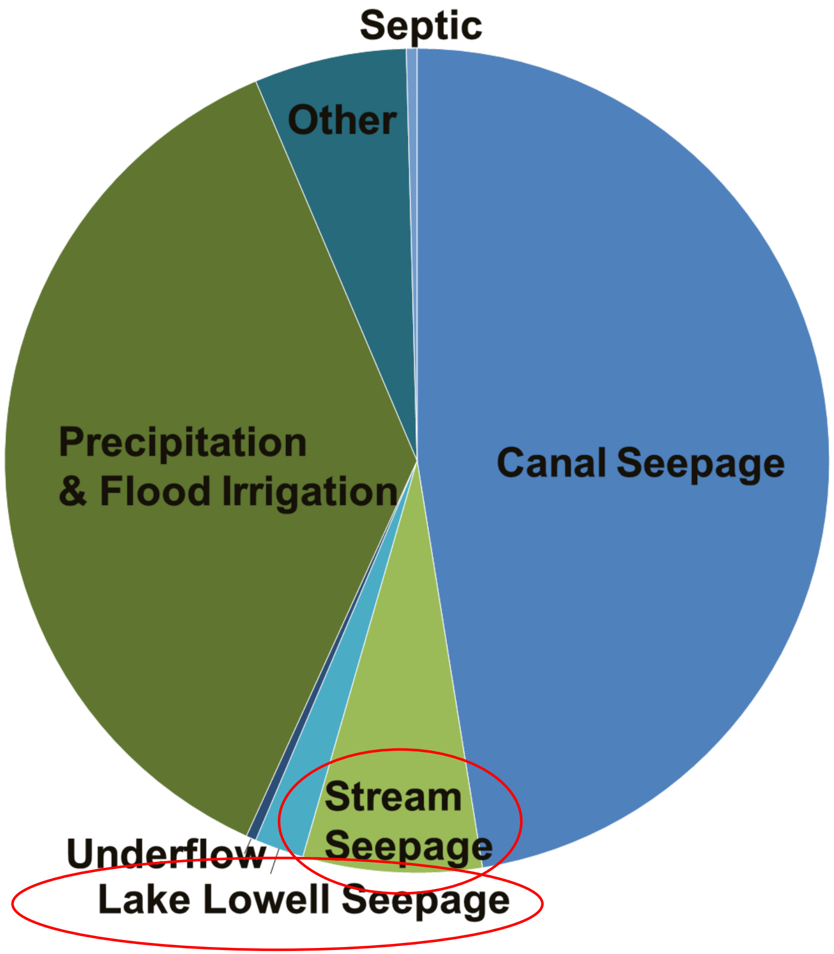
Importance

Groundwater discharges overwhelmingly to rivers and drains

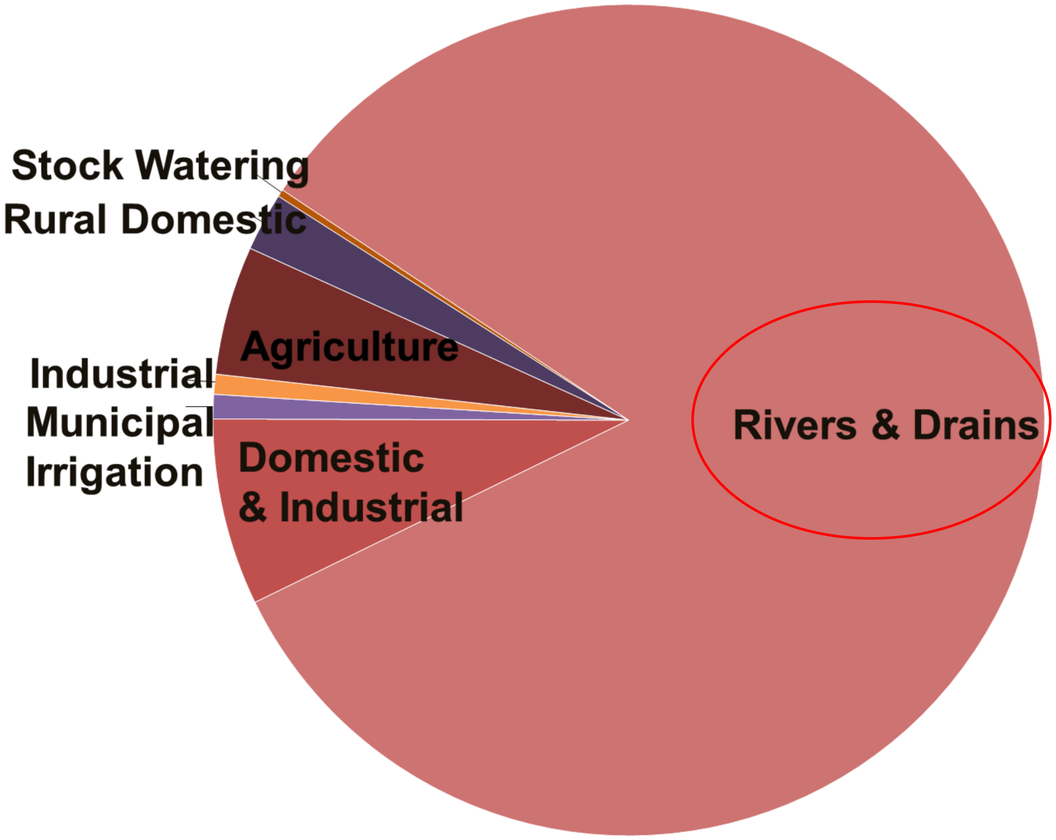
(much larger than pumping)

Lowell is locally important

Inflows
(Urban, 2004)



Outflows
(Urban, 2004)



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Past Model Conclusions

12. Conclusions and Recommendations

A numerical model was constructed to simulate regional-scale, steady-state, ground water flow in the Treasure Valley of southwestern Idaho. Conclusions from simulations using this model consist of the following:

1. PEST-calibrated parameter values indicate relatively higher K_h values in the uppermost aquifer zones, corresponding with known areas of coarser-grained sediments. PEST-calibrated parameter values also indicate relatively higher K_h and K_v values in areas of the eastern and central portion of the valley associated with fluvial deltaic deposition.
2. Simulated fluxes between model layers in the base calibration indicates a relatively small amount of water moving vertically between model layers, especially in the lower layers. Based on simulation results, most recharge occurring in shallow aquifer zones does not reach lower zones.
3. A 10% increase or decrease in recharge led to minimal changes in water levels or parameter value estimates. This is because shallow ground water levels in central portions of the basin are controlled, in part, by elevations of surface water channels. Decreased or increased recharge resulted in changes in the rates of water discharging to model drain, general head boundary (Lake Lowell), constant head (Snake River), and river (Boise River) cells.
4. Underflow does not appear to be consistently distributed along the Boise Front. The model experienced difficulty in applying rates as high as 8,000 ft^3/day/cell (similar to water budget estimates) in some model areas, especially in the far eastern portions of the model domain.
5. Simulated minimum water levels (maximum impact) indicated that some ground water level declines might occur with a 20% increase over 1996 levels. Simulated modest declines were observed in the Boise area in layers 1 and 2. Greater simulated declines were observed in the central portion of the valley (especially in the Lake Lowell area) in layers 3 and 4. Simulated water level declines and/or changes in mass balance components reflect a combination of parameter uncertainty and response to a changed hydraulic stress.
6. The simulated 20% increase in ground water withdrawals resulted in increased losses from the Boise River (23%), decreased discharge to agricultural drains (62%), and decreased discharge to the Snake River (9%). Again, simulated water level declines and/or changes in mass balance components reflect a combination of parameter uncertainty and response to a changed hydraulic stress.
7. Uncertainty in the model calibration limits a more precise description of responses to changes in recharge and/or withdrawals.
8. Changes in land use that lead to decreases in shallow-aquifer recharge may not have a substantial effect on shallow ground water levels until the water table elevations remain below those of nearby surface channels.

Additional simulations should be considered to better define aquifer system characteristics or scenario predictions. These include the following:

1. Maximum and minimum hydraulic head predictions with no changes in model stresses from the base simulation. Use the results from these simulations for comparisons in scenario predictions.
2. Increases and decreases of 30% (over 1996 levels) in aquifer recharge.
3. Across-the-board withdrawal increases and decreases in aquifer withdrawals over 1996 levels.
4. Increased local withdrawals in various locations in the valley to test responses in water levels and in recharge rates to lower model layers.
5. Simulations with reductions in recharge and increases in withdrawals to estimate at what point shallow ground water levels drop below drain elevations in the central portion of the valley.
6. Horizontal and vertical variations in underflow along the Boise Front.
7. Conduct additional simulations to refine the understanding of ground and surface water interaction in the Boise River corridor using a more refined grid than, and/or submodel of, the current model .
8. Develop response ratios for the interaction between ground water extractions and seepage from or discharge to surface channels.

Additional recommendations include the following:

1. Expand monitoring in areas showing recent ground water level declines.
2. Consider incorporating new monitoring data into the model as they become available.
3. Better define discharge rates to surface water channels to allow more constraint on simulated discharge.
4. Better define temporal diversion and return rates for transient simulations.
5. Refine model based on newly compiled diversion and return data.
6. Install additional multi-completion monitoring wells to expand vertical gradient data.
7. Search for opportunities to enhance ground water level monitoring in portions of the valley with relatively few current data.

Drains in Treasure Valley

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Example

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Example

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Example

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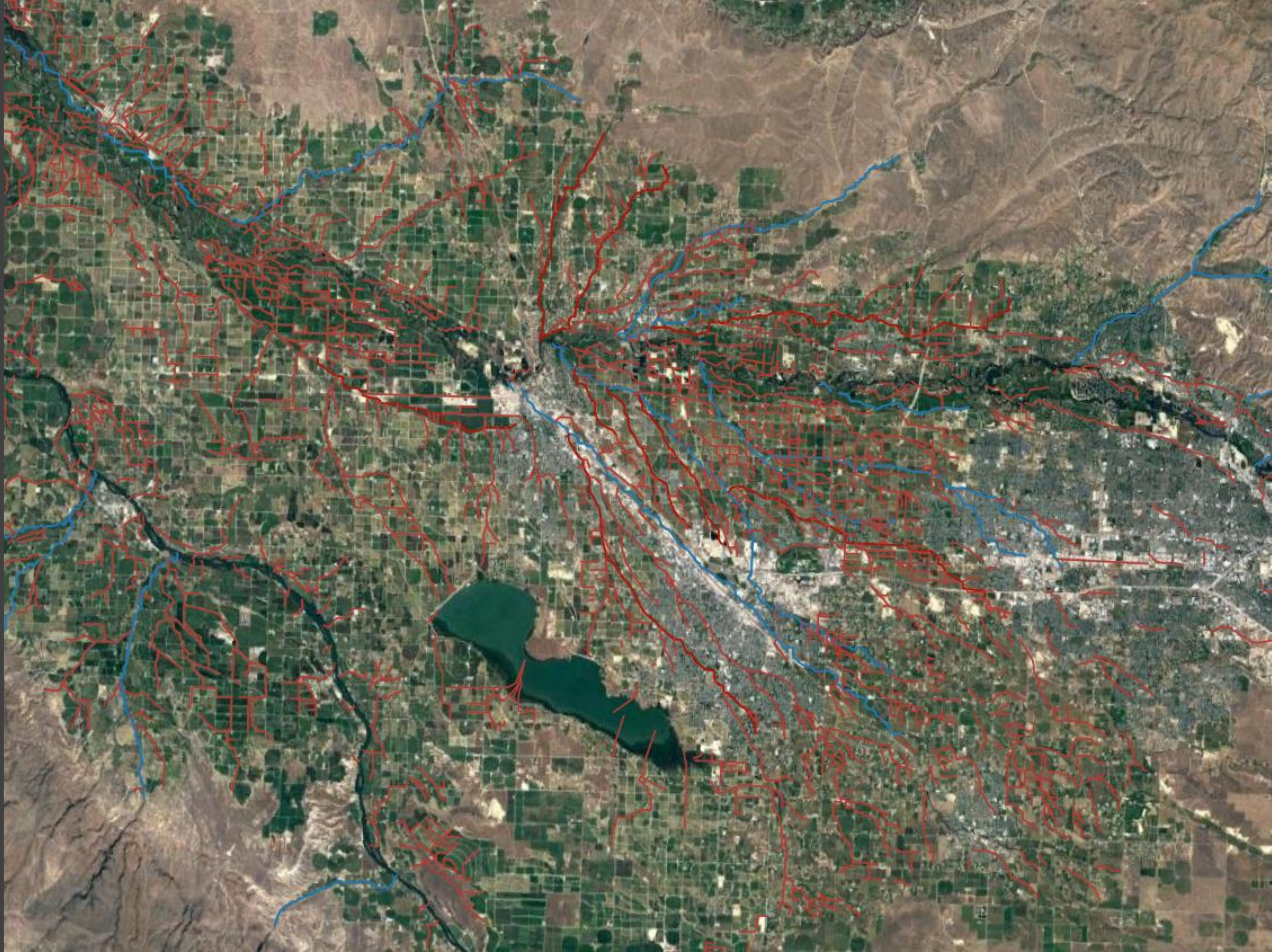
Areal Extent



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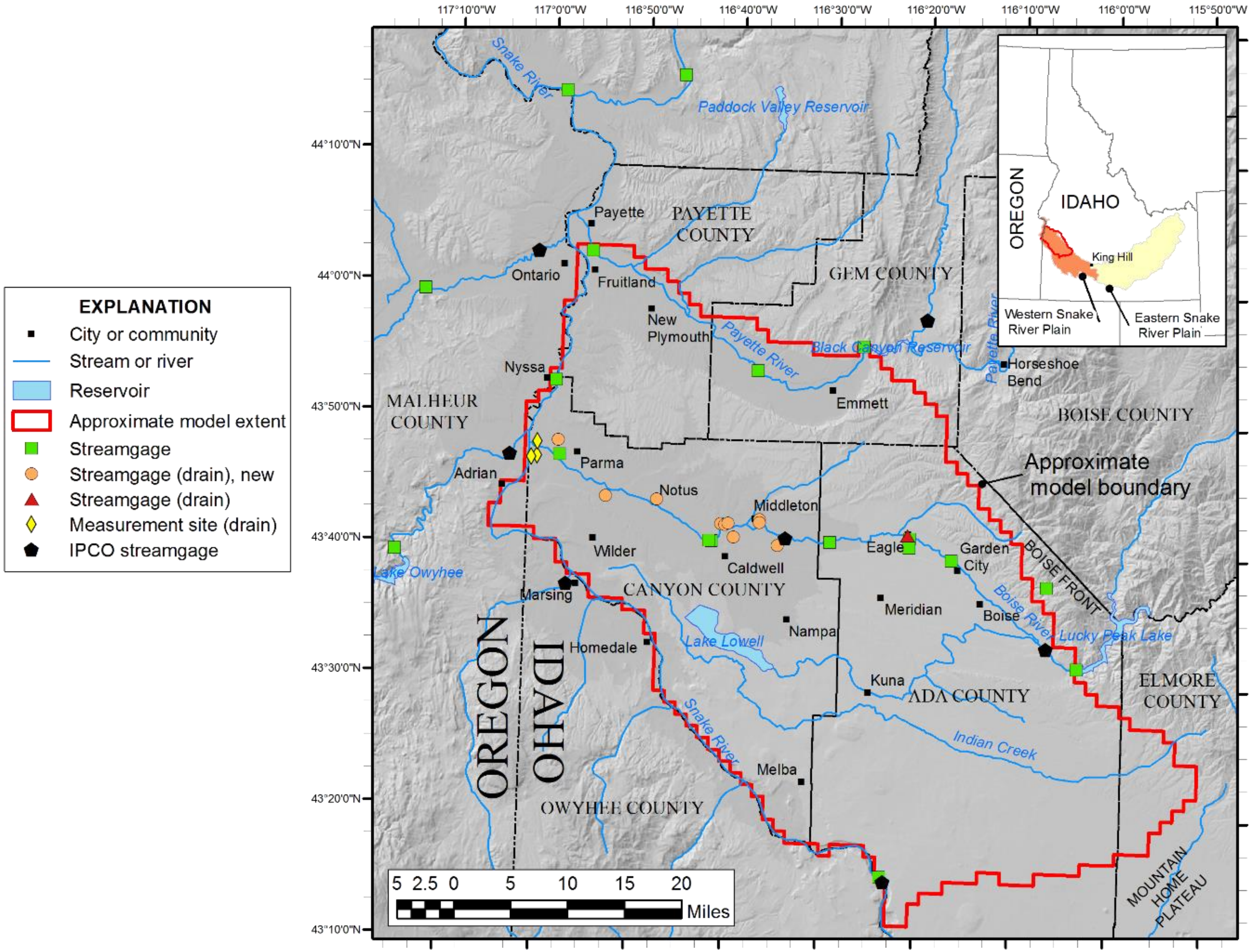
Measured Drains



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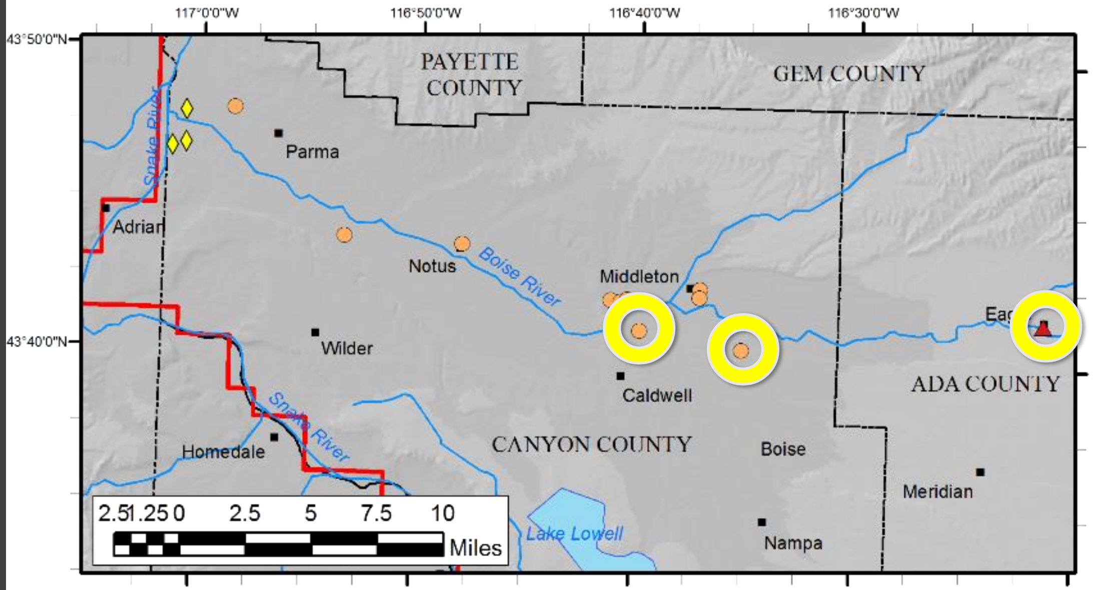
Measured Drains



13206400-Eagle Drain
13210980-Fifteenmile Creek nr Midland Blvd nr Middleton
13210980-Mason Creek at Caldwell

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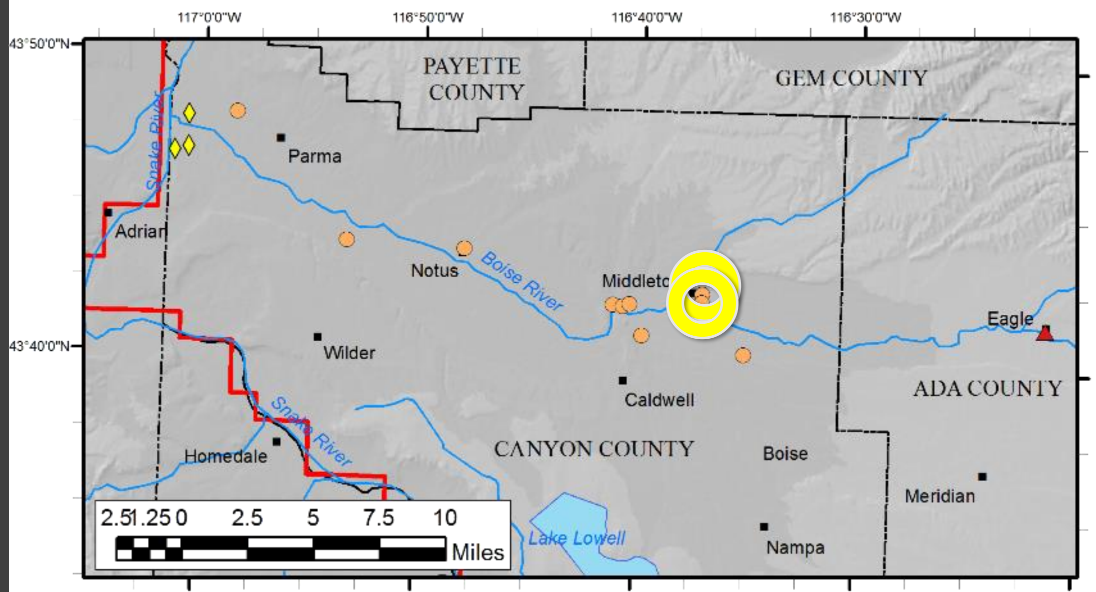
Measured Drains



13210840-N. Middleton Drain
13210831-S. Middleton Drain

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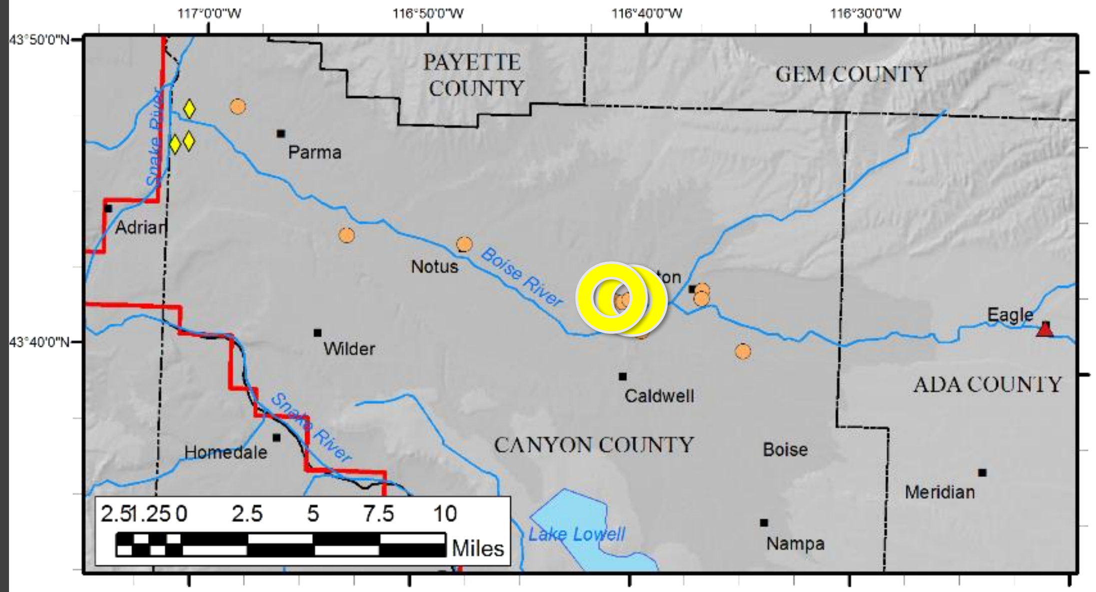
Measured Drains



132109867-E. Hartley Abv Backwater nr Wilder
13210986-W. Hartley Gulch nr Caldwell

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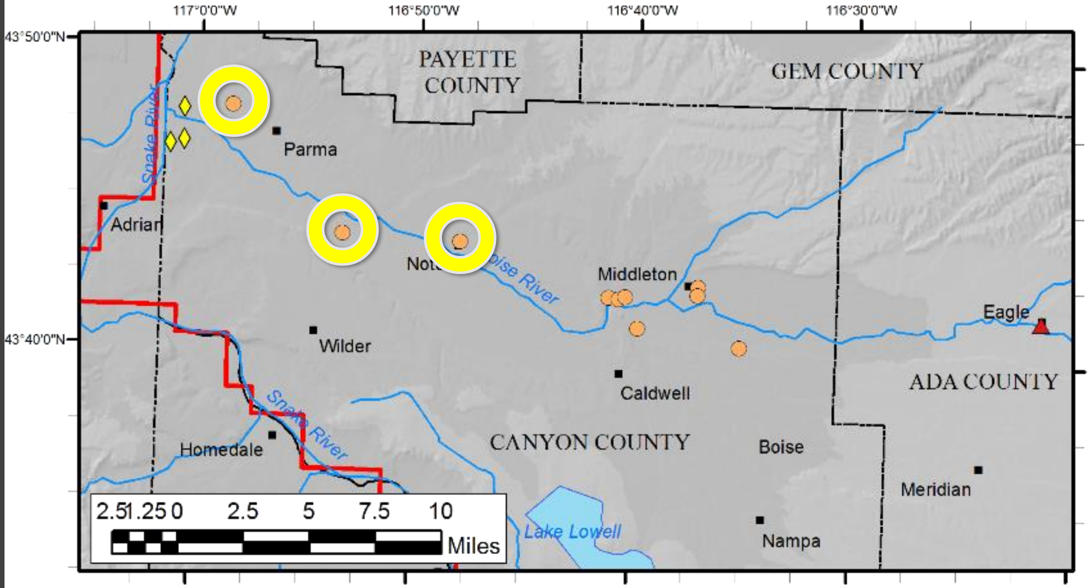
Measured Drains



13212549-Conway Gulch Below 1st St. at Notus
13212890-Dixie Drain nr Wilder
13213072-Sand Run Gulch nr Parma

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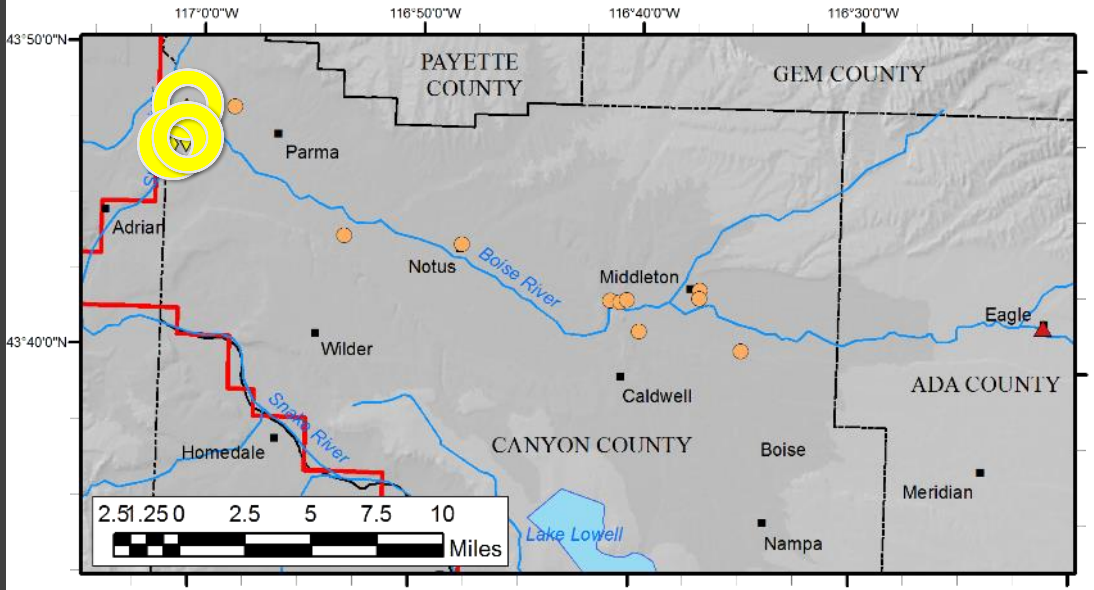
Measured Drains



13173635-Ross Drain
13173630-S. Boise Drain
13173632-N. Alkali Drain

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Drain boundaries in MODFLOW

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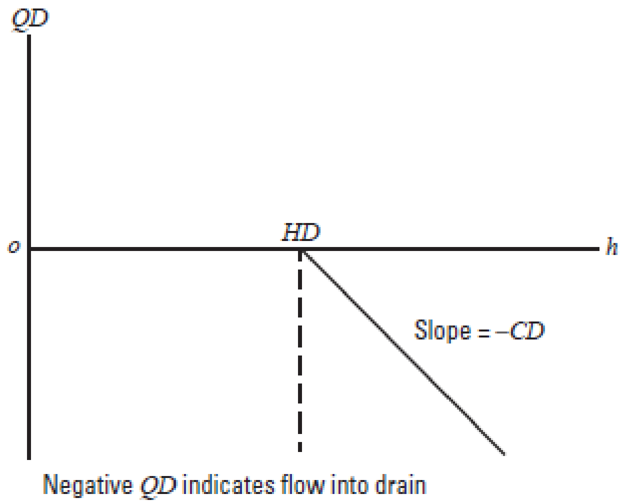
MODFLOW Drain Package

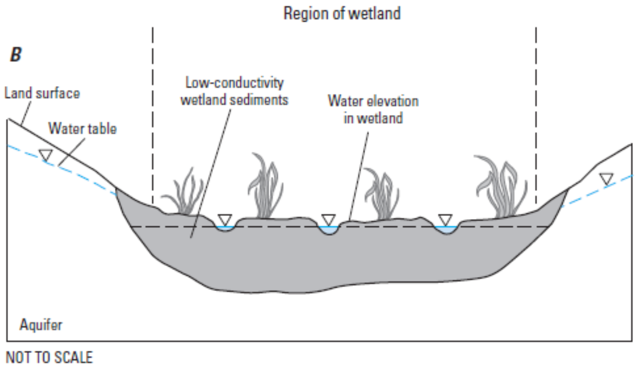
Water only exits

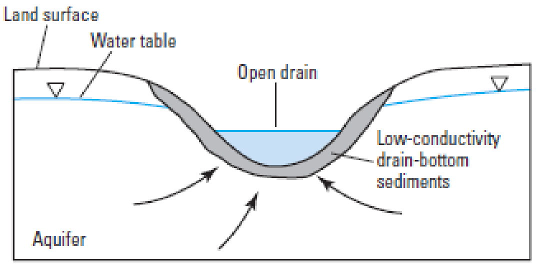
Not a source of recharge

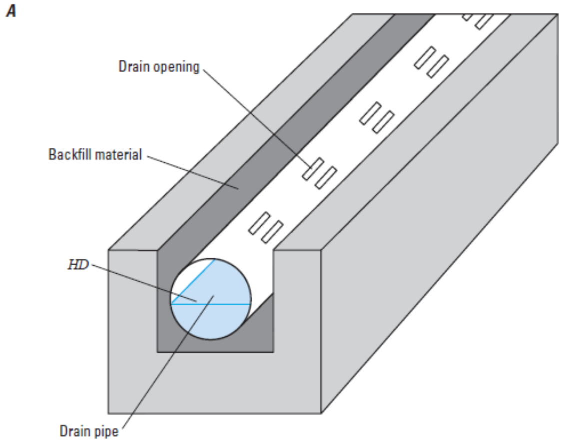
Flow proportional to head difference when head above a certain elevation; Zero flow when below

$$Qout_{nb} = CDRN_{nb}\left(h_n - HDRN_{nb}\right), \qquad h_n > HDRN_{nb}$$
$$Qout_{nb} = 0, \qquad h_n \le HDRN_{nb},$$









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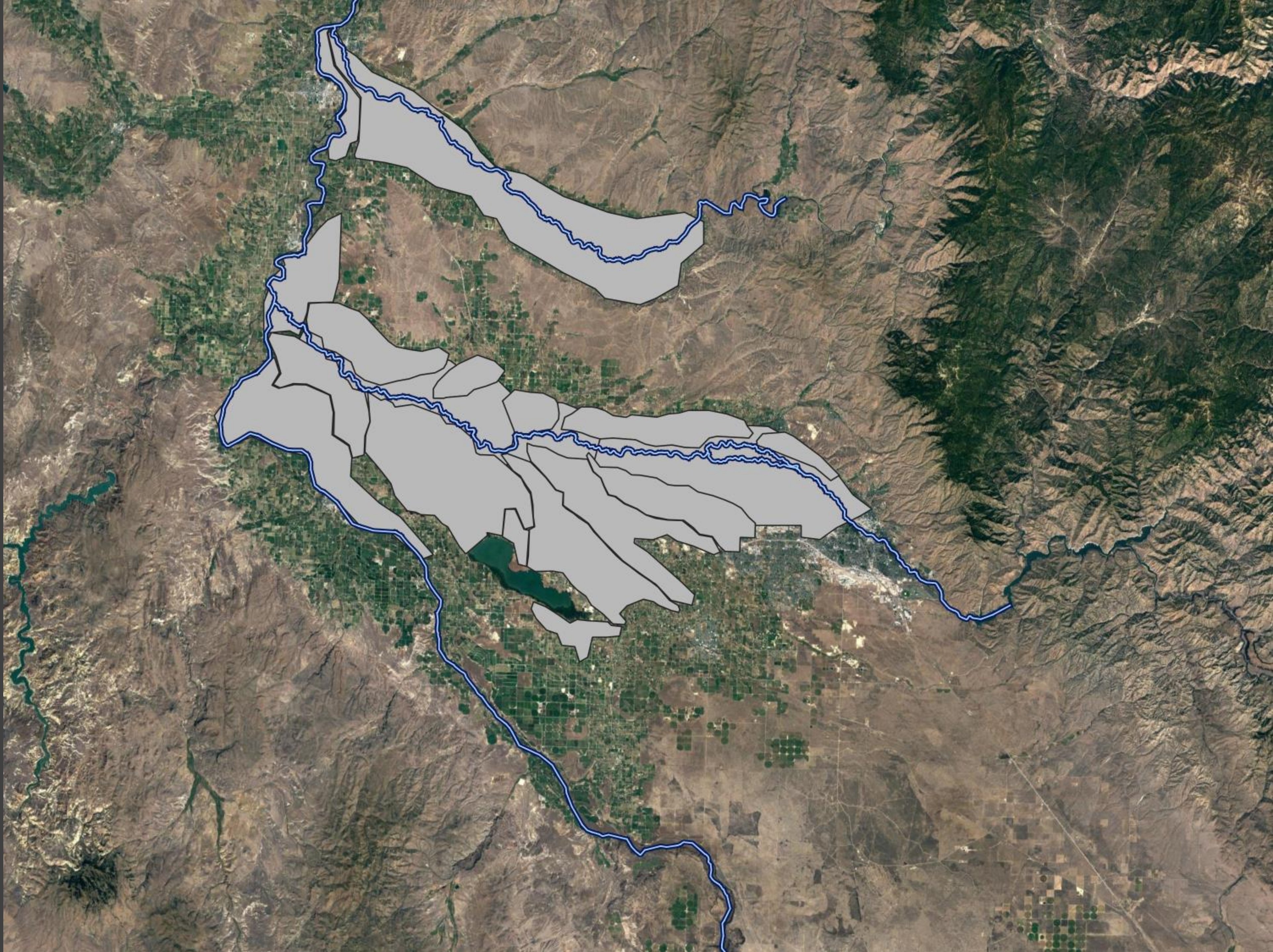
Implementation

Drain Cell Locations

Drain Cell Locations



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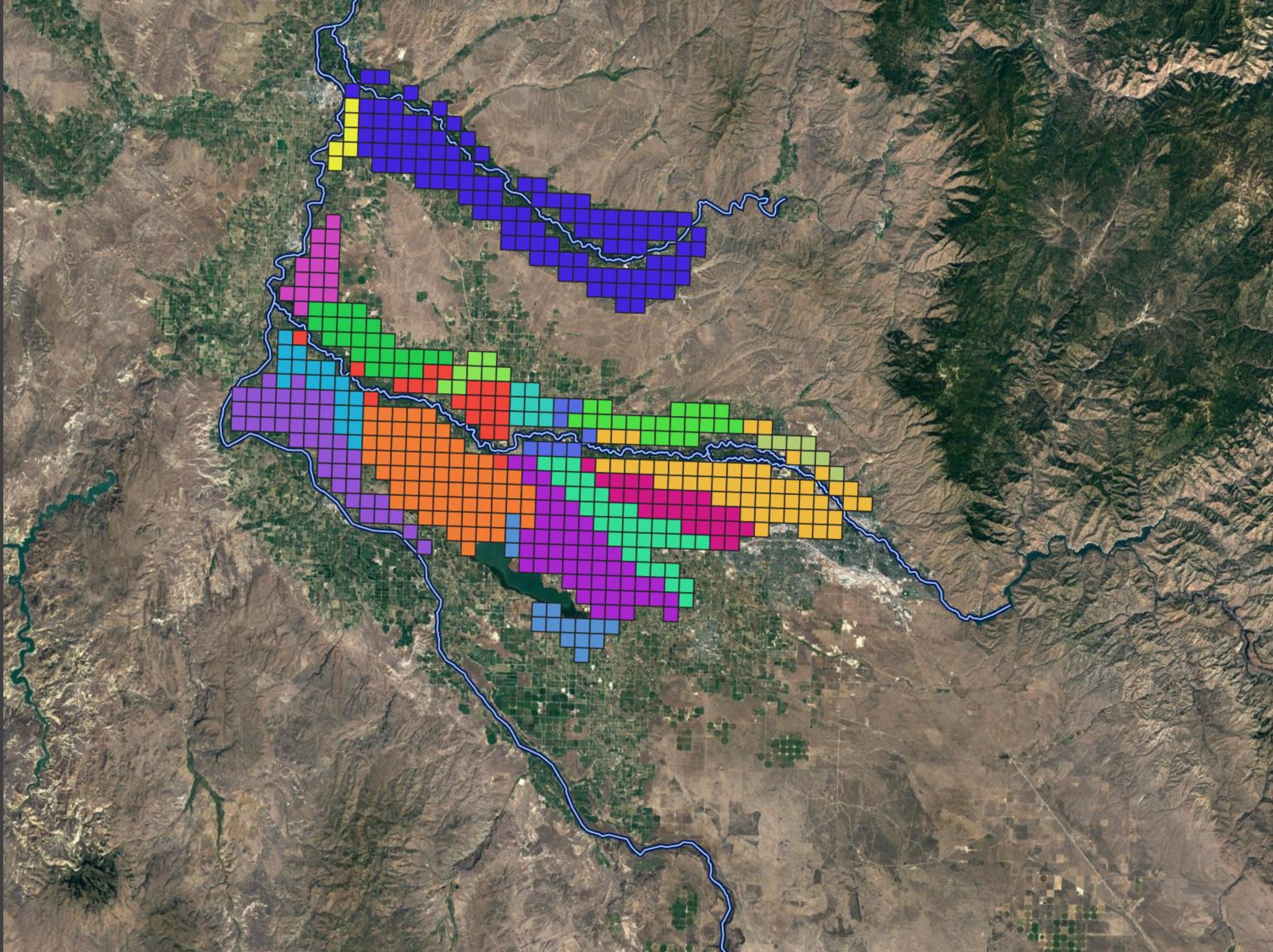
Drain Cell Locations



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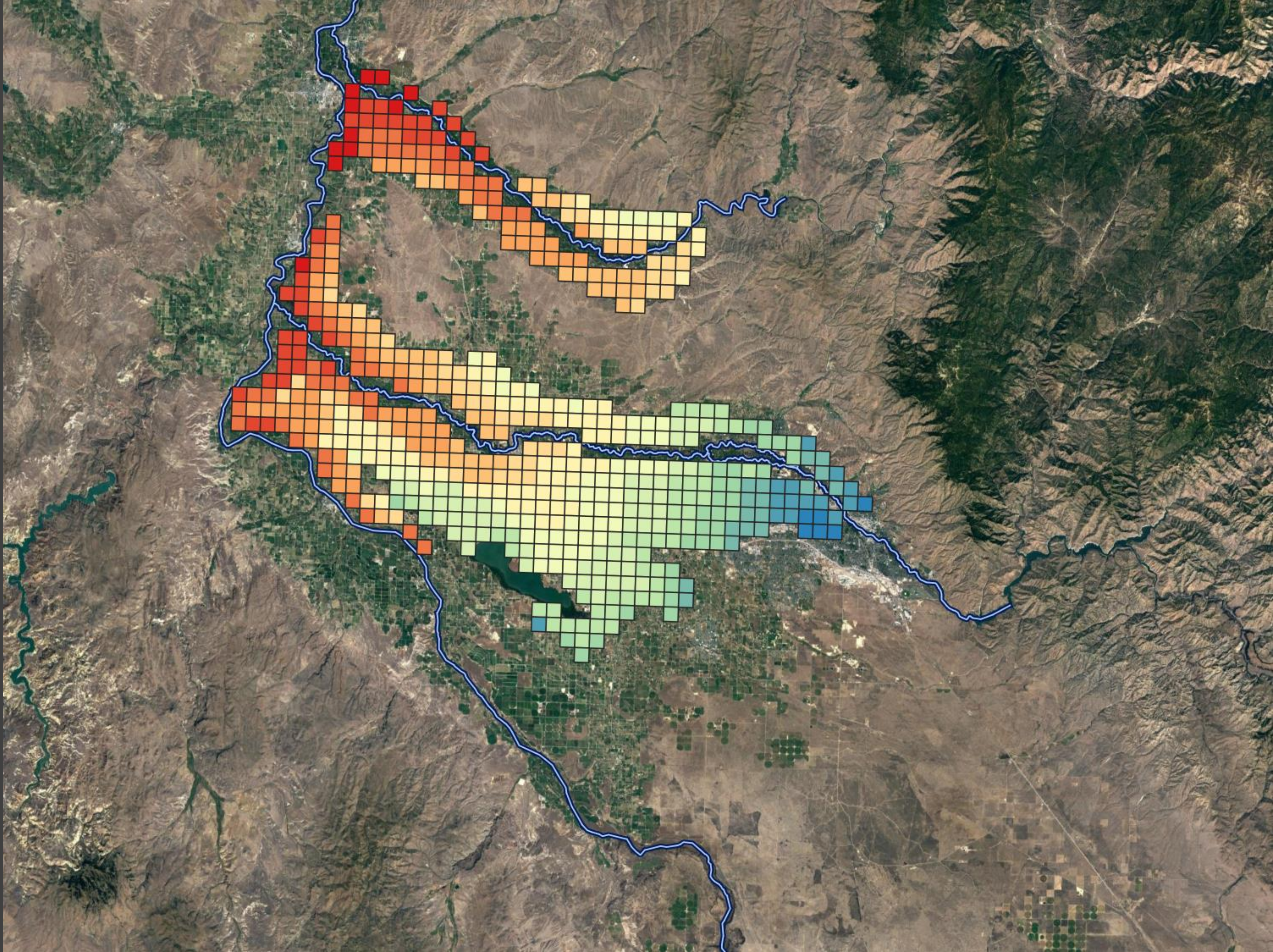
Drain Elevations



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Drain Discharge

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Discharge Data

USGS 13210824 N MIDDLETON DRAIN (MILL SLOUGH) AT MIDDLETON ID

Available data for this site Time-series: Monthly statistics GO

Canyon County, Idaho
Hydrologic Unit Code 17050114
Latitude 43°42'23.58", Longitude 116°37'05.49" NAD83
Drainage area 63 square miles
Gage datum 2,390 feet above NAVD88

Output formats
- HTML table of all data
- Tab-separated data
- Reselect output format

00060, Discharge, cubic feet per second,

YEAR	Monthly mean in ft3/s (Calculation Period: 2016-12-01 -> 2019-12-31) Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016												21.3
2017	24.3	35.2	28.7	37.9	35.4	50	49.3	46.3	44.7	35.5	25.6	25.6
2018	24.3	21.6	20.8	25.4	36.3	39	34.5	44.4	41.3	39.4	31.9	32.3
2019	24.9	29.1	26.3	33.2	45	32.5	30.5	34.4	36.7	30.5	35.3	32.9
Mean of monthly Discharge	24	29	25	32	39	41	38	42	41	35	31	28

** No Incomplete data have been used for statistical calculation

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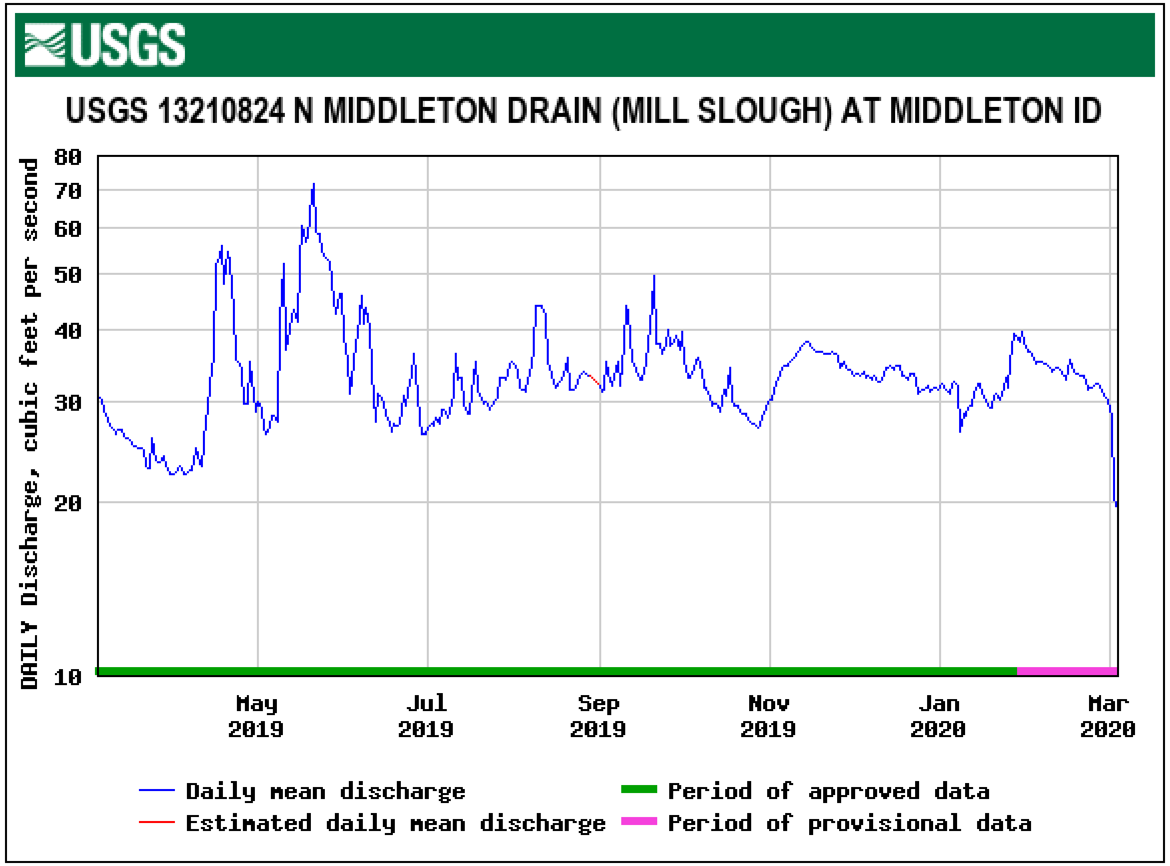
Discharge Data



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Rivers

Rivers

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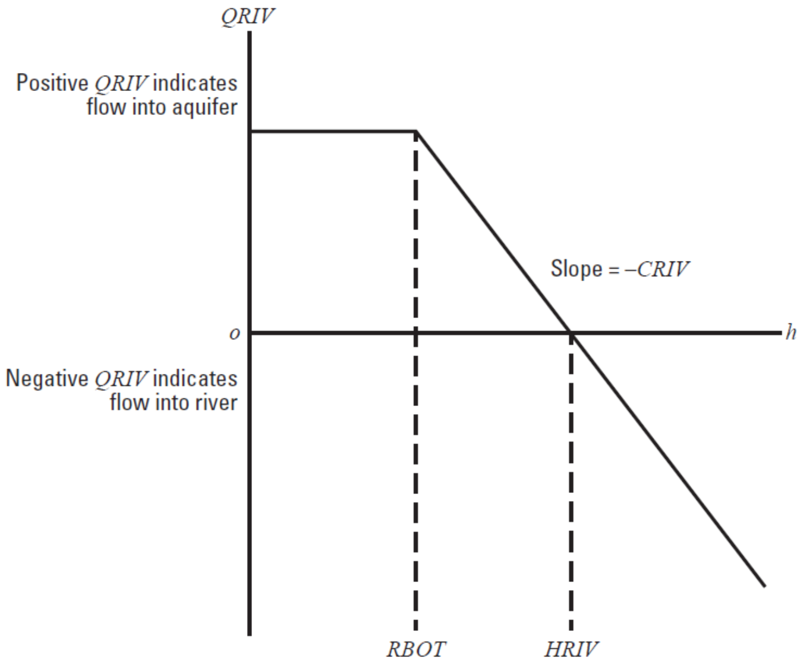
Rivers
Boise & Payette

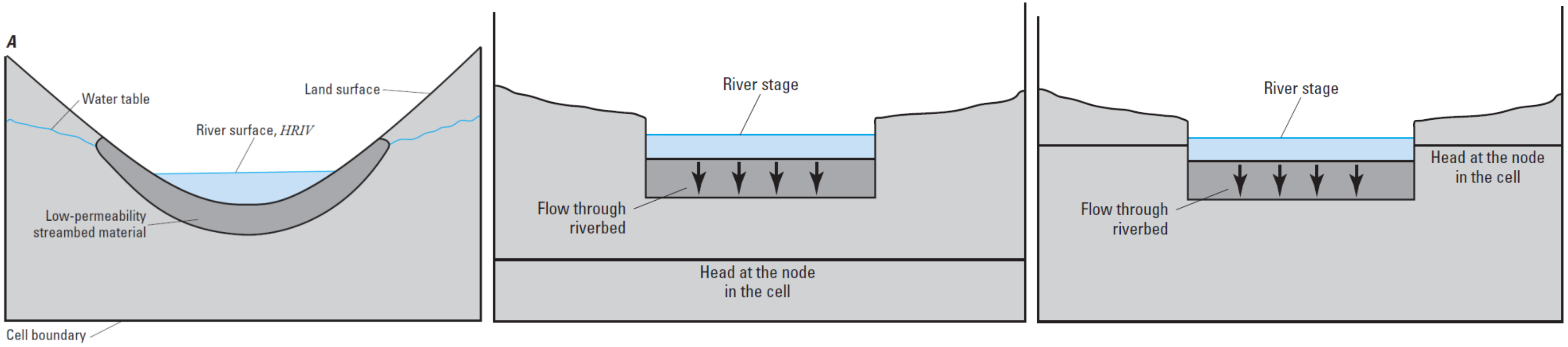
Water can flow either way

Recharge and discharge

Flow proportional to head difference when head above a certain elevation; Flow is constant when below

$$QRIV_{nb} = CRIV_{nb}\left(HRIV_{nb} - h_n\right), \qquad h_n > RBOT_{nb}$$
$$QRIV_{nb} = CRIV_{nb}\left(HRIV_{nb} - RBOT_{nb}\right), \qquad h_n \leq RBOT_{nb}$$





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Rivers

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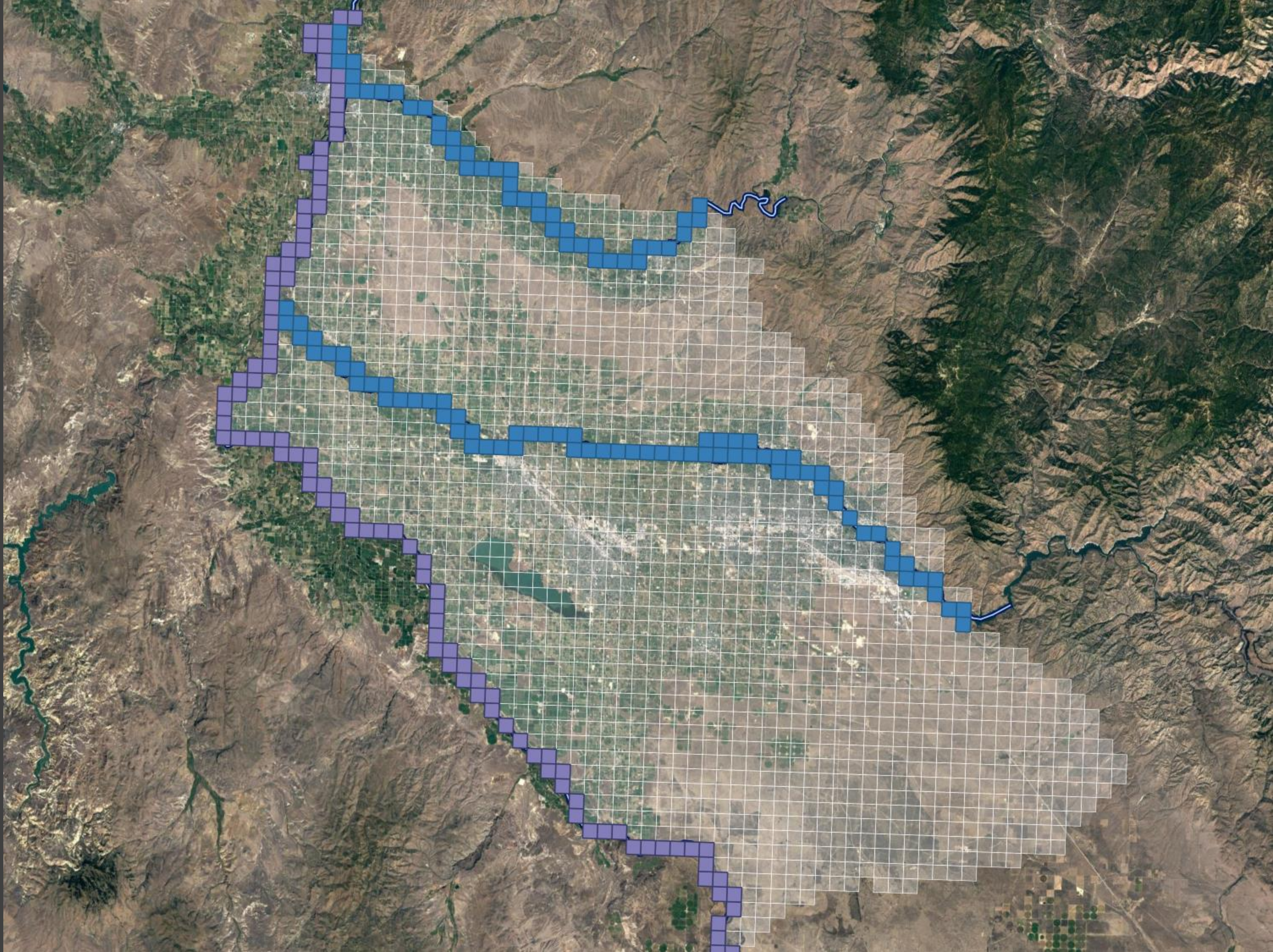
Rivers



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Lake Lowell

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Lowell

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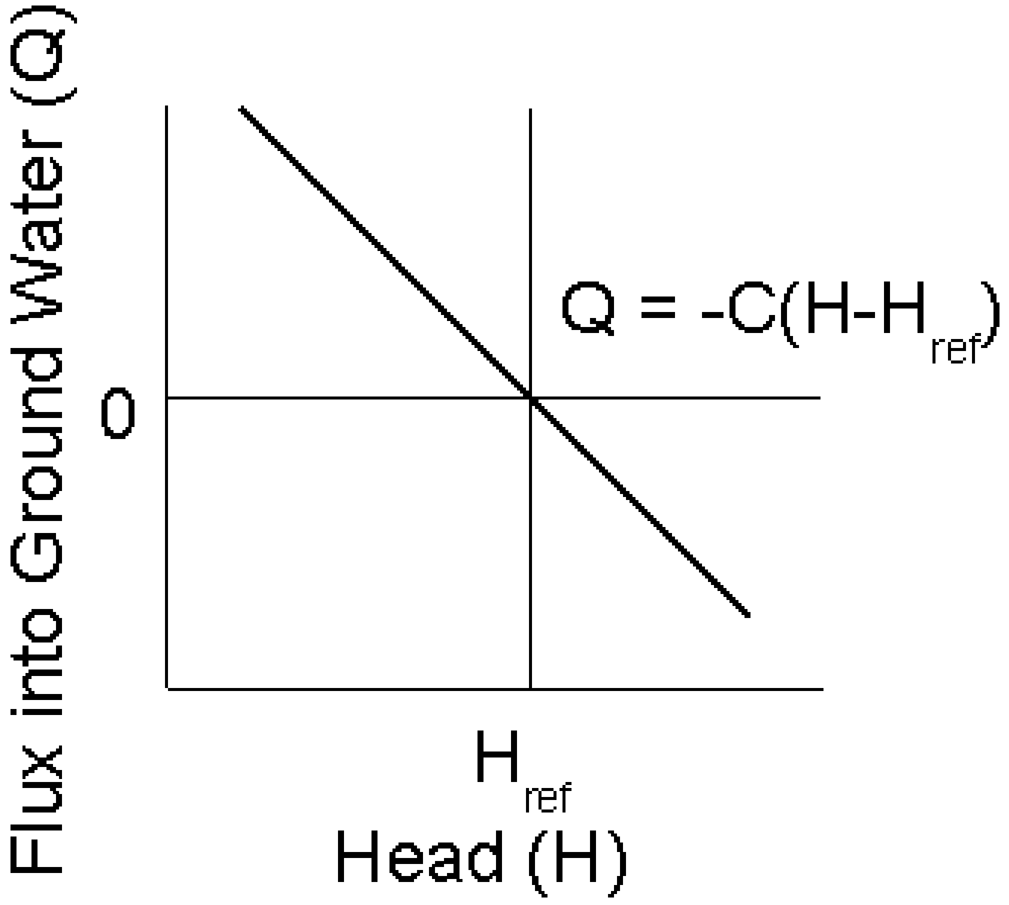
Lowell

General Head Boundary

H: groundwater head

H_{ref}: lake stage

C: lakebed conductance



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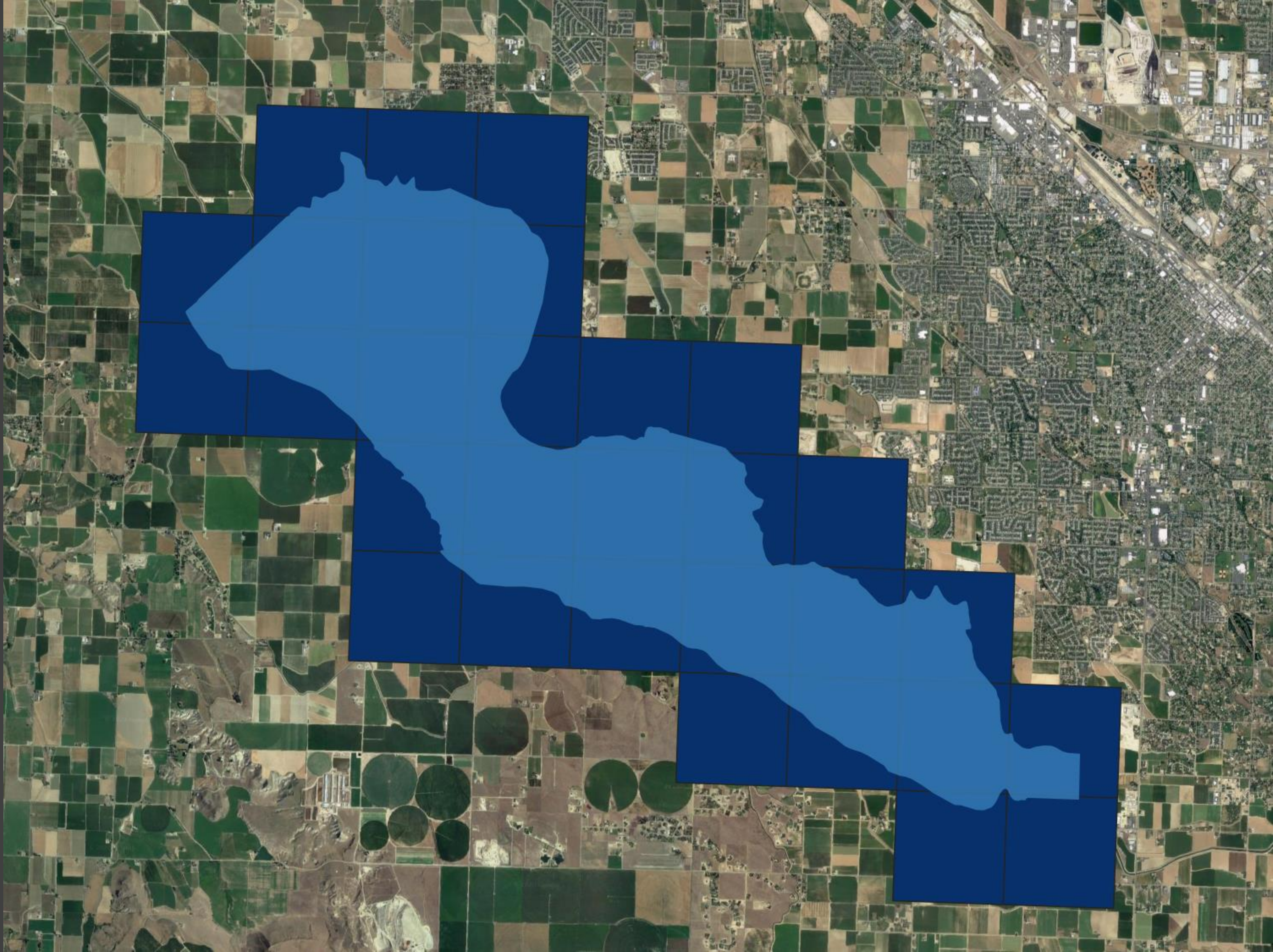
Lowell



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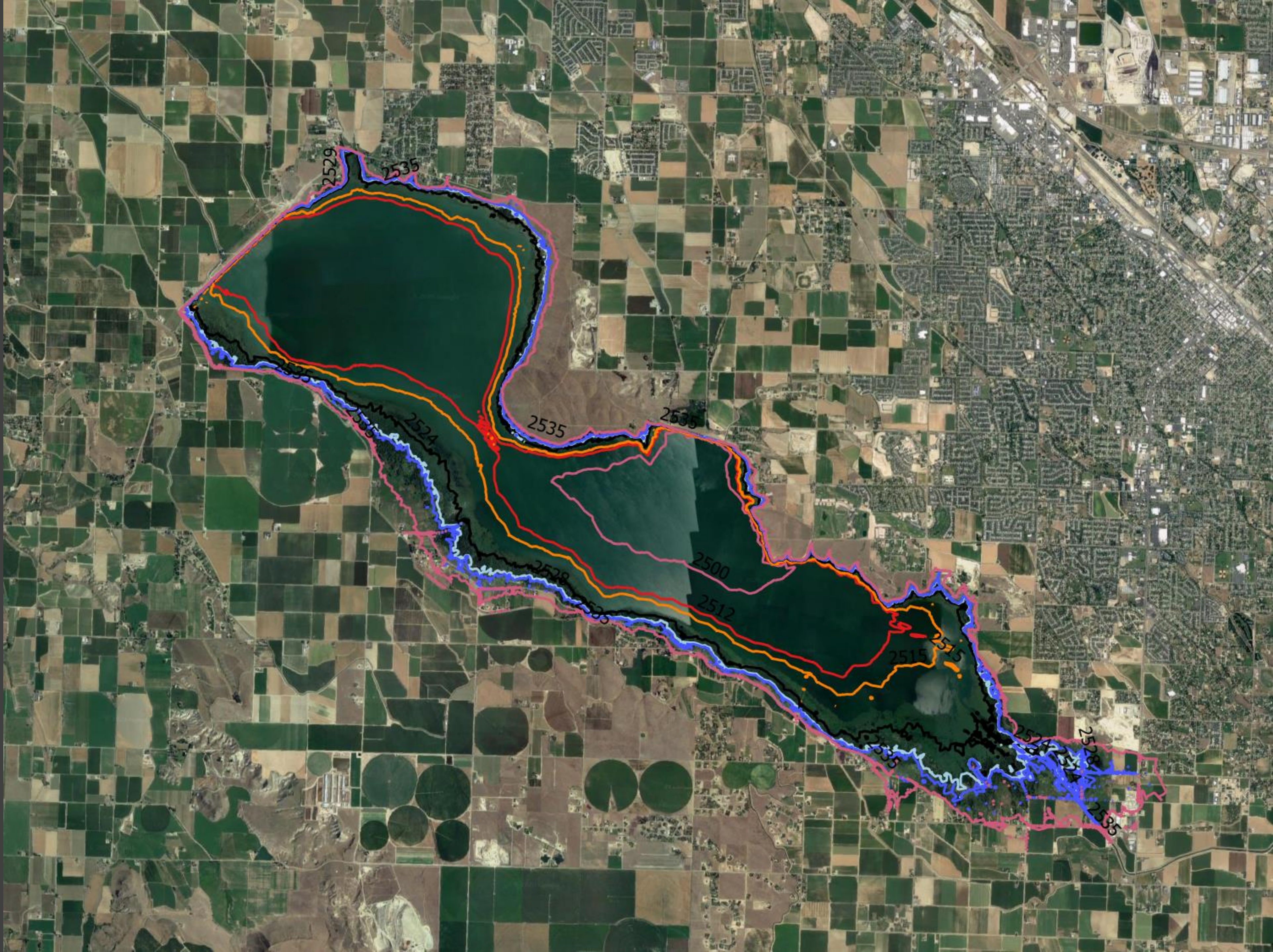
Lowell



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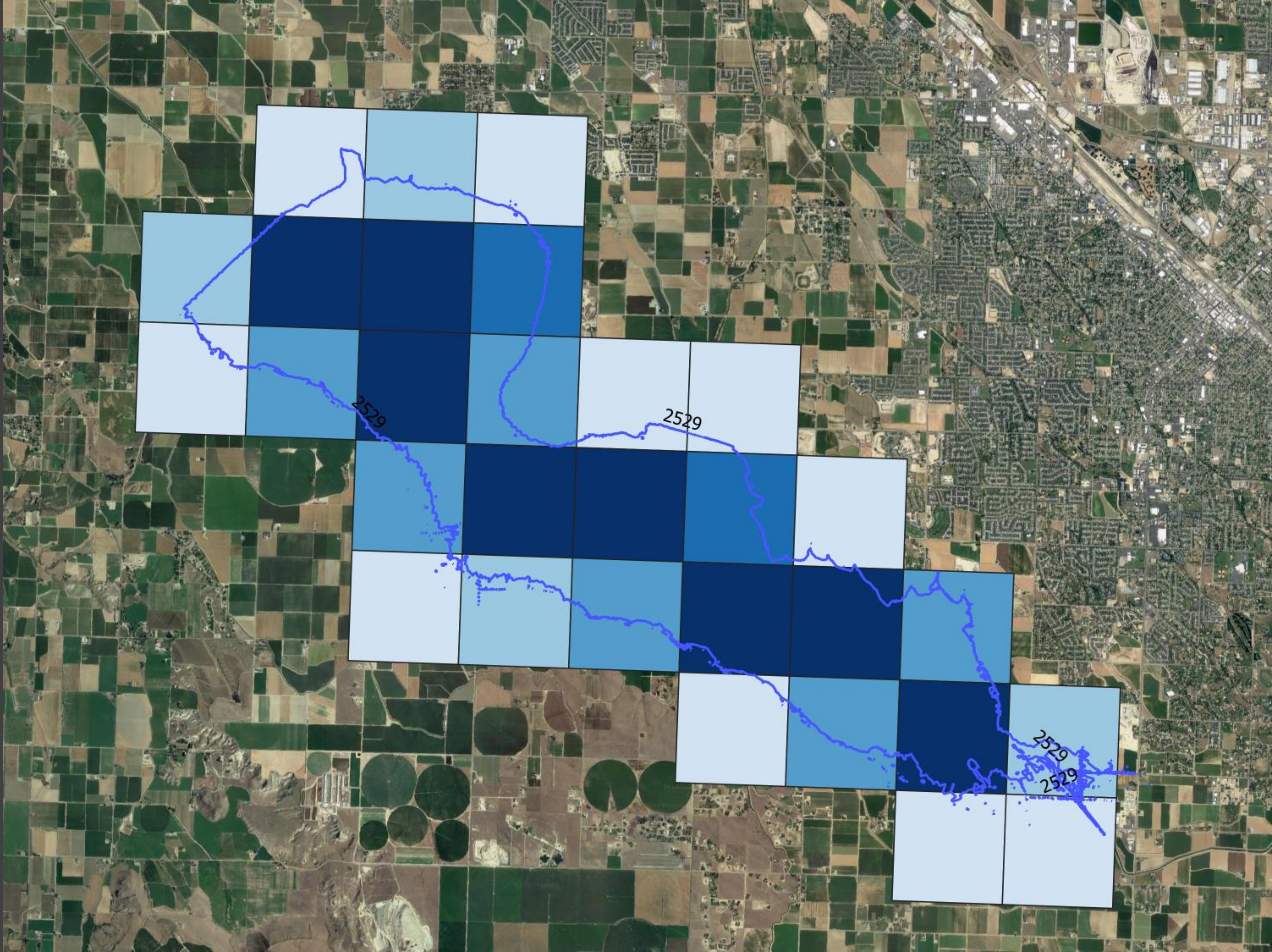
Lowell



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Lowell

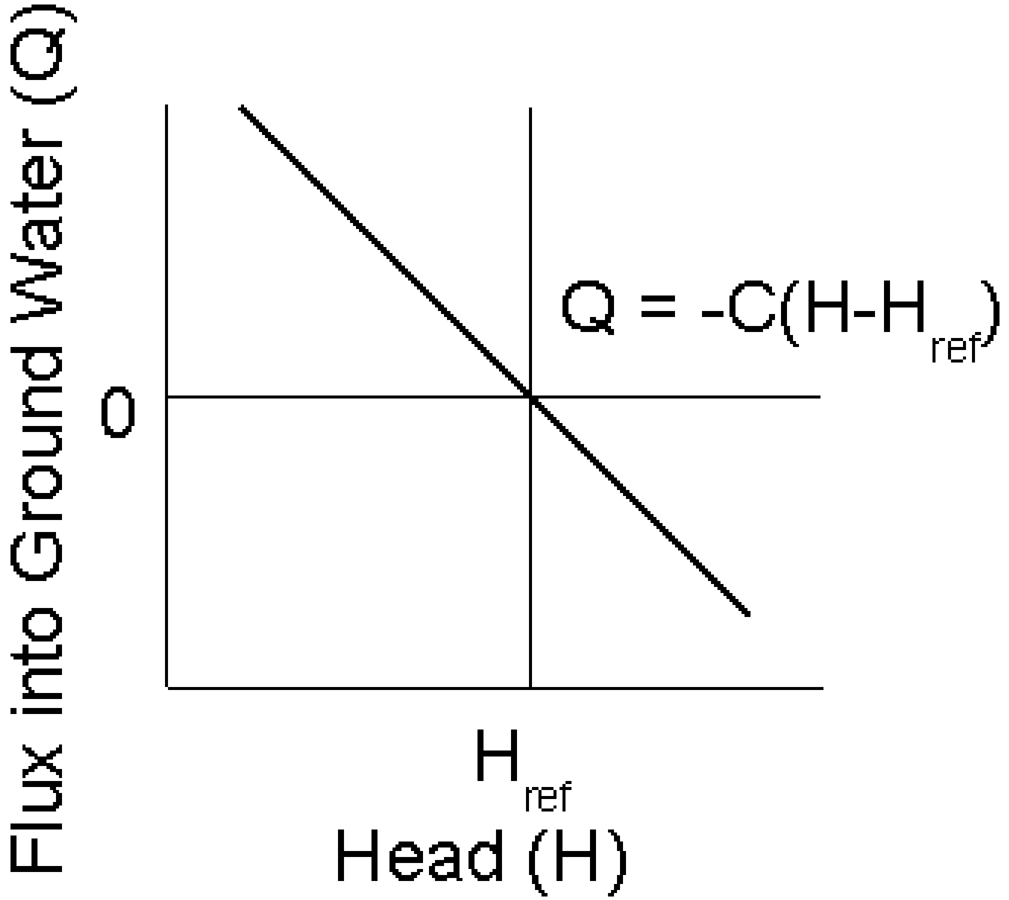
H: groundwater head

$\mathbf{H_{ref}}$: lake stage

C: lakebed conductance

$$\boldsymbol{C = mult_{area} * C_{base}}$$

General Head Boundary



$$\frac{Q}{A} = K\,\frac{\Delta H}{L}$$

$$C = \frac{KA}{L}$$

$$Q(t) = -C(t) * (H - H_{ref}(t))$$

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Thanks for listening!

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