
Central Valley Regional Water Quality Control Board

30 June 2023

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CONDITIONAL APPROVAL OF THE GROUNDWATER PROTECTION TARGETS FOR CENTRAL VALLEY WATER QUALITY COALITIONS

On 15 December 2022, a report titled *Groundwater Protection Targets* (Report) was submitted to the Central Valley Water Board on behalf of third-party groups (Coalitions) approved to represent owners and operators of irrigated lands within the Central Valley. The development of Groundwater Protection (GWP) Targets is required by applicable Irrigated Lands Regulatory Program (ILRP) Waste Discharge Requirements General Orders for the purpose of establishing township-level nitrogen loading performance goals necessary to achieve compliance with Receiving Water Limitations in High Vulnerability Areas. The proposed GWP Targets build upon previous Coalition efforts to quantify current township-scale nitrogen loading at the root zone based on grower-reported Irrigation and Nitrogen Management Plan Summary data. The framework used to develop the GWP Targets considers hydrologic and geologic conditions that govern recharge and groundwater flow, non-ILRP sources of nitrogen, and post-root zone attenuation. Coalitions are required to revise the GWP Targets, where necessary, every five years.

The Report was circulated for public comment on 21 December 2022 and reviewed by Central Valley Water Board staff (staff). Based on staff's review of the Report, the GWP Targets are founded on the best available information, rely on reasonable assumptions, and are appropriate as a beginning point for incorporation into the Groundwater Quality Management Plans (GQMPs). However, staff, the Coalitions, and interested members of the public have all acknowledged that model inputs and assumptions contain inherent uncertainty; ongoing verification and refinement of the model are significant priorities. Therefore, I am approving the GWP Targets for incorporation into individual Coalition GQMPs with the condition that a workplan be developed to evaluate model uncertainties and describe future validation efforts. Additional details are provided below and in the enclosed staff memorandum. The results of this effort are expected inform potential refinements to the next iteration of the GWP Targets, **due 30 June 2028**.

Note that the subject of this conditional approval is the GWP Targets and not the near-term performance goals (milestones) proposed in the Report. I agree with staff's

MARK BRADFORD, CHAIR | PATRICK PULUPA, ESQ., EXECUTIVE OFFICER

recommendation to consider whether the milestones are appropriate during review of the GQMP updates that incorporate the GWP Targets.

By 1 April 2024, please provide a workplan that describes a proposed methodology for conducting a detailed uncertainty analysis that also contains, at minimum, the elements described in the enclosed memorandum. This workplan shall also contain plans for validating model outputs and key components. Following approval and implementation of the workplan, a final report shall be submitted that includes results of the uncertainty analysis and provides recommendations to refine the GWP Targets during preparation of the 5-Year GWP Targets Update report. This report must also specifically address the “apparent overestimations of nitrate-N contamination” noted in portions of the Sacramento Valley and identify a method to be used to calculate appropriate GWP Targets for these townships during the next 5-year update.

By 1 July 2024, the Coalitions must submit GQMP updates that incorporate the approved GWP Targets and contain the required components identified in Appendix MRP-1 of the ILRP General Orders.

The enclosed memorandum provides further details regarding staff’s review of the Report. If you have any questions regarding this letter, please contact Sue McConnell at (916) 464-4798 or by email at sue.mcconnell@waterboards.ca.gov.



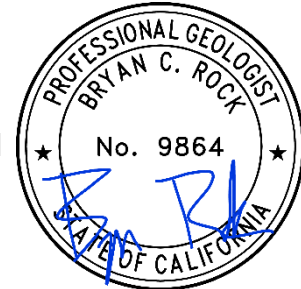
Patrick Pulupa
EXECUTIVE OFFICER

Enclosure: Staff Review of the Groundwater Protection Targets for Central Valley Water Quality Coalitions

Central Valley Regional Water Quality Control Board

TO: Eric Warren, PE
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IRRIGATED LANDS REGULATORY PROGRAM

FROM: Bryan Rock, PG 9864
Engineering Geologist
IRRIGATED LANDS REGULATORY PROGRAM



DATE: 28 June 2023

**SUBJECT: REVIEW OF PROPOSED GROUNDWATER PROTECTION TARGETS
FOR CENTRAL VALLEY WATER QUALITY COALITIONS**

On 19 July 2022, a report containing proposed Groundwater Protection (GWP) Targets was submitted to the Central Valley Water Board on behalf of third-party groups (Coalitions) approved to represent owners and operators of irrigated lands within the Central Valley. GWP Target development is the final step in establishing township-level nitrogen (N) loading rates necessary to achieve compliance with receiving water limitations within High Vulnerability Areas. The Report was submitted in accordance with the State Water Resources Control Board Order WQ 2018-0002 (Petition Order) and Irrigated Lands Regulatory Program (ILRP) General Orders within the Central Valley. GWP Targets are not intended to be enforceable metrics; rather, they are intended to be incorporated into Groundwater Quality Management Plans as performance goals to achieve compliance. GWP Targets are based on current township-scale nitrate loading estimates at the root zone (GWP Values), which were calculated using a method (GWP Formula) that was conditionally approved by the Executive Officer on 19 January 2021. The GWP Values were conditionally approved on 27 October 2021.

The initial GWP Targets Report was circulated for public comment on 27 July 2022. Two comment letters were received from interested parties during the review period. In response to these and additional comments from Central Valley Water Board staff, the Coalitions voluntarily submitted a revised GWP Targets Report (GWP Targets Report, or Report) on 15 December 2022. The revised Report was circulated for public comment on 21 December 2022. The Coalition also submitted a 3 April 2023 Technical Memorandum (Technical Memo) following a staff request for further documentation and expanded discussion concerning model inputs, particularly assumed nitrogen loading

rates from Confined Animal Facilities¹ (CAF) and recharge terms. The following sections provide a summary of the revised GWP Targets Report and Technical Memo, a summary of public comments received with staff responses, and staff's assessment and recommendations.

REVISED GROUNDWATER PROTECTION TARGETS REPORT SUMMARY

Development of the GWP Targets incorporates results of earlier modeling efforts that resulted in the GWP Formula and the GWP Values, which have been summarized in detail previously and are only briefly discussed here. The GWP Formula was developed using a process-based model, the Soil Water Assessment Tool, that was customized for specific use in the Central Valley (CV-SWAT). The model incorporates factors such as climate, soil type, water, nutrient and pesticide dynamics, the nitrogen cycle, plant growth, and management, all of which influence nitrate leaching. The Formula consists of grower-reported Irrigation and Nitrogen Management Plan (INMP) Summary Report data and approximately 40,000 estimates for percolation and nitrate leaching under differing management scenarios (Root-zone Library), as modeled in CV-SWAT. GWP Values were then calculated by matching appropriate percolation and leaching estimates, based on Root-zone Library entries, to grower reported information and aggregating those estimates to the Township scale. GWP Values were developed for 399 townships (GWP Townships) where at least 10% of the total acreage is designated as High Vulnerability Area (HVA), according to each Coalitions' Groundwater Quality Assessment Report.

The Coalitions' general approach for GWP Target development and application consists of (1) identification of GWP Targets intended to achieve compliance with Receiving Water Limitations (i.e., discharges do not cause or contribute to an exceedance of applicable water quality objectives), (2) identification of interim performance goals (milestones) to reduce N-loading in the near term, and (3) periodic review of GWP Targets based on future refinements to the model and its inputs.

GWP Targets

GWP Targets are surface N-loading rates that are meant to serve as a basis for growers to use to achieve Receiving Water Limitations and are expressed as acre-weighted pounds of nitrogen per township. GWP Targets are built upon the GWP Values, and the assessment framework considers hydrologic conditions and recharge, other potential N-contributors, and post-root zone attenuation (i.e., denitrification). The GWP Targets are developed only for townships in which GWP Values were developed, with some exceptions noted below.

The Coalitions utilized the Central Valley Nonpoint Source Assessment Tool (CV-NPSAT) to model groundwater and N-transport for Target development.

¹ Confined Animal Facilities, or CAFs, include facilities and agricultural lands associated with dairies, bovine feedlots, and poultry facilities. Irrigated agricultural lands associated with CAFs are not regulated under the ILRP General Orders but receive regulatory coverage under the Central Valley Water Board's Confined Animal Facilities Program Unit Waste Discharge Requirements General Orders.

CV-NPSAT is a physically based model developed by UC Davis researchers that uses streamline modeling to simulate non-point source constituent transport through groundwater to wells under steady-state conditions. It considers aquifer conditions, groundwater travel time, aquifer mixing and dilution, and groundwater well characteristics, and estimates future produced water quality in a virtual well dataset based on current surface loading. The virtual well dataset is based on approximately 95,000 actual DWR well completion reports. CV-NPSAT has been calibrated to an existing groundwater model (Central Valley Groundwater-Surface Water Simulation Model Fine; C2VSimFG²) that relies on water budget information updated through 2015 and has a finer resolution in some locations than alternative groundwater models.

Sources of current N-loading accounted for in the model include irrigated agriculture³, and other sources such as CAFs, non-municipal land application areas, and urban areas. Irrigated agricultural inputs are based on grower reported data and the CV-SWAT model outputs. Best available estimates were used to input loading for non-ILRP sources.

For each township, the Coalitions began with the GWP Value and iteratively reduced the agricultural N-load until the model indicated that produced water quality in shallow domestic wells would meet the maximum contaminant level of 10 mg N/L. In some cases, model results indicated that the current N-loading associated with irrigated agriculture will result in produced water meeting this threshold. For the 153 townships (of 399 total townships) in which this occurred, the Coalitions proposed no action to reduce current loading.

GWP Targets were not developed for 20 townships with GWP Values in the Sacramento Valley, because comparisons between predicted water quality results from CV-NPSAT and monitoring data show that the model is likely overestimating local nitrate concentrations. It is reported that observed groundwater nitrate concentrations in these townships are less than 5 mg N/L. The Coalitions argue that the overestimation is likely due to underrepresentation of denitrification during modeling. As a result, GWP Targets were ultimately developed for 379 townships.

GWP Targets Refinement

Groundwater within the Central Valley is impacted by a number of complex and dynamic processes subject to varying degrees of understanding that contribute to considerable uncertainty within the GWP Targets. Such processes include water budget components, nitrate-N mass loading from various sources, denitrification, aquifer characteristics, and groundwater flow and mixing.

² C2VSimFG was developed by the California Department of Water Resources (DWR) and includes water budget information updated through 2015. It has a finer modeling resolution in some locations relative to the alternative version of CV-NPSAT, which is calibrated to the United States Geological Society's Central Valley Hydrologic Model that includes water budget information up through 2003.

³ For the purposes of this review, "irrigated agriculture" refers to those lands under the purview of the Irrigated Lands Regulatory Program General Orders, which does not include irrigated cropland associated with CAFs or food processing facilities.

The Coalitions contend that the best available information and tools have been used to develop the currently proposed GWP Targets and acknowledge the limitations of modeling efforts due to uncertainties associated with model inputs. It is anticipated that significant new information will be available by 2027 that will improve the next iteration of GWP Target development. New information should include the following:

- Improved local estimates of current and future water use and recharge dynamics from implementation of Groundwater Sustainability Plans required by the Sustainable Groundwater Management Act (SGMA).
- Methodologies for estimating N-loading from sources other than irrigated agriculture from Priority 1 and 2 Nitrate Control Program Management Plans
- Periodic model updates and refinement
- Updates to groundwater flow models such as the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) and USGS Central Valley Hydrologic Model

Once approved, GWP Targets will be reviewed and revised as necessary every five years to account for new information, research, and model refinements.

Milestones

To ensure near-term progress toward achieving the GWP Targets, the Coalitions additionally developed performance goals (milestones) based on an analysis of nitrogen use and harvest data provided by Coalition members. Milestones are intended to assist growers in working towards achieving the GWP Targets, ultimately resulting in compliance with receiving water limitations. The Coalitions propose to incorporate the milestones into GQMPs, along with the GWP Targets, for the next five-year period.

Milestones are based on crop-specific mass balances (nitrogen applied minus nitrogen removed; A-R) from INMP Summary Report data collected between 2017 and 2020 and reflect township-specific acre-weighted average N-loading at the bottom of the root zone if all growers meet a specific threshold. The threshold for most crops (98% of the acreage) was set to an A-R value associated with the 75th percentile of the crop-specific acreage across the valley. For crops with marginal acreage (less than 10,000 acres of INMP Summary Report data from 2017-2020), the threshold was set to a 45% nitrogen removal efficiency (fraction of N applied that is removed from harvested materials or sequestered in perennial tissue). Where loading in a parcel exceeds the threshold, an alternate scenario was selected from the Root-zone library (developed with GWP Formula) that reflects an adjusted A-R that is at or within the threshold. Milestones were then calculated by aggregating the A-R values of the adjusted and unadjusted parcels.

These performance goals were proposed in townships where CV-SWAT model results indicate that current loading is estimated to discharge greater than 10 mg N/L at the bottom of the root zone. Additionally, milestones were only developed for townships where an interim performance goal was deemed applicable based on the method. Milestones were developed for 191 townships.

PUBLIC COMMENTS RECEIVED

Clean Water Action, Community Water Center, California Coastkeeper Alliance, and Leadership Counsel for Justice and Accountability

On 12 September 2022, a joint comment letter was received from Clean Water Action, Community Water Center, California Coastkeeper Alliance, and Leadership Counsel for Justice and Accountability. The group submitted a second letter on 3 February 2023 in response to the Revised GWP Targets Report. The letters convey concerns regarding the following topics:

- Milestones and GWP Target Incorporation into GQMPs
- Verification of Source Data and Model Results
- Prioritization of Disadvantaged Communities

Milestones and GQMP Target Incorporation

The first concern raised was that the Milestones proposed were not calculated using the same method in which the GWP Targets were developed, and that they are not ambitious enough to achieve compliance with groundwater limitations. The commentors requested that the GWP Targets themselves be incorporated into the GQMPs along with the Milestones.

Staff Response: Staff agree that Groundwater Quality Management Plans need to contain both long-term GWP Targets and short-term milestones to ensure progress. While milestones were proposed in the Report, the GWP Targets are the current subject of review. Annual Groundwater Quality Management Plan Updates provide the opportunity to evaluate whether the proposed milestones are appropriate short-term performance goals.

Verification of Source Data and Model Results

While commentors acknowledge that the CV-SWAT and CV-NPSAT models may be appropriate for GWP Target development, they raised concerns regarding the assumptions and underlying data used in the models and requested an independent third-party review of this effort.

Staff Response: A key issue throughout the GWP development process has been the models' reliance on field-level N loading provided by growers. In accordance with the Petition Order, these data are reported in both an anonymized and aggregated (township-level) format and submitted to the Central Valley Water Board annually. Staff have worked with the commentors, Coalitions, and University of California modeling experts to identify uncertainties and obtain additional information regarding inputs, methodology, and underlying assumptions used to develop the GWP Targets. Staff does not agree that independent verification is necessary but does support ongoing verification and development of a workplan to address uncertainties in the modeling process.

Prioritization of Disadvantaged Communities

The group's final comment raised concern that township-scale GWP Targets will reduce the ability to identify local community impacts and requested that groundwater monitoring in areas with disadvantaged communities that rely on domestic wells or small water systems be prioritized.

Staff Response: The GWP Target process was designed by the State Water Resources Control Board as a township-scale loading assessment. While the GWP Process is not intended to identify local impacts from irrigated agriculture, there are other efforts focused on identifying and mitigating local impacts, such as the drinking water supply well monitoring requirement, the groundwater trend monitoring program, and Early Action Plans under the Central Valley Salinity Alternatives for Long Term Solutions (CV-SALTS) initiative.

Environmental Law Foundation

On 12 September 2022, a letter was received from the Environmental Law Foundation (ELF). ELF submitted a second comment letter on 3 February 2023 in response to the Revised GWP Targets Report. The letters generally reject the proposed GWP Targets and argue that the GWP Targets are not consistent with the Nonpoint Source Policy and the Petition Order for the following reasons:

- GWP Targets unlawfully rely on secret, unverifiable data and model results
- Proposed load reductions do not agree with 2012 estimates⁴ of load reductions necessary to meet receiving water limitations
- GWP Targets assign assimilative capacity to Coalition members and further Antidegradation Analysis is needed

Unverifiable Data and Model Results

Previously, ELF raised concern regarding a lack of public access to the data input files used within modeling efforts, and the ability for the public to reproduce model results. ELF reiterated this concern from earlier GWP Process public comment periods, stating that the GWP Targets Report offers no new transparency into the underlying data, and questioned the process' consistency with the Nonpoint Source Policy.

Staff Response: As noted above, the underlying data used in the model, which is comprised of field-level nitrogen application and removal rates, is reported to the Central Valley Water Board annually in both anonymized and aggregated formats. The anonymous format and township aggregation was prescribed by the State Water Board in the Petition Order and strikes a balance between accomplishing program goals and respecting disclosure concerns of growers. The anonymization of grower data was subject to litigation, and in March 2023 the California Third Appellate District Court of

⁴ Harter et. al. 2012. Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis. 78 p.
<http://groundwaternitrate.ucdavis.edu>

Appeal (Sacramento) affirmed that current reporting formats are appropriate and comply with the Nonpoint Source Policy⁵.

GWP Targets Do Not Agree with Previous Load Reduction Estimates

Commenters highlighted the difference in nitrate load reductions estimated by the GWP Targets and previous estimates developed by UC Davis researchers. According to ELF's analysis, GWP Target load reductions are approximately 46% less than previous estimates.

Staff Response: Dr. Thomas Harter was the lead developer of the software behind the CV-NPSAT model and authored the 2012 report containing the load reduction estimates noted by ELF. In a 21 April 2023 written statement to Central Valley Water Board members, Dr. Harter addressed the issue of load reduction disagreement. Harter's earlier estimates were stated to be suitable for regional characterization of historic loading, but do not account for specific conditions such as soil type, local climate, and grower-reported irrigation and nitrogen management practices that affect N loading to groundwater. It is staff's opinion that these specific aspects of the CV-SWAT model, in addition to the detailed nitrogen use and harvest data now produced through the Irrigated Lands Regulatory Program, make the proposed GWP Targets development methodology a superior approach for assessing future impacts of current loading.

Assimilative Capacity

ELF's final comment claims that the GWP Targets assign assimilative capacity to Coalition members, and in doing so, allows discharge to the level that could cause an exceedance. Commenters request an additional Antidegradation analysis if the GWP Target approach is accepted.

Staff Response: Staff disagree with ELF's characterization of the methodology described in the GWP Targets Report. In townships where there is estimated assimilative capacity (i.e., the current loading from irrigated agriculture meets receiving water limitations), the GWP Target is set to the modeled current loading rate (GWP Value). Since no increased loading is proposed, no new allocation of assimilative capacity is being assigned.

STAFF COMMENTS/RECOMMENDATIONS

Conditions of the GWP Values Approval Fulfilled

The GWP Targets were developed based on current estimates of nitrate loading in High Vulnerability Areas as described in the conditionally approved GWP Values Report. The approval letter specified the need for GWP Values to be calculated for remaining High Vulnerability Townships within the Sacramento Valley Water Quality Coalition.

⁵ California Court of Appeal, Third Appellate District (Sacramento) 17 March 2023 published opinion regarding *Environmental Law Foundation et al. v State Water Resources Control Board et al*; Court of Appeal Case C093513; Supreme Court Case S279677; <https://www.courts.ca.gov/opinions/documents/C093513M.PDF>

GWP Values for the 77 remaining High Vulnerability Townships were provided in the “*Groundwater Protection Values: Addendum*,” dated 15 December 2021. The addendum adequately addressed the conditions of the GWP Values conditional approval.

Staff Assessment of Proposed GWP Targets

The CV-NPSAT model outputs used to develop GWP Targets are a projection of future water quality based on current loading assumptions. As such, outputs for many areas of the Central Valley are difficult to be reliably validated via direct groundwater monitoring at this time. Because of this, staff’s assessment of the proposed GWP Targets focused on whether the inputs and assumptions of the modeling process are reasonable and appropriate. Staff performed multiple analyses, including comparisons of model outputs and measured domestic well nitrate concentrations, and spatial analysis of the recharge and CAFs terms provided in the Technical Memo.

Measured Domestic Well N Data vs Model-Predicted Values

As an initial step in evaluating the GWP Targets, staff conducted an evaluation of the proposed load reductions with respect to current groundwater quality data and current estimated loading from ILRP member parcels (GWP Values). Of particular interest were areas in which groundwater quality impacts currently exist based on observed water quality conditions, root-zone leachate concentrations currently exceed 10 mg N/L, and where model results indicate no load reductions were estimated to be necessary. It should be noted that one-to-one correlations were not expected during this analysis, because (1) GWP Values represent the current N load and concentrations at the root zone, (2) the predicted concentrations associated with the GWP Targets are based on future, steady-state conditions, and (3) domestic well water quality is significantly influenced by local recharge and historical loading from various sources. These may include non-irrigated agricultural sources (e.g., CAFs, urban lands, public owned treatment works, etc.), which may be locally significant.

Staff compiled “Nitrate” and “Nitrate + Nitrite” concentration data collected from over 11,000 Central Valley domestic wells from the GeoTracker GAMA website. The final dataset includes over 21,000 results, mostly collected between 2002 and 2022⁶. The data were processed to reflect one result per well per sample date, then average concentrations were calculated at each well. Average well concentrations were aggregated and then averaged at the township-level, resulting in an average N concentration for 327 GWP Townships. Average township N concentrations could not be calculated for 72 GWP Townships, mostly in the western and southern San Joaquin Valley, where no domestic well N data were available.

Comparison of the GWP Values leachate and measured domestic well data indicate that in most townships, model-predicted leachate values are greater than 10 mg N/L, whereas corresponding measured domestic well concentrations are less than 10 mg N/L. This is expected, since modeled leachate represents N load leaving the

⁶ Five results were collected in 1931. The remaining were collected from 2002 to 2022.

root-zone, prior to being subjected to any attenuation mechanisms (i.e., dilution and denitrification).

Conversely, the analysis identified five townships with modeled leachate concentrations below 10 mg N/L but measured ambient N concentrations exceeding the drinking water standard (M02N06E, M04S09E, M20N02E, M27S25E, S12N21W). No load reductions were proposed in these five townships. Staff investigated these townships further and compared model predicted N values to observed N concentrations from a focused domestic well N dataset associated with ILRP lands collected between 2018 and early 2023. Based on the more recent dataset, ambient water quality in two of the townships (M02N06E and M27S25E) appear to meet the drinking water standard of 10 mg N/L. For the remaining townships, assumed CAF loading rates associated with M04S09E and S12N21W for GWP Target development were 54.2 and 55.6 lb/ac. No CAF loading was accounted for M20N02E. The N load from irrigated agriculture has been fairly well-characterized (i.e., modeled with actual grower reported information in CV-SWAT), which implies that N loading from other sources may not be well represented in these areas or may be driving ambient conditions.

GWP Townships where no load reductions are proposed were also compared with measured domestic well concentrations. Of the 153 GWP Townships where no load reduction is proposed, most have average domestic well concentrations less than 10 mg N/L. There are 28 townships with average domestic well concentrations greater than 10 mg N/L where no load reduction is proposed, and about 15 of these townships are clustered in an area northwest of Merced. Further inspection of two townships within this cluster (M05S09E and M06S10E), which both have measured average domestic well concentrations approximately 24 mg N/L, show a large concentration of CAF facilities. Staff will not speculate as to the specific cause of the discrepancy but are interested in ensuring both the assumed groundwater recharge and N loading rates are appropriately vetted for this area.

Technical Memo Analyses

During review of the Report, staff requested that the Coalitions provide township recharge and CAF inputs used to develop the proposed GWP Targets, and additional information regarding how recharge terms were scaled from the CV-SWAT model to the underlying groundwater model in CV-NPSAT (C2VSimFG). Essentially, subregional C2VSimFG total average aerial recharges, including agricultural lands, native/urban lands, canal seepage, and managed recharge, were redistributed relative to the CV-SWAT recharge pattern⁷. To do this, the township recharge from CV-SWAT was scaled to match the agricultural recharge term in C2VSimFG. Individual township scaling factors ranged from approximately 0.7 up to 8. Staff performed a comparison of the CV-SWAT recharge on HVA versus the up-scaled C2VSimFG HVA recharge and completed spatial comparisons of the CAF and recharge terms to domestic well N concentrations.

⁷ Natural recharge from lakes and streams is accounted for in CV-NPSAT modeling; however, it is not spatially redistributed.

Staff's analysis of the recharge terms indicated that pre- and post-scaling agricultural recharge inputs show a fair amount of agreement in most of the townships; however, the data shows more variance as recharge values increase. This is likely due to non-normal distributions of recharge terms from both the CV-SWAT and C2VSimFG models. Square root transformation of the datasets normalizes the distributions, stabilizes the variance (Figure 1), and further affirms the general agreement among each models' recharge terms.

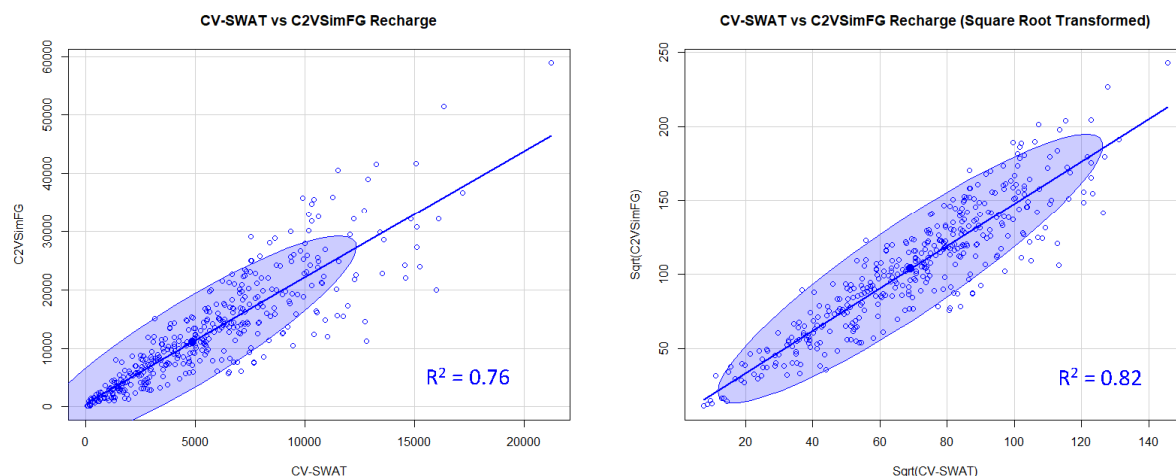


Figure 1. CV-SWAT recharge inputs versus recharge inputs scaled to fit C2VSimFG total aerial recharge scheme with 95% confidence ellipses. Left plot show heteroscedastic relationship or a "fanning out" of points as values increase. Right plot is square root-transformed relationship where variance stabilizes.

While the recharge terms generally agree, a factor greater than 3 was used to scale CV-SWAT recharge on HVA to C2VSimFG HVA recharge in 74 GWP Townships, which appears to be cause for the variance in higher values. Most of these townships are in the San Joaquin Valley and three prominent clusters occur in the Modesto-Turlock area, Fresno, and Tulare County, where modest to no load reductions are proposed. A closer look at the average domestic well N concentrations in these areas indicates that most townships are currently meeting the water quality standard. Where concentrations are greater than 10 mg N/L in these areas (mostly Modesto-Turlock and Tulare County), the CAF loading rates modeled are some of the highest in the region. Similarly, some of the highest agricultural recharge rates occur in these regions. Current agricultural N loading estimates (GWP Values) in the Modesto-Turlock area are mostly between about 3 and 20 lbs/ac, and ranges from 20 to 74 lbs/ac in Fresno and Tulare County. In all three of these areas, the proposed load reductions per township associated with the GWP Targets are less than 15 lbs/ac to none.

The up-scaled recharge values used in GWP Target development are generally in good agreement with values informed by grower reported data and modeled in CV-SWAT. Additionally, the Coalitions use a reasonable approach to convert CV-SWAT recharge values to total township recharge values consistent with DWR's most up to date water budget, used in C2VSimFG. However, spatial comparisons do raise some concerns, including modest to no proposed load reductions associated with higher current N loading rates (from irrigated agriculture and CAFs) and high rates of recharge. Modeling

suggests that CAF loading and/or attenuation via recharge are driving water quality in these areas; though both inputs have some relative uncertainty, as discussed more in the next section. These areas should be of particular importance during future updates, as new information becomes available to refine the model. Otherwise, staff finds that recharge terms used in GWP Target development, and the approach used to scale CV-SWAT recharge terms to the best available subregional total aerial recharge values are reasonable and appropriate.

Uncertainty and Validation Workplan

Degrees of uncertainty are inherent when modeling natural processes to predict future outcomes. As noted previously, the primary sources of uncertainty encountered in development of the GWP Targets include dynamic components such as water budgets, and nitrate loading from non-ILRP sources (particularly CAFs, septic, publicly owned treatment works, and urban lands).

The assessment framework employed the best available groundwater model to represent underlying regional hydrogeology in GWP Target development, though uncertainties exist at the regional scale and may not accurately reflect local hydrogeologic conditions. For instance, the geologic conditions modeled in C2VSimFG, which control the aquifer properties governing groundwater flow, are based on a conceptual texture model informed by over 10,000 lithologic logs but does not capture the fine-scale textural variations of heterogeneous stratigraphy. Similarly, underlying regional hydrology may not reflect local conditions. However, it is important to note that the resolution of physical characteristics is considered representative at the township scale.

Nitrogen loading from sources other than irrigated agriculture provides another factor of uncertainty. The assessment framework is an innovative process to quantify nitrogen loading attributed to irrigated agriculture in the Central Valley. N loading from non-ILRP sources has not been estimated with the same rigor and are accounted for in the model using generic assumptions.

In the current assessment framework, denitrification is accounted for, to a degree, in the saturated zone but is not accounted for in the vadose zone. Modelers adjust GWP Target predictions in areas where denitrification is likely to occur (greater than 90% probability that dissolved oxygen is less than 0.5 mg/L) based on modeled median groundwater residence times, and a median denitrification estimate from published literature. Again, these are general assumptions that are used to account for a dynamic process, that may be representative of a regional scale and not accurately reflect local nitrogen attenuation. This is reflected by the 20 townships in the Sacramento Valley for which GWP Targets were not computed because the Coalitions state that an underrepresentation of denitrification in the modeling has overestimated the reductions needed to meet water receiving limits. While there may be merit to this argument, the General Orders' Monitoring and Reporting Program (MRP) requires that GWP Targets be developed for each township for which a GWP Value has been computed.

As mentioned previously, the N load associated with irrigated agriculture is the best characterized source of N loading used in the model. And while it may be the best representation agricultural N loading available, it is not without uncertainty due in part to field-by-field variability, and non-reporting growers. For instance, the GWP Values were developed based on INMP data collected between 2017 and 2019, when reporting frequency was based on farm size. During that period, not all growers were required to report annually. However, amendments to the ILRP General Orders changed the reporting frequency to annually for all enrolled growers beginning in 2020. More consistent annual reporting should further increase confidence in irrigated agriculture's representative N loading for future iterations of the GWP Process.

Commentors acknowledged that additional data and research is needed to refine the GWP Targets and requested a workplan be developed that identifies data gaps and provides a timeline for addressing model uncertainties. According to the Petition Order, the GWP Targets shall be reviewed, and updated where necessary, every five years following approval. Five-year reviews are expected to incorporate new information, research, and model refinements. The first five-year review is expected to incorporate (1) improved local estimates of current and future water use and recharge dynamics from Groundwater Sustainability Plans associated with SGMA, methodologies for estimating N-loading from sources other than irrigated agriculture from CV-SALTS Nitrate Control Program, and (3) periodic model updates and refinements. While periodic review of the GWP Targets is required, staff agrees that a workplan is needed that includes an uncertainty analysis, addresses data gaps, and provides a plan for future validation efforts.

Staff Recommendations

Staff have reviewed the 21 December 2022 GWP Targets Report and accompanying 3 April 2023 Technical Memorandum and find that the model inputs and assumptions used to develop the GWP Targets are based on the best available information and are reasonable and appropriate. Additionally, staff acknowledges that the best available information at the time of modeling contains inherent degrees of uncertainty; however, activities associated with SGMA and the CV-SALTS Nitrate Control Program are expected to aid in reducing some of that uncertainty and help strengthen the model for the next iteration of GWP Target development. Research, calibrations, and verifications of the underlying models used in the GWP Process and model inputs are ongoing. Therefore, staff recommends approval of the GWP Targets upon the condition that the Coalitions submit a workplan, describing a proposed methodology to conduct a detailed uncertainty analysis and work to further validate model outputs and key components; the results of which will be used to inform further improvements to future iterations of the GWP Targets (i.e., 5-Year Reviews).

The proposed analysis should quantify model error and uncertainty associated with the sources of uncertainties mentioned in the preceding sections and give thorough accounts of the limitations associated with each. Discussion should be provided that includes, at minimum, identification of available sources of input data, issues concerning accurate representations of the data, implications of such data in model runs, and an assessment of current and future research that may be helpful for validating model

components. In addition, the Coalitions should evaluate the anomalous townships identified from staff's assessment of the GWP Values and Targets as compared to ambient groundwater quality, and those townships where the most scaling was used to match CV-SWAT recharge on HVA to C2VSimFG recharge on HVA.

The workplan should also include a timeline with projected dates for expected model input refinements and updates, such as other N loading estimates stemming from CV-SALTS requirements, and model validation efforts, including those from CV-NPSAT model developers and other relevant researchers. Additionally, the workplan should describe how new INMP Summary data will be incorporated to refine the GWP Values and Targets. Lastly, the Report does not include GWP Targets for each township for which GWP Values were computed, which is not consistent with the MRP. This inconsistency should be addressed by local refinements in the townships without GWP Targets based on results of the uncertainty analysis and validation efforts, or by some alternate approach that the Coalition may propose. Regardless, staff recommends that a GWP Target be developed for each township where a GWP Value has been computed.