Updating Groundwater Discharge Boundaries and Estimates in Select Nevada Basins

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Project Background

Over fifty years ago, the Nevada Division of Water Resources (NDWR) published a series of statewide reconnaissance reports covering Nevada's hydrographic areas, creating the original groundwater budgets that are still in use today. Within these reports are maps of groundwater discharge areas.

NDWR uses natural groundwater discharge as the upper limit for appropriating groundwater rights. Therefore, it's important that accurate estimates of groundwater discharge from phreatophytes exist. Across Nevada, phreatophyte vegetation is the primary conduit of groundwater discharge.

New work by DRI has improved the science to more accurately estimate the extent of groundwater discharge via phreatophyte evapotranspiration (ETg). At the request of the NDWR, and in conjunction with the USGS, DRI is updating these estimates using the best available science. This project is the Nevada Water Initiative (NWI).

Objectives

- Develop a comprehensive, statewide dataset delineating groundwater discharge boundaries across Nevada.
- Using contemporary satellite-based methods, update statewide groundwater discharge estimates under pre-development conditions.
- Highlight comparisons between existing ETg volumes, established by Reconnaissance Series Reports (RR) and Water Resource Bulletins (e.g. Columbus Salt Marsh and Monte Cristo Valley).

NWI Statewide Groundwater Discharge Database, with Select Focus Area in red.

Methods for Mapping Groundwater Discharge Areas

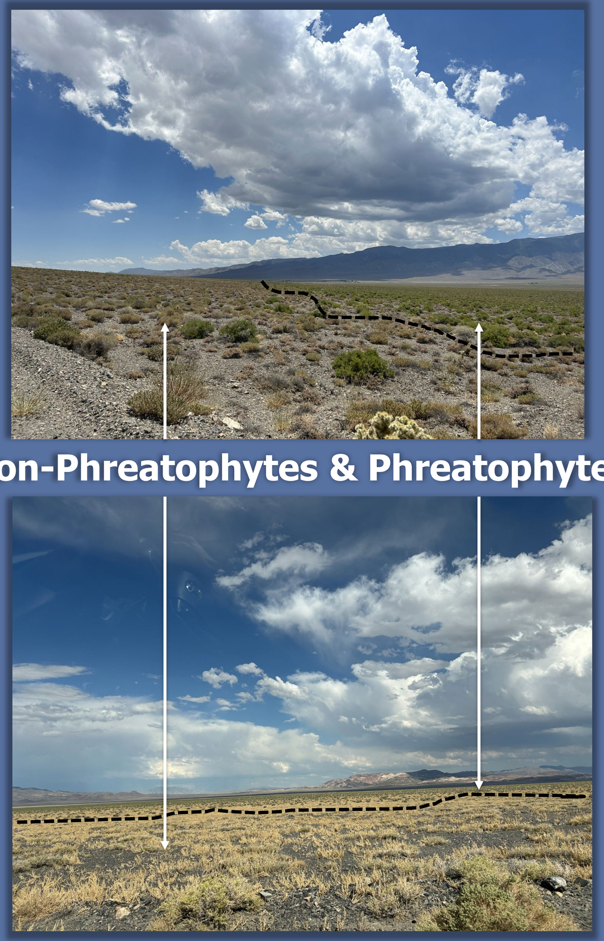
Groundwater discharge areas in Nevada are mapped with a combination of remote sensing data and extensive field work. Columbus Salt Marsh and Monte Cristo Valley are showcased below; two examples selected from the hundreds of hydrographic areas the NWI project spans. Techniques used for mapping include the following:

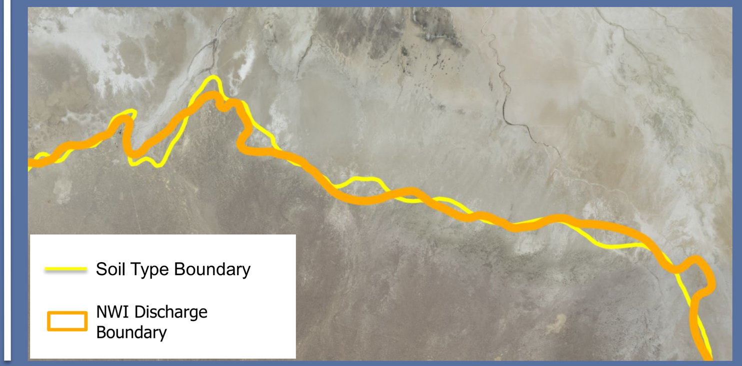
- NAIP aerial imagery is high resolution and shows contrast between phreatophyte and non-phreatophyte vegetation.
- Water level data reveals where groundwater is accessible for phreatophytes (<50 ft depth to water).
- Land surface temperature is an excellent indicator of groundwater discharge due to evaporative cooling.
- Soil data shows boundaries between soil types. Discharge area boundaries typically follow soil boundaries closely.
- Historical aerial imagery shows discharge areas under pre-development conditions.
- Extensive field work is necessary to verify the boundaries of discharge areas mapped in the lab.

Mapping

Closeup of NAIP imagery and the delineation of discharge areas.

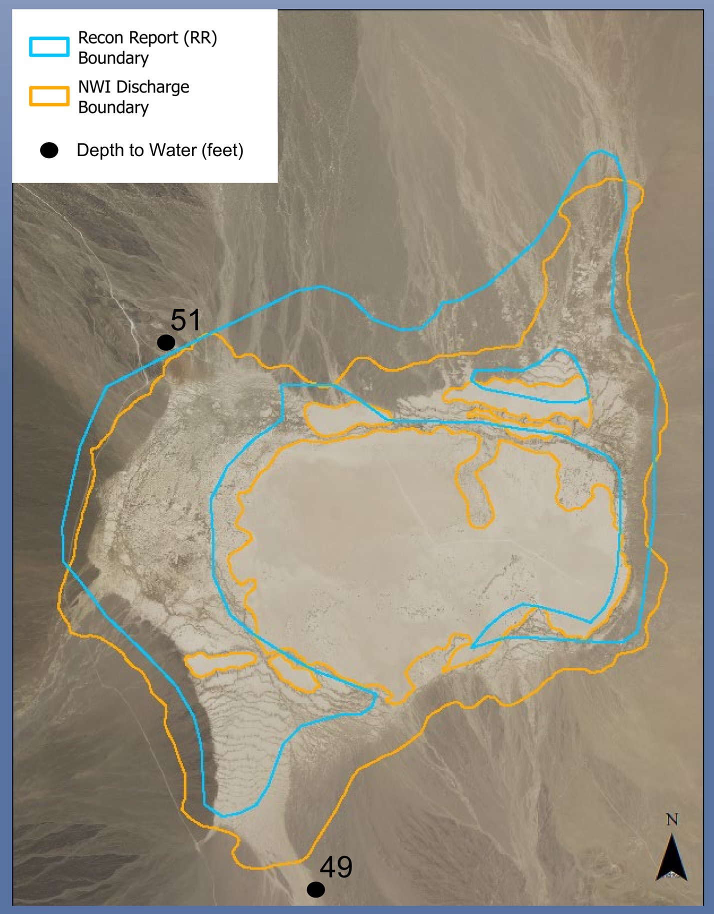
Field expedition verifying discharge boundaries like the ones below.



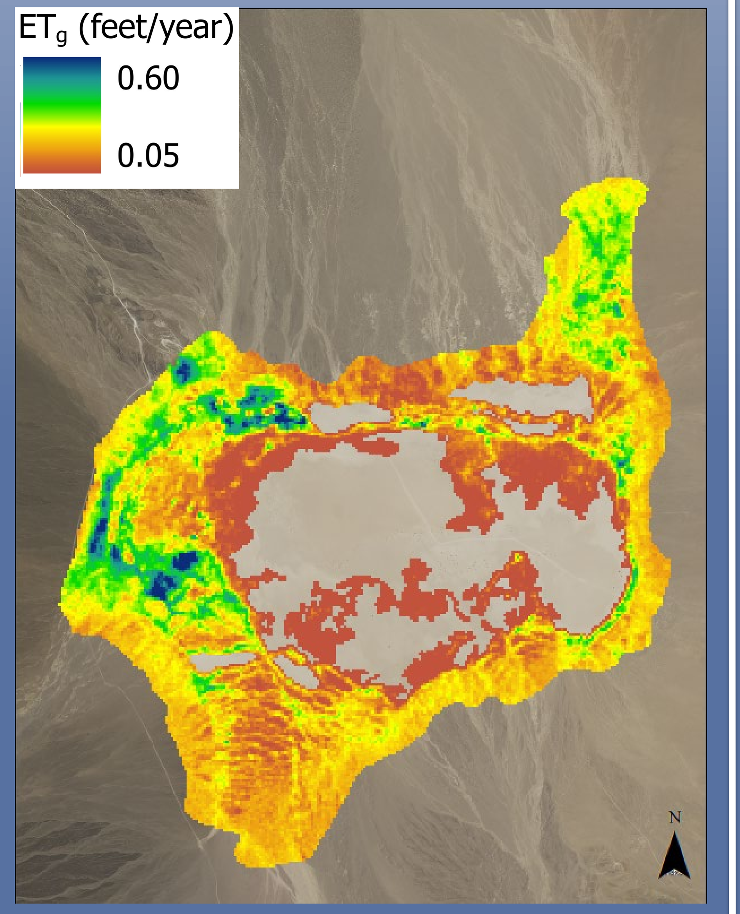


Discharge area boundary closely following soil type.

Monte Cristo Valley



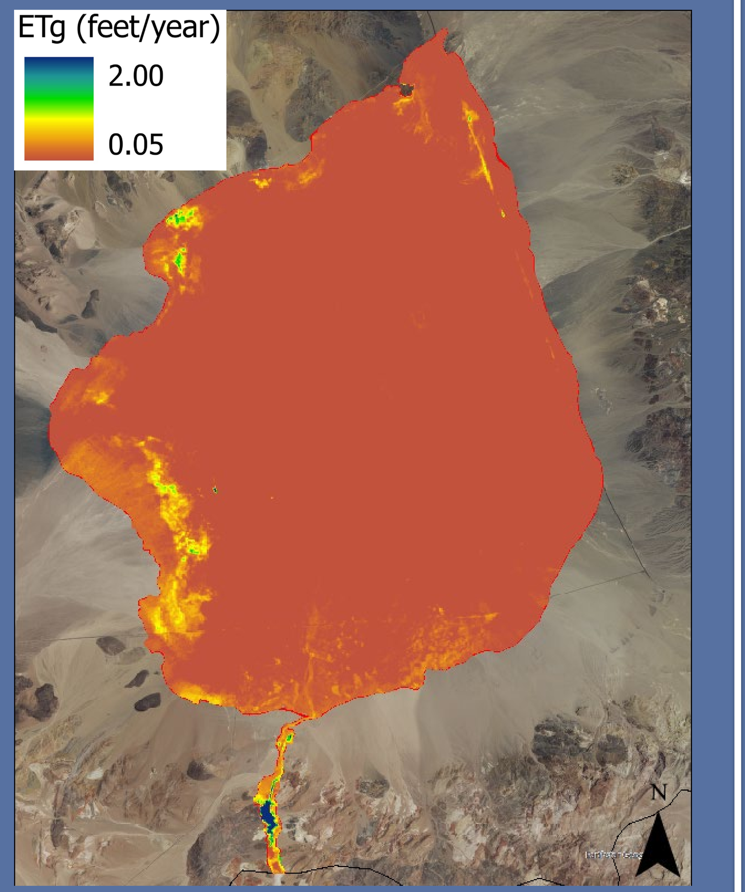
A comparison of new NWI discharge boundaries and Reconnaissance Report Boundary published in 1970.



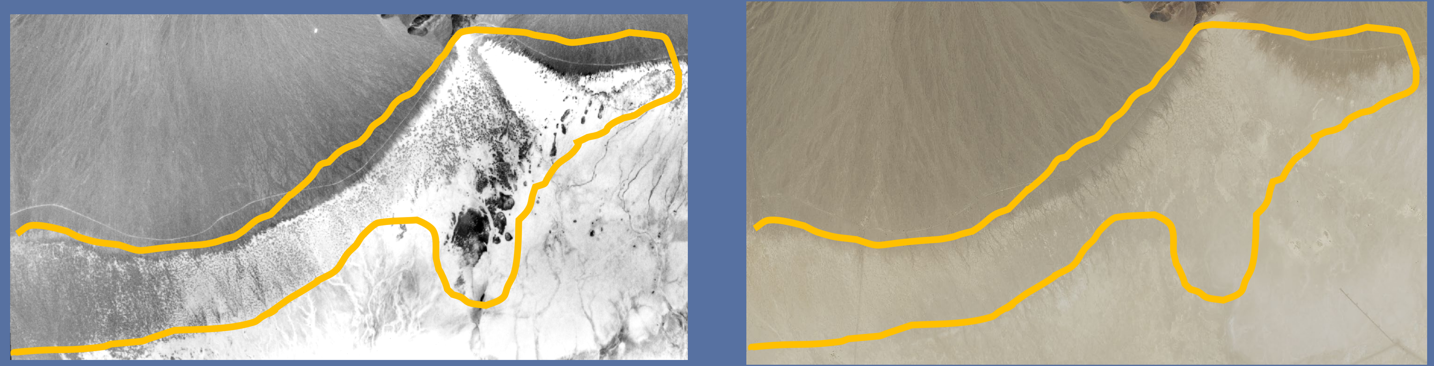
Groundwater Discharge in Monte Cristo Valley feet-per-year.

Columbus Salt Marsh

A comparison of new NWI discharge boundaries and Reconnaissance Report Boundary published in 1970.



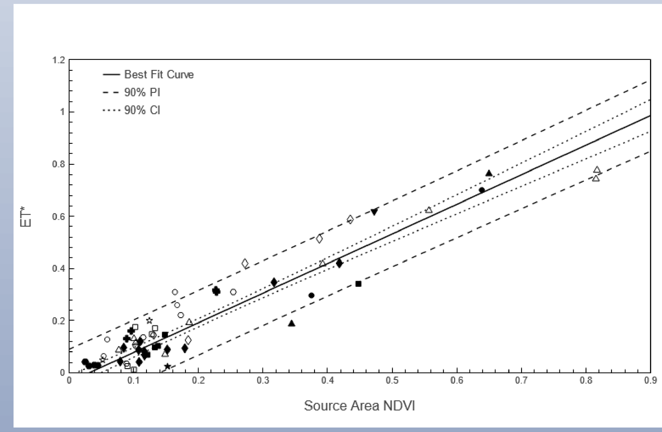
Groundwater Discharge in Columbus Salt Marsh in feet-per-year.



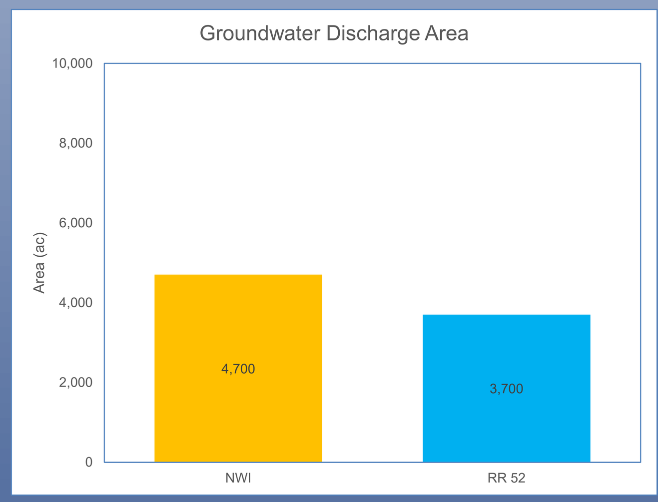
Historical aerial imagery (left) from 1955 compared to modern NAIP imagery (right). Note the dense phreatophyte vegetation under pre-development conditions compared to the complete lack of discharging phreatophytes today.

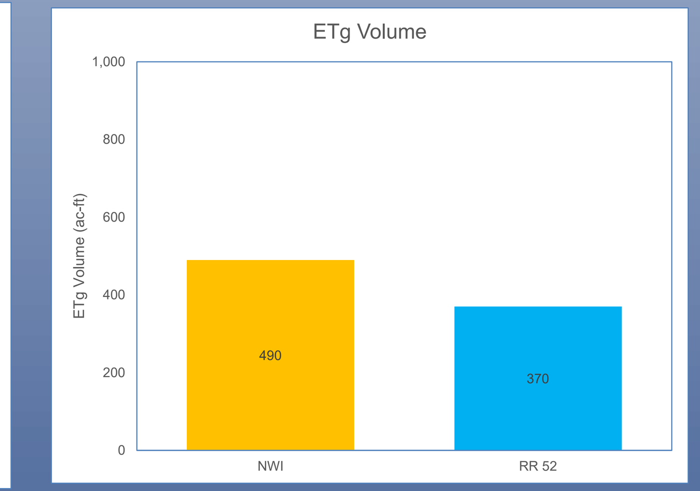
Results of Discharge Area Mapping and Estimating ET_g

ETg estimates for Monte Cristo and Columbus were developed using the Beamer-Minor method. This method relies on a regression that correlates remotely sensed Normalized Difference Vegetation Index (NDVI) with ETg in the discharge area.

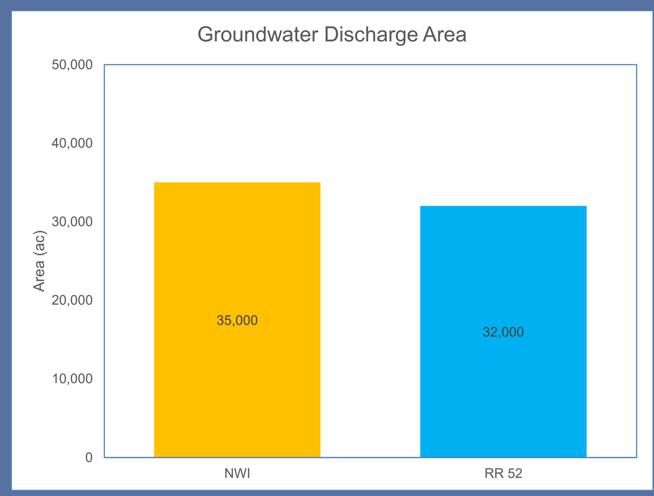


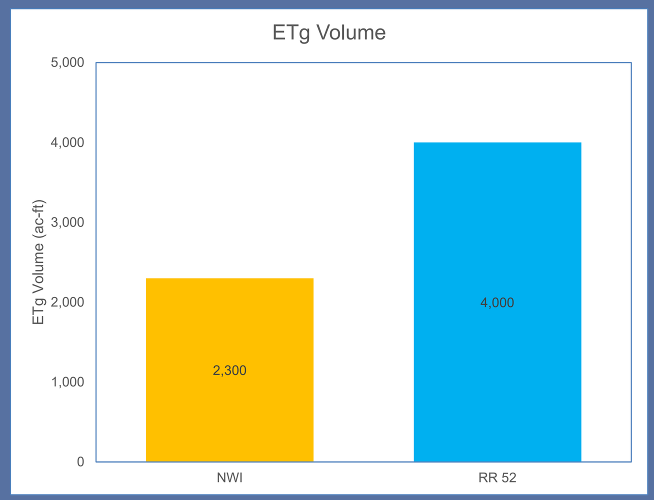
Monte Cristo Valley





Columbus Salt Marsh





- The discharge area in Monte Cristo grew, and as a result, so did the discharge volume.
- Note how a larger discharge areas doesn't always result in larger ETg.
  - In Columbus Salt Marsh, the NWI discharge area is larger than the RR. But the annual ETg is 1,700 acre-feet lower than what was estimated in the RR.
  - RR rate for the phreatophyte zones is 0.1 feet/year, the same as the NWI rate.
  - RR applied a rate of 0.1 feet/year to the Columbus Salt Marsh playa while the NWI applied a rate of 0.05 feet/year.
- The NWI ETg rate (feet of discharge per acre averaged) doubled Columbus Salt Marsh when compared to the RR rate. In Monte Cristo Valley, the rate stayed the same.

Conclusion

The updated groundwater discharge boundaries and ETg estimates presented here refine historical estimates from NDWR Reconnaissance Series Reports. By integrating high-resolution NAIP imagery and satellite-derived metrics with field verification, this study enhances the delineation of phreatophyte areas and evapotranspiration rates under pre-development conditions. Results reveal adjustments to discharge areas in both Monte Cristo Valley and Columbus Salt Marsh, showing the value in applying these contemporary methods for estimating groundwater discharge. These findings provide a foundation for managing groundwater resources across Nevada.

Acknowledgements

[1] Funding and resources from the State of Nevada, the State Engineer's Office, the Department of Water Resources, and the USGS.

[2] Huntington, J. L., Bromley, M., Minor, B. A., Morton, C. G., & Smith, G. T. (2022). Groundwater Discharge from Phreatophyte Vegetation, Humboldt River Basin, Nevada. Desert Research Institute.

[3] Van Denburgh, S., & Glancy, P. A. (1970). Water-Resources Appraisal of the Columbus Salt Marsh-Soda Spring Valley Area, Mineral and Esmeralda Counties, Nevada (Water Resources-Reconnaissance Series Report 52). Nevada Department of Conservation and Natural Resources, Division of Water Resources; U.S. Geological Survey.

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