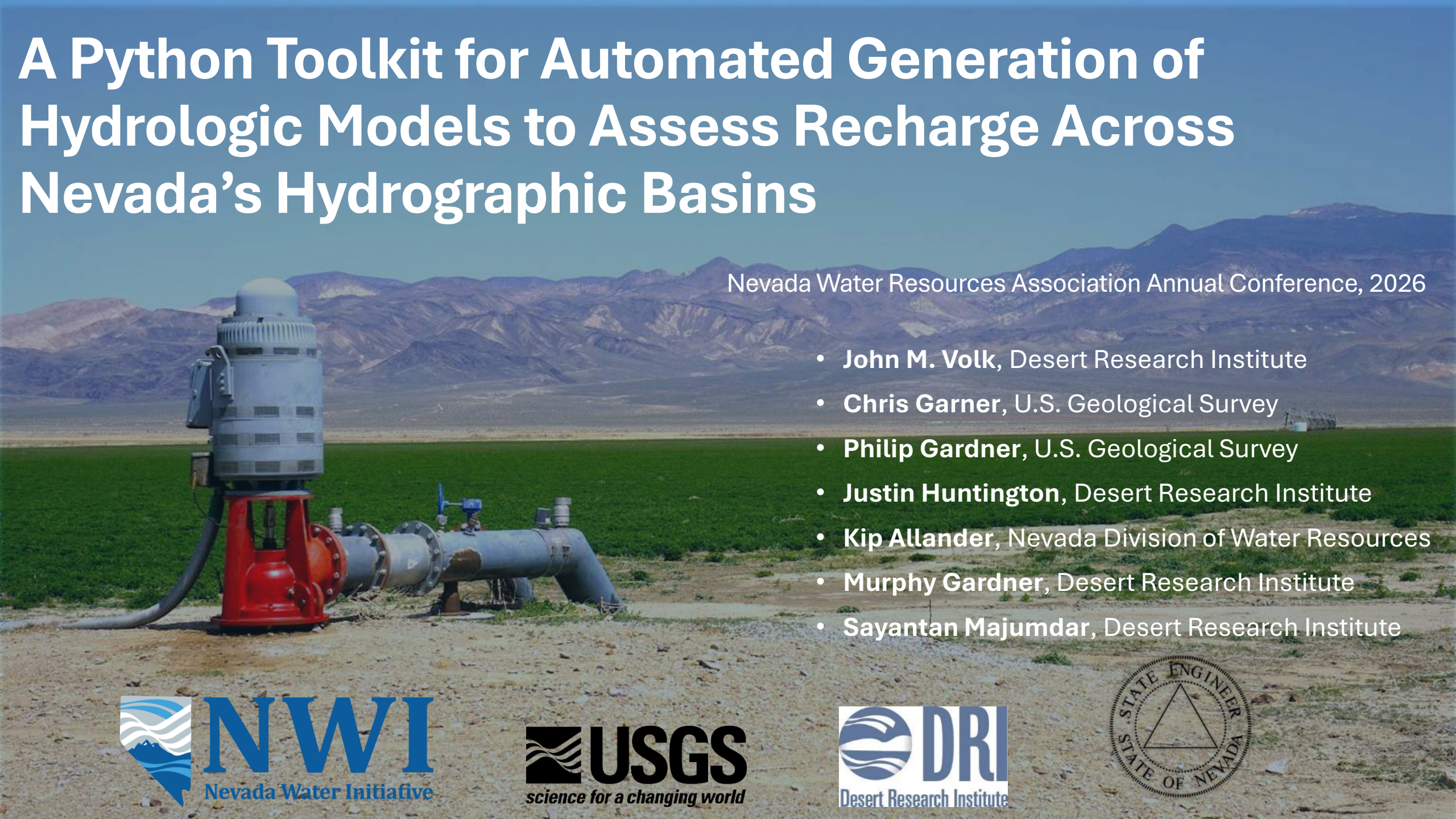
A Python Toolkit for Automated Generation of Hydrologic Models to Assess Recharge Across Nevada's Hydrographic Basins



Nevada Water Resources Association Annual Conference, 2026

- **John M. Volk**, Desert Research Institute
- **Chris Garner**, U.S. Geological Survey
- **Philip Gardner**, U.S. Geological Survey
- **Justin Huntington**, Desert Research Institute
- **Kip Allander**, Nevada Division of Water Resources
- **Murphy Gardner**, Desert Research Institute
- **Sayantan Majumdar**, Desert Research Institute

NWI Nevada Water Initiative

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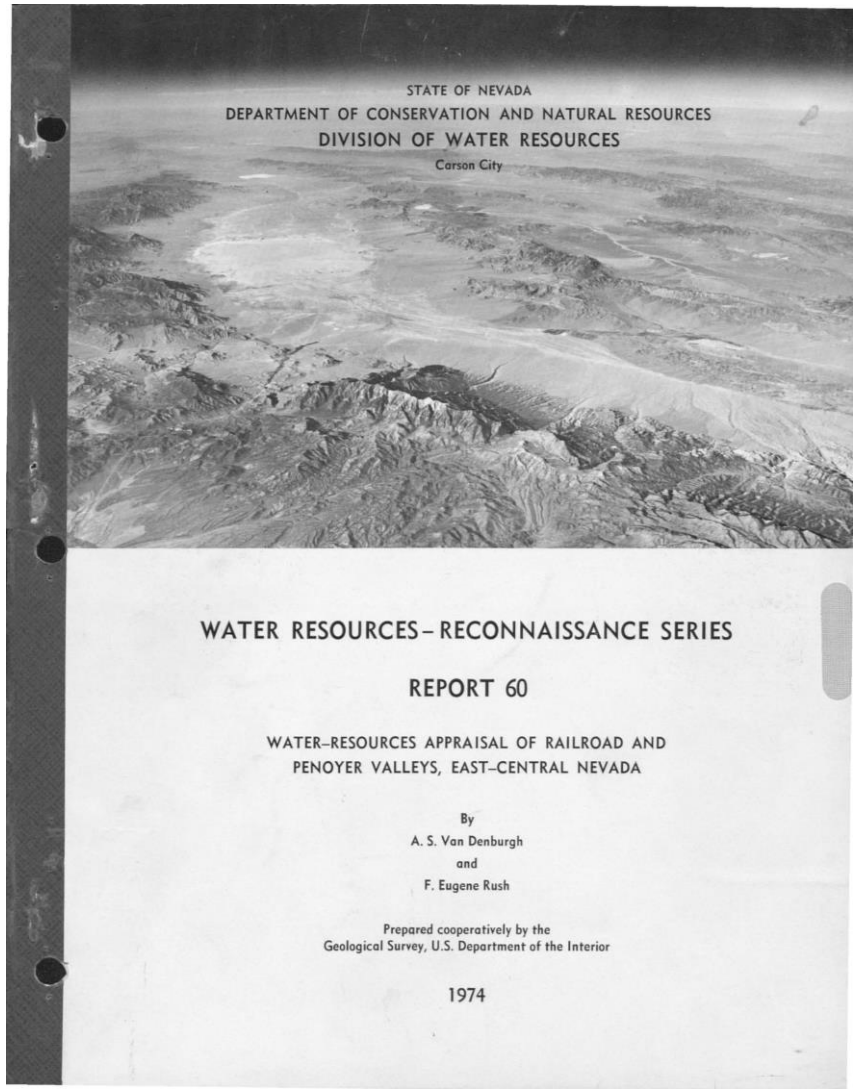
Why update Nevada recharge estimates now?

- Groundwater depleting
- Nevada manages water by hydrographic basin.
- Recharge is the least certain budget term, complex and episodic, but key for sustainable pumping.
- Need for repeatable, distributed recharge estimates that can be updated basin-by-basin.


STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
Carson City

WATER RESOURCES–RECONNAISSANCE SERIES

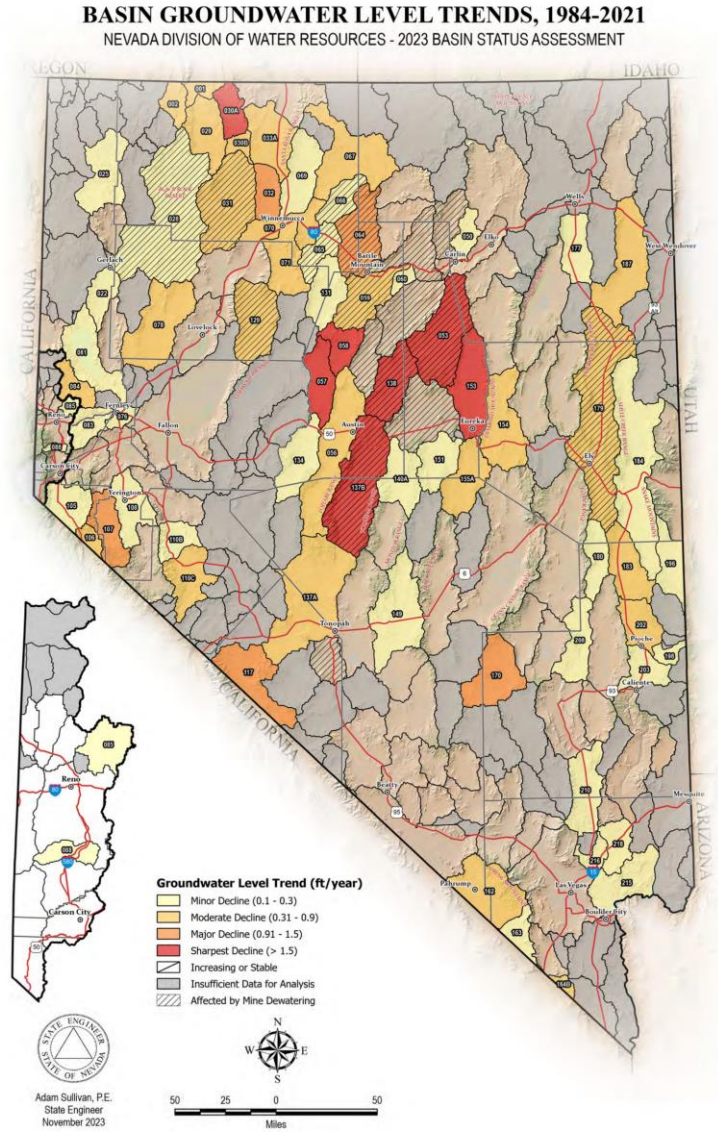
REPORT 60

WATER-RESOURCES APPRAISAL OF RAILROAD AND PENOYER VALLEYS, EAST-CENTRAL NEVADA

By
A. S. Van Denburgh
and
F. Eugene Rush

Prepared cooperatively by the
Geological Survey, U.S. Department of the Interior

1974



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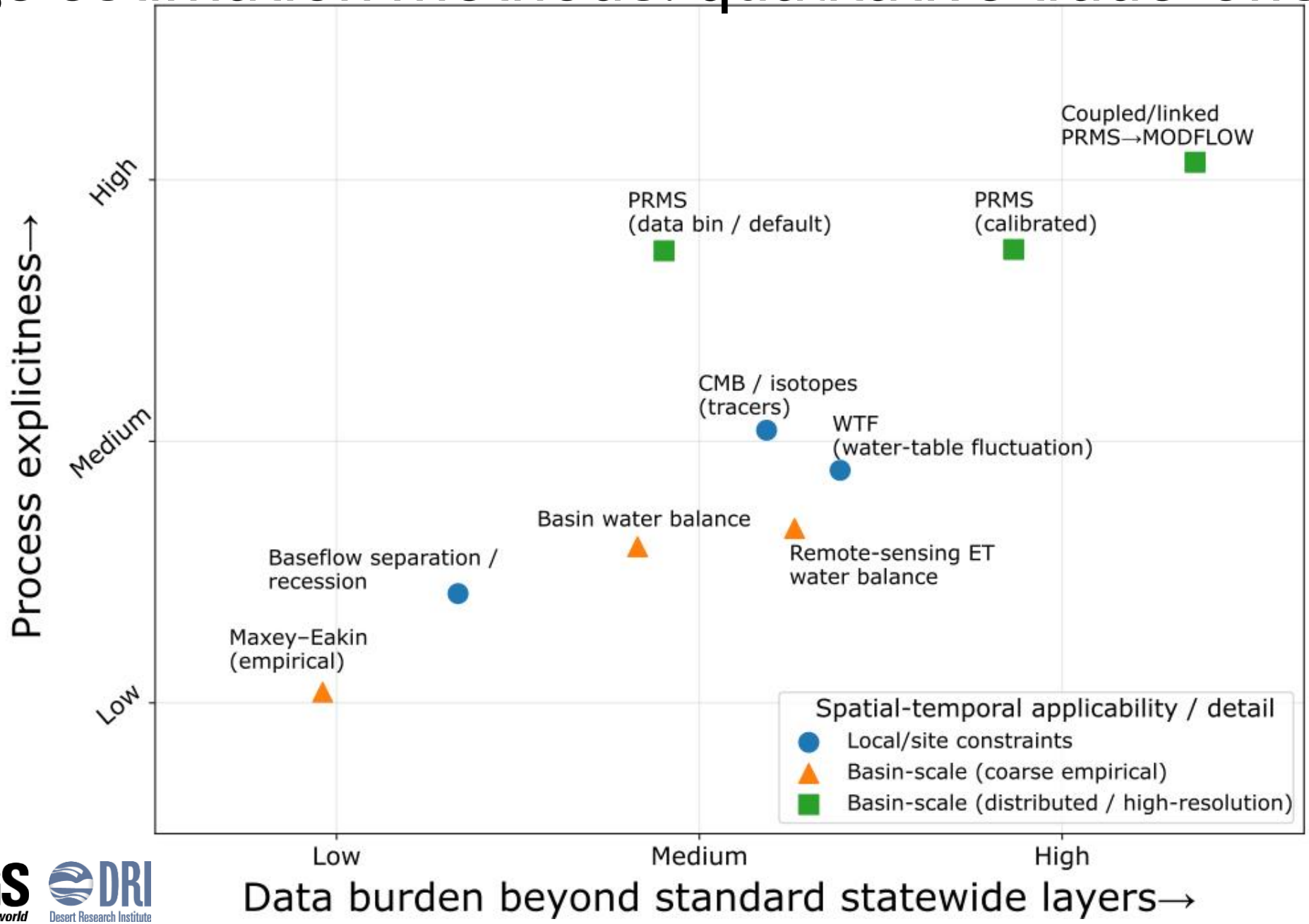
Recharge estimation methods: qualitative trade-offs



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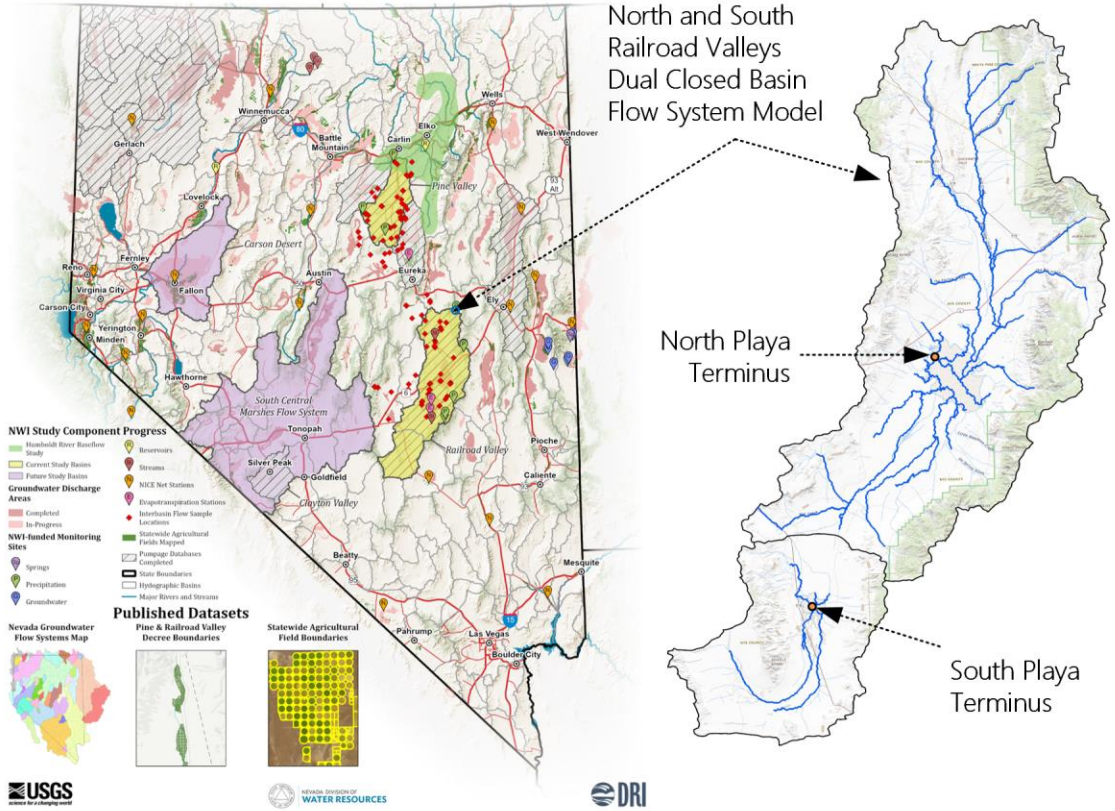
Model Development Workflow Key

Summary

This flow chart summarizes the Hydrologic modeling workflow used to develop Precipitation Runoff Modeling System (PRMS) models in support of the Nevada Water Initiative (NWI). The NWI is a collaborative effort between the Nevada Department of Water Resources (NDWR), the U.S. Geological Survey (USGS), and the Desert Research Institute (DRI). The team is developing hydrologic models of Nevada hydrographic basins to revaluate prior water budget estimates and to provide spatially distributed estimates of groundwater recharge that will be used as input boundary conditions in groundwater models of the major Nevada groundwater flow sytems.



1
Raw Publicly Available Geospatial Datasets
DEM (10-meter NED)
PRISM 800m 30-year monthly climatologies (1991-2020)
PRISM 4km daily proxy station station time series
NLCD Imperviousness
LANDFIRE Vegetation Type & Cover Density
SSURGO Soil Hydraulic Properties
NDWR HA Boundaries

Upscaling
Resample geospatial data to modeling scale (200m) for the entire study extent
Albers Equal Area Projection

Data Bin
Resampled geospatial input datasets required to develop a precipitation-runoff model of a hydrographic basin.
Data stored in a publicly accessible location.

2
Python Setup,
Initial User Decisions,
&
Data Bin to Model Workspace

3
Routing
D-ANY

4
Build PRMS Model
PyGSFLOW

5
Pre-Flight Checks of PRMS Model

6
PRMS Calibration & Evaluation

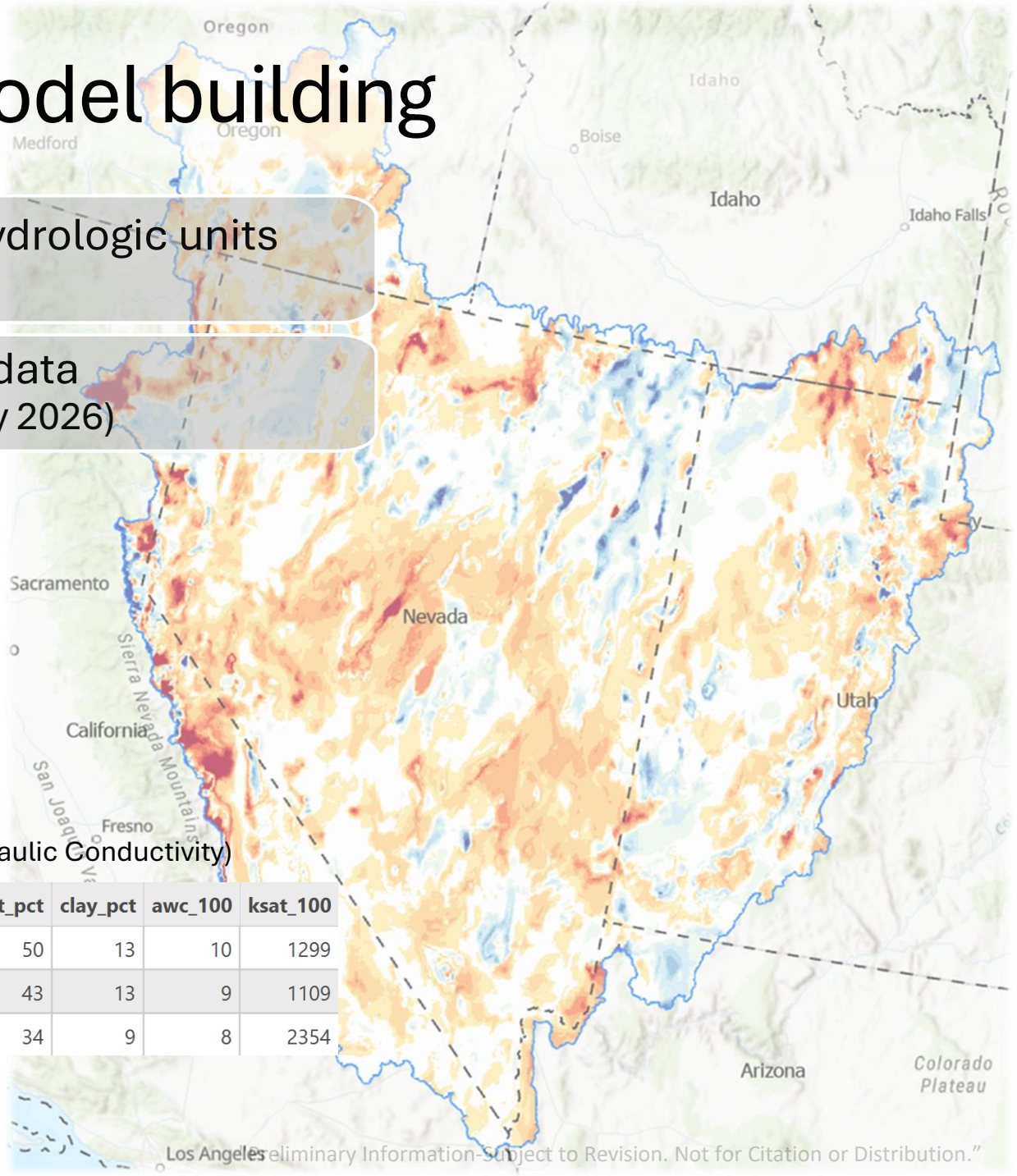
NWI “Data Bin” for PRMS model building

Boundary: Polygon feature class based on WBD hydrologic units
https://doi.org/10.5066/P145RFI4

200-meter Grid: Point feature class with attribute data
https://doi.org/10.5066/P14FAQFQ (in press; ETA February 2026)

- **Why use points**
  - Over 13,000,000 records allow for ease of use.
  - Users can convert relevant subsets to polygons or raster formats
- **Attributes include**
  - **DEM** (median)
  - **NLCD** (imperviousness)
  - **LANDFIRE** (existing vegetation cover, existing vegetation type)
  - **gNATSGO** (Average thickness, % Sand, % Silt, % Clay, AWC, Saturated Hydraulic Conductivity)

rgrid_id *	active *	elev_cm	imp_pct	evc_2023	evt_2023	mukey	b_ave_cm	sand_pct	silt_pct	clay_pct	awc_100	ksat_100
1376	0	197829	0	120	7062	3385460	50	37	50	13	10	1299
1377	0	201193	0	222	7126	3122411	66	44	43	13	9	1109
1378	0	196857	0	150	7045	3385467	103	56	34	9	8	2354



Recharge toolkit software design “PyRCHRG”

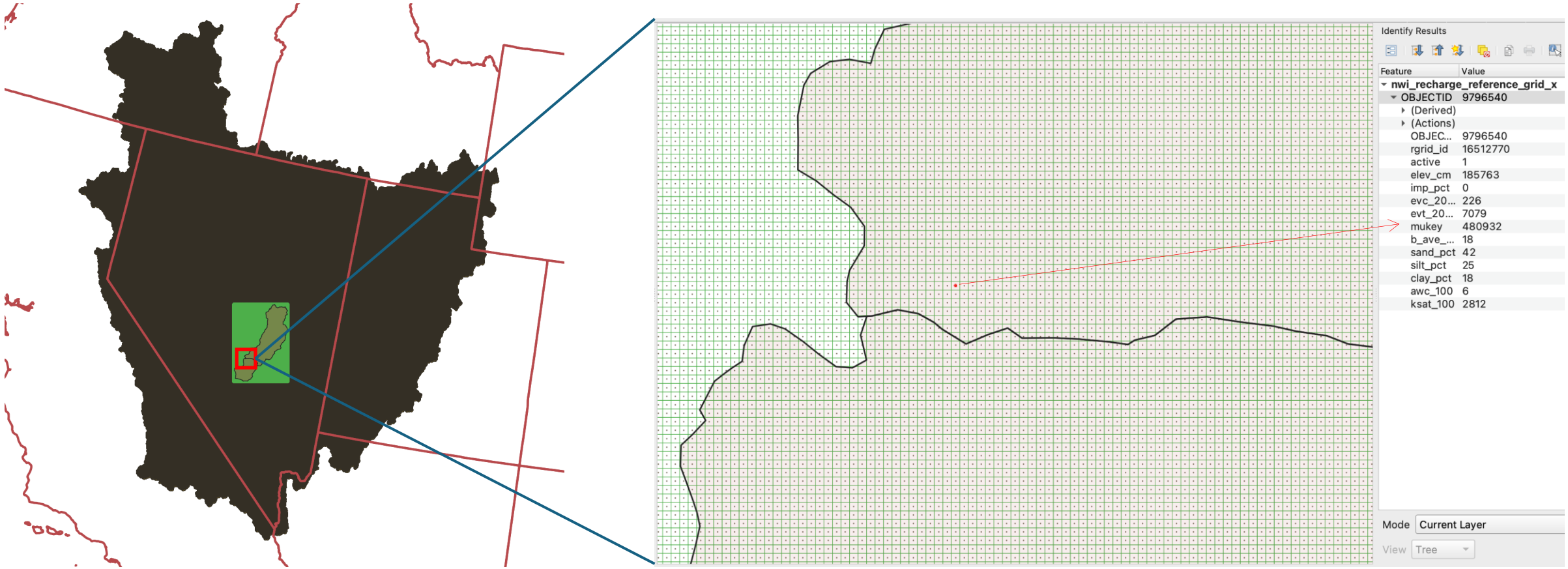
- Reproducibility (configuration file, consistent inputs, versioning Git); Open source; Python
- Object-oriented and modular
  - Python packages DANY, FloPy, PyGSFLOW
  - Modules:
    - Config reader
    - Grid builder
    - Data Bin interface
    - DEM and flow routing
    - Parameter estimation
    - Forcing data and PRISM climate
    - Pairing with observations
    - Calibration and evaluation tools
- Minimal coding experience
  - Optional **command line interface** that incorporates entire workflow

RailroadValley_config.ini

```
[BASIN]
basin_name = Railroad
crs = EPSG:5070
cell_size = 200.0


[PATHS]
data_dir      = data
plot_dir      = plots
grid_shp      = data/shapefiles/grid.shp
watershed_shp = data/shapefiles/RV_up_low.shp

[DATABIN]
gpkg     = data/data_bin/data_bin/nwi_recharge_reference_grid/nwi_recharge_reference_grid.gpkg
layer    = nwi_recharge_reference_grid_x
elev_var = elev_cm

[DEM_CONDITIONING]
burn_depth = 10.0
max_fill   = 10.0
eps        = 0.1

[STREAMS]
FA_threshold = 1.5e7

[POUR_POINTS]
0 = -1688445, 1891785
1 = -1729645, 1843885

[MODFLOW]
aquifer_thickness = 100.0

[PRMS]
...
```

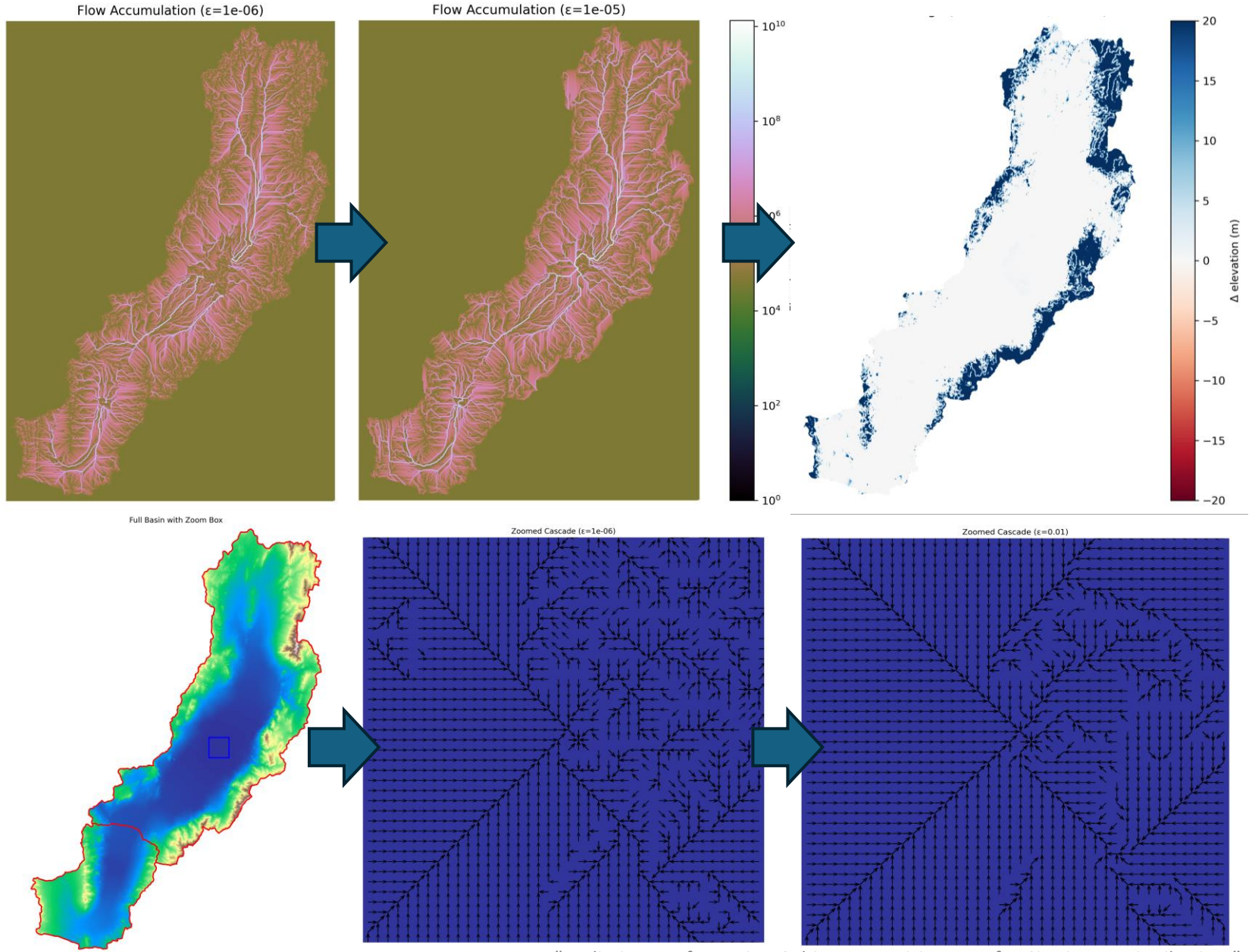
Example configuration file for Railroad Valley

Example: model grid builder and alignment with “Data Bin” and National Hydrogeologic Grid



Example: DEM processing and flow routing

- Burn pour points- works with closed basins
- Iterate:
  - Fill sinks
  - Adjust epsilon in the filling algorithm
  - Limit flooding of DEM by digital dams (caused by DEM upsampling)
    - Replace with the original DEM based on a threshold delta
  - Compute and visualize PRMS stream and cascade flow vectors



Example: climate distribution parameters (PRISM)

climate_dist (module)
ClimDistParams
(load config, paths)

↓

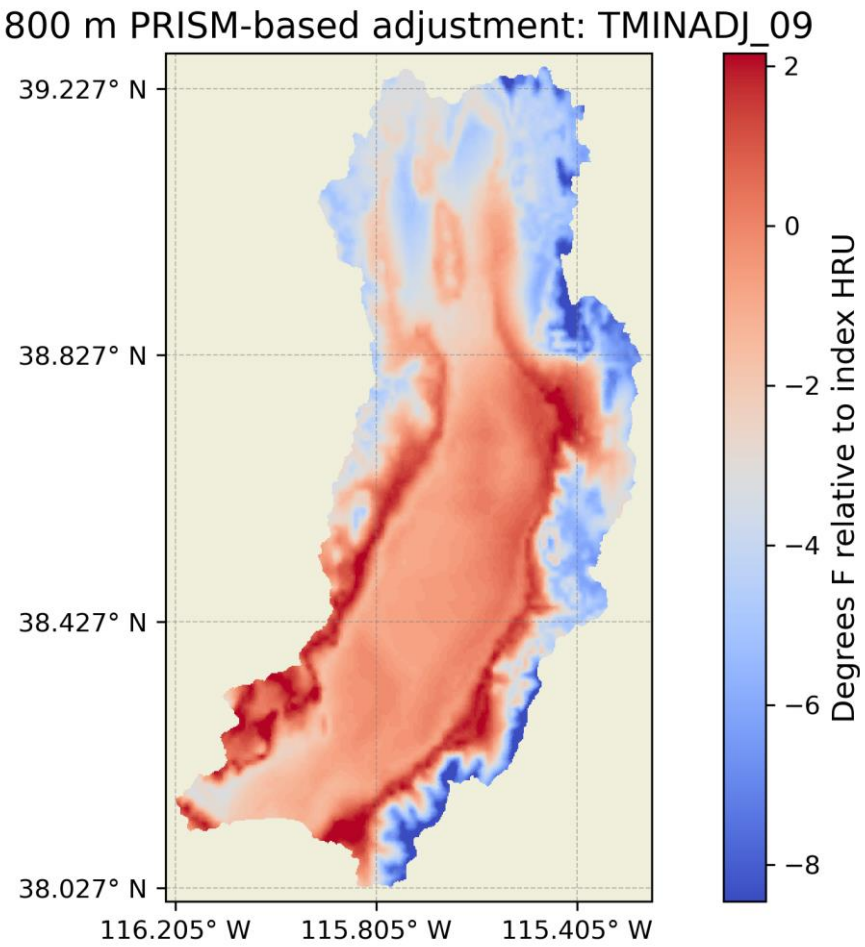
Download PRISM monthly normals
ppt, tmin, tmax
(30 arc-sec ~800 m)
→ clip to basin/grid

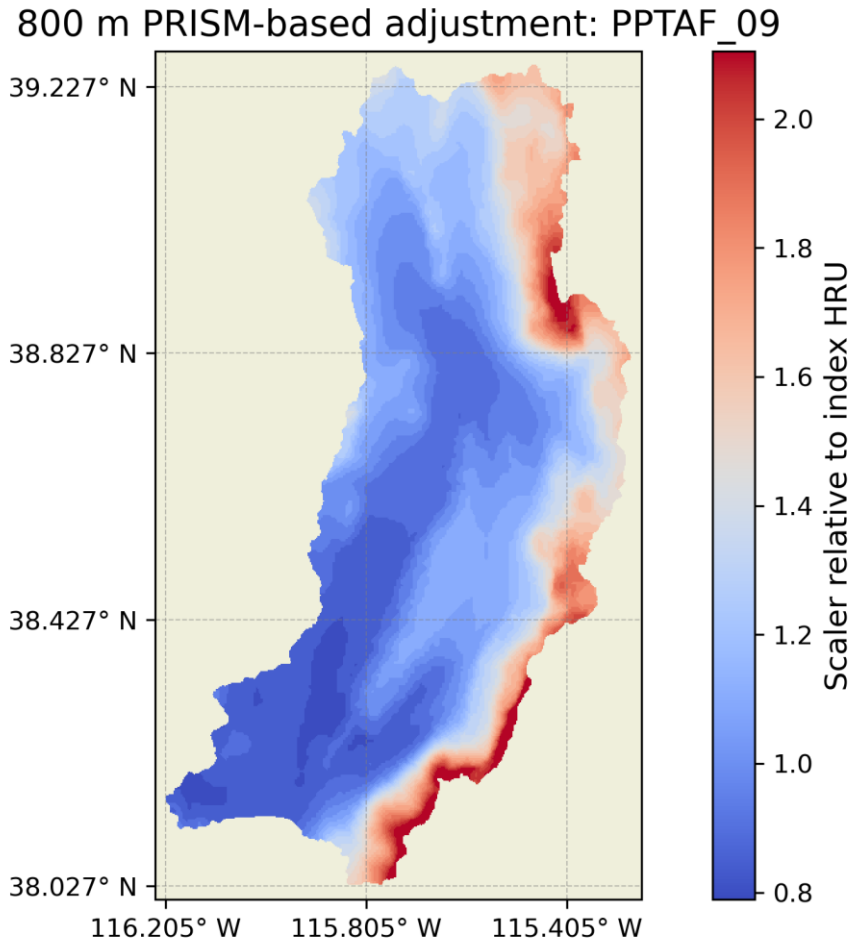
↓

Choose index/wx HRU (forcing cell)
Compute spatial adjustments:
PPT_ratio[m] = P[m]/P_index[m]
TΔ[m] = T[m] − T_index[m] (°F)

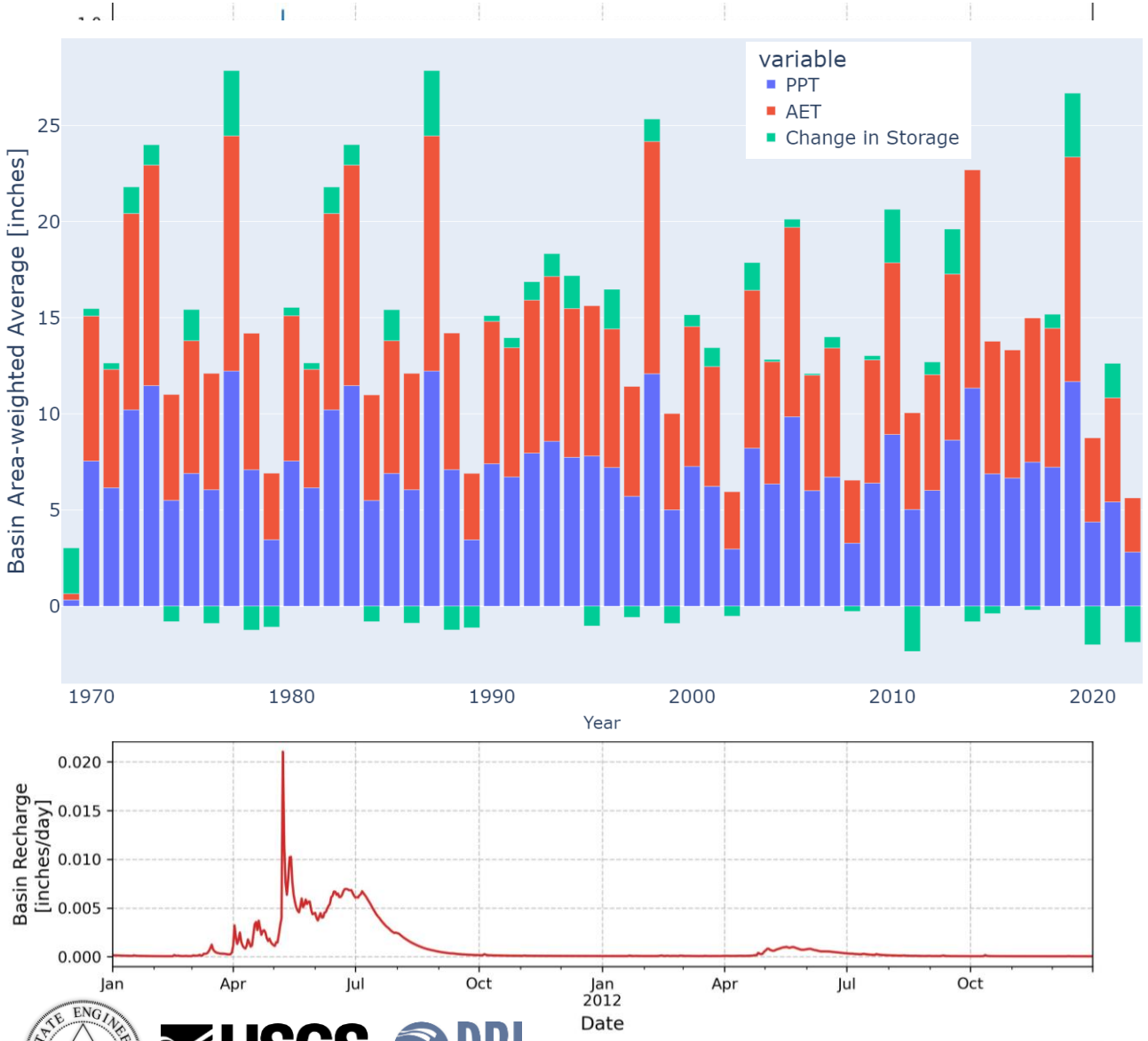
↓

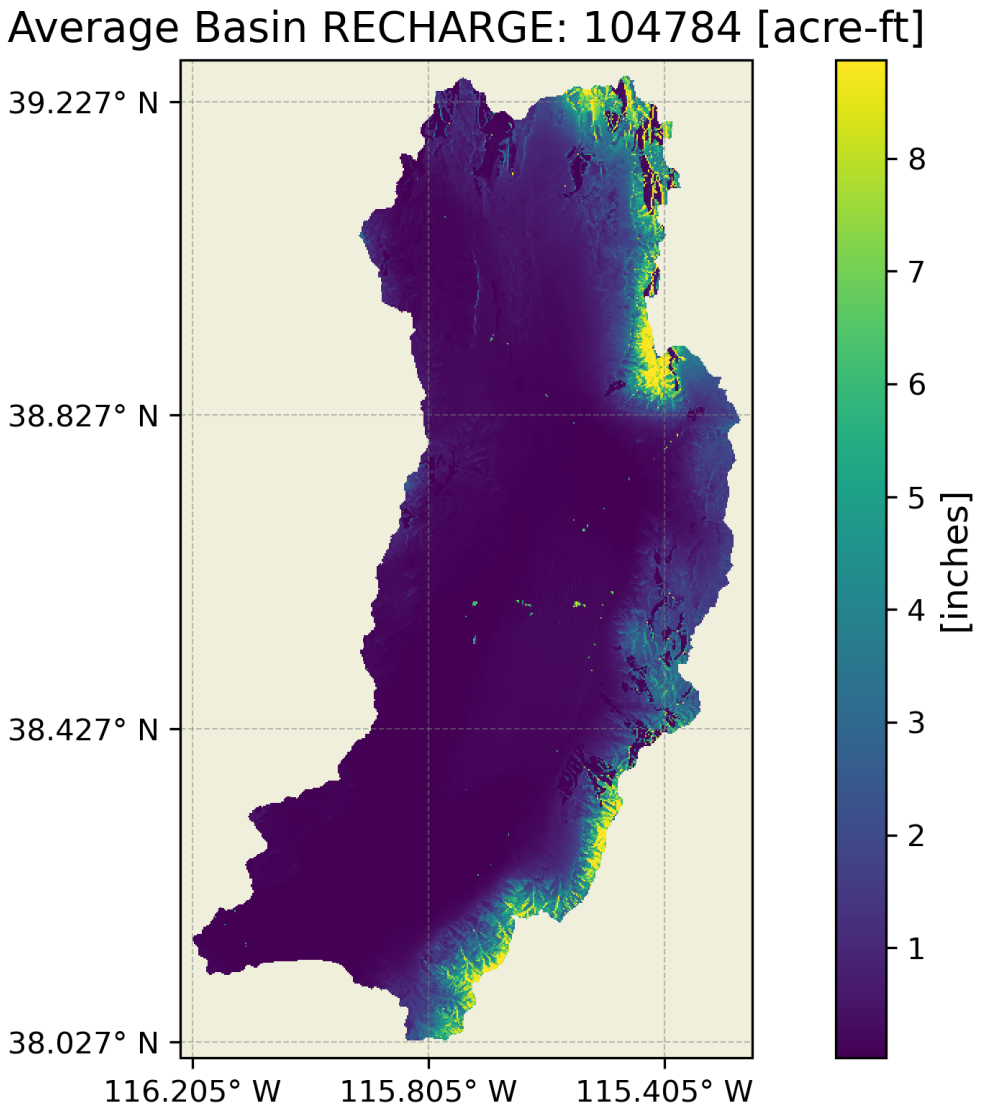
Write PRMS inputs
Parameters: rain_adj, snow_adj,
tmin_adj, tmax_adj
+ Data file forcing





PRMS recharge results – Railroad Valley, preliminary

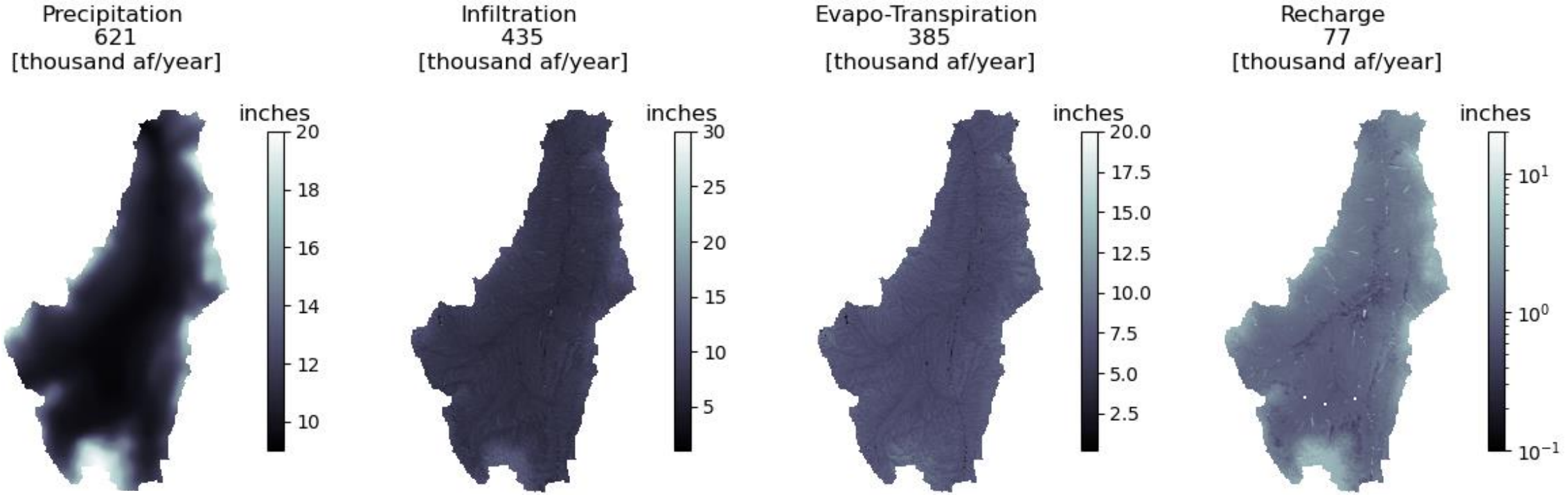




"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

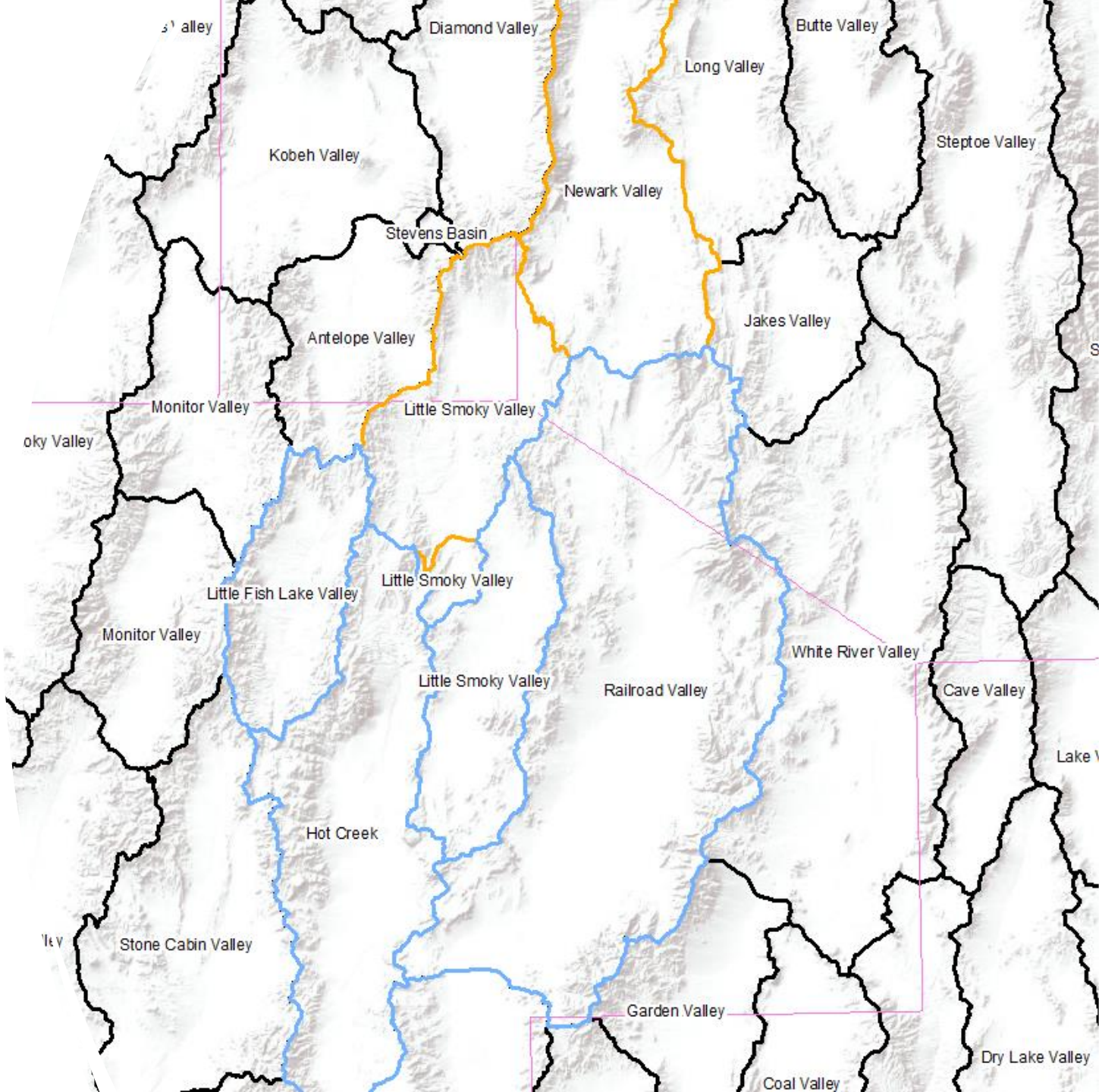
PRMS Results – Pine Valley, preliminary

- Preliminary Pine Valley PRMS model constructed
- Initial water budget results below
- Recharge ~1.7x greater than Eakin estimation



Takeaways & next steps

- Foundation for basin recharge assessment with potential for fast scaling to other flow systems
- Packaging and documentation
- Calibration and validation
- Flow systems and interbasin flow



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Questions?