A Cooperative Study of the Walla Walla River Basin Groundwater System, Oregon-Washington

Project update July 27, 2022

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DEPARTMENT OF ECOLOGY State of Washington

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OREGON WATER RESOURCES DEPARTMENT

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Objective

Develop a conceptual and quantitative understanding of the Walla Walla River Basin (WWRB) groundwater-flow system and evaluate how it interacts with surface water and human water use

Workplan Tasks and Timeline

	Federal fiscal year				
Project task	21	22	23	24	25
Literature review and data compilation	x	x			
Data collection	x	x	x	x	
Hydrogeologic framework	x	x	x	x	
Groundwater-budget estimation	x	x	x		
Flow-system evaluation		x	x	x	
Workplan development for phase II--simulation tool			x	x	x
Products			x	x	x

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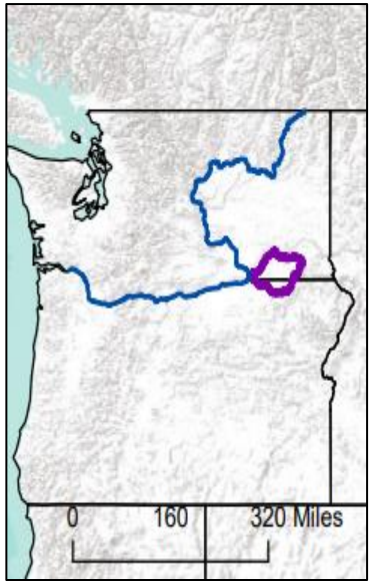
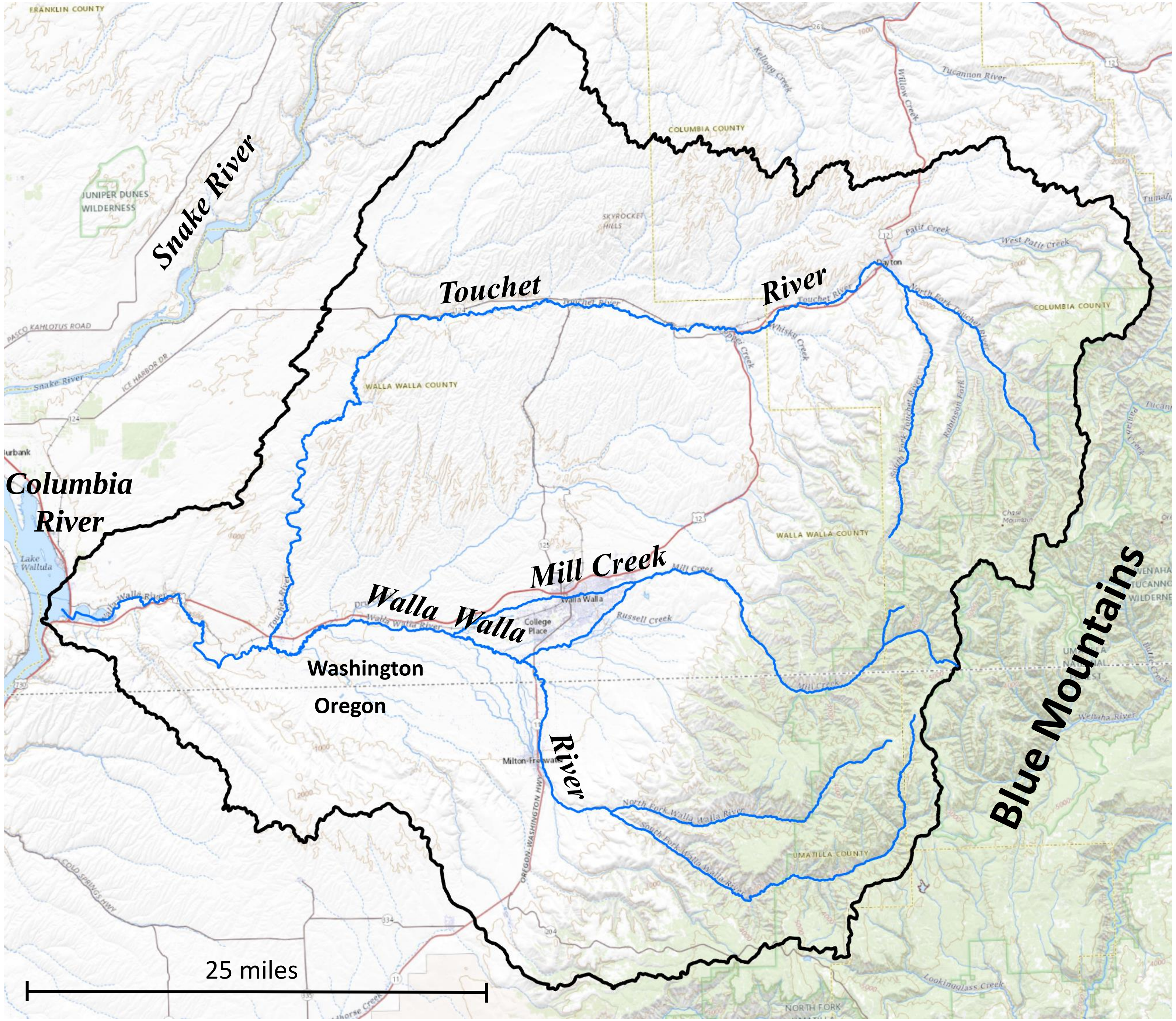
Outline

- Data collection
  - Groundwater
  - Surface water
- Hydrogeologic framework
- Groundwater budget
  - Recharge
  - Discharge
- Flow-system evaluation

Walla Walla River Basin (WWRB)





Stream network from Walla Walla Basin Watershed Council (WWBWC)

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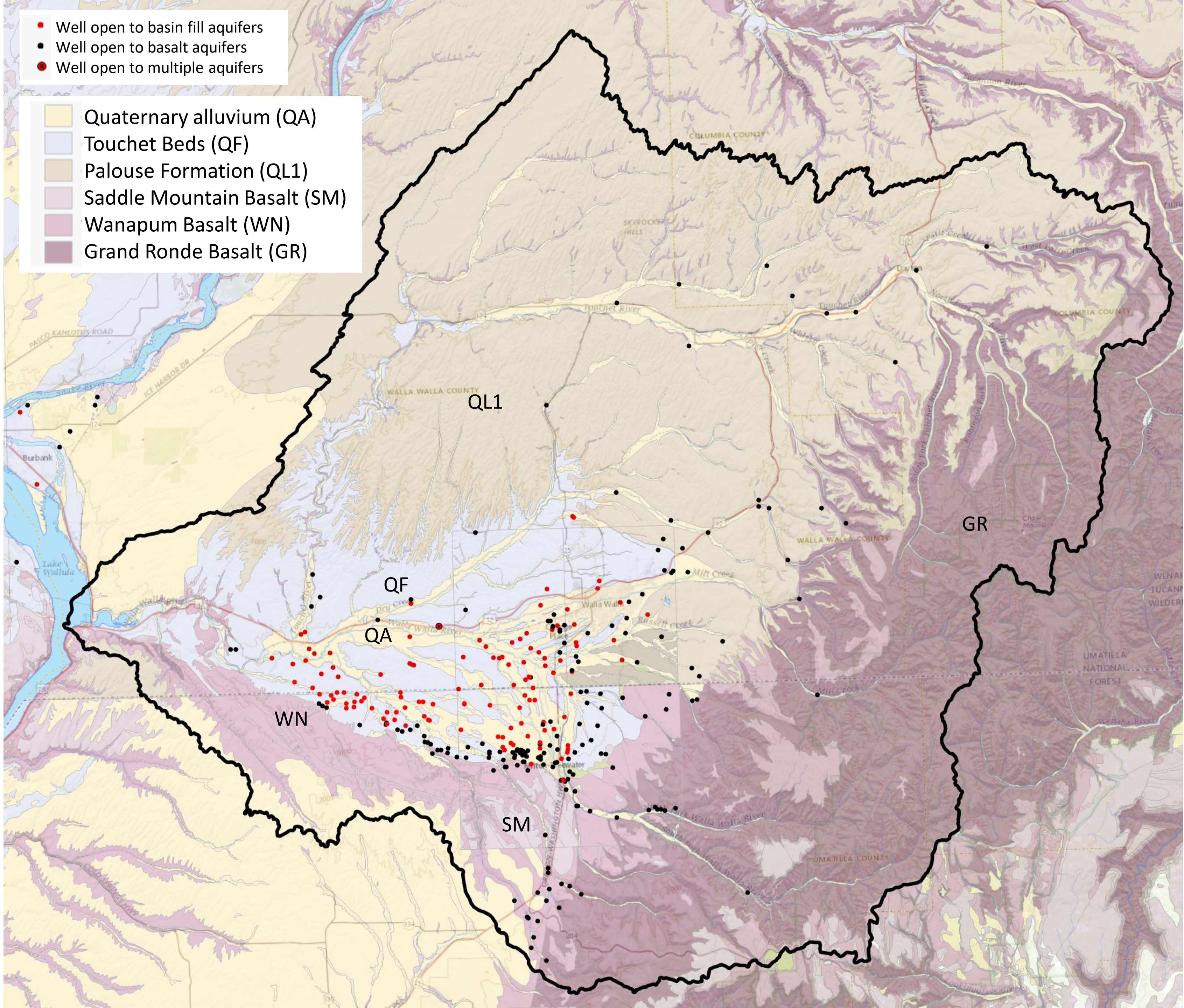
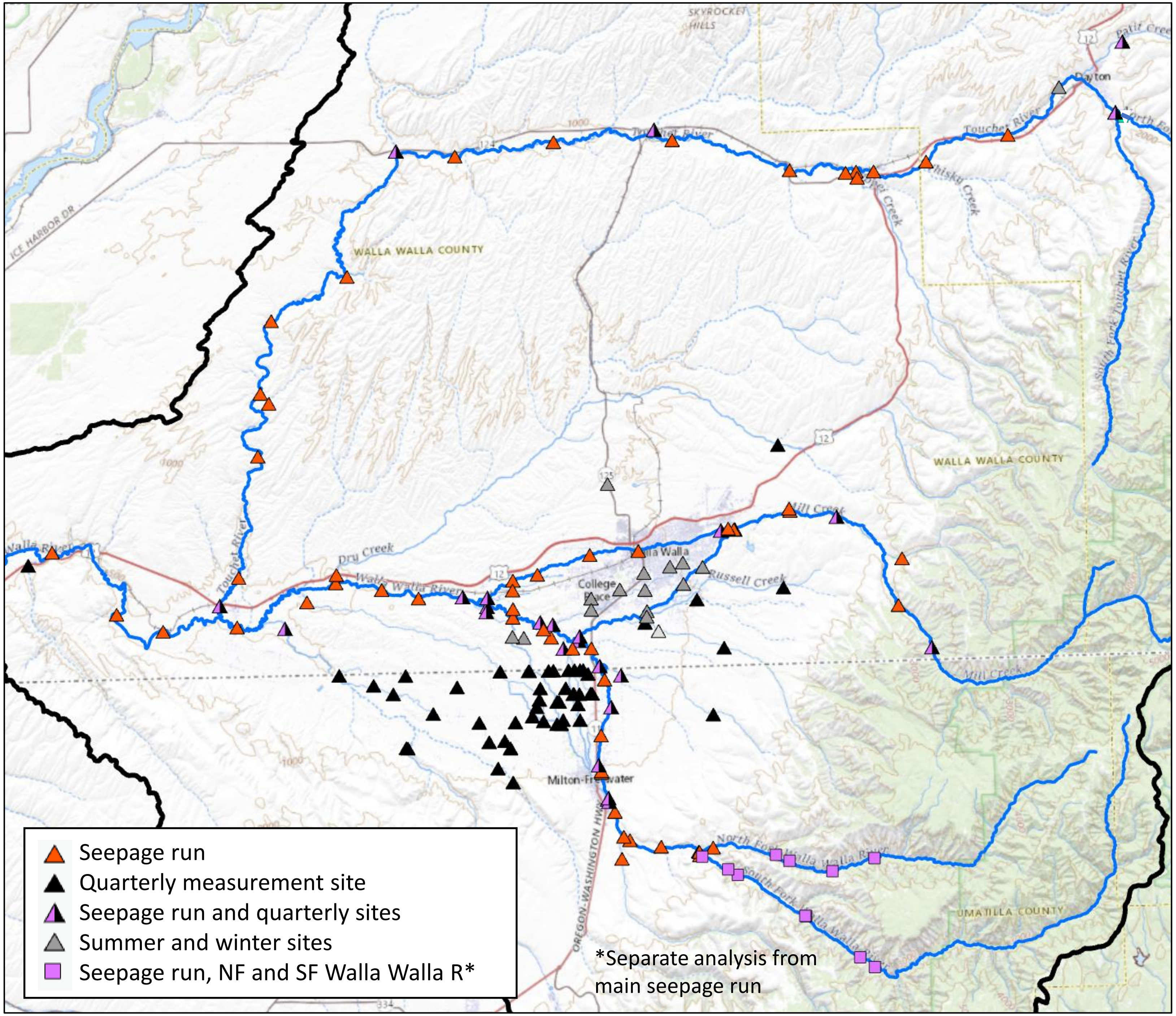
Groundwater Data Collection

- Synoptic water-level measurements
  - Annual network (270 wells)
  - Quarterly network (170 wells)
- Continuous water-level gauges
- Geochemical sampling at selected sites



Surface-Water Data Collection

- Synoptic streamflow measurements
  - Biannual network (Aug 2020 – Feb 2023)
  - Quarterly network (Nov 2021 – May 2023)
- Streamflow gain/loss and estimates
- Springflow
- Geochemical sampling at selected sites



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Hydrogeologic Framework
Major tasks and progress

- Define hydrogeologic units (HGUs) for the study area
  - From geologic maps, well logs, and previous studies (e.g., Newcomb, 1965)
  - *In progress*
- Develop a surficial hydrogeologic map
  - Merge geologic maps and group geologic units into HGUs
  - *In progress*
- Create a digital hydrogeologic model
  - Define map extents of HGUs
  - Interpolate top/bottom elevation surfaces of HGUs (3D)
  - *Not started; expected draft version in FY23*

Define Hydrogeologic Units

- Annotated bibliography
  - Relevant previous studies
- Well database
  - Compile and cross reference wells from USGS NWIS, OWRD, Ecology, WWBWC, WADNR, Newcomb (~660 currently)
  - QA/QC – assess quality of logs and locations
  - Create digital database of logs and lithology
  - Analyze – HGU picks made based on surficial mapping, lithology, previous studies, and other nearby wells
- Geologic/hydrogeologic correlation table
  - See next slide

Example well logs of good, fair, and poor quality

1 Good

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	5
Gravels & Cobbles	5	20
Basalt Rocks With Clay, Brown	20	52
Basalt, Gray & Brown, Hard	52	67
Basalt, Gray & Brown, Med. Hard	67	70
Basalt, Gray & Rusty Red, Soft	70	95
Basalt, Gray, Hard	95	110
Basalt, Gray & Rusty Red, Med. Hard	110	115
Broken Basalt, Gray & Brown, With Clay, White, Soft	115	143
Broken Basalt, Gray & Brown, Soft	143	150
Basalt, Gray & Brown, Hard	150	200
Broken Basalt, Gray/Brown, M. Hard	200	245
Basalt, Gray & Brown, Hard	245	265
Broken Basalt, Gray/Brown, Soft	265	270
Basalt, Gray & Brown, Hard	270	310
Basalt, Gray & Brown, Soft	310	318
Basalt, Gray & Brown, Hard	318	355
Basalt, Gray & Brown, Soft	355	390
Basalt, Gray/Brown, Some Clay, White, Hard	390	415
Broken Basalt, Gray/Brown	415	438
Basalt, Gray Some Brown, Hard	438	480
Broken Basalt, Gray & Red	480	485
Rusty Red Basalt, Med. Hard	485	490
Basalt, Black & Blue, Hard	490	500
10" Drive Shoe Utilized		
8" Drive Shoe Utilized		

RECEIVED NOV 19 1993

Legible, detailed, lots of lithologic descriptors

2 Fair

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Topsoil	0	21
Sand & Gravel	21	29
Brown Clay	29	38
Gravel	38	42
Brown Clay	42	49
Sand & Gravel	49	56
Brown Clay & Gravel	56	71
Brown Clay	71	89
Gravel	89	96
Brown Clay	96	129
Gravel - water	129	156
Brown Clay & Gravel	156	160
Gravel - water	160	172

Fewer lithologic descriptors, but still adequate

BR	BEDROCK
BF	BASIN FILL

3 Poor

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GWC 6962-A

WELL LOG
Record by Driller
Source Driller's Record
Location: State of WASHINGTON
County Franklin
Area
Map
SE¼
Drilling Co ... a Walla
Addre
Metho ... Jan. 9, 1969
Owner
Address Pasco, Washington
Land surface, datum ... ft above/below
SWL: 80' Date ..., 19... Dims.: 12"x142

Diagram of Section

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	From (feet)	To (feet)
	Irrigation use		
	Soil, sandy	0	32
	Gravel, sandy	32	100
	Gravel (water)	100	130
	Rock, black	130	142
	Casing installed from 0 to 131'		
	Perforated from 100 to 131'		
	Yield: 1000 gpm w/15' dd after 4 hrs		
	(a 75 h.p. centrifugal booster was put in w/100 h.p. turbine and well now produces 1200 gpm w/21' dd.		
	Pump: 100 h.p. Jacuzzi turbine		

Limited lithologic descriptors, vague, usually OLD logs

Geologic/Hydrogeologic Correlation Table

- Correlate geologic units from several maps
  - Oregon Department of Geology and Mineral Industries (DOGAMI), multiple maps at different scales
  - Washington Geological Survey (WGS), 1:100,000 and 1:24:000 scale
- Include other key publications
  - Several publications dating from 1933-2011.

Potential Simplified Geologic Unit	Potential Hydrogeologic Unit (HGU)
Young alluvium	QA
Loess	QL2
Touchet beds/flood deposits	QF
Loess - undifferentiated	QL1
Older alluvium/sedimentary rocks	QOA
Saddle Mountains Basalt	SM
Wanapum Basalt	WN
Grande Ronde Basalt	GR

Preliminary data subject to change

Hydrogeologic Map

- Merge geologic maps
  - WGS and DOGAMI
  - High resolution (1:24k) and coarse (1:100k)
- Edge-match across map boundaries
- Group geologic units into hydrogeologic units
  - Based on similar hydrogeologic characteristics

Data Sources:
WA: https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases
OR: https://www.oregongeology.org/pubs/dds/p-OGDC-7.htm

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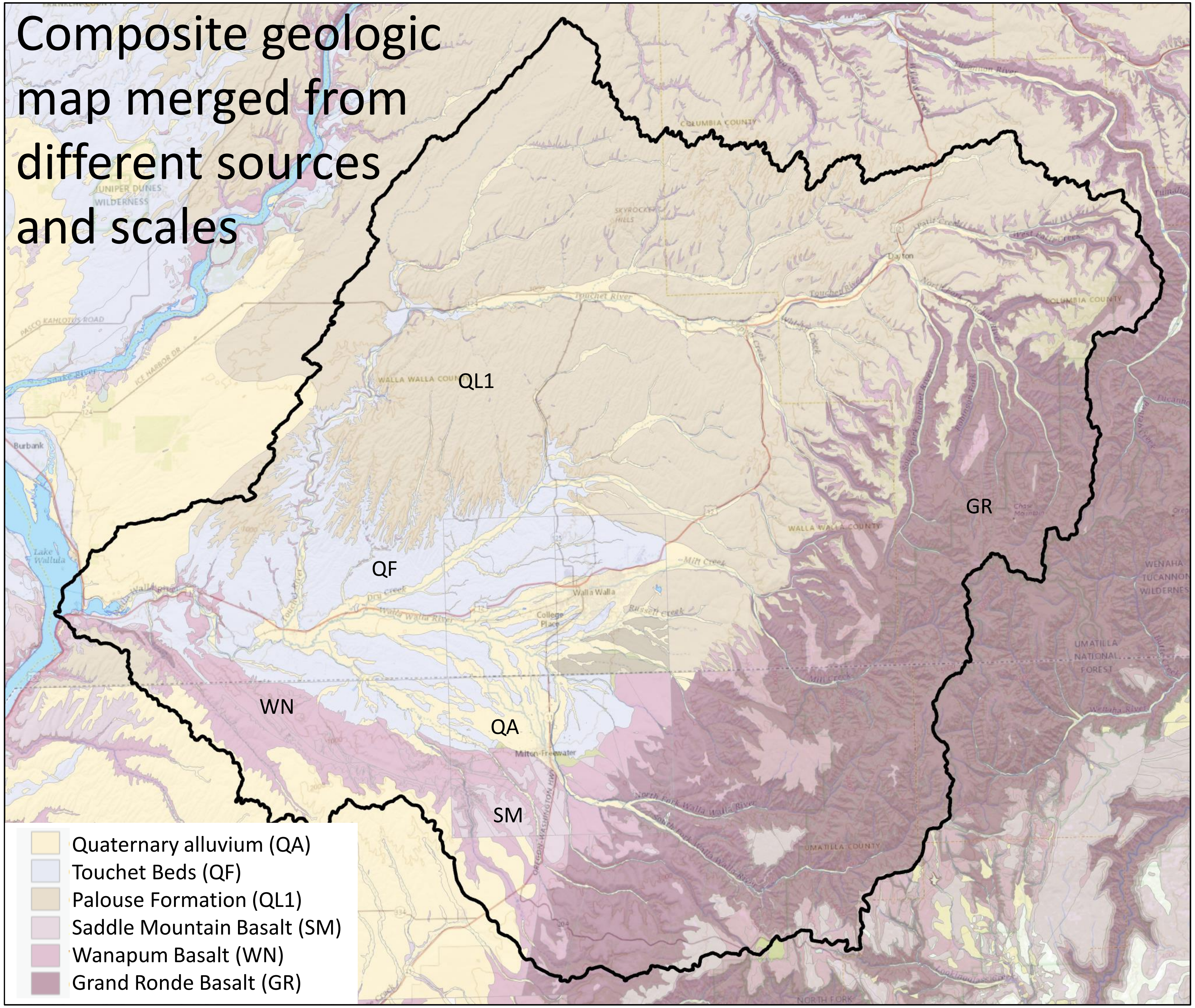


Groundwater Budget

Describes the inflows (recharge) to and outflows (discharge) from the Walla Walla River Basin groundwater system

Recharge components

- Infiltration of precipitation
- Infiltration of surface water
- Infiltration of irrigation water
- Managed aquifer recharge (MAR)
- Aquifer storage and recovery (ASR)
- Interbasin groundwater flow

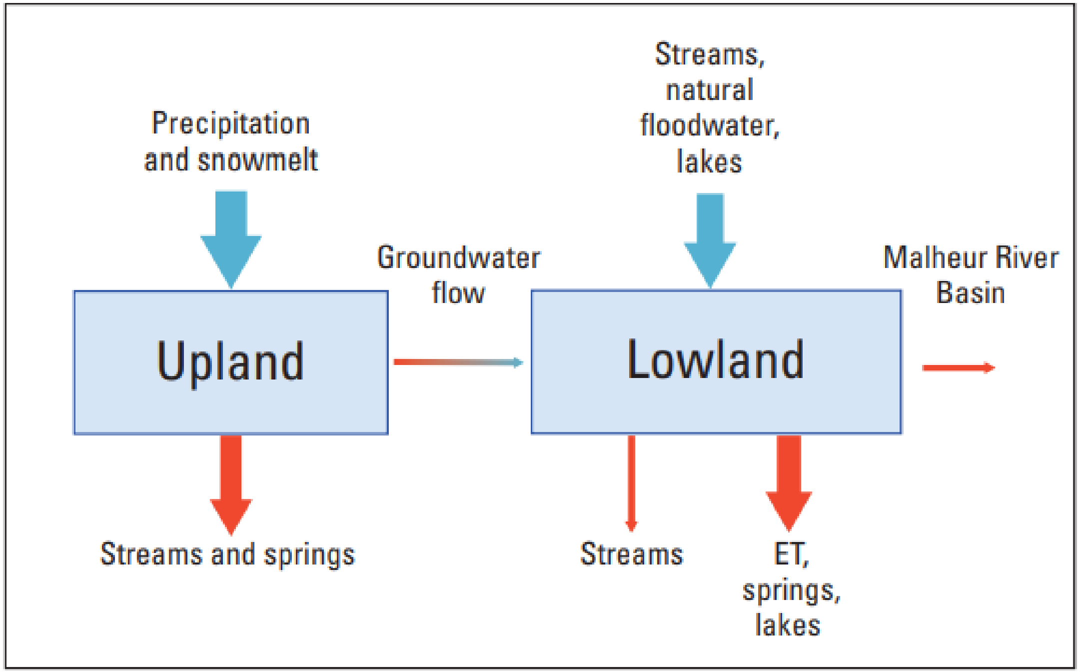
Discharge components

- Base flow to streams
- Spring discharge
- Evapotranspiration
- Groundwater pumping (water use)
- Interbasin groundwater flow

Groundwater Budget

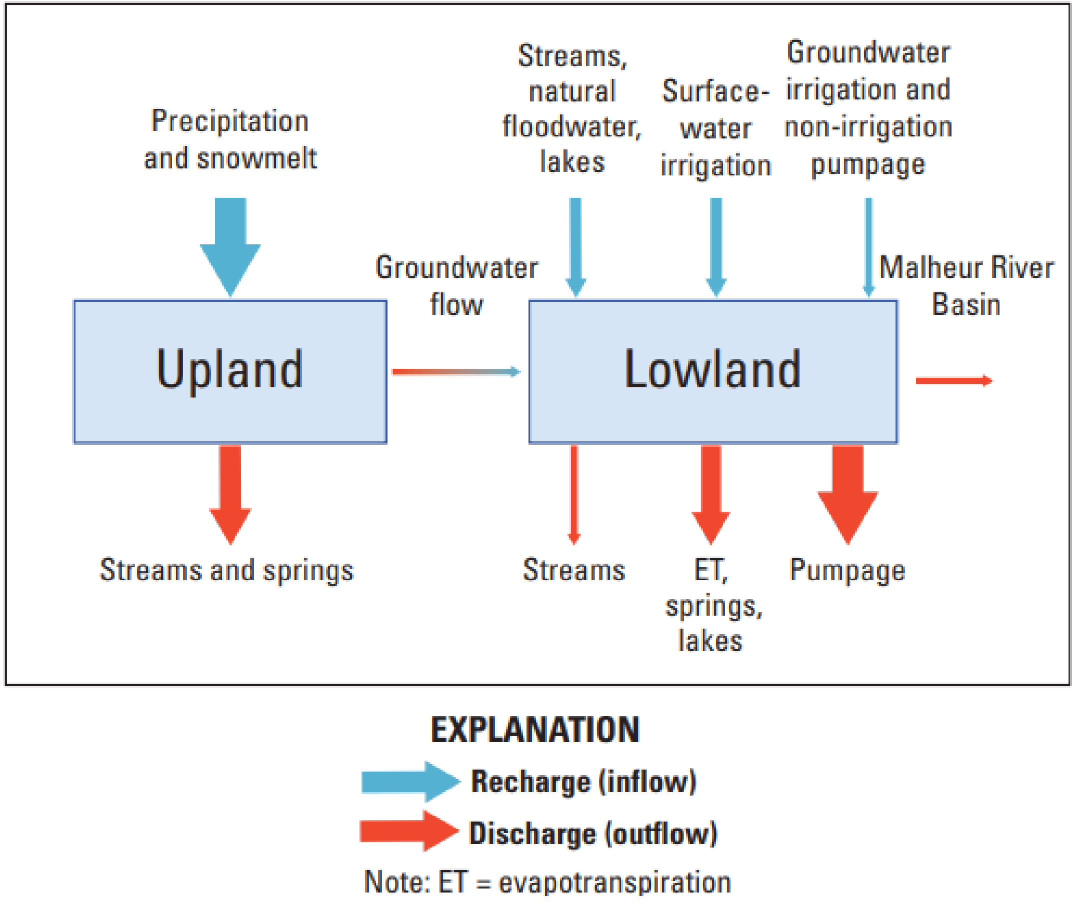
Example from Harney Basin, Oregon

Predevelopment



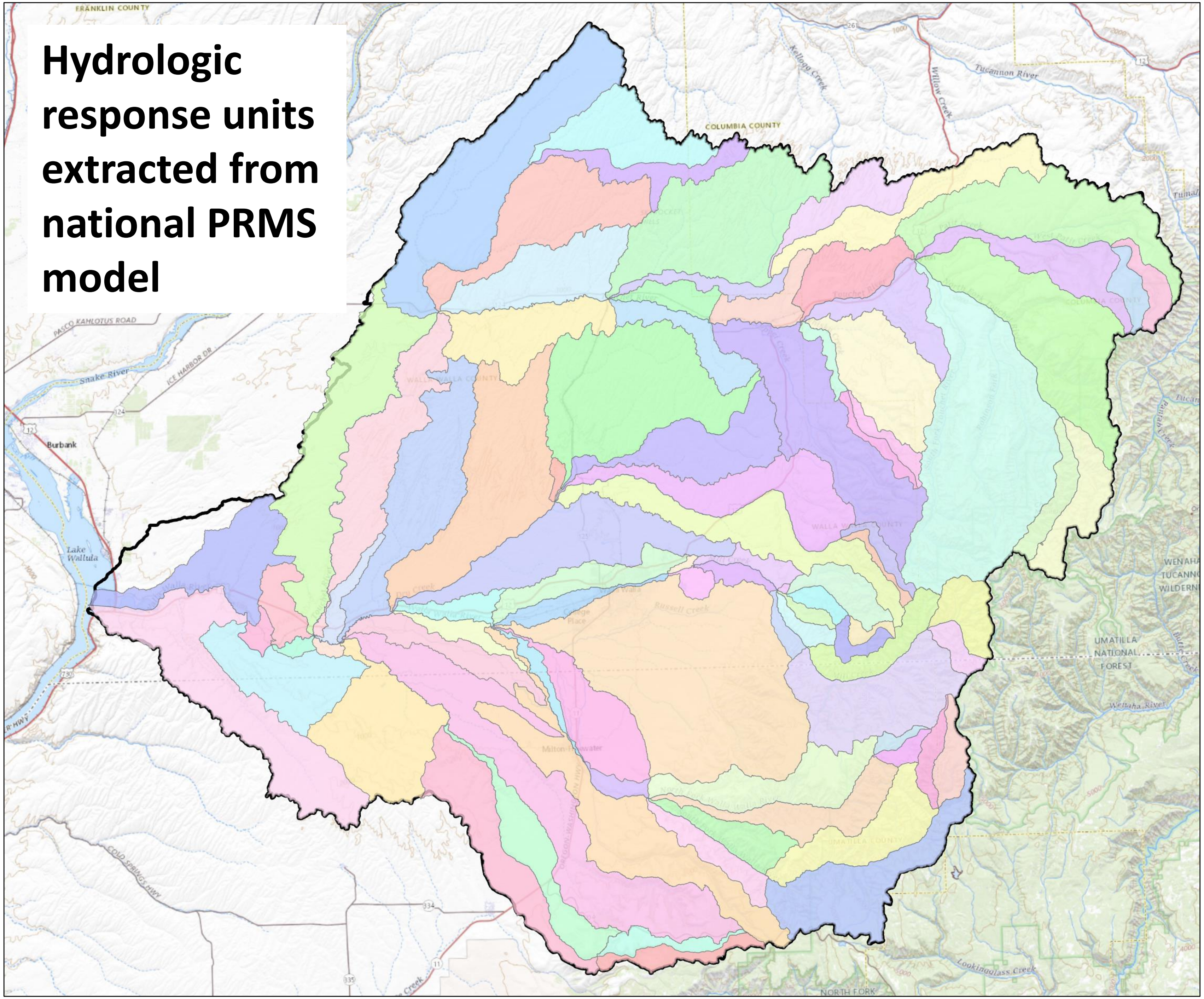
Garcia and others (2022)

Post-development



Groundwater Recharge

- Infiltration of precipitation
- Precipitation Runoff Modeling System (PRMS)
  - WWRB extracted from national model
  - Simulates ET, runoff, baseflow, snowpack, snowmelt
  - Refine and calibrate to local data



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Groundwater Recharge

- Seepage runs*– estimating streamflow losses to (and gains from) groundwater

*Seepage run: a series of streamflow measurements from upstream to down stream to estimate gains from or losses to groundwater

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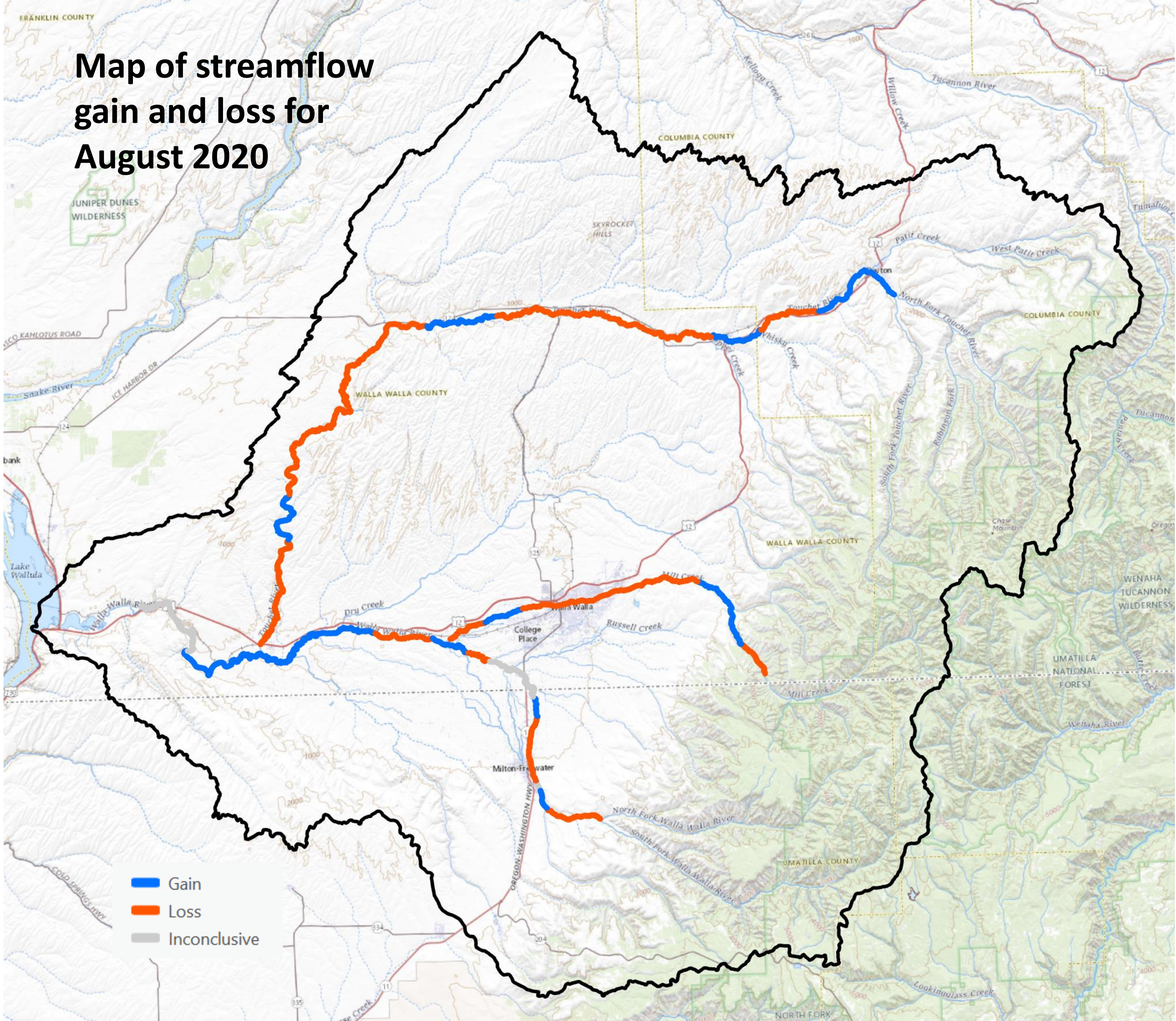
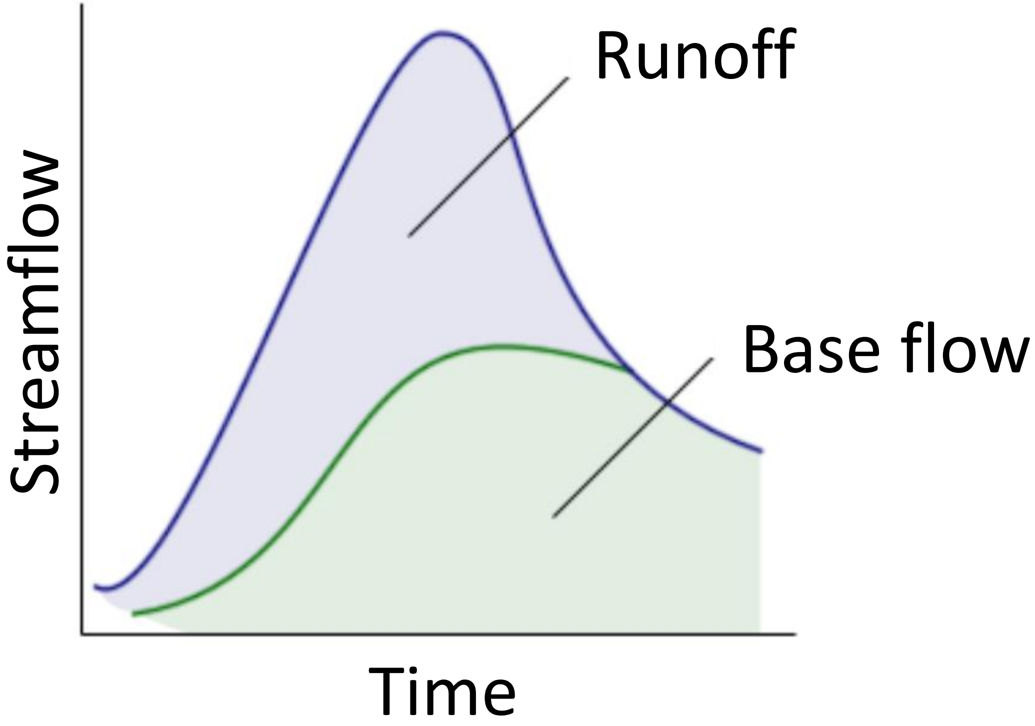


Groundwater Discharge

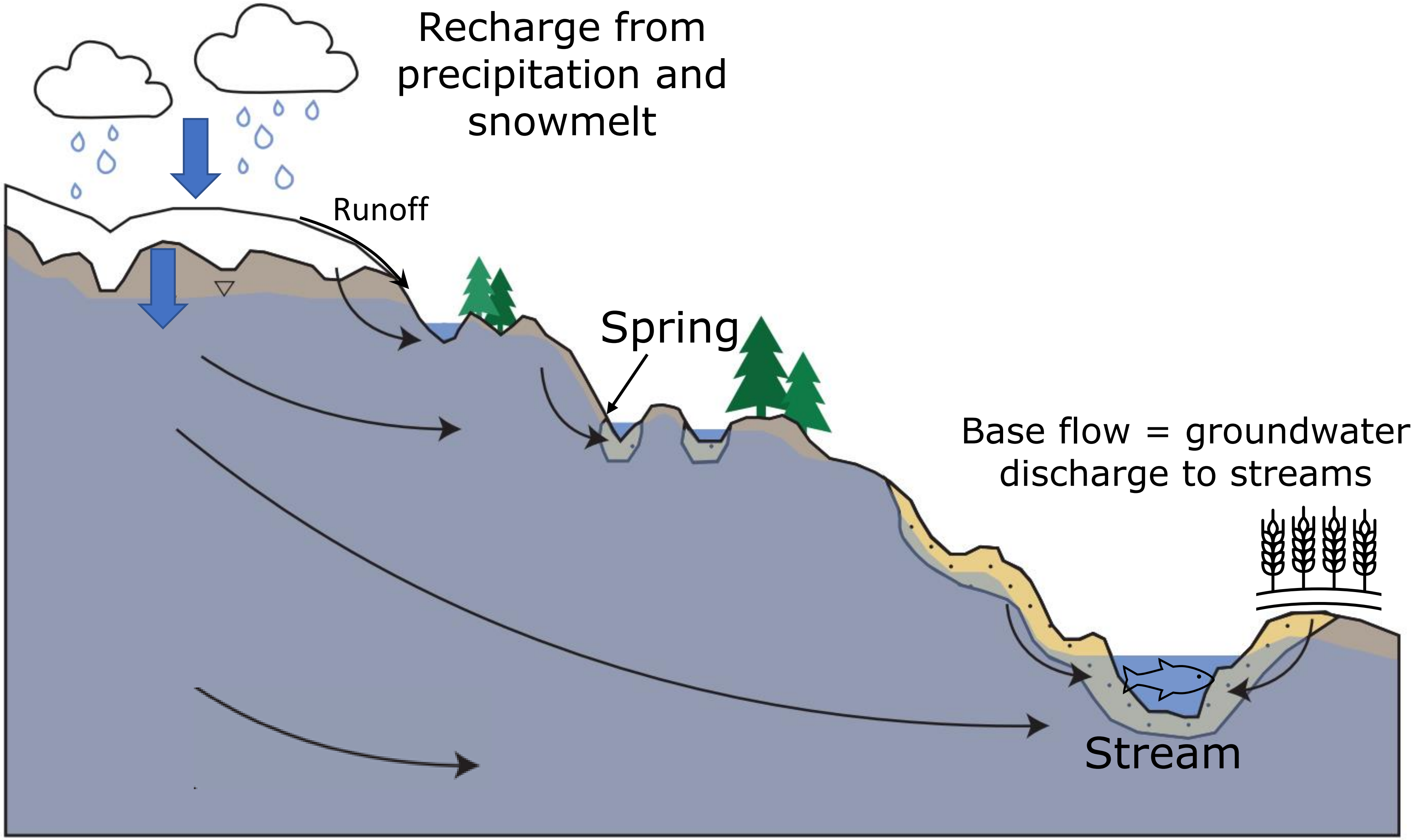
To streams and springs

- Seepage runs* and quarterly measurements that include springs
- Base flow from continuous gages
    - Done for unregulated, mostly upland areas
    - Methods are hydrograph separation and low flow methods



Modified from University Corporation of Atmospheric Research, 2005

Conceptual Walla Walla River Basin (WWRB) Cross Section



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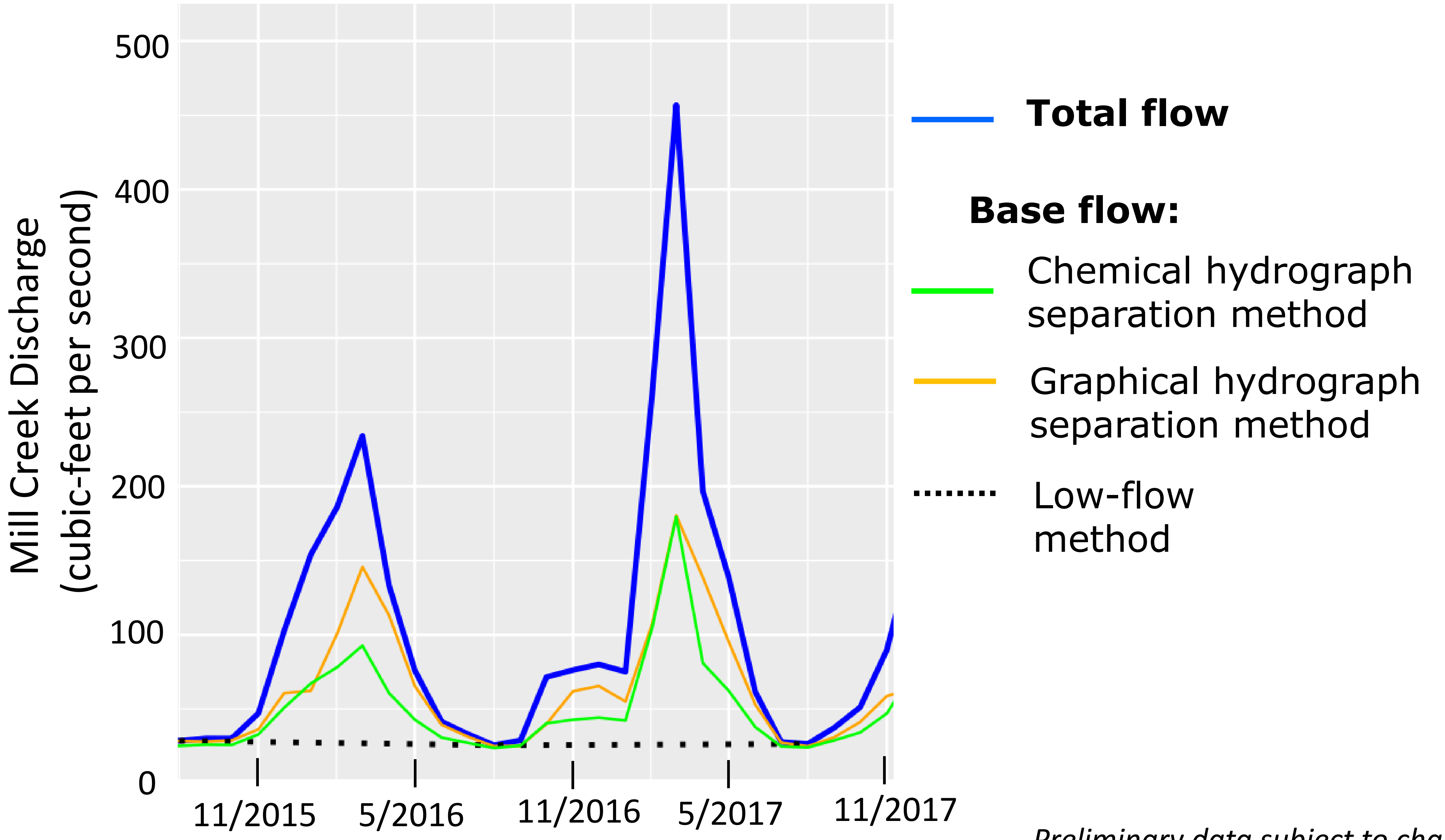
Example of Base-Flow Estimation Methods



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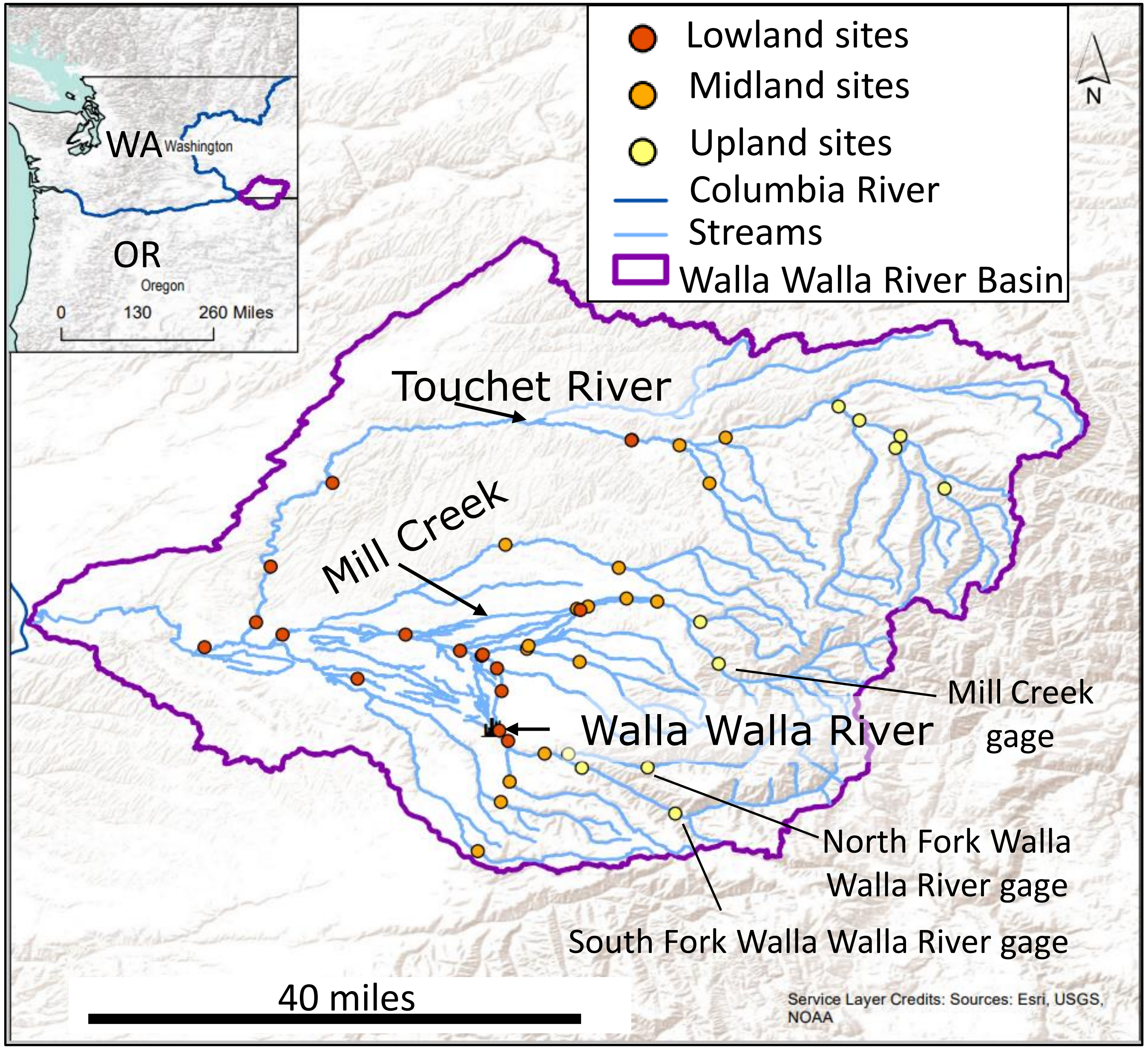
Groundwater Discharge

Base-flow estimation

- 44 sites with continuous data
  - Upland, midland, and lowland sites have different characteristics
  - Baseflow estimated at upland and midland sites currently
  - Other sites may be added if criteria are met
- Preliminary estimates
  - 55-65% base flow at South Fork Walla Walla River and Mill Creek gages
  - ~35% base flow at North Fork Walla Walla River gage



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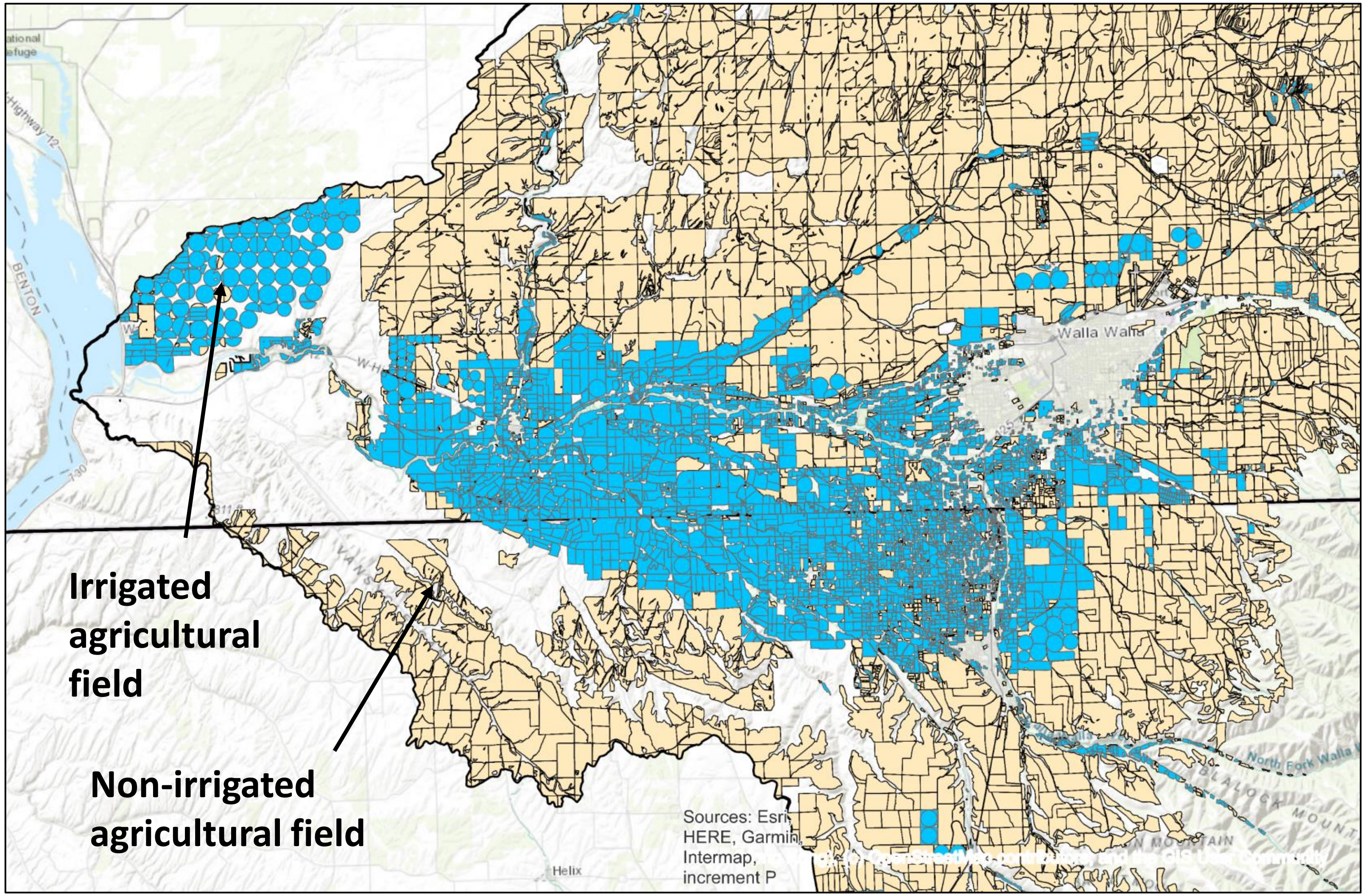
Groundwater Discharge – Water Use

Agricultural fields and irrigation status

- Maximum extent of agricultural fields from multiple state sources
- Seasonal irrigation status from IrrMapper (see reference)
- Available for 1986-2021



Reference:
Ketchum and others, 2020 – IrrMapper: A Machine Learning Approach for High Resolution Mapping of Irrigated Agriculture Across the Western U.S. Remote Sensing

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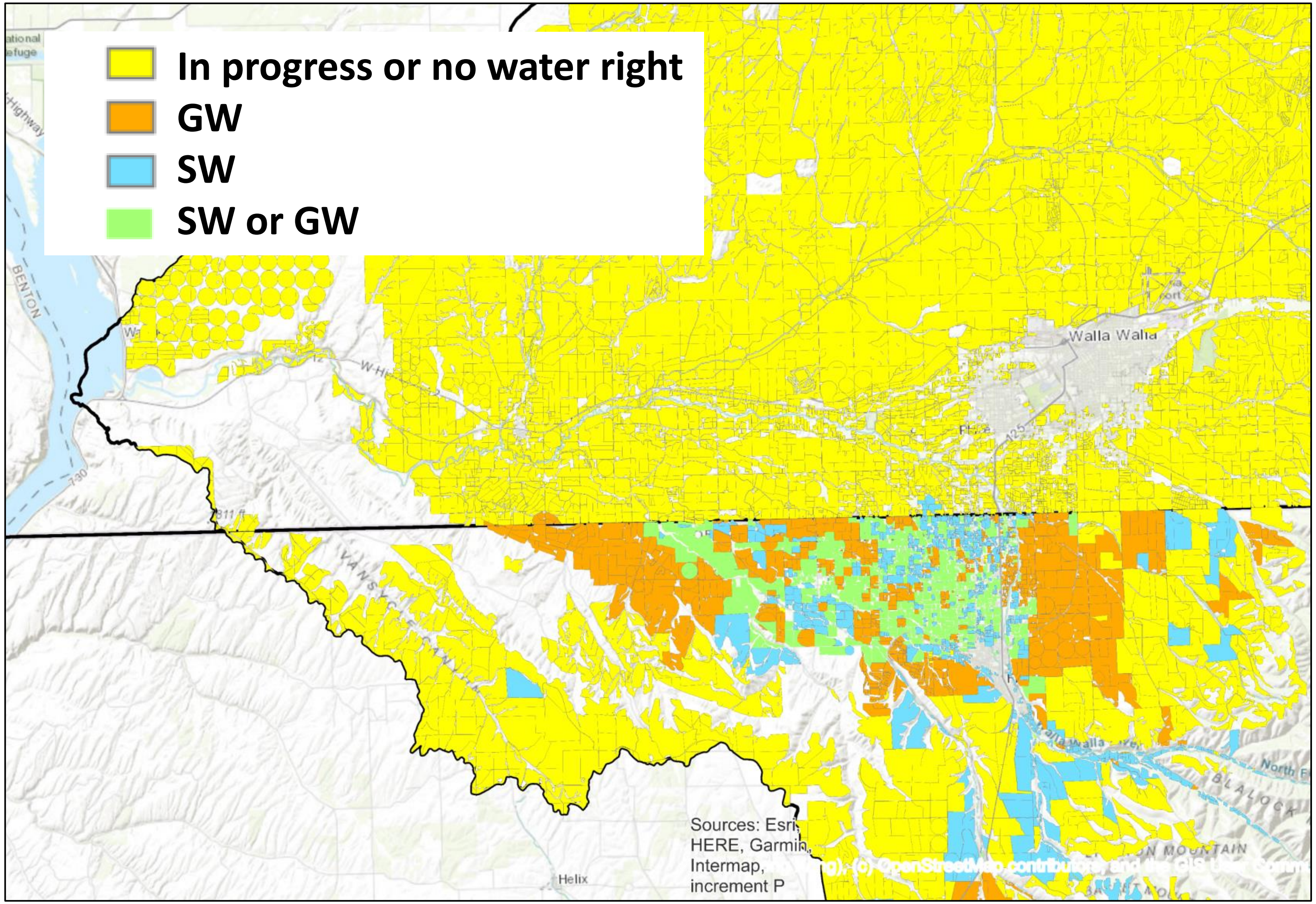
Groundwater Discharge – Water Use

Irrigation source for each field

- Does the field have a water right?
- Is it from GW or SW?
- *OR is completed*
- *WA is next*



Source: OR and WA water rights place of use (POU) databases

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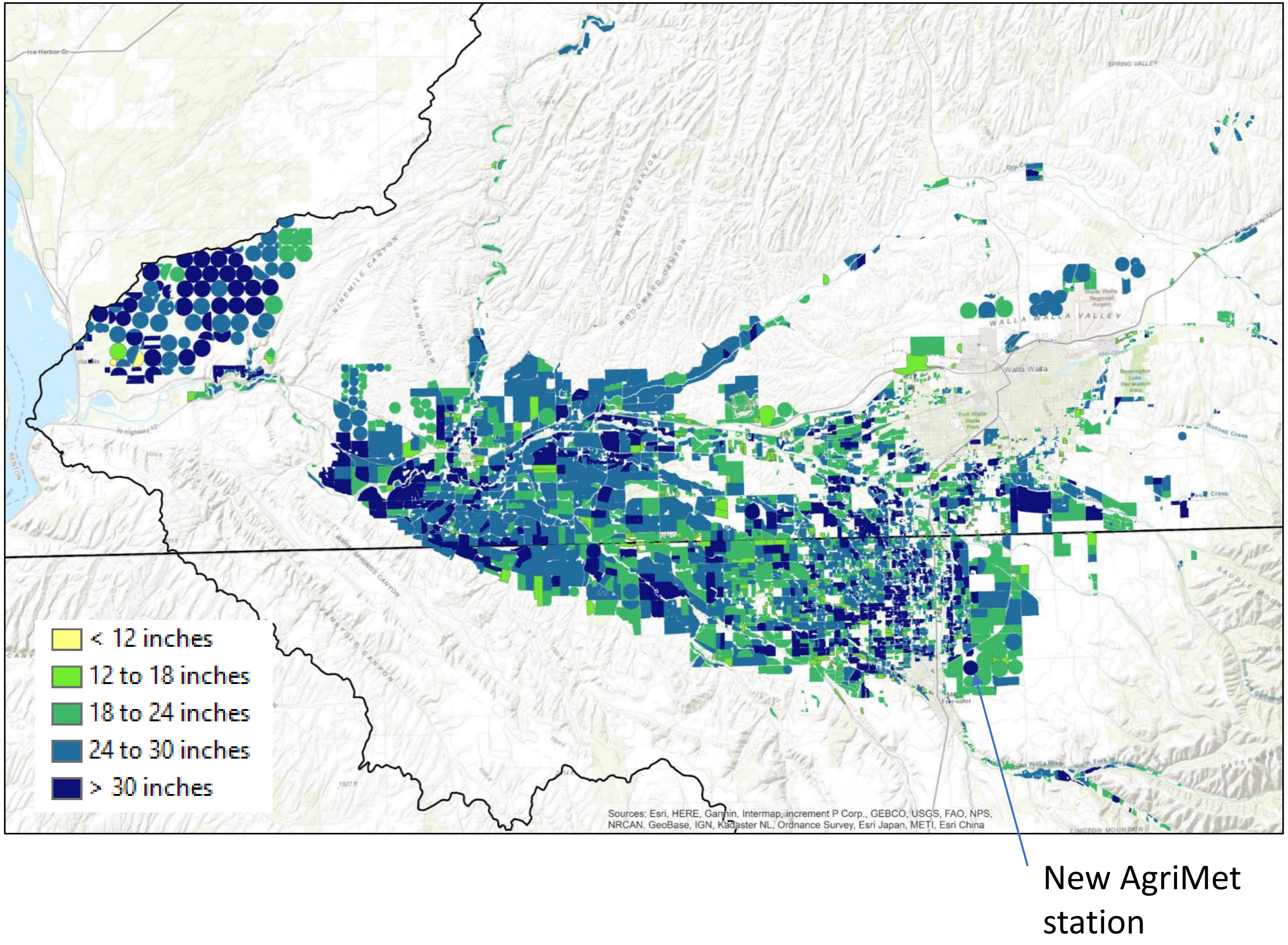
Groundwater Discharge – Water Use

Evapotranspiration (ET) from irrigated fields

- Used to estimate actual consumptive use by month and season
- Available for 2016-2021
- 1985-2015 estimates delayed in contracting



Source: OpenET (Melton et al., 2021)

Preliminary data subject to change

Groundwater Discharge – Water Use

Irrigation system type

- Map of system type is in progress
- Use this map with the previous datasets to estimate applied water (AW)
- Account for irrigation efficiency

Pivot sprinkler systems

Wheel line sprinkler systems

Controlled and wild flood irrigation

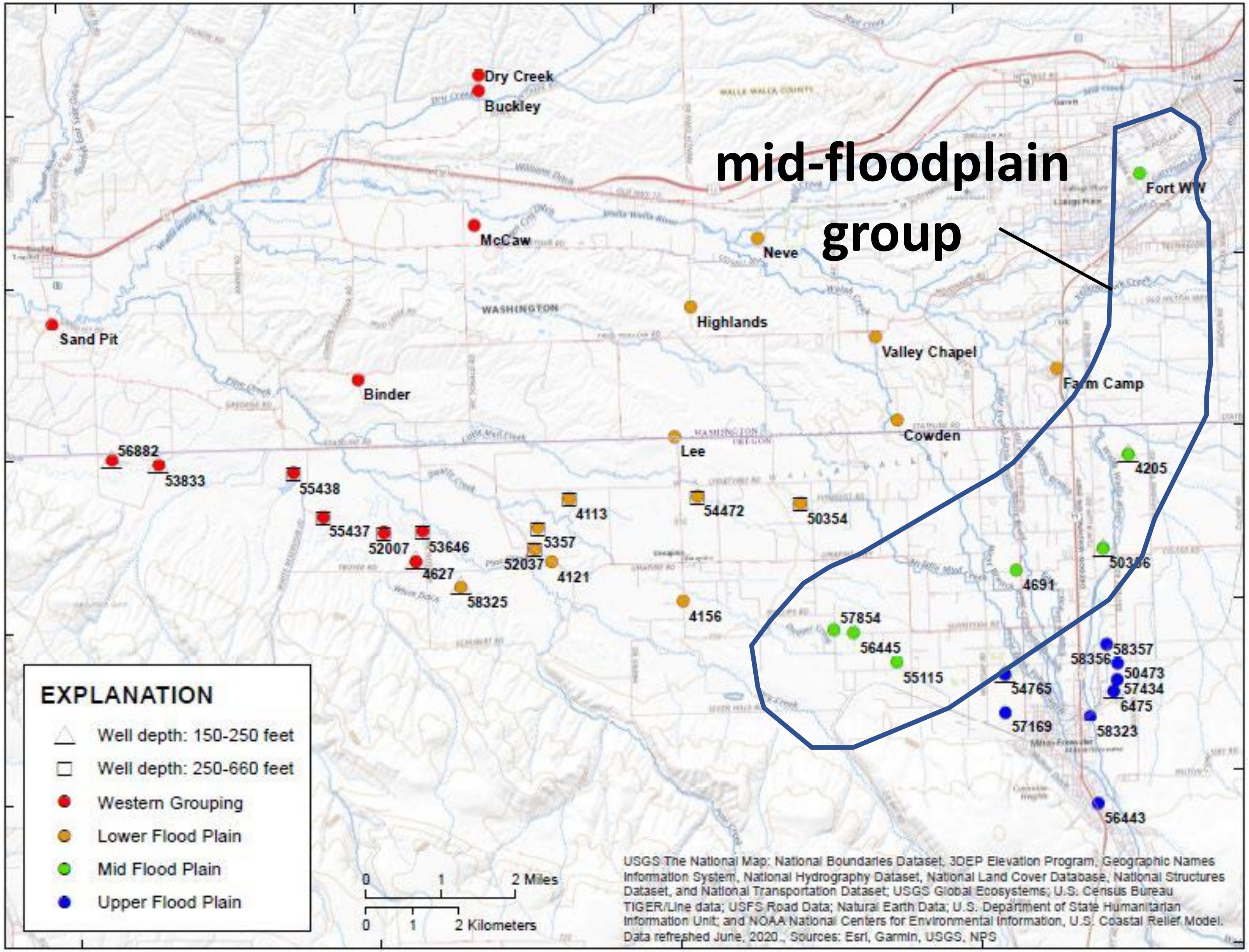
Micro and drip irrigation

Flow-System Evaluation

Groundwater-level trends

- Alluvial well example
- Wells were grouped by water-level characteristics
  - (e.g., trends, overall levels)

Alluvial well subset



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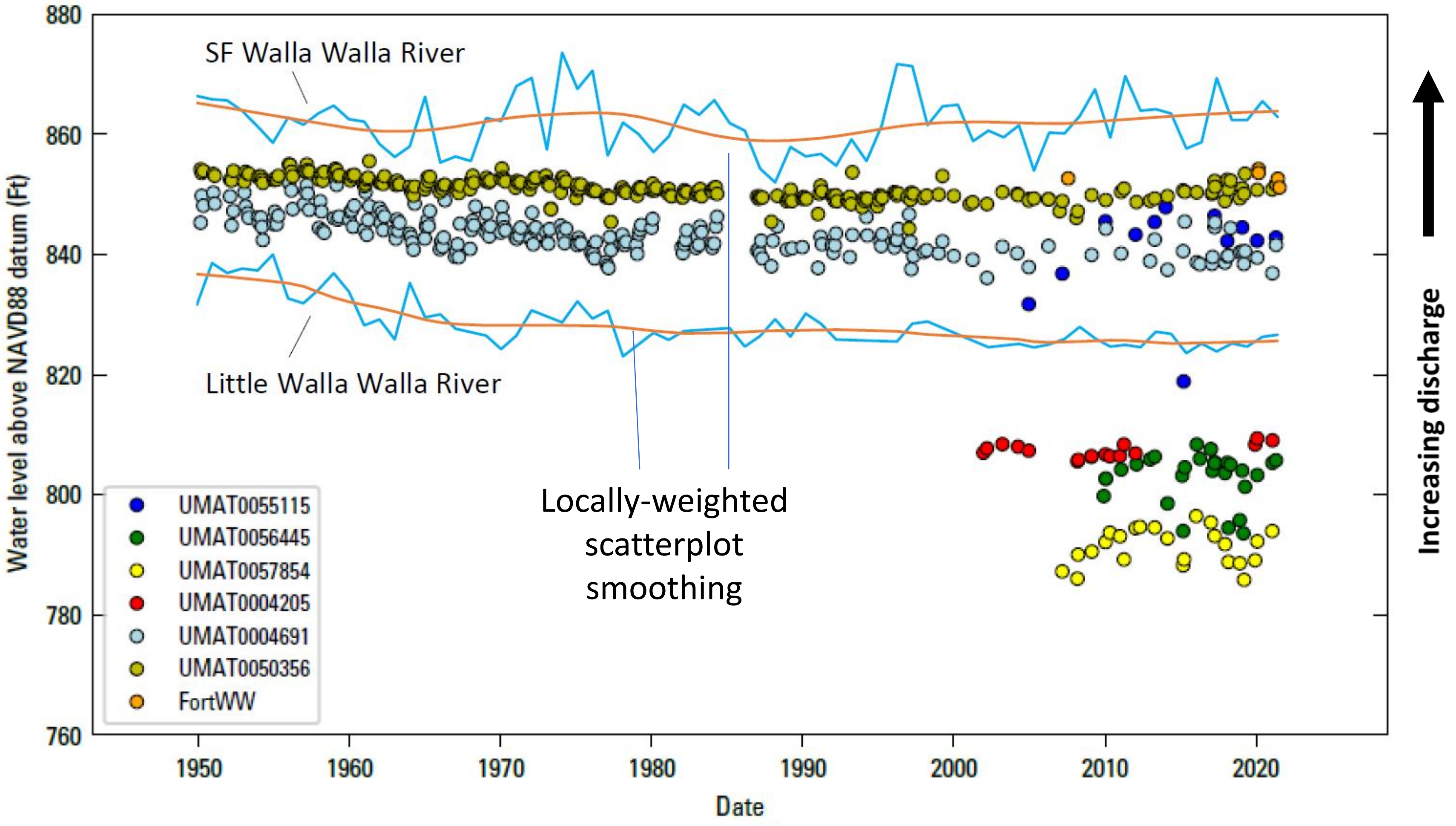
Flow-System Evaluation

Groundwater-level trends

- Alluvial groundwater levels
- 30-yr (1990-2019) trend is negative
- Decline similar to decline in Little Walla Walla River discharge

Alluvial well subset (mid-floodplain group)



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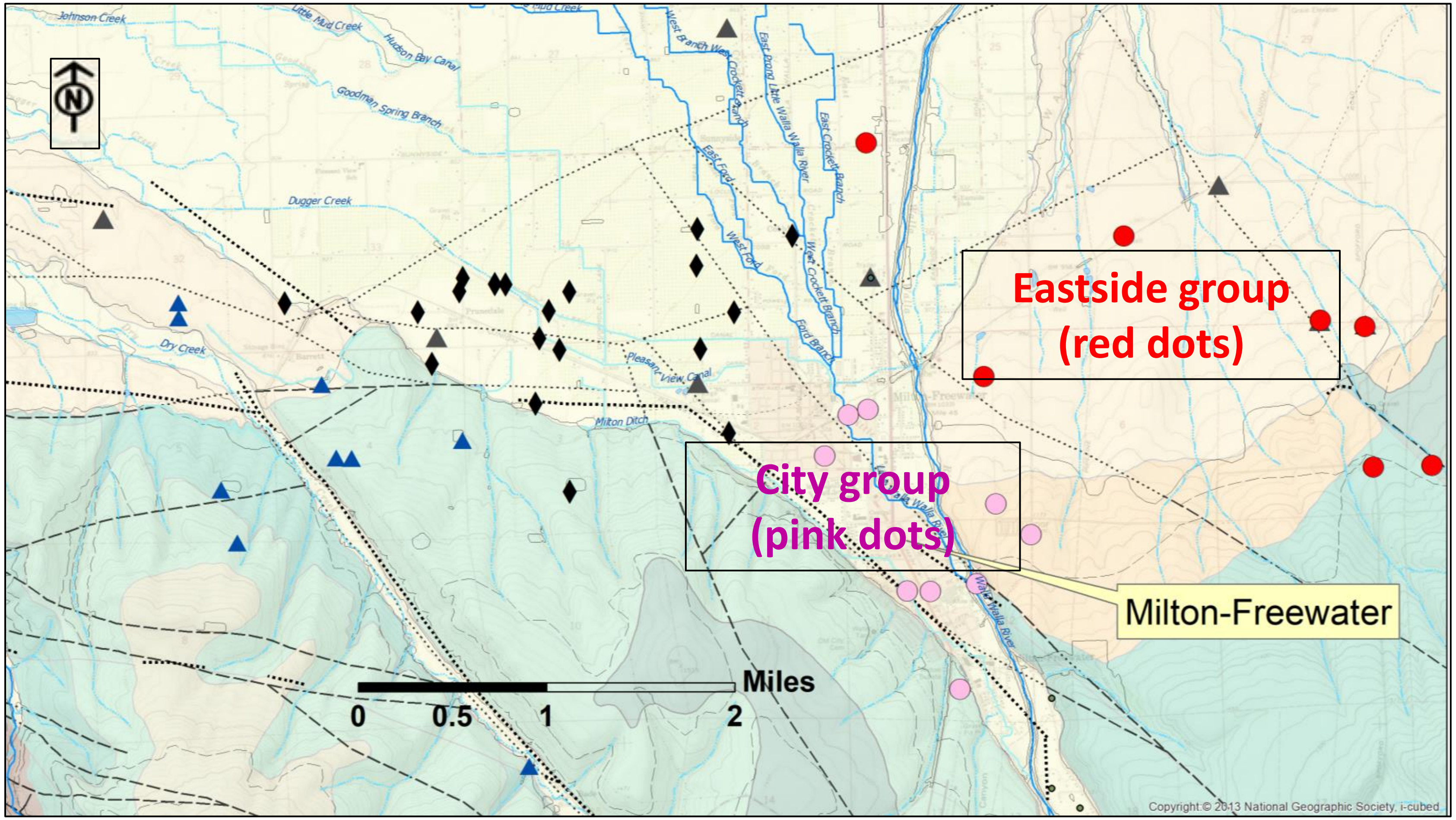
Flow-System Evaluation

Groundwater-level trends

- Basalt well example
- Wells were grouped by water-level elevation and hydraulic responses to pumping

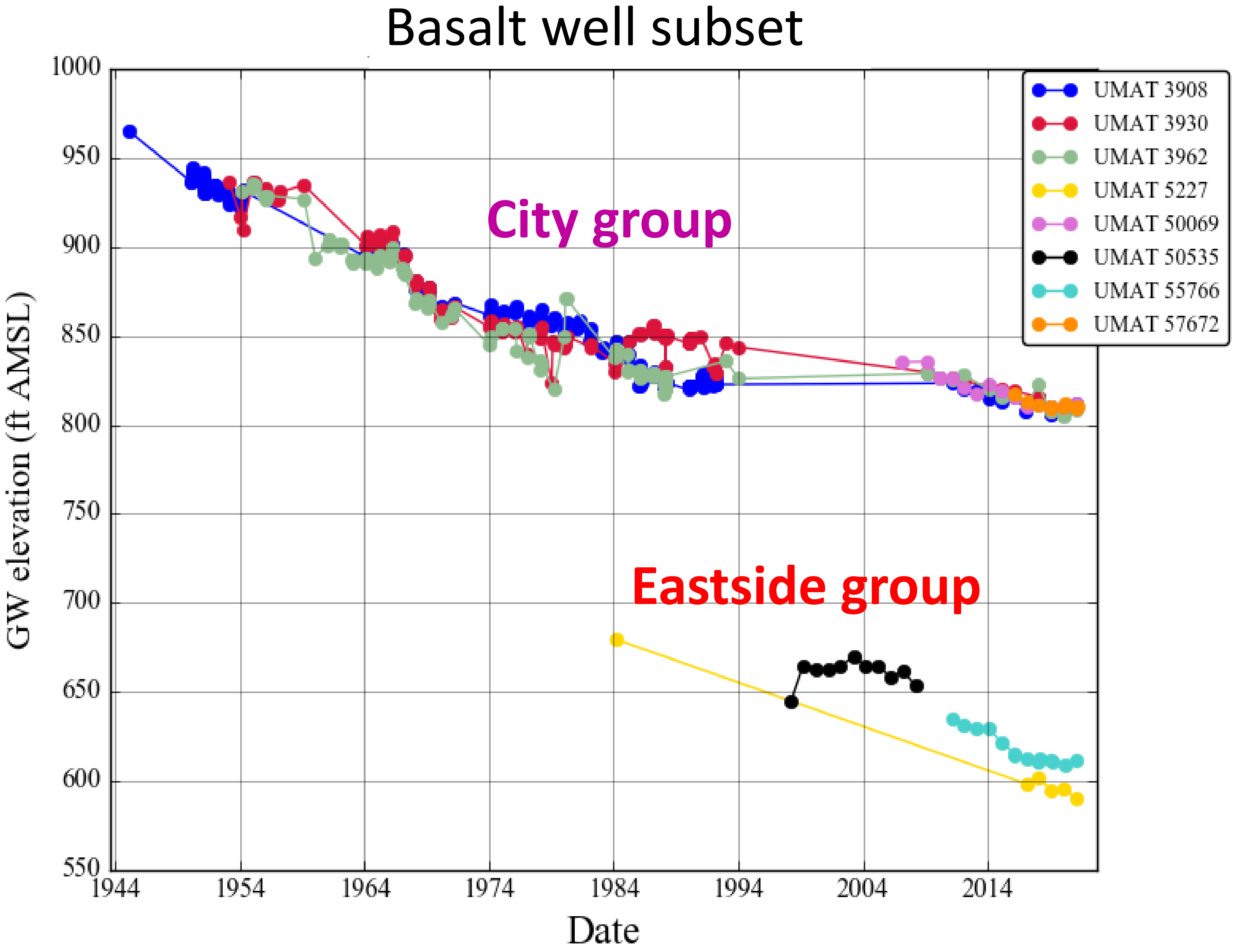
Basalt well subset (Oregon)



Flow-System Evaluation

Groundwater-level trends

- Basalt groundwater levels
- Steep declines 1950–1980 in OR and WA
- More gradual decline 1980–2020
- Investigating possibility of structural controls on water levels and recharge distribution



Preliminary data subject to change

Flow-System Evaluation – Geochemistry

- Geochemical analyses inform groundwater recharge areas, flow paths, and residence time
- Study is utilizing a variety of tools to evaluate groundwater chemistry
  - Specific conductance
  - Stable isotopes of water
  - Major ion composition
  - Age tracers – tritium, carbon-14, sulfur hexafluoride

Photo credit: Hank Johnson, USGS

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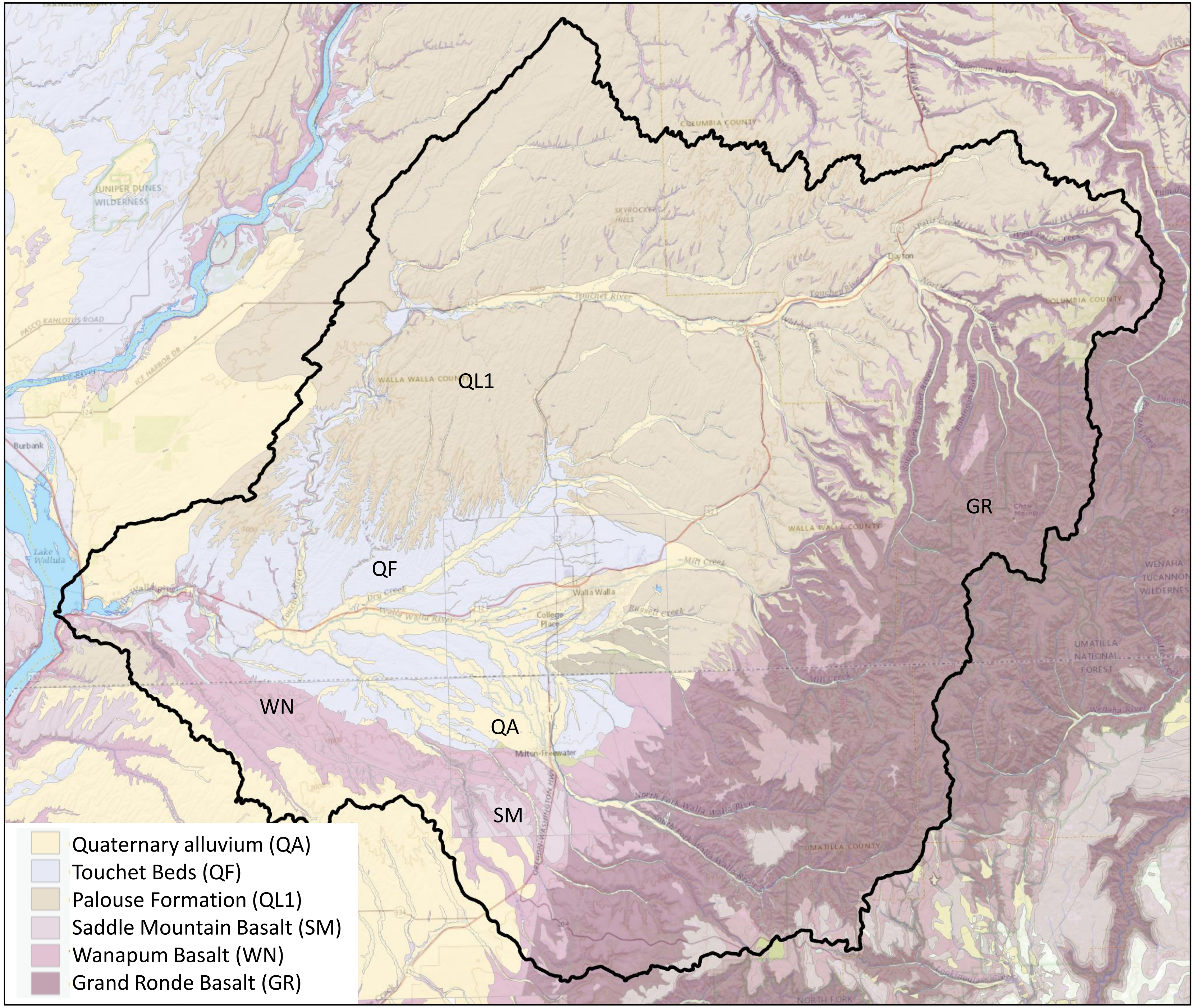
Flow-System Evaluation – Geochemistry

Stable isotopes

- Deep and shallow groundwater have different stable isotope signatures in the basin
- Lowland springs and most high-elevation springs are similar to shallow groundwater
- Some springs in the Walla Walla River canyon have uncertain origin and need further analysis

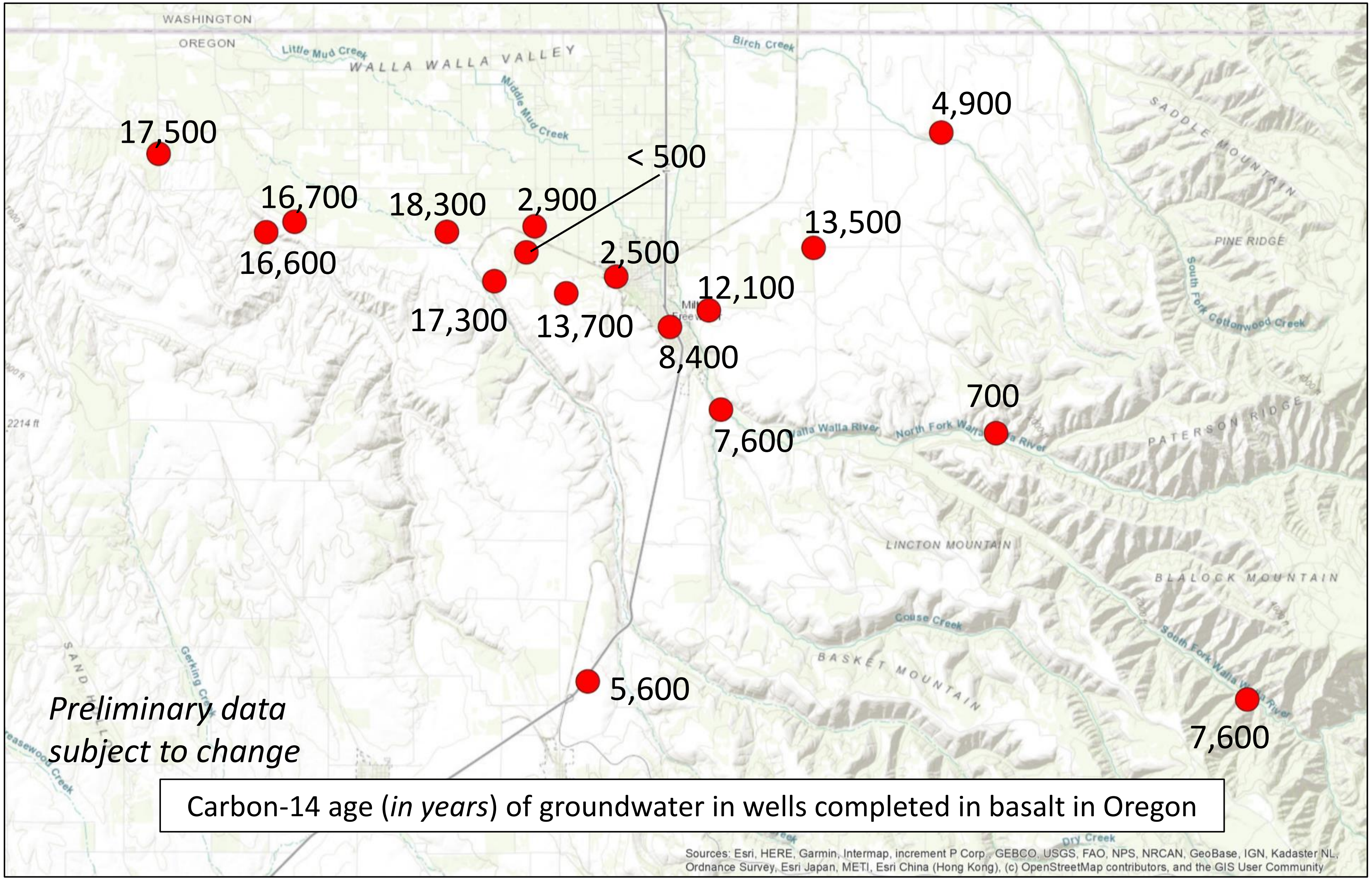


Flow-System Evaluation – Geochemistry

Groundwater in basalt aquifers in Oregon is old

- Mean age 9,700 years
- 8 of 17 samples were recharged prior to the end of the Pleistocene (~1,700 years)

Columbian Mammoth, Charles Knight, 1909 (public domain)



Carbon-14 age (*in years*) of groundwater in wells completed in basalt in Oregon

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Flow-System Evaluation

- Groundwater occurrence and flow
  - Integrating chemistry, contour maps, water budgets, and geology to characterize and better understand groundwater flow
- Groundwater-surface water interactions
  - Integrating seepage, base flow, and spring discharge estimates with chemistry and geology to understand where, when, and why interactions occur

OWRD and USGS staff measuring groundwater levels

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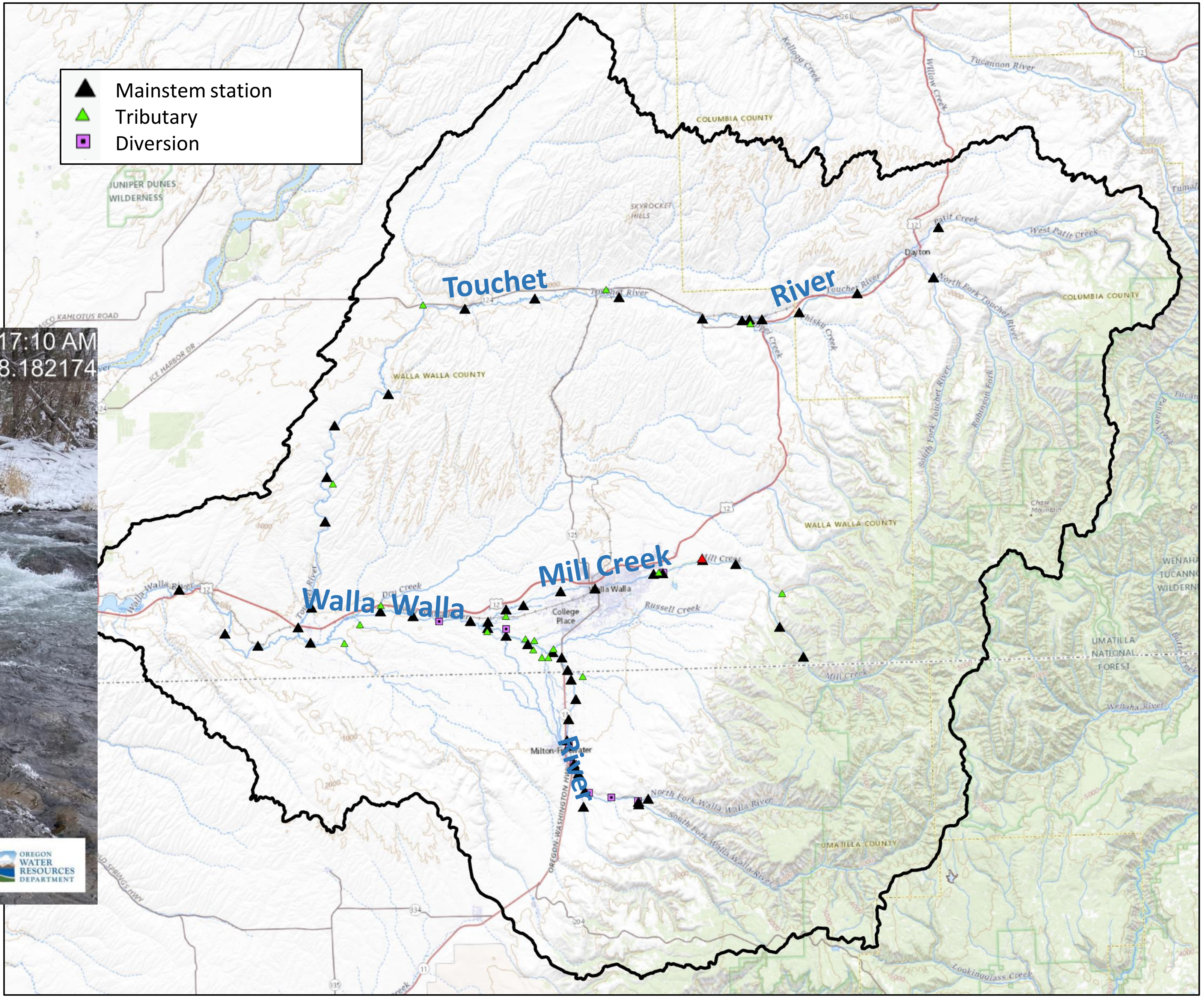
Groundwater/Surface-Water Interactions

Streamflow gain or loss by reach (seepage runs)



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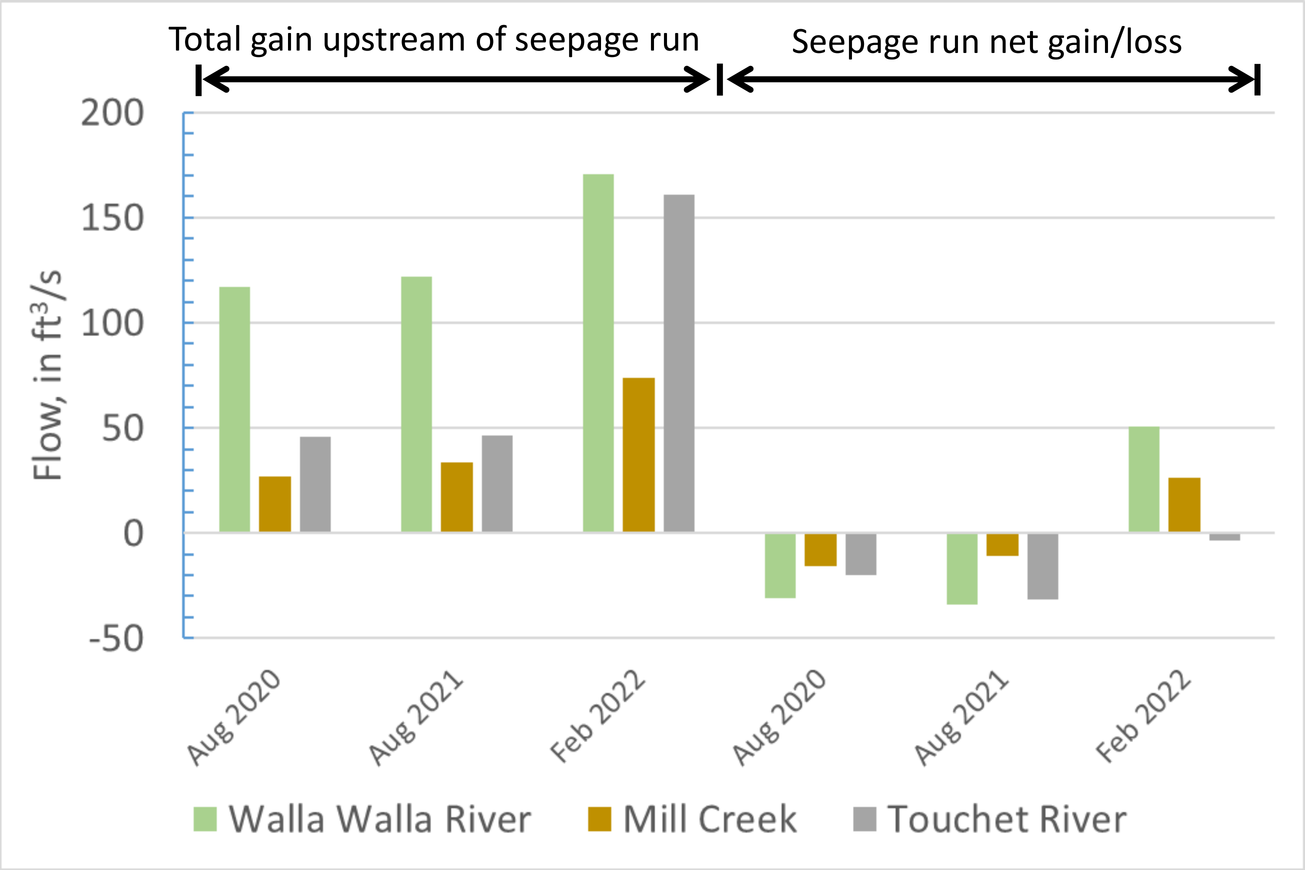
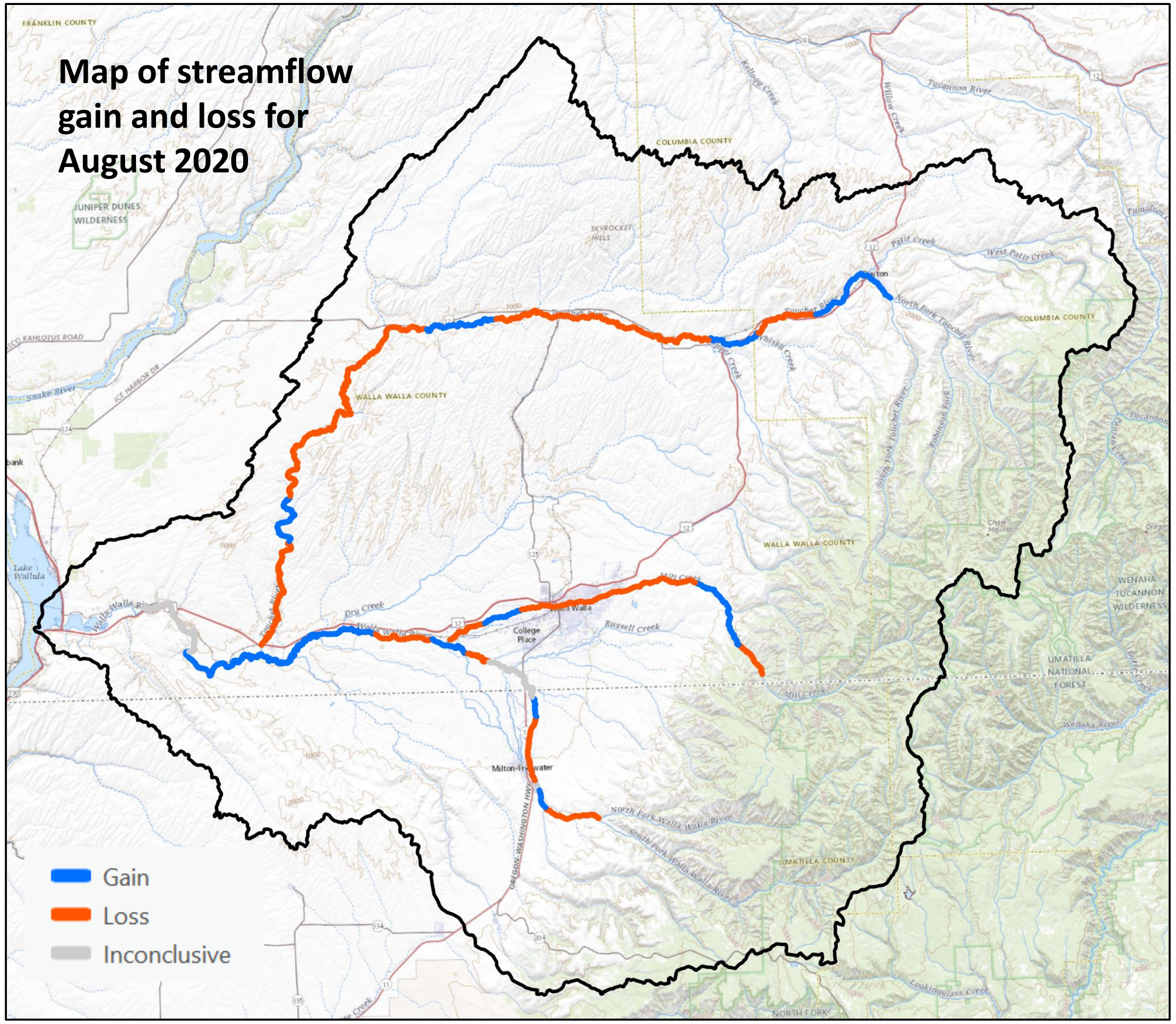
Groundwater/Surface-Water Interactions

Streamflow Gain or Loss Summary





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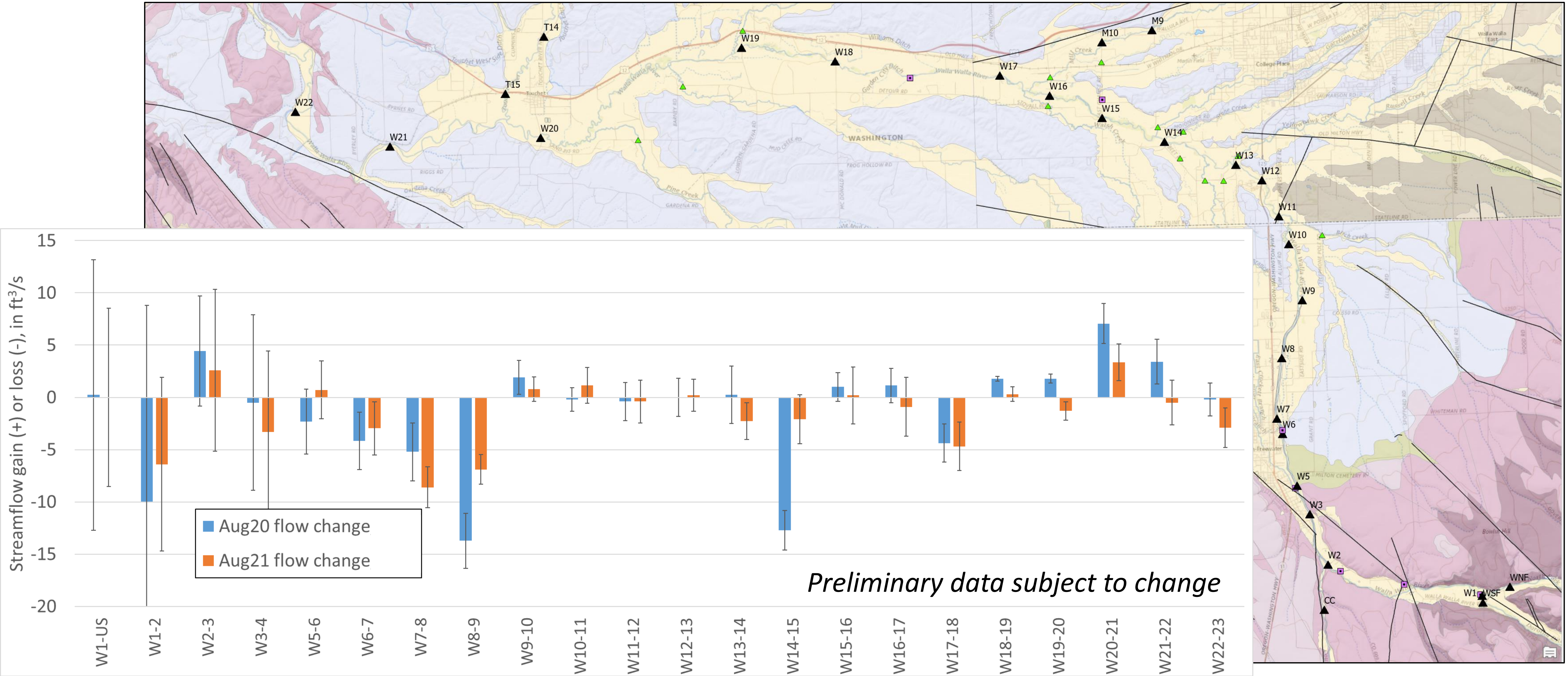
Streamflow Gain or Loss Summary – Walla Walla River



Error bars were computed as the propagation of individual measurement error estimates

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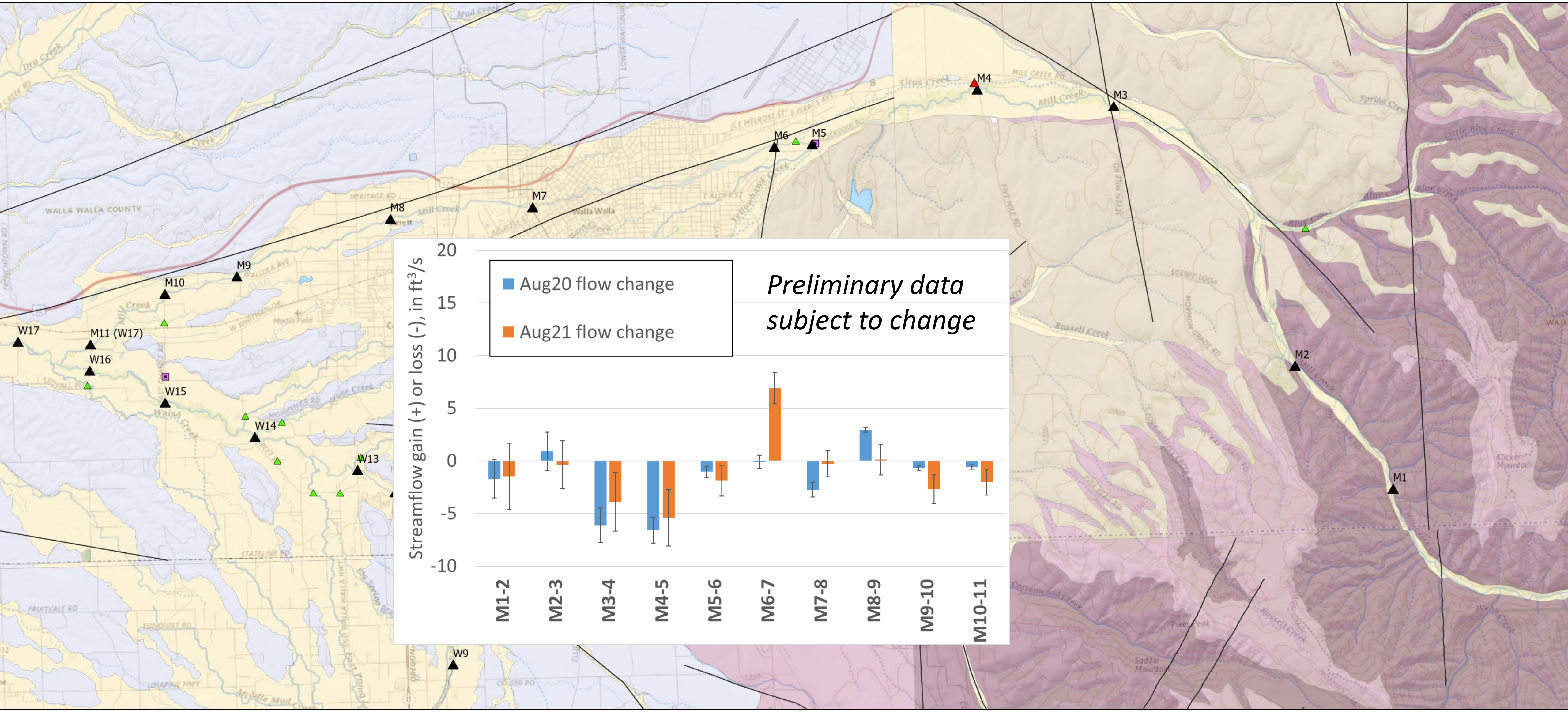
Streamflow Gain or Loss Summary – Mill Creek



Error bars were computed as the propagation of individual measurement error estimates

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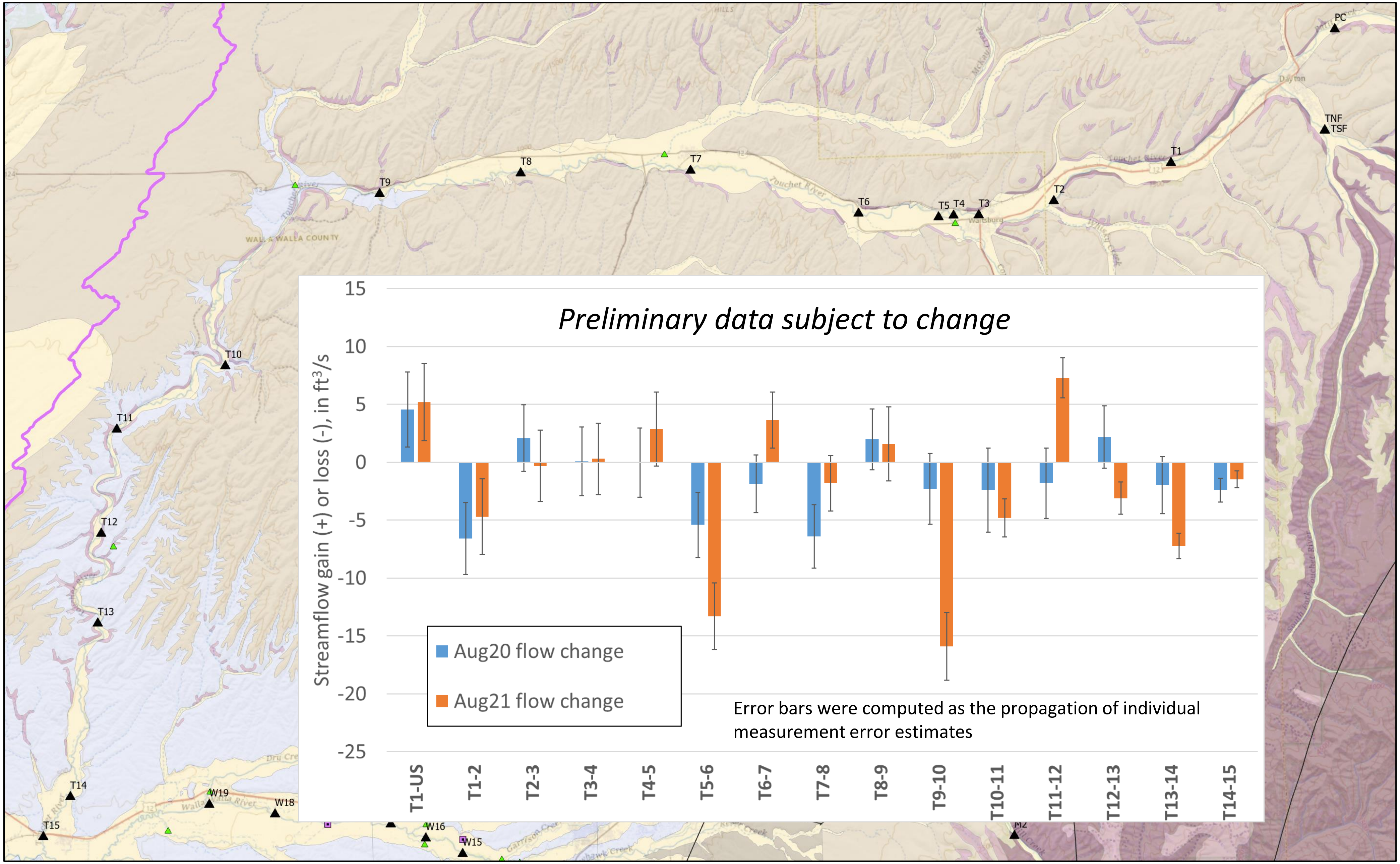
Streamflow Gain or Loss Summary – Touchet River



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Summary

- Data collection
- Hydrogeologic framework
- Groundwater budget estimation
- Flow system analysis

References

Garcia, C.A., Corson-Dosch, N.T., Beamer, J.P., Gingerich, S.B., Grondin, G.H., Overstreet, B.T., Haynes, J.V., and Hoskinson, M.D., 2022, Hydrologic budget of the Harney Basin groundwater system, southeastern Oregon: U.S. Geological Survey Scientific Investigations Report 2021–5128, 144 p., https://doi.org/10.3133/sir20215128.

Ketchum, D., Jensco, K., Maneta, M., Melton, F., Jones, M., and J. Huntington, 2020, IrrMapper: A Machine Learning Approach for High Resolution Mapping of Irrigated Agriculture Across the Western U.S. Remote Sensing, 12(14):2328, https://doi.org/10.3390/rs12142328

Melton and others, 2021, – OpenET: Filling a Critical Data Gap in Water Management for the Western United States - Melton - JAWRA Journal of the American Water Resources Association - Wiley Online Library

Newcomb, R.C., 1965, Geology and ground-water resources of the Walla Walla River Basin, Washington-Oregon, Water Supply Bulleting No. 21: State of Washington Department of Conservation.