

**Incorporating the needs of groundwater-dependent ecosystems into
SGMA Implementation in the Vina Subbasin.**



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Background

SGMA defines groundwater-dependent ecosystems (GDEs) as “ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” [23 CCR §351(m)]. GDEs may rely on groundwater to meet some or all of their water supply needs, and these ecosystems are comprised of both aquatic and terrestrial species that are directly or indirectly linked to groundwater availability. Across California, GDEs serve as biodiversity hotspots and essential drought refugia, supporting rare and sensitive species and habitats.

Under SGMA, GSAs must consider all beneficial uses and users in a groundwater basin when developing and implementing their local GSP. Environmental users of groundwater are explicitly recognized as beneficial users in SGMA [California Water Code Section 10723.2(e)], and a description of impacts to groundwater dependent ecosystems is a required element of GSPs [California Water Code Section 10727.4(l)]. GDEs can be impacted by groundwater management related to two of SGMA’s sustainability indicators: chronic lowering of groundwater levels and depletion of interconnected surface waters. Short-term loss of groundwater to vegetative GDEs may result in water stress, while longer-term loss of groundwater access for GDEs can lead to undesirable results such as diminished reproduction and loss of species and habitats. GSPs must demonstrate that the interests and groundwater needs of GDEs were considered during plan development and implementation, including in the determination of the minimum groundwater levels necessary to avoid significant and unreasonable adverse impacts to all beneficial users.

The Nature Conservancy (TNC) and Audubon California partnered with staff from the Butte County Water and Resource Conservation Department to provide technical assistance in the Vina subbasin by assisting environmental stakeholders and groundwater sustainability agencies (GSAs) with the technical resources and capacity to incorporate the needs of GDEs into SGMA implementation. Technical tasks included an assessment of GDE protections under existing sustainability management criteria (SMC), analysis investigating the application of statewide recommendations as interim ecological thresholds at shallow monitoring well locations, and the development of a GDE prioritization map. This work also included the coordination and engagement of community environmental stakeholders in the Vina Subbasin to build technical knowledge among local watershed groups and other NGOs. The results from stakeholder engagement will be shared in a separate report, written by Audubon California. Lessons learned from this direct engagement will inform state agencies and high-level decision makers to guide groundwater sustainability into the future.

This report covers the methodology and results of the following – 1) the assessment of GDE protections under existing SMC, historical groundwater conditions, and the current groundwater monitoring network, 2) expansion of the shallow groundwater monitoring network, 3) an ecological threshold analysis using statewide recommendations and the best available science, and 4) a prioritization workflow for identifying at risk GDEs. It also provides management recommendations for Vina subbasin based upon the findings of this technical assistance work that if implemented, would result in increased protection to groundwater dependent ecosystems at the subbasin scale.

Review of Existing Ecosystem Protections

Previous research on GDE protections under SGMA has examined the relationship between the rooting depth of mapped GDEs and existing sustainability management criteria for the ‘lowering of groundwater levels’ sustainability indicator (Perrone, Rohde, Wagner et al. 2023). This research examined GDE polygons located within 1.5 miles of existing monitoring wells, classifying GDEs statewide as ‘covered’ and ‘not covered’, based on their proximity to existing monitoring wells, and ‘protected’ and ‘not protected’ based on whether the estimated rooting depth of the GDE polygon was located at or below the minimum threshold set for the monitoring well (Figure 1).

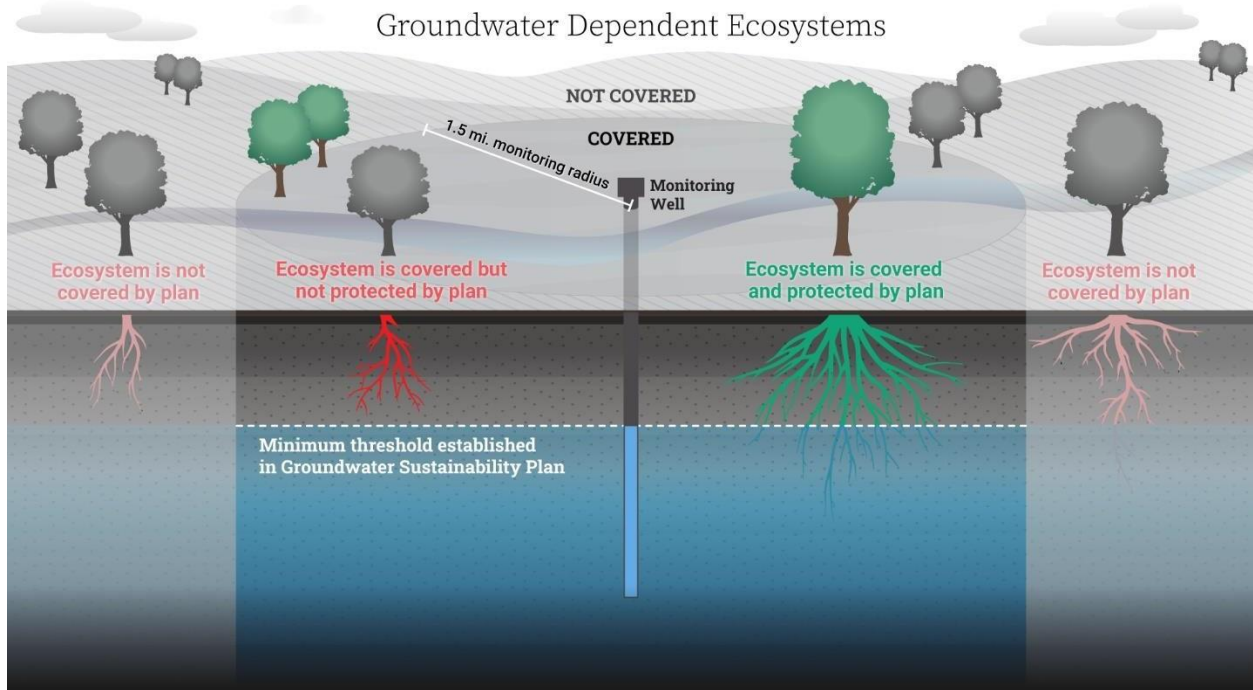


Figure 1 (Perrone, Rohde, Wagner et al. 2023).

This analysis identified gaps in both monitoring network coverage and protections under SGMA SMC, with ~42% of ecosystems covered statewide, and only 9% of ecosystems classified as ‘protected’ (Perrone, Rohde, Wagner et al. 2023). Vina subbasin showed preliminary results that ranked more poorly than statewide results, with <1% of GDEs ‘protected’, ~35% ‘covered, not protected’, and ~64% ‘not covered’.

These initial protection analysis results were of particular concern, especially since Vina subbasin has large areas of deep-rooted GDE species including Valley Oak. Across the state, deep-rooted Valley Oak species are more commonly ranked as ‘protected’ compared to more

shallow-rooted groundwater dependent ecosystems (cottonwood, willow, etc.). Figure 2 is an example of one of Vina subbasin’s monitoring wells for the lowering of groundwater levels SMC, from their initial GSP submission. The technical assistance team has strong concerns related to the large gap between historically observed groundwater level observations and the existing Minimum Thresholds in the Vina Subbasin. In the Figure 2 example, the existing minimum threshold is ~80ft lower than the historically observed minimum groundwater level elevation. While the GSP references potential impacts to deep rooted groundwater dependent ecosystems, it does not incorporate environmental considerations into the establishment of its existing sustainable management criteria related to the lowering of groundwater levels.

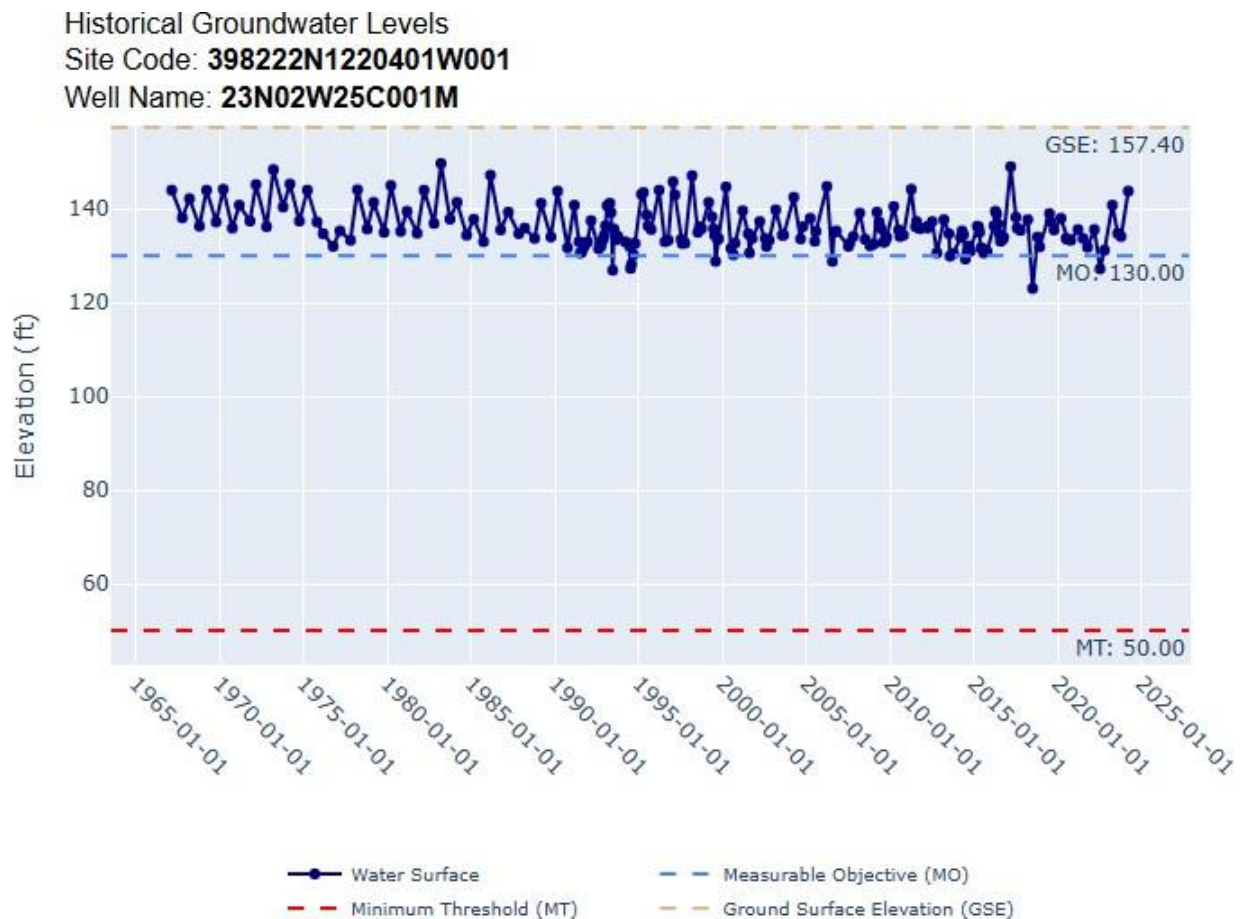


Figure 2: Vina Subbasin monitoring well with existing SMC for the ‘Lowering of Groundwater Levels’ SMC in the existing submitted GSP.

The initial results from the Perrone, Rohde, Wagner et al. 2023 research and our concerns regarding unprotected deep-rooted GDEs served as the starting point for technical assistance discussions with Butte County staff who provide technical assistance staff support to Vina GSA. Staff had concerns regarding the use of the existing groundwater monitoring network to evaluate GDE protections, as they described limitations of the selected RMS wells in representing shallow

groundwater conditions and therefore concluded the wells were not appropriate for assessment of GDE impacts. Vina's original GSP was not able to establish Sustainable Management Criteria designed to prevent impacts to environmental beneficial users, and the GSP identifies shallow monitoring as a data gap to be filled through future SGMA implementation efforts.

Shallow Groundwater Monitoring Network Expansion

At the time of this technical assistance, the SGM grant funded Data Gap Identification and Data Improvement Project was actively working to establish a shallow groundwater monitoring network and address the above issues. The URCTA technical team worked with staff as shallow groundwater monitoring well locations were identified by the Data Gap project (Figure 3).

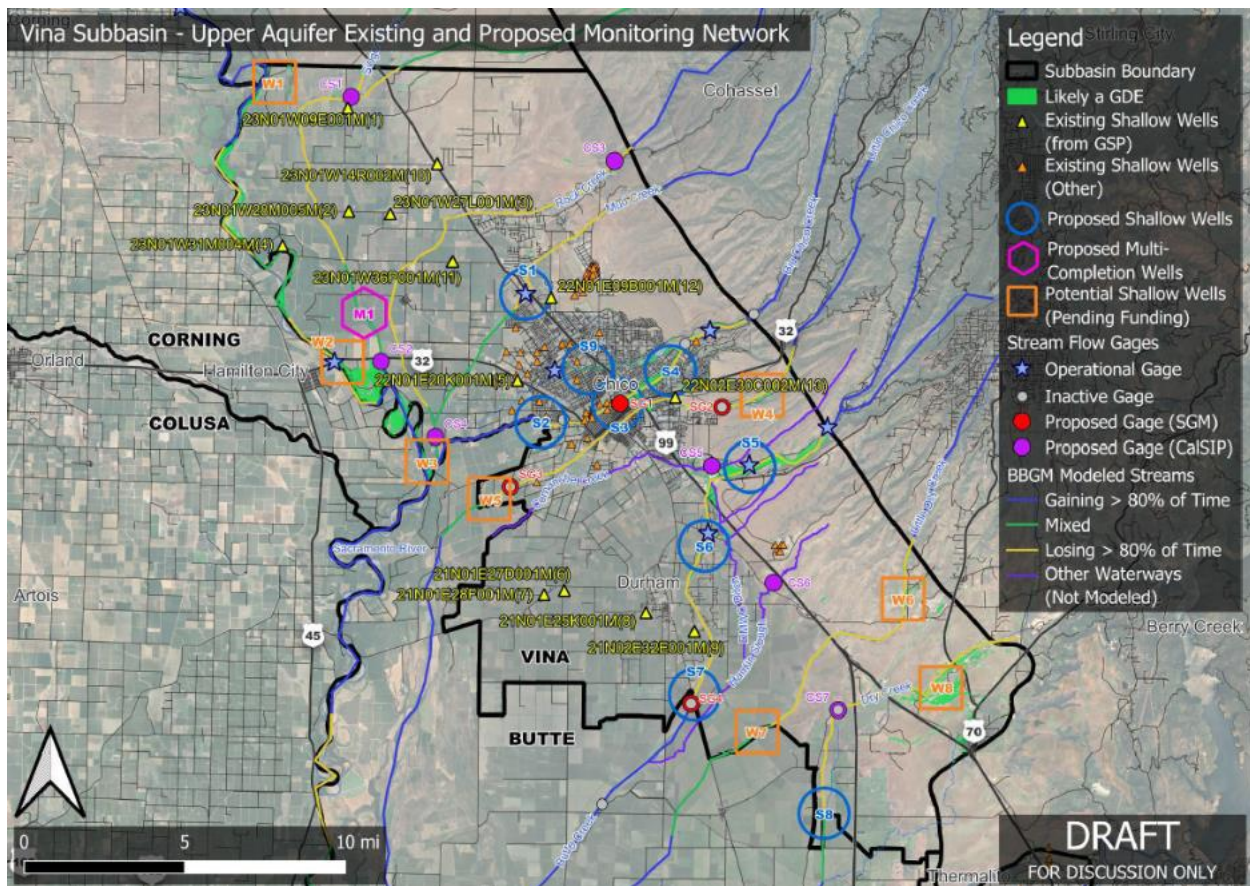


Figure 3: Shallow Groundwater Monitoring Network Expansion Plan. Source: Vina Subbasin SHAC Meeting Materials.

This process identified several methods in which the Data Gap project was leveraging available resources in novel and effective ways. Larry Walker Associates, in partnership with Dr. Todd Greene from CSU Chico, analyzed available Airborne Electromagnetic (AEM) survey data to delineate aquifer boundaries and identify existing monitoring well locations that were screened in the shallow aquifer system (Figure 4).

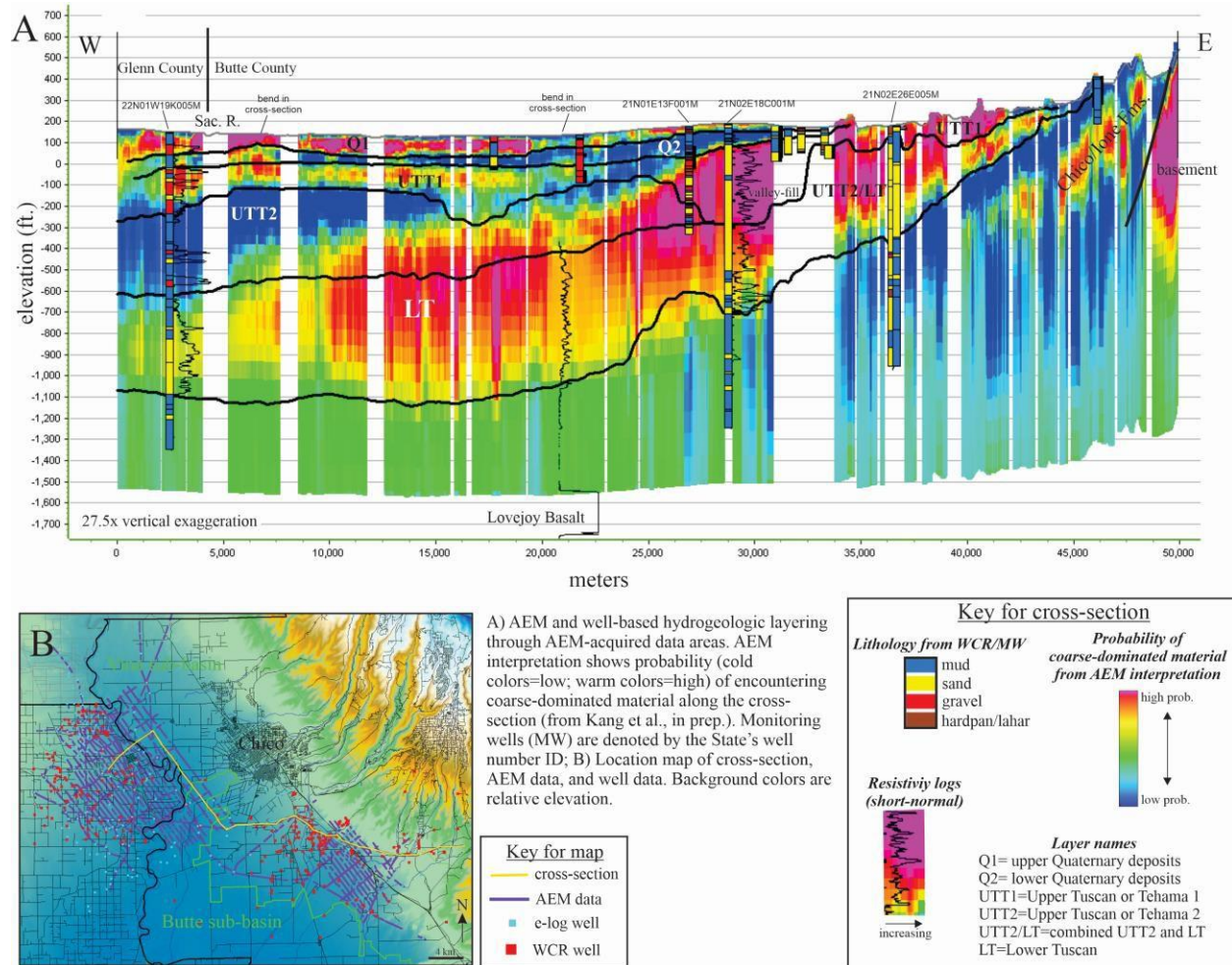


Figure 4: Results from Dr. Todd Greene AEM Analysis, identifying individual aquifer units and corresponding shallow and deep monitoring well locations.

The analysis identified nine existing monitoring wells that were confirmed to be screened within the upper Quaternary deposits (Figure 4, Q1 & Q2), indicating their suitability for inclusion in the newly developed shallow groundwater monitoring network. Many of these wells have long records of historic groundwater observations, making them a valuable resource for GSA staff when considering future development of sustainability management criteria. This AEM analysis resulted in the inclusion of monitoring wells into the SGMA monitoring network that otherwise may not have been identified as suitable candidates. The AEM survey data for the Vina Subbasin is available at a higher resolution than the rest of the state, which increased the suitability of this analysis to identify shallow monitoring wells. However, this approach may be replicated in other groundwater subbasins across the state and represents a novel opportunity to expand monitoring networks with existing wells. Data gaps in shallow groundwater monitoring networks are commonly cited as an issue in groundwater sustainability plans across the state, and the ability to scale this methodology should be further investigated. This has the potential to be a low-cost alternative to the drilling and development of new monitoring wells when filling shallow groundwater monitoring network data gaps.

Ecological Threshold Analysis and Recommendations

Following the development of the shallow groundwater monitoring network, the technical team focused on potential workflows to develop sustainable management criteria for the newly identified monitoring wells. Specifically, we adopted statewide results and management recommendations from Rohde et al. 2024 to estimate ecologically protective groundwater levels at each of the nine shallow groundwater monitoring wells.

Rohde et al. 2024 estimates ecologically protective groundwater levels by combining NDVI and groundwater level time series for groundwater dependent ecosystem polygons mapped in the Natural Communities Commonly Associated with Groundwater dataset, which was developed by a working group that included the California Department of Fish and Wildlife, DWR, and TNC. Figure 5 is an example of the proposed sustainability management criteria for the lowering of groundwater levels undesirable result at these newly incorporated shallow groundwater monitoring wells. The dotted blue line represents mean summertime groundwater conditions observed in the historic monitoring record, and the dotted green line represents the recommended ecological threshold following Rohde et al. 2024. Our technical assistance work in the Yolo subbasin expanded upon this research and used modeled shallow groundwater levels to perform a subbasin-specific analysis. The results were comparable to the statewide recommendations and serve as an indicator that statewide recommendations are appropriate to implement in lieu of subbasin-specific analyses.

We recommend adoption of these ecological thresholds at the newly incorporated shallow groundwater monitoring wells as an opportunity to address deficiencies outlined in the DWR determination for the existing groundwater sustainability plan, address local environmental stakeholder concerns, and protect groundwater dependent ecosystems at a higher degree than currently exists in the Vina subbasin. Future technical assistance work in the Vina subbasin could investigate using modeled regional groundwater levels from existing numerical models following the same subbasin-specific workflow that was applied in the Yolo subbasin. This would tailor ecological threshold conditions to local groundwater conditions and observed responses between groundwater dependent ecosystems and fluctuations in shallow groundwater levels.

Additionally, we also recommend that Vina subbasin update their sustainable management criteria for the lowering of groundwater levels at existing monitoring wells in the 2022 GSP. There is not currently sufficient evidence that the operational range defined in the Vina GSP is protective of all beneficial users. The existing GSP does not analyze if undesirable results to GDEs occur if groundwater levels fall to the current minimum thresholds, set below historically observed lows, for extended periods of time. Lowering levels in the deeper aquifer systems to unprecedented depths could impact hydraulic gradients across aquifer systems, impacting shallow groundwater availability to groundwater dependent ecosystems.

Groundwater Level for Well: 23N01W27L001M

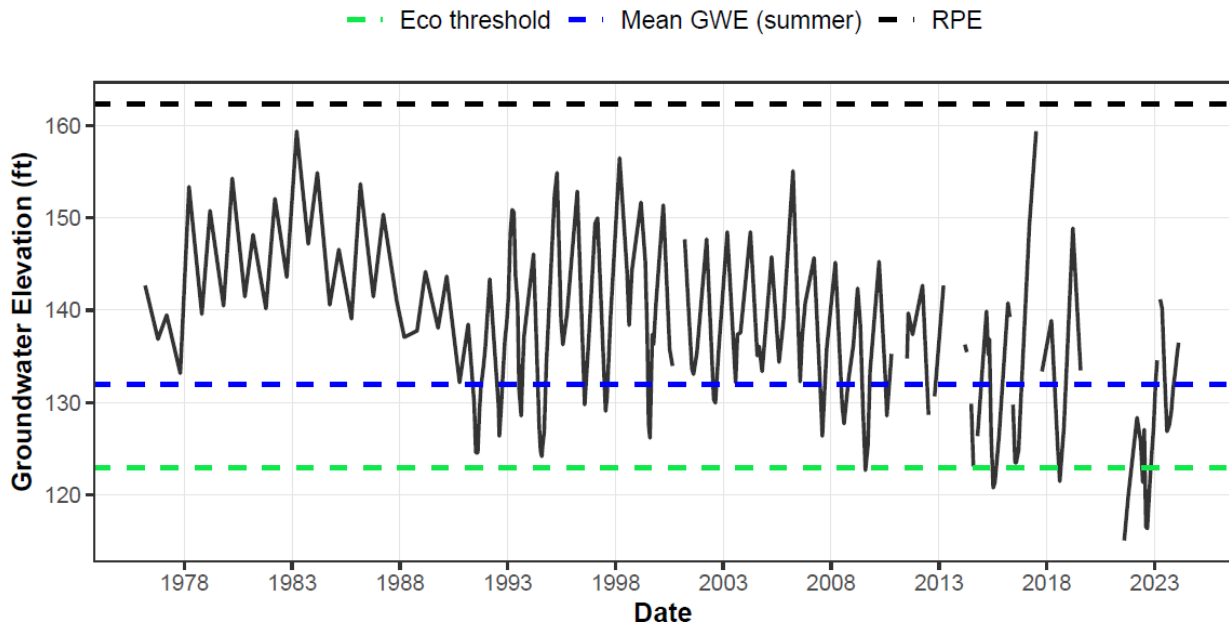


Figure 5: Recommended ecological thresholds for existing shallow groundwater monitoring locations in the Vina Subbasin. The black line represents the historic observed groundwater level elevation. The dotted black line represents the reference point elevation. The dotted blue line represents the mean summertime groundwater level. The dotted green line represents the recommended ecological threshold based upon the statewide analysis (Rohde et al. 2024).

GDE Prioritization Analysis

Although the Vina subbasin currently lacks sufficient shallow groundwater level datasets to analyze subbasin-specific ecological threshold recommendations, staff suggested that the technical team investigate methods that prioritize groundwater dependent ecosystems for future SGMA implementation and project and management action planning purposes. The following results are a preliminary analysis that prioritizes GDEs based on habitat value and susceptibility to future impacts. Figure 6 defines the steps of the prioritization analysis, and the categorization scheme used. Each NCCAG polygon in the Vina subbasin is ranked based upon the habitat value and susceptibility to impact indices (Figure 6a.).

Throughout the local environmental stakeholder engagement process, we often heard concerns that the NCCAG dataset was not comprehensive enough for the mapping of groundwater dependent ecosystems in the Vina Subbasin. One of the top priorities for stakeholders is the continued investigation into how local datasets can expand GDE mapping and identification efforts. If this prioritization workflow is included in future SGMA implementation efforts, continued advancement and refinement of GDE polygons across the Vina subbasin through local environmental stakeholder engagement will increase the utility of this tool and incorporate environmental stakeholders into key SGMA planning and decision-making processes.

Prioritization Matrix

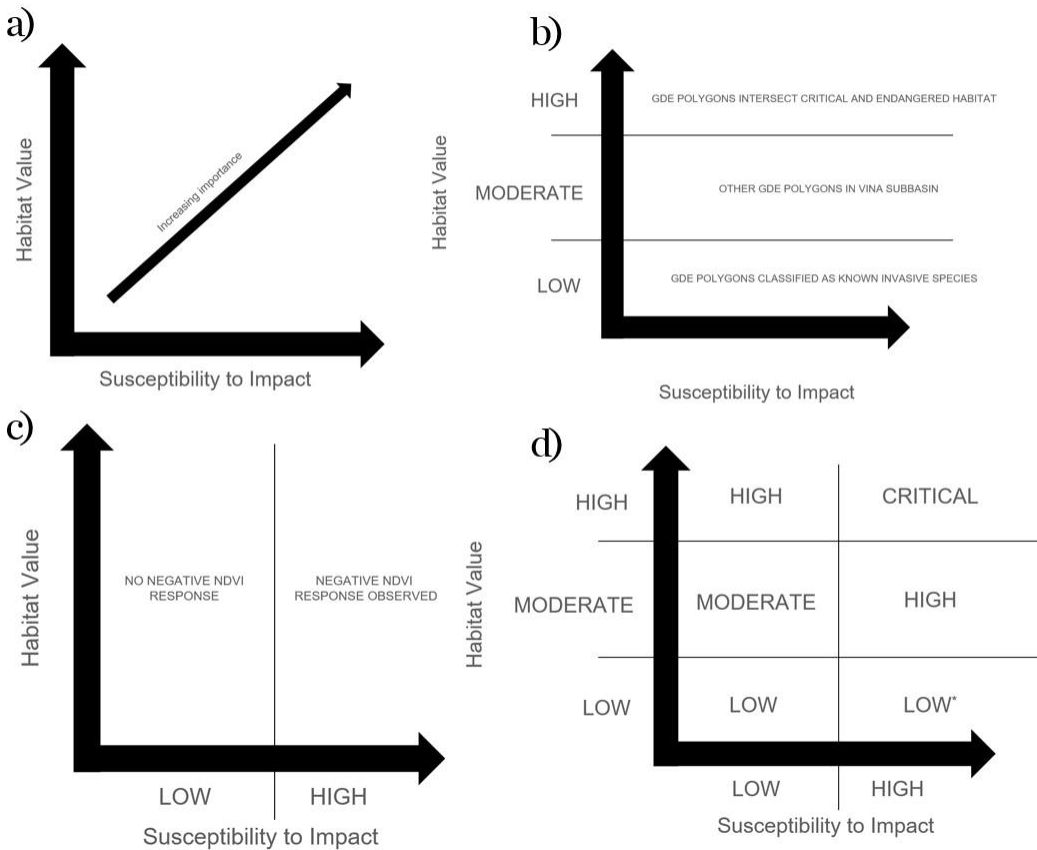


Figure 6: Prioritization matrices and methodology for GDE Prioritization Workflow.

Habitat value was ranked based on a synthesis of the California Department of Fish and Wildlife’s California Natural Diversity Database (CNDDDB), an inventory of the status and locations of rare plants and animals in California, The Nature Conservancy’s Critical Species Lookbook 2019 report, and a classification of known invasive species. The technical team used the Critical Species Lookbook to first determine which rare plants and animals in California had a linked reliance on groundwater. We then used the CNDDDB database to determine where in the Vina subbasin these species are present. We combined groundwater dependent species presence with existing NCCAG polygons, ranking these locations as ‘high habitat value’. Known invasive species polygons in the NCCAG dataset were deprioritized for projects and management actions related to groundwater dependent ecosystems, and were ranked ‘low habitat value’. NCCAG polygons that were neither ‘high’ nor ‘low’ value were ranked as ‘medium habitat value’ (Figure 6b, Figure 7).

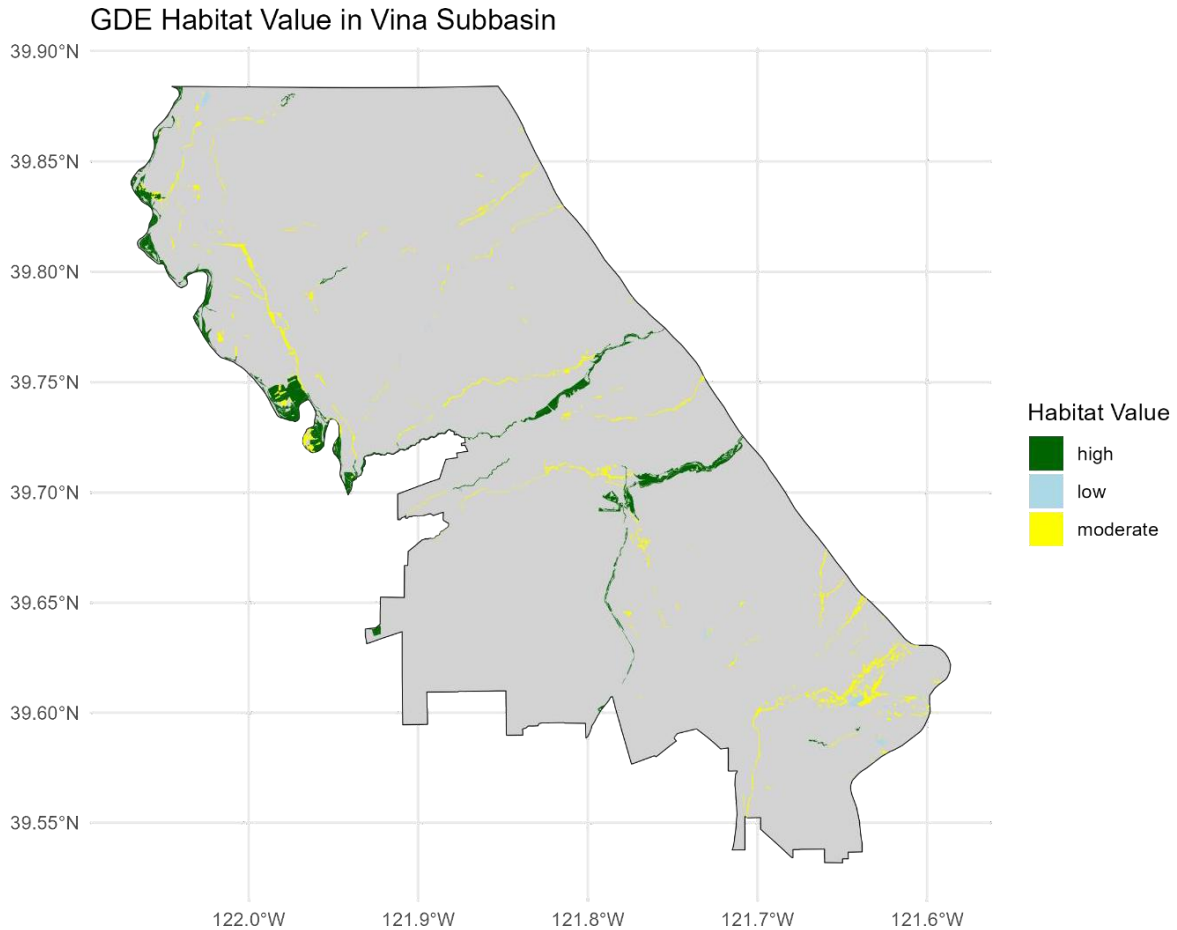


Figure 7: Preliminary Habitat Value Results from the Vina Subbasin Prioritization Workflow.

Susceptibility to impacts is determined using the same methodology to assess vegetative health that was applied in Rohde et al. 2024. A Z-score analysis was applied to a Landsat-derived normalized difference vegetation index (NDVI) dataset to quantify which NCCAG polygons have experienced statistically significant negative ecological responses over the period of interest (Figure 8). This is effectively one step in the ecological threshold workflow developed by Rohde et al. 2024. If paired with groundwater level data, it can identify which NCCAG polygons have experienced a negative health response directly attributable to declining groundwater levels. In this case, where sufficient groundwater level data is available for the complete analysis, it indicates that polygons we have identified as likely or potential GDEs have shown a negative ecological response and are associated with a high risk of impact (Figure 6c, Figure 9). Often, these responses have occurred during historic droughts, which we qualitatively know correspond to decreased shallow groundwater availability. The results from this Z-score analysis can be applied to this prioritization framework to identify GDEs that have experienced negative health impacts previously and therefore may be more susceptible to impacts in the future. Paired with habitat value, we have been able to identify high-priority areas across the Vina subbasin for future monitoring and project implementation efforts.

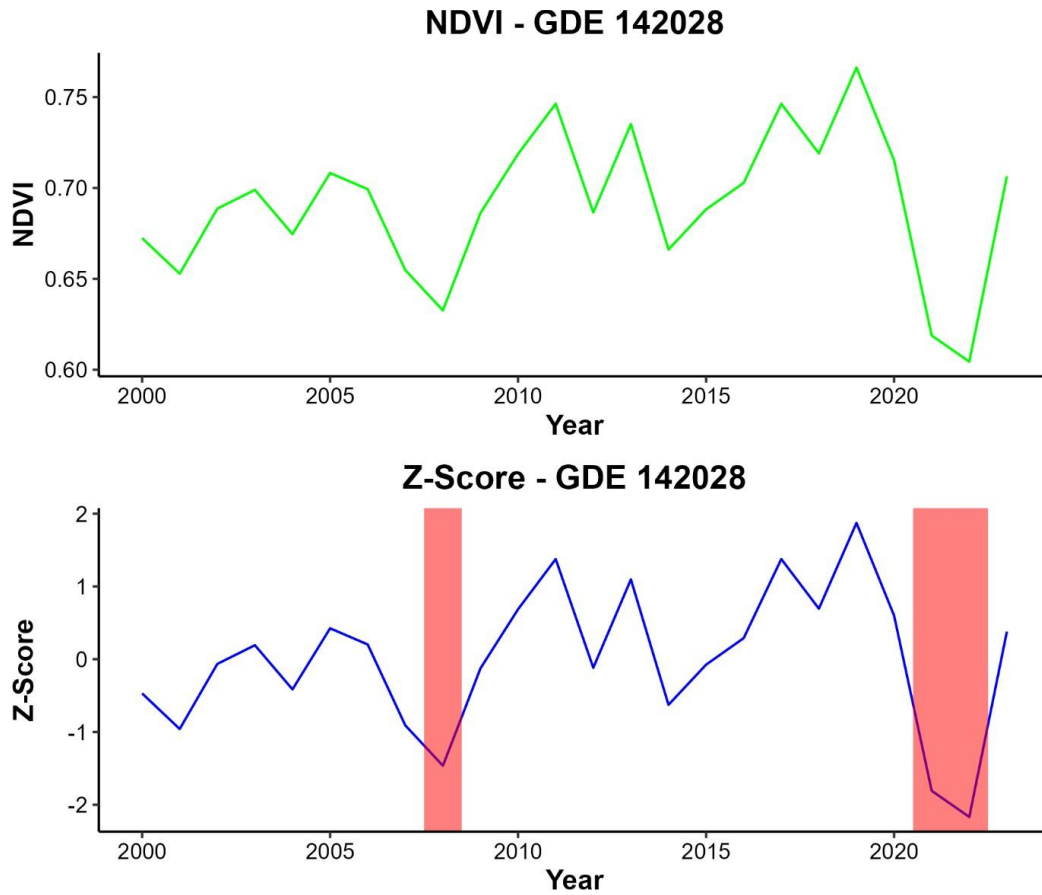


Figure 8: Susceptibility to Impact Methodology. Shaded red areas represent a year where summertime NDVI has a Z-score of -1 or less.

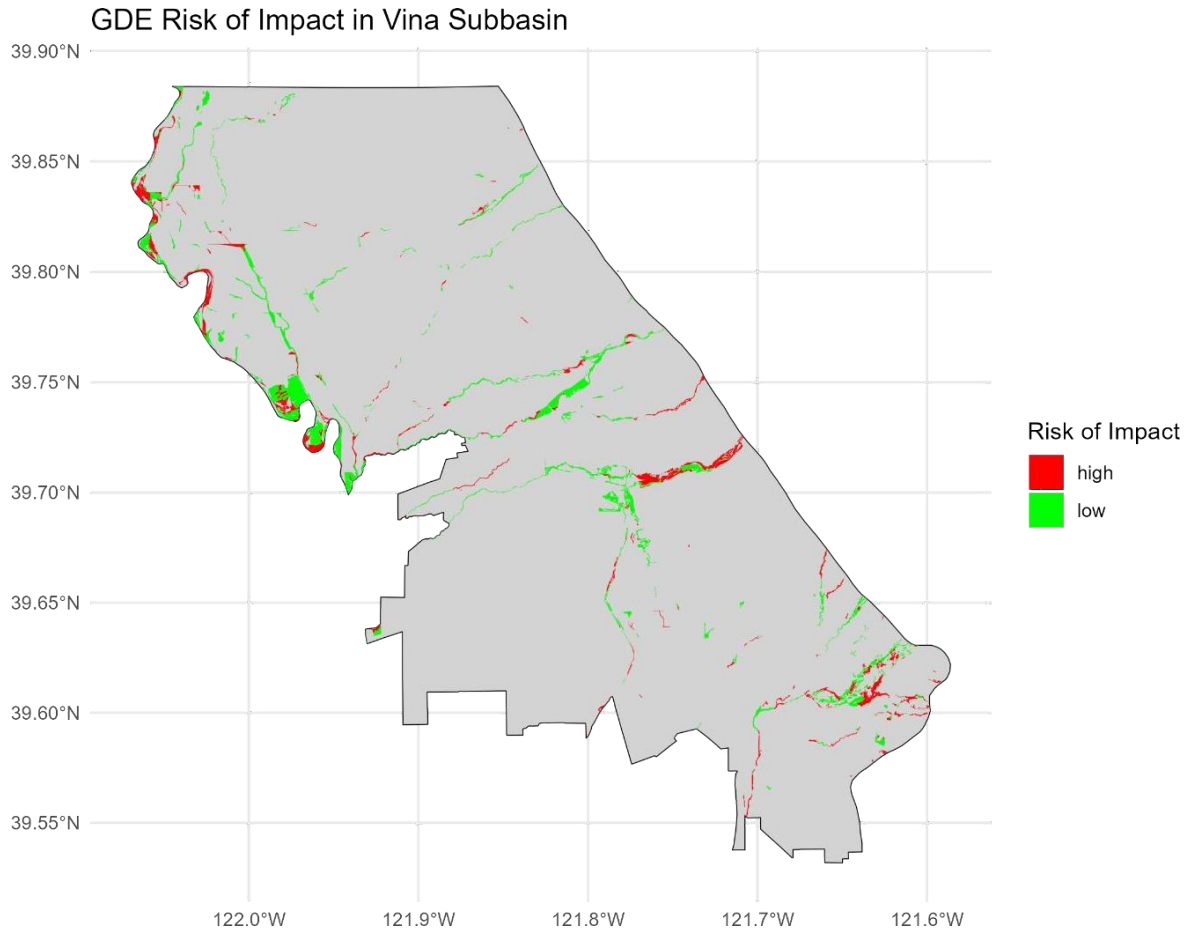


Figure 9: Preliminary Susceptibility to Impact Results from the Vina Subbasin Prioritization Workflow.

Combining rankings for habitat value and susceptibility to impacts allows us to determine our prioritization values for each NCCAG polygon in the Vina subbasin. Mapped invasives with a low habitat value ranking receive a prioritization score of ‘low’. Polygons with a moderate habitat value ranking, and a low susceptibility to impacts are ranked ‘moderate’. Polygons with a moderate habitat value ranking and a high susceptibility to impacts are ranked ‘high’. Polygons with a high habitat value ranking and a low susceptibility to impacts are ranked ‘high’. Polygons with a high habitat value ranking and a high susceptibility to impacts are ranked ‘critical’ (Figure 6d). The results for this preliminary prioritization analysis are presented in Figure 10.

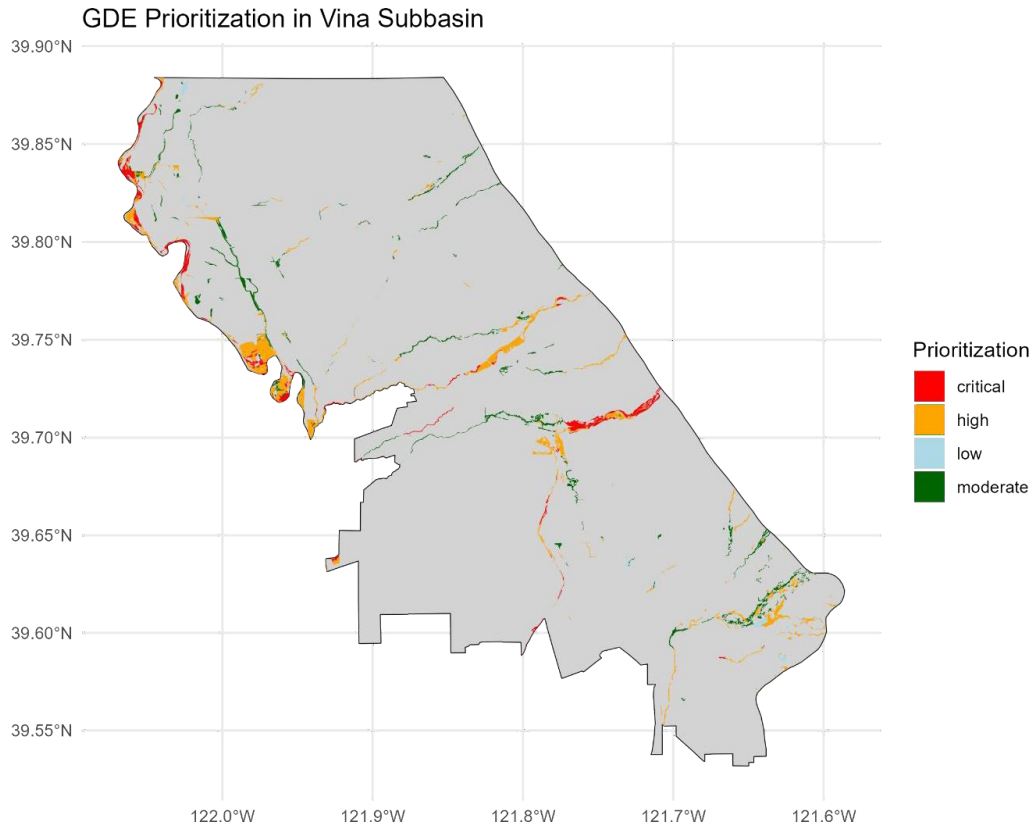


Figure 10: Preliminary GDE Prioritization Results for the Vina Subbasin.

Conclusions and Recommendations

SGMA requires GSPs to prevent significant and unreasonable impacts to environmental beneficial users, including groundwater-dependent ecosystems (GDEs). The technical assistance engagement in the Vina Subbasin identified major gaps in protection for groundwater dependent ecosystems under current SGMA implementation. Existing sustainable management criteria (SMC) and monitoring networks do not adequately represent shallow groundwater conditions or demonstrate the prevention of significant impacts to environmental beneficial users.

However, our engagement identified the ongoing steps that the Data Gap Project is taking to address these deficiencies. By leveraging novel methodologies like the analysis of AEM data to identify shallow groundwater monitoring wells, recent efforts are actively addressing gaps in the shallow groundwater monitoring network, and plan to incorporate these wells into the upcoming 2027 5-year update. Additionally, applying the results from the prioritization workflow can assist in future monitoring and project planning. Future efforts in updating the prioritization workflow should include the investigation, and where appropriate, the inclusion of local GDE mapping efforts. Environmental stakeholders in the Vina subbasin have continuously emphasized to the technical team and through feedback to the GSA that one of their top priorities is to build and incorporate local datasets into the GDE identification and monitoring process.

Ecological threshold analyses based on the best-available science offer a clear path to implementing more protective SMC, and we recommend that the Vina GSA staff apply ecological thresholds to shallow groundwater monitoring wells into the upcoming 2027 5-year GSP update. We also recommend that the SMC for existing wells in the groundwater monitoring network are updated in the 2027 5-year GSP update to address concerns from stakeholders, technical assistance staff, and the DWR recommended corrective actions.

Implementing these recommendations will improve resilience for ecosystems and communities, enhance biodiversity conservation, and advance SGMA's goal of sustainable groundwater management for all beneficial users.

References

Perrone, D., Rohde, M.M., Hammond Wagner, C. et al. Stakeholder integration predicts better outcomes from groundwater sustainability policy. *Nat Commun* 14, 3793 (2023).

Rohde, M.M., Stella, J.C., Singer, M.B. et al. Establishing ecological thresholds and targets for groundwater management. *Nat Water* 2, 312–323 (2024).