Borrego Springs Watermaster
Technical Advisory Committee Meeting
September 22, 2025 @ 10:00 a.m.
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AGENDA

Items with supporting documents in the TAC Meeting Package are denoted with a page number.

I. Roll Call

II. Public Comments
This is an opportunity for members of the public to address the TAC on items included on the agenda. Comments will be limited to three minutes per commenter

III. Discuss DWR Corrective Actions regarding Sustainable Management Criteria –

A. **Groundwater Quality .....Page 3**
Note that the attachment for this agenda item is the memo included in the agenda package for the September 17, 2025 Watermaster Board meeting. At the TAC meeting, Staff will lead a discussion on recommendations to address DWR comments on the Judgment/GMP for groundwater quality. Staff will also summarize the Board comments received on this topic during its September 17, 2025 meeting.

B. **Land Subsidence .....Page 23**

IV. TAC Assignment to Evaluate/Rank Proposals for Peer Reviewer of GDE Study Report .....Page 30

V. Review of Pumping Projections ..... Verbal Update
At the TAC meeting, Staff will report-out from the September 17, 2025 Watermaster Board meeting where the Board directed Staff to run an additional pumping projection using the BVHM in which additional pumping is shifted to the North Management Area.

VI. Public Comments (time permitting)
This is an opportunity for members of the public to address the TAC. Comments will be limited to three minutes per commenter, time permitting.

VII. Future Meetings

VIII. Adjournment

Borrego Springs Watermaster
Board of Directors Meeting
September 17, 2025
AGENDA ITEM IV.E

To: Board of Directors

From: Andy Malone, Technical Consultant
Samantha Adams, Executive Director

Date: September 13, 2025

Subject: Workshop: Sustainable Management Criteria Updates for Degraded Water Quality

☐ **Recommended Action**	✓ **Provide Direction to Staff**	✓**Information and Discussion**
☐ **Fiscal Impact**	☐ **Cost Estimate: $**	

Recommended Action

Provide input and feedback to staff on its recommended approach to addressing CA Department of Water Resources (DWR) feedback on how the Judgment and GMP address Degraded Groundwater Quality.

Overview

Degraded Groundwater Quality is one of six Sustainability Indicators identified in the Sustainable Groundwater Management Act (SGMA). SGMA requires that groundwater management plans address each element of sustainability that is applicable to a groundwater basin. The Groundwater Management Plan (GMP) for the Borrego Springs Subbasin (Basin) identifies Degraded Groundwater Quality as one of three relevant Sustainability Indicators for the Basin. SGMA further requires the establishment of Sustainable Management Criteria (SMC) for each relevant Sustainability Indicator to assist basin managers to understand: what conditions constitute sustainable vs significant and unreasonable management outcomes (e.g. Undesirable Results), how current conditions and trends will be monitored and assessed, the management actions necessary (now or in the future) to avoid or mitigate Undesirable Results caused/exacerbated by basin management. The August Board Workshop memo provided a detailed overview of SMC and related definitions – see agenda item IV.D here[1].

The purpose of this memo is to summarize the information that will be presented in the workshop and describe Staff's draft approach to responding to DWR feedback and Recommended Corrective Actions (RCA) related to groundwater quality management. This memo and the workshop will cover the following topics:

- What does SGMA require as it relates to managing groundwater quality?
- What are the historical and current groundwater quality conditions in the Basin?

[1] https://borregospringswatermaster.com/wp-content/uploads/2025/08/20250820_Board-Agenda-Package.pdf

- How could groundwater management in accordance with the Judgment impact groundwater quality?
- What does the GMP establish as SMC for groundwater quality?
- What are the groundwater quality management actions defined in the Judgment and GMP?
- What was DWR's feedback on the Judgment and GMP as it relates to groundwater quality?
- How should DWR's comment be addressed, and what changes to the GMP does Staff recommend now and potentially in the future?

What Does SGMA Require?

SGMA's role is forward-looking: it requires basin managers to monitor conditions, set sustainability criteria, and avoid management actions that cause *new* or *worsening* water-quality problems. SGMA does not require the Watermaster to fix or remediate water quality issues that pre-date 2014 or that are caused by other mechanisms outside the Watermaster's control. In short, the Watermaster's role under SGMA is **to monitor, track, and respond to water-quality degradation related to its management actions**, not to solve all water quality issues in the basin. The table below summarizes this distinction.

SGMA Requires Watermaster to:	**SGMA Does *Not* Require Watermaster to:**
Manage groundwater to avoid future "significant and unreasonable" degradation of water quality caused by basin management actions	Fix or remediate water quality problems that existed before 2014 (prior to SGMA's passage)
Establish Sustainable Management Criteria (SMC) for degraded water quality, including: • Definition of Undesirable Results • Minimum Thresholds • Measurable Objectives and Interim Milestones	Be a catch-all solution for every groundwater quality concern in the basin
Monitor water quality through a representative well network and assess/track trends over time	Serve as a substitute for other regulatory programs (e.g., Regional Water Boards, Safe Drinking Water Act, Superfund) that address drinking water-quality compliance, permitting, and cleanup
Consider the impacts on beneficial uses and users (municipal systems, domestic wells, agriculture) when setting SMC and defining management actions	Replace or repair wells that are affected by poor water quality, unless impacts are caused/exacerbated by Watermaster management actions
Adapt management actions if new or worsening water-quality problems are occurring as a result of Judgment/GMP Implementation	Take responsibility for contamination caused by other, such as septic systems, fertilizers, industrial discharges, or natural geochemical condition

Groundwater Quality in the Borrego Springs Subbasin

Historical Groundwater Quality

"Historical groundwater quality" is defined herein as groundwater-quality conditions within the Basin *prior to* enactment of the SGMA in 2014.

Most historical monitoring of groundwater quality was conducted by the Borrego Water District (BWD), the DWR, and the United States Geological Survey (USGS). The GMP stated that these historical data and related USGS publications (Burnham, 1954; Moyle, 1983; USGS, 2015) were of sufficient detail to identify nitrate, TDS, arsenic, sulfate, and fluoride as the main constituents of concern (COCs) within the Basin. These data and publications indicated that only nitrate and TDS concentrations frequently exceeded California primary and secondary maximum contaminate levels (MCLs), respectively, and that the highest nitrate and TDS concentrations occurred at wells screened across the shallow aquifer system in the northern part of the Basin. Some limited monitoring data also indicated relatively high TDS concentrations in deeper groundwater in the vicinity of the Borrego Sink. More recent analyses of water quality at wells that supply irrigation water for the Ram's Hill golf course indicate exceedance of the primary MCL for arsenic (>10 micrograms per liter [µg/L]) in the deeper portions of the aquifer system in the South Management Area.

The USGS (2015) stated the following about historical nitrate and TDS concentrations in the Basin:

Nitrate. *Water-quality samples from wells distributed throughout the valley show that NO3-N concentrations ranged from less than 1 mg/L to almost 67 mg/L. NO3-N concentrations were highest in the shallow aquifer and exceeded the CA-MCL of 10 mg/L in some samples from the shallow and middle aquifers in the northwestern part of the basin* (see fig. 26 attached)*. NO3-N concentrations in samples from the lower aquifer did not exceed 6.7 mg/L*.

TDS. *Water-quality data show that TDS concentrations ranged from less than 500 mg/L to as high as 2,330 mg/L. Similar to the nitrate concentrations, the maximum TDS concentrations were in samples from the shallow aquifer and generally were highest in the northwestern part of the basin* (see fig. 27 attached)*. TDS concentrations in samples from the middle aquifer were as high as 1,350 mg/L. With the exception of one sample, TDS concentrations in the lower aquifer did not exceed 1,000 mg/L, and most samples had TDS concentrations lower than those in samples from the upper and middle aquifers*.

Current Groundwater-Quality Conditions

"Current groundwater quality" is defined herein as groundwater-quality conditions within the Basin as reported by the Watermaster in its *Water Year 2024 Annual Report for the Borrego Springs Subbasin*. Current groundwater quality is better characterized compared to historical groundwater quality because of increased sampling and analysis of groundwater due to implementation of the Watermaster's groundwater-quality monitoring program.

The 2024 Annual Report stated the following about current COC concentrations in the Basin:

Nitrate. *The highest concentrations of nitrate (as nitrogen) were measured in the North and Central Management Areas* (see Figure 20 attached). *The primary MCL of 10 mg/L was exceeded at 6 wells; however, none of these wells are used for potable water supply. Five of the wells with concentrations exceeding the MCL represent new data points due to recent efforts to expand the monitoring network.*

TDS. *TDS concentrations are highest in the North and South Management Areas and in groundwater near the Borrego Sink* (see Figure 19 attached). *The "recommended" level for the California secondary MCL of 500 milligrams per liter (mg/L) was exceeded at 16 wells across the Basin, only three of which are used for potable water supply. The "upper" level for the California secondary MCL of 1,000 mg/L was exceeded at 6 wells across the Basin none of which are used for potable water supply*.

Arsenic. *The highest concentrations of arsenic were generally measured in the South Management Area* (see Figure 21 attached). *The primary MCL of 10 µg/L was exceeded at 3 wells, all of which are non-potable irrigation wells. BWD reported that a municipal supply well in the South Management Area, ID1-8, was not sampled because the well was decommissioned due to elevated arsenic concentrations.*

Sulfate. *The highest concentrations of sulfate occurred in the North Management Area and in groundwater near the Borrego Sink* (see Figure 22 attached). *The secondary MCL of 250 mg/L for sulfate was exceeded in 14 wells across the basin, only one of which is used for potable water supply*.

Fluoride. *Fluoride concentrations are generally the same across all Management Areas* (see Figure 23 attached). *One observation well in the North Management Area exceeded the primary MCL of 2 mg/L for fluoride.*

HISTORICAL VERSUS CURRENT GROUNDWATER-QUALITY CONDITIONS

Comparison of current and historical groundwater quality conditions show similar spatial distributions and magnitudes for all COCs across the Basin, although current conditions are better characterized due to implementation of the Watermaster's groundwater-quality monitoring program. The time-series charts on Figures 19 thru 23 do not show significant increasing concentration trends for the wells with long-term time histories.

These observations indicate that the areas/depths within the Basin that currently exhibit relatively high COC concentrations (i.e., concentrations higher than MCLs) are groundwater-quality conditions that existed prior to enactment of SGMA in 2014.

SOURCES OF COCS IN GROUNDWATER

The GMP describes the various sources for COCs in the Basin:

> **Nitrate**. *Sources of nitrate in groundwater are commonly associated with fertilizers and septic tanks; however, nitrate can also be naturally occurring. Fertilizers and septic tanks are common anthropogenic sources of nitrate detected in groundwater. Potential natural sources of nitrate in groundwater may result from leaching of soil nitrate, which occurs by atmospheric deposition, and dissolution of evaporative minerals, igneous rocks, and deep geothermal fluids.*

In desert groundwater basins, the largest source of naturally occurring nitrates in groundwater occurs from incomplete utilization of nitrate by sparse vegetation. This nitrate accumulates in the unsaturated zone and may become mobile when surficial recharge percolates through the unsaturated zone (Walvoord et al. 2003). In arid environments, nitrate stored in the unsaturated zone may become mobilized by artificial recharge from irrigation return flow, septic effluent, and infiltration basins. Because the Borrego Springs Subbasin lacks appreciable evaporitic deposits (other than near the area of the Borrego Sink), anthropogenic sources (irrigation and wastewater return flows) are likely the main contributors of nitrates to groundwater.

TDS. *Sources of TDS in groundwater include interaction of groundwater with the minerals that comprise the aquifer matrix material. Over time, TDS will increase as more minerals in contact with groundwater dissolve. In desert basins, evaporative enrichment near dry lake beds (playas) is known to naturally increase TDS in groundwater. This process also occurs in plants, both in agriculture and natural systems. Anthropogenic sources include synthetic fertilizers, manure, wastewater treatment facilities, and septic effluent. Repeated irrigation is also a known cause of elevated TDS, as minerals concentrate in the soil column with repeated evaporation. These increased concentrations can then be mobilized into the underlying groundwater table.*

Arsenic. *Arsenic is naturally occurring. In semi-arid and arid groundwater basins, groundwater recharge is limited due to low precipitation and the residence time of the groundwater in the basin is high. The long residence time of the groundwater in the basin allows for more interaction between the groundwater and the minerals that comprise the aquifer matrix material. With time, arsenic desorbs from sediments and enters the groundwater. This process is more efficient in groundwater with higher pH. The groundwater in the Subbasin has a pH of 7.5 to 9.0, a range that is conducive for this transfer of arsenic from the sediment to the water.*

Sulfate. *Natural sulfate sources include atmospheric deposition, sulfate mineral dissolution, and sulfide mineral oxidation of sulfur. Gypsum is an important source of natural sulfate near localized economically important deposits such as in the Ocotillo Wells Subbasin near Fish Creek Mountains in Imperial County. Fertilizers can also be a source of sulfate in groundwater.*

Fluoride. *Fluoride is a naturally occurring element in groundwater resulting from the dissolution of fluoride-bearing minerals from the aquifer sediments and surrounding bedrock*.

In addition, the historical overdraft of the Basin has caused significant lowering of groundwater levels and a reduction is subsurface outflow of groundwater (and its dissolved COCs) from the Basin. This "hydrologic closing" of the Basin (along with repeated cycles of groundwater pumping, outdoor water use, and return flows) can cause COCs to accumulate in the Basin, which can result in increasing COC concentrations over time. This is a common occurrence in groundwater basins.

Potential Effects of Judgment/GMP Implementation on Groundwater-Quality Conditions

The main groundwater-management activities associated with implementation of the Judgment/GMP that could impact groundwater quality include the following:

- The Rampdown of total pumping from the Basin to the Sustainable Yield by 2040
- The fallowing of irrigated farmlands (primarily in the northern half of the Basin) to facilitate the implementation of the Rampdown
- The allowance of transfers of water rights to facilitate the Rampdown
- A PMA that envisions a potential shift of BWD pumping from the Central Management Area (CMA) to the North Management Area (NMA) to maintain a balance of recharge and discharge
- Watermaster's authority to approve or deny new well construction

These activities could have the following effects on groundwater-quality conditions in the Basin in the future:

- The fallowing of irrigated farmlands will reduce the magnitude of loading of COCs to the Basin via decreased return flows of irrigation water past the root zone that percolate to deeper groundwater. These return flows can have relatively high COC concentrations because of the application of fertilizers and the consumptive use of the irrigated water by the crops. *The fallowing of irrigated farmlands represents a **positive effect** of Judgment/GMP implementation on groundwater quality conditions*.
- The Rampdown of pumping is predicted to primarily occur in agricultural areas in the NMA. The decreased pumping in the NMA may cause increases in groundwater levels, which could increase the rate of groundwater flow (and its dissolved COCs) from the NMA to municipal and other well uses in the CMA. *This would represent a potential **negative effect** of Judgment/GMP implementation on groundwater quality conditions in the CMA*.
- A shift of BWD pumping from the CMA to the NMA could slow, stop, or reverse the predicted increases in groundwater levels in the NMA, which would mitigate the predicted increase in the rate of groundwater flow (and its dissolved COCs) from the NMA to the CMA. *This would represent a **positive effect** of Judgment/GMP implementation on groundwater quality conditions in the CMA.*
- Watermaster has authority to approve or deny changes in pumping location, new wells, or de minimis pumping applications if they would cause significant or unreasonable degradation in groundwater quality. *This authority provides the Watermaster with a tool to mitigate the potential for new wells and/or pumping to cause significant or unreasonable degradation in groundwater quality*.

Groundwater Quality SMC

DWR has published guidance documents on setting SMC, including for Degraded Groundwater Quality.[2] Key components of the guidance are as follows:

- **Definition of Undesirable Result**: Significant and unreasonable degraded water quality occurs when groundwater conditions impair water supplies. This can include the migration of contaminant plumes or increasing concentrations of naturally occurring or anthropogenic contaminants that reduce the beneficial use of groundwater.
- **Requirement to Quantify**: GSAs must establish quantitative Minimum Thresholds for groundwater quality, typically based on water-quality measurements at representative monitoring sites. These thresholds may be defined as:
    - Exceedance of a Maximum Contaminant Level (MCL)
    - Movement of contaminant plumes
    - Location of a water-quality isocontour
    - Degradation of a specified volume of groundwater
- **Considerations for Setting Thresholds**:
    - Historical and spatial trends of water quality in the basin
    - Number of supply wells impacted
    - The aquifers primarily used for water supply
    - Estimated volume and extent of contamination
    - Applicable state, federal, or local standards (e.g., MCLs) and justification if thresholds differ
    - Major sources of contamination (point and nonpoint)
    - Effects on beneficial uses and users of groundwater, such as domestic wells or agriculture
- **Protecting Beneficial Uses:** Thresholds should be set to avoid significant and unreasonable impacts on beneficial uses and users, such as communities relying on shallow domestic wells or irrigators dependent on groundwater for crops.
- **Monitoring and Adaptive Management**: Progress toward sustainability is to be tracked with empirical data, and plans must include monitoring networks capable of detecting degradation and evaluating whether minimum thresholds and measurable objectives are being met.

The GMP defines the following SMC for Degraded Groundwater Quality:

Sustainability Goal: *The sustainability goal is for California Title 22 drinking water standards to continue to be met for potable water sources, and that water quality in irrigation wells be suitable for*

[2] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf

agricultural and recreational irrigation use. Water quality monitoring will occur throughout Physical Solution implementation. (pp. ES-9 to ES-10)

Undesirable Result: *Undesirable results occur if there are significant and unreasonable degraded water quality conditions. The primary undesirable result associated with degraded water quality is the loss of adequate water resources to support current and/or potential future beneficial uses and users, where alternative means of treating or otherwise obtaining sufficient alternative groundwater resources are not technically or financially feasible. Groundwater quality degradation will be considered significant and unreasonable if it results in exceedances of state drinking water standards for potable supplies or renders groundwater unsuitable for agricultural or recreational irrigation uses*. (GMP Section 3.2.4)

The table on the following page lists the Minimum Thresholds, Measurable Objectives, and Interim Milestones for each of the five COCs in the GMP. In all cases:

- Quantitative Minimum Thresholds are set at the primary or secondary Maximum Contaminant Limit (MCL) for the protection of drinking water as defined by CA Title 22 drinking water standards.
- The Measurable Objectives are:
    - To maintain concentrations below the CA Title 22 drinking water MCLs for potable supply wells
    - To maintain concentrations suitable for intended uses at irrigation, recreation, or other non-potable wells (these use thresholds are not quantified in the GMP)
- The Interim Milestones are framed simply as check in points at five-year increments. The Interim Milestones are not quantified, but the intent is to assess the trend at these points to assess if the trend is on track to meet the Measurable Objective.

As discussed earlier in the memo, the GMP documents that some wells had historical COC concentrations that exceeded MCLs (e.g., nitrate in the north, TDS and sulfate near Borrego Sink, arsenic in the south). These are presented as existing conditions rather than as automatic triggers of an Undesirable Result. That said, the GMP is not explicit as to which wells in the monitoring network the SMC should apply given historical water-quality conditions.

Sustainable Management Criteria (SMC) for Constituents of Concern – Borrego Springs GMP

Constituent of Concern (COC)	Minimum Thresholds (MTs)	Measurable Objectives (MOs)	Interim Milestones
Total Dissolved Solids (TDS)	For municipal and domestic wells: **500–1,000 mg/L** (Secondary MCL) For irrigation wells: **Not defined**, but water quality should be suitable for the beneficial use	Maintain levels below MCLs for drinking water Quality remains usable for irrigation water and other purposes	At 5-year increments (2025, 2030, 2035, etc.), track progress toward meeting the Measurable Objective. No quantitative milestones included.
Nitrate (NO_3-N)	For municipal and domestic wells: **10 mg/L** (Primary MCL) For irrigation wells: **Not defined**, but water quality should be suitable for the beneficial use	Maintain nitrate concentrations below MCL for drinking water	
Arsenic (As)	For municipal and domestic wells: **10 µg/L** (Primary MCL) For irrigation wells: **Not defined**, but water quality should be suitable for the beneficial use	Maintain arsenic concentrations below the MCL for drinking water	
Sulfate (SO_4^{2-})	For municipal and domestic wells: **250 mg/L** (Secondary MCL) For irrigation wells: **Not defined**, but water quality should be suitable for the beneficial use	Maintain sulfate concentrations below MCL for drinking water Quality remains usable for irrigation water and other purposes	
Fluoride (F^-)	For municipal and domestic wells: **2 mg/L** (Primary MCL) and **1 mg/L** (Secondary MCL for taste/odor) For irrigation wells: **Not defined**, but water quality should be suitable for the beneficial use	Maintain fluoride concentrations below MCL for drinking water	

Groundwater Quality Management Actions Defined in the Judgment and GMP

The Judgment defines two actions related to groundwater quality in Section VI.B:

> **Water Quality Monitoring**. The Judgment requires Watermaster to establish a Water Quality Monitoring Plan within 24 months of entry of the Judgment. A groundwater monitoring plan was developed with both TAC and local stakeholder input and was completed in March 2023 (within the stated deadline). This groundwater monitoring plan supersedes the monitoring program defined in the GMP.
>
> The monitoring plan implementation has moved forward with great success due to funding from the DWR SGM grant. Several resources on the Watermaster website[3] document the monitoring results and expansion of the monitoring network through conversion of inactive and abandoned wells and stakeholder participation.
>
> **Water Quality Management**. The Judgment states that "*The Watermaster will determine if changes in water quality are significant and unreasonable following consideration of the cause of impact, the affected beneficial use, potential remedies, input from the Technical Advisory Committee, and subject to approval by this Court exercising independent judgment*."

The GMP's **PMA No. 5 on Water Quality Optimization** proposes a program to investigate and, if necessary, implement measures to protect and enhance water quality so it remains suitable for municipal and irrigation uses. The stated purpose of the PMA is to identify as-needed direct and indirect treatment options for BWD and other pumpers to optimize groundwater quality and its use and minimize the need for expensive water treatment to meet drinking water standards.

The implementation approach is generally as follows:

- Begin with investigation: identify the sources and extent of existing or potential water quality impairments, review existing data, fill data gaps, and engage stakeholders. A robust water quality monitoring program is identified as essential to the success of the PMA.
- If needed, develop work plans: evaluate mitigation alternatives, identify costs and funding opportunities, and prepare a formal Groundwater Quality Optimization Plan.
- If warranted, implement projects: this may include direct or indirect treatment (blending, wellhead treatment, or other measures), or changes in pumping and well management.

The GMP does not provide a detailed step-by-step timeline beyond showing the PMA on the basin-wide implementation schedule through 2040. It acknowledges uncertainty about the degree and timing of water quality changes, which depend on aquifer conditions and pumping patterns, noting that water quality issues may evolve over time and may require adaptive management.

[3] https://borregospringswatermaster.com/groundwater-monitoring-program/

DWR feedback on the Judgment and GMP as it Relates to Groundwater Quality

In February 2025, the DWR issued a Staff Report approving the Borrego Springs Subbasin Alternative (i.e., Judgment and GMP) with seven Recommended Corrective Actions (RCAs) to improve the use of the Judgment and GMP as an alternative to a SGMA-compliant Groundwater Sustainability Plan. The DWR Staff letter can be accessed on the Borrego Springs Watermaster Website.[4]

The Department was largely satisfied with the description and characterization of groundwater quality conditions in Borrego Springs, but characterized perceived deficiencies in how the GMP translates that information into enforceable management tools. To highlight a few comments:

- **Sufficient Analysis of Conditions**: The GMP provides a solid technical basis, identifying constituents of concern (TDS, nitrate, arsenic, sulfate, fluoride), describing sources, documenting historical exceedances, and acknowledging increasing trends. DWR staff found this adequate and consistent with best available information.
- **Deficiencies in SMCs (RCA No. 5)**: The GMP's SMCs for water quality are too general (e.g., "meet Title 22 standards," "suitable for agriculture") and not consistently expressed in quantitative Minimum Thresholds or Measurable Objectives. No clear definition of Undesirable Results or basin-wide applicability is provided. DWR directed Watermaster to develop quantified thresholds, measurable objectives, and undesirable result definitions. The exact language of RCA No. 5 is:

  "*Quantify the 'generally accepted threshold limits for [crop] irrigation used by State Water Resources Control Board,' and discuss how those limits will be used to track progress in the Subbasin to avoid undesirable results associated with degradation of groundwater quality. Describe the groundwater conditions and the associated impacts to beneficial uses and users of the Subbasin at those limits.*"

  Watermaster Staff interprets DWR concern in RCA No. 5 to be that Minimum Thresholds at higher concentrations that are protective of agricultural uses are not protective of more sensitive beneficial uses, such as potable water supply.
- **Integration of Judgment and GMP (RCA No. 7)**: DWR noted that the Judgment gives the Court authority to determine whether changes in water quality are "significant and unreasonable," considering cause, remedies, and TAC input. But the GMP does not clearly link its SMC and Projects & Management Actions to this Court process, leaving uncertainty about how the Watermaster and Court will apply GMP criteria in practice. DWR flagged this gap and requested clearer integration to ensure water-quality management under the Judgment is aligned with SGMA's SMC framework.

[4] Available at: https://borregospringswatermaster.com/wp-content/uploads/2025/03/DWR_BorregoSprings_GSP2025_Determination.pdf

Recommendations to Address DWR Comments and Update the GMP

Staff recommends the following actions:

1. Redefine and clarify what constitutes an Undesirable Result for degraded water quality. The recommended revised definition for the Undesirable Result is:

   Significant and unreasonable degradation of groundwater quality occurs when the magnitude of degradation in any Management Area or subarea of the Basin precludes the use of groundwater for current and/or potential future beneficial uses, if:

   - *The degradation that impairs the beneficial use(s) occurs after the enactment of SGMA (2014).*
   - *The cause of the degradation is demonstrated to be related to implementation of the Judgment/GMP.*
   - *There are no technically or financially feasible alternative means of treating or otherwise obtaining sufficient groundwater resources*.

2. Update the GMP to:
   a. Reframe the purpose of the Minimum Thresholds as protecting the most sensitive beneficial use, which is potable water supply.
   b. Specify that the Minimum Thresholds apply to representative monitoring wells with water quality that was less than the CA drinking water standards prior to 2014.
   c. Emphasize that the basin-wide monitoring network will enable monitoring of groundwater-quality conditions and trends throughout the basin so that impacts to all beneficial uses can be considered and addressed in accordance with the Judgment.
3. Document in the 5-Year GMP Assessment Report that the Watermaster will revisit the water quality SMC as part of the 2030 GMP Assessment Report. Currently, there is insufficient data and analytical tools available to improve the characterization of Minimum Thresholds and Measurable Objectives. As data are collected and analyzed over the next few years, a more comprehensive understanding of basin-wide conditions will be available and can be relied on to improve the SMC for groundwater quality.
4. Update the GMP to modify PMA No. 5 as follows:
   a. Rename the PMA to: Water Quality Monitoring and Management
   b. Integrate the water-quality management process defined in Section VI.B.2 of the Judgment into the PMA No. 5. The Judgment provisions can be restated as a management process as follows:
      - Establish and implement a water quality monitoring plan to collect water quality data throughout the Basin
      - Analyze groundwater quality results annually to assess conditions and trends
      - When trends in a well or area of the Basin indicate increases in COC concentrations that may be considered significant and unreasonable, direct Staff to assess the following:

- What are the historical conditions, current conditions, and trends in concentration over time?
- What is the observed or potential impact to beneficial uses caused by the increase in contaminant concentrations?
- What are the sources of the COC?
- What are the causes of the increase in COC concentrations?
- Considering all causes, what is the relative contribution of Watermaster actions to the increase in COC concentrations?
- What are the potential solutions to avoid or mitigate impacts to beneficial uses and users?
- Are the solutions technically or financially feasible?

▪ Based on the analysis, and in consultation with the TAC, determine if (i) Watermaster management action(s) resulted in a significant and unreasonable impairment to a beneficial use and (ii) there are technically or financially feasible alternative means of treating or otherwise obtaining sufficient groundwater resources.

▪ If Watermaster management action(s) resulted in a significant and unreasonable impairment to a beneficial use, and there are no technically or financially feasible alternative means of treating or otherwise obtaining sufficient groundwater resources, then implement adaptive management actions.

c. Define a specific water quality condition/trend that would trigger Watermaster to assess whether a change in water quality is significant or unreasonable per the considerations defined in Judgment Section VI.B.2. This should be defined in collaboration with the TAC, and will be a topic at the September 22, 2025 meeting.

d. Clarify the role of monitoring and periodic analysis of water quality in guiding Watermaster actions in accordance with the Judgment.

Next Steps

- Staff is seeking input from the Board on the recommendations to address the DWR comments and update the GMP.
- The TAC will be discussing the recommendations at its September 22nd meeting.
- Based on Board and TAC feedback, staff will update the discussion points and recommendations for presentation to Stakeholders at the October Open House.
- TAC and stakeholder feedback will be presented to the Board at the October Board meeting.
- A final recommendation will be presented to the Board in December for documentation in the 5-Year Assessment Report and GMP Update.

Enclosures: Figures excerpted from USGS (2015) and Watermaster 2024 Annual Report

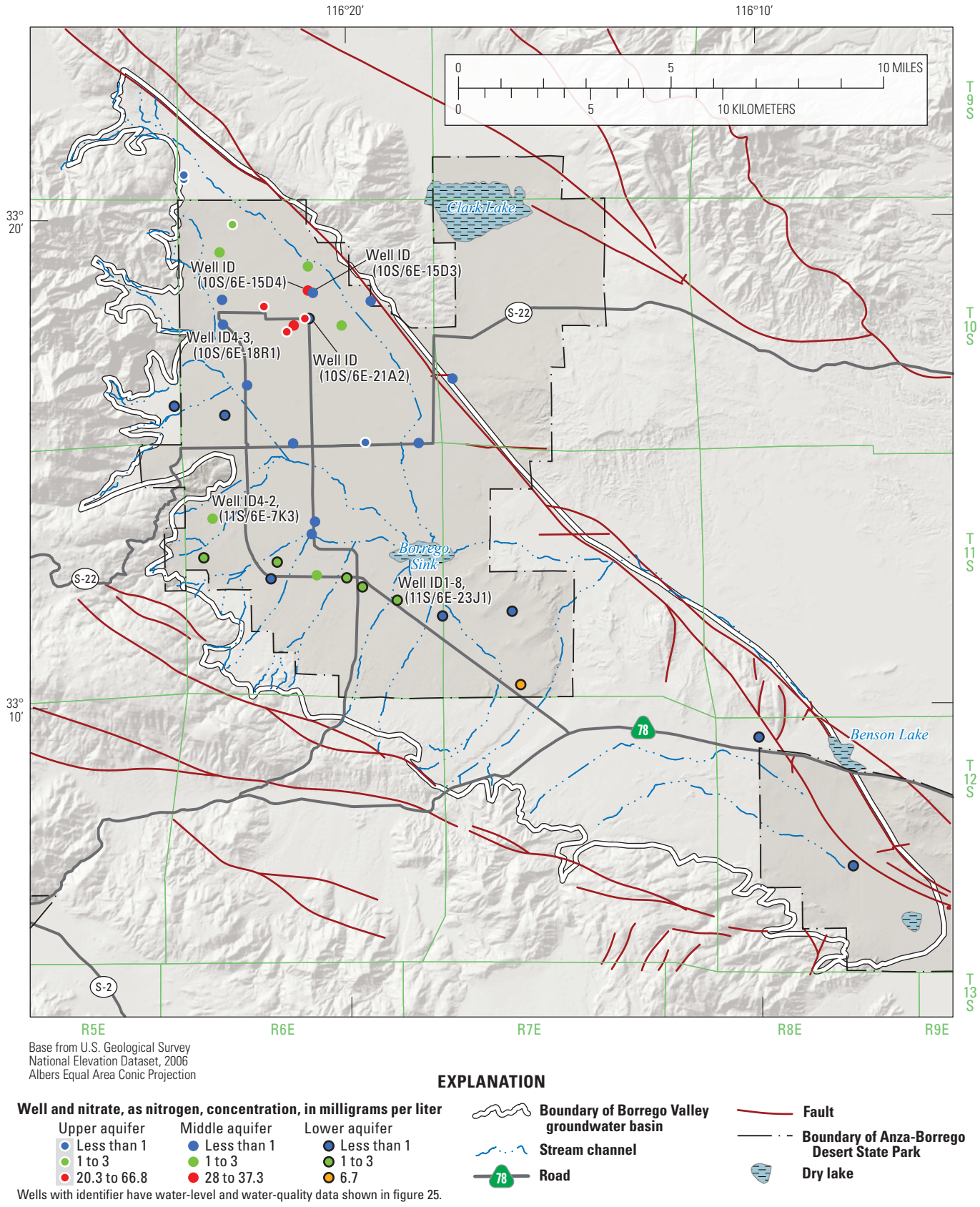


Figure 26. Distribution of nitrate as nitrogen concentrations in the upper, middle, and lower aquifers, Borrego Valley, California, for the most recent sample.

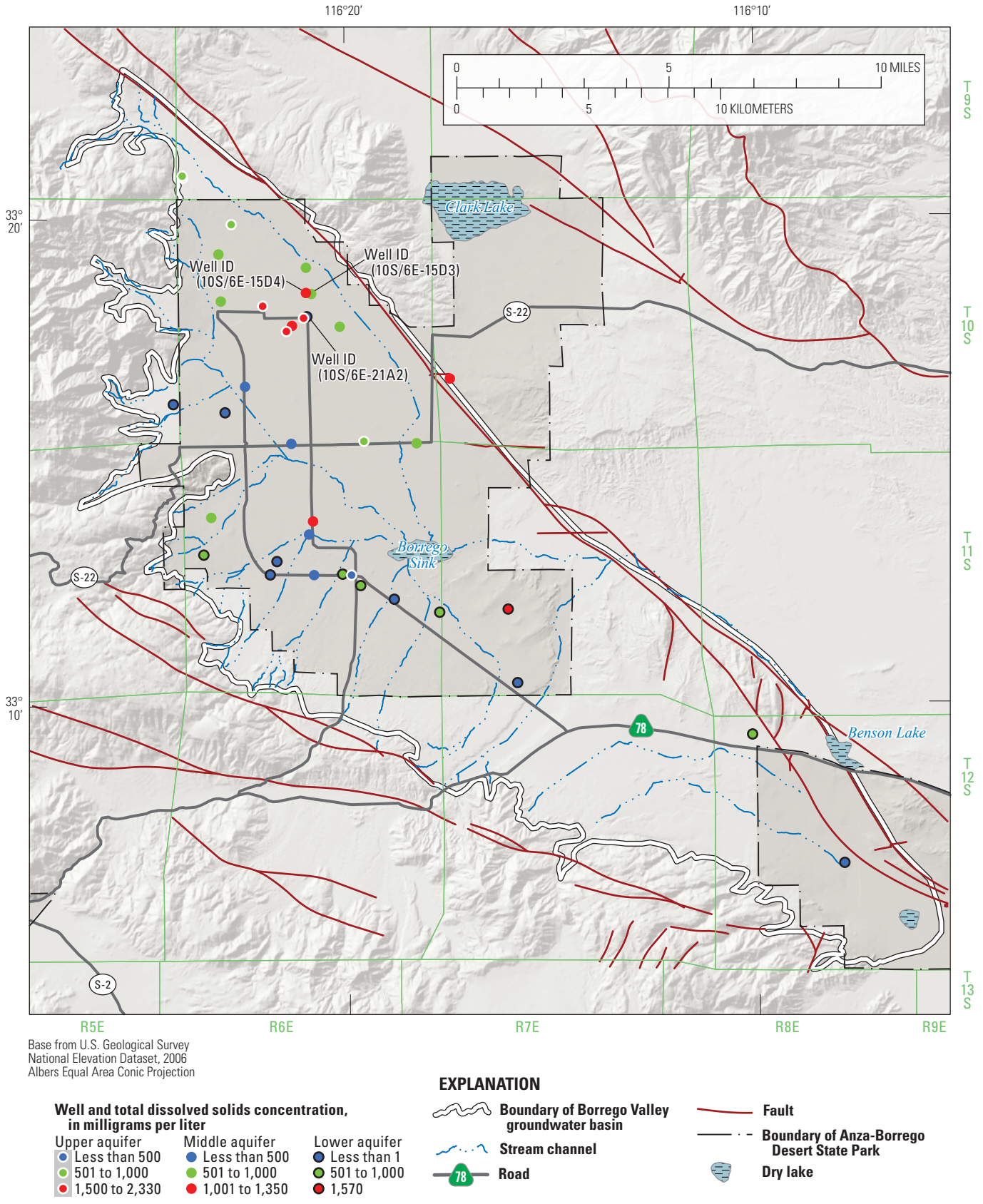
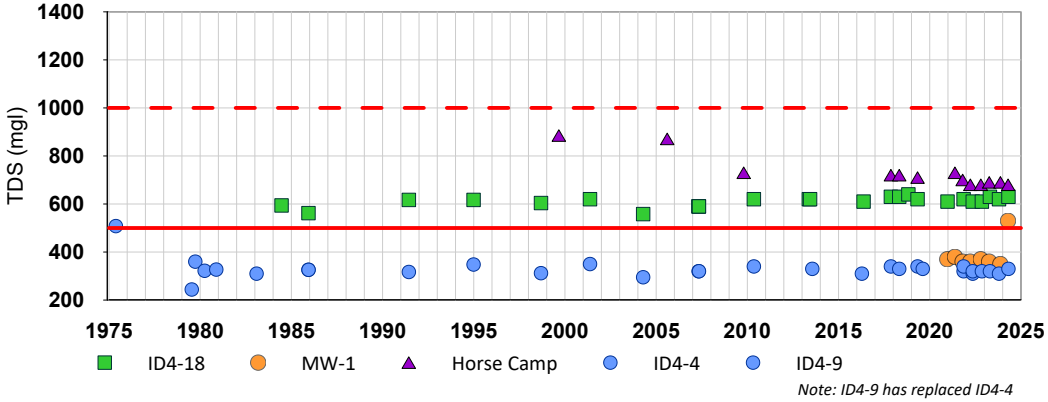


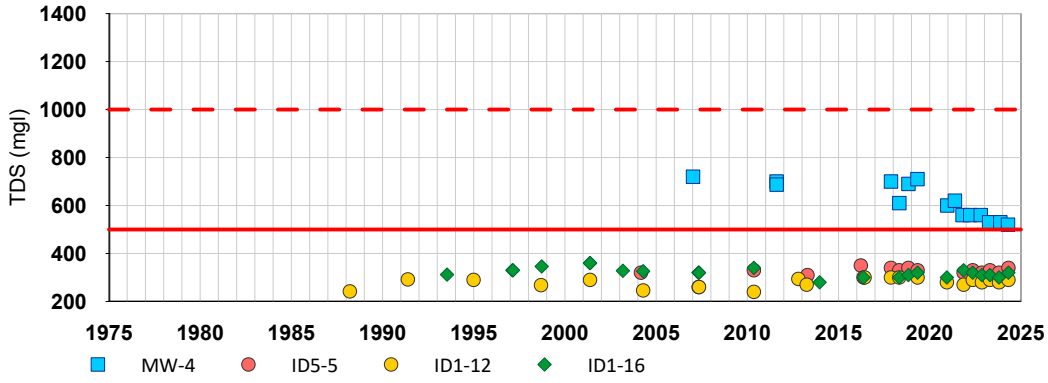
Figure 27. Distribution of total dissolved solids concentrations in the upper, middle, and lower aquifers, Borrego Valley, California.

North Management Area

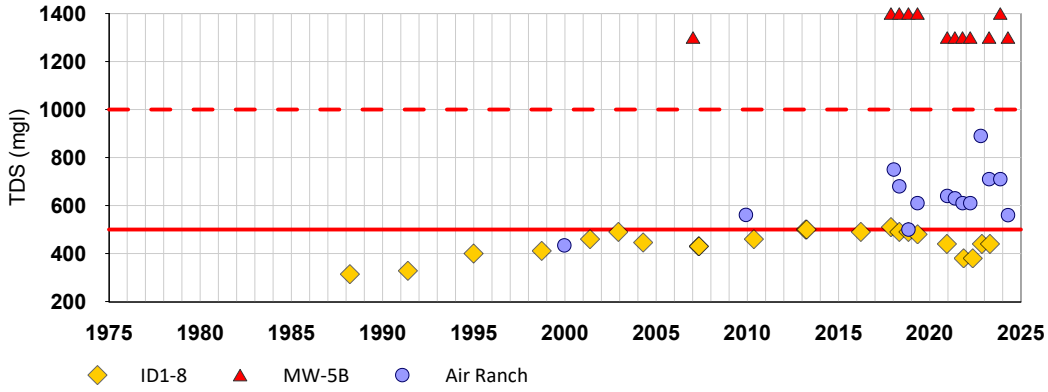


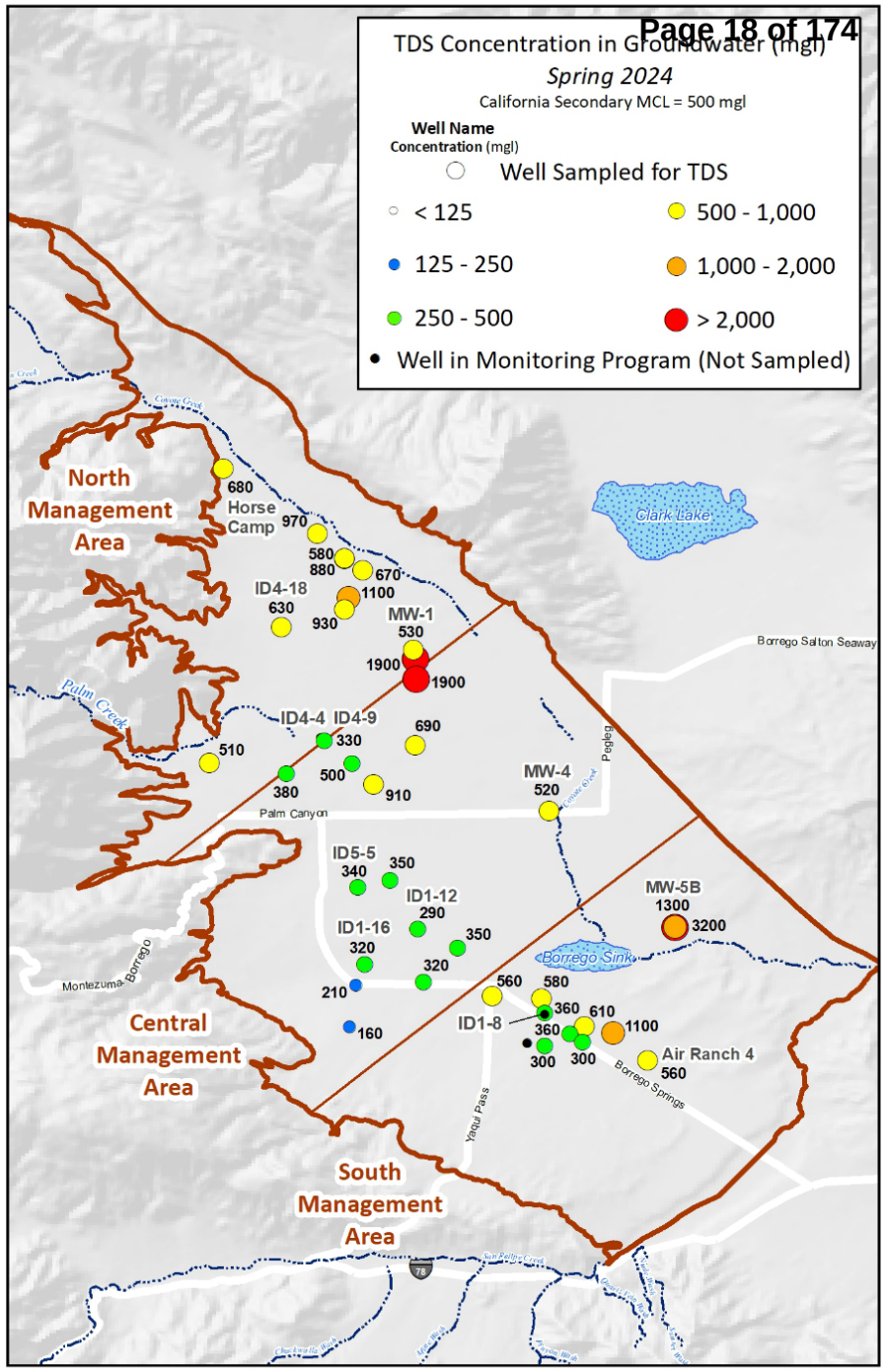
Note: ID4-9 has replaced ID4-4

Central Management Area



South Management Area





Wells by Principal Aquifer

- △ Upper
- ◊ Lower
- □ Upper and Middle
- ◇ Upper, Middle, and Lower
- ○ Middle and Lower

Maximum Contaminant Level

- Upper Secondary MCL
- Recommended Secondary MCL

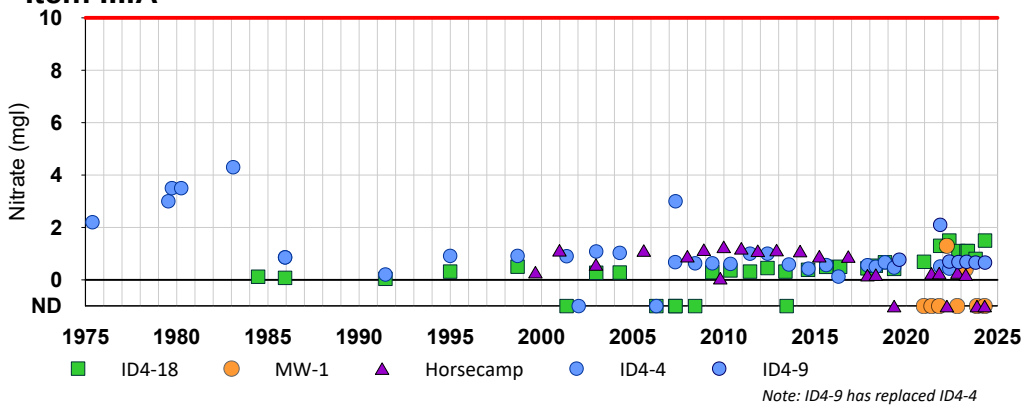
WEST YOST
Water. Engineered.

Author: CK
Date: 20241111
File: TDS

Figure 19

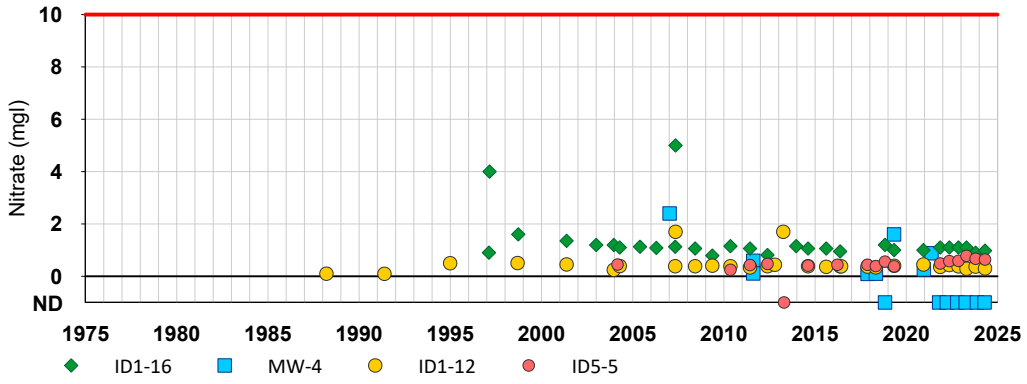
Total Dissolved Solids (TDS) in Groundwater

North Management Area

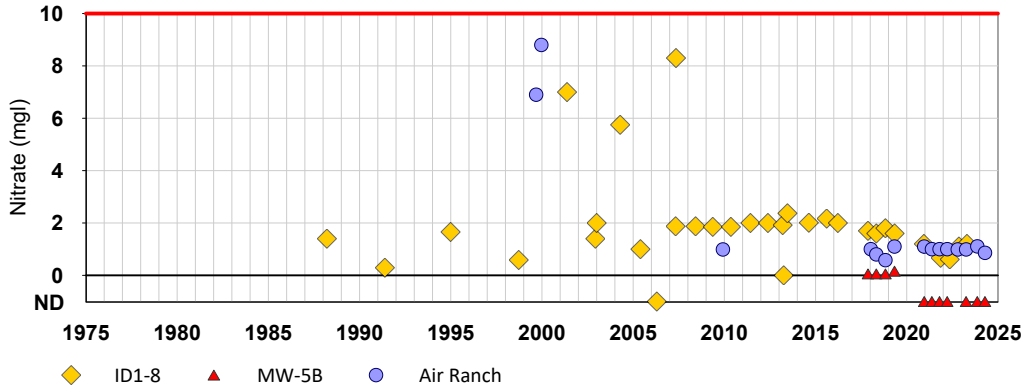


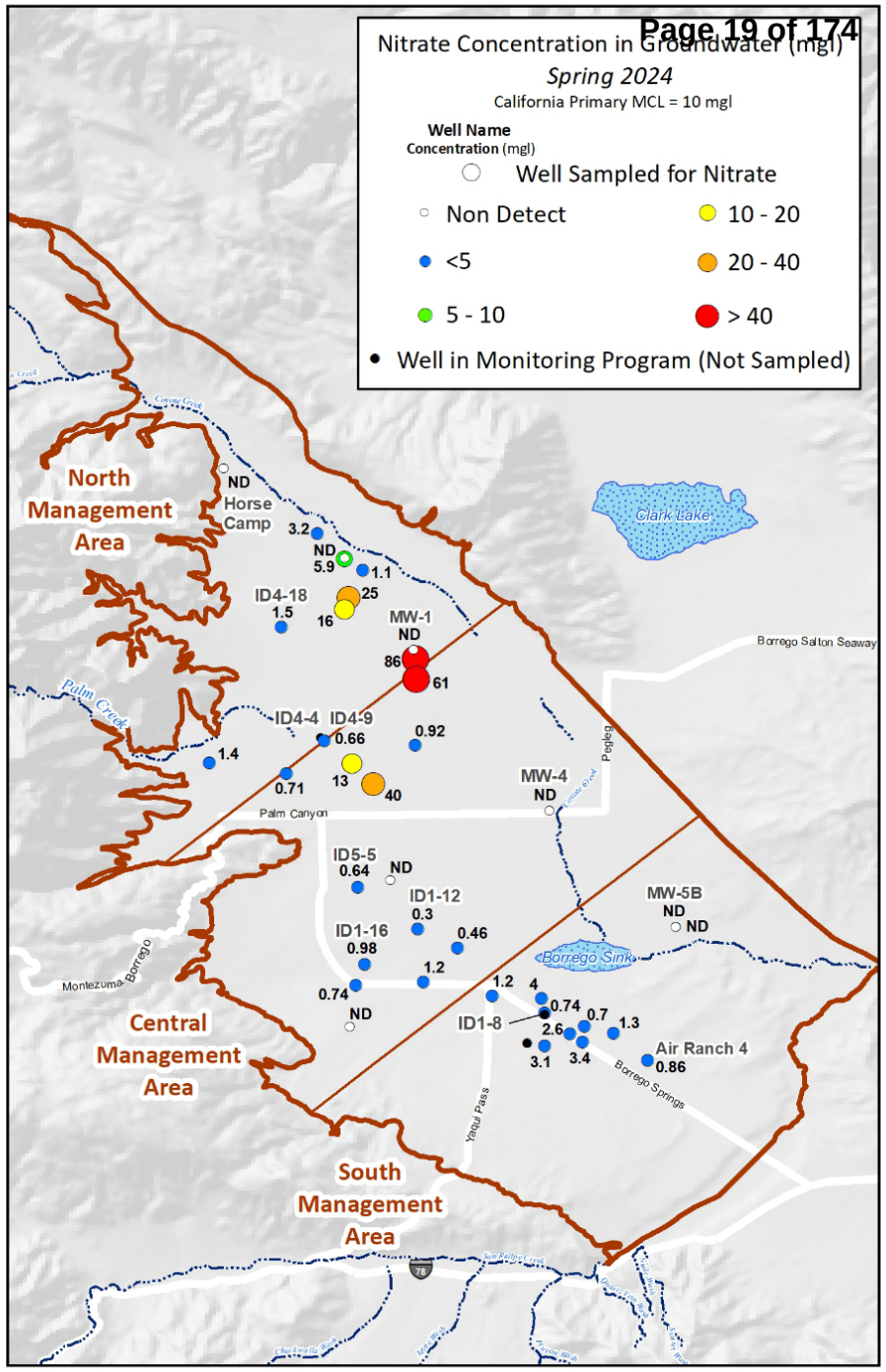
Note: ID4-9 has replaced ID4-4

Central Management Area



South Management Area





Wells by Principal Aquifer

- △ Upper
- ◊ Lower
- □ Upper and Middle
- ◇ Upper, Middle, and Lower
- ○ Middle and Lower

Maximum Contaminant Level

- Primary MCL

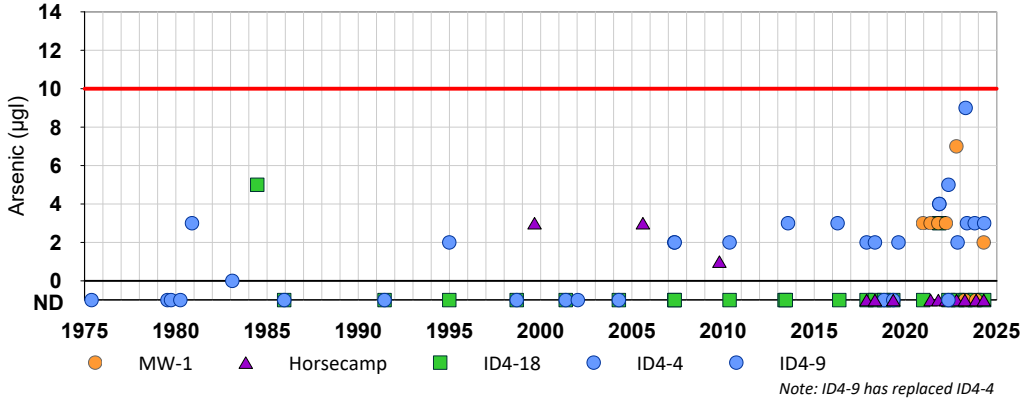
WEST YOST
Water. Engineered.

Author: CK
Date: 20241111
File: Nitrate

Figure 20

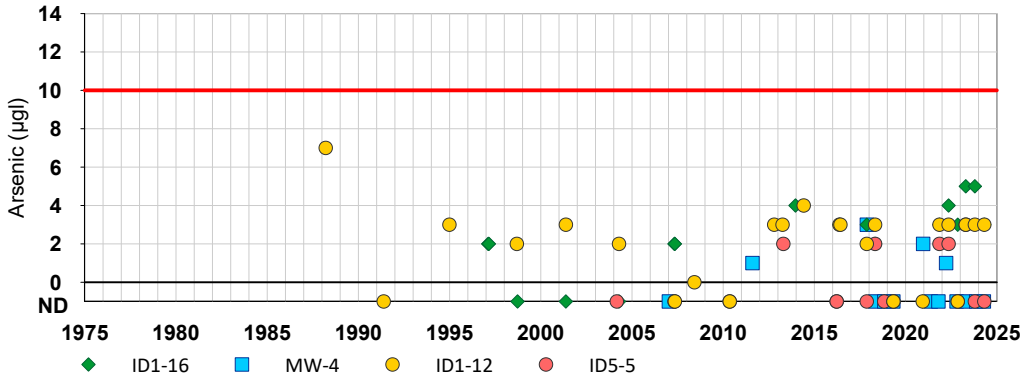
Nitrate (as Nitrogen) in Groundwater

North Management Area

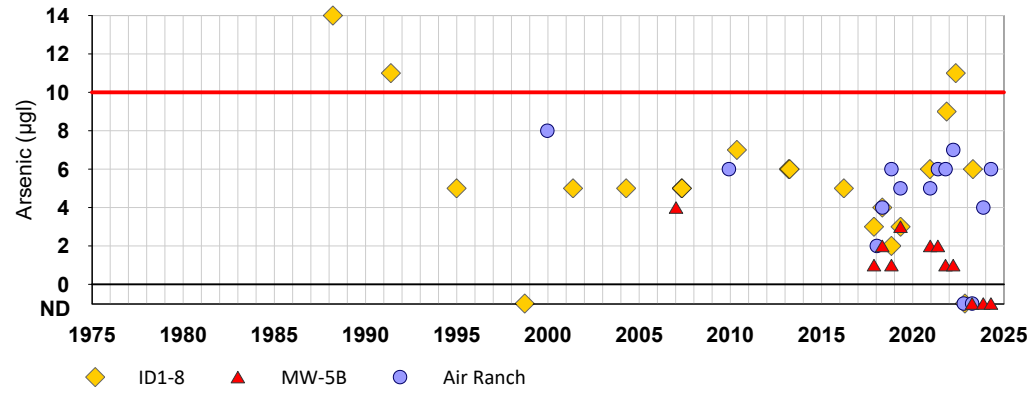


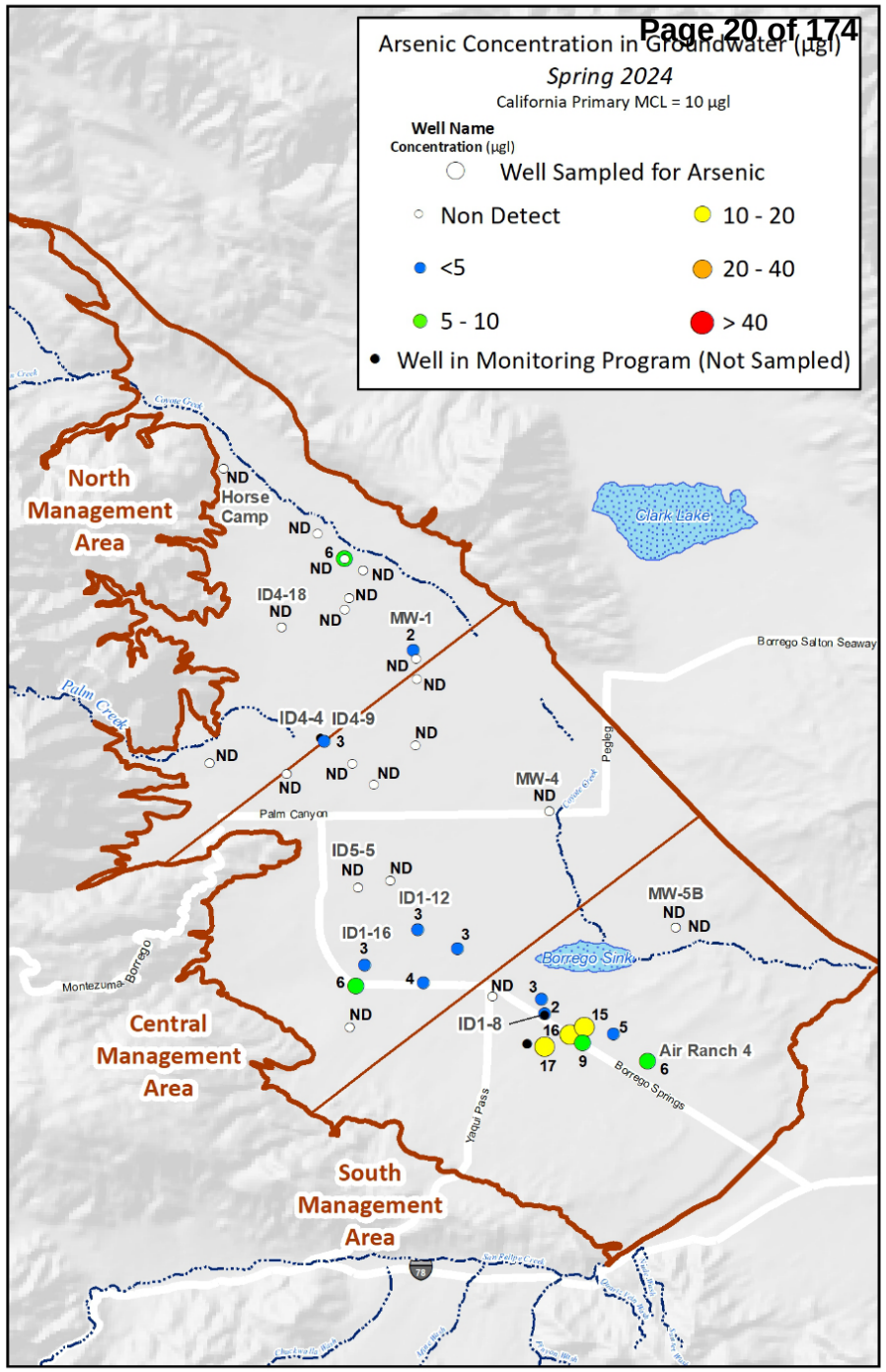
Note: ID4-9 has replaced ID4-4

Central Management Area



South Management Area





Wells by Principal Aquifer

- △ Upper
- ◊ Lower
- □ Upper and Middle
- ◇ Upper, Middle, and Lower
- ○ Middle and Lower

Maximum Contaminant Level

- Primary MCL

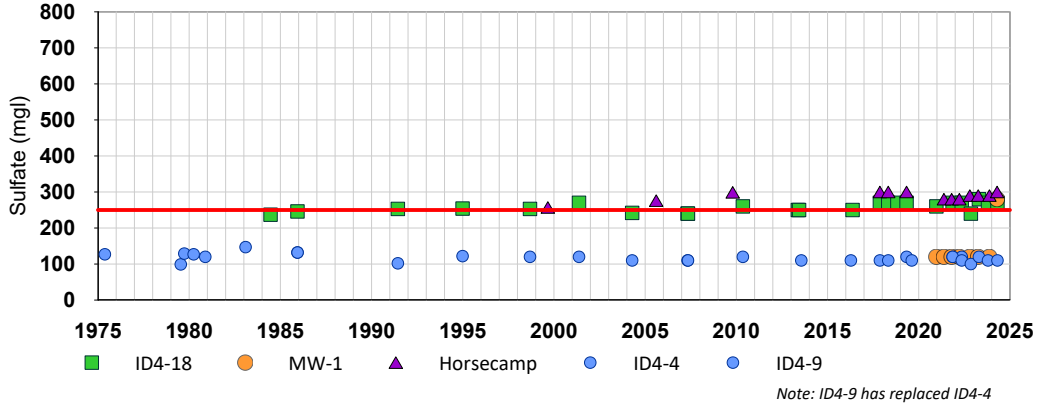
WEST YOST
Water. Engineered.

Author: CK
Date: 20241111
File: Arsenic

Figure 21

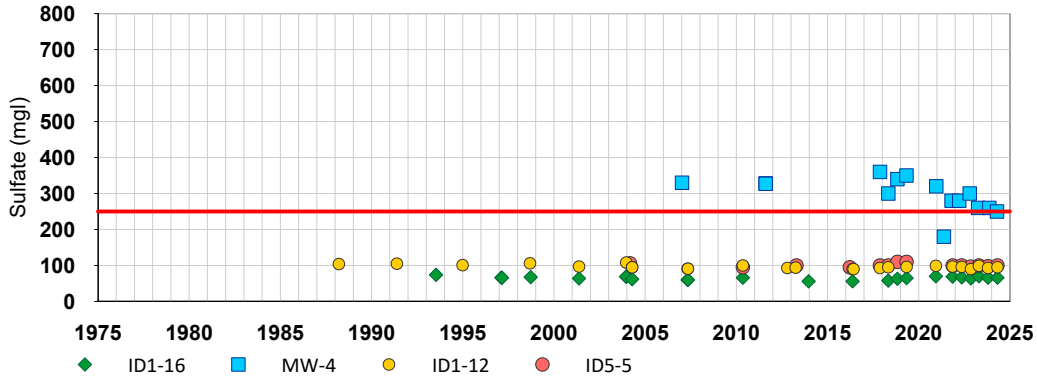
Arsenic in Groundwater

North Management Area

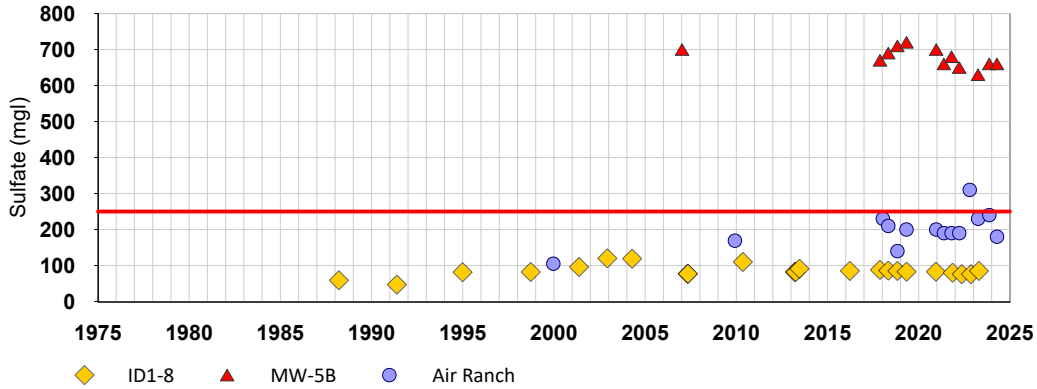


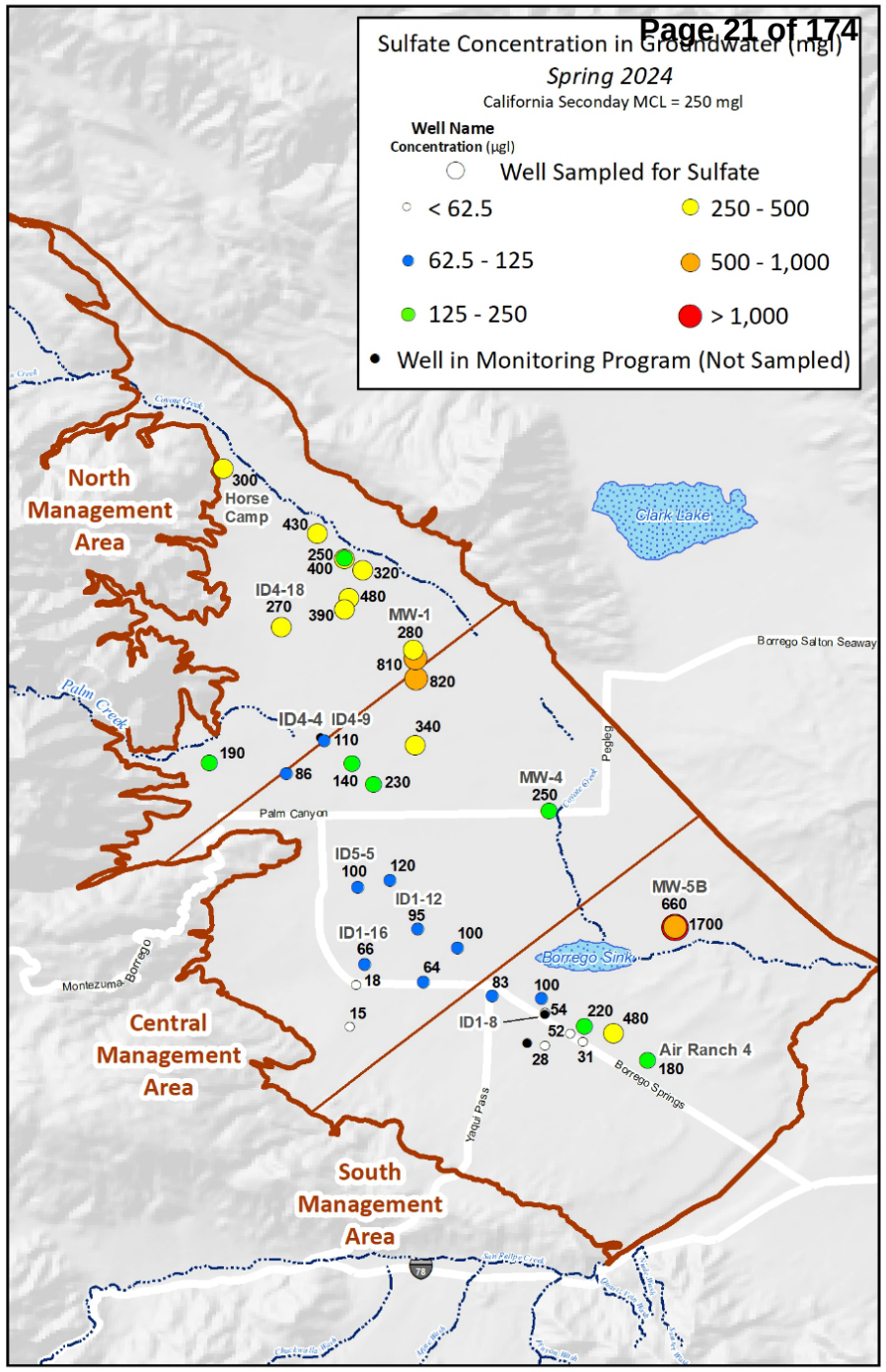
Note: ID4-9 has replaced ID4-4

Central Management Area



South Management Area





Wells by Principal Aquifer

- △ Upper
- ◊ Lower
- □ Upper and Middle
- ◇ Upper, Middle, and Lower
- ○ Middle and Lower

Maximum Contaminant Level

- Secondary MCL

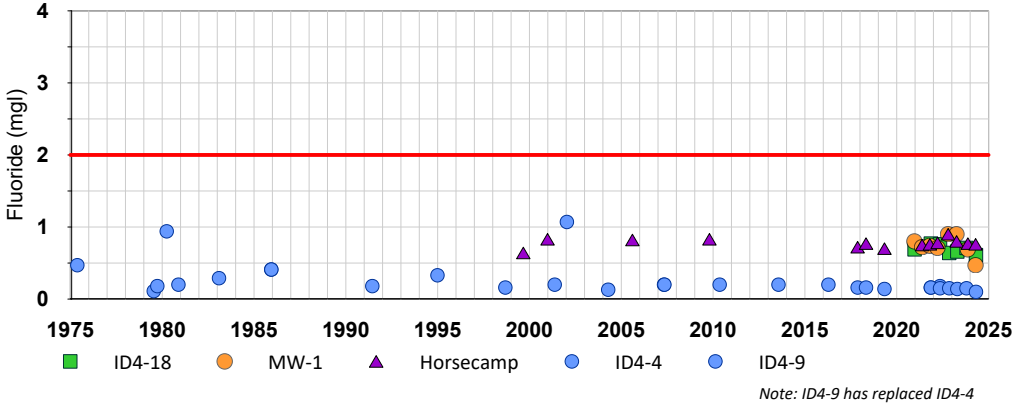
WEST YOST
Water. Engineered.

Author: CK
Date: 20241111
File: Sulfate

Figure 22

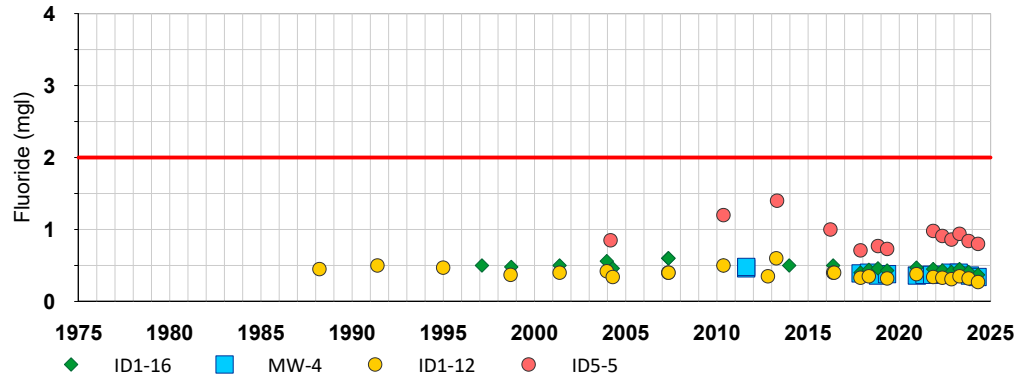
Sulfate in Groundwater

North Management Area

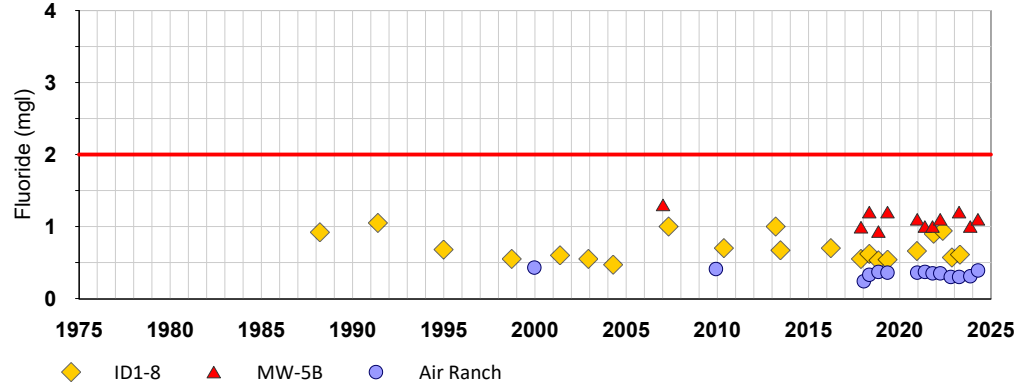


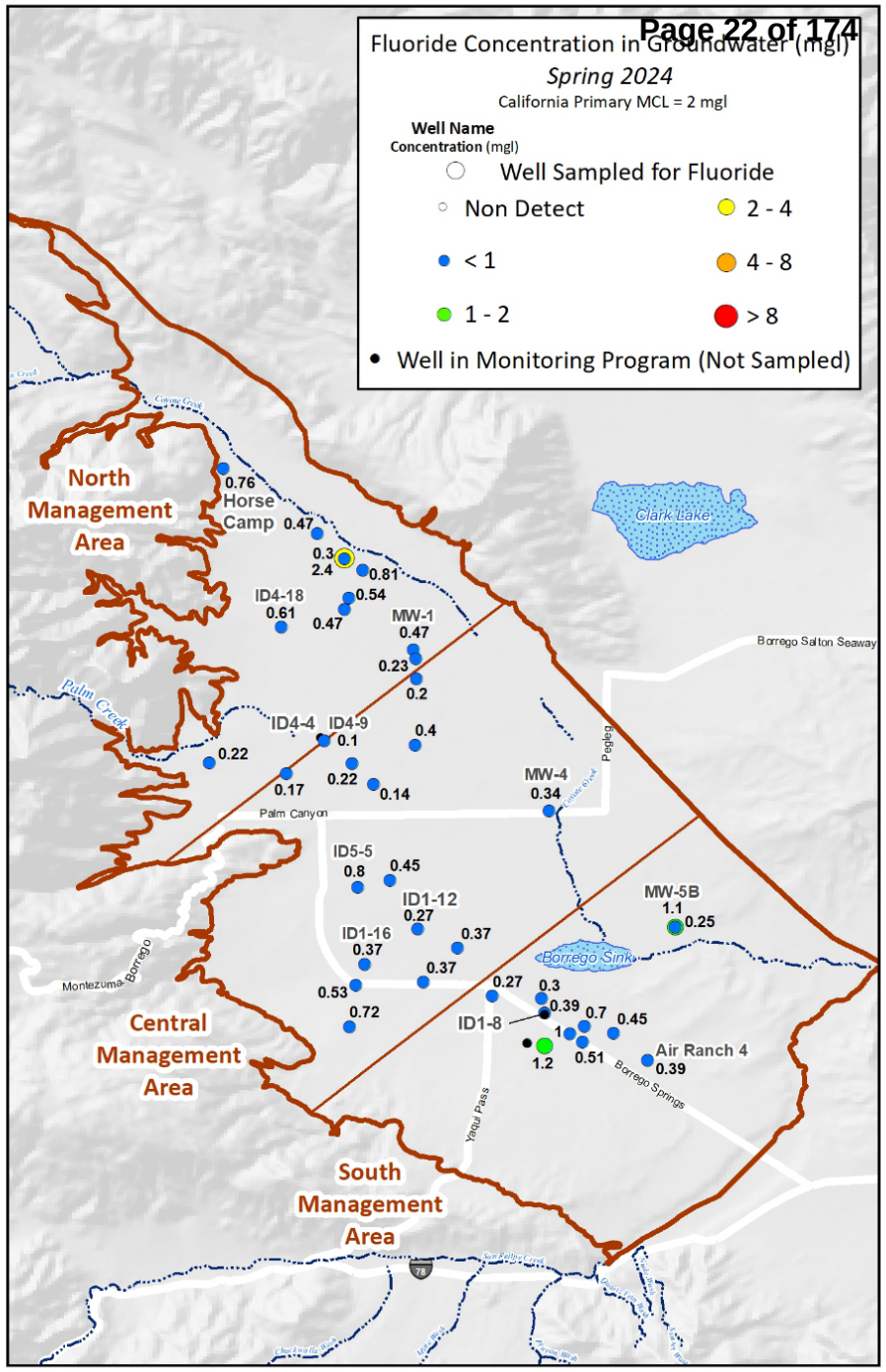
Note: ID4-9 has replaced ID4-4

Central Management Area



South Management Area





Wells by Principal Aquifer

- △ Upper
- ◊ Lower
- □ Upper and Middle
- ◇ Upper, Middle, and Lower
- ○ Middle and Lower

Maximum Contaminant Level

- Primary MCL

WEST YOST
Water. Engineered.

Author: CK
Date: 20241111
File: Fluoride

Figure 23

Fluoride in Groundwater

Borrego Springs Watermaster
Technical Advisory Committee Meeting
September 22, 2025
AGENDA ITEM III.B

To: Technical Advisory Committee (TAC)

From: Andy Malone, PG (West Yost), Technical Consultant

Date: September 18, 2025

Subject: Updating Sustainable Management Criteria – Land Subsidence

Background and Objectives

The Borrego Springs Watermaster submitted to the California Department of Water Resources (DWR) its Judgment and Groundwater Management Plan (GMP) as an alternative Groundwater Sustainability Plan (GSP) for the Borrego Springs Subbasin (Basin) on June 25, 2021 to comply with the requirements of the Sustainable Groundwater Management Act of 2014 (SGMA). Together, the Judgment and GMP represent the Physical Solution for the Basin to achieve its Sustainability Goal by 2040, which is defined as operating the Basin at its Sustainable Yield without causing Undesirable Results. On February 25, 2025, the DWR approved the Judgment/GMP as an alternative GSP but also listed several Recommended Corrective Actions (RCA) that should be implemented by the Watermaster to maintain the approval status of the Judgment/GMP.[1] RCA #6 relates to how the Judgment/GMP should address the potential for land subsidence to cause Undesirable Results in the Basin.

The objective of this memorandum is to describe a proposed approach to address RCA #6.

How the GMP Addresses Land Subsidence

Land subsidence is one of six Sustainability Indicators[2] defined by SGMA. To describe the historical occurrence of land subsidence in the Basin, the GMP relied on subsidence data collected and analyzed by the USGS (2015)[3] during a period of overdraft in the Basin (1978-2018):

However, the current GMP does not define Sustainable Management Criteria (SMC) to avoid significant and unreasonable land subsidence for the following reasons:

- Based on GPS survey measurements at numerous geodetic monuments and wells located across the Basin from 1978 to 2009, vertical ground motion was shown to be less than +/- 0.54 feet and included both upward and downward ground motion.

[1] Non-Party Department of Water Resources' Assessment and Recommended Corrective Actions Approving SGMA Alternative.

[2] Sustainability Indicators are the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, become Undesirable Results.

[3] USGS. 2015. *Hydrogeology, Hydrologic Effects of Development, and Simulation of Groundwater Flow in the Borrego Valley, San Diego County, California*. Scientific Investigations Report 2015-5150.

- From 2003 to 2007, interferometric synthetic aperture radar (InSAR) data indicated the occurrence of seasonal fluctuations of the land surface (elastic), with total maximum subsidence in the central part of the Basin of about 0.05 ft.
- From 2015 to 2018, InSAR data indicated total maximum subsidence of about 0.023 ft in the area northwest of the Borrego Sink.

Based on these measured observations during a period of overdraft in the Basin, the GMP stated the following:

- "The degree of land subsidence occurring in the Plan Area is minimal, has not substantially interfered with surface land uses in the past, and is not anticipated to substantially interfere with surface land uses in the foreseeable future. The minor amount of subsidence that has occurred when compared to over a hundred feet of groundwater level decline in the northern parts of the Plan Area indicate that the subsurface strata may be less sensitive to land subsidence due to its coarse-grained nature. There is sufficient data to qualify the subsidence criterion as insignificant, and not currently an undesirable result of groundwater overdraft (USGS 2015). Given the low sensitivity of subsurface strata to land subsidence in response to historical groundwater level declines, along with the lack of infrastructure in the Plan Area that may be sensitive to subsidence (i.e., linear infrastructure such as canals and high hazard pipelines), subsidence is also not expected to become an undesirable result over the planning and implementation horizon." (see Section 2.2.2.5 of the GMP)
- Therefore, this GMP does not propose minimum thresholds or measurable objectives specific to this sustainability indicator. If during the GMP implementation timeline, it becomes evident that minimum thresholds and measurable objectives for lowering of groundwater levels and groundwater in storage are not being met, the degree to which land subsidence may become an undesirable result will be re-evaluated. (see Section 3.2.5 of the GMP)

RCA #6 – Land Subsidence

In its letter and Staff Report that conditionally approved the Judgement and GMP as a SGMA Alternative, the DWR made the following statements and recommendations regarding the monitoring and management of land subsidence:

- "….the decision [in the GMP] to not develop sustainable management criteria or monitor land subsidence is not supported by adequate evidence."
- "…additional information be developed and included in the GMP to at least annually monitor for subsidence using InSAR data or other reliable methods and reconsider whether and where any subsidence could adversely impact surface land uses in the Subbasin so that managers are prepared to quickly act if further overdraft during plan implementation causes unexpected increases in subsidence rate or extent."
- "The Department also recommends that the Watermaster set an objective, quantitative standard for subsidence monitoring (for each management area) that, if triggered, would require further assessment of whether any undesirable results related to subsidence might

be occurring and whether projects or management actions are necessary to mitigate or avoid such impacts (see Recommended Corrective Action 6)."

RCA #6 summarizes the DWR concerns and recommendations:

- "Until pumping reductions have been fully implemented to the point where overdraft is eliminated and groundwater pumping equals the sustainable yield, monitor for land subsidence and evaluate, at least every five years, whether land subsidence is interfering with property interests and surface uses or otherwise impacting beneficial uses and users (e.g., flood depths, flows, or risks, well casings or other infrastructure, etc.). Describe the amount of land subsidence or impacts that would be significant and unreasonable and therefore cause or constitute undesirable results in the basin."

Recent and Potential Future Land Subsidence within the Basin

The most recent land subsidence data being collected across the Basin includes the following:

- The DWR has provided InSAR data across the Basin for the period 2015 to 2024. These data were collected by the European Space Agency Sentinel-1A satellite and processed by TRE ALTAM1RA Inc., under contract with the DWR as part of DWR's SGMA technical assistance to provide important SGMA-relevant data to GSAs for GSP development and implementation.

- Continuous Global Positioning System (CGPS) Station 486 is located on the north side of the runway at Borrego Valley Airport. This station is a USGS and NSF GAGE Facility and part of the NOTA Monitoring Network.[4] These GPS stations typically collect position data every 15 seconds, which is then processed to produce a daily and 31-day moving average position. Vertical displacement data from Station 486 are available on the SGMA Data Viewer.

Watermaster staff used these data to prepare the following:

- Figure 1 is a map that illustrates vertical ground motion that occurred across the Basin between June 2015 and June 2024. During this 9-year period, the total maximum subsidence in the Basin was estimated to be about 0.16 ft (0.017 ft/yr), which occurred in the Central Management Area just north of the Borrego Sink. Subsidence was much less or absent across the North Management Area and South Management Area. Also shown on this figure is a time-series chart of subsidence as measured by CGPS Station 486, which corroborates the InSAR estimates of subsidence at this location of about 0.082 ft (0.009 ft/yr) and illustrates that the subsidence has occurred persistently and gradually with minor seasonal fluctuations. Also shown on the time-series chart are measured groundwater elevations at a nearby well (MW-4), which illustrates the relationship between declining groundwater heads versus land subsidence.

- Figure 2 is a map that illustrates potential future subsidence that could occur within the Basin over the SGMA implementation period of 2015-2040. This estimate was based on the assumption that the historical subsidence rates for 2015-2024 (shown on Figure 1) will

[4] https://www.unavco.org/instrumentation/networks/networks.html

continue to occur for the period 2024-2040. This is a conservative assumption for future land subsidence because declines in groundwater levels are expected to slow and stabilize over 2024-2040 due to the pumping Rampdown. Figure 2 shows that during 2015-2040, the total maximum subsidence in the Basin is estimated to be about 0.43 ft (0.017 ft/yr), which is projected to occur in the Central Management Area just north of the Borrego Sink. Subsidence is expected to be much less or absent across the North Management Area and South Management Area.

Recommendations to Address RCA #6

To address RCA #6, Watermaster Staff proposes the following tasks to perform over the period 2026 to 2030:

1. **Implement an Annual Land Subsidence Monitoring/Reporting Program**. Each year, the map and chart shown on Figure 1 will be updated with the most recent subsidence and groundwater-elevation data. The figure will be included in the Watermaster's annual report to the DWR, with a short section of text that describes/interprets the monitoring results. This task directly responds to DWR's recommendation to monitor land subsidence annually.
2. **Characterize Potential Impacts of Subsidence on Overlying Beneficial Uses/Users.** This task involves:
    a. Identify and map the overlying beneficial uses/users that could be impacted by land subsidence (pipelines, property interests within/near flood-prone areas, well owners, etc.). These features should be included on Figure 2 to compare their locations to the historical and potential future land subsidence that could occur within the Basin.
    b. Identify experts that could help describe the thresholds for land subsidence, that if exceeded, could adversely impact the overlying beneficial uses/users.
    c. Working with the beneficial uses/users or experts, set a quantitative standard for the magnitude of subsidence (in each management area) that, if exceeded, would require further assessment of whether any undesirable results related to subsidence might be occurring and whether projects or management actions might be necessary to mitigate or avoid such impacts.
3. **Document Results.** Findings from the two tasks above will be summarized annually in the Watermaster's Annual Report to the DWR and evaluated in each future 5-year GMP Assessment. Based on the findings and input from stakeholders, the Watermaster will determine whether establishing SMC for land subsidence is warranted, or whether continued monitoring and reporting without formal SMCs is sufficient.

Consistency with DWR Guidance

The DWR recently released a new draft guidance document for land subsidence entitled: *Subsidence Best Management Practices of the Sustainable Management of Groundwater* (DWR Subsidence BMP), which provides the following recommendations:

- Subsidence is a SGMA Sustainability Indicator and must be monitored.

- Identify infrastructure and land uses most at risk of land subsidence.
- Estimate "critical head" thresholds below which inelastic compaction may occur.
- Establish monitoring networks (InSAR, GPS, extensometers, groundwater levels).
- Use groundwater levels as a proxy for subsidence when subsidence is minimal.
- Conduct outreach with potentially affected parties.

The proposed methods described above (i) are consistent with the draft DWR Subsidence BMP, and (ii) address RCA #6 provided by the DWR. The methods consider the current understanding of the Basin, include monitoring and outreach, acknowledges overlying beneficial uses/users and infrastructure most sensitive to subsidence, and recognizes that formal SMC may not necessary but will be evaluated during each 5-year GMP Assessment.

Next Steps

At the TAC meeting, the Technical Consultant will describe this proposed technical approach for establishing a land subsidence monitoring program, responding to DWR RCA #6, and updating the GMP Assessment Report and will receive TAC feedback. Specifically, the TAC will be asked:

- Do you agree with this approach?
- What property interests and infrastructure are you aware of within the Basin that may be sensitive to subsidence?
- Who should we contact to learn more about the potential subsidence impacts to overlying property interests and infrastructure?

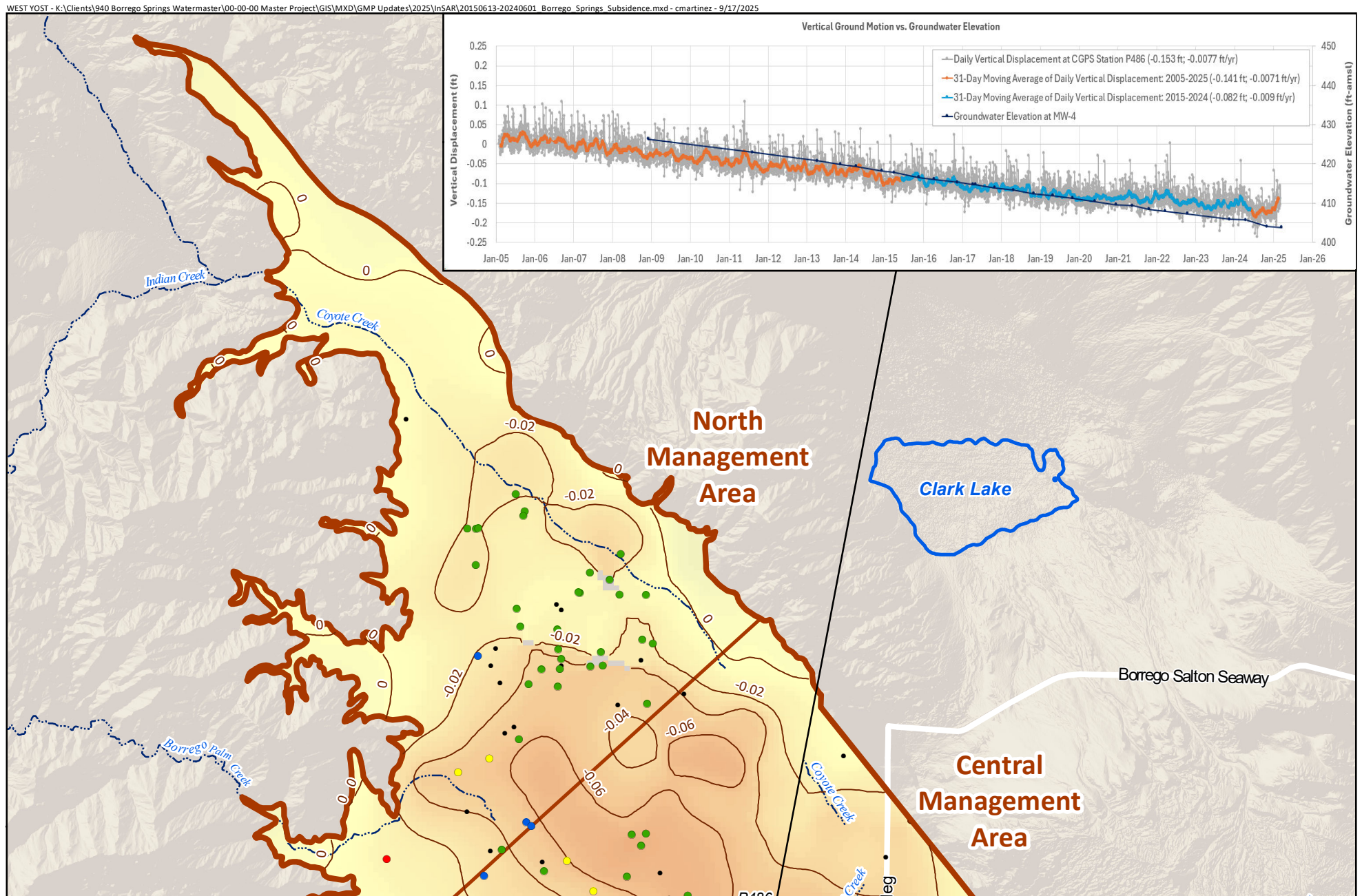
Following the TAC meeting, the TAC is asked to provide written feedback to Andy Malone (amalone@westyost.com) and Lauren Salberg (lsalberg@westyost.com) by October 22, 2025. The TAC is asked to CC: the entire TAC membership in its email correspondence with the Technical Consultant.

Enclosures

Figure 1. Historical Vertical Ground Motion as Estimated by InSAR – *June 2015 to June 2024*

Figure 2. Projected Vertical Ground Motion based on InSAR – *June 2015 to June 2040*

WEST YOST - K:\Clients\940 Borrego Springs Watermaster\00-00-00 Master Project\GIS\MXD\GMP Updates\2025\InSAR\20150613-20240601_Borrego_Springs_Subsidence.mxd - cmartinez - 9/17/2025



Relative Change in Land Surface Elevation as Estimated by InSAR (June 2015 to June 2024)

+0.2 ft

0 ft

-0.2 ft

Subsidence Contour (0.02 ft interval)

Wells by Sector

- Agriculture
- Recreation
- Municipal
- Other Non-Deminimis
- De Minimis

Other Features

- Borrego Springs Subbasin with Management Area Divisions
- Stream
- Dry Lake
- Wastewater Percolation Ponds
- Continuous Global Positioning System (CGPS) Station P486

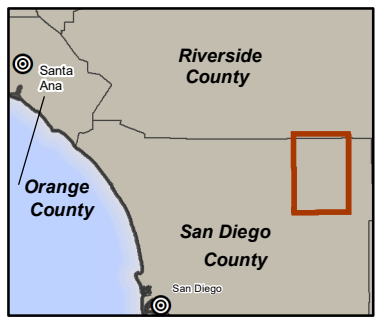


Figure 1

Vertical Ground Motion

(2015-2024)

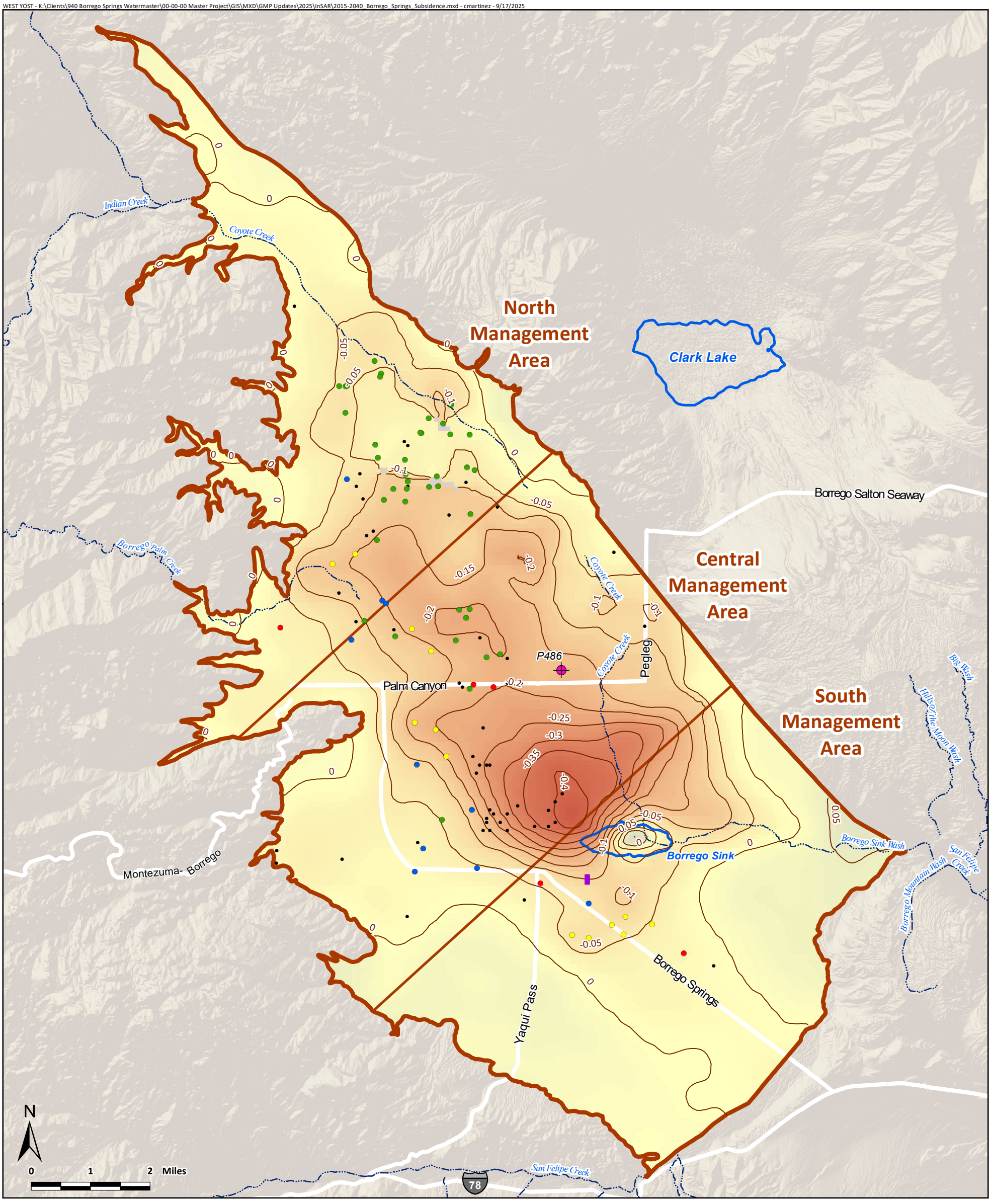
Borrego Springs Watermaster

2025 GMP Update

Prepared by:

WEST YOST

WEST YOST - K:\Clients\940 Borrego Springs Watermaster\00-00-00 Master Project\GIS\MXD\GMP Updates\2025\InSAR\2015-2040_Borrego_Springs_Subsidence.mxd - cmartinez - 9/17/2025



Projected Relative Change in Land Surface Elevation as Estimated by InSAR (June 2015 to June 2040)

+0.5 ft

0 ft

-0.5 ft

Subsidence Contour (0.05 ft interval)

Wells by Sector

- Agriculture
- Recreation
- Municipal
- Other Non-Deminimis
- De Minimis

Other Features

- Borrego Springs Subbasin with Management Area Divisions
- Stream
- Dry Lake
- Wastewater Percolation Ponds
- Continuous Global Positioning System (CGPS) Station P486

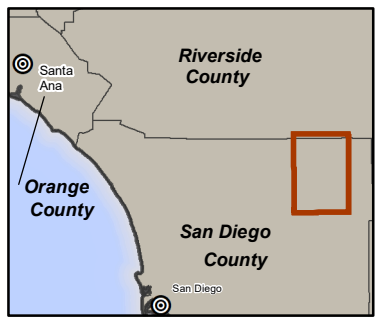


Figure 2

Projected Vertical Ground Motion
(2015-2040)

Borrego Springs Watermaster
2025 GMP Update

Prepared by:

WEST YOST

Borrego Springs Watermaster
Technical Advisory Committee Meeting
September 22, 2025
AGENDA ITEM IV

To: Technical Advisory Committee (TAC)

From: Andy Malone, PG (West Yost), Technical Consultant

Date: September 18, 2025

Subject: TAC Assignment to Evaluate/Rank Proposals for Peer Review of GDE Study Report

Background and Discussion

The Board is considering hiring an environmental consultant with subject matter expertise in Mesquite Tree biology and groundwater dependent ecosystems (GDE) to perform an independent technical peer review of the UCI GDE Study Report. The Technical Consultant identified five (5) candidates to perform the technical peer review and requested proposals from the candidates by September 17, 2025. Four (4) proposals were received and are attached to this memo.

The Board has requested TAC feedback on the proposals to assist its decision in selecting a peer reviewer. At the TAC meeting, Staff will discuss the Board's request and will introduce a "score sheet" that will be provided to each TAC member to evaluate and rank each proposal. The goal of this agenda item is to ensure the TAC is clear on their assignment and schedule to evaluate/rank the proposals.

The TAC meeting is also an opportunity for the TAC to discuss and ask questions about their own assignment to review and comment on the UCI GDE Study Report as "best available science." An email was sent to the TAC on September 12, 2025 that described the scope of this task, which is to review the UCI GDE Study Report and the Watermaster's policy on "best available science," and then prepare written comments stating your opinions on whether or not the UCI GDE Study Report constitutes "best available science" that can be relied upon by the Watermaster to take action or make policy decisions.

Next Steps

Following the TAC meeting, the score sheets will be shared with the TAC. TAC members are asked to evaluate and rank the proposals to assist the Board in its selection of a peer reviewer.

By Thursday, October 9, 2025, the TAC is asked to provide to Andy Malone (amalone@westyost.com) and Lauren Salberg (lsalberg@westyost.com) the following:

- Their completed evaluation and ranking of the peer reviewer proposals (i.e., completed score sheets)
- Written comments on the UCI GDE Study Report as "best available science"

The TAC is asked to CC: the entire TAC membership in its email correspondence with the Technical Consultant. All TAC input will be shared with the Board ahead of and during the Board meeting on October 15, 2025.

Enclosures

Proposals to perform a peer review of the GDE Study Report from:

- Northern Arizona University
- Rohde Environmental (supported by The Nature Conservancy)
- University of California Riverside
- United States Geological Survey (USGS)

BIODIVERSITY ANALYTICS

Proposal for Review of UCI GDE Study Report – Biodiversity Analytics LLC

I. Technical Approach to Peer Review

We define four levels of analysis for review:

1. Methods of data collection

2. Indices/metrics

3. Statistical analysis

4. Interpretation

We propose to follow a structured assessment of the first three levels of analysis above using the following review criteria:

1. Appropriateness of approach. Does this method accurately quantify the stated phenomenon, pattern or process? Do derived indices or metrics represent the stated phenomenon well? Is the statistical analysis appropriate for the types of data?

2. Alternative methods. Are there other ways of quantifying the same phenomenon, or representing it in terms of other indices or metrics? Are there other ways of statistically analyzing the data?

3. Missing metrics, covariates or other data. Would additional data help to provide important context for understanding the responses of selected metrics to environmental or management drivers? Could those additional data be incorporated into formal statistical analyses?

For the fourth level of analysis (Interpretation), we will assess whether the conclusions that were reached accurately reflect the statistical results presented, as well as the potential for alternative interpretations or alternative outcomes if other methods were applied.

Furthermore, we will assess the sufficiency of cited literature, whether findings of the present study contradict or confirm previous findings, and discuss the potential context for any disagreements.

BIODIVERSITY ANALYTICS

Results of the peer review will be presented both in a tabular summary form as well as a more detailed narrative. The table will essentially be a detailed extension of Table 1.1 in the GDE report, providing summarized results of the review criteria outlined above. The table will be color-coded to quickly draw readers' attention to potential issues. The narrative will provide more in-depth discussion of any potential issues and their broader context. In ecology, perhaps more than in most scientific disciplines, context matters. Many external variables can differ from one site, study or time period to the next in ways that can significantly alter ecological processes and management outcomes. These issues of context will be carefully considered and interpreted to our best abilities in a way that will facilitate management decisions.

II. Cost Estimate

Biodiversity Analytics LLC charges a rate of $150/hr for all aspects of this project. We anticipate a total of 40 hours, for a total cost of $6000. Hours per deliverable and associated task, as well as the timeframe for each task, are presented in the following Gantt chart.

Deliverable	Tasks	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Hours
Draft Report	Review TAC/EWG comments								2
	Review UCI report and relevant literature								15
	Meet with UCI scientists and TAC/EWG								3
	Write draft report								10
	TAC/EWG meeting								2
	Watermaster Board meeting								2
Final Report	Write final report								4
	Watermaster Board meeting								2
								Total hours	**40**

III. Short Biographical Sketch – Brad Butterfield, PhD (Principal, Biodiversity Analytics LLC)

Dr. Butterfield has more than two decades of experience conducting research in ecosystems of the Southwest, across the US and internationally. He has published 75 peer-reviewed studies on topics including plant ecohydrology, terrestrial and wetland plant communities, environmental and biotic drivers of ecosystem dynamics, and management of dryland ecosystems. Dr. Butterfield has a applied many data collection and statistical

techniques through this extensive and diverse body of research. His regional experience with the ecosystems and organisms of the Desert Southwest, coupled with deep analytical expertise, makes him well suited to review this report. Please see the attached CV for further details.

Bradley J. Butterfield, Ph.D.

Associate Research Professor
Department of Biological Sciences
Northern Arizona University

Flagstaff, AZ 86011-5640
Bradley.Butterfield@nau.edu
(928)853-0359

Education

Ph.D. 2009 Plant Biology, Arizona State University, Tempe, AZ (Dean's Fellowship)

Advisors: John Briggs and Ann Kinzig

Dissertation: Structure and dynamics of Sonoran Desert perennial plant communities

B.A. 2004 Biology, Rice University, Houston, TX

Advisors: Evan Siemann and William Rogers

Honors thesis: Growth of Chinese tallow tree (*Sapium sebiferum*) and four native trees under varying water regimes

Professional Experience

2019 – Associate Research Professor, Department of Biological Sciences, Northern Arizona University

2012 – 2018 Assistant Research Professor, Department of Biological Sciences, Northern Arizona University

2009 – 2011 Postdoctoral Researcher, Department of Environmental Science, Policy and Management, UC Berkeley. Supervisor: Katharine Suding

Knowledge

Biodiversity science
Environmental restoration
Climate change adaptation
Ecosystem services
Ecohydrology
Terrestrial and aquatic ecosystems

Skills

Computing languages: R, SQL, Python
Parallel computing for informatics / big data
GIS / spatial data analysis
Process-based modeling
Machine learning

Experience

Collaboration with federal, tribal and private stakeholders
Cross-disciplinary work with economists and social scientists
Fundraising
Public outreach
International collaborations

Research Funding >$3 million to date

BLM New Mexico. Building a Regeneration Window Tool for Rangeland Restoration. PI, $1,200,000 (all NAU)

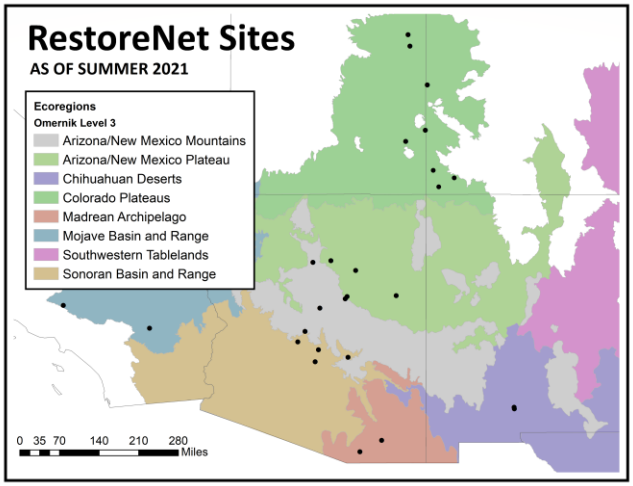
USGS Grand Canyon Monitoring and Research Center. Monitoring and analysis of riparian vegetation on the Colorado River. 2021-2024. PI, $298,970 (all NAU).

USGS Southwest Biological Science Center. Modeling long-term ecological drought in dryland ecosystems of western North America. 2017-2021. PI, $43,000 (all NAU).

USGS Grand Canyon Monitoring and Research Center. Assessing and modeling vegetation change along the Colorado River in support of trends assessment and vegetation resource management. 2017-2020. PI, $404,648 (all NAU).

Funding Highlight: RestoreNet

Through collaboration with federal and tribal partners, ranchers and land managers, we developed RestoreNet, a distributed set of experiments aimed at identifying solutions for restoration of degraded drylands. My lab group focused primarily on restoration of ecosystem functioning – water infiltration, forage production, soil stabilization, weed suppression, etc. – through the lens of plant functional traits. The network continues to expand, addressing questions like seed mix selection, soil amendments, and restoring plant communities that are resilient to climate change.



BLM Colorado Plateau Native Plants Program. Integrated Monitoring and Seed Testing to Improve Restoration Outcomes on the Colorado Plateau. 2016-2021. PI, $490,378 (all NAU).

USGS Southwest Biological Science Center. Building a restoration assessment and monitoring program for the Southwest. 2016-2020. PI, $278,358 (all NAU).

USFS Great Basin Native Plants Program and BLM Colorado Plateau Native Plants Program.

Genetic and Environmental Regulation of Functional Traits: New Approaches for Restoration in a Changing Climate. 2015-2017. PI, $179,459 (all NAU).

USGS Southwest Biological Science Center. Measurements and Modeling to Inform Dryland Sustainability. 2014-2018. PI, $278,561 (all NAU).

BLM Colorado Plateau Native Plants Program. Ranking Native Plant Species and their Ecotypes for Use in Restoration on the Colorado Plateau. 2014-2015. PI $11,750 (all NAU).

USGS Southwest Biological Science Center. Using Environmental Tolerances to Predict Long-Term Vegetation Dynamics. 2013-2014. PI $18,303 (all NAU).

Arizona Department of Emergency Management. Vegetation Survey and Floral Inventory of Camp Navajo. 2011-2012. PI $60,000 (all NAU).

Frontiers in Life Sciences at ASU (Co-PI). "Dynamic Deserts: Resource Uncertainty in Arid Environments". A multidisciplinary conference sponsored by ASU School of Life Sciences (SoLS), Feb. 28-Mar. 1, 2009. $35,000 (ASU).

T&E Inc. Conservation Grant (PI). 2006. Influences of established vegetation and climatic factors on growth and survival of Sonoran Desert perennial plant seedlings. $2,450 (ASU).

ASU Graduate and Professional Student Association Research Grant (PI). 2006. Dynamics of plant-soil interactions in the Sonoran Desert. $785 (ASU).

Publications

Google Scholar statistics (Aug 14, 2025): Publications – 75, Citations – 6729, H index - 34

**Graduate student or *Postdoc under direct supervision

2025

Noel, A., Schlaepfer, D.R., Barrett, I.P., Duniway, M.C., Norris, J., Domschke, C.T., **Butterfield, B.J.**, Swan, M.C., Hartwig, K., Crist, M.R., and Bradford, J.B. In press. Shifts in suitability of pinyon-juniper communities: A climate adaptation framework for range-wide management of arid woodland resources. *Forest Ecology & Management.*

Butterfield, B.J., Schlaepfer, D.R., Al-Chokhachy, R.K., Dunham, J.B., Groom, J.D., Muhlfeld, C.C., Torgersen, C.E., and Bradford, J.B. In press. Greater aquatic-terrestrial drought synchrony in more arid watersheds and drier years in the western United States. *Ecosphere*.

Butterfield, B.J., and Palmquist, E.C. In press. Daily fluctuating flow affect riparian plant species distributions from local to regional scales. *Applied Vegetation Science*.

Palmquist, E.C., Ogle, K., **Butterfield, B.J.**, Whitham, T.G., Allan, G.J., and Shafroth, P.B. 2025. Hotter temperatures alter riparian plant outcomes under regulated river conditions. *Ecological Monographs*, 95, e1645.

Noel, A., Schlaepfer, D.R., **Butterfield, B.J.**, Swan, M.C., Norris, J., Hartwig, K., Duniway, M.C., and Bradford, J.B. 2024. Most pinyon-juniper woodland species distributions are projected to shrink rather than shift under climate change. *Rangeland Ecology & Management*, 98, 454-466.

2024

Noel, A., Schlaepfer, D.R., Butterfield, B.J., Swan, M.C., Norris, J., Hartwig, K., Duniway, M.C., and Bradford, J.B. 2024. Most pinyon-juniper woodland species distributions are projected to shrink rather than shift under climate change. *Rangeland Ecology & Management*, 98, 454-466.

Butterfield, B.J., and Palmquist, E.C. 2024. Divergent physiological responses of hydric and mesic riparian plant species to a Colorado River experimental flow. *Plant Ecology*, 225, 125-133.

Butterfield, B.J., and Palmquist, E.C. 2024. Inundation tolerance, rather than drought tolerance, predicts riparian plant distributions along a local hydrologic gradient. *Wetlands*, 44, 6.

Michalet, R., Losapio, G., Kikvidze, Z., Brooker, R.W., Butterfield, B.J., Callaway, R.M., Cavieres, L.A., Lortie, C.J., Pugnaire, F.I., and Schob, C. 2024. Assessing the accuracy of paired and random sampling for quantifying plant-plant interactions in natural communities. *Population Ecology*, 66, 39-53.

2023

Butterfield, B.J., and Munson, S.M. 2023. Do seeding and seedling planting result in similar restored plant communities? *Applied Vegetation Science*, 26, e12758.

Butterfield, B.J., Farrell, H.L.*, and Munson, S.M. 2023. Plant water-use strategies predict restoration success across degraded drylands. *Journal of Applied Ecology*, 60, 1170-1180.

Farrell, H.L.*, Munson, S.M., Butterfield, B.J., Duniway, M.C., Faist, A.M., Gornish, E.S., Havrilla, C.A.*, Larios, L., Reed, S.C., Rowe, H.I., Laushman, K.M., and McCormick, M.L. 2023. Soil surface treatments and precipitation timing determine seedling development across southwestern US restoration sites. *Ecological Applications*, 33, e2834.

Palmquist, E.C.*, Ogle, K., Whitham, T.G., Allan, G.J., Shafroth, P.B., and Butterfield, B.J. 2023. Provenance, genotype, and flooding influence growth and resource acquisition characteristics in a clonal, riparian shrub. *American Journal of Botany*, 110, e16115.

Palmquist, E.C.*, Butterfield, B.J., and Ralston, B.E. 2023. Assessment of riparian vegetation patterns and change downstream from Glen Canyon Dam from 2014 to 2019. USGS Open File Report, 2023-1026.

Butterfield, B.J., Palmquist, E.C.**, and Yackulic, C. 2023. The hydroclimate niche: A tool for predicting and managing riparian plant community responses to streamflow seasonality. *River Research and Applications*, 39, 84-94.

2022

Munson, S.M., Bradford, J.B., Butterfield, B.J., and Gremer, J.R. 2022. Primary production responses to extreme changes in North American Monsoon precipitation vary by elevation and plant functional composition through time. *Journal of Ecology*, 110, 2232-2245.

Balazs**, K.R., Munson, S.M., and Butterfield, B.J. 2022. Functional composition of plant communities mediates biomass effects on ecosystem service recovery across an experimental dryland restoration network. *Functional Ecology*, 36, 2317-2330.

Balazs**, K.R., Munson, S.M., Havrilla, C.A.*, and Butterfield, B.J. 2022. Directional selection shifts trait distributions of planted species in dryland restoration. *Journal of Ecology*, 110, 540-552.

Yang, B., Balazs, K.R.**, Butterfield, B.J., Laushman, K.M., Munson, S.M., Gornish, E.S., and Barberan, A. 2022. Does restoration of plant diversity trigger concomitant soil microbiome changes in dryland ecosystems? *Journal of Applied Ecology*, 59, 560-573.

2021

Havrilla*, C.A., Munson, S.M., Yackulic, E.O., and Butterfield, B.J. 2021. Ontogenetic trait shifts: Seedlings display high trait variability during early stages of development. *Functional Ecology*.

Losapio, G., Schoeb, C., Staniczenko, P.P.A., Carrara, F., Palamara, G.M., De Moraes, C.M., Mesher, M.C., Brooker, R.W., Butterfield, B.J., Callaway, R.M., Cavieres, L.A., Kikvidze, Z., Lortie, C.J., Michalet, R., Pugnaire, F.I., and Bascompte, J. 2021. Network motifs involving both competition and facilitation predict biodiversity in alpine plant communities. *PNAS USA*, 118.

Butterfield, B.J., Palmquist, E.C.**, and Hultine, K.R. 2021. Regional coordination between riparian dependence and atmospheric demand in willows (*Salix* L.) of western North America. *Diversity and Distributions*, 27, 377-388.

Kasprak, A., Sankey, J.B., and Butterfield, B.J. 2021. Future regulated flows of the Colorado River in Grand Canyon foretell decreased areal extent of sediment and increases in riparian vegetation. *Environmental Research Letters*, 16, 014029

Durning, L.E., Sankey, J.B., Yackulic, C.B., Grams, P.E., Butterfield, B.J., and Sankey, T. 2021. Hydrologic and geomorphic effects on riparian plant species occurrence and encroachment: remote sensing of 360 km of the Colorado River in Grand Canyon. *Ecohydrology*, e2344.

Palmquist, E.C.**, Allan, G.J., Ogle, K., Whitham, T.G., Butterfield, B.J. and Shafroth, P.B. 2021. Riverine complexity and life history inform restoration in riparian environments in the southwestern US. *Restoration Ecology*, e13418.

Guerrero-Ramirez, N.R. … Butterfield, B.J., and many others. 2021. Global root traits (GRooT) database. *Global Ecology and Biogeography*, 30, 25-37.

2020

Kushwaha, P., Neilson, J.W., Barberan, A., Chen, Y, Fontana, C.G., Butterfield, B.J. and Maier, R.M. 2020. Arid ecosystem vegetation canopy-gap dichotomy: Influence on soil microbial composition and nutrient cycling functional potential. *Applied and Environmental Microbiology*, 87, e02780-20.

Havrilla, C.A.*, Munson, S.M., McCormick, M.L., Laushman, K.M., Balazs, K.R.** and Butterfield, B.J. 2020. RestoreNet: An emerging restoration network reveals controls on seedings success across dryland ecosystems. *Journal of Applied Ecology*, 57, 2191-2202.

Strawhacker, C., Snitker, G., Peeples, M.A., Kinzig, A.P., Kintigh, K.W., Bocinsky, K., Butterfield, B.J., Freeman, J., Oas, S., Nelson, M.C., Sandor, J.A., and Spielmann, K.A. 2020. A landscape perspective on climate-driver risks to food security: exploring the relationships between climate and social transformation in the preshispanic US Southwest. *American Antiquity*, 85, 427-451.

Balazs, K.R.**, Kramer, A.T., Munson, S.M., Talkington, N., Still, S. and Butterfield, B.J. 2020. The right trait in the right place at the right time: Matching traits to environment improves restoration outcomes. *Ecological Applications*, 30, e02110.

Butterfield, B.J., Grams, P.E., Durning, L.E., Hazel, J., Palmquist, E.C.**, Ralston, B.E. and Sankey, J.B. 2020. Associations between riparian plant morphological guilds and fluvial sediment dynamics along the regulated Colorado River in Grand Canyon. *River Research and Applications*, 36, 410-421.

Kattge, J. and many others, including B.J. Butterfield. 2020. TRY plant trait database – enhanced coverage and open access. *Global Change Biology*, 26, 119-188.

Hartsell, J.A., Copeland, S.M.*, Munson, S.M., Butterfield, B.J. and Bradford, J.B. 2020. Gaps and hotspots in the state of knowledge of pinyon-juniper communities. *Forest Ecology and Management*, 455, 117628.

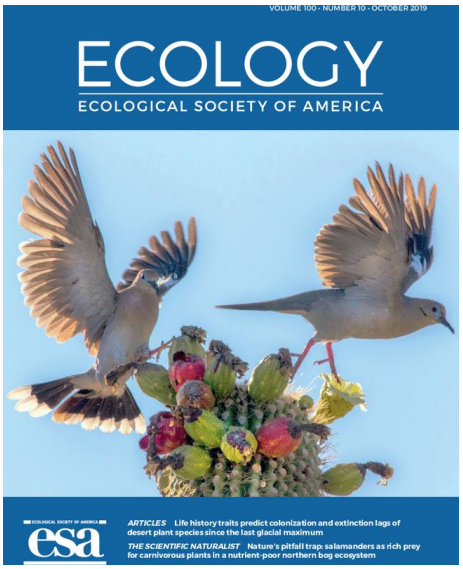
2019

Camhi, A.L.**, Perrings, C., Butterfield, B.J. and Wood, T.E. 2019. Market-based opportunities for expanding native seed resources for restoration: A case study on the Colorado Plateau. *Journal of Environmental Management*, 252, 109644.

McCabe, L.M.**, Cobb, N.S. and Butterfield, B.J. 2019. Environmental filtering of body size and darker coloration in pollinator communities indicate thermal restrictions on bees, but not flies, at high elevations. *PeerJ*, e7867.

Publication Highlight

In this cover article for *Ecology*, we used paleo-ecological data to demonstrate that species without specialized long-distance dispersal mechanisms lagged thousands of years behind other species during a period of climate warming, and that unique combinations of seed bank and vegetative longevity allowed species to persist thousands of years longer than others in the trailing edges of their distributions. These findings have important implications for predicting and assisting responses to current climate change.



Butterfield, B.J., Holmgren, C.A., Anderson, R.S. and Betancourt, J.L. 2019. Life history traits predict colonization and extinction lags of desert plant species since the Last Glacial Maximum. *Ecology*, e02817.

Potts, D.L., Barron-Gafford, G.A., Butterfield, B.J., Fay, P.A. and Hultine, K.R. 2019. Bloom and Bust: ecological consequences of precipitation variability in aridlands. *Plant Ecology*, 220, 135-139.

Butterfield, B.J., Holmgren, C.A., Anderson, R.S. and Betancourt, J.L. 2019. Extinction debt and delayed colonization have had comparable but unique effects on plant community-climate lags since the Last Glacial Maximum. *Global Ecology and Biogeography*, 28, 1067-1077.

Munson, S.M., Bunting, E.L., Bradford, J.B., Butterfield, B.J. and Gremer, J.R. 2019. Plant production responses to precipitation differ along an elevation gradient and are enhanced under extremes. *Ecosystems*, 22, 699-708.

Roybal, C.M.** and Butterfield, B.J. 2019. Species specific trait-environment relationships among populations of widespread grass species. *Oecologia*, 189, 1017-1026.

Copeland, S.M.*, Munson, S.M., Bradford, J.B., Butterfield, B.J. and Gunnell, K.L. 2019. Long-term plant community trajectories suggest divergent responses of native and non-native perennials and annuals to vegetation removal and seeding treatments. *Restoration Ecology*, doi:10.1111/rec.12928.

2018

Copeland, S.M.*, Munson, S.M., Bradford, J.B. and Butterfield, B.J. 2018. Influence of climate, post-treatment weather extremes, and soil factors on vegetation recovery after restoration treatments in the southwestern US. *Applied Vegetation Science*, 24, 1844-1859.

Hultine, K.R., Dettman, D.L., Williams, D.G., Puente, R., English, N.B., Butterfield, B.J. and Burquez, A. 2018. Relationships among climate, stem growth, and biomass $\delta^{13}C$ in the giant saguaro cactus (*Carnegiea gigantea*). *Ecosphere*, 9, e02498.

Butterfield, B.J., Palmquist, E.** and Ralston, B. 2018. Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon. *Applied Vegetation Science*, 21, 572-583. **[Featured Cover Article]**

Winkler, D.E., Backer, D.M., Belnap, J., Bradford, J.B., Butterfield, B.J. *et al.* 2018. Beyond traditional ecological restoration on the Colorado Plateau. *Restoration Ecology*, 26, 1055-1060.

Bradford, J.B., Betancourt, J.L., Butterfield, B.J., Munson, S.M. and Wood, T.E. 2018. Anticipatory natural resource science and management for a dynamic future. *Frontiers in Ecology and the Environment*, 16, 295-303.

Roybal, C.M.** and Butterfield, B.J. 2018. Functional trait heritability and local climatic adaptation among grasses: A meta-analysis. *Plant Ecology*, 4, 369-379.

Copeland, S.M.*, Bradford, J.B., Duniway, M.C. and Butterfield, B.J. 2018. Life history characteristics may be as important as climate projections for defining range shifts: An example for common tree species in the intermountain western US. *Diversity and Distributions*, 24, 1844-1859.

Copeland, S.M.*, Munson, S.M., Pilliod, D.S., Welty, J.L., Bradford, J.B. and Butterfield, B.J. 2018. Long-term trends in restoration and associated land treatments in the Southwest United States. *Restoration Ecology*, 26, 311-322.

2017

Butterfield, B.J., Bradford, J.B., Munson, S.M. and Gremer, J.R. 2017. Aridity increases belowground niche breadth in grass communities. *Plant Ecology*, 218, 385-394.

Hungate, B.A., Barbier, E.B., Ando, A.W., Marks, S.P., Reich, P.B., van Gestel, N., Tilman, D., Knops, J.M.H., Hooper, D.U., Butterfield, B.J. and Cardinale, B.J. 2017. The economic value of grassland species for carbon storage. *Science Advances*, 3, e1601880.

Doherty, K.D., Butterfield, B.J. and Wood, T.E. 2017. Matching seed to site by climate similarity: techniques to prioritize plant materials development and use in restoration. *Ecological Applications*, 27, 1010-1023.

Funk, J.L., Larson, J.E., Ames, G.M., Butterfield, B.J., Cavender-Bares, J., Firn, J., Laughlin, D.C., Sutton-Grier, A.E., Williams, L. and Wright, J. 2017. Revisiting the Holy Grail: using plant functional traits to understand ecological processes. *Biological Reviews*, 92, 1156-1173.

Butterfield, B.J., Copeland, S.M.,* Munson, S.M., Roybal, C.M.** and Wood, T.E. 2017. Prestoration: Using species in restoration that will persist now and into the future.

Restoration Ecology, 25, S155-S163.

2016

Hultine, K.R., Williams, D.G., Dettman, D.L., Butterfield, B.J. and Puente-Martinez, R. 2016. Stable isotope physiology of stem succulents across a broad range of volume-to-surface area ratio. *Oecologia* 182, 679-690.

Butterfield, B.J. and Munson, S.M. 2016. Temperature is better than precipitation as a predictor of plant community assembly across a dryland region. *Journal of Vegetation Science* 27, 938-947.

Butterfield, B.J., Camhi, A.L.**, Rubin, R.L.** and Schwalm, C.R. 2016. Tradeoffs and compatibilities among ecosystem services: Biological, physical and economic drivers of multifunctionality. *Advances in Ecological Research* 54, 207-243.

Butterfield, B.J., Bradford, J., Armas, C., Prieto, I. and Pugnaire, F.I. 2016. Does the stress gradient hypothesis hold water? An assessment of vegetation effects on soil moisture and implications for plant-plant interactions. *Functional Ecology* 30, 10-19.

Spasojevic, M.J., Butterfield, B.J., Bahlai, C.A., Bradley, B., Sistla, S., Tuanmu, M.-N., Wiederholdt, R. and Suding, K.N. 2016. Functional diversity increases resilience of forest productivity to fire: scaling up community assembly theory to the continental scale. *Global Change Biology*, 22, 1421-1432.

2015

Butterfield, B.J. and Wood, T. 2015. Local adaptation and cultivation, but not ploidy, predict functional trait variation in *Bouteloua gracilis* (Poaceae). *Plant Ecology*, 216, 1-9.

Kikvidze, Z., Brooker, R.W., Butterfield, B.J., et al. 2015. The effects of foundation species on community assembly: a global study on alpine cushion plant communities. *Ecology* 96, 2046-2069.

Butterfield, B.J. 2015. Environmental filtering increases in intensity at both ends of climatic gradients, though driven by different factors, across woody vegetation types of the southwest USA. *Oikos* 124, 1374–1382.

2014

Schöb, C., Callaway, R.M., Anthelme, F., Brooker, R.W., Cavieres, L.A., *et al.*, and Butterfield, B.J. 2014. The context dependence of beneficiary feedback effects on benefactors in plant facilitation. *New Phytologist*, 204, 386-396.

Schöb, C., Michalet, R., Cavieres, L.A., Pugnaire, F.I., Brooker, R.W., Butterfield, B.J., *et al*. 2014. A global analysis of bi-directional interactions in alpine plant communities shows facilitators experience strong reciprocal fitness costs. *New Phytologist* 202, 95-105.

Cavieres, L.A., R.W. Brooker, Butterfield, B.J., *et al.* 2014. Facilitative plant interactions and climate simultaneously drive alpine plant diversity. *Ecology Letters* 17, 193-202.

2013

Spafford, R.D., Lortie, C.J. and B.J. Butterfield. 2013. A systematic review of arthropod community diversity in association with invasive plants. *NeoBiota* 16, 81-102.

Butterfield, B.J., Cavieres, L.A., Callaway, R.M., Cook, B.J., Kikvidze, Z., Lortie, C.J., *et al.* 2013. Alpine cushion plants inhibit the loss of phylogenetic diversity in severe environments. *Ecology Letters*, 16, 478-486.

Butterfield, B.J. and R.M. Callaway. 2013. A functional-comparative approach to facilitation and its context-dependence. *Functional Ecology*, 27, 907-917.

Butterfield, B.J. and K.N. Suding. 2013. Single-trait functional indices outperform multi-trait indices in linking environmental gradients and ecosystem services in a complex landscape. *Journal of Ecology*, 101, 9-17.

2012

Clark, C.M., Flynn, D.F.B., Butterfield, B.J. and P.B. Reich. 2012. Testing the link between functional diversity and ecosystem functioning in a Minnesota grassland experiment. *PLoS ONE*, 7, e52821.

Schöb, C., Butterfield, B.J. and F.I. Pugnaire. 2012. Foundation species influence trait-based community assembly. *New Phytologist*, 196, 824-834.

Pre-2012

Butterfield, B.J. and J.M. Briggs. 2011. Regeneration niche differentiates functional strategies of desert woody plant species. *Oecologia*, 165, 477-478.

Butterfield, B.J., Betancourt, J.L., Turner, R.M. and J.M. Briggs. 2010. Facilitation drives 65 years of vegetation change in the Sonoran Desert. *Ecology*, 91, 1132-1139.

Butterfield, B.J. 2009. Effects of facilitation on community stability and dynamics: Synthesis and future directions. *Journal of Ecology*, 97, 1992-1201.

Butterfield, B.J. and J.M. Briggs. 2009. Patch dynamics of soil-biotic feedbacks in the Sonoran Desert. *Journal of Arid Environments*, 73, 96-102.

Butterfield, B.J., Rogers, W.E. and E. Siemann. 2004. Growth of Chinese tallow tree (*Sapium sebiferum*) and four native trees under varying water regimes. *Texas Journal of Science*, 56, 335-346.

Selected Presentations

Effects of daily fluctuation flows on riparian plant distributions. Grand Canyon Monitoring and Research Center Annual Reporting Meeting, Phoenix, AZ, Apr 9, 2025.

Predictive vegetation modeling: progress and opportunities for growth. Grand Canyon Monitoring and Research Center Annual Reporting Meeting, Phoenix, AZ, Jan 24, 2023.

The hydroclimate niche: a tool for predicting and managing riparian plant community responses to streamflow seasonality. Invited Speaker, Colorado Plateau Biennial Conference of Science and Management, Flagstaff, AZ, Sept. 14, 2022.

Facilitation and BEF in restoration. Facilitation and Biodiversity-Ecosystem Functioning Workshop funded by SNF, Lausanne, Switzerland, May 31, 2022.

The hydroclimate niche: a useful target for management? RiversEdge West (Remote), Feb 24, 2022.

Leveraging community assembly theory in restoration of dryland ecosystems. Invited Speaker, EBIO Department Seminar, University of Colorodo, Boulder, Oct. 15, 2021.

The RestoreNet biodiversity-ecosystem function experiment. Invited Special Symposium, Society for Ecological Restoration Annual Meeting (Remote), June 22, 2021.

Life-history traits predict colonization and extinction lags of desert plant species since The Last Glacial Maximum. Colorado Plateau Biennial Conference of Science and Management, Flagstaff, AZ, Sept. 11, 2019.

Extinction debt and delayed colonization have comparable but unique effects on community-climate lags since The Last Glacial Maximum. Colorado Plateau Biennial Conference of Science and Management, Flagstaff, AZ, Sept. 11, 2019.

Outreach Highlight

I work with diverse stakeholders to provide decision support for ecosystem restoration and management. I conduct this work both in both upland and riparian ecosystems. These activities were typified by two invited presentations I gave in 2019 with organizations that bring together agency, non-profit and corporate entities involved in land management:

Translating research into decision-support tools for restoration practitioners. Keynote Speaker, Intermountain Native Plant Summit IX, Boise, ID, Nov. 5, 2019.

*Riparian dependence increases with atmospheric demand among species of willows (*Salix L.*) of Western North America*. Invited Speaker, RiversEdge West Annual Meeting, Grand Junction, CO, Feb. 5, 2019.

Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon. International Association of Vegetation Scientists Annual Meeting, Bozeman, MT, 2018.

Seed traits and desert plant community reassembly since the Last Glacial Maximum. EcoRe3 Working Group Meeting, Salt Lake City, UT, 2018.

Temperature mediates precipitation responses in drylands. Invited Speaker for Organized Session, Bloom and Bust: Ecological Consequences of Precipitation Variability in Aridlands. Ecological Society of America Annual Meeting, Portland, OR, 2017.

Prestoration: Using species in restoration that will persist now and into the future. Invited Speaker, Society for Ecological Restoration Southwest Chapter Annual Meeting, Las Vegas, NV, 2016.

Can we Prestore the Colorado Plateau? Colorado Plateau Biennial Conference of Sciences and Management, Flagstaff, AZ, 2015.

Environmental tolerances of woody vegetation across the Southwest USA. Colorado Plateau Biennial Conference of Sciences and Management, Flagstaff, AZ, 2013.

Interaction networks in desert plant communities. Invited speaker, Desert Botanical Garden Research Seminar, Phoenix, AZ, 2012

Linking environment to multiple ecosystem services: How best to represent functional diversity? Invited speaker, Symposium – Revisiting the Holy Grail: Using trait-based ecology as a framework for preserving, utilizing, and sustaining our ecosystems, ESA Annual Meeting, Portland, OR, 2012

*Evolutionary history constrains ecological convergence in alpine plant communities on 5 continent*s. ESA Annual Meeting, Austin, TX, 2011

Phylo-functional facilitation. Invited speaker, Plant Interactions and Environmental Gradients Symposium, Benasque, Spain, 2010

Desert perennial plant functional strategies are related to facilitative response and precipitation variability. ESA Annual Meeting, Albuquerque, NM, 2009

Effects of facilitation on temporal community dynamics: Synthesis and future directions. Invited speaker, British Ecological Society Annual Symposium, Aberdeen, Scotland, 2009

Facilitation dominates 65 years of desert plant community dynamics. ESA Annual Meeting, Milwaukee, WI, 2008

Patch dynamics of soil biotic feedbacks in the Sonoran Desert. Research Insights in Semiarid Environments Symposium, University of Arizona, 2007

Courses Taught

Northern Arizona University, 2012-

Community Ecology

Ecological Niche Modeling

Introductory Ecology

Concepts in Ecology

Teaching Associate, School of Life Sciences, Arizona State University, 2007-2008

Introductory biology lab

Ecology lab (field and analytical methods)

Teaching Assistant, Rice University, Department of Biology, 2004

Ecology

Graduate Students and Post-Docs

Advisor

Megan Korte, Post-Doc, 2024 – present

Shelby Byerly, NAU Biology, PhD, 2019 – 2023

Caroline Havrilla, Post-Doc, 2019 – 2021

Caitlin Winterbottom, NAU Biology, MS, 2018 – 2021

Austin Rueda, NAU Biology, MS, 2017 – 2020

Stella Copeland, Post-Doc, 2016 – 2018

Kathleen Balazs, NAU Biology, NAU Presidential Fellow, PhD, 2016 – 2021

Carla Roybal, NAU Biology, MS, 2015 – 2018

Committee Member

Brooke Harris, NAU Biology, MS, 2024 – present

Paige Chesshire, NAU Biology, PhD, 2021 – 2023

Erika LaPlante, NAU Biology, PhD, 2020 – present

Sara Gabrielson, NAU Biology, PhD, 2018 – 2023

Madeline Moran, ASU SOLS, MS, 2021 – 2022

Ashlee Simpson, NAU SES, MS, 2018 – 2020

Stephanie Miller, NAU Forestry, PhD, 2017 – 2021

Lindsie McCabe, NAU Biology, PhD, 2015 – 2020

Katrina Tso, NAU Biology, MS, 2015 – 2017

Andrew Smith, NAU Biology, MS, 2013 – 2017

Emily Borodkin, NAU Biology, MS, 2012 – 2016

Lisa Dowling, NAU Forestry, MS, 2012 – 2014

Lindsie McCabe, NAU Biology, MS, 2012 – 2014

Proposal for

Review of the University of California, Irvine Groundwater Dependent Ecosystem Study Report

Submitted to
Borrego Springs Watermaster

Submitted by
Melissa M. Rohde, Ph.D.

ROHDE | Environmental Consulting, LLC

September 16, 2025

Introduction

Rohde Environmental Consulting, LLC is pleased to present this proposal to the Borrego Springs Watermaster. Rohde Environmental Consulting, LLC is a single-member LLC founded by Melissa M. Rohde, PhD in 2022 that specializes in ecohydrology and water resource management. Dr. Rohde has 20 years of technical and policy experience in the environmental sciences, and more than 10 years of experience working on groundwater-dependent ecosystems (GDEs) and SGMA-related topics in California.

Over the past decade, Dr. Rohde has led numerous scientific studies in California and across the globe to advance the best available science on GDEs, which have been published in prestigious scientific peer-review journals such as *Nature* and the *Proceedings of the National Academy of Sciences*. Along with her research colleagues, Dr. Rohde has led and participated in a wide range of scientific studies, which include identifying GDEs and groundwater impact analyses utilizing advanced methods such as remote sensing, isotopic analyses, machine learning, and advanced statistics. In addition, Dr. Rohde (in her previous role as Groundwater Scientist at The Nature Conservancy and in her current consulting role) has also worked on developing decision-support tools and technical guidance to assist numerous local and state agencies across California to employ best available science when developing sustainable groundwater management plans under the California Sustainable Groundwater Management Act (SGMA).

The Borrego Spring Watermaster's request for a peer-review of the UCI GDE Study Report is a natural fit for Rohde's technical and water policy expertise. Rohde is passionate about GDE science and sustainable groundwater management and looks forward to supporting Borrego Springs Watermaster in their determination of whether the UCI GDE Study Report constitutes "best available science".

Proposed Approach

Task	Description	2025		2026			
		Nov	Dec	Jan	Feb	Mar	Apr
Task 1	Prepare draft report based on UCI GDE Study peer-review and TAC/EWG comments						
	Present draft report findings to TAC/EWG						
Task 2	Revise report based on TAC/EWG feedback						
	Present revised report findings to Board						
Task 3	Revise report based on Board feedback						
	Present final report for Board consideration						

Task 1. Conduct Peer-review Assessment

Rohde will conduct a peer-review of the UCI GDE Study, and address comments provided by the Technical Advisory Committee (TAC) and Environmental Working Group (EWG). A 5-10 page draft report that

synthesizes the peer-review findings will be developed, which will include:

- A summary of "best available science" on GDEs to-date.
  Over the past decade, advancements in GDE science and its implementation in water management practices have improved significantly. This section will provide an overview of the latest GDE methods for identifying GDEs and evaluating groundwater impacts. This section will draw from the scientific literature with solicited input from scientific experts in the field, and provide examples of the use of best available science on GDEs in other SGMA basins.

- Section-by-section feedback on the UCI study, indicating where best-available science has been used, and what changes are recommended. Feedback will include whether the science presented is consistent with scientific and engineering professional standards of practice.

- Address specific comments/questions raised by TAC/EWG. All specific TAC/EWG feedback will be tabulated and provided in an Appendix.

Task 1 Deliverables:

1. Draft report summarizing findings from peer-review.
2. Track-change revisions on the UCI GDE Study Report will be provided as an Appendix.
3. PowerPoint presentation to the TAC/EWG in Feb 2026.

Task 2. Revise Report

Rohde will collect oral and written feedback on the draft report from the TAC/EWG. Feedback will be tabulated, so that the response and resultant changes in the revised report can be logged line-by-line. This feedback will be incorporated into a revised report.

Task 2 Deliverables:

1. Revised report with TAC/EWG feedback incorporated.
2. TAC/EWG feedback and associated changes will be tabulated and provided as an Appendix.
3. PowerPoint presentation to the Board in March 2026.

Task 3. Revise Report

Rohde will collect oral and written feedback on the draft report from the Board. Feedback will be tabulated, so that the response and resultant changes in the revised report can be logged line-by-line. This feedback will be incorporated into a final report.

Task 3 Deliverables:

1. Final report with TAC/EWG and Board feedback incorporated.
2. Board feedback and associated changes will be tabulated and provided as an Appendix.
3. PowerPoint presentation to the Board in April 2026.

Budget

Task	Description	Melissa M. Rohde, PhD $285 per hour	
		Number of hours	Cost
Task 1	Prepare draft report based on UCI GDE Study peer-review and TAC/EWG comments	60	$ 17,100.00
	Present draft report findings to TAC/EWG	10	$ 2,850.00
Task 2	Revise report based on TAC/EWG feedback	10	$ 2,850.00
	Present revised report findings to Board	5	$ 1,425.00
Task 3	Revise report based on Board feedback	10	$ 2,850.00
	Present final report for Board consideration	5	$ 1,425.00
	Total	100	$ 28,500.00

Personnel Bio

Melissa M. Rohde, PhD
Principal - Rohde Environmental Consulting, LLC

Education

Ph.D., Environmental Sciences,
SUNY College of Environmental Science & Forestry

M.S., Environmental Engineering & Science,
Stanford University

M.Sc., Water Science, Policy & Management,
Oxford University

B.Sc., Biology & Oceanography,
University of British Columbia

20+ years of experience

Melissa M. Rohde, Ph.D. is Principal of Rohde Environmental Consulting, LLC with more than 20 years of international research experience and expertise in hydrology, ecosystems, and sustainable water management. Over the past decade, Dr. Rohde's scientific studies, technical guidance, and decision-support tools have been advancing the use of best-available science for GDEs under SGMA. Dr. Rohde was Groundwater Scientist for The Nature Conservancy, where her scientific research on groundwater-dependent ecosystems was used to provide technical and policy support to state and local water agencies, and continues to do so in her new consulting role. Her work has been featured in numerous reports and scientific journals. Additionally, her work has been featured in a wide range of media outlets including the San Francisco Chronicle, Los Angeles Times, Huffington Post, The Guardian, The New York Times, and USA Today.

Relevant projects include:

- Project lead for the Groundwater Leadership Forum's review of all 2020 and 2022 Groundwater Sustainability Plans for the inclusion of groundwater-dependent ecosystems (and other beneficial users) using best-available science:
  Scientific paper published in *Nature Communications*, Policy Report, Interactive website, GSP Public Comment Letters.
- Ecological thresholds and targets for groundwater management (funded by the California Department of Water Resources Technical Assistance Grant, in collaboration with The Nature Conservancy, Audubon, Vina Groundwater Sustainability Agency, and Yolo Groundwater Sustainability Agency). Scientific paper published in *Nature Water*.
- Groundwater Dependent Ecosystem tool development for The Nature Conservancy's Groundwater Resource Hub:
  GDE Guidance Document, GDE Pulse, NCCAG version 2, Shallow Groundwater Estimation (SAGE) Tool.
- Project lead for a Global Groundwater Dependent Ecosystem Mapping project in partnership with The Nature Conservancy, The World Bank, Desert Research Institute, and academia. Scientific paper published in *Nature*.

Curriculum Vitae

Melissa M. Rohde, PhD

1752 NW Market Street #4750
Seattle, WA 98107
+1 (650) 468-1901

ORCID: 0000-0002-1252-0711
GitHub: melrohde
http://www.RohdeEnvironmental.com

PROFESSIONAL

2024 – Pres	Adjunct Professor, SUNY College of Environmental Science & Forestry, USA
2022 - Pres	Principal, Rohde Environmental Consulting, LLC, USA
2015 - 2022	Groundwater Scientist, The Nature Conservancy, USA
2015	Consultant, Resources Legacy Fund (Water Foundation), USA
2013 - 2015	Research Scientist, Water in the West, Stanford University, USA
2011	Research Assistant, Europaeum, University of Oxford, United Kingdom
2009 - 2010	Technician, Geosciences Department, Princeton University, USA
2007 - 2008	Technician, Institute for Environmental Geosciences, Universität Basel, Switzerland

EDUCATION

2018-2023	Ph.D. Environmental Science, SUNY College of Environmental Science & Forestry
2011-2014	M.S. Environmental Engineering, Stanford University
2008-2009	M.Sc. Water Science, Policy and Management, University of Oxford (with distinction)
2003-2007	B.Sc. Biology & Oceanography (Honors), University of British Columbia

PEER-REVIEWED PUBLICATIONS

*shared first authorship

31. Saito, L., S. Byer, L. Munn, K. Badik, L. Provencher, D.J. McEvoy, **M.M. Rohde.** 2025. Strategies to Address Stressors and Threats to Groundwater Dependent Ecosystems. *Hydrological Processes*, doi: 10.1002/hyp.70229.

30. Kui, L., J. Williams, M.B. Singer, J.C Singer, C.L. Kibler, T.E. Dawson, **M.M. Rohde,** A.M. Lambert, D.A. Roberts. Increased groundwater dependence of riparian vegetation in response to drought. 2025. *Ecohydrology*, doi: 10.1002/eco.70060.

29. Albano, C.M., C.E. Soulard, B.A. Minor, J.J. Walker, B.W. Smith, E.K. Waller, M.D. Bartles, T.W. Corringham, A.T. O'Geen, **M.M. Rohde**, A.M. Wein. Assessing causes and consequences of winter surface water dynamics in California's Central Valley using satellite remote sensing. 2025. *Journal of Flood Risk Management,* doi: 10.1111/jfr3.70080.

28. Dyring, M., H. Hofmann, A. McDougall, S. Marshall, D.I. Cendón, D. Stanton, N. Hamer, **M.M. Rohde**. 2025. A hydrogeochemical approach to coastal groundwater-dependent ecosystem conservation: The case of Cooloola Sand Mass, Australia. 2025. *Science of the Total Environment*, doi: 10.1016/j.scitotenv.2024.177892.

27. **Rohde, M.M.** 2024. Mapping groundwater-dependent ecosystems shows the need for more protection globally. *Nature*, doi: d41586-024-03238-z.

26. **Rohde, M.M.,** C.M. Albano, X. Huggins, K.R. Klausmeyer, C. Morton, A. Sharman, E. Zaveri, L. Saito, Z. Freed, J.K. Howard, N. Job, H. Richter, K. Toderich, A. Rodella, T. Gleeson, J. Huntington, H.A. Chandanpurkar, A.J. Purdy, J.S. Famiglietti, M.B. Singer, D.A. Roberts, K. Caylor, J.C. Stella. 2024. Groundwater-dependent ecosystem map exposes global dryland protection needs. *Nature,* doi: s41586-024-07702-8.

25. Zipper, S., A. Brookfield, H. Ajami, J. Ayers, C. Beightel, M. Fienen, T. Gleeson, J. Hammond, M. Hill, A. Kendall, B. Kerr, D. Lapides, S. Parimalarenganayaki, M. Porter, **M.M. Rohde**, C. Wardropeer. 2024. Streamflow depletion caused by groundwater pumping: Fundamental research priorities for management-relevant science. *Water Resources Research*, 60, e2023WR035727. https://doi.org/10.1029/2023WR035727

24. **Rohde, M.M.,** J.C. Stella, M.B. Singer, D. A. Roberts, K. Caylor, C.M. Albano. 2024. Establishing ecological thresholds and targets for groundwater management. *Nature Water*, doi: 10.1038/s44221-024-00221-w.

23. Sacco, M., S. Mammola , F. Altermatt , R. Alther , R. Bolpagni , A. Brancelj , D. Brankovits , C. Fišer , V. Gerovasileiou , C. Griebler , S. Guareschi , G. Hose , K. Korbel , E. Lictevout , F. Malard , A. Martinez , M. Niemiller , A. Robertson , K. Tanalgo , M. Bichuette , Š. Borko , T. Brad , M. Campbell , P. Cardoso , F. Celico , S. Cooper , D. Culver , T. Di Lorenzo , D. Galassi , M. Guzik , A. Hartland , W. Humphreys , R. Ferreira , E. Lunghi , D. Nizzoli , G. Perina , R. Raghavan , Z. T. Richards , A. Reboleira , **M.M. Rohde** , D. Sánchez-Fernández , S. Schmidt , M. van der Heyde , L. Weaver , N. White , M. Zagmajster , I. Hogg , A. Ruhi , M. Monique Gagnon, M. Allentoft , R. Reinecke. 2023. Groundwater is a globally threatened keystone ecosystem. *Global Change Biology*, doi: 10.1111/gcb.17066.

22. **Rohde, M.M.** 2023. Financial incentives can leverage existing infrastructure to replenish groundwater. *Nature Water*, doi: 10.1038/s44221-023-00140-2.

21. Dyring, M., **M.M. Rohde**, R. Froend, H. Hoffman. 2023. Coastal groundwater-dependent ecosystems fall through policy gaps. *Groundwater*, doi: 10.1111/gwat.13352.

20. Perrone, D.*, **M.M. Rohde***, C.H. Wagner*, R. Anderson, S. Arthur, N. Atume, M. Brown, L. Esaki-Kua, M. Gonzalez, K. Garvey, K. Heidel, W. Jones, S. Khosrowshahi Asl, C. Munill, R. Nelson, J.P. Ortiz-Partida, E. Remson. 2023. Stakeholder integration predicts better outcomes from groundwater sustainability policy. *Nature Communications*, doi: 10.1038/s41467-023-39363-y.

19. Howard, J.K., K. Dooley, K. Brauman, K.R. Klausmeyer, **M.M. Rohde**. 2023. Ecosystem services produced by groundwater dependent ecosystems: a framework and case study in California. *Frontiers in Water*, doi: 10.3389/frwa/2023.1115416.

18. Huggins, X., T. Gleeson, D. Serrano, S. Zipper, F. Jehn, **M.M. Rohde**, A. Hartmann. 2023. Overlooked risks and opportunities for global protected areas revealed by mapping groundwatersheds. *Nature Sustainability*, doi: 10.1038/s41893-023-01086-9.

17. **Rohde, M.M.** 2023. Floods and Droughts are Intensifying Globally. *Nature Water,* doi: 10.1038/s44221-023-00047-y.

16. **Rohde, M.M.,** T. Biswas, I.W. Housman, L.S. Campbell, K.R. Klausmeyer, J.K. Howard. 2021. A machine learning approach to predict groundwater levels in California reveals ecosystems at risk. *Frontiers in Earth Science*, doi: 10.3389/feart.2021.784499.

15. **Rohde, M.M.,** J. Stella, D. Roberts, M.B. Singer. 2021. Groundwater dependence of riparian woodlands and the disrupting effect of anthropogenically altered streamflow. *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.2026453118.

14. Saito, L., B. Christian, J. Diffley, H. Richter, **M.M. Rohde**, S. Morrison. 2021. Managing groundwater to ensure ecosystem function. *Groundwater*, doi:10.1111/gwat.13089.

13. Kang, M., D. Perrone, Z. Wang, S. Jasechko, **M.M. Rohde**. 2020. Base of fresh water, groundwater salinity and well distribution across California. *Proceedings of the National Academy of Sciences*, doi: 10.1073/pnas.2015784117.

12. **Rohde, M.M.**, M. Reynolds, and J. Howard. 2019. Dynamic multibenefit solutions for global water challenges. *Conservation Science and Practice*, doi:10.1111/csp2.144.

11. **Rohde, M.M.**, S.B. Sweet, C. Ulrich, and J. Howard. 2019. A Transdisciplinary Approach to Characterize Hydrological Controls on Groundwater-Dependent Ecosystem Health. *Frontiers in Environmental Science*, 7:175. doi: 10.3389/fenvs.2019.00175.

10. Zipper, S., J. Carah, C. Dillis, T. Gleeson, B. Kerr, **M.M. Rohde**, J. Howard, J. Zimmerman. 2019. Cannabis and residential groundwater pumping impacts on streamflow and ecosystems in Northern California. *Environmental Research Communications*, 1:125005. doi: 10.1088/2515-7620/ab534d.

9. Matsumoto, S., **M.M. Rohde**, S. Heard. 2019. Economic Tools to Achieve Groundwater Sustainability for Nature: Two Experimental Case Studies from California. *Water Economics and Policy*, doi: 10.1142/S2382624X19710024.

8. Zipper, S.C., T. Gleeson, B. Kerr, J.K. Howard, **M.M. Rohde**, J. Carah, and J. Zimmerman. 2019. Rapid and accurate estimates of streamflow depletion caused by groundwater pumping using analytical depletion functions. *Water Resources Research*, 55(7): 5807-5829.

7. **Rohde, M.M.**, R. Froend, J. Howard. 2017. A Global Synthesis of Managing Groundwater Dependent Ecosystems Under Sustainable Groundwater Policy. *Groundwater,* 55(3).

6. Perrone, D. and **M.M. Rohde.** 2016. Benefits and Economic Costs of Managed Aquifer Recharge in California. *San Francisco Estuary & Watershed Science*, 14(2).

5. **Rohde, M.M.,** W.M. Edmunds, S. Sharma. 2015. An accessible hydrogeological tool to monitor critical groundwater resources in hard-rock aquifers, *Frontiers in Environmental Science*, 3(67), doi: 10.3389/fenvs.2015.00067.

4. **Rohde, M.M.**, W.M. Edmunds, D. Freyberg, O.P. Sharma, A. Sharma. 2015. Estimating aquifer recharge in fractured hard rock: An analysis of the methodological challenges and its application to obtain a water balance, *Journal of Hydrogeology*, 23(7), p. 1573-1586, doi: 10.1007/s10040-015-1291-9.

3. **Rohde, M.M.,** J. Granger, D.M. Sigman, and M.F. Lehmann. 2015. Coupled nitrate N and O stable isotope fractionation by a natural marine plankton consortium. *Frontiers in Marine Science,* 2(28), doi: 10.3389/fmars.2015.00028.

2. Granger, J., D.M. Sigman, **M.M. Rohde**, M.T. Maldonado, and P.D. Tortell. 2009. N and O isotope effects during nitrate assimilation by unicellular prokaryotic and eukaryotic plankton cultures, *Geochimica Et Cosmochimica Acta*, 74(3), 1030-1040.

1. Robinson, R. S., D. M. Sigman, P. J. DiFiore, **M. M. Rohde**, T. A. Mashiotta, and D. W. Lea. 2005. Diatom-bound15N/14N: New support for enhanced nutrient consumption in the ice age subantarctic, *Paleoceanography*, 20.

OTHER PUBLICATIONS

16. Milonova, S., T. Moran, E. Ginney, K. Sterle, A. Kraus-Polk, D. Kunz, K. Steele, J. Davids, **M.M. Rohde**. 2024. Telemetered Water Monitoring Project: Telemetry Report Part One. California Water Data Consortium. Sacramento.

15. **Rohde, M.M.,** M. Reynolds, K. Easterday. 2023. Falling through the cracks: Pathways for conserving California's coastal ecosystems. The Nature Conservancy. San Francisco, California.

14. Chapelle, C., S. Arthur, N. Atume, J.P. Ortiz-Partida, E.J. Remson, **M.M. Rohde**. 2023. Achieving Groundwater Access for All: Why groundwater sustainability plans are failing many users. Groundwater Leadership Forum.

13. Arthur, S., N. Atume, J.P. Ortiz-Partida, **M.M. Rohde**. 2022. Groundwater Sustainability Assessments: A Review of the Department of Water Resources' Determinations on Groundwater Sustainability Plans in Critically Overdrafted Basins. Groundwater Leadership Forum.

12. Parker, S.S., B. Franklin, A. Williams, B.S. Cohen, M. Clifford, **M.M. Rohde.** 2022. Potential Lithium Extraction in the United States: Environmental, Economic, and Policy Implications.

11. Gleeson, T., X. Huggins, R. Connor, P. Arrojo-Agundo, E.V. Sune, K. Villholth, **M.M. Rohde**, J. van der Gun, D. Kreamer, M. Manzano, L. Scrinzi, G. Arduino, T.C. Resende, N. Moosdorf, V. Walsh, A. Harjung. 2022. Groundwater and Ecosystems. In UNESCO World Water Assessment Programme (WWAP). The United Nations World Water Development Report 2022: Groundwater: Making the invisible visible. Paris, France: UNESCO. pp.89-100.

10. Thompson, B., **M.M. Rohde**, J.K. Howard, S. Matsumoto. 2021. Mind the Gaps: The Case for Truly Comprehensive Sustainable Groundwater Management. Water in the West. Stanford Digital Repository. Available at: https://purl.stanford.edu/hs475mt1364.

9. Kang, M., D. Perrone, Z. Wang, S. Jasechko, **M.M. Rohde**. 2020. Deep groundwater is poorly safeguarded in California. Research Brief.

8. **Rohde, M.M.**, L. Saito, R. Smith. 2020. Groundwater Thresholds for Ecosystems: A Guide for Practitioners. The Nature Conservancy.

7. Hamel, P., A. Garcia, C. Schloss, **M.M. Rohde**, A.D. Guerry, and K. Wyatt. 2019. Stormwater management services maps for the San Francisco Bay Area. Working paper. Available at: https://naturalcapitalproject.stanford.edu.

6. **Rohde, M.M.,** B. Seapy, R. Rogers, X. Castañeda (editors). 2019. Critical Species LookBook: A compendium of California's threatened and endangered species for sustainable groundwater management. The Nature Conservancy, San Francisco, California.

5. Klausmeyer, K., T. Biswas, **M.M. Rohde**, F. Schuetzenmeister, N. Rindlaub, J.K. Howard. 2019. GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data. San Francisco, California.

4. **Rohde, M.M.** and S. Matsumoto. 2018. The Groundwater Resource Hub: Tools and Resources for Addressing Groundwater Dependent Ecosystems under SGMA. Hydrovisions, 27(2): 7-9.

3. **Rohde, M.M.**, S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. Remson. 2018. Groundwater Dependent Ecosystems Under The Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy: San Francisco.

2. **Rohde, M.M.** 2017. Securing Food, Energy, and Water in India: Shifting the governance landscape to tackle socio-economic challenges through integrated policies. In Pereira, L.M., C. McElroy, A. Littaye, A.M. Girard (Eds.), *Food, Energy and Water Sustainability: Emergent Governance Strategies*. Abingdon, U.K: Earthscan.

1. Perrone, D. and **M.M. Rohde.** 2014. Storing Water in California: What Can $2.7 Billion Buy Us? Water in the West, Stanford University, Stanford, California.

GRANTS & FELLOWSHIPS

2025-2028	Advancing a collaboratory for equitable stewardship of the Sacramento-San Joaquin River Delta watershed. Delta Science Program, Delta Stewardship Council ($1,817,316; $155,000 to co-PI M.M. Rohde)
2021-2026	Is there a least-cost path to recovery? Comparing alternative management strategies to address multiple interacting stressors on Least Bell's Vireo populations, SERDP ($2,609,561; $329,238 to co-PI M.M. Rohde)
2013	Solar Irrigation Project in India, SunEdison and Engineers for a Sustainable World ($5,000)
2012	Borlaug Fellow in Global Food Security, Purdue University ($15,000)
2012	Human Centered Design MicroGrant, IDEO ($5,000)
2011	Haas Graduate Public Service Fellow ($4,000)
2011-2014	National Science Foundation Graduate Research Fellowship ($129,500)
2009	Groundwater monitoring in a rural India, Kellogg College Alumni Grant ($5,000)
2009	Huber Technology Research Fund ($5,000)
2007-2008	International Polar Year Field School in Svalbard, IPY-Norway and University of the Arctic ($101,771)
2007-2009	Seattle Landscaping & Urban Gardening for Schools, City of Seattle ($18,000)
2007	Juneau Icefield Research Program, NASA undergraduate scholarship ($5,000)
2007	International Ocean Color Coordinating Group, Canada ($2,000)
2006	NSERC Undergraduate Summer Research Fellowship ($10,000)
2005	CEBIC Undergraduate Research Fellowship, Princeton University ($5,000)
2003	Union Street School Parent Council Scholarship ($1,000)
2002	Fred Brine Memorial Scholarship, University of New Brunswick ($1,000)
2002	William & Lois Paine Founder's Scholarship, University of New Brunswick ($1,000)

HONORS & AWARDS

2013	Rising Environmental Leader Fellow, Woods Institute, Stanford University
2012	Antarctica Service Medal of the United States of America, National Science Foundation
2009	World Meteorological Organization & The International Council for Science Certificate of Appreciation for contributing to the International Polar Year 2007-08
2006	American Society of Limnology Oceanography Outstanding Student Poster Award, Victoria, Canada

COMMUNITY OUTREACH & ACTIVITIES

2011-2014	Project Leader, Solar Irrigation in India, Engineers for a Sustainable World, Stanford University, California, USA
2012-2013	Organizing Member, Education Without Borders 2013 Conference in Dubai, UAE
2009-2010	Chief Science Leader, Indian Himalayas Expedition, British Schools Exploring Society
2008-2009	Co-Organizer, Water Enterprise Forum, Oxford University
2008-2009	Co-Director, Oxford Green Schools, Cherwell School, Oxford, UK
2008	Member, Green Committee, Coler & Colantonio, Norwell, Mass, USA
2007-2009	Co-coordinator, International Polar Year Field School, Svalbard, Norway
2007-2009	Co-founder, Seattle Landscaping & Urban Gardening for Schools, USA
2005-2006	Co-founder/Secretary, UBC Oceanography Society, Canada

FIELDWORK

2010-2011	Research Technician, Ice Core Drilling, Princeton University, Antarctica
2008	Intern, Wetland delineation and endangered species tracking, Coler & Colantonio, Massachusetts, USA
2008	Research Assistant II, Water sampling and on-board productivity surveys along the Columbia River Coastal Estuary, Oregon Health & Science University, Oregon, USA
2007	Technician, Dam deformation monitoring, Coler & Colantonio, Massachusetts, USA
2007	Participant, Glaciology mass balance & photogrammetry, Juneau Icefield Research Program, Alaska, USA
2006	NSERC fellow, Hydrographic surveying of Frasier River Estuary, University of British Columbia, Canada
2005	Research Assistant, Ocean sediment and water sampling, R/V New Horizon, Princeton University, Channel Islands, California, USA

SELECT MEDIA

Los Angeles Times. "How a water scientist hopes to save California habitats that could be pumped dry." (May 26, 2024) [Link]

Los Angeles Times. "Thousands of California wells are at risk of drying up despite landmark water law." (September 20, 2023) [Link]

Washington Post. "A warmer world causes extreme drought and rain. 'Indisputable' new research proves it." (March 13, 2023) [Link]

Los Angeles Times. "As California droughts intensify, ecosystems and rural communities will bear the brunt." (November 25, 2022) [Link]

Los Angeles Times. "A frenzy of well drilling by California farmers leaves taps running dry." (December 16, 2021) [Link]

Stanford Law Journal. "California Burning: Stanford research looks at drought, wildfires, and smoke and the growing risks of climate change in the golden state." (December 15, 2021) [Link]

The Wildlife Society. "Human water demand can imperil California's endangered species." (September 1, 2021) [Link]

Inside Climate News. "Forests of the Living Dead". (July 6, 2021) [Link]

Courthouse News. "California's riparian woodlands at risk of decline." (June 14, 2021) [Link]

High Country News. "How 'sustainable' is California's groundwater sustainability act?" (May 10, 2021) [Link]

CalMatters. "California needs comprehensive groundwater management" (Op-Ed April 8, 2021) [Link]

waterloop podcast. "Digging up groundwater data with Ben Kerr, Melissa Rohde, and Tom Gleeson" (Feb 24, 2021) [Link]

McGill News. "Big data offers promise of better groundwater management in California" (Dec 9, 2020) [Link]

Ensia. "Freshwater Springs Support Amazing Ecosystems and Reflect the Health of Aquifers Humans Rely On. What Can We Do To Protect Them?" (March 19, 2019) [Link]

Water Deeply. "Why the Environment Is a Big Winner in California's Groundwater Law" (August 20, 2018) [Link]

Yale Environment 360. "In a rare U.S. preserve, water pressures mount as development closes in" (August 2017) [Link]

Salon. "California farmers use floodwater to replenish aquifers" (February 2017) [Link]

SF Chronicle. "California's statewide water restrictions still needed" (Op-Ed April 2016) [Link]

Desert Sun (USA Today). "Use Local Water to Recharge Aquifers" (Op-Ed March 2016) [Link]

Los Angeles Times. "To save water, an underground movement to bank El Niño's rainfall" (November 2015) [Link]

Huffington Post. "California Whiplash" (February 2015) [Link]

SF Gate Opinion. "Getting our money's worth from $7.5 billion water bond" (November 2014) [Link]

The Guardian. "Get used to toilet-to-tap water, Californians told" (August 2014) [Link]

SFGate Opinion. "California's invisible reservoirs" (August 2014) [Link]

New York Times Opinion Pages. "How Conservation and Groundwater Management Can Gird California for a Drier Era" (August 2014) [Link]

Stanford News. "Stanford's Water in the West program offers new way to view groundwater resources" (July 2014) [Link]

AGU Blogosphere. Measuring groundwater recharge could protect rural farmers' livelihoods (December 2012) [Link]

SELECT PRESENTATIONS

Invited Speaker: "Consideration of groundwater-dependent ecosystems in the Flood-MAR context", Lunch-MAR, 4 Dec 2024, online.

Invited Speaker: "Nature-based solutions for improving water quality during managed aquifer recharge." Innovations in the Science and Policy of Water Quality Measurement Workshop, 12 April 2024, Caltech, Pasadena, California, USA.

Session Co-convener: "Conservation Ecohydrology". American Geophysical Union Fall Meeting 2023, 11-15 December 2023, San Francisco, California, USA.

Invited Panelist: "SGMA Review: Achieving Groundwater Access for All & Visual Data Tool Demonstration". Groundwater Exchange Webinar, 15 Aug 2023, online.

Invited Speaker: "Mapping groundwater dependent ecosystems globally to build resilient communities, combat climate change, and mitigate biodiversity loss". American Geophysical Union (AGU) Fall Meeting, 12-15 December 2022, online.

Invited Panelist: "Long-term Drought Impacts on Ecosystems". California Water Commission Meeting. 16 November 2022. [Link]

Session Convener: "Mapping Groundwater Dependent Ecosystems Across the Globe with Satellites and Machine Learning". Session 10636: "Groundwater for Ecosystems: Preserving Biodiversity, Socio-economic, and Cultural Values". World Water Week, Stockholm. 31 August 2022. Hybrid In-Person and Virtual Event.

Invited Panelist: "What's Beneath Our Feet?". POLIS Water Sustainability Project, University of Victoria, 22 March 2022, online.

Invited Panelist: "NGO Findings – Review of 2020 Groundwater Sustainability Plans". Groundwater Resource Association Groundwater Sustainability Agency Summit, 9-10 June 2021, online.

Invited Webinar: "Managing California's Groundwater: Interconnected Surface Waters & Environmental Users". The Local Government Commission and the Groundwater Exchange Webinar, 7 June 2021, online.

Rohde, M.M., J. Stella, M.B. Singer, D. Roberts. Detecting riparian vegetation responses to groundwater changes using Sentinel satellite imagery and cloud-based computing. American Geophysical Union (AGU) Fall Meeting, 1-17 December 2020, online.

Invited Presentation: "Groundwater & Ecosystems: Insights from an innovative programme in California (USA)" The Nature Conservancy Latin America Region Water Funds Workshop, 2 Dec 2020, online.

Rohde, M.M., J. Stella, M.B. Singer, D. Roberts. Detecting riparian vegetation responses to groundwater changes using Sentinel satellite imagery and cloud-based computing. Geological Society of America (GSA) Annual Meeting, 26-30 October 2020, online.

Rohde, M.M., J. Stella, M.B. Singer, D. Roberts. Detecting riparian woodland response to groundwater changes using Sentinel satellite imagery and cloud-based computing. Ecological Society of America (ESA) Annual Meeting, 3-6 August 2020, online.

Invited Speaker: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act", Greater Ventura County Webinar, 19 June 2020, online.

Invited Speaker: "Dynamic Multi-benefit Managed Aquifer Recharge", Economics of Managed Aquifer Recharge Workshop, USDA Economic Research Service, 26 June 2019, Washington, D.C., USA.

Invited Speaker: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans", American Water Works Association Annual Conference, 26 March 2019, Sacramento, California, USA.

Invited Panelist: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans". Nevada Water Resources Association 2019 Annual Conference, 31 January 2019, Atlantis Hotel & Casino, Reno, Nevada, USA.

Invited Speaker: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans". Salinas Valley Groundwater Sustainability Agency Board of Directors Special Meeting, 10 January 2019, Gonzales, California, USA [Video].

Invited Panelist: "Connecting the Dots between Water, Agriculture, and Ecosystems". Central Coast Regional Climate Symposium, 10 December 2018, University of Santa Cruz, California, USA.

Invited Panelist: "Take me to the (Ground)Water: Hot Legal Issues in Groundwater Law". Groundwater Resources Association First Annual Western Groundwater Congress, 27 September 2018, Sacramento, California, USA.

Invited Speaker: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act". Delta-Mendota Subbasin GDE Workshop, 24 August 2018, Los Banos, California, USA.

Invited Speaker: "Groundwater Dependent Ecosystems Defined and New Tools for Developing Sustainable Management Criteria. Groundwater Resources Association First Annual Groundwater Sustainability Agency Summit, 7 June 2018, Sacramento, California, USA.

Invited Webinar: "Live Online Walkthrough - Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans". Association of California Water Agencies Webinar, 31 May 2018.

Invited Speaker: "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Tools & Guidance for Preparing Groundwater Sustainability Plans". Association of California Water Agencies, Groundwater Committee Meeting, 8 May 2018, Sacramento, California, USA.

Invited Speaker: “Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans”. Sustainable Water Resources Roundtable, 4 May 2018, Sonoma, California, USA.

Invited Speaker: "Securing Water for People and Nature". World Water Day Celebration, 11 April 2018, Orbach Library, University of California, Riverside campus, California, USA.

Rohde, M.M., C. Ulrich, J. Howard, S. Sweet. 2017. Monitoring and Assessing Groundwater Impacts on Vegetation Health in Groundwater Dependent Ecosystems. American Geophysical Union (AGU) Fall Meeting 2017, New Orleans, Louisiana, USA [POSTER]

Session Co-convener: “Practical Research at the Intersection of Ecology and Hydrology for Sustainable Water Management”. American Geophysical Union Fall Meeting 2017, 12 December 2017, New Orleans, Louisiana, USA.

Workshop Convener: “Monitoring Groundwater Dependent Ecosystems under California’s Sustainable Groundwater Management Act (SGMA) and Beyond. Part 1: Putting Policy into Practice and Part 2: Measure to Manage.” Riparian Summit Workshop, 19 October 2017, University of California, Davis, California, USA.

Presenter: “Avoiding Undesirable Results: How GDE Data Can Inform Minimum Thresholds & Measurable Objectives under SGMA. Groundwater Resources Association Annual Meeting, 3 October 2017, Sacramento, California, USA.

Session Convener: “Putting Policy into Practice - Achieving Sustainable Groundwater Management for People and Nature”. Special Session at the Ecological Society of America Annual Conference, 7 August 2017, Portland, Oregon, USA.

Invited Webinar: “Tools for Mapping and Managing Groundwater Dependent Ecosystems in SGMA Groundwater Sustainability Plans”. Groundwater Resources Association Webinar (GRA Cast), 15 February 2017.

Co-Presenter: “Considering Groundwater Dependent Ecosystems and Interconnected Surface Waters under SGMA: Tools, Mapping, and a Guidance Framework”. Groundwater Resources Association Annual Conference, 29 September 2016, Sacramento, California, USA.

Rohde, M.M., S. Liu, B. Bondy, T. Morgan, D. Detmer, K. Klausmeyer, J. Howard. 2016. Considering Groundwater Dependent Ecosystems under SGMA: A Case Study from Ventura County. Groundwater Resources Association (GRA): Developing Groundwater Sustainability Plan for Success Conference 8-9 June 2016, Sacramento, California, USA [POSTER]

Invited Panelist: The Stanford Woods Institute's 10th Anniversary Symposium: Breaking Through to Global Sustainability. Panel on the Next Generation Environmental Solutions, 11 November 2014, Cemex Auditorium, Stanford University, Stanford, California, USA.

Invited Speaker: "To pump or not to pump: the groundwater question". Presentation for Breakout Session at Connecting the Dots: The Water, Food, Energy, and Climate Nexus Conference. 16 April 2012, Arilliaga Alumni Center, Stanford University, Stanford, California, USA.

Rohde, M.M., W.M. Edmunds, O.P. Sharma, J. Davis. 2012. A Participatory Water Management Tool for the Determination of Groundwater Recharge. American Geophysical Union (AGU) Fall Meeting 2012, San Francisco, California, USA [POSTER]

Rohde, M.M., W.M. Edmunds, O.P. Sharma, A. Sharma. 2011. A Watershed Approach for the Determination of Groundwater Recharge in Rajasthan, India. American Geophysical Union (AGU) Fall Meeting 2011, San Francisco, California, USA [POSTER]

Rohde, M.M. 2009. Lessons from India: sustainable solutions to the water crisis. In: Green Economics Institute Conference Proceedings held at Oxford University, Oxford, United Kingdom [PDF]

Rohde, M.M., J. Granger, D.M. Sigman, P.D. Tortell. 2006. The Effect of Light on Coupled N and O stable Isotope Fractionation During Nitrate Assimilation by Marine Phytoplankton, American Society of Limnology & Oceanography (ASLO) Summer Meeting 2006, Victoria, British Columbia, Canada [POSTER]

PROFESSIONAL DEVELOPMENT

2020	Active Bystander Training, The Nature Conservancy
2016	Communicate to Influence Program for Communication and Leadership Excellence, Decker Communications
2016	Highly Effective Teams Training, The Nature Conservancy
2016	Resistivity Imaging Training, Advanced Geosciences, Inc.

TEACHING EXPERIENCE

2014	Teaching Assistant, CEE165C/265C: Water Resources Management, Stanford University
2014	Teaching Assistant, CEE73: Understanding Water, Stanford University
2014	Course Assistant, GEOPHYS 104: The Water Course, Stanford University
2012	Teaching Assistant, CEE177X/277X: Design for a Sustainable Word, Stanford University
2006	Teaching Assistant, EOSC 448E: Seminal Papers in Marine Biogeochemistry, University of British Columbia

MENTORING

2022	Karlee Liddy, Masters Student, University of California, Santa Cruz, USA
2021-22	Maddy Dyring, PhD Candidate, University of Queensland, Australia
2020-21	Sarah Tooms, Masters Student, University of Oxford, UK

PROFESSIONAL SERVICE

Journal Reviewer

Earth's Future
Frontiers in Environmental Science
Geocarto International
Hydrogeology Journal
Journal of Hydrology
Nature Water
Remote Sensing in Ecology and Conservation
Water Resources Research
Water Security

Institutional Service, Committees, Workshops

2024-2025	Member, San Juan County Clean Water Advisory Committee
July 22, 2024	Invited Participant, President's Council of Science and Technology (PCAST) Workshop, Safeguarding America's Groundwater Security: Addressing Challenges and Risks.
2022	Member, Sonoma County Well Ordinance Technical Working Group
2018 - 2022	Member, Global Groundwater Group, The Nature Conservancy (Chair 2018-19)
2020 - 2021	Committee Member, Groundwater Dependent Ecosystem Practitioner Work Group Sonoma Valley Groundwater Sustainability Agency
2020 - 2021	Committee Member, Sonoma Sustainable Management Criteria for Depletion of Interconnected Surface Water Work Group, Sonoma Valley Groundwater Sustainability Agency
2020 - 2021	Committee Member, Surface Water Technical Advisory Group, Santa Margarita Groundwater Agency
2019	Member, FloodMAR Research Advisory Committee: Tool and Application Development, California Department of Water Resources
2018 - 2019	Committee Member, Surface Water Working Group, Santa Cruz Mid-County Groundwater Agency
2014 - 2016	Member, Environmental and Water Resources Committee Member, Santa Clara Valley Water District

PROFESSIONAL MEMBERSHIPS

American Association for the Advancement of Science (AAAS) - Member (2018)
American Geophysical Union - Member (2011-present)
Groundwater Resources Association of California - Member (2016 - present)
National Groundwater Association - Member (2014)
Water Environment Federation - Member (2014)

SKILLS

- **Data Science:** ArcGIS, R statistical software, Python, Jupyter Lab, Google Earth Engine, Anaconda
- **Coding Languages:** R, Python, Java
- **Languages:** English (native), Spanish (beginner)
- PADI Open Water Diver Certification
- Solo Wilderness First Aid Medicine Certification / CPR Certification with American Heart

Peer Review of GDE Study Report in Borrego Springs

G. Darrel Jenerette

Professor, Department of Botany and Plant Sciences

Director, Center for Conservation Biology

University of California Riverside

- **A description of your technical approach to the peer review**

My approach to the peer review will include a detailed read of the report and critical evaluation of data included the report. I will provide an in-depth comparison of methods and findings compared to best practices in evaluating tree water sources and needs. I will engage with the report authors and watermaster designees to identify sources of uncertainty and potential points of confusion. I will provide a professional evaluation of report findings.

- **Cost estimate**

I estimate the review will cost $20,000 based on ~80 hours at $250 / hour. Work includes review, report development, engagement, and revision.

- **Short bios of personnel that will conduct the peer review (include full CVs as attachments)**

I am broadly trained in ecosystem and landscape ecology and have worked extensively at the interface of ecology and hydrology – ecohydrology. I have conducted research on Mesquite ecology associated with both water relationships and growth historically (Jenerette et al. 2008; Scott et al. 2009; Jenerette et al. 2009; Barron-Gafford et al. 2012; Barron-Gafford et al. 2013; Scott et al. 2014; Shen et al. 2016). Current I am participating in an on-going study to identify water sources of a Mesquite bosque in the Coachella valley affected by altered groundwater (Sweet et al. *in prep*). I have enclosed my full CV. I will conduct the review personally.

G. Darrel Jenerette
Director, Center for Conservation Biology
Professor, Department of Botany and Plant Sciences
University of California Riverside
Riverside, CA 92521-0124
951/214-0564 • darrel.jenerette@ucr.edu

Research Interests
Landscape ecology • Ecosystem ecology • Ecohydrology • Drylands • Cities • Sustainability

Academic Appointments
2017 – present Director, Center for Conservation Biology, UC Riverside
2017 – present Professor, Department of Botany and Plant Sciences, UC Riverside
2013 – 2017 Associate Professor, Department of Botany and Plant Sciences, UC Riverside
2008 – 2013 Assistant Professor, Department of Botany and Plant Sciences, UC Riverside

Education and Training
Postdoctoral Fellow. Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ. 2005 – 2007

Postdoctoral Researcher. Carbon Management and Sequestration Center, School of Natural Resources, The Ohio State University, Columbus, OH. 2004 – 2005

Ph.D. Plant Biology, Arizona State University, Tempe, AZ. 2004

B.S. Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA. 1995

Awards
Outstanding Paper in Landscape Ecology, United States Chapter of the International Association for Landscape Ecology 2017

Visiting Fellowship for Young International Scientists, Chinese Academy of Sciences. 2011-2012

Early Career Fellowship, Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) 2007

Biological Informatics Postdoctoral Fellowship, National Science Foundation. 2005-2007

Graduate Fellowship, Urban Ecology Integrative Graduate Education and Research Traineeship (IGERT), National Science Foundation. 2001-2004

Tony Gonzales Excellence in GIS Scholarship. Arizona Geographic Information Council. 2004

Outstanding Poster. Central Arizona Phoenix Long Term Ecological Research Poster Symposium. 2000

Funded Research Projects ($30.1M total; $6.0M to Jenerette)
09/2023 – 08/2025 **National Science Foundation**, NSF Convergence Accelerator Track K: Unraveling the Benefits, Costs, and Equity of Tree Coverage in Desert Cities. CoI (with A Mayer PI) $650,000 (with $105,256 to UCR)

09/2023 – 08/2025 **University of California**, Community-engaged research to manage fire and water in California landscapes. CoI (with S Allison PI) $5,538,311 (with $503,008 to UCR)

09/2023 – 08/2025 **State of California - The Natural Resources Agency**, Assessing the Wildland Urban Interface in the Coachella Valley. CoI (with L Sweet PI and J Allison) $ 313,942

03/2022 – 02/2024 **State of California - The Natural Resources Agency**, The Desert Climate Resilience Initiative for the Coachella Valley. CoI (with L Sweet PI) $398,000

09/2019-08/2022 **National Science Foundation**, CNH2-L: Toward a Theory of Urban Trees as Living Infrastructure. PI (with S Pincetl, M Avolio, T Eisenman, M Chester) $436,224 ($219,508 to UCR)

09/2019-08/2022 **National Science Foundation**, Collaborative Research: Understanding the hydrologic consequences of urban irrigation across the U.S. PI on Collaborative Proposal (with D Pataki Project PI) $830,372 ($330,968 to UCR)

03/2019-05/2021 **Earthwatch Institute**, Operation Smart Water. PI $45,406

08/2017-08/2021 **National Science Foundation**, Pulses of biogenic nitrogen cycling lead to atmospheric-based nutrient spiraling in southern California. PI (with J Sickman, E Aronson, J Wang) $891,141

09/2017-08/2022 **National Science Foundation** S&AS:INT: Autonomous Multi-Robot Visual Monitoring for Urban, Agricultural, and Natural Resource Management. coI (with AR Chowdhury PI, K Karydis, Q Zhu, A Mourikis) $1,000,000

02/2017-01/2018 **National Aeronautics and Space Administration**, Citizen science in urban regions to address satellite subpixel uncertainties in the vegetation, climate, and air quality nexus. PI (with J Wang, M Chandler) $197,521

06/2016-12/2017 **United States Forest Service**, Resampling the Los Angeles Urban Forest. PI $26,721

04/2016-03/2021 **Earthwatch Institute**, Towards designing a more sustainable urban forest. PI $85,000

04/2016-03/2019 **National Institute of Food and Agriculture**, USDA Cultivating Diversity in a 2+2+2 Collaborative Project. coI (with M McGiffen PI, and H Liu) $90,490

07/2016-06/2020 **National Institute of Food and Agriculture**, Reducing gaseous nitrogen losses from high temperature agricultural systems. PI (with J Wang, P Oikawa) $499,251

09/2015-08/2019 **Earthwatch Institute**, Linking urban tree leaf traits to potential cooling benefits across a large US metropolitan area. PI $88,071

07/2015-07/2016 **UC Agricultural and Natural Resources Division**, Ensuring the success of ANR Flux: Evaluation of long-term network configuration and initial science applications. PI $61,360

08/2015-08/2021 **National Science Foundation**, Urban Water Innovation Network (U-WIN): Transitioning Toward Sustainable Urban Water Systems. Sub-Award PI, Project Senior Personnel (with M Arabi Project PI, A Berkowitz, E Bou-Zeid, GE Pivo, R Haggerty, C Welty, M Sukop) $12,000,000 ($319,210 to UCR)

01/2015-12/2018 **National Aeronautics and Space Administration**, Enhanced data-driven decision support for highly invasive vectors. Sub-Award PI (with C Barker Project PI, WK Reisen, T Scott, F Melton) $1,189,773 ($161,630 to UCR)

07/2014-12/2015 **UCMexus**, Effect of land use, soil type and agricultural practices on preserving organic soil carbon stocks. coI (with M Allen PI, E Allen, H Estrada Medina, J Jiminez-Osornio) $14,900

06/2014–05/2015 **National Science Foundation**, Dissertation Research: Connecting dryland soil trace gas emissions of NO_x, N_2O and CO_2 to microbial community dynamics along a nitrogen deposition gradient. PI in support of J Eberwein (DDIG) $19,745

08/2013-07/2015 **U.S. Agency for International Development,** Evaluating climate change impacts on the arid lands and water resources of Jordan, coI (with Y Jaraweh PI) $87,000

11/2012-10/2015 **National Aeronautics and Space Administration**, Assessing relationships between urban land cover, surface temperature, and transpiration along a coastal to desert climate gradient, PI $501,326

08/2012-09/2013 **California Institute for Energy and the Environment**, Carbon balance in California deserts: Impacts of widespread solar power generation, coI (with M Allen PI, L Santiago) $149,890

06/2012-05/2014 **National Science Foundation**, Dissertation Research: The effect of human management and soil properties on heavy metal content of Los Angeles Community Garden soils, PI in support of L Clarke (DDIG) $14,980

06/2012-08/2012 **California Avocado Commission**, Initial scoping of ecosystem services provided by avocado orchards in southern California, PI $20,000

10/2011-11/2013 **United States National Park Service**, Atmospheric nitrogen deposition assessment in the Santa Monica Mountains NRA and the effects on weed invasion, coPI (with E Allen PI, J Sickman, M Fenn) $100,000

07/2011-07/2014 **United States Forest Service**, Assessing the effects of local water district policies on urban forests and their implications across socio-economic groups, coI (with K Baerenklau PI, K Schwabe) $64,000

10/2011-12/2016 **United States Forest Service**, Base-level vegetation mapping for the Angeles National Forest, PI $164,740

07/2011-06/2015 **National Institute of Food and Agriculture**, Life cycle assessment of sequestration and exchange of water, carbon and nitrogen in the dedicated bioenergy feedstock, energy cane, coI (with D Grantz PI) $967,769

07/2011-06/2014 **National Science Foundation**, Collaborative research: Assessing decadal climate impacts on urban populations in the Southwestern USA, ($147,000 to UCR) PI on Collaborative Proposal (with B Ruddell Project PI, M Maoustaouri, E Vivoni) $897,000

02/2011-02/2014 **United States Golf Association**, Water-Use efficiency and carbon sequestration influenced by turfgrass species and management practices, PI (with J Baird) $55,553

07/2009-06/2013 **National Science Foundation**, Collaborative research: Toward a biogeography of urban forests, PI on Collaborative Proposal (with D Pataki Project PI, S Pincetl, T Gillespie) $791,498 ($249,670 to UCR)

07/2009-06/2010 **National Science Foundation**, Research starter grant: An urban environmental observatory, PI $50,000

01/2009-06/2009 **Coachella Valley Association of Governments**, JS-CVCC CVMSHCP Monitoring Program 2009 Administrator, coI (with M Allen PI, C Barrows, E Allen, R Redak, J Rotenberry, W Walton) $116,000

01/2009-12/2010 **Kearney Foundation**, Soil metabolic variability across a 3000 meter topographic gradient: Understanding the long term consequences of short duration dynamics, PI (with M Allen) $89,900

10/2010-10/2012 **National Park Service**, Alien invasion: Effects of atmospheric nitrogen deposition on sagebrush steppe vegetation dynamics at Upper Columbia Basin network parks, coI (with E Allen Project PI, J Sickman) $100,000

09/2008-02/2013 **National Science Foundation**, Collaborative Research: Urban vulnerability to climate change: A systems dynamics analysis, PI on Collaborative Proposal (with S Harlan Project PI, C Martin, T Lant, S. Grossman-Clark, W. Stefanov, M Elser) $1,500,000 ($135,000 to UCR)

06/2008-09/2008 **United States Department of Agriculture**, LAMillion Trees: Distribution and physiological characteristics, PI $15,500

Publications (*Lab members in **bold**)* H Index: WoS = 52, Google Scholar = 63
150 Total Publication: 131 Journal Articles and Reviewed Conference Proceedings; 19 Book Chapters and Other articles

Journal Articles
2025

(133) S Zhao, A Krichels, EZ Stephens, AC Calma, EL Aronson, **GD Jenerette**, MJ Spasojevic, JP Schimel, EJ Hanan, PM Homyak. 2025. Nitrogen availability and changes in precipitation alter microbially mediated NO and N2O emissions from a Pinyon–Juniper dryland. *Global Change Biology* In Press

(132) Marquez-Torres A, S Kumar, C Aznarez, **GD Jenerette**. 2025. Assessing the cooling potential of green and blue infrastructure from twelve US cities with contrasting climate conditions. *Urban Forestry and Urban Greening* 104: 128660

(131) **GD Jenerette**. 2025. Resilient urbanization for water limited environments. *Cambridge Prisms: Drylands In Press*

2024

(130) J Wu, A Buyantuev, I Fernandez, J Gilman, **GD Jenerette**, X Wang. 2024. Forty milestones in landscape ecology: commemorating the 40th anniversary of the Allerton Park workshop. *Landscape Ecology* 39:216

(129) M Wilfong, E Litvak, NH Grijseels, **K Hamilton**, **D Kucera**, L Welsh, J Endter-Wada, **GD Jenerette**, DE Pataki. 2024. Irrigation rates and turfgrass evapotranspiration in cities with contrasting water availability. *Journal of the American Water Resources Association* DOI: 10.1111/1752-1688.13236

(128) M Jiao, **GD Jenerette**, W Zhou, J Wang, Z Zheng. 2024. Adaptive shading: How microclimates and surface types amplify tree cooling effects? *Urban Forestry and Urban Greening* 128546

(127) FT Maestre, L Biancari, N Chen, M Corrochano-Monalve, **GD Jenerette**, C Nelson, KN Shilula, Y Shpilkina. 2024. Research needs on the biodiversity–ecosystem functioning relationship in drylands. *Nature Biodiversity* 3:12

(126) Ibsen PC, BR Crawford, L Corro, KJ Bagstad, BE McNellis, **GD Jenerette**, JE Diffendorfer. 2024. Urban tree cover provides consistent mitigation of extreme heat in arid but not humid cities. *Sustainable Cities and Society* 105677

(125) E Warmann, **GD Jenerette**, G Barron-Gafford. 2024. Agrivoltaic system design tools for managing trade-offs between energy production, crop productivity and water consumption. *Environmental Research Letters*

(124) **Jenerette GD** and **D Herrmann**. 2024. A Global Synthesis of Urban Tree Carbon Production Reported Rates and Approaches. *Frontiers in Ecology and Evolution*

2023

(123) **Kucera D** and **GD Jenerette**. 2023. Urban greenness and its cooling effects are

influenced by changes in drought, physiography, and socio-demographics in Los Angeles, CA. *Urban Climate* 52: 101743

(122) **Krichels AH**, **GD Jenerette**, H Shulman, **S Piper**, AC Greene, **HM Andrews**, J Botthoff, JO Sickman, EL Aronson, PM Homyak. 2023. Bacterial denitrification drives elevated N2O emissions in arid southern California drylands. *Science Advances In Press*

(121) Avila CCE, MV Schaefer, AM Duro, TP Haensel, A Garniwan, Y Lin, **GD Jenerette**, PS Nico, E Dubinski, M Keiluweit, EL Brodie, YH Lin, PM Homyak, SC Ying. 2023. Carbon dynamics as a function of soil moisture following repeated wet-dry cycles in irrigated soils. *Geoderma* 439:116681

(120) Waugh DW, B Zaitchik, AA Scott, PC Ibsen, **GD Jenerette**, J Schatz, CJ Kucharik. 2023. Limited role of absolute humidity in intraurban heat variability. Journal of Applied Meteorology and Climatology *In Press*

(119) **Schwab ST**, **GD Jenerette**, L Larios. 2023. Prescribed burning may produce refugia for invasive forb, Oncosiphon pilulifer. Restoration Ecology *In Press* DOI: 10.1111/rec.13922

(118) **Andrews HM**, **AH Krichels**, PM Homyak, **S Piper**, EL Aronson, J Botthoff, AC Greene, **GD Jenerette**. 2023. Wetting-induced soil CO2 emission pulses are driven by interactions among soil temperature, carbon, and nitrogen limitation in the Colorado Desert. Global Change Biology 29: 3205-3220 DOI: 10.1111/gcb.16669

(117) **Ibsen P**, L Santiago, S Shiflett, M Chandler, **GD Jenerette**. 2023. Irrigated urban trees exhibit greater functional trait plasticity compared to natural stand analogs. Biology Letters 19:20220448 DOI: 10.1098/rsbl.2022.0448

(116) **Krichels AH**, AC Greene, **GD Jenerette**, MJ Spasojevic, SI Glassman, PM Homyak. 2023. Precipitation legacies amplify ecosystem nitrogen losses from nitric oxide emissions in a Pinyon-Juniper dryland. Ecology 104:e3930 DOI: 10.1002/ecy.3930

2022

(115) Wang J, L Castro-Garcia, **GD Jenerette**, M Chandler, C Ge, **D Kucera**, **S Koutzoukis**, J Zeng. 2022. Resolving and predicting neighborhood vulnerability to urban heat and air pollution: Insights from a pilot project of community science. Geohealth 10.1029/2021GH000575

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(8) **Jenerette GD** and **KP Alstad**. 2010. Water Use in Urban Ecosystems: Complexity, costs and services of urban ecohydrology. In J. Aitkenhead-Peterson and A. Volder (eds.) Urban Ecosystem Ecology 353-371

(7) Scott RL, **GD Jenerette**, TE Huxman. 2010. Semiarid Ecohydrological Array – SECA. Fluxletter 2:10-12

(6) Hary A, A Akoglu, Y B Al-Nashif, S Hariri, **GD Jenerette**. 2010. Design and evaluation of self-healing Kepler for scientific workflows. 340-343. HPDC 2010 - Proceedings of the 19th ACM International Symposium on High Performance Distributed Computing

(5) **Jenerette GD** and J Wu. 2010. Quantitative measures and landscape ecology. In L. Kapustka, W. Landis, and A. Johnson (eds.) Environmental Risk Assessment and Management from a Landscape Perspective John Wiley and Sons. 75-96

(4) Jararweh Y, A Hary, Y B Al-Nashif, S Hariri, A Akoglu, **GD Jenerette**. 2009. Accelerated discovery through integration of Kepler with data turbine for ecosystem research. AICCSA, pp.1005-1012, 2009 IEEE/ACS International Conference on Computer Systems and Applications

(3) Wu J, **GD Jenerette**, and JL David. 2003. Linking land use change with ecosystem processes: A hierarchical patch dynamics model. In S. Guhathakurta (ed.) Integrated Land Use and Environmental Models Springer-Verlag. 99-119

(2) **Jenerette GD** and J Wu. 1999. On the definitions of scale. *Bulletin of the Ecological Society of America* 8:104-105

(1) **Jenerette GD**, J Lee, D Waller, and RE Carlson. 1998. The effect of spatial dimension on regionalization of lake water quality data. In T.K. Poiker and N. Chrisman (eds.) 8th International Symposium on Spatial Data Handling 256-265. International Geographical Union

Synergistic Activities

Congressional Briefings

Association of Ecosystem Research Centers sponsored briefing to the U.S. Congress – Cities, Agriculture, and Wildlands: Ensuring Continued Ecosystem Services from Our Rapidly Changing Landscapes. Washington, D.C. October 2014

Ecological Society of America sponsored briefing to the U.S. House of Representatives and Senate – Water Resources in the West: Assessing Tradeoffs in a changing climate. Washington, DC. July 2009

Event Organization

Los Angeles' Urban Fires: Understanding background, impacts, and research needs. Pasadena, CA. 2025

International Association of Landscape Ecologists – North America Annual Meeting. Riverside, CA. 2023

Wildland Urban Interfaces: Expanding Perspectives in Southern California. Riverside, CA. 2019

Toward a Theory of the Urban-Wildland Interface. Riverside, CA. 2018

Toward a Landscape Perspective of Green Infrastructure. Symposium at the U.S. International Association for Landscape Ecology Meeting, Baltimore, MD. 2017

Accelerating Research and Discovery with EcoInformatics: Cyberinfrastructure, Instrumentation, and Theory. Biosphere 2 and CUAHSI Synthesis Workshop. Oracle, AZ. 2008

Collaborative Interdisciplinary Research for Graduate Students. Workshop at the Long Term Ecological Research Graduate Student Symposium. Blue River, OR. 2005

Case Studies of Short Term Collaborations. Workshop at the Long Term Ecological Research All Scientists Meeting Seattle, WA. 2003

Complexity Theory and Ecological Applications. Symposium at the U.S. International Association for Landscape Ecology Meeting, Tempe, AZ. 2001

Funding Agency Panel Member

National Science Foundation 2025, 2024, 2023, 2022, 2021, 2019, 2018, 2017, 2014, 2011,

2010
Environmental Protection Agency 2009

Funding Agency Ad hoc Reviewer
National Science Foundation
Department of Energy
Kearney Foundation of Soil Science

Editorial Board Member
Ecology and Ecological Monographs, Editor 2021 - Present
Landscape Ecology, Reviews Editor 2018 – Present; Coordinating Editor 2008 - 2018
Landscape and Urban Planning, Editorial Board 2016 – Present
Frontiers in Ecology and Evolution 2015 – 2025
Science of the Total Environment, Associate Editor 2018-2020

Journal Referee
Agricultural and Forest Meteorology • Applied Geography • Biogeosciences • Bioscience • Cities • Ecological Applications • Ecological Complexity • Ecological Economics • Ecological Modelling • Ecology • Ecology Letters • Ecosystems • Environmental Health Perspectives • Environmental Management • Environmental Pollution • Frontiers in Ecology and the Environment • Geographic Information Science • Global Change Biology • Global Ecology and Biogeography • Hydrological Processes • Journal of American Water Resources Association • Journal of Arid Environments • Journal of Ecology • Journal of Environmental Management • Journal of Geophysical Research – Atmospheres • Journal of Geophysical Research – Biogeosciences • Landscape and Urban Planning • Landscape Ecology • Nature Sustainability • New Phytologist • Proceedings of the National Academy of Sciences • Remote Sensing of the Environment • Science Advances • Science of the Total Environment • Scientific Reports • Water Resources Research • Urban Ecosystems • Urban Forestry and Ubran Greening

Societal Memberships
American Association for the Advancement of Science • American Geophysical Union • Ecological Society of America • International Association for Landscape Ecology

Professional Committees
2023 Annual Meeting Host (Chair), North American Chapter, International Association for Landscape Ecologists *2022-2023*

2022 Annual Meeting Committee, North American Chapter, International Association for Landscape Ecologists *2020-2022*

Council-at-Large (elected), North American Chapter, International Association for Landscape Ecologists *2022-2024*

Awards Committee, North American Chapter, International Association for Landscape Ecologists *2019-present*

Terrestrial Biogeochemistry Technical Working Group, National Ecological Observatory Network *2018*-2021

Nominating Committee, North American Chapter, International Association for Landscape Ecologists *2018-2021*

Technical Committee American Geophysical Union Hydrology Section's Ecohydrology *2010-2015*

Invited Workshop / Working Group Participant

Growing the Urban Forest, Socio-Environmental Synthesis Center, Annapolis, MD. February 2016

The Role of Environmental Change on the Human-Wildland Interface: The Lowland Maya as a Model System, Merida, Mexico. December 2015

Detecting Signatures of Socio-Ecological Innovation in Urban Ecosystems, Socio-Environmental Synthesis Center, Annapolis, MD. October 2015

Eddy Flux Measurements for the Groundwater-Surface Water Interaction Zone, Pacific Northwest National Laboratory, Richland, WA. September 2014

Urban Heat Island Network Workshop, St. Paul, MN. June 2013

CUAHSI Synthesis Team – Water Cycle Dynamics in a Changing Environment: Advancing Hydrologic Science through Synthesis. 2007-2009

Second International Young Scientists' Global Change Conference. System for Analysis, Research, and Training. Beijing, Peoples Republic of China. November 2006

Uncertainty and Variability in Ecological Inference, Forecasting, and Decision Making. Center for Global Change at Duke University. Durham, NC. June 2006

Global Ecology Workshop. Mathematical Biosciences Institute at the Ohio State University. Columbus, OH. June 2006

Monsoon Region Climate Applications: A Binational Workshop. National Oceanic and Atmospheric Administration. Guaymas, Mexico. May 2006

Dissertation Initiative for the Advancement of Climate Change Research Symposium (DISCCRS) II. National Science Foundation. Pacific Grove, CA. March 2006

Science Environment for Ecological Knowledge: Ecological Informatics Workshop. Long Term Ecological Research Network. Albuquerque, NM. January 2006

Long Term Ecological Research Graduate Student Symposium. Long Term Ecological Research Network. Blue River, OR. March 2005

Woodstoich: Ecological Stoichiometry Workshop. Center for Advanced Studies. Finse, Norway. August 2004

Chapman Conference on Eco-Hydrology of Semiarid Landscapes: Interactions and Processes. American Geophysical Union. Taos, NM. September 2002

Complex Systems Summer School. Santa Fe Institute. Santa Fe, NM. June 1997

Invited Outreach

Panelist, "What is the Value of a Tree", Riverside, Idyllwild, and Palm Desert, CA. February 2017

Panelist, "How Citizen Science IS Making a Difference" as part of the Citizen Science for Conservation in Southern California Symposium, Aquarium of the Pacific, Long Beach, CA. February, 2016

Urban Forestry Advisory Group, Climate Action through Conservation, The Nature Conservancy. August 2014-December 2015

Nature Reserve of Orange County Science Panel Meeting, Irvine, CA. November 2013

Invited Presentations

University of Alicante, Instituto Multidisciplinar para el Estudio del Medio, Alicante, Spain May 2023

University of Lanzhou, College of Earth and Environmental Sciences, Lanzhou, China May 2023

North America - International Association of Landscape Ecologists, Riverside, CA March 2023

Autonomous University of Barcelona, Center for Research on Ecology and Forestry Applications (CREAF), Barcelona, Spain February 2023

Basque Center for Climate Change (BC3), Leioa, Spain January 2023

7th Landscape Sustainability Science Forum, Xining, China July 2019

University of Southern California, Department of Earth Sciences, Los Angeles, CA May 2019

University of California Santa Barbara, Bren School of Environmental Science and Management, Santa Barbara CA May 2019

Biodiversity of Cities Symposium, Chapel Hill, NC April 2019

United States – International Association of Landscape Ecologists, Fort Collins, CO April 2019

Los Angeles County Natural and Urban Ecosystems Symposium, Los Angeles, CA March 2019

Ecological Society of America Annual Meeting, New Orleans, LA August 2018

United States – International Association of Landscape Ecologists, Chicago, IL April 2018

University of Iowa, Department of Chemical and Biochemical Engineering, Iowa City, IA February 2018

Ecological Society of America Annual Meeting, Portland, OR August 2017

University of California Los Angeles, Department of Ecology and Evolutionary Biology, Los Angeles, CA November 2016

Southern California Botanists Symposium, Pomona, CA October 2016

Jet Propulsion Laboratory, Pasadena CA October 2016

University of Pittsburgh, Department of Geology and Environmental Sciences, Pittsburgh PA September 2016

United States – International Association of Landscape Ecologists, Asheville, NC April 2016

American Geophysical Union Fall Meeting, San Francisco, CA December 2015

Soil Science Society of America Annual Meeting, Minneapolis, MN November 2015

World Congress of the International Association of Landscape Ecologists, Portland, OR July 2015

Southern California Chaparral Symposium, Arcadia, CA June 2015

American Geophysical Union Fall Meeting, San Francisco, CA December 2014

Natural History Museum, Los Angeles, CA December 2014

Pacific Northwest National Laboratory, Richland, WA September 2014

Ecological Society of America Annual Meeting, Sacramento, CA August 2014

American Association for the Advancement of Science Pacific Division, Riverside, CA June 2014

Air Pollution and Global Change Symposium, Pacific Grove, CA June 2014

International Conference of Geography and Environment, Mexico City, Mexico October 2013

University of California Los Angeles, Department of Atmospheric and Oceanic Sciences, Los Angeles, CA October 2013

University of California Agriculture and Natural Resources Statewide Conference, Ontario, CA April 2013

University of California Berkeley, Department of Environmental Science, Policy, and Management. Berkeley, CA March 2013

American Geophysical Union Fall Meeting, San Francisco, CA December 2011

University of Maryland Baltimore County, Center for Urban Environmental Research and Education, Baltimore, MD October 2011

8th World Congress International Association for Landscape Ecology, Beijing, China August 2011

Long Term Ecological Research Science Council Meeting, Jekyll Island, GA May 2011

Ecological Society of America Annual Meeting, Pittsburg, PA August 2010

University of Puerto Rico, Department of Biology, San Juan, Puerto Rico February 2010

American Geophysical Union Fall Meeting, San Francisco, CA December 2009

Xinjiang Institute of Ecology and Geography, Chinese Academy of Science. Urumqi, China September 2009

Chinese Agricultural University, Beijing, China September 2009

University of Arizona, Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA) Tucson, AZ September 2009

Hydrological Sciences Synthesis Summer Institute. Vancouver, Canada. July 2009

South China Botanical Garden, Chinese Academy of Science. Guangzhou, China June 2008

Institute of Botany, Chinese Academy of Science. Beijing, China June 2008

University of California Irvine, Department of Earth System Science. Irvine, CA March 2008

University of California Los Angeles, Department of Civil and Environmental Engineering. Los Angeles, CA January 2008

University of Illinois Urbana-Champaign, Department of Natural Resources. Urbana-Champaign, IL March 2007

North Carolina State University, Department of Forestry and Environmental Resources. Raleigh, NC February 2007

University of California Riverside, Department of Botany and Plant Sciences. Riverside, CA February 2007

University of California Davis, College of Agricultural and Environmental Sciences. Davis, CA January 2007

Chinese Academy of Science, Institute of Botany. Beijing, China November 2006

Second International Young Scientists' Global Change Conference. Beijing, China November 2006

Monsoon Region Climate Applications: A Binational Workshop. Guaymas, Mexico May 2006

University of Washington, College of Forest Resources. Seattle, WA May 2006

Dissertation Initiative for the Advancement of Climate Change Research Symposium (DISCCRS) II. Pacific Grove, CA March 2006

University of California Davis, Department of Plant Sciences. Davis, CA June 2005

Auburn University, School of Forestry and Wildlife Sciences. Auburn, AL May 2004

Arizona Geographic Information Council Annual Meeting. Prescott, AZ August 2003

University of New Mexico, Biocomplexity Seminar Series. Albuquerque, NM April 2003

Chapman Conference on Eco-Hydrology of Semiarid Landscapes: Interactions and Processes. Taos, NM September 2002

University of Washington, Urban Ecology IGERT. Seattle, WA May 2002

Teaching and Advising

Postdoctoral Advising (14 total)
Dustin Herrmann 2020-2022; Alex Krichels 2019-2021; Julie Ripplinger 2016-2018; Jingli Yan 2016-2018; Isaac Park 2015-2017; Amin Tayyebi 2014-2016; Sheri Shiflett 2014-2015; Gudina Feyisa 2013-2014; Liyin Liang 2013-2015; Jongyoun Kim 2013; Alex Buyantuyev 2013; Patricia Oikawa 2011-2013; Karrin Alstad 2009-2010; Amitava Chatterjee 2008-2010

Ph.D. Student Advising
Completed (9 total)
Stephanie Piper 2024; Dion Kucera 2023 (NASA FIELDS Fellow); Stuart Schwab 2023; Peter Ibsen 2021 (GAANN Fellow); Holly Andrews 2021 (NASA FIELDS Fellow, NSF EAPSI Fellow); Cara Fertitta 2017 (GAANN Fellow); Steven Crum 2017; Jennifer Eberwein 2016 (EPA STAR Fellow); Lorraine Weller (NSF EAPSI Fellow) 2014

In Progress
Lindsey Zapokal

M.S. Student Advising - Completed
Anam Qayyum 2023; Lauren Velasco 2016; Kristin Hamilton 2022

Visiting Scholar Host (7 total)
Min Jiao 2018 – 2019; Zin Zhang 2015-2016; Lan Zhichun 2012-2013; Jen Hooper 2011-2013; Liangtao Li 2011-2012; Weijun Shen 2010-2011; Hou Ying 2008-2009

Undergraduate Research Advising (33 total)
Max Guditta 2024-2025; Yanina Aldeo Galvin 2021-2024; Soledad Guerrero 2019 – 2021; Melissa Le 2018 – 2019; Lashon Steward 2018-2020; Biririana Castellon 2018; Adrian Wong 2018 - 2019; Cynthia Lwin 2018-2019; Roxana Ramirez-Huerta 2017-2018 (2+2+2 Fellow); Engi Shalaby 2017; Demi Famisan 2017; Miguel Valencia 2017 (UWIN Fellow); Breanna Marquez 2017 (2+2+2 Fellow); Jacob Valasquez 2017; Andrew Loera 2017-2019; Dillon Schneider 2016 (Bridges Fellow); Sandeep Aurora 2016; Bruno Pita 2016; Mia Rochford 2015-2017; Sara Alperts 2015 (Bridges Fellow); Jeremy Gonzalez 2014; Neha Chandru 2013-2014; Colin Reis 2013; Ariana Contreras (CNAS Fellow, Chancellor's Research Fellow) 2012-2014; Jen Antes 2012-2013 (Bridges Fellow); Kyle Ricio (Chancellor's Research Fellow) 2012-2014; Alice Brown 2012; Sarah Juster (MRSP Fellow) 2011-2014; Angela Choi 2011-2013; Yuheng Ning 2011-2012; Anais Monay 2011-2012; Maeraj Sheikh (CNAS Fellow) 2010-2011; Josue Jaimes 2009-2012; Justin Richardson 2009-2010; Alea Miehls 2008-2009

Courses
University of California Riverside
- Plants and Human Affairs – 4 Credit, Undergraduate
- Introductory Ecology and Evolution – 4 Credit, Undergraduate (400+ students)
- Introductory Organismal Biology – 4 Credit, Undergraduate (400+ students)
- Applied Ecological Modeling – 2 Credit Lecture, 2 Credit Lab, Graduate
- Landscape Ecology – 4 Credit, Graduate
- Foundational and Modern Ecosystem Science – 2 Credit, Graduate

Plant Resilience to Climate Change – 2 Credit, Graduate
Sustainability Science – 2 Credit, Graduate
Ethnobotany – 2 Credit, Graduate
Introduction to Graduate Studies – 2 Credit, Graduate

University of Arizona
Ecological Responses to Global Changes – 1-3 Credit, Graduate

Arizona State University West
Ecological Modeling – 3 Credit, Undergraduate

Invited Trainer
Collaborative Graduate Student Research Workshop, Long Term Ecological Research Student Symposium, Blue River, OR

US Geological Survey (USGS) Southwest Biological Science Center (SBSC) Proposal to Provide a Technical Review of a University of California - Irvine (UCI) Report to the Borrego Springs Watermaster Board and Their Advisory Committees

Reviewer:
Pamela Nagler, Ph.D., Research Physical Scientist
U.S. Geological Survey, Southwest Biological Science Center
520 N. Park Ave., Tucson, AZ 85719
Tel: 520.670-3357, Fax: 520.670.5592, pnagler@usgs.gov
https://www.usgs.gov/staff-profiles/pamela-nagler

This US Geological Survey Cooperator Report will be provided by Dr. Pamela Nagler (pnagler@usgs.gov) of the USGS Southwest Biological Science Center (SBSC) and undergo a federally required review by two USGS approved reviewers.
Reviewer are expected to be a Hydrologist from a USGS Water Science or a Research Physical Scientist from the USGS Earth Resources Observation & Science (EROS) Center.

Summary: This proposed technical review by Nagler, to be submitted to the Board of Directors of the Borrego Springs Watermaster as a publicly accessible USGS Cooperator Report, will assess whether the best available science has been suggested and summarized in a scientific study and report submitted to the Borrego Springs Watermaster by scientists from University of California at Irvine (UCI). Nagler will evaluate the potential of groundwater dependent ecosystems (GDEs) that overlies the Borrego Spring groundwater subbasin in Southern California. In particular, this technical review will assess a Mesquite Bosque at Borrego Sink, which the Groundwater Management Plan (GMP) states the rooting depths of the mesquite (Prosopis spp.) has largely become disconnected from the regional aquifer of the Basin by ca. 1985 due to long-term declines in groundwater levels occurring since the 1940s. Stromberg (1993) reported more than 30 years ago that mesquite forests, or bosques, historically represented one of the most abundant riparian communities in the Southwest, and have been reduced to remnant status. This technical review of the UCI submission supports the USGS Ecosystems and Water Mission Areas by utilizing knowledge of ecohydrological research to serve the public. Any USGS product, in this case a technical review of the UCI study which falls under a "Cooperator Report" (as the type of USGS product) requires two USGS approved reviewers. In this case, Nagler expects to utilize a Research Hydrologist or Hydrologist from the USGS Water Science Centers in the southwestern US. Two levels of USGS reviews and approvals are required to release information both as interim presentations and as a draft report, and three levels of USGS approvals for a final report "Cooperator Report" which will be made public by the Borrego Springs Watermaster (Borrego Springs Watermaster – The official site of the Borrego Springs Watermaster ; *https://borregospringswatermaster.com/*, last accessed 15 September 2025). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the US Government.

Introduction:

This proposal provides context for my approach to reviewing a scientific study and report submitted to the Borrego Springs Watermaster by scientists from University of California at Irvine (UCI). The rationale for the review of the UCI technical study and report (not read by Nagler at this time) is that the Watermaster follows a policy regarding the use of best available science and technical information; hence, the UCI report and their findings was produced for the Watermaster. However, an independent review, such as from the USGS or another research institute, is required. This external review, and recommendations henceforth from that review, will be provided to the Technical Advisory Committee (TAC), the Environmental Working Group (EWG), and to any consultants. This review will identify the specific gaps, complexities, or potential issues that warrant a closer look, such as methodological questions or controversial findings.

Nagler will evaluate the original science study, its objectives, and its importance to the Watermaster. Scrutiny of the scientific methods presented by UCI will determine the effectiveness of their approach to determining the water requirement of the groundwater dependent ecosystem (GDE) that overlies the Borrego Spring groundwater subbasin in Southern California. Nagler will acquire and read a broad range of academic background literature, which is needed to provide a thorough review of groundwater dependent ecosystems (GDEs) in the Borrego Sink area in the Mojave Desert region of California. Nagler has provided an initial draft list of related research contributions under 'References.' In particular, a key literature search for studies of mesquite bosques in arid lands in the Mojave Desert will be necessary in order to evaluate the UCI's study and data provided for the Mesquite Bosque at Borrego Sink. For example, the ecohydrologic significance of hydraulic redistribution Scott et al., 2008) and the influence of soil texture on hydraulic properties and water relations of mesquite, a dominant warm-desert phreatophyte (Hultine et al., 2006), are some pertinent topics that can be mined for appicable findings. Furthermore, a comprehensive literature search will contain myriad methodologies which could be explored to determine if the UCI study has room for improvement or covers the broadest state-of-knowledge. With data acquired over decades, there is much spatiotemporal time series information available, data which ranges from groundwater to vegetation index from satellites (as a proxy for plant greenness and health) to climate data from point-based locations (CIMIS, https://cimis.water.ca.gov/Default.aspx) and gridded information (Daymet, PRISM). The use of Climate Engine (Huntington et al., 2017), OpenET (Melton et al., 2022; Volk et al., 2024) and multi-scalar drought indices, such as the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) could be utilized in this review of the UCI study. Furthermore, natural infrastructure in dryland streams (NIDS) store water, sediment, and carbon and provide effective nature-based solutions (Norman et al., 2022). Restoration approaches such as a) preserving water-vegetation-habitat, b) measuring long-term, bird-community response to restoration (Gonzalez-Sargas et al., 2024), c) allowing for strategic restoration planning for birds and other species (Grand et al., 2024), and d) tracking GDEs and vegetation health in riparian corridors (Nagler et al., 2020, 2021) and for Culturally Important Riparian Areas (CIRAs), Springs and GDEs (Nagler et al., 2022) are some possibilities that may provide important opportunities for water conservation efforts for the Borrego Spring area.

Background:

In the arid/semi-arid southwestern US, riparian areas (including wetlands, springs and GDEs) are estimated to be less than 2% of the total land area (Ffolliott et al., 2004), yet these ecosystems are supporting a very diverse and larger number of wildlife population, are more productive, and serve more ecological functions compared to adjacent terrestrial uplands and other ecosystems in the arid/semi-arid Southwest (Schultz et al., 2009; Zaimes et al., 2007). Yet, recent work measuring riparian ecosystem health using satellite vegetation indices (VIs) has shown an ongoing cover and productivity decline of 34-38% in greenness and actual evapotranspiration (ETa) on the much-altered Lower Colorado River since 2000 in both Mexico and the U.S. (Nagler et al., 2020, 2021). These declines come from a loss in healthy, green, riparian plant-cover, not a change in plant water use efficiency nor efficient use of managed water resources (Nagler et al., 2021). These results suggest further decline of biodiversity, wildlife habitat and other key ecosystem services. Measuring landscape vegetation greenness change is integral to predicting changes in water balance due to disturbances from drought and increasing maximum temperatures; changing patterns of precipitation and timing of monsoon rains; and increases in fire, salinity, land clearing, and land use activities (Nagler et al., 2021). Water shortage is one of the major threats to GDEs, in particular riparian corridors, GDEs, springs, and wetland ecosystems, which are considered hotspots of biodiversity and act as refuges to aquatic and terrestrial flora and fauna (Stevens and Meretsky, 2008). In drylands, more than 90% of continental precipitation returns to the atmosphere in the form of ET. A sound understanding of riparian plant transpiration and therefore the water use in arid land ecosystems is integral to predicting water balance changes.

To determine the effectiveness of the UCI study's approach to determining the water requirement of the GDE that overlies the Borrego Spring groundwater subbasin, satellite-based VI information can be used to determine changes in the GDE's vegetative greenness, density, extent and magnitude (a proxy for plant biomass, density, and health). In turn, VIs are used to calculate the GDE's ETa, and then is used in the calculation of consumptive use (CU). Ground-based mapping efforts of vegetative land cover, particularly for uncultivated arid regions (Nagler et al., 2004, 2009a), assisted in estimating ETa and CU for uniquely narrow (riparian) or small (restoration sites, springs, GDEs) landscapes (Senay et al., 2007; Murray et al, 2009; Nagler et al., 2009b, 2022a,b), but newer methodologies and models have been proposed and tested in conjunction with ancillary information (i.e., critical ecohydrological and weather variables). Notably, remote sensing-based methods have been developed, validated, and applied in a variety of biomes with remarkable results (Nagler et al., 2005, Senay et al., 2007, 2011, Murray et al, 2009). Though many of these methods use and depend on the thermal bands from medium-resolution satellites, such as Landsat; thermal data are not always collected by spaceborne Land Imagers.

There are several ways to calculate ETa, one with optical bands on satellite sensors such Landsat (30-m resolution) using the "Nagler ETa" remote sensing method (Nagler et al., 2013, 2020) or energy balance methods (SSEBop, this model is based on the Simplified Surface Energy Balance (SSEB) approach (Senay et al., 2007, 2011; see *https://www.usgs.gov/landsat-missions/landsat-collection-1-provisional-actual-evapotranspiration-product*) which utilize the thermal bands on Landsat-8 / Operational Land Imaging Spectrometer (OLI). An operational ETa using the Visible Infrared Imaging Radiometer Suite (VIIRS) and global weather datasets was recently developed

through the Simplified Surface Energy Balance Model (SSEBop) model (Senay et al., 2025). Both the optical- and thermal- band ETa models use monthly and annual time scales evaluated using eddy covariance (EC) flux tower stations. The Nagler ETa utilized sap flux data on mesquite shrubs and trees as well as a handful of other riparian species (Nagler et al., 2008, 2009a,b). This natural vegetation follows a different phenology than cropped species (Nagler et al., 2009b; Murray et al., 2009) and ETa is provided both for 16-day periods aligning with the Landsat overpass as well as peak growing season (May 1 to Oct 30) so that phenology changes year over year can be ascertained using the Phenology Assessment Metric (PAM) ETa (Nagler et al., 2020). OpenET (Melton et al., 2022; Volk et al., 2024) provides an easy opportunity to compare and contrast various ETa algorithms for the Borrego Springs GDE; however, it is important to note that the heat flux from the barren desert surrounding the Borrego Sink area in the Mojave Desert can mask the thermal signal used to measure ETa by energy balance (most of the algorithms available on OpenET) (see a comparison between SSEBop and Nagler ETa in Nagler et al., 2022c). Further confounding the use of this platform to estimate ETa for the GDE region is the surrounding mountains, which contribute to changes in wind and vapor pressure deficit (VPD) that have a relationship with ET and impact water supply and demand (some examples from recent research presented in Sept 2025 in Arizona is provided at the end of this proposal as **Supplementary Information**).

Without having read the UCI study, Nagler expects to evaluate all aspects of data utilized to prepare their report (e.g., statistical analysis, experimental design, data interpretation, validation). The objective would be to list the specific, measurable, and achievable goals of the UCI study and report in the external technical review.

Technical approach

Nagler will determine if the experimental design adequately controls for confounding variables. An evaluation will assess whether a data fusion approach is used in estimating the GDE water requirement. It will be necessary to critique the methods used by UCI for determining if the rooting depth of the GDE (mesquite bosque) remains disconnected from the regional aquifer due to long-term declines in the groundwater level as found to be in the mid-1980s. Nagler will verify and assess The UCI report to determine if the most robust and well-tested methods were applied in determining the hydrological component data, which contributes to the GDE water use (ETa), and the weather components, which drive potential ET in this area (i.e., wind, VPD, Precipitation, Temperature Max, Mean, Min), as well as soil moisture, which varies (e.g., by type, texture and salinity). An analysis of the vegetation health and water use methods should consider factors such as ecohydrological and meteorological factors, as well as sources of remote sensing imagery used in any analysis. Nagler will seek to understand any anomalies found in the study period and compare this information with previously reported findings from the literature.

A Note on Methodology to Aid in the Review Process

Before the advent of thermal imaging, ET estimation relied on optical-band (visible and near-infrared) satellite imagery, combined with modeling and scaling techniques using ground-based ET measurements. These included data from lysimeters, neutron probes, sap flow sensors, and energy and moisture flux towers. The ETa method developed by Nagler et al. (2005a,b) used field measurements of biophysical characteristics from plant species (including mesquite) in arid and

semi-arid riparian corridors. This approach offered a rapid, cost-effective, and accurate remote sensing technique specifically tailored to riparian environments. This method was extended to incorporate ground data from irrigated agricultural regions in dryland areas of the U.S. and Spain. A riparian ETa coefficient, similar to the crop coefficient, was developed and adopted by the Bureau of Reclamation's Lower Colorado River Accounting System (LCRAS) to more accurate estimate of the contributions from uncultivated areas (Nagler et al., 2009b; Murray et al., 2009). Further refinements were made by Nagler et al. (2013), who updated the 2005 greenness and weather-based ETa equation for broader application across drylands, particularly riparian zones, adjacent uplands, and agricultural lands (see Equation 1).

$$ET_{a\ (Landsat)} = ET_{o\ (weather\ station)} * 1.65(1\text{-}e^{-2.25EVI2}) - 0.169 \quad (1)$$

Equation 1 was successfully correlated with field and radiometric measurements and is now a fully validated algorithm for estimating ETa from Landsat, and other sensors using optical bands. The model was scaled from leaf to canopy to the river-reach level in western U.S. rivers that contain riparian plants including mesquite. Further improvements by using gridded weather data, such as the 1-km Daymet, or 4-km PRISM, confirmed that using gridded ETo is a suitable and robust approach for areas where point-based weather data is not available, is too far away, or is inadequately scarce. This method was successfully evaluated with superior performance for refining water accounting for the different riparian plants (trees, shrubs, grasses) considered across the Little Colorado River riparian corridors on the Navajo Nation (Nagler et al., 2022b).

Landsat based energy-balance methods were developed, tested, and used widely for different land covers; however, one of their major drawbacks for *riparian corridors*, *GDEs*, and *wetlands*, is the 'current' limit imposed by the 100-m thermal band's resolution, even though it is resampled to a 30-m common spatial resolution. This coarse resolution is not suitable for the narrow riparian corridors GDEs, or smaller areas such as restoration sites within riparian zones, not only for their small footprint, but also due to the heat flux from the adjacent desert masking the wetter corridor water fluxes. In contrast, the Nagler ETa model was scaled and adapted to Landsat 30-m visible (VIS) and near-infrared (NIR) bands and can also be used with Sentinel-2 (10 m) and other finer-resolution imagery, such as Planet or Venus, that capture the riparian corridor's smaller footprint. It can also be applied across years (i.e., from 2000 when MODIS was launched) using the Landsat time series (Landsat 5, 7, 8, and 9) if 'cross sensor' continuity is addressed. Jarchow et al. (2018) proposed a simple regression algorithm for generating reliable sensor-independent measurements that span these multiple missions. The multi-sensor methods were tested and validated across the Colorado river using MODIS (250-m) and Landsat 30-m data with an $r^2 \sim= 0.90$ for every reach of the Colorado delta to the estuary in the Gulf of California (ca. 130 km) (Nagler et al., 2020).

OpenET

The collaborative platform, OpenET (*https://etdata.org*), produces high-resolution, satellite-derived ET data to support water management, agriculture, and environmental monitoring efforts. Developed by a partnership of researchers, government agencies, and private sector stakeholders, OpenET integrates six remote sensing and energy balance models (PT-JPL, SIMS, eeMETRIC, geeSEBAL, SSEBop, and DisALEX), to estimate ETa across the western U.S. It relies on publicly available satellite data from sources such as Landsat. OpenET provides consistent ETa estimates, enabling

users to monitor water use, improve irrigation efficiency, and support data-driven policy decisions. The platform also offers cloud-based tools and APIs tailored to water resource management applications. OpenET generates ETa data with outputs at a spatial resolution of 30-m. Most of these models rely on thermal data for surface energy balance calculations of ETa. However, SIMS and PT-JPL differ by using VI data and crop type parameters instead of thermal bands. The algorithms currently available may change once the performance of each is evaluated in myriad studies across various landcover types. The landcover type where accuracy could be improved is riparian and wetlands, which would include GDEs.

Advances in estimating ETa with remote sensing have contributed to improving hydrological, agricultural, and climatological studies. Abbasi et al. (2021) evaluated the applicability of ETa using VI-based methods and crop harvested areas' time series changes for mapping and monitoring drought in arid agricultural systems in a region where a lack of ground data hampers ETa work (Abbasi et al., 2021). Following this, Abbasi et al. (2023) used the Google Earth Engine (GEE) platform to compare ETa using scaled NDVI to the performance with the ET(EVI2) and crop ET from the Lower Colorado River by comparing it to data from four USDA-ARS wheat fields. They also assessed the ease and feasibility of the transferability of these methods to other regions. Research in process evaluates the performance of OpenET platform methods in arid croplands to the Nagler ET(EVI2) method. This GEE-based algorithm uses an updated version of the Nagler ET(EVI2), termed METEVI2, which incorporates a meteorological coefficient ("M") derived from flux tower observations at 16 global sites (Abbasi et al., in review). Early results show that the non-thermal ETa approach outperforms thermal-based methods, which exhibited large variability in ETa.

OpenET accuracy can be limited over certain land cover types, particularly riparian vegetation and wetlands. This is primarily due to interference from surrounding land, such as agricultural fields or desert, which can modify the thermal signals. Additionally, moisture in these ecosystems can obscure both optical and thermal signals, complicating ETa estimation. OpenET primarily produces annual ET estimates for cropland irrigation management, however, many riparian species experience peak growth between May and October. The Nagler ETa method, by contrast, offers greater temporal flexibility, providing ETa estimates at 16-day and monthly intervals, as well as seasonal and annual scales. These temporal resolutions could be further improved by incorporating higher spatiotemporal satellite data from Sentinel, Planet, or other platforms in future work. Overall, the findings suggest that the semi-empirical Nagler ETa model is both simple and effective, offering reliable performance in narrow riparian corridors and the adjacent uplands, often outperforming the more complex and data-intensive thermal-based methods.

Machine Learning (ML) Techniques

It is feasible to explore these data with Machine Learning (ML) techniques to help identify where and when departures from normal in ET and CU are occurring. Machine Learning models and techniques are very efficient in analyzing large data records and finding any underlying correlations with the potential drivers like climate, anthropogenic factors, and management decisions. Linking these changes to management practices is also possible, and these may include groundwater pumping, drought, fire or other events, including seasonal phenological anomalies from defoliation by Tamarisk beetles (*Diorhabda* spp.) (Nagler et al., 2012, 2014, 2018; Dennison et al., 2009). This can help guide future protection and restoration activities based on how the Borrego Springs GDE

habitat health is impacted by changes of vegetation greenness and water use. Nagler expects to assess the UCI report's accurate water use and consumption values (which can serve as a validation framework for ETa estimation using Nagler ETa and the OpenET platform), which also serve to provide standard anomalies for any provided water metrics in the Borrego Springs study area.

This review of the UCI will also include working with established partners, consultants, and the Technical Advisory Committee (TAC) and Environmental Working Group (EWG) to help strategize for an improved resource management approach that leads to conserving water resources, promoting water savings, protecting habitat and/or creating a pathway for economic benefits that are strategically sustainable. The goal of this review of the UCI report is to evaluate their methods and demonstrate areas to explore and to apply (inexpensive) methodologies that could further the existing research. This external review will help decision-makers determine how water should be partitioned and allocated for the environment and for anthropogenic uses, both of which successfully serve the public.

Audiences and Product Review:

The technical review will follow the standard USGS approval process. The final review will be considered a Cooperator Report, which requires two peer-reviewers approved by the USGS. Furthermore, it requires reconciled and approved versions to meet the publication requirements assessed by the Supervisor and Deputy Center Director, and finally a review by the Bureau Approving Official (BAO) who oversees 20 USGS Centers. The final USGS approved Cooperator Report will be released to the public and hosted on the Borrego Springs Watermaster public website: *https://borregospringswatermaster.com/*.

Deliverables to the Technical Advisory Committee (TAC) and the Environmental Working Group (EWG) in the form of presentation materials will also require approvals at the USGS-SBSC (Center level approvals). Presentation materials will not be sent to two selected reviewers yet will require a Supervisory approval and Deputy Center Director approval in advance of each presentation given. This may slow the process somewhat, but it meets federal procedure for making a document public.

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USGS REQUIRES 2 FEDERAL REVIEWS OF NAGER TECHNICAL REPORT

Reviewer 1:
Libby Wildermuth
https://www.usgs.gov/staff-profiles/libby-wildermuth
USGS Arizona Water Science Center Hydrologist
lwildermuth@usgs.gov ; Tel: 520-670-3335 ; Fax: 520-670-5592
OrcID: https://orcid.org/0000-0001-5333-0968
Arizona Water Science Center, 520 North Park Avenue, Suite 221, Tucson, AZ 85719, USA

A second reviewer from these possibilities:

Reviewer 2:
Gabriel B. Senay, Ph.D., P.E. and Research Physical Scientist
https://www.usgs.gov/staff-profiles/gabriel-b-senay
USGS Earth Resources Observation & Science (EROS) Center &
USGS North Central Climate Adaptation Science Center
senay@usgs.gov ; Tel. (605) 594-2758 (o); +1 (571) 591-2097 (c);
OrcID: https://orcid.org/0000-0002-8810-8539
Fort Collins Science Center, 2150 Centre Ave, Bldg C; Fort Collins, CO 80526

Reviewer 3:
David C. Goodrich, Ph.D.
Research Hydrologist (semi-retired)
https://www.ars.usda.gov/pacific-west-area/tucson-az/southwest-watershed-research-center/people/david-goodrich/
Southwest Watershed Research Center, USDA-Agricultural Research Service
2000 E. Allen Road, Tucson, AZ 85719 USA ; Tel: (520) 647-9236

Reviewer 4:
Pat Chavez*
Adjunct Research Professor, Remote Sensing Expert (semi-retired)
https://www.researchgate.net/profile/Pat-Chavez-Jr-2
Department of Geography, Planning, & Recreation, Northern Arizona University (NAU)
19 W McConnell Dr, Flagstaff, AZ 86011 USA ; Tel: (928) 523-2492 ; Pat.Chavez@nau.edu
*Retired from the US Geological Survey (USGS) (38 years), Flagstaff, AZ

Reviewer 5:
Sattar Chavoshi, Ph.D.
Senior Hydrologist
Department of Science, University of Technology, Sydney (UTS); chsatar@gmail.com

TIMELINE

*requires two USGS reviewers and two levels of USGS approval to release information both as interim presentations and as a draft report, and three levels of USGS approvals for a final report "Cooperator Report"

Task/Deliverable	Nov 2025	Dec 2025	Jan 2026	Feb 2026	Mar 2026
Preparatory reading of UCI GDE report and TAC and EWG ideas					
Identify, acquire and categorize literature as part of review					
Summarize UCI areas for improvement					
Describe alternate approaches, suggest algorithms, models					
Submit interim draft report to USGS approved reviewers					
Send to additional hydrology reviewers for input					
Review and revise comments as they are received					
Develop the Cooperator Report in format for Watermaster Board					
Develop the Cooperator Report as a Presentation for the TAC/EWG meeting					
Send USGS revised technical report formatted as a Cooperator Report, with Responses to Reviewers comments to the USGS Center Approver					
Send USGS Presentation prepared for the TAC/EWG meeting to the USGS Center Approver					
Integrate and Respond to USGS Center Comments for both the Technical Review Report and the Revised Presentation to be prepared for the Feb joint TAC/EWG meeting					
Submit integrated USGS Center Comments for USGS Center Approval to Present Presentation and Report at the joint TAC/EWG meeting in February					
TAC/EWG meeting where USGS Presentation is provided					
Review/address/respond/revise TAC/EWG written comments on the Presentation and Technical Review Report					
Send USGS revised Technical Review Report (and any revisions to the Presentation), with the responses to the TAC/EWG comments, for USGS Center Approval (a 2nd time) this time for the Presentation to the TAC/EWG at the March Board Meeting					
Present Report with integrated TAC/EWG comments to Board in March with 2nd presentation					
Respond to March mtg TAC/EWG comments and Revise the Cooperator Report					
APRIL Board Meeting with USGS Approved Final Presentation and Report					
Submit the revised Technical Review Report, with the responses to the TAC/EWG comments, to both the USGS Center Approval and the USGS Bureau Approving Official (BAO) (April)					
Submit the revised Technical Review Report to the TAC/EWG for the April Board meeting (April)					
Publish Cooperator Report as a USGS Publication (April)					

BUDGET REQUEST

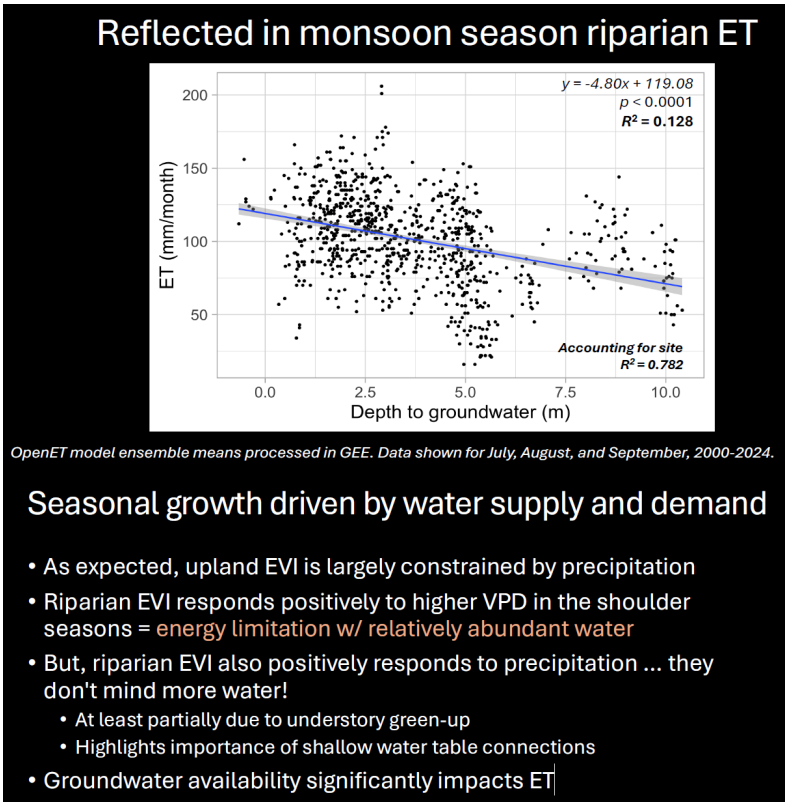
Technical Review as USGS Cooperator Report for the Borrego Springs Watermaster

	FY26 (8 PP / 16 wks)
USGS PI Nagler, Salary + Benefits (8 Pay Periods)	$75,440
Total with Overhead @52.345%	$114,929.07
Total Gross Request	**$114,929***

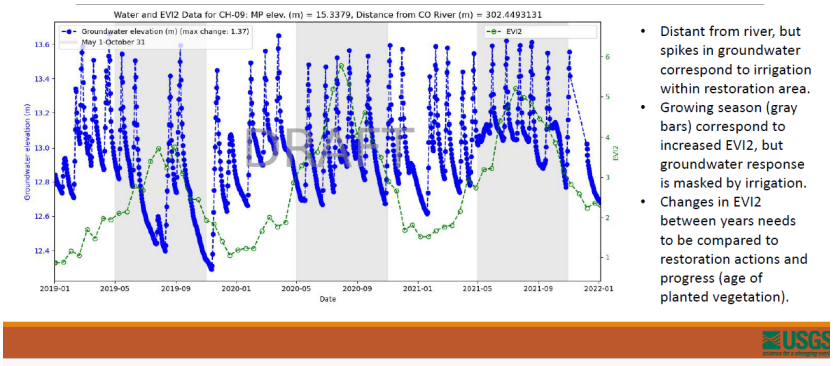
*Note that this salary request for Nagler includes ca. three months in a six-month period (November 2025 to April 2026) and includes the required salary for two Hydrology and/or Research Physical Scientists Reviewers from USGS Water Science or EROS Centers at 1-pay period (PP) each (or more if required) estimated at 2-PP for USGS reviewers.

Supplementary Information (for examples of GDE methods)

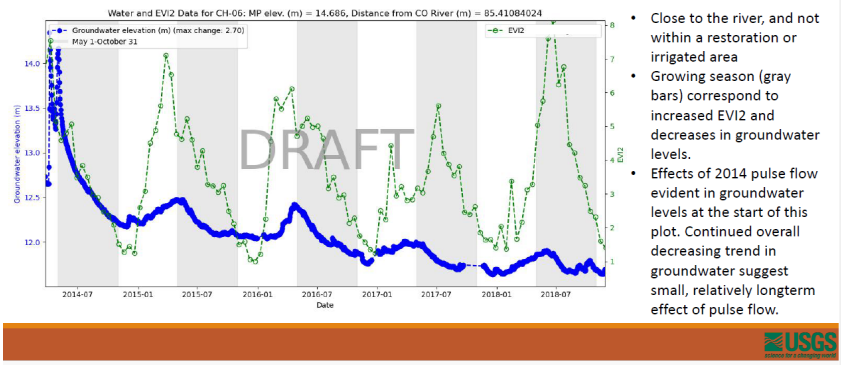
Figures of Interest from Recent USGS-Approved Presentations (Sept. 2025)



From Bromley (Sept 2025)



From Wildermuth (Sept 2025)



From Wildermuth (Sept 2025)

Hydrologic data collected should likely include groundwater levels, river discharge, and delivery volumes
Vegetation data include remotely sensed EVI2 and NDVI

Figure 2-4. Long-term groundwater hydrographs, indicating the reach number (R) and river kilometer (downstream distance from Morelos Dam) of the piezometer for which each hydrograph was recorded. Units: masl = meters above sea level; fasl = feet above sea level. Graph courtesy E. Rodríguez-Burgueño, UABC.

From Wildermuth (Sept 2025)

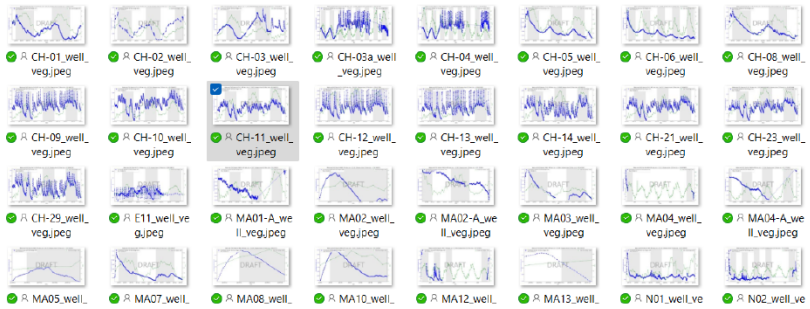
What relationships are shown in the data (groundwater level changes vs. vegetation changes, flows in the channel vs. groundwater levels, irrigation releases vs. groundwater levels)

a. Of these, which are useful to include in future reports (plots/graphs)

b. Of these, which can be built into the model, and what set of packages/conditions/boundaries would enable the model to simulate these relationships

First step towards meeting these objectives

1. What relationships are shown in the data (groundwater level changes vs. vegetation changes, flows in the channel vs. groundwater levels, irrigation releases vs. groundwater levels…)
   a. Of these, which are useful to include in future reports (plots/graphs)
   b. Of these, which can be built into the model, and what set of packages/conditions/boundaries would enable the model to simulate these relationships



Data shown are provisional and subject to revision

From Wildermuth (Sept 2025)

What can be done (from Wildermuth): Parameterize relationships observed in EVI2 and groundwater
•Apply that parameterization to the ET package of the groundwater model
•History matching with ET as a target
•Explore discretization in time and space
•Test sensitivity of model to structure and parameters in all packages (calibrate)
•Set up model for model ensembles to test scenarios chosen by Science Team

Pamela L Nagler Bio: *https://www.usgs.gov/staff-profiles/pamela-nagler*

Pamela Nagler has worked with the USGS Southwest Biological Science Center (SBSC) in Tucson, Arizona since 2005. Before this current Research Physical Scientist position within this Ecosystems area at SBSC, she started her work with the USGS in the 1980s with the USGS Water Resources Division in Atlanta, Georgia, assisting Hydrologists involved in biogeochemical studies as a Hydrological Technician. While earning a Masters' Degree from the University of Maryland in Geography with Dr. Goward (Landsat Program), she worked at the USDA-Agricultural Research Service in Beltsville, Maryland in the 1990s. She was awarded a National Science Foundation fellowship to work with the Japanese Institute for Agro-Environmental Sciences from 1996 to 1997. She credits the USDA and Japan Ministry for teaching that a key element of remote sensing research requires ground-based observation acquisition that includes biophysical and radiometric data, which are needed to formulate algorithms for scaling leaf- to plot-information to the landscape.

At the University of Arizona, she applied these skills in ground validation campaigns for cultivated and uncultivated land covers in biomes across the globe with one of the key leaders (Dr. Huete) of vegetation index (VI) algorithm development (NDVI, SAVI, EVI). And with colleagues in soils, water, and environmental sciences (Dr. Glenn), natural biosystems (NASA) and agriculture (USDA-ARS), she developed an actual evapotranspiration (ET) algorithm that has remained a viable estimation technique in arid and semi-arid landscapes even with the addition of thermal bands on Landsat-8 (Operational Land Imager, OLI), which aided in the development of energy balance equations used on public platforms that support these ET equations, such as those provided on OpenET.

Dr. Nagler's expertise includes remote sensing applications in ecohydrology with a focus on scaling ground-based plant water use measurements in drylands to estimate actual ETa, in not only uniquely narrow riparian corridors in the southwestern US, but also for wide-area/regional estimates in arid and semi-arid shrublands, grasslands, rangelands, wetlands and groundwater dependent ecosystems. Her research is in demand because accurately quantifying vegetation phenology for species (natives and invasives) improves both seasonal and annual estimates of ETa, which helps to improve consumptive use values. This importantly provides natural resource managers with simple and timely estimates for decision-making. Quantification of water availability and use in uncultivated and natural ecosystems has the potential to improve water partitioning within human and natural environments and the governing of resources for wildlife and healthy habitat.

Research Physical Scientist, Southwest Biological Science Center,
Email: pnagler@usgs.gov ; Phone 520-670-6671 ; Fax 520-670-5001 ;
OrcID: 0000-0003-0674-103X
520 North Park Avenue, Tucson, AZ 85719, USA

U.S. Geological Survey – Research Scientist Record

Pamela Nagler
Research Physical Scientist, GS-1301-15-6

Center name: Southwest Biological Science Center
Duty station: Tucson, AZ
Date of entrance on duty to federal service: June 8, 1986
Date of last promotion: September 12, 2025
Supervisor: Kathryn A Thomas

Education

Ph.D. University of Arizona, Department of Soil, Water, Environmental Science, University of Arizona, Tucson, AZ. Attended: Jan. 1998 – Dec. 2001. Major: Soil, Water, and Environmental Science; Minor: Remote Sensing and Spatial Analysis. Doctor of Philosophy, December 2001.

M.A. University of Maryland. Department of Geography, College Park, MD. Attended: Jan. 1994 – Dec. 1997. Major: Geography (Remote Sensing/Physical Science). Master of Arts, May 1997.

B.S. University of Florida. Department of Geography, University of Florida, Gainesville, FL 1989. Attended: Sept. 1987 – Dec. 1989. Major: Geography (Physical Science); Minor Certificate: Environmental Studies; Gamma Theta Upsilon Honor Society. Bachelor of Science, December 1989.

Research Interests and Expertise

1. Remote Sensing (Optical, Thermal, Hyperspectral, Imaging Spectroscopy);
2. Algorithm Development, Image Processing, Geospatial Environmental Application;
3. Hydrology, Ecohydrology and Evapotranspiration Research and Quantification;
4. Geospatial Ecology, Phenology, Dynamic Land Cover Mapping;
5. Riparian/ Wetland Ecosystems; Biocontrol, Invasive Species & Threats Assessment;
6. Southwest and Transborder Terrestrial Vegetation Health, Habitat, Water Use Monitoring;

Academic Appointment (Designated Campus Colleague)

1. College of Agriculture and Life Science, Soil, Water, and Environmental Science (SWES) Department (January 2006 – present) *https://cals.arizona.edu/SWES/erl/people/cv/pamerla_nagler.htm*
2. College of Agriculture and Life Science, School of Natural Resources and the Environment (SNRE) (2009 – present); *https://snre.arizona.edu/people/pamela-nagler-0*
3. College of Engineering, Biosystems Engineering, Vegetation Index & Phenology lab (VIP) (2019– present) *https://be.arizona.edu/person/pamela-nagler*

Board Member / Associate Editor

1. Remote Sensing Journal, Member of the Biogeosciences Section
2. Hydrological Processes Journal
3. Biological Invasions Journal
4. Springer Nature Editorial Community

Guest Editor for Special Issues

Guest Editor Assignments

1. Lead Guest Editor, Hydrological Processes, **2011.** The role of remote sensing observations and models in hydrology: the science of evapotranspiration, *25(26*). *https://doi.org/10.1002/hyp.8436*
2. Guest Contributor, Ecological Engineering Journal, **2013.** Wetlands of the Colorado River Delta, *59*. *https://doi.org/10.1016/j.ecoleng.2013.04.057*
3. Guest Editor, Ecological Engineering Journal, **2017.** Environmental Flows for the Colorado River Delta: Results of an Experimental Pulse Release from the US to Mexico, *106*(Part B), *https://www.sciencedirect.com/journal/ecological-engineering/vol/106/part/PB*
4. Guest Editor, Association of Hydrological Sciences (IAHS Red books), **2018**. Earth Observation retrievals and data products linked to the water cycle, *http://www.iahs.info*
5. Lead Guest Editor, Hydrological Processes, **2020**. A Tribute…Scientific Environmental Assessment and Applications in Hydrological Processes, *33(25)*. *https://doi.org/10.1002/hyp.14172*
6. Lead Guest Editor, Remote Sensing Journal, Biogeosciences, **2021.** Remote Sensing of Evapotranspiration III.
7. Lead Guest Editor, Remote Sensing Journal, Biogeosciences, **2023-2024**. Monitoring Ecohydrology with Remote Sensing. Guest Editors: Pamela Nagler, Tanya Doody, Sicong Gao.
8. Guest Editor, Journal of Remote Sensing, a Science Partner journal. **2024-2025**. Remote Sensing for Dryland Sustainability. Guest Editors: Xuanlong Ma, Alfredo Huete, Tanya Doody, Pamela Nagler, Alishir Kurban, Rasmus Fensholt. *https://spj.science.org/page/remotesensing/si/dryland-sustainability*
9. Guest Editor, Hydrological Processes, Identification of vegetation groundwater dependent ecosystems from field-based studies. **2024-2025**. Guest Editors: Tanya Doody, Christian Birkel, Peter Cook; Lindsay Hutley, Pamela Nagler, Steve Loheide.
10. Guest Editor, Ecological Engineering, Colorado River Delta Minute 323 Research from 2017-2027. **2025-2026.** Guest Editors: Eduardo Gonzalez-Sargas, Martha M. Gomez-Sapiens, Patrick Shafroth, & Pamela Nagler.

Research Environment

I am a Research Physical Scientist with the Terrestrial Drylands Ecology (TDE) Branch of the Southwest Biological Science Center (SBSC) in Tucson, AZ. I perform research on i) river ecosystems, ii) plant, soil, water interactions, and iii) wildlife and habitat, with the purpose of understanding environmental issues of concern to the public and to convey scientific and technical findings to project partners, end-users, colleagues, collaborators, cooperators, managers and policymakers. My funding comes from the Ecosystems Mission Area (EMA) with projects in invasive species, water availability and use, and land change science using remote sensing (RS). My role as a leader in geospatial ecological studies allows me to utilize RS tools to examine land cover change and its drivers and processes. I have achievements in RS which are both i) scientific/technical and ii) applications-based for natural resource management. I use RS to monitor vegetation health and function in the face of climate/land change and disturbances ranging from excessive heat, invasive species, and wildfire to drought, water availability, supply/delivery, evapotranspiration (ET) and consumptive water use. My research utilizes ground-based information and imagery for the discrimination, detection, and quantification of species of concern in the landscape, for the measurement and modeling of bioclimatic, ecological and hydrological processes that drive change, and for the monitoring of ecosystems and their water availability and use in drylands.

As these areas are undergoing some of the highest urban growth and most severe climate changes, managers are seeking guidance, data, information and technical approaches to resolving problems they face. I provide actionable science that aids in the preservation, conservation, restoration and management of biological and water resources to stakeholders across governments (cities, counties, states, tribes, federal) and non-governmental organizations (NGOs).

My academic service (10%) includes i) advising graduate students as a Designated Campus Colleague in three departments at University of Arizona (UofA), ii) serving as a reviewer (journals, proposals), and iii) chairing/leading sessions at regional, national and international meetings (AGU, EcoSummit, EGU, ESA). I hold three journal Associate Editorships (Biological Invasions, Hydrological Processes, and Remote Sensing) and have been the Lead Guest Editor on many Special Issues (currently three: groundwater dependent ecosystems, drylands, remote sensing measurement of evapotranspiration). I am a Board Member of FWS Sonoran Joint Venture since 2005. For nearly the same two decades, I participated annually with the Tamarisk Coalition, now Rivers Edge West, as a Working Group Leader, Co-organizer, Session Chair. As the Liaison for the USGS, I am an active participant and the USGS Board Member for the Desert Southwest Cooperative Ecosystems Services Unit (DSCESU) (2009-2012; 2022-2025). I am an invited, active participant for several USGS Science Communities of Practice. My memberships for Scientific Meetings include 35 years with the American Geophysical Union (AGU), 10 years

with the European Geophysical Union (EGU), and I am an intermittent member of the Geological Society of America (GSA), Ecological Society of America (ESA), American Water Resources Association (AWRA), and the Association of American Geographers (AAG). My Professional Experiences include membership with the USGS Executive Committees since 2017: Council of Senior Science Advisors (COSSA) / Presidential Early Career Award for Scientists and Engineers (PECASE).

Previous Professional Positions

I previously worked for the USGS from 1986-1991 as a **Hydrological Technician**. I left USGS to work in the Office of Solid Waste, EPA (Region IV) as a **Physical Scientist**, from 1991-1992. I spent the next two years (1992-1994) as a **Cartographer** for DoD, Defense Mapping Agency (now the National Geospatial Agency). In 1994, I worked two full-time positions for three months (June-August) before beginning graduate studies with a research assistantship as a **Physical Scientist** at the USDA-Agricultural Research Service (ARS) in Beltsville, Maryland (June 1994–Dec.1997). Within this period, in 1996, I was granted an NSF Fellowship in Japan and worked for nearly two years at the Remote Sensing Lab of the National Institute of Agro-Environmental Sciences, Japan Ministry of Agriculture, Forestry, and Fisheries. I returned to the U.S. to begin my Ph.D. research at the start of 1998 because I was granted a research assistantship at the University of Arizona. I was employed by the University as a Research Associate and Assistant Research Scientist from 1998 until September 2005 before beginning in my present USGS position. Although I was acknowledged for my research contributions in publications from 1988, my first journal publication was in 2000. My USGS current position as a **Research Physical Scientist** began September 18, 2005.

1. **Hydrologic Technician,** GS-1361-05, June 1986 – April 1991
   U.S. Geological Survey, Water Resources Division
   6481-A Peachtree Ind. Blvd., Doraville, GA 30360
   Supervisor: Norman Jake Peters, Ph.D.; ne_peters@mac.com (retired);
   Jamie Shanley, Ph.D., jshanley@usgs.gov
2. **Science and Mapping Technician,** November 1988 - December 1989
   KBN Engineering and Applied Sciences, 1034 NW 57th Street, Gainesville, FL 32605
   Supervisor: Robert C. McCann, Ph.D.; T. 904-331-9000 (retired)
3. **Intern,** January 1990 - August 1990
   The National Geographic Society
   Research and Exploration Division, 16th and M Streets, NW, Washington, DC 20036
   Supervisor: Barry Bishop, Ph.D. (1st American to Summit Everest, deceased)
4. **Physical Scientist**, GS-1301-09, May 1991 - September 1992
   U.S. Environmental Protection Agency
   Region IV, Office of Solid Waste; 345 Courtland Street, NE, Atlanta, GA 30365
   Supervisor: Mrs. Patricia S. Zwaig; T. 404-347-2091 (retired)
5. **Cartographer**, GS-1370-09, September 1992 - August 1994
   U.S. Department of Defense, Defense Mapping Agency (now the National Geospatial Agency)
   Scientific Data, Hydro-Topo Center (HTC); 4600 Sangamore Rd, Bethesda, MD 20816*:*
   Product Generation Department (PGD); 12310 Sunrise Valley Drive, Reston, VA 22090
   Supervisors: Mrs. Grant (HTC); T. 301-227-3252; Mr. Howard (PGD); T. 703-264-7268, retired
6. **Graduate Research Assistant,** June 1994 - December 1997

University of Maryland at College Park, Department of Geography
U.S. Department of Agriculture, Agriculture Research Service (ARS)
Hydrology & Remote Sensing Lab, 5601 Sunnyside Ave; Beltsville, MD 20705-2350
Supervisor: Craig S.T. Daughtry, Ph.D.; T. 301-504-5015 (retired)
Martha Anderson, Ph.D., martha.anderson@ars.usda.gov

7. **NSF Fellow, Summer Program in Japan 1996,** 1996 - 1997 Intermittently
Japan Ministry of Agriculture, Forestry, and Fisheries
National Institute of Agro-Environmental Sciences
Remote Sensing Lab, 3-1-1 Kannondai, Tsukuba, Ibaraki, 305
Supervisor: Yoshio Inoue, Ph.D.; T.0298-38-8159 (retired)
8. **Graduate Research Associate**, **Ph.D. research,** January 1998 - May 2000
University of Arizona; Soil, Water, and Environmental Science Department (SWES)
Terrestrial and Biophysics Remote Sensing (TBRS) Lab; Shantz, Bldg. 38, Tucson, AZ 85721
Supervisor: Alfredo R. Huete, Ph.D., Alfredo.Huete@uts.edu.au
Kamel Didan, Ph.D., didan@arizona.edu
9. **Assistant Research Scientist**, **Post-doctoral research,** June 2000 – September 2005
University of Arizona, Soil, Water, and Environmental Science Department (SWES)
Environmental Research Lab (ERL), 2601 E. Airport Dr., Tucson, AZ 85706
Supervisor: Edward P. Glenn, Ph.D., deceased; *Jon Chorover*, *Ph.D., chorover@arizona.edu*
10. **Physical Scientist (9-Factor), GS-1301-12,** September 18, 2005 – February 3, 2008
USGS SBSC Sonoran Desert Research Station, University of Arizona
520 N. Park Ave., Tucson, AZ 85719
Supervisor: Charles van Riper III, Ph.D.; Tel. 520-670-6671x267; deceased
Kathryn A Thomas, Ph.D., Kathryn_a_thomas@usgs.gov

Factor 1: Research Assignment

As a physical scientist, I utilize RS for geospatial applications in ecology using the long-term data record freely available for use by USGS/NASA and other high-resolution imagery, lidar, GIS and topographic information. Included in my data collection methods are literature reviews and data harvesting efforts of biologic and hydrologic field studies to characterize dynamics and identify what is known at discrete locations. To meet project objectives, I use data fusion methods for discriminating landcover features, for which I identify and measure changes due to environmental and anthropogenic pressures. My primary research focus is on aquatic (wet) and terrestrial (dry) ecosystems, and those in the transition zone: the riparian ecotone. Their interface is defined by disturbance and unstable physical, chemical and biotic parameters. Because water and water-dependent ecosystems are scarce in drylands, I have been drawn to ecohydrological research in these ephemeral, intermittent, or perennial surface water features or wetland areas that support aquatic, riparian, and terrestrial vegetation; these are considered hotspots of biodiversity and act as a refuge for aquatic and terrestrial flora and fauna. The riparian ecosystems in this region are <2% of the land area, yet they contain larger numbers and more diverse species, are more productive, and serve more ecological functions than adjacent terrestrial uplands and other ecosystems in the U.S. Southwest.

My research in riparian corridors utilizes ground and RS data across unique biomes that are rarely studied at both the organism and landscape scales. My field knowledge has allowed me to creatively apply biophysical data collected using ground-based measurements of plant transpiration, fractional cover and flux-tower ET and then scale to the wider area using RS. Since water use is the part of the water budget least known and most difficult to measure, quantify and validate, one of my contributions has been the novel development of an easy-to-use, empirical-based approach for the remote estimation of landscape-level, actual ET for vegetation in vast and inaccessible arid biomes; this method utilizes vegetation index (VI) and meteorological data. I was the first USGS scientist to successfully scale ET to the landscape-scale across uncultivated vegetation types and to validate seasonal and annual ET for these vegetation communities despite disturbances or phenological changes. Before my contributions, there were no studies of landscape-level ET for riparian vegetation, wetlands or uplands. This expertise in geography and landscape scaling aided me in creating recently updated RS algorithms with imagery fusion methods and new weather datasets for the detection, quantification and monitoring of landscape variables, including vegetation greenness, a proxy for health, daily and annual ET and consumptive water use.

Although my primary research focus has been on riparian corridors and associated wetlands and uplands, I have also studied ecohydrology and habitats in montane areas, rangelands, shrublands, grasslands and desert scrublands in the Mojave and Sonoran Deserts. My recent research includes ET flux within riparian restoration sites, phytoremediation sites where uranium mine tailings exist, invaded ditches and canals, urban green spaces (UGS) and desert biomes with groundwater dependent ecosystems (GDE). My research is mainly conducted within the Colorado River Basin (CRB) and the Sonoran Desert, including the lands of many Tribal Nations, as well as a large extent covering the Southwest U.S. and Northwest Mexico; the Sonoran Desert has myriad transboundary biomes crossing the U.S.-Mexico border. I have published research on riparian floodplains in Australia, UGS in Australia and Europe, irrigated agriculture in Iran, and olive orchards in Spain.

I provided the first wide area estimates of riparian plant fractional cover by native species and the non-native species, saltcedar (*Tamarix* spp.) and also quantified changes to ET resulting from defoliation by the biocontrol beetle (*Diorhabda* spp.); these impacts were produced for the first time for the individual plant level and the landscape level. I was the first to measure the rate of beetle movement by remotely tracking defoliation; this has implications for other beetle-disturbed landscapes. There have been no dynamic vegetation/phenology maps created for the US-Mexico transboundary at a scale useful for wildlife management. There is also no comprehensive data about the locations of GDE in these deserts. The lack of available research focused on these data streams and in these critically important arid/semi-arid landscapes influenced my development of techniques used in data collection contributing new knowledge. My studies inform the management of natural resources, invasive species and restoration efforts for wildlife conservation in the drylands of the Southwest. By overcoming obstacles (difficult quantification of variables and a lack of methodology for measurement and scaling), I am producing new knowledge on ecosystem processes and habitat health expanding understanding of the overall ecosystem impacts from drought, fire, beetle damage, water diversions, and urbanization on the US-Mexico transboundary region, for areas within three deserts (Sonoran, Mojave, Chihuahuan), and for most landcovers in the Lower CRB (LCRB).

To facilitate the transfer of information and my research findings, I developed two novel products for the end-user: i) change maps (any time interval – daily, monthly, annually from 2000-present)

that demonstrate vegetation health, ET and dynamic phenology in vegetation and GDE communities and ii) a searchable prototype Data Explorer focused on both wetland/riparian ecosystems and arid land vegetation communities of the Sonoran Desert in the Borderlands, Navajo Nation (NN) and LCRB. My knowledge is best disseminated to the end-user community through stakeholder meetings for sharing data, answering questions and providing technical training.

Although my ET research is not global/continental in scale and does not provide a RS product, my accomplishments are universally important since they provide the first estimates of vegetation health and validated VI-based ET in the Southwest. The spatiotemporal trends that I acquire (and validate) in these uncultivated ecosystems are of great importance for improved understanding of ecohydrological processes and environmental pressures; they have not been previously studied on a landscape scale due to their size; yet these areas are critically important to the communities that need accurate data to make decisions. My science is used to form not only management decisions and strategies, but also to create new policy on both sides of the U.S.-Mexico border. My findings have encouraged new studies of ecological aspects of Earth using RS for understanding landscape vegetation health and ET.

Factor 2: Duties, Accomplishments and Related Skills

In this research position, I develop remote sensing tools for quantifying actual evapotranspiration (ET), monitoring land-water interactions between vegetation health, tracked vegetation community composition for both uncultivated, natural, ecosystems and cultivated landscapes over large spatial scales. I develop algorithms and monitoring tools relevant for watershed and ecoregional planning and decision-making related to land and water resource management for the public, which includes farmers, industry, and urban development. I create significant new avenues to contribute to important changes in theories, methods and techniques, which further existing research and address important science questions. I design new algorithms, create technological methods and applications that contribute to computational advances, further questions, and provide a path to solutions of exceptionally difficult problems. I provide technical leadership and guidance in a subject matter area of major importance to USGS, which includes natural landcover and land use health and water accounting, plant community composition changes due to fire and/or invasive species, water availability and consumption via ET.I conceive, plan and conduct investigations and lead teams of scientists in broad areas of considerable novelty and importance for which precedents are lacking in areas critical to USGS programs. My novel scientific research requires the development of new or improved techniques, procedures or methods applied to remote sensing applications in ecohydrology, landcover and land use change analyses, landscape health, riparian and phreatophyte ecosystems, plant stress and water balance, empirical modeling for natural decision support systems, and environmental monitoring and assessment for natural resource management. The scope and complexity of my research is broad and complex with problems that are exceptionally difficult to investigate and require novel approaches and new research techniques, including major development of methods to solve research areas than require further progress in scientific areas of exceptional interest to the professional community, for example forecasting changes in vegetation greenness and water use for uniquely small and covers, and those with inherent rapid change, such as riparian corridors. My results and conclusions and

data interpretations are recognized as authoritative and have an impact on important Agency programs (i.e., Land Change and Water).

1. Specializes in uncultivated and cultivated Ecosystem Water Use, actual evapotranspiration (ET) dynamics, dryland ecosystem ecology, and remote sensing-based scaling of vegetation and land cover change across arid regions containing uncultivated (natural) land covers (i.e., riparian, wetland, uplands, grasslands, shrublands, desert scrublands) and cultivated restored and agricultural lands.
2. Water Management: Developed widely adopted techniques (e.g., "Nagler ET") for scaling ET across landscapes to assess water consumption by native vs. invasive vegetation. Her work supports climate-informed water resource planning—key to managing scarce water in western basins and riparian corridors.
3. Colorado River Delta and U.S.-Mexico Water Treaty: Provides scientific support for high-stakes binational water agreements (Minute 319/323), informing restoration outcomes, water savings, and policy implementation—supporting international cooperation and transboundary water governance.
4. Ecological Restoration & Biocontrol Evaluation: Assesses vegetation cover, composition, health and ET changes due to Tamarisk biocontrol, revealing lower-than-expected water savings—critical insight for adaptive restoration and invasive species management.
5. Innovation in Remote Sensing and Machine Learning: Pioneered ET estimation using optical-only wavebands (Nagler ET(EVI2)) linked with MODIS and Landsat EVI and EVI2, leaf area index, and phenology metrics (PAM ET). Current research includes applications using AI and Machine Learning to satellite vegetation indices which may detect invasive species and ecosystem disturbances.
6. Promotes sustainable water resources management: leader for restoration and agricultural resilience, which supports goals of sustainable water accounting to strengthen agriculture.

Factor 3: Projects

USGS Ecosystems Mission Area: United States - Mexico 1944 Water Treaty
Research and Monitoring in the Colorado River Delta
A1. Minute 319: Pulse Flow to the Colorado River Delta
A2. Minute 323: Measuring and monitoring of restoration sites and unrestored areas in the Colorado River Delta
USGS Ecosystems Mission Area: Biological Threats & Invasive Species Program
A3. Invasive Species – Tamarisk: Tamarisk Beetle Dispersion Model
A4. Invasive Species - Tamarisk: Tamarisk Science to Inform Management Actions
A5. Invasive Species - Tamarisk: Southwestern Tamarisk in the Upper and Lower Colorado River Basins
A6. Invasive Species - Tamarisk: Saltcedar Science and Tools to Support Successful Resource Management Action
USGS Water Availability and Use Program: Evapotranspiration and Groundwater Flux at Southwestern Uranium Mill Tailings Sites
A7. Phytoremediation at Uranium Mill Tailings Sites
A8. Studies of Groundwater Flux and Evapotranspiration/Water Use at Uranium Mill Tailings Sites
A9. Calibration of Evapotranspiration Estimates in a Semi-arid Sagebrush Steppe
USGS-FWS Science Support Partnership (SSP)

A10. Population trends, extinction risk, and conservation guidelines for Ferruginous Pygmy Owls in the Sonoran Desert
A11. High-resolution Transboundary Vegetation Community Dynamic Map of the Sonoran and Mojave Desert Ecoregion to Support Critical Landscape Conservation Planning and Land Management Needs
A12. Meteorological Data and Water Use for Land Cover in the Transboundary Bird Conservation Region 33

Navajo Nation

A13. Riparian Ecosystem Evapotranspiration and Consumptive Use Analysis for Navajo Nation (NN) Lands within the Little Colorado River Watershed in Arizona
A14. Culturally Important Riparian Areas (CIRA) for the Navajo Nation (NN)

USGS EarthMap/ASSIST

A15. A Drought Data Explorer for the Colorado River Basin: Integrated and Dynamic Web-Based Delivery of Actionable Information
A16. Evapotranspiration Estimates for Riparian Vegetation Along the Lower Colorado River: Multi-Species Conservation Plan Restoration Sites

Data Explorer for Dynamic Mapping & Monitoring for Researchers, Stakeholders, & Partners

A17. Interactive Remote Sensing Data Explorer: An Online Platform in Support of the Colorado River Delta Ecosystems
A18. Interactive Remote Sensing Data Explorer: An Online Platform in Support of Riparian Ecosystems on the Lower Colorado Basin Rivers
A19. Interactive Remote Sensing Data Explorer: An Online Platform in Support of the Borderlands Transboundary Vegetation Dynamic Maps in the Sonoran and Mojave Desert Ecoregions for Bird Conservation Region #33
A20. Interactive Remote Sensing Data Explorer: An Online Platform in Support of the Navajo Nation's tributary and stream vegetation monitoring for riparian and Groundwater Dependent Ecosystems (GDEs) of the Little Colorado River Watershed

Sensor Fusion / Data Calibration Studies

A21. Global Drought Project: Evapotranspiration Estimates using ET(EVI2) with Flux Towers around Globe
A22. Sensor Calibration: Independent Vegetation Index-Evapotranspiration Estimates Across Globe

Factor 4: Bibliography

PUBLISHED REPORTS (n=241) (# =Journal Articles, n=115, Reviews=6)

Google Scholar: ***Pamela L Nagler***
https://scholar.google.com/citations?view_op=search_authors&mauthors=nagler+pamela&hl=en&oi=ao
Research Scientist, USGS SBSC, Verified email at usgs.gov; Cited by 10121, Sept.2025

B1. **Nagler, P.L.,** C.S.T. Daughtry, M.S. Kim, & S.N. Goward. 1995. Shortwave Infrared Spectral Reflectance of Crop Residues and Soils, pp. 23-28, *Proceedings:* American Society of Agronomy. St. Louis, Missouri, Gateway to the Future, Oct 29-Nov 3, 1995. *https://www.acsmeetings.org/future-past-meetings/*
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B5. **Nagler, P.L.,** Y. Inoue, & C.S.T. Daughtry. 1997. Shortwave Infrared Reflectance of Mixed Plant Litter and Soils Samples for Quantitative Estimation of Percent Cover, vol.2, pp. 988-991. *Proceedings:* International Geoscience & Remote Sensing Symposium (IGARSS). Singapore. Aug. 3-8, 1997. *https://doi.org/10.1109/IGARSS.1997.606359*

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B7. **Nagler**, **P.L.** 1997. Plant Litter and Soil Reflectance. *Thesis:* University of Maryland.

B8. **Nagler, P.L.,** Y. Inoue, C.S.T. Daughtry, & A.L. Russ. 1998. Shortwave Infrared Reflectance of Mixed Scenes of Soils and Crop Residues, pp. 118-121, *Proceedings:* American Society of Agronomy. Baltimore, Maryland. Oct 18-22, 1998.

B9. **Nagler**, **P.L.**, C.S.T. Daughtry, & S.N. Goward. 2000. Plant Litter and Soil Reflectance. *Journal Article: Remote Sensing of Environment*, 71(2), 207-215. *https://doi.org/10.1016/S0034-4257(99)00082-6*

B10. **Nagler, P.L.,** K. Gillon, J. Pitt, B. Snape, & E.P. Glenn. 2000. Application of the U.S. Endangered Species Act across international borders: the case of the Colorado River Delta, Mexico. *Editorial, Journal Article: Environmental Science and Policy,* 67-72. https://doi.org/10.1016/s1462-9011*(00) 00072-1 & https://ur.booksc.eu/book/5018856/381160*

B11. **Nagler, P.L.** 2001. Remote Sensing Applications: Environmental Assessment of the Colorado River Delta, Mexico. University of Arizona, Tucson, Arizona. *Dissertation:* University of Arizona. *https://www.researchgate.net/publication/253581613_Remote_sensing_applications_Environmental_assessment_of_the_Colorado_River_Delta_in_Mexico*

B12. Zamora-Arroyo*, F., **P.L. Nagler***, M. Briggs, D. Radtke, H. Rodriquez, J. Garcia, A. Huete, C. Valdez, & E.P. Glenn. 2001. Regeneration of native trees in response to flood releases from the United States into the Delta of the Colorado River, Mexico. *senior co-authors. *Journal Article: Journal of Arid Environments,* 49, 49-64. *https://doi.org/10.1006/jare.2001.0835*

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B14. Glenn, E.P., F. Zamora-Arroyo, **P.L. Nagler**, M. Briggs, W. Shaw, & K. Flessa. 2001. Ecology and conservation biology of the Colorado River Delta, Mexico. *Journal Article: Journal of Arid Environments,* 49(1), 5-16. Published: Sept. 2001. *https://doi.org/10.1006/jare.2001.0832*

B15. **Nagler, P.L.**, E.P. Glenn, & A.R. Huete. 2001. Assessment of spectral vegetation indices for riparian vegetation in the Colorado River Delta, Mexico. *Journal Article: Journal of Arid Environments,* 49(1), 91-110. Published: Sept. 2001. *https://doi.org/10.1006/jare.2001.0844*

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B17. Hinojosa-Huerta, O., **P.L. Nagler,** Y. Carrillo-Guerrero, E. Zamora-Hernandez, J. Garcia-Hernandez, F. Zamora-Arroyo, & E.P. Glenn. 2002. Andrade Mesa Wetlands of the All-American Canal. *Journal Article: Natural Resources Journal,* 42(4), 899-914. https://www.researchgate.net/*publication/257526110_Andrade_Mesa_Wetlands_of_the_All-American_Canal*

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B208. **Nagler, Pamela**, Ibrahima Sall, Martha Gomez-Sapiens, Armando Barreto-Muñoz, Christopher J. Jarchow, Karl Flessa, & Kamel Didan. 2024. Greenness and actual evapotranspiration in the unrestored riparian corridor of the Colorado River Delta in response to in-channel water deliveries in 2021 and 2022. *Journal Article: Remote Sensing*, SI in Monitoring Ecohydrology with Remote Sensing. *https://doi.org/10.3390/rs16101801*
IP-159485, BAO Approval Date: 04/06/2024

B209. Lurtz, Matthew, Ryan Morrison, & **Pamela Nagler**. 2024. On connecting hydrosocial parameters to vegetation greenness differences in an evolving groundwater dependent ecosystem. *Journal Article: Remote Sensing*, 16(14): 2536 *https://doi.org/10.3390/rs16142536*
IP-165588, BAO Approval Date: 06/13/24

B210. **Nagler, Pamela L.** 2024. DOI Remote Sensing Report, Extended Abstract: "Colorado Delta Riparian Plant Health Improvement." U.S. DOI Remote Sensing Activities Report, 2024, for the Ecosystems – Water Availability and Use Program. *https://eros.usgs.gov/doi-remote-sensing-activities/2024 and https://eros.usgs.gov/doi-remote-sensing-activities/2024/usgs/colorado-delta-riparian-plant-health-improvement*
(published June 2025)
IP-169348, BAO Approval Date: 08/14/24

B211. **Nagler, Pamela L.** 2024. DOI Remote Sensing Report, Extended Abstract: "U.S.-Mexico Borderland & Vegetation Community Map." U.S. DOI Remote Sensing Activities Report, 2024, for the Ecosystems – Land Change Science Program". *https://eros.usgs.gov/doi-remote-sensing-activities/2024 and https://eros.usgs.gov/doi-remote-sensing-activities/2024/usgs/us-mexico-borderland-and-vegetation-community-map* (published June 2025)
IP-169494, BAO Approval Date: 08/26/24;

B212. Biggs, Trent W., **Pamela L. Nagler**, Anderson Ruhoff, Triantafyllia Petsini, Michael Marshall, Stefanie Kagone, Gabriel B. Senay, George P. Petropoulos, Camila Abe, and Edward P. Glenn. 2024. *Book Chapter:* Part V: Water use and water productivity, Remote Sensing of Evapotranspiration from Croplands (Chapter 10) *in* Thenkabail, P.S., ed., Remote Sensing Handbook—Water, Hydrology, Floods, Snow and Ice, Wetlands, and Water Productivity, v. V, 2d edition. Boca Raton, CRC Press.
IP-162608, BAO Approval Date: 04/11/24 ; Disseminated by EROS 07/30/25.

B213. Petrakis, Roy E., Laura M. Norman, Miguel L. Villarreal, Gabriel Senay, MacKenzie Friedrichs, Florance Cassassuce, Florent Gomis, Pamela L. Nagler. 2024. An Ensemble Mean Method for Remote Sensing of Evapotranspiration to Estimate Water Budget Response Across a Restoration Landscape. *Journal Article:* SI Monitoring Ecohydrology with Remote Sensing, *Remote Sensing,* 16(12): 2122; *https://doi.org/10.3390/rs16122122*
IP-160120, BAO Approval Date: 03/29/24

B214. **Nagler, P.L.**, Ibrahima Sall, Armando Barreto-Muñoz, Martha Gomez-Sapiens, Karl Flessa, Armando Barreto-Muñoz, Christopher J. Jarchow, & Kamel Didan. 2024. Greenness and actual

ET in the unrestored riparian corridor of the Colorado River Delta from 2014-2022. *Journal Article:* SI Monitoring Ecohydrology with Remote Sensing, *Remote Sensing*, 16(10), 1801. *https://doi.org/10.3390/rs16101801*
IP-159485

B215. Nagler, Pamela, Ibrahima Sall, Martha Gomez-Sapiens, Karl W. Flessa, Armando Barreto-Muñoz, & Kamel Didan. 2024. Cooperator Report: Effects of in-channel water deliveries on vegetation in an unrestored riparian corridor of the Colorado River Delta in Mexico. Chapter 6 in the Third Biennial Report for Monitoring of Environmental Flows in the Limitrophe and Delta of the Colorado River and delta of the Colorado River: Tucson, Ariz., International Boundary and Water Commission (IBWC) United States and Mexico.
https://www.ibwc.gov/Files/2024_Minute_323_Monitoring_Report.pdf.
IP-151496, BAO Approval Date: 08/29/23

B216. Nagler, Pamela, Ibrahima Sall, Martha M. Gómez Sapiens, Karl Flessa, Armando Barreto-Muñoz, & Kamel Didan. 2024. Cooperator Report: Effect of water deliveries on the greenness and water use of riparian plants in restoration sites in Reaches 2 and 4 of the Colorado River Delta in Mexico from 2014-2022: Chapter 4 in the Third Biennial Report for Monitoring of Environmental Flows in the Limitrophe and Delta of the Colorado River. Tucson, Ariz., International Boundary and Water Commission (IBWC) United States and Mexico.
https://www.ibwc.gov/Files/2024_Minute_323_Monitoring_Report.pdf.
IP-156888, BAO Approval Date: 09/19/23

B217. González-Sargas, Eduardo, Pamela Nagler, & Patrick B. Shafroth. 2024. Cooperator Report: Executive Summary of the analyses and preliminary results conducted by the Birds-Vegetation-Water Group within the Binational Science Team to assess avian responses to restoration in the Colorado River Delta. Chapter 9 in the Third Biennial Report for Monitoring of Environmental Flows in the Limitrophe and Delta of the Colorado River and delta of the Colorado River: Tucson, Ariz., International Boundary and Water Commission (IBWC) United States and Mexico, May 2024.
https://www.ibwc.gov/Files/2024_Minute_323_Monitoring_Report.pdf
IP-156384, BAO Approval Date: 11/21/2023

B218. González-Sargas, E., T.D. Meehan, O. Hinojosa-Huerta, S. Villagomez-Palma, C. Dodge, M. Gómez-Sapiens, **P.L. Nagler**, & P.B. Shafroth. 2025. Bird guilds exhibit varied responses to floodplain forest restoration in the Colorado River delta, Mexico. *Journal Article:* *Journal of Arid Environments*, JAE24-781
IP-167498, BAO Approval Date: 06/30/24;

B219. **Nagler, P.L.**, Jimenez-Hernandez, E., Barreto-Muñoz, A., & Didan, K. 2025. Cooperator Report: Colorado River Delta Riparian Health as Measured by Remote Sensing: Analysis of Vegetation Trends by Remote Sensing for Minute 323, the Binational Monitoring Program, Environmental Working Group (EWG), International Boundary Water Commission (IBWC) Monitoring Report 2023-2024.
IP-176865

B220. Gonzalez-Sargas, E., T. Meehan, M. Gomez-Sapiens, O. Hinojosa-Huerta, S. Villagomez-Palma, A. Calvo-Fonseca, E. Soto, A. Melendez, P.B. Shafroth, **P.L. Nagler**, & C. Dodge. 2025. Cooperator Report: Key findings of the bird-vegetation-water Science Team of Minute 323, the Binational Monitoring Program, Environmental Working Group (EWG), a part of the International Boundary Water Commission (IBWC) Monitoring Report 2023-2024.
IP-177214.

B221. **Nagler, Pamela**, Jennie Duberstein, James Broska, Myles Traphagen, & Kamel Didan. 2025. Cooperator Report: High-resolution Transboundary Vegetation Community Dynamic Maps of

the Sonoran and Mojave Desert Ecoregion to Support Critical Landscape Conservation Planning and Habitat Management Needs. U.S. Geological Survey in cooperation with the U.S. Fish and Wildlife Service, Sonoran Joint Venture, the University of Arizona and the Wildlands Network. (USGS: *https://www.sciencebase.gov/catalog/item/66d8b12ed34eef5af66cb12d*) and FWS: *https://fws.gov ;*
IP-170033

B222. **Nagler, P.L**., Barreto-Muñoz, A., Jiménez Hernández, E., Traphagen, M., & Didan, K. 2025. Seamless high-resolution transboundary dynamic landcover map of the Sonoran and Mojave Desert ecoregion within Bird Conservation Region 33: U.S. Geological Survey Data Release, *https://doi.org/10.5066/P1NQ8VEJ* ;
IP-172881

B223. **Nagler, P.L.,** Jimenez-Hernandez, E., Sall, I., Barreto-Muñoz, A., & Didan, K. 2025. Compilation of actual evapotranspiration and vegetation indices along critical riparian zones on the Navajo Nation from 2013-2023: U.S. Geological Survey Data Release, *https://doi.org/10.5066/P13VMGER*
IP-175418; BAO Approval Date: 01/31/25;

B224. Phillips, Fred, Emily Ontiveros, Jack Schmidt, Pamela Nagler, Matthew Lurtz, Crystal Tulley-Cordova, Richard Begay, Jason John, Samuel Ebright, Andrew Boyd, & Allen Haden. 2024. Cooperator Report: Restoration Concepts: Little Colorado River Basin, Navajo Nation, Culturally Important Riparian Area Restoration Plans, for Navajo Nation.
IP-164398, BAO Approval Date: 1/10/25;

B225. Jimenez-Hernandez, **Pamela Nagler**, Emily Ontiveros, Fred Phillips, Armando Barreto-Munoz, & Kamel Didan. 2025. Cooperator Report as Presentation: Baseline Remote Data used for Restoration on the Navajo Nation: Riparian Site Quantitative Trends of Actual Evapotranspiration Using a Landsat Greenness Index. Colorado Basin Terrestrial Riparian Meeting, Boulder City, NV.
IP-173171, BAO Approval 12/2/2024

B226. Gonzalez-Sargas, E., T. Meehan, M. Gomez-Sapiens, O. Hinojosa-Huerta, S. Villagomez-Palma, A. Calvo-Fonseca, E. Soto, A. Melendez, P.B. Shafroth, **P.L. Nagler**, C. Dodge. Cooperator Report as Presentation: Key findings of the bird-vegetation-water science team, Minute 323 Binational Monitoring Program, 2023-2025. International Boundary Waters Commission, March 7, 2025.
IP-177214, BAO Approved: 03/05/2025

B227. **Nagler, P.L.,** Jimenez-Hernandez, E., Barreto-Muñoz, A., and Didan, K. 2025. Cooperator Report as Presentation: Colorado River Delta Riparian Health as Measured by Remote Sensing: Analysis of Vegetation Trends by Remote Sensing *in the* Environmental Working Group (EWG) Monitoring Report. Minute 323 Binational Monitoring Program, 2023-2025. International Boundary Waters Commission, March 7, 2025.
IP-176865, BAO Approved: 03/05/2025

B228. **Nagler, P.L**., Sall, I., Gómez-Sapiens, M.M., Flessa, K.W., Barreto-Muñoz, A., & Didan, K. 2025. Effect of water delivery and irrigation for riparian restoration in the Colorado River Delta, Mexico. *Journal Article: Restoration Ecology*, *33*(1), e14226. *https://doi.org/10.1111/rec.14226*
IP-162779, BAO Approval Date: 06/03/24

B229. Gao, S., **Nagler, P.L**., Woodgate, W., Huete, A. and Doody, T.M., 2025. Advancing broadscale spatial evapotranspiration modelling by incorporating sun-induced chlorophyll fluorescence measurements. *Journal Article: Journal of Hydrology*, p.133404.
https://doi.org/10.1016/j.jhydrol.2025.133404
IP-172126, BAO Approval Date: 04/13/24

B230. Chavoshi Borujeni, Sattar, Alfredo Huete, Biswajeet Pradhan, Hamideh Nouri, Neda Abbasi, & **Pamela Nagler**. 2025. Climate-Adaptive Urban Planning: Quantitative Assessment of Drought Impacts and Practical Strategies for Climate-Resilient Urban Green Spaces. *Journal Article: Environmental Research Communications, Submitted August 2025*
IP-178086, BAO Approval Date: xx/xx/25; (submitted 08/08/2025)

B231. Bromley, Fern, Patrick Broxton, Jiaqi Zhang, Willem van Leeuwen, **Pamela Nagler** and Jia Hu. Groundwater dependency and hydroclimatic influences on riparian and upland vegetation productivity, Upper San Pedro, Arizona, United States. *Journal Article: Hydrological Processes, Special Issue: Groundwater Dependent Ecosystems*, HYP-25-0573
IP-180542; BAO Approval Date: xx/xx/xxxx (submitted 07/02/2025)

B232. Palmquist, Emily, **Pamela Nagler**, Kiona Ogle, Claudia DiMartini, Jeffrey R. Kennedy, & Joel Sankey. 2025. A synthesis of riparian plant water use over two decades in North American drylands. *Invited Journal Article: Hydrological Processes*, HYP-25-0671
IP-180955; (submitted 07/30/2025)

B233. **Nagler, Pamela**, Emily Palmquist, Keirith Snyder, Matthew J. Johnson, Mary Anne McLeod, Eduardo Jimenez-Hernandez, Christian Edwards & Kevin R. Hultine. 2025. Revisiting tamarisk biocontrol in the western United States: ecological and societal implications. *Journal Article: Frontiers in Ecology and the Environment*.
IP-xxxxxx; (submitted 07/30/2025)

B234. **Nagler, P.L.,** Jimenez-Hernandez, E., Sall, I., Barreto-Muñoz, A., & Didan, K. 2025. Remotely sensed observations using Landsat time-series from 2000-2023 to determine water savings for riparian corridor sites in the Lower Colorado River Basin affected by tamarisk defoliation. U.S. Geological Survey Data Release, *https://doi.org/10.5066/P142ZSGY*
https://www.sciencebase.gov/catalog/item/685c2511d4be02637b051839

B235. **Nagler, P.L.,** Jimenez-Hernandez, E., Barreto-Muñoz, A., & Didan, K. 2025. Colorado River Delta Riparian Health as Measured by Remote Sensing: Analysis of Vegetation Trends by Remote Sensing in the Environmental Working Group (EWG) Monitoring Report 2023-2024. U.S. Geological Survey Data Release, *https://doi.org/10.5066/P13MDAUN*

B236. **Nagler, P.L**., Sall, I., Jimenez-Hernandez, E., Barreto-Muñoz, A., & Didan, K. 2025. Riparian trees and shrubs and their greenness and water use in the Upper San Pedro River in the USA from 2000-2023. U.S. Geological Survey Data Release, *https://doi.org/10.5066/*P13EZ676
https://www.sciencebase.gov/catalog/item/68277821d4be02693eeab33a
IP-179291 (Nagler, standalone Data Release).

B237. **Nagler, P.L**., Jimenez-Hernandez, E., Barreto-Muñoz, A., & Didan, K. 2025. Estimates of plant water use needs for Tres Rios wetland and riparian corridor based on Landsat greenness and evapotranspiration time series from 2013-2024. U.S. Geological Survey Data Release, *https://doi.org/10.5066/P1Z76FGW*
https://www.sciencebase.gov/catalog/item/6824c165d4be0236b06af62e
IP-179194 (Nagler, Data Release)

B238. **Nagler, P.L**. 2025. DOI Remote Sensing Report, Extended Abstract: "Chlorophyll Fluorescence in ET Modelling." U.S. DOI Remote Sensing Activities Report, 2025, for the Ecosystems – Water Availability and Use Program. *https://eros.usgs.gov/doi-remote-sensing-activities/2025*
IP-182660, BAO Approval Date: 09/02/2025

B239. **Nagler, P.L**. 2025. DOI Remote Sensing Report, Extended Abstract: "Colorado Delta Riparian Growth and Water Use." U.S. DOI Remote Sensing Activities Report, 2025, for the Ecosystems – Water Availability and Use Program. *https://eros.usgs.gov/doi-remote-sensing-activities/2025*
IP-182512, BAO Approval Date: 09/03/2025

B240. **Nagler, P.L**. 2025. DOI Remote Sensing Report, Extended Abstract: "Culturally Important Riparian Areas: Navajo ET." U.S. DOI Remote Sensing Activities Report, 2025, for the Ecosystems – Land Change Science Program. *https://eros.usgs.gov/doi-remote-sensing-activities/2025* IP-182692, BAO Approval Date: 09/04/2025

B241. Abbasi, Neda, Hamideh Nouri, Kamel Didan, Sattar Chavoshi Borujeni, Christian Opp, **Pamela Nagler**, & Stefan Siebert. 2025. Vegetation Index-based estimation of crop evapotranspiration - evaluation of the METEVI2 index. *Journal Article: Remote Sensing*, to be submitted.

Acknowledgements (2025)

1. Reitz, M., Volk, J.M., Ott, T., Anderson, M., Senay, G.B., Melton, F., Kilic, A., Allen, R., Fisher, J.B., Ruhoff, A. and Purdy, A.J. 2025. Performance mapping and weighting for the evapotranspiration models of the OpenET ensemble. *Water Resources Research*, 61(8), p. e2024WR038899. *https://doi.org/10.1029/2024WR038899*
2. DeJonge, K.C., Allen, R.G., Kilic, A., Thorp, K.R., Kukal, M., Marek, G.W., Altenhofen, J., Amatya, D., Blankenau, P., Datta, S. and Grabow, G., 2025. Evapotranspiration terminology and definitions. ASCE Environmental and Water Resources Institute, Evapotranspiration in Irrigation and Hydrology Committee. 2025. Evapotranspiration Terminology and Definitions. *ASCE Journal of Irrigation and Drainage Engineering*, 151(5), p.06025003. *https://ascelibrary.org/doi/10.1061/JIDEDH.IRENG-10491*

Factor 5: Professional and Scientific Review Panels

1. 2006: NASA IDS 2006 Panel – Biodiversity and Disturbance panel of the NASA Research & Education Support Services (NRESS). Crystal City, VA, July 25-27.
2. 2006: Review Board for Proposals submitted to Reclamation Science & Technology Program
3. 2006: Remote Sensing Reviewer for Methods, National Phenology Network (NSF-RCN)
4. 2006: Review Board for Proposals submitted to Kearney Foundation
5. 2006: Reclamation Science and Technology Proposal Review Panel (multiple proposals)
6. 2007: Reclamation Science and Technology Proposal Review Panel (multiple proposals)
7. 2007: Reviewer for scientific research on ecosystem and remote sensing technology for the National Institute for Agro-Environmental Sciences (NIAES), Japan
8. 2008: Reclamation Science and Technology Proposal Review Panel (multiple proposals)
9. 2008: Southern Nevada Water Authority, Reviewer for Technical ET & Remote Sensing proposals
10. 2010: Federal Training Manual for Phenology Data Collection: NPS Document Review, for the Northeast Temperate Network (NETN), USA National Phenology Network (USGS NPN), & Academic Institutes (Harvard University & University of Vermont)
11. 2011: USDA-ARS Program Review (5-year)
12. 2011: Reclamation Science and Technology Proposal Review Panel (multiple proposals)
13. 2011: USGS Team for Reviewing publications for Awarding a Best Paper
14. 2011: US Bureau of Land Management, Eco-Regional Assessment: Sonoran Desert
15. 2011: Desert Botanical Gardens, Scientific Applicant Review
16. 2012: National Fish and Wildlife Foundation Research Review
17. 2012: Southern Nevada Water Authority Proposal Review Panel (multiple proposals)
18. 2012: Review Board for Proposals submitted to Kearney Foundation
19. 2012: PhD Dissertation Review, University of Arizona
20. 2012: City of Tucson and Pima County, Santa Cruz Riparian Council Plan Review

21. 2013: CSIRO technical reviews for ET related reports
22. 2013: NASA Document Review #08-ATBD11-0001, MODIS Global Terrestrial (ET) Product (NASA MOD16A2/A3) Algorithm Theoretical Basis Document (ATBD)
23. 2014: Desert Botanical Gardens, Scientific Applicant Review
24. 2014: Nazarbayev & Oak Ridge Associated Universities Panel for Proposal Reviews
25. 2014: USDA ARS Scientific Applicant Review
26. 2014: Lancaster University College at Beijing Jiaotong University Applicant Review
27. 2015: USDA-ARS Program Review (5-year)
28. 2015: National Science Foundation, Proposal Reviewer, Sept. 15.
29. 2015: USGS Internal Review of Remote Sensing of Invasive Species for GCMRC, Oct. 20.
30. 2015: USGS RGE and EDGE Fall 2015 Ecology Panel Chair, Nov. 11-13.
31. 2015: USGS Wisdom Women in Science, Workshop Participant, Nov. 17.
32. 2016: National Institutes for Water Resource (NIWR-USGS) National Competitive Grants Program Project Reviewer
33. 2016: National Science Foundation, Proposal Reviewer, Nov. 23.
34. 2016: Desert Botanical Gardens, Scientific Career Review
35. 2017: University of Technology Sydney (UTS) PhD Dissertation Reviewer, Zunyi Xie.
36. 2017: Kuwait Project, Vegetation Team. Reviewer of Kuwait literature for State-of-Knowledge Assessment
37. 2017: USGS Internal Review of Thermal-based Remote Sensing of Evapotranspiration Methods for the USGS EROS and NCCA Science Centers
38. 2017: Nevada System of Higher Education, NV Regents Mid-Career Res. Award, Reviewer
39. 2017: Lancaster University College at Beijing Jiaotong University Applicant Review
40. 2017: USGS Internal Review of Ground and Satellite Sensors for Ecological Change and Climate Lessons in Wetlands and Uplands for USGS EROS
41. 2018: USGS Internal Review of Technical Hyperspectral Remote Sensing Methods in 2019 for the USGS Geology, Geophysics, and Geochemistry Science Center
42. 2018: Expert Witness, San Pedro River Adjudication, Requested by Justice Dept. (DoJ)
43. 2018: USGS COSSA-PECASE Workshop to Review USGS State of Science, Dec. 12, Invited (but absent due to chairing AGU session) *https://internal.usgs.gov/cossa/highlights.html*
44. 2018: IAHS Remote Sensing & Hydrology Symposium, Technical Reviewer of Research contributions for Remote Sensing of Hydrology, Water Resources & Environment
45. 2018: Nebraska Service Center, C&I Services Technical Review
46. 2018: International Review-University of Southampton, Candidate Review, Technical Ability
47. 2019: National Science Foundation (NSF) Research Review Panel
48. 2019: Invited Iran Water Conf., Panel on Remote Measurement & Monitoring of ET (postponed)
49. 2019: USDA-ARS Scientific Applicant Senior Scientist Reviewer.
50. 2019: Nevada System of Higher Education, NV Regents Mid-Career Res. Award, Reviewer
51. 2019: NASA Proposal Reviewer for Riparian Phenological Change Methods
52. 2019: International Review-Technical Proposal Review, Anja Langeveld, The Netherlands
53. 2019: International Review-Nazarbayev University Research Review Fall
54. 2020: Nevada System of Higher Education, NV Regents Faculty Award, Reviewer
55. 2020: International Review-University of Bristol, UK, Technical Fellowship Award
56. 2020: UofA, Technical Review of a Professional Development Course: Transdisciplinary Environmental Science for Society (TESS), Communication Strategies for Collaborative Research
57. 2020: USDA-ARS Long Term Agroecosystems: Walnut Gulch Experimental Watershed
58. 2020: Navajo Nation & US Dept. Justice (DoJ), Expert Witness, Little CO River Adjudication

59. 2020: NASA New Investigator Proposal Reviewer
60. 2020: USGS Internal Review of Riparian Restoration Technical Methods for WGSC
61. 2021: USGS Internal Review of Remote Sensing Monitoring Techniques for GCMRC
62. 2021: Technical review for Navajo Nation's expert witness on riparian water consumption
63. 2021: International Review-NERC Independent Research Fellowship UK-US Reviewer
64. 2021: USGS Climate Adaptation Science Centers, Climate Adaptation Postdoctoral Program
65. 2023: WRR Invited Review Request for Proposals (n=1)
66. 2023: CASC Invited Review Request for Proposal (n=2)
67. 2023: NSF Invited Review Request for Proposal Panel (n=10)
68. 2023: Participant, PECASE Selection Committee, invited by Cara Campbell, RGE/EDGE Senior Scientist, USGS Office of Science Quality and Integrity (June 2023)
69. 2023: Leader, RGE Panel Lead for Climate and Hydrological Remote Sensing, invited by Jeannie Barlow, USGS Office of Science Quality and Integrity (Sept. 2023)
70. 2024: Nomination Package for Laura Norman, Farouk El-Baz Award (Awarded, Sept).

Factor 6: Invited (not University) Presentations

Contributed Presentation List (n=200) is Available Upon Request.

C1. **Nagler, P.L.** 2001. ***Invited*** *by Charlie Sanchez (USFWS),* *Oral Presentation:* Monitoring Vegetation in the Colorado River Delta. Tucson, Arizona. January 29.

C2. **Nagler, P.L.** 2001. ***Invited*** *by Craig Daughtry (USDA-ARS Beltsville, MD),* *Oral Presentation:* The use of hyperspectral cellulose-absorption index for non-agricultural litters, and for discriminating soil and litter in mixed scenes: Results from the Agro-Environmental Institute Fellowship in Japan. AGU Meeting. San Francisco, CA. December 12.

C3. **Nagler, P.L.** 2002. ***Invited*** *by Bruce Kimball (USDA-ARS Arid Land Agricultural Research Center),* *Oral Presentation:* Remote Sensing Applications: Environmental Assessment of the Colorado River Delta, Mexico. USDA-ARS, Water Conservation Laboratory, Phoenix, AZ. Jan. 28.

C4. Rodriguez, E. Patricia, Alfredo R. Huete, David Schaub, Kamel Didan, Tomoaki Miura, Ed Glenn & **Pamela Nagler**. 2002. ***Noteworthy**** *Oral Presentation:* Application of MODIS Vegetation Indices to Monitor the Seasonal Responses and Water Use Impacts over the Colorado River Delta Area, NW Mexico. Buenos Aires, Argentina, April 8-12. *Our research in the Colorado River Delta is of interest to researchers of arid/semi-arid river Delta in other regions of the globe.

C5. Rodriguez, E. Patricia, Alfredo R. Huete, David Schaub, Kamel Didan, Tomoaki Miura, Ed Glenn & **Pamela Nagler**. 2002. *Oral Presentation:* Application of MODIS Vegetation Indices to Monitor the Seasonal Responses and Water Use Impacts over the Colorado River Delta Area, NW Mexico. Missoula, Montana. July 15-18.

C6. **Nagler, P.**, E. P. Glenn, & T.L. Thompson. 2002. ***Invited*** *by Wim van Leeuwen (U. Arizona, Office of Arid Lands),* *Oral Presentation:* Comparison of transpiration rates among riparian trees using sap flow and leaf temperature methods. 87th Annual Ecological Society of America (ESA) Meeting. Tucson, Arizona. August 4-9.

C7. **Nagler, P.**, & E. Glenn, K. Schiff, R. Romo, C. Curtis. 2003. ***Invited*** *by Susan Moran (USDA-ARS, Southwest Research Center),* *Oral Presentation:* Mapping Vegetation on the Lower Colorado River. NASA/USDA Workshop on Agricultural Decision Support System. Denver, CO. March 4-5.

C8. **Nagler, P**., & E. Glenn. 2003. ***Invited*** *by Tim Carlson (Director, Tamarisk Coalition),* Oral Presentation: Saltcedar and Native Trees: Stress Tolerance, ET Rates, & Ecophysiology. Tamarisk Symposium. Grand Junction, CO. October 22-24.

C9. **Nagler, P.**, O. Hinojosa-Huerta, R. Romo, E. Glenn, A. Huete, & C. Curtis. 2003. ***Invited*** *by Susan Moran (USDA-ARS, Southwest Research Center),* Oral Presentation: Quantifying land cover and avian habitat in the Delta of the Colorado River. 30th International Symposium on Remote Sensing of Environment. Honolulu, HI. November 10-14.

C10. **Nagler, P**., E. Glenn., R. Romo, H. Kim, & C. Curtis. 2003. ***Invited*** *by Craig Westenberg (USGS NVWSC),* Oral Presentation: Remote Sensing Tools for Vegetation Mapping and ET Estimation on the Lower Colorado River. U.S. Geological Survey (USGS). Henderson, NV. December 10.

C11. **Nagler, P**., R. Romo, & E. Glenn. 2003. ***Invited*** *by Rick Brusca (Director Arizona Sonoran Desert Museum),* Oral Presentation: Ground, Aerial, and Satellite Images of the Estuaries along the Sea of Cortez, Mexico. Colorado River Delta and Northern Gulf Ecosystems Workshop. Tucson, AZ. December 15-17.

C12. **Nagler, P.**, Curtis, C.C., & E.P. Glenn. 2004. ***Invited*** *by Pat Chavez (USGS Flagstaff).* Oral Presentation: An inexpensive digital vegetation mapping system. 4th International Symposium Mobile Mapping Technology. Kunming, China. March 29-31.

C13. Huete, A.* (speaker), K. Didan, D. Lampkin, E. Glenn, & **P. Nagler**. 2004. ***Invited*** *by Susan Moran (USDA-ARS, Southwest Research Center),* Oral Presentation: Multi-Year MODIS Time Series Analysis of Land Conversion Processes in Semiarid Regions. Multi-temporal Image Analysis and Applications - Part VIII: Land Cover Trend Analysis at the 70th ASPRS Imaging and Geospatial Information Society Meeting. Denver, Colorado, May 23-28.

C14. **Nagler, P.**, & E.P. Glenn. 2004. ***Invited*** *by Rick Brusca (Director Arizona Sonoran Desert Museum),* Oral Presentation: Ecological Models and Conservation Strategies for the Coastal Wetlands of the Northern Gulf of California. Gulf of California Esteros Working Group Workshop & Planning Proposal for Packard Foundation. Tucson, Arizona. June 17.

C15. **Nagler, Pamela L**., Edward P. Glenn, Craig Westenberg, & John Osterberg. 2005. ***Invited*** *by John Swenson (Cocopah Indian Tribe, Env. Protection Office),* Presentation: Restoration strategies for riparian vegetation in the Delta of the Colorado. Parker, Arizona. July 12-14.

C16. **Nagler, Pamela L**., Edward P. Glenn, Russ Scott, James Cleverly, Craig Westenberg, & Alfredo Huete. 2005. ***Invited*** *by Susan Moran (USDA-ARS),* Presentation: Evapotranspiration on Western U.S. Rivers Estimated by Remote Sensing and Eddy Covariance Flux Tower Data. American Geophysical Union (AGU), Special Session in Hydrology – *H23: Remote Sensing Approaches*. San Francisco, CA, Dec. 5-9.

C17. **Nagler, P**. 2006. ***Invited*** *by Alejandro Hinojosa-Corona (CICESE, Dept. Remote Sensing),* Oral Presentation: Ecological Relationships and Water Use by Native Vegetation and Exotic Saltcedar on Western U.S. Rivers. Tijuana – Ensenada, Mexico. February 2.

C18. **Nagler, P.**, E. Glenn, H Kim, W. Emmerich, R. Scott, T. Huxman, & A. Huete. 2006. ***Invited*** *by Bill Kustas (USDA-ARS, Hydrology & Remote Sensing Lab),* Oral Presentation: Seasonal and Interannual Variation of Evapotranspiration for a Semiarid Watershed Estimated by Moisture Flux Towers and MODIS Vegetation Indices. American Geophysical Union (AGU), Special Session in Hydrology, *H07: Monitoring the Terrestrial Water Cycle Through the Merger of Land Surface Models & Remote Sensing Observations*. Baltimore, MD. May 23-26.

C19. **Nagler, Pamela L**., Edward P. Glenn, Russ Scott, James Cleverly, Craig Westenberg, & Alfredo Huete. 2006. ***Invited*** *by Gary Hansen (Colorado River Indian Tribe),* Presentation: Lessons Learned: Recent Ecology of the Colorado River Delta. Parker, AZ, October 17-19.

C20. **Nagler, P.** 2006. ***Invited*** *by Prof. Shunlin Liang (U. Maryland),* Oral Presentation: Estimated Evapotranspiration of Large-Area Saltcedar Stands on the Lower Colorado River, USA (**科罗拉多河下游大面积柽柳立地蒸散估计)**. The Chinese Academy of Sciences, Institute for Geographic Sciences & Natural Resources Research, Earth Observation, Ecosystem & Human Activities. International Partnership Project on "Human Activities and Ecosystem Changes." Peking University in Beijing, China. Dec. 21-23.

C21. **Nagler, P.**, & E. Glenn. 2007. ***Noteworthy**** Oral Presentation: Regeneration of Native Trees and Wetlands: Results of an Unplanned, Twenty Year Experiment in the Colorado River Delta, Mexico. American Geophysical Union (AGU), Special Session in Hydrology, *H29--Geomorphic, hydrologic, and ecologic linkages in a transborder dryland river--The Colorado River.* Acapulco, Mexico. May 22-25. ***This was the first data to demonstrate long-term impact of fire & flows on age & health of native tree cohorts (published).*

C22. **Nagler, P.** 2007. ***Noteworthy**** Poster Presentation: Relationship Between Evapotranspiration and Precipitation Pulses in a Semiarid Rangeland Estimated by Moisture Flux Towers and MODIS Vegetation Indices. American Geophysical Union (AGU), Special Session in Hydrology, *H19-- Land Surface Hydrology of the North American Monsoon Region*. Acapulco, Mexico. May 22-25. ***Although a poster, this scaling of ET and Precipitation in semi-arid rangelands with medium-resolution satellite imagery was the first research to demonstrate soil moisture holding capacity in the ecosystem from year-to-year during periods of drought (published).*

C23. **Nagler, P.** 2007. ***Invited*** *by Ann Bleed (Director, Nebraska Department of Natural Resources),* Oral Presentation: Estimates of Evapotranspiration Rates by Tamarisk Using a Combination of Ground and Remote Sensing Methods. Nebraska Water Law, Policy and Science Conference. University of Nebraska Water Center. Lincoln, NE. March 26-27.

C24. **Nagler, P.,** & E. Glenn. 2007. ***Invited*** *by Stephen Sebestyen (USDA-FS),* Oral Presentation: Hydrology and Ecology of the Colorado River Delta in the Face of Changing Climate and Land Use Practices: the Next Fifty Years. American Geophysical Union (AGU), Special Session in Global Change, *GC24-Environmental Monitoring: Luxury or Necessity?* SanF, CA. Dec. 10-14.

C25. Hultine, K., & **P. Nagler.** 2008. ***Invited*** *by Jim Ehleringer (U. Utah),* Oral Presentation: Tamarisk (*Tamarix*) water flux patterns before, during and after episodic defoliation by the saltcedar leaf beetle on the Colorado Plateau, USA. International Society for Horticultural Science, 7th International Workshop on Sapflow. Seville, Spain. Oct. 21-24.

C26. Glenn, E., & **P. Nagler**. 2008. ***Invited*** *by Tim Carlson & Stacy Beaugh (Directors, Tamarisk Coalition)* Oral Presentation: Tamarisk and Russian Olive Water Use Compared to Native Vegetation on Western U.S. Rivers. CO River Saltcedar Ass. Panel. Santa Cruz, CA. Nov. 10-12.

C27. **Nagler, Pamela L.**, & Edward P. Glenn. 2008. ***Invited*** *by Kate Kitchell (SBSC Center Director),* Oral Presentation: Water Use by Riparian Plants on the Lower Colorado River. **Water Education Foundation** (WEF): Colorado River Basin Science & Resource Management Symposium, Scottsdale, Arizona. November 18–20.

C28. **Nagler, P.**, & E. Glenn. 2008. ***Noteworthy**** Oral Presentation: Scaling sap flux measurements of grazed and ungrazed shrub communities with fine and coarse-resolution remote sensing in Monument Valley, Arizona. American Geophysical Union (AGU), Special Session in Biogeosciences, *B40: Interpretation of vegetation biophysical processes using xylem sap flux data and remote sensing techniques*. San Francisco, CA. Dec. 15-19.
***Data from the Navajo Nation provided the first effects of grazing on arid shrubland transpiration rates and provided scaled evapotranspiration (ET) for the valley (published).*

C29. **Nagler, P.** 2009. ***Noteworthy**** Oral Presentation: Comparative Water Use by Native and Non-Native Riparian Species on Western U.S. Rivers. Tamarisk & Russian Olive Research Conference.

Reno, NV. Feb. 18-19. ***Water use data presented to myriad end-users and natural resource managers for uncultivated riparian species in arid lands that contrasted native and non-native species at the river reach scale.***

C30. **Nagler, P.** 2009. ***Noteworthy* & Invited*** *by Alfredo Huete (U. Arizona, Terrestrial Biophysics and Remote Sensing Lab), Poster Presentation*: Combining ground and remote sensing methods to scale riparian and agricultural water use over the Lower Colorado River. The 4th Global Vegetation Workshop, University of Montana: Long term global monitoring of vegetation variables using moderate resolution satellites. Missoula, MT. June 16-19. ***Despite being a poster presentation, this research highlighted the use of MODIS imagery for estimating actual ET of riparian woodland corridors cheaply & quickly for land/water managers (published).***

C31. **Nagler, P.** 2009. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: The Myths About Saltcedar. For USGS Leadership: USGS NRP (Water) and BRD (USGS Biological Resources) Scientists & Managers***** (*noteworthy*). Tucson, AZ. May 19-21.

C32. **Nagler, P.** 2009. ***Invited*** *by Kristin Byrd (USGS WGSC),* Poster and Oral Presentations: (i) Scaling Riparian and Agricultural ET … from MODIS. Part I. Description of method, and (ii) Part II. Application to the Lower Colorado River in the US. USGS Western Region Postdoctoral/New Researcher Colloquium. Menlo Park, CA. September 21.

C33. **Nagler, P.** 2009. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Activities Related to Tamarisk Science Studies. For USGS Leadership: Sharon Gross, USGS Invasive Species Program Coordinator***** (*noteworthy*). Phoenix, AZ. December 3.

C34. **Nagler, P.** 2009. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Scaling Riparian and Agricultural ET in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, & MODIS EVI. For USGS Leadership: Sue Hazeltine, USGS Biological Resources Division Chief***** (*noteworthy*). Tucson, AZ. Dec. 8. **This was the first time a simple, optical-band onl,y remote sensing method that was validated with ground measurements was used to estimate water use of riparian woodlands and adjacent agriculture which improved water balance estimates for the LCR (published).*

C35. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Scaling Riparian and Agricultural ET in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, & MODIS EVI. For USGS Leadership at the Flagstaff Science Center***** (*noteworthy*). Flagstaff, AZ. April 5. **This was the first time a simple, optical-band only remote sensing method that was validated with ground measurements was used to estimate water use of riparian woodlands and adjacent agriculture which improved water balance estimates for the LCR (published).*

C36. **Nagler**, **Pamela**. 2010. ***Invited*** *by Terry Slonecker (USGS, Geology, Geophysics & Geochemistry SC), Oral Presentation:* Narrow-band Cellulose Absorption Index and multi-temporal indices in study of plant litter, soils, green plants and riparian vegetation, Special Session: *Hyperspectral Remote Sensing Applications at USGS.* Amer. Assoc. Geographers (AAG). Wash., D.C. April 14-18.

C37. **Nagler**, **Pamela**. 2010. ***Invited*** *by Craig Daughtry (USDA-ARS Beltsville, MD; Remote Sensing Lab), Oral Presentation:* Scaling Riparian and Agricultural Evapotranspiration (ET) in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, and MODIS EVI. Beltsville, Maryland. April 14-18.

C38. Kokaly* (speaker), Raymond, **Nagler, P**., Daughtry, C., Olssen, A., & Morrisette, J. 2010. ***Noteworthy* & Invited*** *by NASA Goddard, Oral Presentation*: Application of hyperspectral, narrow-band Cellulose Absorption Index in study of the invasive species *Pennisetum ciliare* (buffelgrass) combined with thermal band remote sensing measurement of land surface temperature and

ground-based air temperatures for early detection and resulting water use. HyspIRI Science Symposium on Ecosystem Data Products. Greenbelt, MD. May 4.
***This remote sensing research provided the first use of my thesis research on the development of a hyperspectral index, CAI, for comparing invasive grasses against desert shrubs and soils based on senescent cellulose features in the short-wave infrared*.

C39. **Nagler**, **Pamela**. 2010. ***Invited*** *by Julio Betancourt (USGS), Oral Presentation:* Application of hyperspectral, narrow-band Cellulose Absorption Index in study of the invasive species *Pennisetum ciliare* (buffelgrass), Special Session: *Science and management priorities for mitigating the impacts of buffelgrass invasion and novel fire regimes in the Sonoran Desert.* First Annual Buffelgrass Workshop. Tucson, AZ. May 5.

C40. **Nagler**, **Pamela**. 2010. ***Invited*** *by Alfredo Huete (U. Arizona, Terrestrial Biophysical & Remote Sensing Lab), Oral Presentation:* Modeling the phenology and spread of tamarisk beetle infestation and impact on water savings, Special Session - *Land*: including Land Degradation and Land Process studies with remote sensing. ISPRS Commission VIII Symposium. Kyoto, Japan. August 9-12.

C41. **Nagler**, **Pamela**. 2010. ***Invited*** *by Prof. Rick Allen (Idaho), Oral Presentation:* Scaling Riparian and Agricultural Evapotranspiration (ET) in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, and MODIS EVI. Remote Sensing and Hydrology Symposium, Jackson Hole, WY. September 27-30.

C42. **Nagler**, **Pamela**. 2010. ***Invited*** *by Prof. Chris Neale (Utah State), Oral Presentation:* Monitoring impacts of *Tamarix* leaf beetles (*Diorhabda elongata*) on the leaf phenology and water use of *Tamarix* spp. using ground and remote sensing methods. Remote Sensing and Hydrology Symposium, Jackson Hole, WY. September 27-30.

C43. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Rama Kotra (USGS Office of Science Quality and Integrity (OSQI))* for Award at the USGS Western Regional Awards Ceremony. DOI and USGS Leadership: Marcia McNutt, USGS Director and Science Advisor to the Secretary of DOI, and Anne Castle, Assistant Secretary for Water and Science* (*noteworthy*). Reston, VA. October 15.

C44. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Monitoring impacts of *Tamarix* leaf beetles (*Diorhabda elongata*) on the leaf phenology and water use of *Tamarix* spp. using ground and remote sensing methods. For USGS Leadership Team: USGS Western Region Center Directors and Regional Executives Annual Meeting***** (*noteworthy*). Flagstaff, AZ. October 26.

C45. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Field Trip Guide and Road Trip Log; plus Invited Roadside Talk: Tamarisk – State of Knowledge: Its Water Use and Ecology on Western U.S. Rivers. For USGS Leadership: USGS Western Region Center Directors and Regional Executives Annual Meeting* (*noteworthy*). October 26-28. Flagstaff, AZ. October 27.

C46. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Water relations, tamarisk, tamarisk beetle, and other projects on buffelgrass and hyperspectral remote sensing, Science Session: Riparian/Aquatic Ecosystems Overview and Science Presentations, moderated by Barb Ralston. USGS SBSC All Hands Meeting & USGS Western Center Directors* (*noteworthy*). Flagstaff, AZ. November 29-December 2.

C47. **Nagler, P.** 2010. ***Noteworthy* & Invited*** *by Marcia McNutt (USGS Director) to attend the Award Ceremonies for the* Presidential Early Career Award for Scientists and Engineers (PECASE). First honored by Deanna Archuleta, Deputy Assistant Secretary for Water and Science, and the Hon. Dr. Carl E. Wieman, Associate Director for Science, Office of Science and Technology Policy, at the U.S. Department of Agriculture Building; then honored by **Director John P. Holdren,** Director of the

Office of Science and Technology Policy, and President Obama, **Executive Office of the President, at the** Executive Office Building. Washington, D.C. December 13.

C48. **Nagler**, **Pamela**. 2011. ***Invited*** *by John Osterberg (Reclamation), Oral Presentation:* Scaling Riparian & Agricultural Evapotranspiration (ET) in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, and MODIS EVI. Evapotranspiration (ET) Conference. Ohio Alliance Universities. Las Vegas, NV. February 23-25.

C49. **Nagler, Pamela**. 2011. ***Invited*** *by Kate Kitchell (SBSC Center Director), Oral Presentation:* Regional-scale impacts of Tamarix leaf beetles (*Diorhabda carinulata*) on leaf phenology and water use of Tamarix spp. determined by ground and remote sensing methods. USGS SBSC Climate and Land Use Change Symposium for Matt Larsen (USGS Associate Director, Climate and Land Use Change) and Bruce Quirk (Land Remote Sensing Program). Flagstaff, AZ. March 4.

C50. Glenn, Edward* (speaker), & **Pamela Nagler**. 2011. ***Invited*** *by Jeff Milliken (Reclamation)*, *Oral Presentation*:* Remote Sensing Applications for US-Mexico Border Water Management. Workshop for Transboundary Water Allocations with California Dept of Water Resources, Jet Propulsion Lab (JPL), ARC, MSFS, Water Education Foundation (WEF). San Diego, CA. June 8-9.

C51. **Nagler, Pamela**, Edward Glenn, & Alfredo Huete. 2011. ***Invited*** *by Jennifer Pitt (Environmental Defense), Oral Presentation:* Vegetation index methods for estimating evapotranspiration by remote sensing. University Council on Water Resources (UCOWR), The National Institutes for Water Resources (NIWR) Conference: Planning for tomorrow's water: snowpack, aquifers, and reservoirs. Boulder, CO. July 11-14.

C52. **Nagler, Pamela**. 2011. ***Invited*** *by Prasad Thenkabail (USGS-Geog), Oral Presentation:* Comparison of evapotranspiration (ET) models using remote sensing. USGS Powell Center Special Session *Water Use/ET Modeling Effort for Global Croplands and Their Water Use for Food Security in the Twenty-first Century.* Ft. Collins, CO. September 26-30.

C53. **Nagler**, **Pamela**. 2011. ***Invited*** *by Marcia McNutt & Kavli (USGS Director), Oral Presentation:* Regional-scale impacts of the *Tamarix* leaf beetles (*Diorhabda carinulata*) on the leaf phenology and water use of *Tamarix* spp. U.S. National Academy of Sciences (NAS) and the Chinese Academy of Sciences (CAS), 14th Annual Chinese-American Kavli Frontiers of Science Symposium. Shenzhen, China. November 5-7**.**

C54. **Nagler**, **Pamela.** 2011. ***Invited*** *by Sharon Megdal (Director of The University of Arizona Water Resources Research Center, WRRC), Oral Presentation:* Regional-scale impacts of Tamarix leaf beetles (*Diorhabda carinulata*) on leaf phenology and water use of Tamarix spp. on western U.S. rivers. American Water Resources Association (AWRA). Albuquerque, NM. November 7-10.

C55. **Nagler, Pamela**. 2011. ***Invited*** *by Julia Fonseca (Pima County, AZ, Sustainability & Conservation Senior Planning Manager)*, *Oral Presentation:* Monitoring riparian vegetation with remote sensing and ground data. San Pedro Riparian National Conservation Area (SPRNCA) Technical Meeting, University of Arizona, Tucson, AZ. July 6-7.

C56. **Nagler, Pamela**, & Edward Glenn. 2012. ***Invited*** *by Prof. Georgianne Moore (Texas A&M), Oral Presentation*: Ecohydrology of saltcedar (Tamarix spp.) in the western United States and implications of water balance following a biocontrol agent introduction. American Geophysical Union (AGU), Special Session in Hydrology, *H04: `Ecohydrology of Novel Ecosystems`.* San Francisco, CA. December 3-7.

C57. **Nagler, Pamela**. 2012. ***Invited*** *by John Hoffmann (AZWSC Director), Oral Presentation:* Eco-hydrology of saltcedar (Tamarix spp.) in the western United States and implications of water balance following a biocontrol agent introduction. USGS Lunch Talk, Tucson, AZ. Nov. 9.

C58. **Nagler, Pamela.** 2013. ***Invited*** *by Ian Overton (CSIRO Land and Water Director)*, *Oral Presentation:* Ecohydrology of terrestrial ecosystems in an era of rapid change Ecohydrology of

saltcedar (*Tamarix* spp.) in the western United States and implications of water balance following a biocontrol (beetles) introduction. CSIRO Land and Water Flagship, Adelaide, Australia. Feb 13.

C59. **Nagler, Pamela.** 2013. ***Invited*** *by Carol Couch (CSIRO Land and Water Theme Leader)*, *Oral Presentation:* How regional climate change will affect local & basin-scale riparian vegetation, water use and habitat on the Murray-Darling Basin (MDB), as a focal point in Australia, and as a proof of concept study for forecasting the potential changes in riparian vegetation in response to climate variability and climate change. CSIRO Flagship and Stream Leaders: A presentation of Nagler OCE Award Research. CSIRO Headquarters, Canberra, Australia. March 1.

C60. **Nagler, Pamela**. 2013. ***Invited*** *by Paul Bertsch (CSIRO Land and Water Chief)*, *Oral Presentation:* Forecasting the effects of climate change on riparian ecosystems along the Murray-Darling Basin in response to reduced water availability. CSIRO. Adelaide, Australia. April 15.

C61. **Nagler, Pamela**. 2013. ***Invited*** *by Rod Oliver (CSIRO Land and Water Stream Leader)*, *Oral Presentation:* Forecasting the effects of climate change on riparian ecosystems along the Murray-Darling Basin in response to reduced water availability. CSIRO. Adelaide, Australia. April 22.

C62. **Nagler, Pamela**, Tanya Doody (presenter), Edward Glenn, Kiyomi Morino, & Kevin Hultine. 2013. ***Noteworthy**** *Poster Presentation*: Phreatophytes under stress: review of studies on transpiration and stomatal conductance of Tamarix across a western U.S. floodplain. International Society for Horticultural Science, 9th International Workshop on Sap Flow. Ghent, Belgium. June 3-7. ***Despite being a poster presentation, this research provided a key contribution comparing physiological responses for groundwater dependent species for land/water managers*.

C63. **Nagler, Pamela**, Edward Glenn, Kevin Hultine, & Kiyomi Morino. 2013. ***Invited*** *by Craig Daughtry (USDA-ARS, Hydrology & Remote Sensing Lab), Oral Presentation:* Environmental controls on saltcedar (*Tamarix* Spp.) transpiration and stomatal conductance and implications for determining evapotranspiration of saltcedar stands by remote sensing. International Geoscience and Remote Sensing (IGARSS), Special Session, *Impact of Remote Sensing Programs II*. Melbourne, Australia. July 22-26.

C64. **Nagler, Pamela**. 2013. ***Invited*** *by Rod Oliver (CSIRO Land and Water Stream Leader), Oral Presentation:* Final CSIRO OCE Award Project Results: Forecasting the effects of climate change on riparian ecosystems along the Murray-Darling Basin in response to reduced water availability. CSIRO Adelaide, Australia. CSIRO OCE Distinguished Visiting Scientist Final Report and Presentation. CSIRO Adelaide, Australia. Dec. 5.

C65. **Nagler, Pamela**. 2014. ***Invited*** *by NASA/USGS to Chair AGU Panel: After the pulse flow: Greening the Colorado River Delta. https://www.nasa.gov/content/goddard/2014-nasa-agu-events/#coloradoriver*. American Geophysical Union, San Francisco, CA. December 17.

C66. **Nagler**, **Pamela**. 2015. ***Noteworthy* & Invited*** *by USGS (Bruce Quirk), Presentation:* Use of unmanned aerial systems (UAS) for detection & monitoring of invasive plant species in western riparian corridors. For USGS/NASA/Federal Agencies.* Unmanned Aerial Systems (UAS) 1st Inter-Agency Technical Workshop. Reston, VA (USGS Headquarters)* (*noteworthy*). May 19-21.

C67. **Nagler**, **Pamela**. 2015. ***Invited*** *by Craig Daughtry (USDA-ARS, Hydrology & Remote Sensing Lab), Oral Presentation*: Use of unmanned aerial systems (UAS) for detection and monitoring of Buffelgrass and Tamarix in the Southwestern USA. USDA-ARS. Beltsville, MD. May 22.

C68. Jarchow* (speaker), C. J., **P.L. Nagler**, & E. P. Glenn. 2015. ***Noteworthy* & Invited*** *by Karl Flessa (U. Arizona, Geosciences Dept.), Oral Presentation:* Response of Riparian Vegetation to the Minute 319 Environmental Pulse Flows to Mexico: Greenup and Evapotranspiration by Remote Sensing. Policy and Decision Makers Tour for the Minute 319 Flows to the Colorado River Delta in Mexico* *(noteworthy*). Mexicali, Sonora, Mexico. November 5. *student.

C69. **Nagler, Pamela L**., Edward P. Glenn, Christopher J. Jarchow, Armando Barreto-Muñoz, Kamel Didan, Hamideh Nouri, Sharolyn Anderson, & Tanya M. Doody. 2015. ***Invited*** *by Gabriel Senay (SBSC-EROS),* Oral Presentation: Estimating wide-area evapotranspiration at multiple scales using optical vegetation index methods. American Geophysical Union (AGU), Special Session in Hydrology - *H045: Evapotranspiration: Advances in In Situ Measurements and Remote Sensing Based Modeling Approaches*. San Francisco, CA, Dec. 14-19.

C70. **Nagler, Pamela L.,** Christopher J. Jarchow, Charles van Riper III, Uyen Nguyen, & Edward P. Glenn. 2016. ***Invited*** *by Prof. Daniel Potts* (State University of New York College at Buffalo), Oral Presentation: Estimating wide-area greenness and evapotranspiration in riparian corridors at multiple scales using optical remote sensing vegetation index methods. 101st Ecological Society of America Meeting, Special Session *#11731: Ecosystem Consequences of a Changing Water Cycle in the Southwest*. Ft. Lauderdale, FL. August 7-12.
IP-073344

C71. **Nagler, Pamela L**., Uyen Nguyen, Heather Bateman, Dan Bean, Christopher J. Jarchow, Patrick Shafroth, Jody Waugh, Charles van Riper III, & Edward P. Glenn. 2017. ***Invited*** *by Rusty Lloyd (RiversEdge West Director),* Oral Presentation: Defoliation of Saltcedar (Tamarix spp.) by Saltcedar Beetles (*Diorhabda carinulata*) in the Upper Colorado River Basin: Potential for Water Savings. Tamarisk Coalition Conference. Fort Collins, CO. February 7-9.
IP-080809

C72. **Pamela L. Nagler,** Waugh, W. Joseph, John Vogel, Christopher J. Jarchow, & Edward P. Glenn. 2017. ***Noteworthy* & Invited*** *by Johnathan Stock (USGS National Innovation Center),* Poster: Effects of Changes in Tamarisk Evapotranspiration on Groundwater Flow and Contaminant Transport at a Southwestern Uranium Mill Tailings Site. USGS and Federal Partners UAS Meeting, NASA Ames Research Center* *(noteworthy audience with myriad Federal Agencies; Virginia Burkett (USGS, Chief Scientist for Climate and Land Use Change), keynote speaker and she highlighted my drone project results on invasives & GW flux)*. Moffett Field, CA. Mar. 28-31.
IP-082432

C73. **Nagler, Pamela L.,** Uyen Nguyen, Heather L. Bateman, Christopher J. Jarchow, Edward P. Glenn, William J. Waugh, & Charles van Riper III. 2017. ***Invited*** *by Arjen Hoekstra,* Oral Presentation: A review of the Northern Tamarisk beetle (*Diorhabda carinulata*) and tamarisk (*Tamarix* spp.) interactions in the Colorado River basin in the Western USA. Water Engineering and Management, Faculty of Engineering Technology, University of Twente, Enschede, The Netherlands. October 11.
IP-090707

C74. **Nagler, Pamela L**., Christopher J. Jarchow, and Edward P. Glenn. 2017. ***Invited*** *by Bob Su,* Oral Presentation: Water use of riparian and upland plants in the arid southwestern USA and remotely sensed measurements of wide area estimates of evapotranspiration. Spatial Hydrology and Water Resources Management, University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), Dept. Water Resources, Enschede, Netherlands. Oct. 24.
IP-091050

C75. **Nagler, Pamela** L., W. Joseph Waugh, Christopher J. Jarchow, & Edward P. Glenn. 2018. ***Invited*** *by Rusty Lloyd,* Oral Presentation: Measuring Changes in Tamarisk Evapotranspiration in a Riparian Ecosystem at Shiprock, NM. 2018 Tamarisk Coalition. Grand Junction, CO. Feb. 6-8.
IP-092450

C76. **Nagler, Pamela L.,** Christopher J. Jarchow, & Edward P. Glenn. 2018. ***Invited*** *by Prof. Chris Neale (U. Nebraska, Director for Research, Daugherty Water for Food Global Institute),* Oral Presentation: Using optical remote sensing to evaluate changes in greenness and evapotranspiration in riparian vegetation in response to the Minute 319 environmental pulse flow to Mexico, Special Session:

Earth Observation retrievals and data products linked to the water cycle, Remote Sensing & Hydrology Symposium, ICRS-IAHS Proceedings. Andalusian Institute for Earth System Research (IISTA), University of Córdoba, Córdoba, Spain. May 8-10.
IP-095466

C77. **Nagler, P.** 2019. ***Noteworthy*& Invited*** *to coordinate and host the visit by Jim Reilly, USGS Director** (*noteworthy*) *for SBSC during his visit to the Tucson, AZ USGS*. Tucson, AZ.

C78. **Nagler, P.L**., Jarchow, C.J., Barreto-Muñoz, A., & Didan, K. 2019. ***Invited*** *by Andrew French (USDA-ARS Maricopa), Oral Presentation:* Greenness and evapotranspiration in the lower Colorado River Delta in response to environmental pulse flows. USD-ARS. Maricopa, AZ. Feb. 4.
IP-102719, BAO Approved 01/30/19

C79. **Nagler, P.L.,** Jarchow, C.J., Waugh, W.J., Barreto Muñoz, A., Hermann, S., & Didan K. 2019. ***Invited*** *by Kevin Hultine (Desert Botanical Gardens), Oral Presentation:* Remote sensing estimates of evapotranspiration at a southwestern uranium mill tailings site. RiversEdge West Meeting at the Desert Botanical Gardens, Phoenix, AZ. February 5.
IP-102718, BAO Approved 01/28/19

C80. **Nagler, Pamela** research contributions. 2019. ***Invited*** *by* Sasha Reed and Seth Munson (SBSC, TDE) to contribute to their Oral Presentations*: SBSC's priority research science efforts in support of landscape management and invasive species. For USGS Ecosystem Mission & Program Area Leaders, Darrin Thome, Mark Sogge, et al. Flagstaff, AZ. Nov. 18-20.

C81. **Nagler, Pamela**. 2020. ***Invited*** *by Mark Sogge (USGS Interior Region 8 & 10 (Western) & USGS Regional Director), Oral Presentation:* Briefing on the Colorado River Delta: Two decades of greenness & ET changes. Darrin Thome, Mark Sogge, & Scott Vanderkooi. Virtual, Sept. 14.
IP-133080, BAO Approved 09/05/20

C82. **Nagler, Pamela L**., Kamel Didan, Armando Barreto-Muñoz. 2020 (virtual). ***Invited*** *by William Andrews (USGS Science Coordinator for Rocky Mountain Region), Oral Presentation:* Riparian ET in the Lower Colorado River Basin for *EarthMap,* SBSC Riparian Corridor Data for the Lower Colorado River. EarthMAP Capacity Assessment Team & Rocky Mountain Region Science Seminar and Research Exchange. September 16.
IP-123257, BAO Approved: 09/08/20

C83. **Nagler, Pamela**, Ray Kokaly, Jeff Morrisette, Aaryn Olssen, Phil Dennison, & Craig Daughtry. 2021. ***Invited*** *by Itiya Aneece (Hyperspectral Coordinator), Oral Presentation (virtual):* Exploring the cellulose absorption index from hyperspectral data for detection and monitoring of plant litter, crop residue, standing senescent vegetation and woody invasive plant species. USGS Hyperspectral Community. May 7.
IP-133087, BAO Approved 04/30/21 (abstract)
IP-133088, BAO Approved 04/30/21 (presentation)

C84. **Nagler, Pamela**. 2023. ***Invited*** *by Laura Norman (*Western Geographic Science Center*), Oral Presentation (recorded)*: From the giants of the past to the visions of the future: Using ground-validated remote sensing methods for determining actual evapotranspiration. Tucson, AZ. Nov.29.
IP-159406; BAO Approved 11/06/23;

C85. Doody, Tanya, Sicong Gao, & **Pamela Nagler**. 2023. ***Invited*** *by Gabriel Senay (EROS) Oral Presentation (in person)*: Scaling *In-situ* Tree Evapotranspiration Measurements Regionally using Random Forest Modelling. American Geophysical Union (AGU) in the *Special Session:* H058 - Evapotranspiration (ET): Advances in *In Situ* ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation. San Francisco, CA. Dec. 11-15, 2023.
https://www.agu.org/Fall-Meeting/Pages/Attend/Register
IP-160667; BAO Approved 12/08/23

C86. **Nagler, Pamela**. 2024. ***Invited*** *(in-person) by Rachel O'Connor* (Climate Resilient Water Systems, Environmental Defense Fund, for The OpenET Consortium, Senior Manager), *Oral Presentation (in person)*: Using ground-validated remote sensing methods for determining actual evapotranspiration (ETa) with a simple Vegetation Index-based equation. Open ET Workshop, Santa Ana Pueblo, NM. Feb. 27-28, 2024.
IP-161911; BAO Approved 1/24/24;

C87. Grand, Joanna, Meehan, T.D., DeLuca, W.V., Morton, J., Pitt, J., Calvo-Fonseca, A., Dodge, C., Gómez-Sapiens, M., González-Sargas, E., Hinojosa-Huerta, O., **Nagler, P.L.,** Restrepo-Giraldo, C., Shafroth, P.B., Villagomez Palma, S., & Wilsey, C.B. 2024. ***Invited*** *(in-person)* Strategic restoration planning for land birds in the Colorado River Delta, Mexico, Abstract ID# AB230. **North America Congress for Conservation Biology, Vancouver, Canada**. June 23-28, 2024
https://imis.conbio.org/imis/iCommerce/NACCB_Sign_In.aspx?ssoredirect=https://xcdsystem.com/scbna/api/imis/index.cfm later presented at the American Ornithological Society Annual Meeting, Estes Park, CO, October 1-5, 2024 in *https://meeting.americanornithology.org/*
IP-162951, BAO Approved 02/20/24

C88. **Nagler, Pamela**, Duberstein, J. N., Edo, S., Jiminez-Hernandez, E., Barreto-Munoz, A., & Didan, K. 2025. ***Invited*** *by Luiza Maria T. Aparecido* (Assistant Professor, School of Biological Sciences, University of Utah), *Oral Presentation (in person)*: Changes in Dryland Plant Community Water Use based on Vegetation Phenology in the Sonoran and Mojave Desert Ecoregion to Support Critical Landscape Conservation Planning and Habitat Management Needs, *in the Session*: Water in the Southwest: Past, present and future. Ecological Society of America (ESA), Baltimore Convention Center, Baltimore, MD, August 10-15, 2025.
IP-176342, Abstract BAO Approved 02/24/25

C89. **Nagler, Pamela**, Ibrahima Sall, Barreto-Muñoz, Kamel Didan. 2024. ***Invited*** *by Libby Wildermuth* (USGS Arizona Water Science Center), *Oral Presentation (virtual)*: San Pedro River Ecohydrological Research for Riparian Plant Greenness and Water Use. 2024 Upper San Pedro Partnership (USPP), BLM and USGS AZWSC. May 15, 2024.
IP-166072, BAO Approved 05/14/24

C90. **Nagler, Pamela.** 2024. ***Invited*** *by Paul Heimowitz (*USGS Ecosystems, Terrestrial Invasive Species Program Director), *Oral Presentation (virtual)*: The transformation of dryland rivers: The future of introduced *Tamarix* spp. U. S. Geological Survey - United States Army Corps of Engineers "Invasive Research Discovery Session." June 17, 2024
IP-166865, BAO Approved 06/06/24

C91. **Nagler, Pamela**, Duberstein, J. N., Edo, S., Jiminez-Hernandez, E., Barreto-Munoz, A., & Didan, K. 2025. ***Invited*** *(in-person) by Luiza Maria T. Aparecido* (Assistant Professor, School of Biological Sciences, University of Utah), *Oral Presentation (in person)*: Changes in Dryland Plant Community Water Use based on Vegetation Phenology in the Sonoran and Mojave Desert Ecoregion to Support Critical Landscape Conservation Planning and Habitat Management Needs, *in the Session*: Water in the Southwest: Past, present and future. Ecological Society of America (ESA), Baltimore Convention Center, Baltimore, MD, August 10-15, 2025.
IP-176342, BAO Approved 8/12/2025

Factor 7: Conference Organizer, Chair, Co-Convener

D1. Howard A. Keith, & **Pamela L. Nagler**. 2007. *Organizer and Chair*, *National Meeting, Oral and Poster Sessions*: American Geophysical Union (AGU), Special Session in Hydrology, *H29--Geomorphic, hydrologic, and ecologic linkages in a transborder dryland river--The Colorado River*.

D2. **Nagler, P.** & K. McDonald. 2008. *Organizer and Chair, National Meeting, Oral and Poster Sessions*: American Geophysical Union (AGU), Special Session in Biogeosciences, *B40: Interpretation of vegetation biophysical processes using xylem sap flux data & remote sensing techniques*. San Fran., CA. Dec. 15-19.

D3. **Nagler, P.** 2009. *Organizer, Chair & Panel Host*: *Regional Meeting, Oral and Poster Sessions:* Tamarisk & Russian Olive Research Conference, Special Session: *Impacts of Tamarix & Tamarix Management on Western Ecosystems*. Reno, NV. Feb. 18-19.

D3. **Nagler, P.** 2010. *Organizer and Chair, National Meeting, Oral Session*: Geological Society of America (GSA), USGS 3rd Modeling Conference, Special Session: *Water Census and Ecosystems: Remote Sensing based Models of Water Availability and Water Use (ET) in the Dry Ecosystems of Southwestern USA*. Denver, CO. June 7-11.

D4. **Nagler**, **Pamela**, & Tim Carlson. 2011. *Organizer & Conference Host*: *Pamela Nagler (USGS) and Tim Carlson (Tamarisk Coalition), Regional Meeting, Oral and Poster Sessions:* USGS & Tamarisk Coalition Research Conference with five Invited Speakers: Laura Norman, Matthew Chew, Connie Woodhouse, Julio Betancourt, Scott Nissen. Tucson, AZ. February 16-17.

D5. **Nagler**, **Pamela**, & Kevin R. Hultine. 2011. *Chair & Science Advisory Team, Regional Meeting, Oral Session:* USGS & Tamarisk Coalition Research Conference - Special Session: *The Landscape Ecology of Tamarisk*. Tucson, AZ. Feb. 16-17.

D6. **Nagler**, **Pamela**, & Kevin Hultine. 2011. *Chair and Panelist:* Colorado Plateau Biennial Science Meeting, 11th Biennial Conference of Research on the Colorado Plateau, Special Session: *Global change impacts on ecohydrologic processes of the Colorado Plateau*. Flagstaff, AZ. Oct. 24-27.

D7. **Nagler**, **Pamela**, Karl Flessa. 2014. ***Invited*** *by* NASA-USGS, American Geophysical Union (AGU) *Invited Panelist*: *After the pulse flow: Greening the Colorado River Delta***.** December 17. *https://www.nasa.gov/content/goddard/2014-nasa-agu-events/#coloradoriver*

D8. **Nagler, Pamela L.**, & Edward P. Glenn. 2016. *Chair: International Meeting, Oral and Poster Session:* EcoSummit, 5th International Meeting, Ecological Sustainability, Engineering Change, Special Session - *Resilient Rivers*. Montpellier, France, August 29 – September 2.

D9. **Pamela Nagler,** Randy Long, & Matthew Johnson. 2017. *Chair and Panelist, Regional Meeting, Oral Session*: 14th Biennial Conference of Science & Management on the Colorado Plateau & Southwest Region, Theme: Inter-disciplinary Approaches & Solutions for Conserving the Southwest's Land, Water, Biodiversity & Cultures, Special Session - *Tamarisk from Organism to Landscape*. Flagstaff, Arizona. September 11-14.

D10. **Nagler, Pamela L**. 2018. ***Invited*** *Scientific Committee & Panelist, International Meeting Oral & Poster Session:* Remote Sensing and Hydrology Symposium, Special Session - *Earth Observation retrievals and data products linked to the water cycle*. Cordoba, Spain. May 8-10.

D11. **Nagler, Pamela L**. 2018. ***Invited*** *Scientific Committee & Panelist, International Meeting, Oral & Poster Session:* Colorado River Delta Adaptive Management: Minutes 319 & 323 Biennial Science Symposium, Special Session – *Vegetation and Remote Sensing*. Mexicali, Mexico. October 22-24.

D12. Senay, Gabriel, Manohar Velpuri, & **Pamela Nagler**. 2018. *Chair: National Meeting, Oral and Poster Sessions*: American Geophysical Union (AGU), Special Session in Hydrology - *H056: Evapotranspiration: Advances in Remote Sensing Based Estimation, Mapping and Evaluation*. Washington, DC. December 10-14.

D13. **Nagler, Pamela L.**, Hamideh Nouri, Gabriel Senay, & Christopher J. Jarchow. 2019. *Convener & Chair: International Meeting, Oral & Poster Session*: European Geosciences Union (EGU), Special Session in Hydrology*: HS6.5/BG1.44/ESSI1.12/GI3.12 - Estimating evapotranspiration in extreme and sensitive environments using remote sensing, ground data and models (co-organized).* Vienna, Austria. April 7-10, 2019.
IP-100841, BAO Approved 08/13/18

D14. Brugnach, Marcela, **Pamela Nagler**, James Callegary, & Rudy Schuster. 2019. *Convener & Chair: International Meeting, Oral & Poster Session*: European Geosciences Union (EGU), Special Session in Water Policy (PICO): *A Social Framework for Integrated Water Management and Tools for Water Policy Analysis*. Vienna, Austria. April 7-10.
IP-101367, BAO Approved 08/13/18

D15. **Nagler, Pamela**, Kevin Hultine. & Matthew Johnson. 2019. *Convener & Chair: Regional Meeting, Oral Session*: 15th Biennial Conference of Science & Management on the Colorado Plateau & Southwest Region, Special Session - *Tamarisk in the Ecosystem*. Flagstaff, Arizona. Sept. 9-12.
IP-106917, BAO Approved 03/28/19

D16. Senay, Gabriel, Manohar Velpuri, & **Pamela Nagler**. 2019. *Chair: National Meeting, Oral and Poster Sessions*: American Geophysical Union (AGU), Special Session in Hydrology - *H056: Evapotranspiration (ET): Advances in In Situ Evapotranspiration Measurements and Remote Sensing-Based ET Estimation, Mapping and Evaluation*. San Francisco, CA. December 9-13.
IP-111407; BAO Approved 08/23/19

D17. **Nagler, Pamela**, Hamideh Nouri, Megan Blatchford, & Naga Manohar Velpuri. 2020. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual). European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation; HS6.1, Evapotranspiration estimation using remote sensing: modeling, mapping and evaluation*. Vienna, Austria. May 3-8.
IP-112423, BAO Approved 08/30/19

D18. **Nagler, Pamela**, Hamideh Nouri, Huade Guan, & Genxu Wang. 2020. *Convener & Chair, International Meeting, Oral & Poster Session*: EcoSummit 2020 (Postponed to June 2022) Building a sustainable and desirable future: Adapting to a changing land and sea-scape, Special Session: *Providing solutions to a current environmental problem facing our changing world: Improving methods and models used to measure and scale evapotranspiration (ET) to the landscape scale in urban regions, catchments and wetlands*. Queensland, Australia. June 21–25.
IP-109089, BAO Approved 06/14/19

D19. **Nagler, Pamela**, Kevin Hultine, & Patrick Shafroth. 2020. *Convener* (cancelled due to COVID after organizing all the speakers), *National Meeting, Oral Session*: Ecological Society of America (ESA), Special Session - *Riparian bioclimatic processes in a changing world*. Salt Lake City, UT. Aug. 2-7.
IP-114119, BAO Approved 01/10/20

D20. Senay, G., N.M. Velpuri, & **P.L. Nagler**. 2020. *Chair: National Meeting, Oral and Poster Sessions* (virtual): American Geophysical Union (AGU), Special Session in Hydrology - *H051: Evapotranspiration and Surface Energy Budget: Advances in using In-Situ and Remote Sensing Observations*. San Francisco, CA. December 7-11.
IP-123255, BAO Approved 07/07/20

D21. **Nagler, Pamela**, & Hamideh Nouri. 2021. *Convener & Chair, International Meeting, Oral & Poster Session (virtual)*: European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation & HS6.1- Remotely-sensed evapotranspiration*. Vienna, Austria. April 25-30.
IP-123261; BAO Approved 07/07/20

D22. Senay, G., N.M. Velpuri, & **P.L. Nagler**. 2021. *Chair and Co-Convener: National Meeting, Oral and Poster Sessions* (hybrid): American Geosciences Union (AGU), Special Session in Hydrology - *H050: Evapotranspiration (ET): Advances in In Situ ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation*. New Orleans, LA. Dec. 13-17.
IP-xxxxxx; BAO Approved 07/10/21

D23. **Nagler, Pamela**, & Hamideh Nouri. 2022. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual): European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation, HS6.1-Remotely-sensed evapotranspiration*. Vienna, Austria. April 3-8, 2022.
IP-133102; BAO Approved 07/14/21

D24. **Nagler, Pamela**, Hamideh Nouri, Huade Guan, Genxu Wang. 2021. *Convener & Chair, Ecosummit, International Meeting, Oral and Poster Session:* Providing solutions to a current environmental problem facing our changing world: Improving methods and models used to measure and scale evapotranspiration (ET) to the landscape scale in urban regions, catchments and wetlands. EcoSummit 2020 Building a sustainable and desirable future: Adapting to a changing land and sea-scape. Gold Coast, Queensland, Australia. June 21 - 25, 2020.
IP-109089; BAO Approved 06/14/2019.

D25. Senay, G., N.M. Velpuri, & **P.L. Nagler**. 2022. *Chair and Co-Convener: National Meeting, Oral and Poster Sessions* (hybrid): American Geosciences Union (AGU), Special Session in Hydrology - H049 - Evapotranspiration (ET): Advances in *In Situ* ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation. Chicago, IL. Dec. 12-16, 2022.
IP-xxxxxx; BAO Approved 07/12/22

D26. Nouri, Hamideh, **Pamela Nagler** & Neda Abbasi. 2023. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual): European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation,* Remote Sensing of Evapotranspiration. Vienna, Austria. April 23-27, 2023. *https://egu2023.eu/*
IP-144160; BAO Approved 08/09/22

D27. **Nagler, Pamela**. 2024. *Nomination Package for Dr. Laura Norman (USGS- Western Geographic Science Center*), Nomination Speech for the Farouk El-Baz Award, Awarded by the First Vice Chair, Quaternary Geology and Geomorphology Division, Department of Geosciences, Boise State University. Award Ceremony at The Geologic Society of American (GSA). Anaheim, CA. Sept. 22-25, 2024.

D28. Senay, Gabriel, Naga Manohar Velpuri, **Pamela Nagler** & Matthew Lurtz. 2023. *Chair and Co-Convener: National Meeting,* American Geophysical Union (AGU)*, Oral and Poster Session:* H058 - Evapotranspiration (ET): Advances in *In Situ* ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation. San Francisco, CA. Dec. 11-15, 2023.

D29. Nouri, Hamideh, **Pamela Nagler,** Neda Abbasi, Ana Andreu, Sibylle K. Hassler, Corrina Rebmann, & Jannis Groh. 2024. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual): European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation,* Remote Sensing of Evapotranspiration. Vienna, Austria. April 14-19, 2024. *https://egu2024.eu/*
IP-155046; BAO Approved 07/06/23

D30. Senay, Gabriel, Naga Manohar Velpuri, **Pamela Nagler**, Anderson Ruhoff, & Kul Khand. 2024. American Geophysical Union *Chair and Co-Convener: National Meeting,* American Geophysical Union (AGU)*, Oral and Poster Session:* H062 - Evapotranspiration (ET): Advances in *In Situ* ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation. Wash., D.C., Dec. 12-16, 2024.
IP-164394**,** BAO Approved 03/27/24

D31. Nouri, Hamideh, **Pamela Nagler,** Neda Abbasi, Ana Andreu. 2025. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual): European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation,* Evapotranspiration estimation using remote sensing and in-situ methods. Vienna, Austria. April 27-May 2, 2025.
https://meetingorganizer.copernicus.org/EGU25/provisionalprogramme
IP-169780, BAO Approved 08/16/24;

D32. Aparecido, Luiza Maria T., Tyson Terry, & **Pamela Nagler.** 2025. *Chair & Panelist, International Meeting, Oral & Poster Session* (virtual): Ecological Society of American (ESA), Special Session in Water in the Southwest: Past, present and future. Baltimore Convention Center, Baltimore, MD, August 10-15, 2025.

D33. Senay, Gabriel, Naga Manohar Velpuri, **Pamela Nagler**, Anderson Ruhoff, Kul Khand, & Arun Bawa. 2025. American Geophysical Union *Chair and Co-Convener: National Meeting,* American Geophysical Union (AGU)*, Oral and Poster Session:* H064 - Evapotranspiration (ET): Advances in *In Situ* ET Measurements and Remote Sensing-Based ET Estimation, Mapping, and Evaluation. New Orleans, Louisiana. Dec. 15-19, 2025.
IP-180795, Abstract BAO Approved 7/10/25;

D34. **Nagler, P.L.**, Palmquist, E., & Gomez-Sapiens, M. 2025. *Convener:* American Geophysical Union *Chair and Co-Convener: Regional Meeting, Oral (in-person and virtual) Session:* 17th Biennial Conference of Science and Management on the Colorado Plateau and Southwest Region, Northern Arizona University. Flagstaff, AZ. September 8-11, 2025.
https://in.nau.edu/biennial-conference-of-science-management/
IP-176231, BAO Approved 2/20/25

D35. Nouri, Hamideh, Neda Abbasi, Ana Andreu, Mariapina Castelli, & **Pamela Nagler**. 2026. *Convener & Chair, International Meeting, Oral & Poster Session* (virtual): European Geosciences Union (EGU), Special Session in Hydrology - *HS6: Remote sensing and data assimilation,* Remote Sensing of Evapotranspiration. Vienna, Austria. April 27-May 2, 2025.
https://meetingorganizer.copernicus.org/EGU25/provisionalprogramme
IP-169780, BAO Approved 08/16/24;

Factor 8: Invited Academic Seminars *presented by Nagler

List of Graduate Students, Research and Visiting Fellows is available upon request.

E1. 2001. ***Invited*** *by Prof. Edward Glenn (U. Arizona, Lead Scientist for the Colorado River Delta), Poster Presentation:* Aerial extent of habitat types in the Colorado River Delta for high-level policy and decision-makers (>200 invitees) from the International Boundary Water Commission (IBWC), U.S. Department of the Interior (DOI), Mexican Secretariat of Environment and Natural Resources (SEMARNAT), State Lawmakers, NGOs and Tribes. US-Mexico Colorado River Delta Symposium, **Autonomous University of Baja California (UABC).** Mexicali, Mexico. **Sept. 11, 2001**. **Noteworthy: The first binational, federally organized Colorado River Delta summit was*

convened in Mexicali on September 11, 2001. The day's terrorist attacks disrupted the meeting, suspending any progress on solutions for the Delta. The US-Mexico Border was closed for the first time in history. See How the Colorado River Delta is saved: *https://www.edf.org/sites/default/files/pulseflow/index.html*

E2. 2001. ***Invited*** *by Jeff Silvertooth (U. Arizona, SWES Dept Head),* Oral Presentation: Remote Sensing Applications: Environmental Assessment of the Colorado River Delta, Mexico. PhD Defense Presentation to Remote Sensing Committee, Department Soil, Water, Environmental Science (**SWES**), **University of Arizona**. Tucson, AZ. September 28, 2001.

E3. 2002. ***Invited*** *by Karl Flessa (U. Arizona, Geosciences),* Oral Presentation: Colorado River Delta vegetation response to river flow. **Dept. Geosciences, UofA**. Tucson, AZ. May 20.

E4. 2002. ***Invited*** *by Dr. Alejandro Hinojosa (SDSU Researcher),* Oral Presentation: Ground, Aerial, and Satellite Images of the Colorado River Delta. Color Booklet of each reach of the river, including the saltcedar, wetland, and marine zones. **San Diego State University**. Oct. 15-17.

E5. 2002. ***Invited*** *by Prof. Saul Alvarez (Director of CICESE), Centro de Investigación Científica y de Educación Superior de Ensenada* (CICESE), Oral Presentation: Remote sensing methods of mapping vegetation in the Colorado River Delta riparian and wetland ecosystems using satellite imagery, aerial photographs and ground-data. International Center for Ecology and Conservation, **Dept. Geology & Geography, CICESE**. Ensenada, Mexico. November 17-19.

E6. 2002. ***Invited*** *by Karl Flessa (U. Arizona, Geosciences),* Oral Presentation: Building upon the Anderson-Ohmart vegetation classification system: Improved methods of mapping vegetation in the Colorado River Delta using satellite imagery, aerial photographs and ground-data. **Department of Geosciences, University of Arizona.** Tucson, AZ. December 10.

E7. 2003. ***Invited*** *by Karl Flessa (U. Arizona, Geosciences),* Oral Presentation: Remote sensing tools for mapping and monitoring the lower Colorado River and its Delta in the United States and Mexico. **Department of Geosciences, University of Arizona**. Tucson, AZ. April 9.

E8. 2004. ***Invited*** *by Jennifer Pitt (Environmental Defense),* Oral Presentation: Restoration potential of wetlands and riparian habitats in the Colorado River Delta in Mexico. **SNRE/Arid Lands, University of Arizona**. Tucson, AZ. February 2.

E9. 2005. ***Invited*** *by Bob Webb (USGS-NRP),* Oral Presentation: Response of Riparian Vegetation to Flows in the Colorado River Delta. **University of Arizona**. Tucson, AZ. April 22 (Earth Day).

E10. 2006. ***Invited*** *by Jeff Silvertooth (U. Arizona, SWES Dept, Department Head),* Oral Presentation: Ecological Relationships and Water Use by Native Vegetation and Exotic Saltcedar on Western U.S. Rivers. Adjunct Faculty Evaluation Seminar, Soil, Water and Environmental Science (**SWES**), **University of Arizona**. Tucson, AZ. January 30.

E11. 2006. ***Invited*** *by Jeff Silvertooth (U. Arizona, SWES Dept, Department Head),* Oral Presentation: Careers in Environmental Science Seminar, Soil, Water and Environmental Science (**SWES**), **University of Arizona**. Tucson, AZ. October 24.

E12. 2006. ***Invited*** *by Prof. Subramania Sritharan**, (**Assoc. Director of Research, Ag. Res. Development Program, Center for Water Resources Management).* Oral Presentation: Results to the Ohio Alliance Universities and the USBR: Estimation of evapotranspiration by tamarisk from three 1-km^2 sites at Cibola NWR on the lower Colorado River. **Center for Water Resources Management, Central State University**, Dayton, OH. April 6-7.

E13. 2006. ***Invited*** *by Prof. Brad Wilcox (Texas A&M),* Oral Presentation: Measuring and scaling evapotranspiration of a cottonwood restoration plot on the Lower Colorado River. Seminar Series, *Ecological Restoration*. Department of **Rangeland Ecology and Management**, **Texas A&M** University, College Station, TX. Feb. 20-22.

E14. 2007. ***Invited*** *by Principal (TUSD Steele Elementary School), Oral Presentation:* Your environment from a bird's eye view. **Steele Elementary** School in Tucson, AZ. March 12.

E15. 2008. Murray* (student), & P**.** Nagler**.** 2011. ***Invited*** *by Ed Glenn (U. Arizona, SWES), Oral Presentations:* Integrating Ground and Remote Sensing Data to Estimate Wide-Area Transpiration by Saltcedar (*Tamarix ramosissima*) on the Lower Colorado River: A Crop Coefficient Method. Soils Graduate Course #504 Guest Speaker, Soil, Water and Environmental Science (**SWES**), **University of Arizona**. March 23.

E16. 2008. ***Invited*** *by John Osterberg (Reclamation), Oral Presentation:* Actionable Science for Lower Colorado River Basin Riparian Revegetation Planning. **University of Nevada Las Vegas (UNLV)**. Las Vegas, NV. May 7-9.

E17. 2008. ***Invited*** *by Prof.* ***Christopher Neale, (****Director of Remote Sensing Services Lab, Irrigation Engineering). Oral Presentation:* Estimates of ET Rates for Riparian Vegetation at Cibola National Wildlife Refuge. ***College of Engineering, Irrigation Engineering,*** **Utah State University**. Logan, UT. October 8-10.

E18. 2008. ***Invited*** *by Jayne Belnap (USGS SBSC).* Meeting to Build a Webpage on Upper Colorado River Basin Science – Impacts of Climate and Land Use on the Future Status of the Volume, Quality, and Timing of Water Availability. **San Diego State University**, La Jolla, CA. Sept. 17-19.

E19. 2008. ***Invited*** *by Kyle McDonald (Cal Tech, JPL).* Meeting on Soil Salinity and Sap Flow Testing Methods. **Jet Propulsion Lab (JPL), CALIF Institute of Technology**, Pasadena, CA. Sept. 4-8.

E20. 2008. ***Invited*** *by Kevin Hultine (University of Utah).* Episodic defoliation of tamarisk by the saltcedar leaf beetle: implication for regional-level riparian ET on the Colorado Plateau. Department of Biology Stable Isotope Ratio Facility for Environmental Research, **University of Utah**, Salt Lake City, UT. Sept. 28-30.

E21. 2009. ***Invited*** *by Dave Rus (USGS NWSC).* Water salvage from riparian vegetation management: Separating myth from fact using several evapotranspiration studies along a national climatic gradient. **University of Nebraska**, Lincoln, NE. January 14-16.

E22. 2009. ***Invited*** *by Kevin Hultine (University of Utah).* Developing a Salt and Water Budget for Saltcedar Stands and Replacement Vegetation on the Lower Colorado River at Cibola National Wildlife Refuge and Dolores River at Entrada Research Station. Department of Biology Stable Isotope Ratio Facility for Environmental Research, **University of Utah**, Salt Lake City, UT. March 30-31.

E23. 2010. ***Invited*** *by Kate Kitchell (USGS SBSC Center Director), Oral Presentation*: Scaling Riparian and Agricultural Evapotranspiration (ET) in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, MODIS EVI. **Northern AZ Uni.** Flagstaff, AZ. Apr. 5.

E24. 2010. ***Invited*** *by Prof. Stuart Marsh (U. Arizona, Head SNRE), Oral Presentation:* Scaling Riparian and Agricultural Evapotranspiration (ET) in River Irrigation Districts Based on Potential ET, Ground Measurements of Actual ET, and MODIS EVI. Spring Seminar Series, School of Natural Resources and the Environment (**SNRE**), **University of Arizona**. Tucson, AZ. May 5.

E25. 2010. ***Invited*** *by Lara Schmidt (USGS-NAU Workshop Coordinator), Oral Presentation*: Using MODIS satellite data to track recent trends in vegetation health for the USGS-NAU Climate Workshop. Climate Change in the Delta of the Colorado River. **Northern Arizona University**. Flagstaff, AZ. May 21-22.

E26. 2010. ***Invited*** *by Jayme Lopez (SPRNCA Tucson Field Manager), Oral Presentation*: Riparian Woodlands Habitat Estimated by the Normalized Difference Vegetation Index (NDVI) for San Pedro Riparian National Conservation Area (SPRNCA). **University of AZ**. Tucson, AZ. July 6-7.

E27. 2010. ***Invited*** *by Prof.* ***Subramania Sritharan, (****Assoc. Director of Research, Ag. Res. Development Program, Center for Water Resources Management). Oral Presentation:*

Compilation of Transpiration Estimates at Cibola National Wildlife Refuge Using Sap Flux and Remote Sensing from 2005-2009. Alliance Universities – Reclamation (USBR) Applied Remote Sensing Project. **Center for Water Res. Mngt., Central State Uni.**, Dayton, Ohio. August 16-18.

E28. 2011. Hernandez-Morlan* (student), & P**.** Nagler. 2011. *Presentation by Hernandez-Morlan,****** *Oral Presentation:* Legacies of the Colorado River Delta, Mexico: Over 30 Years of Landscape Changes. **Arizona State University**, Phoenix, AZ. March 11-16.

E29. 2011. ***Invited*** *by Charles van Riper III (SW NCCWSC Advisory Team Leader). Oral Presentation: Measuring Vegetation Shifts to Quantify Water Use Currently to be Used in Prediction Models*. Forecasting Climate Impacts on Southwestern Wildlife Project. **Northern Arizona University.** Flagstaff, AZ. June 6-7.

E30. 2011. Pearlstein* (student), & P. Nagler. 2011. *Presentation by Pearlstein,****** *Oral Presentation:* Monitoring of *Tamarisk* -- beetle interactions on the lower Virgin River. Environmental Research Graduate Res. Blitz. **Institute of the Environment, U. Arizona**. Tucson, AZ. Nov. 8.

E31. 2012. ***Invited*** *by Prof. Jan Hendrickx (New Mexico Tech). Oral Presentation:* Comparison of remote-sensing techniques to estimate evapotranspiration in semi-arid region riparian zones. **New Mexico Tech**. Socorro, NM. September 24-26.

E32. 2012. ***Invited*** *by Julio Betancourt (USGS NRP). Oral Presentation:* Operational remote sensing method for mapping and monitoring buffelgrass (*Pennisetum ciliare*) in Saguaro National Park. **SNRE**, **University of Arizona**. Tucson, AZ. October 3.

E33. 2012. ***Invited*** *by John Hoffman (USGS AZWSC Director). Oral Presentation:* Ecohydrology of saltcedar (Tamarix spp.) in the western United States and implications of water balance following a biocontrol agent introduction. USGS Seminar, **Uni. Arizona**. Tucson, AZ. Nov. 9.

E34. 2013. ***Invited*** *by Prof. Alfredo Huete (Director, Ecosystem Dynamics Health & Resilience Research Program), Oral Presentation:* Ecohydrology of terrestrial ecosystems in an era of rapid change Ecohydrology of saltcedar (*Tamarix* spp.) in the western United States and implications of water balance following a biocontrol (beetles) introduction. Seminar Series: *Trends in Environmental Research Series (TIERS),* **School of Life Sciences**, **University of Technology, Sydney, Australia**. April 3.

E35. 2013. ***Invited*** *by Prof. Paul Sutton (U. South Australia), Oral Presentation:* How Water Use Estimation for Groundwater Dependent Vegetative Species Helps Ecosystem Services. Special Session: *Leveraging the Economic Valuation of Ecosystem Services*. Barbara Hardy Institute, **School of Natural & Built Environments**, **Uni. of South Australia, Adelaide, South Australia, Australia**. April 11-12.

E36. 2015. ***Invited*** *by Jim Leenhouts (USGS AZWSC Director). Oral Presentation:* Ecohydrology of saltcedar (Tamarix spp.) in the western United States and implications of water balance following a biocontrol agent introduction. Lunch Seminar. USGS & **University of Arizona**. Tucson, AZ. April 23.

E37. 2015. ***Invited*** *by Jim Leenhouts (USGS AZWSC Director). Oral Presentation:* Wide-Area Estimates of Evapotranspiration by Red Gum (*Eucalyptus camaldulensis*) and Associated Vegetation in the Murray-Darling River Basin, Australia. USGS & **UofA**. Tucson, AZ. June 1.

E38. 2015. ***Invited*** *by Prof. Tom Kolb (NAU, Forestry Ecophysiology). Oral Presentation:* Estimates of Floodplain Forrest evapotranspiration by Red Gum (*Eucalyptus camaldulensis*) and associated vegetation in the Murray-Darling River Basin, Australia. **School of Forestry, Northern Arizona University**. Flagstaff, AZ. June 19.

E39. 2015. ***Invited*** *by Elizabeth Tran (CUAHSI), Oral Presentation:* Quantifying consumptive water use using remote estimates of evapotranspiration. CUAHSI Cyber-seminar series on

Evapotranspiration—Frontiers in measurement, modeling and management from the leaf to the landscape. Virtual. **University of New Hampshire**. June 23.

E40. 2015. ***Invited*** *by Kumud Acharya (Sr. Manager, CERM, Desert Research Institute), Oral Presentation:* Improving consumptive water use using remote estimates of evapotranspiration in desert riparian ecosystems. **Center for Environmental Research and Management (CERM)**, **Desert Research Institute (DRI).** Las Vegas, NV. July 10.

E41. 2015. ***Invited*** *by Dale Devitt (Director of CUWC), Oral Presentation:* Improving consumptive water use using remote estimates of ET in desert riparian ecosystems. Center for Urban Water Conservation (CUWC), **University of Nevada, Las Vegas (UNLV)**. Las Vegas, NV. July 10.

E42. 2015. ***Invited*** *by Prof. Steve Archer, Oral Presentation:* Working for the USGS. Course: RNR 200 *Conservation of Natural Environments*. School of Natural Resources and the Environment (**SNRE**), **University of Arizona**. Tucson, AZ. Oct. 22.

E43. 2015. ***Invited*** *by Dr. Georgianne Moore (Texas A&M),* Oral Presentation: Measuring and scaling evapotranspiration of a cottonwood restoration plot on the Lower Colorado River. Fall 2015 Seminar Series: *Ecology at Different Scales: From Bug's Eye to Bird's Eye View*. Department of Ecosystem Science and Management. **Texas A&M University**, College Station, TX. October. 27.

E44. 2016. Jarchow* (student), & P**.** Nagler. 2011. *Presentation by Jarchow,*** Invited** by Prof. Sharon Megdal (WRRC Director), Oral Presentation:* Greenup and Evapotranspiration (ET) of the Colorado River Delta following the Minute 319 Pulse Flows to Mexico. Annual Conference, #AZwaterfuture: Tech, Talk, and Tradeoffs, Water Resources Research Center (**WRRC**), **University of Arizona**. Tucson, AZ. March 21.

E45. 2016. ***Invited*** *by Prof. Jon Chorover (SWES Dept. Head), Oral Presentation:* How did the Delta Respond? An Analysis of Greenup and Evapotranspiration (ET) of the Colorado River Delta following the Minute 319 Pulse Flows to Mexico. Seminar Series SWESx. Department Soil, Water, Environmental Sciences (**SWES**), University of Arizona. Tucson, AZ. April 1.

E46. 2016. ***Invited*** *by NASA* (Team Led by Dennison and 9 others), *Oral Presentation by Dennison*:* Global Measurement of Non-Photosynthetic Vegetation: Need and Effort to Assess Potential Accuracy. *HyspIRI Science and Applications for the NASA Decadal Survey Mission Concept*. **California Institute of Technology**. Pasadena, CA. October 18. IP- 080759

E47. 2016. ***Invited*** *by Prof. Steve Archer, Oral Presentation:* Working for the USGS. Course: RNR 200 *Conservation of Natural Environments*. School of Natural Resources and the Environment (**SNRE**), **University of Arizona**. Tucson, AZ. Oct. 27.

E48. 2017. ***Invited*** *by Prof. Jon Chorover (SWES Dept. Head), Oral Presentation by Jarchow**: An analysis of greenup and evapotranspiration (ET) of the Colorado River Delta following the Minute 319 pulse flows to Mexico. Seminar Series, SWESx. Department Soil, Water, Environmental Science (**SWES**), **University of Arizona**. Tucson, AZ. March 29. **IP-084287**

E49. 2017. Lasse* (student), & P**.** Nagler. ***Invited*** *by William Waugh (DOE LM Contractor), Presentation by Lasse,***** Oral Presentation:* Estimating Evapotranspiration and Recharge Rates Using a Remote Sensing Algorithm. **Colorado School of Mines**, Golden, CO, May 21-24.

E50. 2017. ***Invited*** *by Prof. Arjen Hoekstra (U. Twente), Oral Presentation:* A review of the Northern Tamarisk beetle (*Diorhabda carinulata*) and tamarisk (*Tamarix* spp.) interactions in the Colorado River basin in the Western USA. Water Engineering and Management, Faculty of Engineering Technology, **University of Twente, Enschede, The Netherlands**. October 11.

E51. 2017. ***Invited*** *as a Visiting Researcher by Megan Blatchford & Wim Bastiaanssen (IHE Delft Inst. Water Education), Presentation: Vegetation Index ET.* **Civil Engineering and Geosciences**, **Delft University of Technology, Delft, The Netherlands.** October 23.

E52. 2017. ***Invited*** *by Prof. Bob Su (ITC),* Oral Presentation*:* Water use of riparian and upland plants in the arid southwestern USA and remotely sensed measurements of wide area estimates of evapotranspiration. **Department of Water Resources, Geo-Information Science and Earth Observation Center (ITC), Enschede, The Netherlands.** October 24.

E53. 2018. ***Invited*** *by Prof. Connie Woodhouse (U. Arizona, Geography),* Oral Presentation*:* USGS Biological and Geographical Research in the Federal Government. Professional Development Seminar for Non-Academic Jobs, **School of Geography & Development**, **University of Arizona.** Tucson, AZ. April 27.

E54. 2018. ***Invited*** *by María José Polo Gómez (University of Córdoba, Hydraulic Engineering),* Oral Presentation*:* Using optical remote sensing to evaluate changes in greenness and evapotranspiration in riparian vegetation in response to the Minute 319 environmental pulse flow to Mexico. Remote Sensing & Hydrology, Special Session: *Earth Observation retrievals and data products linked to the water cycle*. Department of Agronomy, Andalusian Institute for **Earth System Research**, **Universidad de Córdoba, Córdoba, Spain**. May 8-10.

E55. 2018. ***Invited*** *by Fatemeh Karandish (University of Zabol),* Oral Key Presentation*:* Water availability in drylands: challenges for characterizing evapotranspiration dynamics of vegetation in agricultural and natural ecosystems. Water Challenges In Iran Conference. **Zabol, Sistan and Baluchestan Province, University of Zabol, Iran.** October 9-12.

E56. 2019. ***Invited*** *by Prof. Greg Garfin & Connie Woodhouse (Univ. Arizona)* to provide an academic course review of a new & virtual Professional Development course crossing multiple disciplines. A review of Fundamentals of Transdisciplinary Research (online course materials) by Professors Connie Woodhouse, Gregg Garfin, Daniel Ferguson, & Mónica Ramirez-Andreotta. **Southwest Climate Adaptation Science Center and School of Geography & Development**, **University of Arizona**. February 28.

E57. 2019. ***Invited*** *by Ted Melis (SBSC Acting Director),* Oral Presentation*:* Talking to Dead People About Aliens: Remote Sensing of ET. USGS All Hands Presentation (NAU and UofA). April 2.

E58. 2019. ***Invited*** *by Prof. Connie Woodhouse (U. Arizona, Geography),* Oral Presentation*:* USGS Biological and Geographical Research in the Federal Government. Professional Development Seminar for Non-Academic Jobs, **School of Geography & Development**, **University of Arizona**. Tucson, AZ. April 24.

E59. 2019. ***Invited*** *by Prof. Phil Dennison (U. Utah, Geography Dept. Head),* Oral Presentation: Remote Sensing of ET and Results of Minute 319 -- Added Water to the Colorado River Delta. Characterizing evapotranspiration dynamics in the riparian zone of the Colorado River Delta to evaluate ecosystem changes in response to the Minute 319 environmental pulse flow to Mexico. Fall Seminar: **Department of Biology & School of Geography**, **University of Utah.** Salt Lake City, UT. Sept. 20.
IP-109527, BAO Approved 06/27/19

E60. 2019. ***Invited*** *by Prof. Don Slack (U. Arizona, Biosystems Engineering),* Oral Presentation by Jarchow*: Evapotranspiration, vegetation, and groundwater dynamics at a former uranium mill site in Shiprock, New Mexico: Implications for managing groundwater contaminants. Fall Seminar & Designated Campus Colleague, Adjunct Faculty Evaluation Seminar, College of Engineering, **Biosystems Engineering (BE), University of Arizona**. Tucson, AZ. October 15.
IP-108623; BAO Approved 07/15/19

E61. 2020. ***Invited*** *by Prof. Don Slack (U. Arizona, Biosystems Engineering),* Oral Presentation: Analyses of plant greenness and evapotranspiration dynamics over the short- and long-term in the riparian zone of the Colorado River Delta before and after the 2014 Minute 319 environmental pulse flow. Fall Seminar & Designated Campus Colleague, Adjunct Faculty

Evaluation Seminar, College of Engineering, **Biosystems Engineering (BE), University of Arizona**. Tucson, AZ. March 23.
IP-115895, BAO Approved 01/16/20

E62. 2023. ***Invited*** *by Dr Tanya Doody* (CSIRO, Australia's national science agency, *Group Leader – Managing Water Ecosystems*), Oral Presentation: The Colorado River Basin Actionable and Strategic Integrated Science and Technology (ASIST) Project: Advanced technologies to support integrated drought science. **CSIRO, Waite Campus**. Adelaide, Australia. June 21, 2023

E63. 2023. ***Invited*** *by Dr Michael Leonard* (Hydrological Society of South Australia, *President of the HydroSocSA*), Oral Presentation: Colorado River natural resources in an era of uncertainty: using science to inform river management. **Adelaide University, Waite Campus**. Adelaide, South Australia. June 22, 2023.

E64. 2023. ***Invited*** *by Dr Huade Guan* (Flinders University, College of Science & Engineering National Centre for Groundwater Research and Training; Assoc. Editor for Journal of Hydrology and Frontiers in Climate, Ecology, and People), Oral Presentation: The Colorado River Basin and the Water Use of Riparian Ecosystems. **Flinders University, College of Science & Engineering National Centre for Groundwater Research and Training**. Adelaide, South Australia. June 23, 2023.

E65. 2023. ***Invited*** *by Dr Tanya Doody* (CSIRO, Australia's national science agency, *Group Leader – Managing Water Ecosystems*), Oral Presentation: Pamela Nagler, Student Summer Awardee, Harriet Easterbrook, with Gabriel Senay, Steve Gao & Tanya Doody, Oral Presentation: A Summer Project: Advancing remote sensing estimates of evapotranspiration (ET) using thermal imagery with a focus on drought assessment in both a large Australia and United States river basin.

E66. 2023. ***Invited*** *(virtual) by Todd Caldwell* (USGS Nevada Water Science Center), Oral Presentation: Riparian Corridors of the Sonoran Desert: New Estimates of Riparian Evapotranspiration Change Using Daymet and Landsat Vegetation Index Methods. The 2nd Global Evapotranspiration Symposium: Advances, Challenges, and Future Needs in Measurement, Modeling, and Applications sponsored by ASABE. **The Pennsylvania State University**, University Park, PA. October 23-27.
https://www.asabe.org/et2023
IP-150192; BAO Approved 02/09/23;

E67. 2023. ***Invited*** *(virtual) by Sharon Megdal* (Director, University of Arizona Water Resources Research Center), *Panelist & Oral Presentation*: Effect of Restoration on Plant Greenness and Water Use in Relation to Drought in the Riparian Corridor of the Colorado River Delta, which is part of the Special Issue "Severe Sustained Drought in the Colorado Basin Revisited" in the *Journal of the American Water Resources Association, JAWRA* 58(5) (2022). **University of Arizona, Water Resources Research Center (WRRC)** Seminars: Severe Sustained Drought in the Colorado Basin Revisited. April 12, 2023.
IP-152540; BAO Approved 04/13/23;

E68. 2024. ***Invited*** *(virtual) by Joey Hulbert* (USDA APHIS PPA *Invasives Project* Director, Puyallup Research and Extension Center, Washington State University), *Panelist & Oral Presentation (virtual)*: Tamarisk and riparian water use in Navajo Nation. 2024 Invasive Species Workshop and Webinars for Tribal Audiences, Impacts on Cultural Resources, **Washington State University**, Pullman, WA. April 9, 2024.
https://extension.wsu.edu/invasive-species/workshops/
IP-164398, BAO Approved 04/04/24

E70. 2024. ***Invited*** *(virtual) by Sara Ricklefs* (Invasive Species Action Network, Executive Director), *Oral Presentation (virtual)*: Understanding Woody Invasive Water Use: The future of introduced *Tamarix* spp.,

Science Advisory Panel and Working Group for the **Montana Woody Invasives** Meeting. Helena, Montana. Oct. 17, 2024.
IP-171598; BAO Approved 10/11/24;

E71. 2024. ***Invited*** *(in-person) by Mitch McClaran* (University of Arizona School of Natural Resources and the Environment, Professor), *Oral Presentation (virtual)*: Understanding Woody Invasive Water Usage Along the Riparian Corridor of the Gila River at the Convergence of the San Pedro. Discussions between the U. S. Geological Survey and **University of Arizona, School of Natural Resources & Environment and Biosystems Engineering**. Tucson, Arizona. October 24, 2024.
IP-172165; BAO Approved 10/25/24;

E72. 2025. ***Invited*** *(in-person) by Triston Hooks* (University of Arizona, Biosystems Engineering Department, Assistant Professor), *Oral Presentation (in person)*: Sustainable Riparian Restoration in Water Scarce Environments. **University of Arizona, Biosystems Engineering Department,** Tucson, AZ. February 24, 2025.
IP-176355, BAO Approved 2/24/25;

E73. 2025. ***Invited*** *(in-person) by Kathryn Stoner* (University of Arizona, School of Natural Resources and the Environment, Department Head), *Oral Presentation (in person)*: Terrestrial Dryland Ecology Research at the U.S. Geological Survey's Southwest Biological Science Center. School of Natural Resources and the Environment Seminar Series. **University of Arizona, School of Natural Resources and the Environment.** Tucson, AZ. February 26, 2025.
https://snre.arizona.edu/events/seminar-terrestrial-dryland-ecology-research-us-geological-surveys-southwest-biological
IP-176454, BAO Approved 2/26/25;

E74. 2025. ***Invited*** *Student* (*Solomon Edo, virtual) by Dept. Head* (South Dakota State University), *Oral Presentation (in person)*: Water Use and Habitat Conservation Efforts Across Biomes in the U.S.-Mexico Border Region. South Dakota ASABE Section Meeting, Raven Precision Agriculture Center, **South Dakota State University**, Brookings, SD. April 3, 2025.
IP-177434, BAO Approved 4/2/25;

E75. 2025. ***Invited*** *Student* (*Solomon Edo, virtual) by Cooperative Extension* (University of Arizona, ALVSCE, Department Head), *Oral Presentation (in person)*: Water Use and Habitat Conservation Efforts Across Biomes in the U.S.-Mexico Border Region. **The University of Arizona, College of Agriculture, Life and Environmental Sciences, Agriculture, Life & Veterinary Science & Cooperative Extension, ALVSCE**, Research Showcase - Thursday, Student Union Ballroom, Tucson, AZ. April 4, 2025**.**
https://research.alvsce.arizona.edu/research-impact/annual-research-showcase
IP-177186, BAO Approved 4/2/25

E76. 2025. ***Invited*** *PostDoc* (*Eduardo* Jiménez Hernández*) by PostDoc Conference Head* (Arizona State University), *Oral Presentation (in person)*: Status of riparian corridor health in the US-Mexico transboundary region. Arizona Postdoctoral Research Conference, **Arizona State University**, Tempe, AZ. September 19, 2025, *https://graduate.asu.edu/postdocs/news-and-events/asu-postdoctoral-career-conference*
IP-180460, BAO Approved 8/20/25;

E77. 2025. ***Invited*** *USGS Researcher* (*Libby Wildermuth), by PostDoc Conference Head* (Arizona State University), *Oral Presentation (virtual):* Comparison of estimated plant water availability and vegetation health to inform forecast ensembles of a groundwater flow model. **Northern Arizona University**, Flagstaff, AZ September 9-11, 2025. *https://in.nau.edu/biennial-conference-of-science-management/*
IP-182858, BAO Approved 9/9/25;

Factor 9: Technical Assistance & Partner Presentations

F1. 2000. ***Invited*** *by Alfredo Huete (U. Arizona) to provide Technical Assistance:* Coordinated and led the validation field work for the NASA MODIS sensor, Terra, launched in Dec. 1999. This continuous months-long and intermittent field work from 1998-2000 included myriad biomes: [dryland agriculture in AZ, grasslands from AZ, NM and KS (Audubon's TRR Appleton-Whittel Research Ranch; USDA's Jornada in NM; Konza Prairie in KS); as well as a variety of conifer forests between MT, British Columbia, Victoria, WA, OR and CA; and lastly desert scrub and riparian corridors in northern Baja & Sonora, Mexico]. I provided the travel logistics for a dozen researchers from Japan "Japanese Science Team from Chiba University" across the western United States for field work, technical discussion workshops, and meetings in parts of Canada and Mexico. Grassland data from the PROVE campaign and other US areas were compared to Mandalgovi, Central Mongolia via CREST campaign. April 1998 – July 2000. *See Impact Letter.*

F2. 2000. ***Invited*** *by Andrew Hautzinger (FWS, Water Resources Chief) to provide Technical Assistance:* Monitoring vegetation in the Colorado River Delta using air- and space-borne remote sensing techniques, for US Fish & Wildlife. January 21.

F3. 2000. ***Invited*** *by Jeff Milliken (Reclamation, LCRAS Mapping) to provide Technical Assistance:* Nagler captured aerial photographs and multi-band optical images for the U.S. Bureau of Reclamation by helicopter, for their LCRAS Survey of the Colorado River from Las Vegas to Yuma. January 21.

F4. 2000. ***Invited*** *by Jeff Milliken (Reclamation, LCRAS Mapping) to provide Technical Assistance:* Nagler captured oblique and nadir aerial photographs and 3-band optical images for the U.S. Bureau of Reclamation by helicopter, for new surveys for LCRAS Survey of the Colorado River and tributaries in the U.S., five days of flights. April 24-29.

F5. 2000. ***Invited*** *by Jeff Milliken (Reclamation, LCRAS Mapping) to provide Technical Assistance:* Inventoried, processed and mosaicked visible and 3-band images of the river landscape from April flights of the Colorado River; worked on exchanging image processing methods. Sacramento, CA. June-July.

F6. 2000. ***Invited*** *by Jody Waugh (DOE Legacy Mines) to provide Technical Assistance:* Nagler captured oblique and nadir aerial photographs and 3-band optical in flights over the Navajo Nation near Monument Valley, UT. September.

F7. 2002. ***Invited*** *by Jeff Milliken (Reclamation, LCRAS Mapping) to provide Technical Assistance:* From March 12-15 Nagler conducted 13 aerial surveys using a University of Arizona Cessna and Reclamation's helicopter for mounting multi-band cameras and for capturing oblique and nadir aerial photographs and 3-band optical images to survey riparian vegetation of the Colorado River and tributaries in the US and in Mexico. March 12 - August 15.

F8. 2002. ***Invited*** *by John Earle (Topock Refuge Manager) to provide Technical Assistance:* Topock Marsh in the Havasu International Wildlife Refuge as a test site for improving on mapping methods with the use of remote sensing, for US Fish & Wildlife, National Wildlife Refuge & US Reclamation. June 1.

F9. 2002. ***Invited*** *by Alfredo Huete (U. Arizona) to provide Technical Assistance:* Led the Japanese Science Team Campaign (scientists from Chiba University) for the riparian ecosystems (Colorado River and Delta) collection of ground data (leaf area index, fractional cover, canopy & biomass measures & hyperspectral imagery from the ground and from a remote-controlled helicopter). September 17-22.

F10. 2002. ***Invited*** *by Steve Cornelius and Francisco Zamora (Sonoran Institute) to provide Technical Assistance:* Conservation Priorities in The Colorado River Delta (see prepared by

authors), for the Binational Workshop & Technical Exchange. Tijuana, Mexico. October 14-17. The result was a document for NGOs and others prepared by Sonoran Institute, Environmental Defense, University of Arizona, Pronatura Noroeste Dirección de Conservación Sonora, Centro de Investigación en Alimentación y Desarrollo, and World Wildlife Fund—Gulf of California Program. 103 pp. *https://sonoraninstitute.org/files/pdf/1conservation-priorities-in-the-colorado-river-Delta-06152005.pdf*

F11. 2002. ***Invited*** *by Lorri Gray (Reclamation Division Director, LCR) to provide Technical Assistance:* Distribution and abundance of riparian vegetation covering the Pinacate Mtns.-Altar Desert-Cienega region and the Colorado River Delta, Mexico, the Gila River, the Cibola Wildlife Refuge, and the Bill Williams River, the Las Vegas Wash, Lake Mead, the Virgin River, & the Grand Canyon, for Reclamation LCRAS Program. Boulder City, NV. April 12.

F12. 2003. ***Invited*** *by Nita Tallent-Halsell (U.S. EPA) to provide Technical Assistance:* Methodologies for making a comparison of transpiration rates of riparian trees using sap flow and leaf temperature methods, for US EPA. Spectral Remote Sensing of Vegetation Conference U.S. EPA. Workshop & Technical Exchange. Las Vegas, NV. March 12-14.

F13. 2003. ***Invited*** *by Craig Westenberg (USGS NVWSC) to provide Technical Assistance:* Methods for making a comparison of transpiration rates of riparian trees using sap flow & leaf temperature methods. Lower Colorado River, Workshop & Tech. Exch. Parker, NV. June 17-18.

F14. 2003. ***Invited*** *by Dave Busch (USGS-Portland) to provide Technical Assistance:* Hyperspectral characterization of riparian & wetland communities along the Colorado River with EO-1 Hyperion sensor. Lower Colorado River, Workshop & Tech. Exchange. Parker, NV. June 17-18.

F15. 2003. ***Invited*** *by John Swett (Reclamation, LCR MSCP) to provide Technical Assistance:* Using scaled ground methods for remote monitoring of restoration sties. The Lower Colorado River, Workshop & Technical Exchange. Parker, NV. June 17-18.

F16. 2003. ***Invited*** *by Jeff Milliken (Reclamation, LCRAS Mapping) to provide Technical Assistance:* Remote Sensing Tools for Vegetation Mapping and ET Estimation on the Lower Colorado River. The Lower Colorado River Plan for Water Accounting. Boulder City, NV. Dec. 10.

F17. 2004. ***Invited*** *by Craig Westenberg (USGS NVWSC) to provide Technical Assistance:* Delineating vegetation groups and quantifying ground-water evapotranspiration in Clarke County, Nevada w/high-resolution multispectral satellite imagery. Henderson, NV. May 17-20.

F18. 2005. ***Invited*** *by Karl Flessa (U. Arizona, Colorado River Delta NSF-RCN) to provide Technical Assistance:* State of conservation priorities in the Delta. The Colorado River Delta Research Coordination Network 1st Science Team Workshop. Biosphere 2. Oracle, Arizona. Sept. 17-19.

F19. 2005. ***Invited*** *by Jake Weltzin (U. Arizona, NSF USA-NPN Leader) to provide Technical Assistance:* Contributions of knowledge and skills for the Implementation Team of the USA National Phenology Network (USA-NPN) in its initial year. A first implementation workshop was funded by the National Science Foundation, with additional support from USGS, NPS, USDA-FS, NASA, EPA, and NOAA, with ~40 scientists. Tucson, AZ. August 24-26.

F20. 2006. ***Invited*** *by Steve Gloss (USGS SBSC) to provide Technical Assistance:* New methods to measure transpiration rates of cottonwood rorests at Cibola National Wildlife Refuge, with John Osterberg, Reclamation, & Bill Seese, Cibola NWR Manager. Tucson, Arizona. January 10.

F21. 2006. ***Invited*** *by Karl Flessa (U. Arizona, Colorado River Delta NSF-RCN) to provide Technical Assistance:* State of the riparian corridor mapping. The Colorado River Delta Research Coordination Network 2nd Science Team Workshop. Biosphere 2. Oracle, Arizona. Feb. 8-9.

F22. 2006. ***Invited*** *by Jennifer Pitt (Environmental Defense) to provide Technical Assistance:* Estimates of Riparian Trees and Saltcedar for a workshop on the state of conservation of the riparian, wetland and estuary regions of the Colorado River Delta, for a binational meeting and

technical exchange hosted by the National Wildlife Federation, Environmental Defense, and Pronatura Noroeste-Sonora. Tucson, Arizona. February 15-16.

F23. 2006. ***Invited*** *by Lorri Gray (Reclamation Division Director, LCR) to provide Technical Assistance:* Studies of Soil Moisture, Salinity and Cottonwood Tree Evapotranspiration, Lower Colorado River Ecological Restoration Project at Cibola National Wildlife Refuge for DOI Reclamation's Landscape Program. Boulder City, NV. March 9.

F24. 2006. ***Invited*** *by Craig Westenberg (USGS NVWSC) to provide Technical Assistance:* Field validation measurements for ET project in Clark County, Nevada Using High-Resolution Satellite Imagery for DOI Bureau Land Management. Henderson, NV. June-Sept.

F25. 2006. ***Invited*** *by Mark Schwartz (USA-NPN) to provide Technical Assistance:* Contributions to the Remote Sensing team of the USA National Phenology Network (USA-NPN) for the purpose of developing a series of experiments that take advantage of planned surface phenological measurements in 2007 growing season. The University of Wisconsin-Milwaukee Field Station, Natural History Workshop. Milwaukee, WI, Oct. 9-13.

F26. 2007. ***Invited*** *by Dave Busch (USGS-Portland) to provide Technical Assistance:* Methods used for measurements in the Cienega de Santa Clara for the Wetlands Research Initiative in Intermountain West (USGS Central & Western Regional interdisciplinary research scientists). Portland, OR. March 2.

F27. 2007. ***Invited*** *by Garrit Voggesser (National Wildlife Federation) to provide Technical Assistance:* Riparian Vegetation Estimation of by Species Type and Water Use in the Colorado River Delta. Bi-National Lower Colorado River Conservation Workshop & Technical Exchange. Tucson, AZ. April 10-11.

F28. 2007. ***Invited*** *by Mark George (USDA*- Natural Resources Conservation Service*) to provide Technical Assistance:* A scientific assessment of the effectiveness of riparian management practices for conservation benefits of rangeland practices. Workshop on the Dynamic Nature and Natural Diversity of Riparian Areas. Camp Verde, AZ. Nov. 8-9.

F29. 2007. ***Invited*** *by Karl Flessa (U. Arizona, Colorado River Delta NSF-RCN) to provide Technical Assistance:* State of the literature on the Colorado River Delta. The Colorado River Delta Research Coordination Network 3rd Science Mtg. Biosphere 2. Oracle, Arizona. Nov. 16-17.

F30. 2008. ***Invited*** *by Jake Weltzin (USGS National Phenology Network) to provide Technical Assistance:* Monitoring the Impacts of *Tamarisk* Defoliation on the Dolores River Using Remote Sensing Phenology Cameras. Tucson, AZ. February 22.

F31. 2008. ***Invited*** *by Daniel Ferguson & Gregg Garfin (USGS/USFWS, CLIMAS) to provide Technical Assistance:* On dryland riparian corridor health for an Interagency meeting on the Effects of Climate Change on Fish, Wildlife, and Habitats in the Arid and Semiarid Southwestern United States: Putting Knowledge and Science into Action. Tucson, AZ. Aug. 19-20. *https://climas.arizona.edu/sites/default/files/pdfknowledge-action.pdf*

F32. 2008. ***Invited*** *by Charles van Riper III (USGS SBSC) to provide Technical Assistance:* Remote sensing and monitoring capabilities for the interagency meeting and monitoring workshop for the Barry Goldwater Range (BMGR)-West Research Initiative. Tucson, AZ. Aug. 26-27.

F33. 2008. ***Invited*** *by Mark Sogge (USGS Ecosystems) & USFWS Invasive Species Program to provide Technical Assistance:* How remote sensing can be used to determine avian species habitat use. Technical Exchange to build a Riparian Model using NDVI and Avian Data. Tucson, AZ. Sept. 3-4.

F34. 2009. ***Invited*** *by Mike Crane (USGS-EROS) to provide Technical Assistance:* Hydrologic flux dynamics in the Southwest US. EROS, Sioux Falls, South Dakota. August 4-6.

F35. 2009. ***Invited*** *by Mary Hill & David Stonestrom (USGS-NRP) to provide* *Technical Assistance:* Hydrology and Ecology of Southwestern Intermittent Stream and Dry Wash Ecosystems on Fort Huachuca and Adjacent Lands, Arizona. Boulder, CO. August 26-28.

F36. 2010. ***Invited*** *by Charles van Riper III (USGS-SBSC) to provide* *Technical Assistance:* Border Fence Science and Impacts. Tucson, AZ. March 11-12.

F37. 2010. ***Invited*** *by Kris Randall (AZ Riparian Council) to provide* *Technical Assistance:* Watershed sustainability and water balance on Tamarisk dominated rivers. Restoring Rivers of the Southwest U.S. and Northern Mexico: A Bi-National Conference on Learning from Past to Benefit the Future. Yuma, AZ. March 17-19.

F38. 2010. ***Invited*** *by Ricardo Lopez (US EPA) to provide* *Technical Assistance:* Potential for water salvage by release of the biocontrol, *Diorhabda elongata*, on Tamarisk dominated rivers. National Resource needs related to Climate Change in the Great Basin and Mojave Deserts, Research Adaptation & Mitigation Workshop & Technical Exchange. Las Vegas, NV. April 20-22.

F39. 2011. ***Invited*** *by Louise W. Misztal (Sky Island Alliance Director).* *Technical Assistance:* How estimates of evapotranspiration over the long-term can provide adaptive management solutions. Between a Rock and a Hot Place: Climate Change Adaptation and Resource Management in the Sky Island Region. Tucson, AZ. April 13-14. See *USDA Forest Service, 2013 Proceedings RMRS-P-67.*

F40. 2011. ***Invited*** *by Dr. Barbara Rusmore (SPRNCA Director).* *Technical Assistance:* Riparian Plant Health in the San Pedro Riparian National Conservation Area (SPRNCA): Food for Thought for the Technical Group, USGS & University of Arizona. Tucson, AZ. July 20-21.

F41. 2012. ***Invited*** *by Russell Norvell & Terri Pope to provide* *Technical Assistance:* Habitat detection and discrimination using remote sensing methods, for Utah Division of Wildlife Resources, Partners in Flight, Non-Game Avian Program. June 13.

F42. 2012. ***Invited*** *by Dana Backer & Pat Chavez to provide* *Technical Assistance:* Remote sensing methods for detecting Buffelgrass in Saguaro NP, for USGS-NRPP project funding. October 28.

F43. 2012. ***Invited*** *by Julia Fonseca to provide* *Technical Assistance:* Riparian vegetation monitoring methods along the effluent-dominated Santa Cruz River near Tucson: Methods to be used with their EPA grant. Tucson, AZ. November 1.

F44. 2013. ***Invited*** *by Andrew Richardson (Northern AZ University, Center for Ecosystem Science and Society) to provide* *Technical Assistance:* U.S. National Park Service Technical Phenology Protocols Development and Training Manual.

F45. 2013. ***Invited*** *by Tanya Doody to provide* *Technical Assistance:* Ecosystem Water Use remote estimation methods for the Goyder Murray Floodplain Initiative on the Flood Ecology Project, Workshop & Technical Exchange. Adelaide, Australia. February 4.

F46. 2014. ***Invited*** *by Aaron Citron (Policy Analyst) to provide* *Technical Assistance:* How remote sensing methods for quantifying water use services to better inform policy, for Environmental Defense Fund. September 16.

F47. 2015. ***Invited*** *by Osvel Hinojosa-Huerta (Pronatura Noroeste, Director of the Program for Water and Wetlands) to provide* *Technical Assistance:* Biological results of the Minute 319 Pulse Flow for the Mexican Commissioner of CILA. January 29.

F48. 2015. ***Invited*** *by Jim Leenhouts (USGS AZWSC Director) to provide* *Technical Assistance:* USGS Colorado River Pulse Flow Monitoring (March-May 2014) Technical Summary for Jennifer Gimbel, Water and Science Assistant Secretary, & Lori Caramanian. March 3.

F49. 2015. ***Invited*** *by Jeff Milliken (Reclamation) to provide* *Technical Assistance:* Results from lidar and high-resolution mapping of the Colorado River Delta vegetation (Reclamation, USGS SBSC), Workshop & Technical Exchange. Sonoran Institute. Tucson, AZ. April 6.

F50. 2015. ***Invited*** *by a woman (USGS Reston) to provide Technical Assistance:* Remote sensing applications research in natural ecosystems; for USGS Contractors (Engineers from Integrity Applications Incorporated) preparing the RCA-EO Requirements Capabilities and Analysis for Earth Observations. Virtual. June 15. *https://eros.usgs.gov/doi-remote-sensing-activities/2016/usgs/requirements-capabilities-and-analysis*-earth-observations-overview

F51. 2016. ***Invited*** *by Ted Melis (USGS SBSC) to provide Technical Assistance:* The use of time-series data from Landsat for Amphibian Research and Monitoring Initiative (ARMI) Research Coordination and Planning Technical Exchange. Tucson, AZ. May 2.

F52. 2016. ***Invited*** *by Seth Munson (USGS SBSC) to provide Technical Assistance:* Restoration in Ecosystems, Workshop & Technical Exchange for the Restoration Assessment and Monitoring Program of the Southwest (RAMPS). Virtual. May 4.

F53. 2016. ***Invited*** *by Ted Melis (USGS SBSC) to provide Technical Assistance:* Tamarisk Removal Coordination Meeting with Ray Suazo, BLM AZ State Director. Virtual. Sept. 22.

F54. 2016. ***Invited*** *by Dave Lytle (USGS SBSC Director) to provide Technical Assistance:* National Invasive Species Council, Early Detection & Rapid Response capabilities for invasive species, Workshop & Technical Exchange. Sept. 21.

F55. 2016. ***Invited*** *by Dave Lytle (USGS) to provide Technical Assistance:* RS measurements and monitoring of vegetation water use for "A Terrestrial Inventory for the State of Kuwait, Environmental Public Authority," also referred to as the Kuwait Technical Report, *Surveying and Establishment of a Comprehensive Database on the Terrestrial Environment of Kuwait (Terrestrial)*. Several Kuwait Workshop & Technical Exchanges with Matthew E. Andersen, Senior Scientist for Biology, International Programs. *Flagstaff, AZ*. Jan. 2016- Feb. 2019.

F56. 2017. ***Invited*** *by Cindy Tam (USGS Reston) to provide Technical Assistance:* Contributed detection methods for saltcedar for the DOI Invasive Species Information Management Working Group Survey, which resulted in the DOI Briefing paper, *Invasive species information management assessment: key findings and recommendations*. May.

F57. 2017. ***Invited*** *by someone (USGS Reston) to provide Technical Assistance:* Remote sensing applications research in natural ecosystems; follow-up to 2015 for USGS Contractors (Engineers from Integrity Applications Incorporated) preparing the RCA-EO Requirements Capabilities and for Earth Observations. Virtual. August 27. *https://eros.usgs.gov/doi-remote-sensing-activities/2016/usgs/requirements-capabilities-and-analysis-earth-observations-overview*

F58. 2017. ***Invited*** *by Jody Waugh (US DOE) to provide Technical Assistance:* Estimating ET and Recharge Rates using Nagler VI-ET for DOE-USGS working group on water accounting in phytoremediation studies at the MODFLOW & More Workshop. Golden, CO. May.

F59. 2017. ***Invited*** *by Hamideh Nouri, Henk Pelgrum & Steven Wonink (eLEAF) to provide Technical Assistance:* Discussions of ET product development and review of optical-band remote sensing of ET key findings and ways to collaborate with Megan Blatchford for her UNESCO sites in Kenya. Wageningen, The Netherlands. October.

F60. 2018. ***Invited*** *by Prof. Sandra García Galiano (Universidad Politécnica de Cartagena, Dept. Civil Engineering) to provide Technical Assistance:* To improve the spatial distribution of agricultural and riparian ET estimates in drylands in Spain and western US by using satellite indices & to collaborate after meeting in person May 8-10.

F61. 2018. ***Invited*** *by Andrew Hautzinger (FWS, Water Resources Chief) to provide Technical Assistance:* How the impact of my USGS Ecosystems study, vegetation assessment of greenup and evapotranspiration using satellite imagery for native and non-native plants in western U.S.A. riparian zones, could be used for avian habitat decision-making. November 2.

F62. 2018. ***Invited*** *by Eleanour Snow (USGS OSQI Program Manager) to provide Technical Assistance:* The science of water use by riparian ecosystems on the Colorado, especially focused on saltcedar. Youth & Educ. in Science (YES), Celebrating Powell 150 Years Colorado River. June 2.

F63. 2018. ***Invited*** *by Prof. Chris Neale (U. Nebraska) to provide Technical Assistance:* Remote Sensing & Hydrology Symposium Proceedings review team. Córdoba, Spain. May 8-10.

F64. 2018. ***Invited*** *by Karl Flessa (Univ. Arizona, Colorado River Delta Science Coordinator) to provide Technical Assistance:* Provided input and technical advice in workshops and in the field about vegetation communities for the Minute 323 Science Team participants to discuss restoration logistics with NGOs, partners, IBWC, scientists from Mexico and US at the Adaptive Management Workshop & Technical Exchange. Mexicali, Mexico. October 23-25.

F65. 2019. ***Invited*** *by Andrew French & Doug Hansaker (USDA-ARS Maricopa) to provide Technical Assistance:* Using high-resolution imagery collected by VENUS for the US croplands near Yuma to be used for ET estimation in the transboundary region in Mexico. Maricopa, AZ. February 4.

F66. 2019. ***Invited*** *by Carolyn Vadnais (USGS Contractor, Centauricorp, Sr Prin. System Engineer) to provide Technical Assistance:* High resolution imagery needs for USGS. Virtual. October 3.

F67. 2019. ***Invited*** *by Dave Demer (NOAA Sr Scientist, La Jolla, CA) to provide Technical Assistance:* Colorado River Delta estuary sciences & fisheries, survey technologies. Virtual. October 18.

F68. 2020. ***Invited*** *by Karl Flessa (Univ. Arizona, Colorado River Delta Science Coordinator) to provide Technical Assistance:* Provided input and technical advice about vegetation communities for the Minute 323 Environmental Working Group (EWG) participants to discuss restoration activities, planning and logistics with NGOs, partners, IBWC, Mexican and U.S. university scientists at the EWG Workshop & Technical Exchange. February 2020.

F69. 2020. ***Invited*** *by Morgan Williams (Navarro Research and Engineering, contractor to DOE Office of Legacy Management) to provide Technical Assistance:* Use of remote sensing fusion methods to measure the effects of pedogenesis on engineering properties of disposal cell covers on uranium mill tailings sites, a project that uniquely bridges the disciplines of soil morphology and geotechnical engineering. Virtual. June 19.

F70. 2020. ***Invited*** *by Karl Flessa (Univ. Arizona, Colorado River Delta Science Coordinator) to provide Technical Assistance:* Provided input and technical advice about Remote Sensing Time-Series Vegetation Index for measuring vegetation communities in the Colorado River Delta for the Minute 323 Science Team; provided advice to partners, IBWC and Reclamation about using a private consultant's data versus ours at USGS. July 21.

F71. 2020. ***Invited*** *by Greg Snyder (USGS National Land Imaging Program) to provide Technical Assistance:* Provided suggestions regarding my research needs related to Lidar and hyperspectral for discriminating species types in the semi-arid southwest USA; NASA/USGS Satellite Needs Survey, conducted by the White House National Science & Technology Council's U.S. Group on Earth Observations (USGEO), requested by USGS researchers. July 31.

F72. 2020. ***Invited*** *by Arturo Lara Flores (NGO, Restauremos de Colorado) to provide Technical Assistance:* Weather station placement in the CO Delta in Mexico, October 18.

F73. 2020. ***Invited*** *by Hamideh Nouri (University of* Göttingen*) to provide Technical Assistance:* Landsat-MODIS ET downloading & image proc. for cropped agric. lands in Iran. Virtual. Oct. 9.

F74. 2021. ***Invited*** *by Jim Wiegand (CA BLM) and Chris Potter (NASA Ames) to provide Technical Assistance:* San Sebastian Marsh, west of the Salton Sea: distinguishing between tamarisk and mesquite with remote sensing. Virtual. May 10.

F75. 2021. ***Invited*** *by Cindy Tam (USGS Reston) to provide Technical Assistance:* Biological Threat Surveillance Tools for saltcedar discrimination specifically using infrared and drone detection

tools. DOI Invasive Species Information Management Working Group Survey for the North American Invasive Species Management Association (NAISMA). Virtual. May 18.

F76. 2021. ***Invited*** *by Miguel Villarreal (USGS WGSC) to provide* *Technical Assistance:* As the first scientist to develop a shortwave infrared algorithm, the Cellulose Absorption Index (CAI), for distinguishing invasive plant species in riparian and grassland biomes based on its utility in separating plant litter, cellulose, lignin from background mineral soils and other non-photosynthetic active characteristics. Application of this hyperspectral index to distinguish soil crusts and their color (light/dark) from soils is an example of its possible current utility despite being applied in agricultural and uncultivated lands many years ago. Virtual. August 13.

F77. 2021. ***Invited*** *by Karl Flessa (Colorado River Project Director), Oral Presentation (virtual):* Lower Colorado River Delta Remote Sensing Key Findings of the Unrestored and Restored Areas. Colorado River Delta Minute 323 Adaptive Management Meeting. Virtual. July 13-15, 2021.
IP-133054 (abstract); BAO Approved 07/12/21; IP-133055 (presentation); BAO Approved 07/12/21

F78. 2022. ***Invited*** *(virtual) by Jennie Duberstein* (US FWS, Sonoran Joint Venture, Director)*, Oral Presentation (virtual):* High-resolution Vegetation Mapping in the Sonoran and Mojave Deserts using Random Forest Classification of Multi-temporal Landsat 8 Data and Phenology Metrics. Sonoran Joint Venture, Management Board Meeting, Nov. 16-17, 2022.
IP-147343; BAO Approved 11/22/22;

F79. 2022. ***Invited*** *(virtual) by Jennie Duberstein* (US FWS, Sonoran Joint Venture, Director)*, Oral Presentation (virtual):* Demonstration of the Searchable Database for the Transboundary Project on High-resolution Vegetation Mapping in the Sonoran and Mojave Deserts using Random Forest Classification of Multi-temporal Landsat 8 Data and Phenology Metrics. FWS Sonoran Joint Venture, Science Working Group Meeting. December 13, 2022.
IP-147343; BAO Approved 11/22/22;

F80. 2023. ***Invited*** *(virtual) by Christopher Dodge* (US Bureau of Reclamation, Lower Colorado River Multi-Species Conservation Plan), *Oral Presentation*: Trends in Greenness and ET of Riparian Vegetation in Restored and Unrestored Reaches of the Lower Colorado River in the USA. Bureau of Reclamation and Lower Colorado River, Multi-Species Conservation Program Sponsored *Colorado River Terrestrial and Riparian Meeting (CRTR).* January 13, 2023.
IP-149018; BAO Approved 1/17/23;

F81. 2023. ***Invited*** *(virtual) by Roberto Real Rangel* (Nature Conservancy), *Oral Presentation*: Riparian Ecosystems in the Colorado River delta in Mexico under Minutes 323. Minute 323 Environmental Working Group, 2023 Adaptive Management Workshop in Yuma, AZ. May 3-4, 2023.
IP-153078; BAO Approved 05/03/23;

F82. 2024. ***Invited*** *(in-person) by Nicole Cook* (RiversEdgeWest), *Oral Presentation (in person)*: Trends in Vegetation Greenness-based Evapotranspiration Rates for Riparian Corridors. Riparian Restoration Conference, Grand Junction, CO. March 5-7, 2024
https://riversedgewest.org/get-involved/events/2024
IP-157834, BAO Approved 09/19/239

F83. 2024. ***Invited*** *(virtual) by Christopher Dodge* (US Bureau of Reclamation, MSCP*), Oral Presentation (virtual)*: Vegetation response to active restoration and in-channel water deliveries in the Colorado River Delta, Mexico. Colorado River Terrestrial and Riparian (CRTR) Meeting at the LCB Regional Conference and Training Center near the Lower Colorado River Multi-Species Conservation Program offices, Boulder City, NV. Jan. 30-31, 2024.
IP-162148; BAO Approved 01/30/24

F84. 2024. ***Invited*** *(virtual) by Sara Ricklefs* (Invasive Species Action Network, Executive Director), *Oral Presentation (virtual)*: Understanding Woody Invasive Water Use: The future of introduced

Tamarix spp., Science Advisory Panel and Working Group for the Montana Woody Invasives Meeting. Helena, Montana. Oct. 17, 2024.
IP-171598; BAO Approved 10/11/24

F85. 2024. ***Invited*** *(in person) by Mitch McClaran,* (University of Arizona School of Natural Resources and the Environment, Professor), *Oral Presentation (in-person)*: Impacts of Plant Evapotranspiration and Water Use on Conservation Efforts in the U.S.-Mexico Border Region. Research Insights in Semiarid Ecosystems (RISE) Symposium, 20th annual RISE symposium at the University of Arizona. Tucson, AZ. Nov. 9, 2024. *https://santarita.arizona.edu/news/2024-rise-symposium-update*
IP-172739; BAO Approved 11/13/24;

F86. 2024. ***Invited*** *(in-person) by Fred Phillips* (Fred Phillips Consulting), *Oral Presentation (virtual)*: Navajo Nation Resources & Development Committee Meeting, Mentmore, New Mexico. November 12, 2024
https://www.navajonationcouncil.org/meetings-2024/
IP-172628; BAO Approved 11/07/24;

F87. 2025. ***Invited*** *(in-person) by Christopher Dodge* (US Bureau of Reclamation, MSCP*), Oral Presentation (virtual)*: Restoration Concepts for the Navajo Nation: Riparian Site Quantitative Trends of Actual Evapotranspiration Using a Landsat Greenness Index. Colorado River Terrestrial and Riparian meeting. Boulder City, NV, Jan. 22-23, 2025.
https://dev.sonoranjv.org/colorado-river-terrestrial-and-riparian-group-meeting/
IP-173171; BAO Approved 11/27/24;

F87. 2025. ***Invited*** *(in-person) by Christopher Dodge* (US Bureau of Reclamation, MSCP*), Oral Presentation (virtual)*: Restoration Concepts for the Navajo Nation: Riparian Site Quantitative Trends of Actual Evapotranspiration Using a Landsat Greenness Index. Colorado River Terrestrial and Riparian meeting. Boulder City, NV, Jan. 22-23, 2025.
https://www.lcrmscp.gov/news_events/CRTR_article?id=51942
IP-173171; BAO Approved 12/02/24;

F88. 2025. ***Invited*** *(in-person) by Martha Gomez-Sapiens* (University of Arizona, Geosciences Department*), Oral Presentation (virtual)*: Colorado River Delta Riparian Health as Measured by Remote Sensing: Analysis of Vegetation Trends by Remote Sensing for Minute 323, the Binational Monitoring Program, Environmental Working Group (EWG), a part of the International Boundary Water Commission (IBWC) Monitoring Report 2023-2024.
IP-176865, BAO Approved 3/7/25

F89. 2025. ***Invited*** *(in-person) by Martha Gomez-Sapiens* (University of Arizona, Geosciences Department), *Oral Presentation (in-person, by* Gonzalez-Sargas*)*: Key findings of the bird-vegetation-water Science Team of Minute 323, the Binational Monitoring Program, Environmental Working Group (EWG), a part of the International Boundary Water Commission (IBWC) Monitoring Report 2023-2024.
IP-177214, BAO Approved 3/18/25

Factor 10: Awards and Recognition

1988 Invitee, Gamma Theta Upsilon Honor Society
1989 Award, National Geographic Society, Prestigious Internship
1991 Award, Federal Employee Point of Light Award
1996 Award, Fellowship, National Science Foundation (NSF) Japan Program
1997 Recognition, National Institute of Agro-Environmental Sciences (NIAES, Japan)
1999 Invitee, EOS Terra MODIS Launch –Vandenberg AFB
2000 Recognition, coordinated months-long field logistics for validating MODIS Terra
2002 Award, Doris Duke Foundation, Conservation Research in the Colorado Delta
2003 Award, Internship, Ke Kua'aina Hanauna Hou, Moloka'i
2005 Award, NSF-Research Coordination Network Executive Committee (4 years)
2006 Recognition, USGS SBSC Outstanding Effort (not EPAP)
2007 Recognition, USGS SBSC Outstanding Effort (not EPAP)
2008 Recognition, USGS SBSC Most Published (not EPAP)
2009 Recognition, Elected to USFWS Sonoran JV Board for remote sensing expertise
2010 Award, USGS Top Achiever, Reston Headquarters Awards Ceremony (McNutt & Castle)
2010 Award, Presidential Early Career Award Science & Engineering (PECASE) (1st USGS)
The PECASE is the highest award in the US for Early Career Scientists & Engineers.
2011 Award, National Academy of Sciences (NAS) & Chinese Academy of Sciences (CAS),
2011 Kavli Fellow Award, *Nominated by USGS Director Marcia McNutt*
2012 Award, USGS Powell Center (Global Croplands & Water Use for Food Security)
2013 Award, CSIRO, Office of the Chief Executive (OCE Fellow), Land & Water (1 year)
The OCE Fellowship is the highest award at CSIRO in Australia.
2014 Recognition, AGU and NASA/USGS Press Coverage of Minute 319
2015 Recognition, Invited by the USGS Director Kimball to join the Women of USGS
2016 Award, NASA Ames highlight for DOE/USGS Project, UAS for scaling riparian ET
2017 Recognition, Women of USGS (Book, pg. 4 & 73) *https://doi.org/10.3133/cir1443*
2017 Recognition, Nomination (Women's Group), USGS Excellence in Leadership Award
2017 Recognition, Visiting Fellow, Netherlands, U. Twente, ITC (Geo Info Sci.& Earth Obs),
2017 Recognition, IHE Delft Institute for Water Education
2017 Invitee, International Expertise in water, Iran Water Conference
2018 Invitee, Dept. Justice, Expert Witness in ecohydrology for San Pedro River
2018 Recognition, AGU Ecohydrology LEAF *https://www.aguecohydrology.org/blog-adding-our-leaves/meet-a-leaf-pamela-nagler*
2018 Recognition, Invited Technical Committee for Hydrology & Remote Sensing, Spain
2018 Award, USGS Leadership101: Medal for Daily Best Leader (& Signed Book, Werkheiser)
2019 Recognition, Earthmap Contributor, Rocky Mtn Region, Colorado River Basin Pilot
2019 Recognition, COSSA/PECASE Senior Scientific Professionals,
https://internal.usgs.gov/cossa/who.html
2020 Invitee, Dept. Justice, Navajo Nation, Expert Witness in ecohydrology, Little CO River
2021 Recognition, Nomination, NASA – USGS Pecora Award.
The PECORA is the highest award in the World for Remote Sensing Scientists.
2023 Award, The Rocky Mountain Regional Office Group Star Award in support of the Colorado River Basin ASIST Workshop Series Program and Subject Matter Experts

Factor 11: External Impact Statements

LETTERS FROM non-USGS COLLEAGUES

1. Dr. Hamideh Nouri, Senior Scientist, Water Engineering and Management, University of Göttingen, Germany (Mentee)
2. Professor Alfredo Huete, University of Sydney Tech, Australia (Mentor)
3. Jennifer Pitt, Director of the Colorado River Program, Audubon Society
4. Doreen McPaul, Attorney General & Director of Natural Resources, Navajo Nation Department of Justice; and Jason John, Director, Navajo Department of Water Resources
5. Gilbert Anaya, Division Chief US IBWC, Environmental Management Division; and Albert Flores; IBWC Environmental Protection Specialist
6. Julia Fonseca, Senior Manager, Office of Sustainability and Conservation, Pima County (AZ)
7. Chris Dodge, Lower Colorado River Multi Species Conservation Program, U.S. Bureau of Reclamation
8. Terri Hogan, Manager, Biological Resources Division, Invasive Species Program, U.S. National Park Service
9. Jennie Duberstein, Director, Sonoran Joint Venture, U.S. Fish and Wildlife Service
10. Aaron Wilkerson, Bureau of Land Management, Arizona
11. Rusty Lloyd, Director of NGO, RiversEdge West