

# Second Statewide Agricultural Expert Panel Report

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March 30, 2026

10 **Cover page pictures:** Clockwise, starting top left: Groundwater monitoring well in an almond  
11 orchard; Tractor cultivation of lettuce; Asian vegetable production under high tunnels; Winter  
12 cover crop planted on beds; Drip-irrigated container nursery; Strawberries grown on beds with  
13 plastic mulch and drip irrigation. Photos provided by Michael Cahn and Thomas Harter.

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66 **Acknowledgments**

67 We would like to thank the many people who shared their insights with us by giving  
68 presentations at Expert Panel meetings. These presentations were invaluable contributions to  
69 the Panel's discussions. Thanks to all who provided comments on our discussions and the draft  
70 of this report. We also thank Sam Magill for facilitating and the State Water Board team for  
71 organizing the Expert Panel meetings.

72

## 73 **Acronyms and Abbreviations**

- 74 A - Nitrogen Applied. For a description of the components of A, see Chapter 1.2
- 75 ACL - Administrative Civil Liability
- 76 APN - Assessor's Parcel Number
- 77 BMP – Best Management Practice
- 78 C – Carbon
- 79 CCOF - California Certified Organic Farmers
- 80 CCSW - Certified California Sustainable Winegrowing program
- 81 CDFA - California Department of Food and Agriculture
- 82 CDO - Cease and Desist Order
- 83 CSA - Community-Supported Agriculture
- 84 CV – Central Valley
- 85 CV-SALTS - Central Valley Salinity Alternatives for Long-Term Sustainability
- 86 ETc - Crop Evapotranspiration
- 87 FE - Farm Evaluations
- 88 FREP - Fertilizer Research and Education Program
- 89 GQMP - Groundwater Quality Management Plan
- 90 HSP - Healthy Soils Program
- 91 ILRP - Irrigated Lands Regulatory Program
- 92 INMP - Irrigation and Nitrogen Management Plan
- 93 MCL - Maximum Contaminant Level
- 94 MPIR - Management Practice Implementation Report
- 95 N – Nitrogen
- 96 NPSAT - Nonpoint Source Assessment Toolbox
- 97 R - Nitrogen removed. For a description of the components of R, see Chapter 1.2
- 98 RWB - Regional Water Quality Control Boards
- 99 SWAT - Soil and Water Assessment Tool
- 100 SWRCB - State Water Resources Control Board
- 101 TSO - Time Schedule Order
- 102 WDR - Waste Discharge Requirements
- 103

## 104 **Executive Summary**

105 Nitrogen (N) is an essential nutrient for crops and is often the most limiting nutrient in cropping  
106 systems. While insufficient N availability can reduce yield and profitability, excess N can be lost  
107 to the environment with undesirable environmental impacts, and ultimately human health.

108 California's agriculture is highly diverse with respect to crops grown, cropping systems and size  
109 of operations. California is a highly productive agricultural region. However, nitrate leaching from  
110 intensive crop production systems has led to increased nitrate concentrations in groundwater  
111 with a large proportion originating from fertilizer and manure applications to crops.

112 The First Agricultural Expert Panel, convened by the State Board in 2014, recommended  
113 adopting a simplified N budget as the primary metric for evaluating progress on source control,  
114 with eventual impact on groundwater quality.

115 The recommended approach was to calculate the N applied over N removed ratio (A/R). Where  
116 A includes N applied with synthetic fertilizer ( $A_{FER}$ ), organic amendments ( $A_{COMP} + A_{ORG}$ ) and  
117 irrigation water ( $A_{IRR}$ ), while R includes N removed via harvest ( $R_{HARV}$ ) and N sequestered in the  
118 permanent wood of perennial crops ( $R_{SEQ}$ ).

119 In their review of the Central Coast Ag Water Quality Order, the State Water Board stated that  
120 substantial progress has been made towards implementing a long-term sustainable irrigated  
121 lands regulatory but that there is still much more work to do. In 2025, the State Water Board  
122 convened a Second Statewide Agricultural Expert Panel to review the recommendations from  
123 the First Expert Panel, to identify critical data gaps in the N budget approach used for the  
124 Irrigated Lands Regulatory Program (ILRP) and to provide expert advice to the State Water  
125 Board on the development of multi-year A/R target values and A-R values.

126 More specifically, the Panel was asked to answer nine questions (see Appendix B). The second  
127 Expert Panel met numerous times between August 2025 and May 2026. The Panel's responses  
128 and recommendations are summarized below. The questions were condensed for the Executive  
129 Summary.

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131 *Question 1 focused on crop-specific N-related limits that are protective of groundwater quality.*

- 132 • Question 1 referred to the development of limits, but in this response, the Expert Panel will  
133 also utilize the concept of targets. Limits can provide effective regulatory clout because they  
134 carry the threat of penalties in cases of non-compliance. However, targets, especially when  
135 used in conjunction with educational efforts, can also help the agricultural industry make  
136 improvements in reducing N loading despite the lack of penalties.
- 137 • In some regions sufficient data and analytical tools are available to set long-term crop-  
138 specific targets/limits for nitrate discharge from agricultural land that is protective of water  
139 quality. Other regions need more time to collect and analyze data to assess groundwater  
140 risks from nitrate; however, this should not preclude these regions from collecting data on  
141 applied N and implementing targets/limits.
- 142 • Targets/limits should be addressed on a local/regional basis. The diversity of agricultural  
143 production systems in the state makes it impossible to impose a one-size-fits-all approach to  
144 the regulatory process.

- 145 • Targets and limits may refer to metrics that quantify potential nitrate loading to groundwater  
146 including N applied (A) minus N removed (R), or A where R data is not available. However,  
147 development of R values for commodities needs to continue to be a priority. In addition, soil-  
148 plant-water, vadose zone, and hydrogeological models can be used to evaluate potential  
149 and future impacts of nitrate discharge from agriculture on groundwater nitrate concentration  
150 while accounting for other processes not captured with A and R.
- 151 • Targets and limits may be applied to a specific crop, a specific multi-cropping system, or to a  
152 specific land area.
- 153 • The Panel agrees that there is a point at which N discharges to groundwater are excessive  
154 and Regional Boards may set initial limits that all growers should be able to meet within a  
155 reasonable timeframe (3 to 5 years). These limits should be considered by individual  
156 Regional Boards, but not as a statewide precedential requirement
- 157 • The Panel recommends that only three-year rolling averages of the selected metrics are  
158 used for regulatory enforcement to account for various disruptions and issues that occur in  
159 agricultural systems.

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161 *Question 2 focused on increasingly protective interim N-related limits can be set now to ensure*  
162 *that all growers make progress towards N-related limits that are protective of groundwater*  
163 *quality?*

- 164 • The Expert Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent  
165 metrics) can be made now and provides a roadmap for reducing nitrate discharges in  
166 regions where groundwater is at risk for nitrate contamination. The interim targets/limits do  
167 not necessarily need to immediately achieve the 10-ppm nitrate-N maximum contaminant  
168 level (MCL). However, an iterative process that gradually brings water quality targets closer  
169 to the operational water quality objective in a steady and measured way that is  
170 environmentally beneficial and agronomically feasible would be the desired path forward.
- 171 • The perspective of the Panel is that it makes more sense to set limits at the higher N  
172 discharge objectives which are agronomically achievable by a high percentage of growers.  
173 Agronomically challenging A-R goals that are to be implemented in the future should be  
174 classified as targets to provide flexibility for growers to develop, experiment, and implement  
175 the necessary practices that will allow them to reach these more restrictive N discharge  
176 objectives.
- 177 • An extensive education and outreach effort should be conducted to help growers utilize best  
178 management practices to improve N use efficiency and to make rapid progress to lower the  
179 values of the selected metric and to reduce potential nitrate discharge to groundwater.

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181 *Question 3 asked whether there are any recent scientific or technical considerations or*  
182 *advances that future policy decisions should consider.*

- 183 • The Expert Panel agrees that some scientific advances have been made to understand  
184 field-level N mass balance, N transformation rates, and nitrate leaching factors. However,  
185 additional research is needed to understand and account for N transformation processes in

186 each region. Root zone and soil crop models can be used in accounting for N transformation  
187 processes.

- 188 • Each region should have the flexibility to determine the best metric, model, or literature  
189 value for accounting for N transformation rate factors.
- 190 • The Expert Panel recommends the use of soil nitrate testing to measure nitrate levels and  
191 applying this information to reduce fertilizer applications without jeopardizing crop yields.

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193 *Question 4 focused on scientifically appropriate metrics and methods to evaluate and quantify N*  
194 *discharges to groundwater.*

- 195 • The Expert Panel agrees that A-R is an appropriate metric to evaluate and quantify N  
196 discharges to groundwater for regulatory purposes. A-R can be calculated for specific crops  
197 or cropping systems and allows for comparison of different fields or farms/ranches in a  
198 region.
- 199 • A/R is not an appropriate metric to assess N discharge, but A/R is an essential metric to  
200 assess grower/ranch performance.
- 201 • While A and R, as proposed by the first Expert Panel, are a simplification and may not be  
202 accurate enough for scientific studies, they rely on data that are generally readily available  
203 to growers and can be accurately determined in most cases at the field or farm scale.
- 204 • The Expert Panel supports complementing the A-R metric with soil-water-crop, vadose zone,  
205 and hydrogeological computer models for assessments at larger scales, e.g. at the township  
206 or groundwater basin scale.
- 207 • These models are also good tools to inform A-R targets and limits that would result in  
208 improved groundwater quality in future years by accounting for factors not easily provided by  
209 growers, such as groundwater recharge, N mineralization, or denitrification.

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211 *Question 5 focused on data collection and reporting practices included in the Eastern San*  
212 *Joaquin Water Quality Order, quality assurance procedures and potential improvements.*

- 213 • The Panel finds that the summary tables required by the Eastern San Joaquin Water  
214 Quality Order are appropriate for the purpose of estimating N discharge to groundwater.  
215 However, the Panel recommends that additional data be reported to facilitate analysis by  
216 the public.
- 217 • The Expert Panel recommends the following additions:
  - 218 • Size of the individual field or parcel as a categorical characteristic.
  - 219 • Simplified information on the predominant soil series.
  - 220 • A summary table prepared by region, which lists, for each crop or cropping system on  
221 an area basis, total acres, average precipitation, irrigation, ET, runoff, and recharge, as  
222 well as the average and distribution of N applied and N removed values.
  - 223 • In regions where soil-crop models are used: The average and distribution of modeled  
224 annual values for different sources of N applied, N from atmospheric deposition and  
225 biological fixation, N removed, N in permanent, woody tissue, N in runoff and  
226 atmospheric N losses, as well as change in soil organic matter N content.

- 227 • The Expert Panel recommends the development of a standardized table of crop names,  
228 crop groups and crop group naming.
- 229 • The Panel recommends developing standardized documentation requirements on how  
230 growers arrived at the reported amount of N applied, the proportion of N mineralized from  
231 organic fertilizer and compost and how they measured the harvested product.
- 232 • Effective verification and auditing processes should be evaluated to ensure reductions in A-  
233 R are validated and enduring.
- 234 • During the first 2-3 years of data collection, many errors and mistakes are made and need  
235 to be corrected. Audits during this period should not result in enforcement actions. After the  
236 initial phase, the level of auditing primarily depends on the quality of the data.
- 237 • A comprehensive comparison and assessment of fertilizer sales in California against ILRP-  
238 reported statewide fertilizer application rates may provide a large-scale verification of ILRP-  
239 reported fertilizer application data.
- 240 • Another important form of verification is the assessment of nitrate discharge from the  
241 landscape via measured groundwater nitrate concentrations.

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243 *Question 6 focused on N fertilizer application limits ( $A_{FER}$ ), which were established in the 2021*  
244 *Central Coast Ag Order.*

- 245 • In addition to synthetic fertilizers ( $A_{FER}$ ), N Applied (A) includes inputs from organic  
246 fertilizers ( $A_{ORG}$ ), composts ( $A_{COMP}$ ), and irrigation water ( $A_{IRR}$ ). Targets/limits on  $A_{FER}$   
247 do not account for contributions of these other inputs of N, as well as the relationship to N  
248 removed (R). Therefore,  $A_{FER}$  alone provides an incomplete assessment of the risk of N  
249 losses.
- 250 • The Panel finds that  $A_{FER}$  limits have questionable benefits. Therefore, the Expert Panel  
251 concludes that the focus should be on determining targets/limits or for A and A-R. Instead of  
252 developing crop specific  $A_{FER}$  target/limits, resources are better used to determine crop  
253 specific removal N, crop N uptake curves, and for grower outreach on practices to improve  
254 N use efficiency.

255

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256 *Question 7 asked whether discount factors to A, additional components of R included the 2021*  
257 *Central Coast Ag Order, as well as excluding N in irrigation water from the calculation of total N*  
258 *applied are appropriate additions.*

- 259 • The use of winter cover crops and high-carbon amendments prevent nitrate losses during  
260 the winter fallow when residual soil nitrate is most at risk for leaching due to uncontrolled  
261 winter rains. The Expert Panel supports N removal credits for these practices as they  
262 provide incentives for growers to implement these practices, which not only help reduce  
263 nitrate leaching, but also have a multitude of other benefits to the operation, soil health and  
264 environment.
- 265 •  $R_{SCAVENGE}$  should be expanded to include other cover crop strategies that have been shown  
266 to reduce nitrate leaching during the winter fallow, namely fall-grown cover crops, low  
267 residue cover crop practices, and cereal-legume cover crop mixes.

- 268 • The re-release of scavenged N to the subsequent crop needs further investigation to know  
269 how much it may affect the calculation of future-crop A-R values. The use of soil nitrate  
270 quick tests to guide fertilization of crops is currently the best management practice to  
271 account for N mineralized from cover crop biomass.
- 272 • Recent research has documented the amount of labile N that mineralizes from composts  
273 and organic fertilizers during the timeframe of the crop cycle. Providing a credit to the labile  
274 fraction of N from compost and organic fertilizers does not penalize growers for all N in  
275 these materials and incentivizes their use.
- 276 • The Panel supports the fundamental principle of “pump and fertilize”. Clearly, the more that  
277 synthetic or organic fertilizer can be replaced by N in irrigation water, the better. Utilizing  
278 nitrate in irrigation water to the maximum possible extent should always be encouraged,  
279 whether through education, incentives, or regulation.
- 280 • The Expert Panel recommends that  $A_{IRR}$  is calculated based on the volume equal to crop  
281 evapotranspiration or the volume of water applied by irrigation, whichever is smaller. The  
282 assumption is that the N in the evapotranspired volume is the amount that a crop takes up  
283 during the season and discounts extra water needed for soil preparation, salt leaching, and  
284 for offsetting non-uniformity of the of the irrigation system and other inefficiencies.
- 285 • For purposes of modeling and estimating potential N loading to the aquifer, growers could  
286 be required to report all the N applied from irrigation water but these values should not be  
287 used for compliance with A-R targets/limits.  
288

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289 *Question 8 asked whether scientific data suggests that small and/or small diversified farms are*  
290 *operated in a fundamentally different manner that results in a reduced water quality impact*  
291 *compared to larger farms, on a per acre basis.*

- 292 • Nutrient management practices can be substantially different on small-scale diversified  
293 farms compared to larger farms. Small diversified productions in California also include  
294 container-grown nursery production, which operate in a significantly different manner than  
295 field grown crops.
- 296 • Nutrient management practices also vary from one operator to the next. Small farms as a  
297 category are unlikely to demonstrate a reduced water quality impact on a per acre basis.
- 298 • We recommend a category such as “reduced-risk small farms” that could be defined as  
299 meeting a number of criteria associated with lower risk for nitrate leaching.
- 300 • This could be combined with alternate reporting requirements, technical assistance with  
301 monitoring soil and plant N levels, and education.  
302

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303 *Question 9 focused on additional exceptions to, or alternative methods for complying with, the*  
304 *precedential nitrogen management requirements in the Eastern San Joaquin Water Quality*  
305 *Order.*

- 306 • The Panel finds that wine-grape vineyards, alfalfa, and non-fertilized pastures are potential  
307 candidates for some form of exception or alternative compliance pathways.
- 308 • An alternative compliance approach for these cropping systems may require a strict limit for  
309 fertilizer applications, thus requiring reporting in some form.

- 310 • We recommend consideration of alternate reporting methods for nurseries, given the  
311 difficulty in accurately computing R for a large variety of ornamental species grown in  
312 containers that leave the nursery for sale.
- 313 • Some organic farms and, in the future, perhaps some farms with demonstrable regenerative  
314 farming practices may have low nitrate leaching, particularly in low N demanding crops.  
315 Since nutrient management practices vary across different approaches to organic  
316 certification, it may be useful to define specific organic and regenerative nutrient  
317 management practices associated with low nitrate leaching rather than relying on organic  
318 certification alone as a defining category.
- 319 • In regions where there is no current and no reasonably foreseeable future groundwater use  
320 for domestic, municipal, commercial, irrigation, public supply, or groundwater dependent  
321 ecosystem purposes, the Panel recommends consideration of alternative compliance  
322 pathways.
- 323 • The alternate reporting requirements in Order WQ 2023-0081 authorized small-scale  
324 diversified farms to initially report A values only but gave the regional water boards  
325 discretion to determine when or how R values should be reported. It may be more effective  
326 to develop alternate compliance pathways that effectively use A or other methods as long-  
327 term solutions.
- 328 • The reduced reporting requirements are only possible when and where such exceptions and  
329 alternative compliance methods do not increase groundwater pollution risk.
- 330

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331

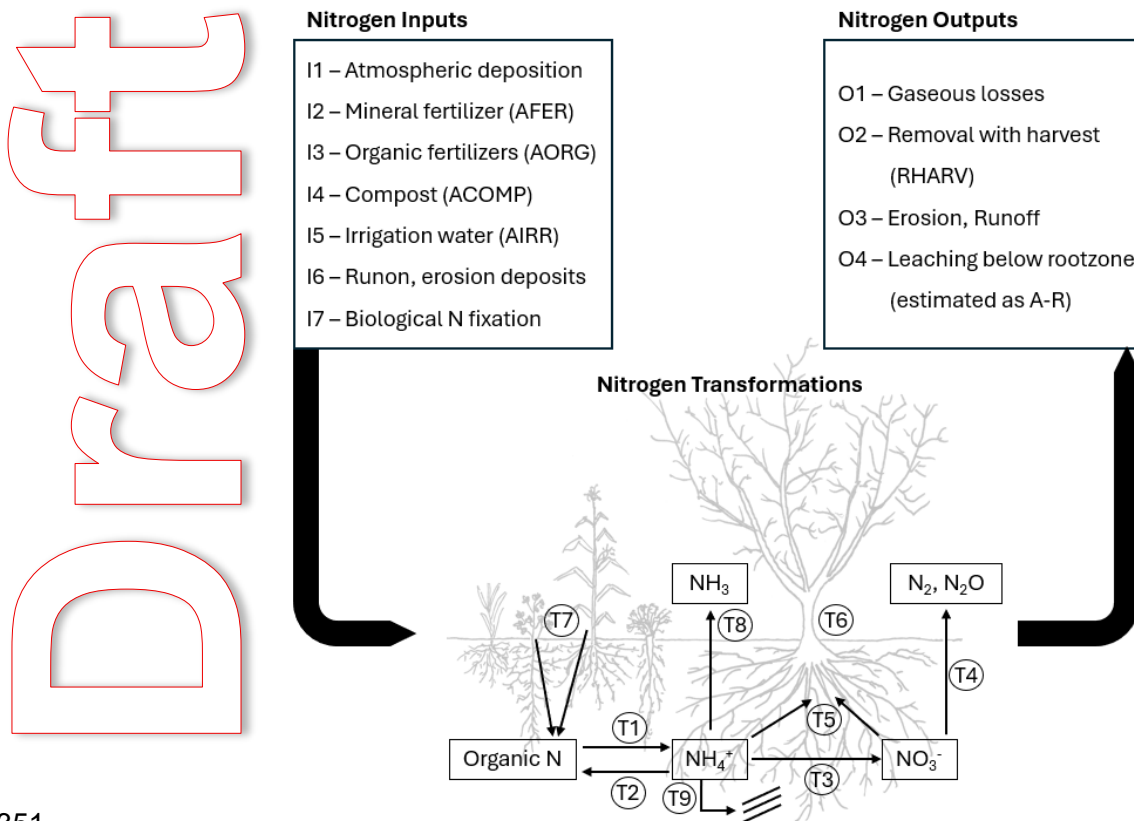
332 In addition, the Panel provides an extensive list of recommendations for effective irrigation and  
333 nitrogen management practices and needs for outreach, research, evaluation and  
334 implementation. The panel also provides detailed information on the use of models to assess  
335 well nitrate contamination risks from agriculture.

336 **1. Background**

337 **1.1. Nitrogen Dynamics in Cropping Systems**

338 Nitrogen (N) is an essential nutrient for crops and is often the most limiting nutrient in cropping  
339 systems. While insufficient N availability can lead to reduced yield and profitability, excess N  
340 can be lost to the environment with undesirable impacts on water, terrestrial, and atmospheric  
341 resources, and ultimately human health. In cropping systems, N is a very challenging nutrient to  
342 manage because it exists in solid, dissolved and gaseous forms. Furthermore, the rates of  
343 transformations from one form into another are strongly influenced by environmental conditions  
344 and farming practices, especially when mediated by soil microorganisms.

345 The largest pool of N in soil is organic matter, which is for the most part not directly plant  
346 available. Soil microorganisms can convert organic materials to plant-available ammonium and  
347 subsequently to nitrate. Nitrate is a negatively charged ion that moves freely through the soil  
348 profile with soil water from rainfall or irrigation. Movement of nitrate below the rootzone and  
349 subsequently to the groundwater is a major pathway for the loss of N from the rootzone and the  
350 focus of this report.



351 **Figure 1:** Sketch of major N inputs, outputs and transformation in cropping systems. System  
352 boundaries are crops and soil in the rootzone. Organic N includes all sources of organic  
353 material, such as soil organic matter, organic fertilizers, compost and crop/ cover crop residues.  
354 NH<sub>4</sub><sup>+</sup>, ammonium; NO<sub>3</sub><sup>-</sup>, nitrate; NH<sub>3</sub>, ammonia; N<sub>2</sub>, atmospheric N; N<sub>2</sub>O nitrous oxide.  
355 Abbreviations in parentheses are metrics used to calculate N applied (A) and removed (R).  
356 These metrics are commonly expressed in lb/ac.  
357

358 **Nitrogen transformations and fluxes shown in Figure 1**

359 **T1 – Gross N mineralization:** When soil microorganisms decompose organic material, excess  
360 N is released into soil solution as ammonium.

361 **T2 – Gross N immobilization:** Soil organisms incorporate N into their own biomass to grow or  
362 multiply. When the decomposing organic material does not contain enough N, mineral N from  
363 soil solution can be taken up and converted to biomass N.

364 **T1 > T2 – Net N mineralization:** When organic material with a favorable (small) carbon (C) to  
365 N ratio (less than approximately 20) is decomposed, gross N mineralization exceeds gross N  
366 immobilization. Hence, surplus N is released into soil solution as ammonium.

367 **T1 < T2 – Net N immobilization:** When organic material with a large C to N ratio (greater than  
368 approximately 20) is decomposed, gross N mineralization is less than gross N immobilization.  
369 Hence, ammonium and nitrate from soil solution is incorporated into soil microbial biomass,  
370 making it less available for losses and plant uptake. Immobilization can be promoted by  
371 incorporating cover crops or organic amendments with a large C to N ratio ( $R_{SCAVENGE}$ ).

372 **T3 - Nitrification:** In aerobic soils, ammonium in soil solution is generally rapidly converted to  
373 nitrate by a specialized group of soil microorganisms.

374 **T4 - Denitrification:** Under anaerobic (waterlogged) conditions when oxygen availability is  
375 insufficient, soil microorganisms convert some or all nitrate to atmospheric N and nitrous oxide.  
376 Denitrification can be promoted in bioreactors or by other technologies ( $R_{TREAT}$ ). Denitrification  
377 contributes to gaseous losses (O1 in Figure 1).

378 **T5 - Plant uptake:** Plants take up predominantly mineral N in the form of ammonium and  
379 nitrate. Organic N is not available to plants or provides at most a small fraction of their N supply.

380 **T6 - N sequestration in permanent biomass of perennial crops ( $R_{SEQ}$ ):** Nitrogen  
381 sequestered in permanent biomass of perennial crops (e.g., tree stem and branches) is a  
382 component of the N removed (R).

383 **T7 - Crop and cover crop residue input:** Nitrogen taken up by crops that is not removed at  
384 harvest or sequestered in permanent biomass (e.g., leaves, trimmings, cover crops) is returned  
385 to the soil where it will be decomposed by soil organisms and contribute to N mineralization and  
386 immobilization.

387 **T8 - Ammonia volatilization:** Ammonium and ammonia are in a chemical equilibrium.  
388 Ammonia losses are most prominent when fertilizers with urea or ammonium N are left on the  
389 soil surface. Ammonia volatilization contributes to gaseous losses (O1 in Figure 1).

390 **T9 - Ammonium fixation in clay minerals:** Certain clay minerals can fix ammonium between  
391 their layers and make it unavailable for microorganisms and plants.

392

393 When N fertilizer applications exceed crop uptake, surplus N can be lost to the environment,  
394 primarily through nitrate leaching to groundwater. California is a highly productive agricultural  
395 region. However, nitrate leaching from intensive crop production systems has led to increased  
396 nitrate concentrations in groundwater with a large proportion originating from fertilizer and  
397 manure applications to crops (Harter et al., 2012).

398 **1.2. Nitrogen Mass Balance as a Tool to Estimate Nitrate Losses to**  
399 **Groundwater**

400 The first Agricultural Expert Panel was convened by the State Board in 2014. The Expert Panel  
401 was asked to evaluate existing agricultural nitrate control programs and provide  
402 recommendations to protect groundwater and surface water quality.

403 The first Expert Panel recommended adopting a simplified N budget as the primary metric for  
404 evaluating progress on source control, with eventual impact on groundwater quality.

405 The recommended approach for a simplified N budget was to calculate the ratio of N applied  
406 over N removed ratio (A/R). Where A includes N applied with synthetic fertilizer ( $A_{FER}$ ), organic  
407 amendments ( $A_{COMP} + A_{ORG}$ ) and irrigation water ( $A_{IRR}$ ), while R included N removed via harvest  
408 ( $R_{HARV}$ ) and N sequestered in the permanent wood of perennial crops ( $R_{SEQ}$ ). These terms are  
409 used to calculate A/R and A-R in Region 5. The acronyms in parentheses were later introduced  
410 in the Central Coast Ag Order 4.0 (see below).

411 The Central Coast Ag Order expanded on A/R by proposing the following metrics, which will be  
412 discussed in detail in the response to Question 7:

413  **$A_{FER}$** : Amount of synthetic fertilizer N applied (other names for synthetic fertilizers include  
414 mineral, inorganic or conventional fertilizers)

415  **$A_{COMP}$** : Amount of compost N applied

416  **$A_{DEPOSITION}$** : Atmospheric deposition of N (typically ranging from 2 - 10 lb/ac/year). This metric  
417 has not been used before but will be discussed in the response to Question 7.

418  **$A_{ORG}$** : Amount of organic fertilizer or amendment N applied

419  **$A_{IRR}$** : Amount of N applied in the irrigation water estimated from the volume required for crop  
420 evapotranspiration (ETc) or volume of water applied, whichever is lower.

421 **C**: Compost discount factor used to represent the amount of N mineralized during the first year  
422 after application.

423 In the Central Coast Ag Order 4.0, the discount for composts that have a C:N ratio of >11 is 5%  
424 (0.05) of the N in the applied compost. This discount corresponds to the quantity of N  
425 mineralized during the first year (R3 order attachment B MRP page 4).

426 **O**: Organic fertilizer discount factor used to represent the amount of N mineralized during the  
427 growing season (approximately 12 weeks). The discount factor is based on research done in  
428 warm soil at an optimal moisture content for 12 weeks. Nitrogen from organic fertilizer that  
429 mineralizes after 12 weeks is not included in A.

430  **$R_{GASEOUS LOSS}$** : This is a proposed factor to include on the R side of the A-R calculation that  
431 accounts for denitrification and volatilization of N that would otherwise be at risk for nitrate  
432 leaching. This metric has not been used before but will be discussed in the response to  
433 Question 7.

434  **$R_{HARV}$** : Amount of N removed from the field through harvest or other removal of crop material.  
435  $R_{HARV}$  is calculated by multiplying grower reported yields with an N removal coefficient.

436  **$R_{SEQ}$** : Amount of N removed from the field through sequestration in woody materials of  
437 permanent or semi-permanent crops.

438 **R<sub>SCAVENGE</sub>**: Nitrogen scavenging credit. Amount of N credited as removed from the field through  
439 N uptake by cover crops grown during the wet/rainy winter season, N immobilization from the  
440 addition of high carbon amendments or high carbon woody materials applied as mulch to the  
441 crop ground surface before the wet/rainy season.

442 In the Central Coast Ag Order 4.0, 97% of the N contained in non-legume winter grown cover  
443 crops (R3 Order Attachment B p.10, Chapter 2iv.) may be included on the R side of the A-R  
444 calculation. Nitrogen removed by high carbon amendments, or high carbon woody materials,  
445 may receive a credit up to 30 lb N/ac/year, but subsequently mineralized N from these materials  
446 is not accounted for on the “A” side of the “A-R” calculation (R3 Order Attachment B pp.8-11).

447 **R<sub>TREAT</sub>**: Amount of N removed from the ranch through a quantifiable treatment method.  
448 Treatments may include the use of denitrification bioreactors or other technology that removes  
449 nitrate from waters potentially at risk for discharge to ground or surface waters.

450 **R<sub>OTHER</sub>**: Amount of N removed from the ranch through other methods not previously quantified.  
451 No method is recommended at this time, but this factor is provided to account for future  
452 developments that may provide reductions in nitrate leaching risk.

453

454 Units for these metrics depend on the cropping system and the purpose of reporting. For  
455 comparison of specific crops, the units are in lb N/acre per crop cycle. For purposes of  
456 estimating or approximating nitrate leaching to groundwater, often with a N mass balance, the  
457 preferred units are lb N/acre/year. Where one crop is grown per year, including perennials, the  
458 two units are the same:

459 
$$\text{lb N/acre/crop} = \text{lb N/acre/year}$$

460 However, where several crops are grown per year, the two units are not the same and must be  
461 carefully distinguished. In this case lb N/acre/crop is always smaller than lb N/acre/year and all  
462 crops grown over a year’s period need to be considered to obtain units of lb N/acre/year. When  
463 applying N mass balance terms, units must be applied consistently to all terms of the mass  
464 balance.

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## **2. Characteristics of Agriculture in California**

California's agriculture is highly diverse. California's agricultural abundance includes more than 400 commodities. Nearly half of the country's vegetables and over three-quarters of the country's fruits and nuts are grown in California. The leading crops grown in the state are fruits, nuts and vegetables (CDFA, 2025a).

According to the 2022 Census of Agriculture, a total of 46,247 farms managed 8.16 M acres of irrigated land in California. The average farm managed 176.4 acres of irrigated land (USDA NASS, 2024). 62% of these farms managed less than 50 acres, while 7% managed more than 1,000 acres. However, irrigated land managed by small farms accounted for only 3.3% of the total irrigated acreage, while the largest farms managed 62.9% of the irrigated acres. Therefore, while a small proportion of the irrigated acres is managed by small farms, they make up the majority of farms in California.

### **2.1. Regional Characteristics**

The Central Valley contributes two thirds of the Gross Value of Agricultural Production in California. Agriculture is dominated by perennial crops, with almonds, grapes (wine, table, and raisins), pistachios and citrus being the Leading Commodities based on Gross Value of Agricultural Production (CDFA, 2025a). Other important commodities include vegetables, such as processing tomatoes, melons, carrots, sweet potatoes, garlic, and onions, and agronomic crops such as corn, wheat, safflower, and rice.

Agriculture on the Central Coast is dominated by cool season vegetables, including lettuce, broccoli, cauliflower and celery. Strawberries and grapes also contribute significantly to the Gross Value of Agricultural Production (CDFA, 2025a). Spinach, cabbage and caneberries are other relevant crops in the region. The Central Coast contributes approximately 15% to the state's Agricultural Gross Value.

In Southern California, Imperial, San Diego and Riverside are the counties contributing most to agricultural production. The dominant commodities are horticultural crops, including floriculture and nursery production, vegetables, especially lettuce and broccoli, as well as alfalfa and other forage crops. The contribution of southern California to the Gross Value of Agricultural Production is approximately 10%.

Agriculture in Napa, Sonoma and Lake counties is dominated by wine grapes. Together, these three counties contribute 3.5% to the Gross Value of Agricultural Production. Along the northern Coast, agriculture is dominated by wine grapes and horticultural crops. Finally, Sierra foothills and mountain region east and north of the Central Valley, pasture, hay, and alfalfa are the most prominent commodities.

### **2.2. Characteristics of Small Farms**

Small farms in California agriculture encompasses a variety of cropping systems. These can include, but are not limited to: (i) small-acreage monoculture farms producing one of California's major commodities; (ii) small acreages of monoculture niche and emerging crops, generally not included in major commodity group representation; and (iii) small-scale diversified farms, which

506 can range from a few to many niche and mainstream crops rotated through several production  
507 seasons within the year and can include mixed crop-livestock systems. High diversity of crops is  
508 often associated with sales to direct market channels such as farmers markets, roadside stands,  
509 direct to retail, institutional procurement, and community-supported agriculture (CSA). A more  
510 detailed description of small farms and how their characteristics affect their fit into the reporting  
511 framework of the Irrigated Lands Regulatory Program (ILRP) is provided in the response to  
512 Question 8.

513

### 514 *2.3. Certified Organic Production*

515 Organic production is an important component of California's agriculture with nearly 1.8 million  
516 acres certified as organic in 2023 (CDFA, 2025a). Within the context of the ILRP, a major  
517 characteristic of organic production is that most N applied to crops is in the form of organic  
518 inputs, such as organic fertilizer, compost or cover crops residue. Therefore, organic crop  
519 production systems rely on soil microorganisms to convert these organic compounds into plant-  
520 available forms of N. Only part of the N becomes plant-available, while the remainder is  
521 incorporated into microbial biomass and ultimately into soil organic matter.

522

### 523 *2.4. Nursery production*

524 California nursery production accounts for 7.5 percent of the state's farm sales. There is  
525 nursery production throughout the state with concentration in the Central Coast and Southern  
526 California counties. Most nurseries consist of highly diverse mixture of ornamental species  
527 planted in containers. For ILRP implementation, N applied and removed in nurseries is  
528 substantially different from farming operations because the soil substrate leaves the nursery  
529 when purchased by the consumer, and ornamental plants usually do not have a harvested  
530 product.

531

## 532 **3. Irrigated Lands Regulatory Program**

### 533 *3.1. Background*

534 The California Water Code, through the 1969 Porter-Cologne Water Quality Control Act,  
535 authorizes the State Water Resources Control Board (SWRCB) and nine Regional Water  
536 Quality Control Boards (RWB) to regulate water quality in California, including discharges from  
537 irrigated agricultural lands. Under this authority, RWB issue Waste Discharge Requirements  
538 (WDRs) or waivers of WDRs to growers to control discharges of waste to surface water and  
539 groundwater. These regulatory actions must comply with the Water Code, applicable Basin  
540 Plans, the State's Nonpoint Source Policy, and State Water Board Resolution No. 68-16, which  
541 establishes antidegradation requirements.

542 To prevent agricultural discharges from impairing the waters that receive these discharges, the  
543 ILRP regulates discharges from irrigated agricultural lands. This is done by issuing WDRs or  
544 conditional waivers of WDRs (Waivers) to growers (WDRs and Waivers collectively referred to  
545 as Orders). Due to regional diversity of farm practices, hydrogeology, and other factors, each  
546 RWB adopts their own Orders to protect water quality from agricultural practices. Over 29,000  
547 farm operations with over six million acres are enrolled in the ILRP (SWRCB; online at:  
548 [https://www.waterboards.ca.gov/water\\_issues/programs/agriculture/](https://www.waterboards.ca.gov/water_issues/programs/agriculture/)).

549 There are nine semi-autonomous RWB that exercise rulemaking and regulatory activities by  
550 basins. The SWRCB works in coordination with the nine RWB. Regional boundaries are based  
551 on watersheds and water quality requirements are based on the unique differences in climate,  
552 topography, geology, and hydrology for each watershed. Each RWB makes critical water quality  
553 decisions for its region, including setting standards, issuing waste discharge requirements,  
554 determining compliance with those requirements, and taking appropriate enforcement actions.

555 In February 2018, the SWRCB adopted the East San Joaquin Water Quality Order (Order No.  
556 WQ-2018-0002). The Order was adopted in response to petitions filed against WDRs issued  
557 within the Central Valley. The East San Joaquin Water Quality Order directed all RWB to revise  
558 their agricultural orders and incorporate the precedential requirements by 2023. The  
559 precedential requirements include educational outreach events, record keeping standards, on-  
560 farm drinking water well monitoring, Farm Evaluations, Irrigation and Nitrogen Management  
561 Plans (INMPs), and Sediment and Erosion Control Plans where necessary.

562 In 2021, the Central Coast RWB adopted Order R3-2021-0040, General Waste Discharge  
563 Requirements for Discharges from Irrigated Lands (2021 Central Coast Ag Order). The 2021  
564 Central Coast Ag Order includes regulatory limits on N application and N discharge using an A-  
565 R metric. The 2021 Central Coast Ag Order also allows growers to factor in certain discounts of  
566 A and additional credit considerations for R. The SWRCB reviewed the Central Coast Ag Order  
567 on petition and remanded it to the Central Coast RWB (Order WQ 2023-0081).



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**Figure 2:** Map of the Regional Water Boards (Source: [https://www.waterboards.ca.gov/publications\\_forms/publications/factsheets/docs/boardoverview.pdf](https://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/boardoverview.pdf))

572 **Table 1:** Year when the Irrigated land Regulatory Program was implemented in different regions  
 573 of California and estimated acreage. Regions are the same as shown in Figure 2.

Region	Year First Implemented	Estimated Acres of Agriculture
1. North Coast Region	2025	270,000
2. San Francisco Bay Region	2018	50,000
3. Central Coast Region	2003	540,000
4. Los Angeles Region	2005	90,000
5. Central Valley Region	2003	6,050,000
6. Lahontan Region	2023	220,000
7. Colorado River Basin Region	2012	608,000
8. Santa Ana Region	2016	18,000
9. San Diego Region	2017	70,000

574 Source: [https://www.waterboards.ca.gov/water\\_issues/programs/agriculture/](https://www.waterboards.ca.gov/water_issues/programs/agriculture/)  
 575

576 **3.2. Second Agricultural Expert Panel**

577 In their review of the Central Coast Ag Water Quality Order (Order No. R3-2021-0040), the  
 578 SWRCB stated that substantial progress has been made towards implementing a long-term  
 579 sustainable irrigated lands regulatory but that there is still much more work to do. The Central  
 580 Coast Ag Water Quality Order also expressed the SWRCB’s intention to convene a Second  
 581 Statewide Agricultural Expert Panel to

- 582 • Review the recommendations from the First Agricultural Panel and best currently available  
 583 information on N application and removal rates.
- 584 • Identify critical data gaps in A/R ratio values (ratios) and A-R difference values (difference  
 585 values).
- 586 • Provide expert advice to the State Water Board on the development, if appropriate, of multi-  
 587 year A/R ratio target values and A-R difference values to inform the California ILRP.

588 More specifically, the Panel was asked to answer nine questions (Appendix B). The Panel’s  
 589 responses and recommendations are presented in Chapter 4.

590

591 **Expert Panel Meetings**

592 The second Expert Panel met numerous times between August 2025 and March 2026. All Panel  
 593 meetings were held in accordance with the Bagley-Keene Open Meetings Act and consisted of  
 594 plenary panel meetings, public listening sessions, and panel working group meetings:

- 595 • August 8, 2025. Kick off Meeting – Day 1
- 596 • August 14, 2025. Kick off Meeting – Day 2
- 597 • October 1, 2025. Listening Session
- 598 • October 13, 2025. Working Group Meeting
- 599 • October 22, 2025. Working Group Meeting

- 600 • October 31, 2025. Expert Panel II Meeting
- 601 • November 14, 2025. Working Group Meeting
- 602 • November 19, 2025. Working Group Meeting
- 603 • December 5, 2025. Working Group Meeting
- 604 • December 12, 2025. Working Group Meeting
- 605 • December 17, 2025. Listening Session
- 606 • January 7, 2025. Working Group Meeting
- 607 • January 14, 2026. Working Group Meeting
- 608 • January 21, 2026. Working Group Meeting
- 609 • January 29, 2026. Working Group Meeting
- 610 • February 11, 2026. Working Group Meeting
- 611 • March 11, 2026. Listening Session
- 612 • April 10, 2026, Public Staff Workshop
- 613

614 The list of presentations given to the Expert Panel is included in Appendix C. At the end of each  
 615 meeting and at listening sessions, comments from the public were received.

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618 **Expert Panel Members**

619 The Panel was made up of eight members that matched the qualifications requested by the  
 620 SWRCB:

- 621 • **Daniel Geisseler**, Cooperative Extension Specialist, UC Davis; Expert Panel Chair
- 622 • **Ngodoo Atume**, SGMA Technical Assistance for Small Farms Coordinator, UC Agriculture  
 623 and Natural Resources (UC ANR)
- 624 • **Michael Cahn**, Farm Advisory for Irrigation and Water Resources, Monterey County, UC  
 625 ANR
- 626 • **Ruth Dahlquist-Willard**, Interim Director, UC Sustainable Agriculture Research and  
 627 Education Program (UC SAREP)
- 628 • **Thomas Harter**, Distinguished Professor and Professor of Cooperative Extension, UC Davis
- 629 • **Ali Montazar**, Irrigation and Water Management Advisor, Imperial County, UC ANR
- 630 • **Richard Smith**, Emeritus Farm Advisor for Vegetable Crop Production and Weed Science,  
 631 Monterey County, UC ANR
- 632 • **Hannah Waterhouse**, Assistant Professor of Agroecology and Watershed Ecology, UC  
 633 Santa Cruz

634 A short bio of each Panel member is provided in Appendix A.

635 **4. Responses to Charge Questions**

636 This chapter includes responses of the Expert Panel to the questions posed by the Water  
637 Board. Drafts of the questions were written and revised by teams of two Panel members.  
638 Revisions were based on discussions among Panel members at public meetings and comments  
639 submitted by individual members. Unless otherwise stated, the recommendations reflect the  
640 opinion of the entire Expert Panel. The questions for the Panel are included in the responses.  
641 They can also be found in Appendix B.

642

643 **Targets vs. Limits**

644 Several questions refer to limits. The following definitions were provided by Karen Mogus, Chief  
645 Deputy Director, State Water Board at the Expert Panel meeting on 10/31/2025:

- 646 • A “target” is a non-enforceable standard, that is subject to limited follow-up such as requiring  
647 additional education or increased monitoring and reporting.
- 648 • A “limit” is an enforceable standard, that is subject to progressive enforcement actions, such  
649 as issuing a cease and desist order (CDO), establishing a time schedule order (TSO) for  
650 compliance, and imposing administrative civil liability (ACL).

651

652

653 **4.1. “The Ultimate Limit/Target” - Response to Question 1**

654 **Question**

655 *Is there enough data and scientific research to set crop-specific nitrogen-related limits (e.g.,*  
656 *A/R, A-R, or other limits) that are protective of groundwater quality and support a long-term*  
657 *sustainable Irrigated Lands Regulatory Program? What metrics and methodology would be*  
658 *used for developing those limits and what would the limits be? What additional data should be*  
659 *collected and/or what additional research needs to be conducted to further support the*  
660 *development of nitrogen-related limits that are protective of groundwater quality and support a*  
661 *long-term sustainable Irrigated Lands Regulatory Program?*

662

663 **Response and Recommendations**

664 *Question 1a: Is there enough data and scientific research to set crop-specific nitrogen-related*  
665 *limits (e.g., A/R, A-R, or other limits) that are protective of groundwater quality and support a*  
666 *long-term sustainable Irrigated Lands Regulatory Program?*

667

668 **In some regions sufficient data, analytical tools and assessment of N fertilizer use**  
669 **patterns are available to set long-term crop-specific targets/limits for nitrate discharge**  
670 **from agricultural land that is protective of water quality. Other regions need more time to**  
671 **collect and analyze data to assess groundwater risks from nitrate; however, this should**  
672 **not preclude these regions from collecting data on applied N and implementing**  
673 **targets/limits.**

- 674 1. Question 1 referred to the development of limits, but in this response, we will also utilize the  
675 concept of targets. The Panel understands that policymakers in the regulatory arena may  
676 either choose enforceable limits as a “stick” or develop compliance pathways that rely on  
677 “targets” as a “carrot” in lieu of enforcement limits. Limits can provide effective regulatory  
678 clout because they carry the threat of penalties in cases of non-compliance. However,  
679 effective use of targets can also help the agricultural industry make improvements in  
680 reducing N loading despite the lack of penalties. Targets used in conjunction with  
681 educational efforts can play an important role in the regulatory framework. The Panel further  
682 understands that in the future, when greater information or improved practices exist, limits  
683 that are protective of groundwater quality can be established and implemented. But even  
684 regulations with limits, as in Ag Order 4.0, may explicitly stipulate regular review and  
685 assessment of limits and interim targets and allow them to be adjusted as needed. The  
686 Panel finds that both approaches have advantages and disadvantages. The Panel is  
687 comfortable with Regional Boards being required to set targets. Based on scientific and  
688 technical considerations the Panel recommends that limits are not required statewide or as  
689 a precedential tool to be used by Regional Boards. Instead, the Panel recommends that  
690 individual Regional Boards may choose (but not be required) to use limits as part of their  
691 orders pending policy and economic considerations that are beyond the Panel’s scope.
- 692 2. Targets/limits should be addressed on a local/regional basis. The diversity of agricultural  
693 production systems in the state makes it impossible to impose a one-size-fits-all approach to  
694 the regulatory process. For instance, few removal coefficients are available for plants grown  
695 in container nurseries and many niche specialty crops. In addition, multi-year production of  
696 potted plants complicates yearly development and evaluation of A-R values. These types of  
697 complications need a thorough evaluation to determine the appropriate regulatory avenues  
698 which may include the enforcement of recommended management practices that are  
699 recognized for reducing nitrate leaching in these production systems.
- 700 3. However, these constraints should not preclude action being taken on cropping systems  
701 where specific metrics can be applied. For discussion of exceptions and alternative  
702 compliance under some circumstances, see response to Question 9.
- 703 4. Targets/limits may refer to metrics that quantify potential nitrate loading to groundwater  
704 including (but not limited to) A-R (lb N/acre/year), or A (lb N/acre/year) where R data is not  
705 available. A discussion and comparison of these metrics is included in the response to  
706 Question 4. Of particular note is that A/R is not an appropriate metric to assess N discharge,  
707 but A/R is an essential metric to assess grower/ranch performance in using N efficiently  
708 (also see response to Question 5). Targets/limits may be applied to a specific crop, a  
709 specific multi-cropping system, or to a specific land area. These reporting criteria should be  
710 left to the discretion of the Regional Boards. For cropping systems where only one crop is  
711 produced per year, crop-specific targets/limits are reasonable. In cropping systems with  
712 more than one crop per season the target/limit would need to account for N applied and N  
713 removed of all crops grown on the land during the year. The Panel recommends that only  
714 three-year rolling averages of the selected metrics are used for regulatory enforcement to  
715 account for various disruptions and unexpected events that occur in agricultural systems,  
716 such as pest damage, low market prices, flooding, etc.; moreover, a three-year rolling  
717 average is also consistent with domestic and public supply well water always being a mix of

- 718 variously aged waters, with a typical age mixing of at least four years and often much more  
719 (see Chapter 6).
- 720 5. Implementation of different N loading metrics such as those used in Regions 3 and 5 are  
721 appropriate and should be left to the discretion of the Regional Boards to decide.
- 722 6. The operational benchmark defined in the 2012 UC Davis Nitrate Report (Harter et al.,  
723 2012) could be used as the lower target/limit to protect groundwater from nitrate  
724 contamination. The operational benchmark acts as a reference point above which N  
725 leaching to groundwater has the potential to cause exceedances of the Maximum  
726 Contaminant Level (MCL) of 10.0 ppm nitrate-N). For the Central Valley, the UC Davis  
727 Nitrate Report determined that N discharge more than 31 lb N/acre/year would have the  
728 potential to exceed the MCL of nitrate. Accounting for additional recharge due to rainfall, the  
729 Central Coast Regional Water Quality Control Board determined that this benchmark would  
730 be 50 lb N/acre/year on the Central Coast. These benchmarks represent the ultimate N  
731 loading targets/limits that agricultural operations need to achieve to safeguard groundwater  
732 quality (for more information, see Chapter 6).
- 733 7. There is ample evidence of exceedance of drinking water standards for nitrate in  
734 groundwater in some regions of the state. Nitrate monitoring of wells in Regions 3 and 5 has  
735 determined that a significant number of wells exceed the drinking water MCL for nitrate-N of  
736 10 ppm. In other regions this may not be the case and nitrate contamination of surface water  
737 may be of concern and taken into consideration.
- 738 8. Due to the variability of geography and diversity of crops among regions, the Panel finds  
739 that it is not reasonable to make specific statewide procedural recommendations. The Panel  
740 agrees that the specific metric and the specific process to setting such a target/limit must be  
741 developed by each Regional Water Quality Control Board. Some Regions, e.g., Region 5  
742 and Region 3 have already set initial targets/limits, and the Panel supports those  
743 approaches. The combination of evaluating A-R, A, and A/R data collected for a region over  
744 several recent years can help inform initial targets/limits.
- 745 9. The Panel agrees that there is a point at which N discharges to groundwater are excessive  
746 and Regional Boards may set initial limits that all growers should be able to meet within a  
747 reasonable timeframe (3 to 5 years). These limits should be considered by individual  
748 Regional Boards, but not as a statewide precedential requirement. One approach discussed  
749 – and not meant to be either prescriptive or to replace already existing approaches in any of  
750 the regions – was to set the initial target/limit at the highest 80<sup>th</sup> or 90<sup>th</sup> percentile of the A-R  
751 data or of other selected metrics of N discharge, including model- or other equation-based  
752 estimates that account for, e.g., climate, soil, and agronomic practice variations. Another  
753 approach discussed is to identify the A-R that corresponds to an excessively high average  
754 A/R value (e.g.  $A/R > 2$ ) in a region.
- 755 10. If Region 3 considers implementing limits, it may make more sense to do so at the highest  
756 A-R target (e.g. 500 lb N/acre, as in Ag Order 4.0) as it is currently agronomically achievable  
757 by 80% or more of the growers. More restrictive A-R objectives should be considered as  
758 targets, since they are more agronomically challenging to achieve (see Question 2, Bullet  
759 1).
- 760 11. Whenever targets/limits are set, they need to be accompanied by technical assistance to  
761 support affected growers in implementing best management practices (BMPs). See section

762 5.2 for technical assistance needs. Finally, and importantly, the Panel recommends that the  
763 determination of targets/limits consider how setting these targets/limits would affect the  
764 overall effectiveness of the regulatory process to avoid unintended consequences that  
765 negatively impact the desired long-term outcome of reducing N discharges from agriculture  
766 to groundwater and surface water supplies.

767

768 *Question 1b. What metrics and methodology would be used for developing those limits and*  
769 *what would the limits be?*

770

771 **The Expert Panel concludes that the best approach to setting targets/limits would be the**  
772 **use of any reasonable methodology (mass balances or more complex simulation models)**  
773 **for estimating potential nitrate discharge to groundwater. Applied (A) minus removed (R)**  
774 **N data provide quantifiable data on nitrate discharge and potential nitrate leaching**  
775 **losses, while soil-plant-water, vadose zone, and hydrogeological models can be used to**  
776 **evaluate potential and future impacts of nitrate discharge from agriculture on**  
777 **groundwater nitrate concentration while accounting for other processes such as**  
778 **denitrification, aquifer recharge, and in-well (and aquifer) mixing of water from various**  
779 **sources prior to extraction and use as drinking water.**

780 12. Regions 3 and 5 have collected data on applied N and harvest yields through their annual  
781 INMP and applied N reports. The INMP data provides the most definitive data on the N use  
782 patterns by agriculture and can be the starting point for deciding on how to establish targets  
783 and limits. In addition, crop removal coefficients (conversion factors to obtain removed N  
784 from yield data) have been developed for most of the major California commodities,  
785 although they are lacking for many small-acreage or niche crops. Hence, the difference  
786 between applied N (from various sources) and removed N (from harvest) can be reasonably  
787 calculated for most commodities and assessed by growers and regulators in these regions.

788 13. Using the above-mentioned data, regulators and water quality coalitions can assess A-R,  
789 A/R, and applied N data and identify outliers based on, e.g. the 80<sup>th</sup> to 90<sup>th</sup> percentiles (the  
790 highest 10-20%) of any one of these metrics. This is the first step in regulatory action that  
791 can address the growers that are farthest from desired water quality goals. In regions where  
792 methodologies for calculating N removed have not been developed growers should report  
793 total applied N and harvest yield.

794 14. As A and R data may be used to inform targets/limits, it is important that growers also  
795 document how their reported A and R values were determined (fertilizer records, fertilizer  
796 sales receipts, product sale records, etc.) so that the quality of the data can be evaluated by  
797 third-party coalitions and Regional Boards.

798 15. Region 5 is currently using the model CV-SWAT to determine nitrate leaching from the root  
799 zone based on grower's reported A and R, crop, and soils information, and the CV-NPSAT  
800 framework is used to assess impacts of N discharge on groundwater nitrate concentrations  
801 at a township scale. Through this process Region 5 estimates N discharge to groundwater,  
802 and develop targets for N discharge to groundwater. With this information, coalitions report  
803 the INMP summary report to their members to work on improvements as needed. This use  
804 of simulation models is very appropriate and may be chosen as an approach by other  
805 regions, but it is recognized that this practice may not be appropriate for all regions. For

806 more details on the modeling approach used in the Central Valley, see Chapter 6 of this  
807 report.

808 16. In Region 3, Ag Order 4.0 laid out a schedule of targets and limits. It provided important  
809 credits and discount factors that made a more accurate accounting of factors on both sides  
810 of the A-R calculation. This approach is also an appropriate model for reducing nitrate  
811 loading in an effective and reasonable manner. The ultimate goal in the approaches taken  
812 by both regions is to protect water quality and, if possible, achieve the operational  
813 benchmark.

814 17. Fee structures for participation in the IRLP process may be devised to reward growers that  
815 achieve water quality outcomes beyond current targets/limits (See Additional Considerations  
816 1). Best management practices should be incentivized to encourage their widespread  
817 adoption (See Additional Considerations 2).

818

819 *Question 1c. What additional data should be collected and/or what additional research needs to*  
820 *be conducted to further support the development of nitrogen-related limits that are protective of*  
821 *groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?*

822

823 **Development of R values for commodities needs to continue to be a priority. The Expert**  
824 **Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent metrics) can**  
825 **be made now and provides a roadmap for reducing nitrate discharges in regions where**  
826 **groundwater is at risk for nitrate contamination. Given the complexities of characterizing**  
827 **removal from agricultural systems such as container nurseries, small diverse growing**  
828 **operations, and substrate produced crops, research is needed to characterize how to**  
829 **evaluate the risk of nitrate leaching posed by these systems. All forms of research on**  
830 **improving N use efficiency in crop production are needed to help move agricultural**  
831 **production in all regions closer to the operational benchmark for nitrate discharge.**

832 18. A thorough evaluation of the unique cropping systems of each region of the state needs to  
833 be conducted to evaluate to what extent they pose a N leaching risk to groundwater. Each  
834 region should have a process to collect applied N data and collect and/or develop removed  
835 N data. This data can be used to assess levels of N loading in their area.

836 19. An effort should be undertaken to develop N removed data for crops that do not have  
837 existing data on N content of removed materials. Ultimately, each crop system should move  
838 towards developing the means to estimate A-R data. In the interim, values for similar crops  
839 can be used in lieu of a specific coefficient. For some commodities (e.g. cut flowers with a  
840 large number of varieties and types), removal coefficients of representative commodities  
841 may be used in lieu of specific coefficients. Potential alternative approaches for nurseries  
842 will be discussed in our response to Question 9.

843 20. Funding for research from State Agencies such as the California Department of Food and  
844 Agriculture (CDFA) should be solicited to invest into continued development and  
845 demonstration of best management practices, development of agronomic information (e.g.  
846 crop N uptake patterns), and technology that can help growers reduce nitrate loading in  
847 agricultural regions that have the greatest risk of causing nitrate contamination of underlying  
848 groundwater.

- 849 21. Regions must identify and designate nitrate control priority zones or vulnerability zones as  
850 seen in the case of the EU nitrate directive and in the CV ILRP and CV-SALTS programs  
851 and consider implementation of buffer zones to protect community wells.
- 852 22. Specific cropping systems that need research include pasture and alfalfa, nursery systems  
853 (many regions), diverse orchard/nursery operations (Regions 8 and 9), small diversified  
854 organic or conventional operations (many regions) and cut flower operations (see response  
855 to Question 9). A more detailed discussion on research needs can be found in Chapter 5.2.

856

## 857 **Additional Considerations**

### 858 *1. Fee adjustment incentives*

859 Currently, the fees paid by growers to their coalition are based on the acreage. The fees  
860 could be adjusted to reflect A-R values: Growers with low A-R values would pay less per  
861 acre while growers with A-R values that are above the operational benchmark and that  
862 are high compared to the A-R values of other growers who grow the same crop in the  
863 region would pay a higher fee per acre. Such a fee structure would reward growers who  
864 already achieve low A-R values, while it would provide a financial incentive for growers  
865 with high A-R values to improve N management in their crops. The structure of such  
866 fees and their evolution over time must consider that ultimately, all growers would be  
867 meeting required targets/limits, thus lessening/removing the need for built-in incentives.  
868 For example, incentive-based fees may have an expiration date. Whether A-R linked  
869 fees are introduced and how they are structured would need to be determined by  
870 individual coalitions.

### 871 *2. Incentivization of practices to improve water quality*

- 872 • Small-scale diversified farms rotating multiple crops per year may have overlapping  
873 crops from one calendar year to the next but can also implement practices to increase N  
874 removal such as winter cover cropping in plots being fallowed. Incentives could focus on  
875 reducing N applied and/or increasing N removal.
- 876 • In Region 3, where cool season vegetables are produced 2-3 times per season,  
877 achieving an A-R metric near the target that protects groundwater from nitrate (~50 lb  
878 N/acre/year) is difficult given current technology and production practices. Development  
879 of interim targets/limits in this region needs to be carefully thought through to balance  
880 environmental objectives with economic limitations. Practices such as judicious use of  
881 soil nitrate testing during the cropping season to guide fertilizer applications, accounting  
882 for nitrate-N in irrigation water to reduce fertilizer applications accordingly and efficiently  
883 irrigating to reduce nitrate leaching during the growing season will help reduce N  
884 applications on the A side of the A-R metric. Use of practices such as cover crops and  
885 high carbon amendments are incentivized by inclusion of their value on the R side of the  
886 equation (these practices are discussed in the response to Question 7).

887

888

889

890 **4.2. “Interim Limits/Targets” - Response to Question 2**

891 **Question**

892 *Based on the data and scientific research that is currently available, what series of increasingly*  
893 *protective interim nitrogen-related limits can be set now to ensure that all growers make*  
894 *progress towards nitrogen-related limits that are protective of groundwater quality and support a*  
895 *long-term sustainable Irrigated Lands Regulatory Program?*

896

897 **Response and Recommendations**

898 **The Expert Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent**  
899 **metrics) can be made now and provides a roadmap for reducing nitrate discharges in**  
900 **regions where groundwater is at risk for nitrate contamination. The interim targets/limits**  
901 **do not necessarily need to immediately achieve the 10 ppm Nitrate-N MCL. However, an**  
902 **iterative process that gradually brings water quality targets/limits closer to the**  
903 **operational water quality objective in a steady and measured way that is environmentally**  
904 **beneficial and agronomically feasible would be the desired path forward.**

905 1. Interim targets/limits need to be set that are agronomically achievable by growers and will  
906 lead to improved water quality. Focused research and consultation with UC farm advisors  
907 and specialists, and technical assistance providers can be used to help determine the  
908 agronomic feasibility of proposed targets. Once a target/limit is established, an iterative  
909 review process can be established by the Regional Water Quality Control Board (e.g. 3-5  
910 years) to evaluate if growers are making concerted efforts to utilize BMPs, can meet the  
911 targets/limits and reasons for success and/or failures to meet those targets. The evaluation  
912 process should consider environmental (e.g. soil type), socioeconomic (land tenure, market  
913 requirements), and agronomic/biological constraints, and data availability for achieving the  
914 target/limit. The evaluation will provide valuable information on focus areas for technical  
915 assistance. If growers can comply with the first target/limit, the Regional Water Quality  
916 Control Board can then establish a new target/limit and the iterative process can be  
917 repeated. The goal is to move the agricultural industry in a reasonable fashion over time  
918 closer to the operational benchmark. This process is similar to the process presented in Ag  
919 Order 4.0 by the Central Coast Regional Water Quality Control Board (Ag Order 4.0, Table  
920 C. 1-3, page 52). The procedure is supported here, but with modifications (see Bullet 2  
921 below). In addition, an evaluation period is recommended with each step down to determine  
922 if the proposed target/limit is agronomically achievable by the ag industry. This approach is  
923 also similar to the approach used in Region 5 where targets are reviewed and updated  
924 every five years. The ultimate goal for the agricultural industry is to achieve nitrate loading  
925 that is protective of water quality and as close as agronomically feasible to the operational  
926 benchmark.

927 2. The schedule for compliance in Ag Order 4.0 includes initial A-R targets that growers need  
928 to achieve in the upcoming year (2027), followed by more restrictive A-R objectives further in  
929 the future that are classified as limits, which will be challenging for farmers to achieve using  
930 current best management practices. This schedule did not include an evaluation process to  
931 determine if the industry was capable of successfully achieve the set goals. The perspective  
932 of the Panel is that it makes more sense to set limits at the higher N discharge objectives  
933 which are agronomically achievable by a high percent of growers. Agronomically challenging

934 A-R goals that are to be implemented in the future should be classified as targets to provide  
935 flexibility for growers to develop, experiment, and implement the necessary practices that  
936 will allow them to reach these more restrictive N discharge objectives. Growers will likely  
937 require greater technical assistance as well as technological advancements to comply with  
938 these more challenging N discharge goals.

939 3. An extensive education and outreach effort should be conducted to help growers utilize best  
940 management practices to improve N use efficiency and to make rapid progress to lower the  
941 values of the selected metric and to reduce potential nitrate discharge to groundwater.  
942 Incentives can be offered by the Regional Boards/coalitions and consequences can result  
943 from continued exceedances (See Chapter 5.2 for more detail).

944 4. In regions where growers generally produce one crop per year and/or permanent crops (e.g.  
945 Region 5), it may be easier to achieve A-R values that are close to the operational  
946 benchmark compared to regions where multiple crops are grown per field per season. If  
947 growers can verify that they are achieving discharge values close to protective water quality  
948 targets/limits, incentives should be developed that help these growers continue progress in  
949 reducing their A-R levels.

950

951

### 952 **4.3. “Beyond A and R in the N Cycle, Part 1” - Response to Question 3**

#### 953 **Question**

954 *Are there any scientific or technical considerations or advances related to the factors discussed*  
955 *in the First Agricultural Expert Panel’s 2014 Report that the State Water Board should take into*  
956 *account in future policy decisions regarding implementation issues or the direct enforceability of*  
957 *the nitrogen-related limits described above?*

958

#### 959 **Overview and Background**

960 The question refers to the following text from the First Expert Panel report:

961 Appendix C-3 p. 65: Definitions and Clarifications for the Panel: Reporting

962 “The [first Agricultural Expert] Panel assessed the relative importance of using field-level  
963 nitrogen computations such as those described below.

964 1. Nitrogen mass balance – The general idea is to have a spreadsheet or model which  
965 incorporates all nitrogen inputs to a field, along with extractions. In general, the deep  
966 percolation of nitrates is a mathematical “remainder”. Differences between various “mass  
967 balance” computations enter when one integrates factors such as:

968 a. Nitrogen transformation rates

969 b. Volatilization

970 c. Crop removal – measured or estimated?

971 d. Carry-over between crops

972 e. Details of leaching factors, such as frequency and intensity of rainfall.

- 973 2. Ratio of [(Nitrogen In)/(Nitrogen Removed by the Crop)] – Again, there can be differences  
974 between the technique used to determine the “nitrogen removed”. There are also questions  
975 regarding what ratio might be acceptable. The applicability of this type of ratio may depend  
976 upon factors such as:
- 977 a. The type of crop. For example, trees versus vines versus leafy greens.
  - 978 b. The amount of rainfall.”

979

## 980 **Response and Recommendations**

981 **The Expert Panel agrees that some scientific advances have been made to understand**  
982 **field-level N mass balance, N transformation rates, and nitrate leaching factors. However,**  
983 **additional research is needed to understand and account for N transformation processes**  
984 **in each region. Root zone and soil crop models can be used in accounting for N**  
985 **transformation processes.**

### 986 *Nitrogen mass balance factors*

- 987 1. The Panel discussed the use of root-zone and soil-crop models to account for N  
988 transformation processes including denitrification, volatilization, immobilization, and  
989 mineralization. The Panel noted that while progress has been made in understanding these  
990 processes through models and metrics, additional research is needed to fully understand  
991 the elements of atmospheric losses by denitrification and volatilization. The Panel agrees  
992 that accounting for these factors is important in reducing nitrate loading to groundwater but  
993 notes that N transformation rate processes can be difficult for growers to self-determine and  
994 report, although they can be more easily calculated by third-party coalitions using modeling  
995 or other accounting methods.
- 996 2. Each region should have the flexibility to determine the best metric, model, or literature  
997 value for accounting for N transformation rate factors. For instance, Region 5 uses the Soil  
998 and Water Assessment Tool (SWAT) to account for various N input and N output terms on  
999 irrigated lands. The SWAT model accounts for N transformation rate factors including  
1000 mineralization, volatilization, nitrification, and denitrification for crops included in the model.  
1001 Furthermore, as part of updating targets in Region 5 every five years, an adaptive model  
1002 update process is in place that also allows for continual incorporation of new research as  
1003 such results become available. Parameters for representing these processes in CV-SWAT  
1004 are based on expert opinion. The data presented to the Panel showed that Region 5 has  
1005 utilized this modeling approach to develop groundwater protection targets/limits on a  
1006 township scale based on N input and output reported by growers. In Region 3, Ag Order 4.0  
1007 utilized a factor of 4.5 lb N/ac/year to account for losses due to potential denitrification in the  
1008 deep vadose zone or in shallow groundwater (Central Coast Regional Water Board, 2021).  
1009 As more research and data become available, any of these approaches must be flexible  
1010 enough to incorporate new knowledge over time, as appears to already be the case in  
1011 Regions 3 and 5. Additionally, it may be more appropriate to have regionally based panels  
1012 review new research findings and discuss incorporation into existing orders than to convene  
1013 a statewide panel for this task.

1014

1015

1016 *Nitrate leaching factors*

1017 3. Advancements have also been made in understanding factors that contribute to nitrate  
1018 leaching including soil type, crop type, irrigation, manure and fertilizer management, climatic  
1019 and hydrologic conditions.

1020

1021 *Best management practices*

1022 4. The Expert Panel recommends the use of soil nitrate testing to measure nitrate levels (from  
1023 sources such as mineralization of soil organic matter, previous crop residues, or prior  
1024 fertilizer applications) and applying this information to reduce fertilizer applications without  
1025 jeopardizing crop yields. This could allow for adjustment of fertilizer application amounts  
1026 based on how much plant-available N is in the soil. An effort should be made to understand  
1027 the soil type and characteristics of each region to assess the leaching capacity of the soils.  
1028 Generally, sandy textured soils present greater challenges for irrigation efficiency and nitrate  
1029 leaching than clay soils.

1030 5. There are advances in understanding how to utilize nitrate in irrigation water to replace a  
1031 portion of the N fertilizer applied to crops. Nitrate from irrigation water can be determined by  
1032 testing ahead of crop fertilization to determine if additional N fertilizer should be applied to  
1033 crops. Frequent irrigation water testing should be conducted by growers with support from  
1034 technical assistance programs. The Board should support technical assistance programs to  
1035 aid limited-resource growers to conduct irrigation water testing.

1036 6. There is new research showing the utility of cover crops in scavenging residual N in soil to  
1037 reduce leaching to groundwater during the winter fallow period when there is increased  
1038 precipitation. In addition, other cover crop strategies have been evaluated such as low  
1039 biomass winter cover crops and fall-grown cover crops. Each of these strategies has specific  
1040 strengths and abilities to scavenge and sequester residual soil nitrate during leaching events  
1041 that commonly occur during the winter fallow period. Therefore, these strategies should be  
1042 encouraged and incentivized for use by growers. In addition, the levels of nitrate scavenging  
1043 by cover crop mixes (e.g. cereals and legumes frequently used by organic growers) are  
1044 being evaluated by researchers and may warrant being encouraged and incentivized for use  
1045 by growers. Temporary immobilization of N by cover crops and high carbon amendments  
1046 and the release during the growth of the following crop should be considered in future policy  
1047 decisions. See response to Question 7 for more on this topic.

1048

1049 7. Crop Nitrogen Removal Coefficients

1050 The Panel discussed the progress in developing and determining crop N removal  
1051 coefficients for various crops to understand N removed or harvested. As mentioned in the  
1052 responses to Questions 1&2, for many crops in Regions 3 and 5 there is sufficient data to  
1053 understand the N applied as well as various crop removal coefficients. Crop removal  
1054 coefficients have been developed for most of the crops in Region 5 that occupy 99% of the  
1055 irrigated acreage in the Central Valley. Region 3 crop removal coefficients have been  
1056 developed for approximately 95% of the acreage occupied by crops. For other regions  
1057 across the state, there has not been sufficient data presented to the Panel to determine if N  
1058 removal coefficients have been developed specific to the regions. So far, crop coefficients  
1059 are not available for many small-acreage, niche, emerging, and subtropical crops, as well as

1060 nursery container-grown crops. The Board should refer to literature reviews from similar  
1061 climates and crop types in the meantime or allow alternate reporting methods that rely on A  
1062 and not R, particularly for nurseries and small-scale, diversified farms.

1063

1064

#### 1065 **4.4. “N Discharge to Groundwater” - Response to Question 4**

##### 1066 **Question**

1067 *Is A-R a scientifically appropriate metric to evaluate and quantify nitrogen discharges to*  
1068 *groundwater (either on its own or used in conjunction with A/R)? Are there any other methods or*  
1069 *metrics that could help quantify nitrogen discharges?*

1070

##### 1071 **Response and Recommendations**

1072 **The Expert Panel agrees that A-R is an appropriate metric to evaluate and quantify N**  
1073 **discharges to groundwater for regulatory purposes (either used on its own or in**  
1074 **conjunction with A/R). Soil-water crop, vadose zone, and hydrogeological models are**  
1075 **also good tools to inform N discharge-based targets/limits that would result in improved**  
1076 **groundwater quality in future years by accounting for factors not easily provided by**  
1077 **growers, such as groundwater recharge, N mineralization, denitrification, and other**  
1078 **factors, which are further discussed in the response to Questions 3 and 7. A/R is not an**  
1079 **appropriate metric to assess N discharge, but A/R is an essential metric to assess**  
1080 **grower/ranch performance in efficiently using N.**

1081 1. The Expert Panel agrees that N budget-based metrics such as Applied N (A) minus  
1082 Removed N (R), referred to as A-R, which provide an estimate of potential nitrate discharge,  
1083 are appropriate for setting targets/limits for the agriculture industry, as they relate back to  
1084 grower management practices at the field or farm/ranch level.

1085 2. In the formula proposed by the first Expert Panel, calculating A requires records of  
1086 application of fertilizer, organic amendments, and irrigation water. The calculation of R  
1087 requires a grower-reported yield, which is multiplied by an N removal coefficient, plus N  
1088 sequestered in the permanent wood of perennial crops.

1089 3. A more scientifically accurate estimate of A would include all N inputs to the soil (Figure 1).  
1090 Similarly, R would include all removal of N from the soil except the N leached into the deeper  
1091 vadose zone (or into the shallow water table, see response to Question 3). However, many  
1092 of the N balance components, such as atmospheric deposition, gaseous losses, or changes  
1093 in total soil N (which is the net effect of organic N inputs and mineralization and  
1094 immobilization of all organic N pools in the soil) cannot be measured by growers and  
1095 scientifically based estimates can be highly variable at the field or farm scale.

1096 4. Therefore, while the formula proposed by the first Expert Panel is a simplification and may  
1097 not be accurate enough for scientific studies, it relies on data that are generally readily  
1098 available to growers and can be accurately determined in most cases at the field or farm  
1099 scale.

1100 5. A-R can be calculated for specific crops (as currently done in Region 5) or cropping systems  
1101 (as currently done in Region 3) and allows for comparison of different fields or

- 1102 farms/ranches in a region. It is therefore a good metric to inform growers how they perform  
1103 in comparison to other growers in the region with respect to their impact on groundwater and  
1104 the need for additional practices to protect groundwater quality.
- 1105 6. The A/R metric is useful for comparing N use efficiency among growers, where a small value  
1106 indicates greater efficiency. The A/R metric is most appropriate for comparing N use  
1107 efficiency among similar crops or cropping systems. Because a greater A may result in  
1108 greater R, a grower could have a greater A-R than another grower but similar A/R values,  
1109 which indicates that they are equally efficient in managing N, but represents different N  
1110 loading amounts. Hence, A-R and A/R are complementary, but A/R cannot be used alone for  
1111 determining N loading.
- 1112 7. A-R and A/R together, or A-R alone, can be considered appropriate metrics for regulatory  
1113 purposes but not for agronomic purposes. Nitrogen budgets for determining the amount of N  
1114 fertilizer required by crops should be based on N uptake of the crop and consider other  
1115 sources of N, such as residual nitrate in the root zone, and N mineralized from residue of the  
1116 previous crop and from soil organic matter. However, these non-fertilizer sources of N can  
1117 be highly variable and transitory due to soil microbial processes, plant uptake, and soil water  
1118 movement. Furthermore, some non-fertilizer sources are difficult to measure by individual  
1119 growers (e.g., atmospheric deposition, N mineralization from soil organic matter). These  
1120 non-fertilizer sources are not recommended to be included in the data reported by growers  
1121 and thus in A-R calculations.
- 1122 8. The current version of A-R can be improved by including discount factors to A and additional  
1123 components of R that better reflect grower management practices and account for organic  
1124 fertilizer and compost N mineralization rates. These improvements will be discussed in detail  
1125 in the Expert Panel's response to Question 7.
- 1126 9. In situations where N removal coefficients or reliable yield estimates are not available, the  
1127 Expert Panel recommends using N applied (A) instead of A-R as the primary metric to  
1128 assess the risk of nitrate losses to ground and surface water. Efforts, however, should be  
1129 made to generate the data needed to estimate R in the future.
- 1130 10. For some cropping systems, such as greenhouse production, mixed container nurseries,  
1131 substrate grown crops, and small growing operations with mixed commodities, the  
1132 calculation of R may be very complex and/or impractical. In these situations, research and  
1133 reviews of literature data from similar climates can be used if available to estimate a  
1134 reasonable average R coefficient for groups of similar crops or a discharge factor based on  
1135 A. As long as robust R values are not available, the distribution of A among the operations  
1136 can be used to identify the highest dischargers for specific production systems. Alternatively,  
1137 in production systems with impermeable surfaces, or tile drainage that result in surface  
1138 discharges, direct monitoring of N discharge may be a more accurate and easier approach  
1139 than the A-R metric. For more details see response to Questions 8 and 9.
- 1140 11. The Expert Panel supports complementing the A-R metric with soil-water-crop, vadose zone,  
1141 and hydrogeological computer models for assessments at larger scales, e.g. at the township  
1142 or groundwater basin scale. These tools could be particularly useful to track site-specific soil  
1143 N transformations based on climate, soil, crop, and irrigation and nutrient management  
1144 practices. These transformations are not captured by A-R, such as N mineralization or

1145 denitrification. For a more detailed discussion on computer simulation models, see Chapter  
1146 6 of this report.

#### 1147 **4.5. “Data Collection and Reporting” - Response to Question 5**

##### 1148 **Question**

1149 *The Eastern San Joaquin Water Quality Order includes additional aspects not specifically*  
1150 *recommended by the First Agricultural Expert Panel. For example, the Order requires the*  
1151 *submission of INMP summary tables.*

1152 *5a. Are these tables, as they currently stand, an effective tool for evaluating A and R data?*  
1153

##### 1154 **Overview and Background**

- 1155 • For the information required by the Eastern San Joaquin Water Quality Order to be included  
1156 in summary reports, see below “Additional Considerations 1”.
- 1157 • The Panel extensively considered specifically the interpretation of what may constitute an  
1158 “effective tool” for evaluating A and R data. The main purpose of reporting A and R data and  
1159 any related details at the field, orchard, vineyard, or farm scale can be considered to be two-  
1160 fold:
  - 1161 ○ First, to assess the nitrate N discharge (N discharge) to groundwater as accurately as  
1162 practicably possible; and,
  - 1163 ○ Second, to provide the grower with useful and accessible information that incentivizes  
1164 improved N management, such as assessing a grower’s performance relative to their  
1165 peer group.

1166 The overarching objective is to lower nitrate leaching to groundwater to acceptable levels,  
1167 where needed.

- 1168 • The First Statewide Expert Panel had recommended focusing on incentivizing growers to  
1169 improve their N use efficiency, with A/R as the most useful metric (Bullet 2 above). However,  
1170 the ILRPs instead elected to focus on the nitrate discharge to groundwater (Bullet 1 above)  
1171 using the N mass balance and related approaches, i.e., focus on A-R rather than A/R (see  
1172 Question 4 above). But the ILRPs also wanted to be sensitive to engaging with growers and  
1173 incentivize improved practices and include A/R reporting. In selecting a “formula” or protocol  
1174 to determine N discharge to groundwater, two variants of the A-R metric family have  
1175 emerged:

1176

##### 1177 *Variant 1:*

1178 Some regions, including Region 5, selected to focus on obtaining the best-possible,  
1179 practicable estimate of N discharge to groundwater. In the Central Valley, third parties are  
1180 responsible for working with their members to assess the level of protection, implementing  
1181 verifiable improvements where needed, and report findings. The summary tables generated  
1182 by the third-party coalitions provide detailed field-by-field documentation of A, R, A/R, and A-  
1183 R, by year and over rolling 3-year periods (see Additional Considerations 1). Specifically in  
1184 Region 5, A and R data are reported at three scales: field, assessor’s parcel number (APN),  
1185 and township. In Region 7, A and R data are reported at two scales: field and township. In

1186 Region 8, data are reported at the field scale only. Field and APN scale data are  
1187 anonymized and, hence, do not include acreage. Aggregated township data include crop  
1188 acreage and disclose the township, for each commodity. The original data provided by  
1189 growers are used by the third-party coalitions to inform a physical model of the soil-water-  
1190 plant continuum, which provides information on N leaching and other N mass balance terms  
1191 (see Chapter 6). Data are accessible to the Regional Board for auditing and review.

1192

1193 *Variant 2:*

1194 • Region 3 also selected to focus on obtaining practicable estimates of N discharge to  
1195 groundwater. The Central Coast Ag Order 4.0 utilizes a mass balance approach to the A-R  
1196 metric that includes several specific terms (Chapter 1), including terms that serve additional  
1197 purposes:

1198 ○ Discount factors for compost and organic amendments are used to estimate the amount  
1199 of labile N that becomes plant-available during the first year. The discount factors  
1200 recognize the recalcitrant portion of organic fertilizers that is not leachable and becomes  
1201 part of the background amount of N from soil organic matter that mineralizes over  
1202 subsequent months and years.

1203 ○  $R_{SCAVENGE}$  is used to credit the amount of leachable N sequestered by cover crops and  
1204 high carbon amendments or high carbon woody materials.  $R_{SCAVENGE}$  was introduced to  
1205 account for the reduction in the amount of nitrate potentially at risk of leaching during the  
1206 winter and to incentivize these practices.

1207 ○ The amount of N applied with irrigation water ( $A_{IRR}$ ) applied in excess of crop ET is not  
1208 included in A to avoid disincentivizing the use of nitrate-containing irrigation water (pump  
1209 and fertilize).

1210 ○ These metrics will be discussed in detail in the response to Question 7.

1211 • In Region 3, most growers report through a third party, but all reported data are submitted to  
1212 the Regional Board. The data submitted to the Regional Water Board includes the identity of  
1213 the ranch and acreage data. Data are reported at the scale of the ranch.

1214

## 1215 **Response and Recommendations**

1216 **The Panel finds that the mentioned tables are appropriate for the purpose of estimating N**  
1217 **discharge to groundwater. However, the Panel recommends that additional data be**  
1218 **reported on the INMP reports and on the outcome of the N mass balance terms obtained**  
1219 **from soil-water-crop systems models (like CV-SWAT in Region 5) where they are used.**  
1220 **These additions will facilitate analysis of the data by the public.**

1221 1. The Panel finds both the first and second variant to obtaining A and R values and associated  
1222 metrics to be acceptable (i.e., the Region 5 vs Region 3 approach). But it is important to the  
1223 public (and other regions needing to design their approach) to understand the fundamental  
1224 distinction in how the A-R and A/R metrics are obtained and that the metrics obtained by  
1225 Region 3 would not be directly comparable with those currently used in Regions 5, 7, or 8.  
1226 For example, under the first variant (Regions 5), all N applied through irrigation water must  
1227 be reported. In contrast, in Region 3 the amount of N applied with irrigation water ( $A_{IRR}$ )  
1228 applied in excess of crop ET is not included in A. Furthermore, there are differences in the

1229 specificity of guidance given to growers between regions. For example, Region 3 provides  
1230 formulas and conversion values for determining the plant-available N in composts and  
1231 organic amendments. The East San Joaquin Valley order in Region 5 leaves it to the  
1232 growers or third-party coalitions to estimate the amount of N available to the plant during the  
1233 growing period, which must be reported in pounds per acre.

1234 2. In the Central Valley, the agricultural water quality coalitions have taken on a central role of  
1235 engaging with growers with the goal of improving practices and meeting regulatory targets.  
1236 As such they are the interested party with the highest need for access to sufficiently detailed  
1237 data for eliminating non-compliant landowners, which includes, e.g., acreage of an individual  
1238 field. These coalitions are in charge of cooperating with and training individual growers to  
1239 improve their management. The Regional Water Board has the capacity to audit the  
1240 coalitions' actions. The public is provided with sufficient information to assess the degree to  
1241 which individual growers improve over time (or not) and the overall range of crop specific N  
1242 balance elements in each township, which provides a very significant public angle to  
1243 transparency and oversight. That said, the currently available reports point to significant  
1244 shortcomings that require explanation and follow-up. Specifically, a large number of  
1245 anonymous field units have unreasonably low or even negative A-R values (e.g., the Kern  
1246 coalition report for 2023 identifies some 5200+ individual fields of which about 1300 fields  
1247 have negative or zero A-R values, and another 600 fields have exceedingly low A-R values.  
1248 Unreasonably low values for metrics, especially when computed over a three-year period,  
1249 should be treated as potentially erroneous and require similar follow-up as outliers at the  
1250 high end of A and R related metrics. This should not be limited to statistical outliers at the  
1251 low end, but to all fields/properties with unreasonably low three-year average A/R or A-R  
1252 values.

1253 3. For regulatory purposes, the regions may adopt anonymization and data privacy frameworks  
1254 to protect individual grower information. These frameworks must still allow the regulating  
1255 body and affected stakeholders to calculate and evaluate N loading at the regional scale.  
1256 For example, access to anonymized APN-level identifiers, field- and crop-level A and R data,  
1257 along with township-level summaries that include crop-specific acreage, would allow  
1258 assessment of individual grower performance and improvements while also evaluating  
1259 overall N budget ranges by crop and township. To encourage the reporting of high-quality  
1260 data and minimize disincentives for accurate reporting, the Expert Panel recommends that  
1261 each region develop data privacy and transparency frameworks that avoid potential  
1262 unintended consequences of publicly available data, including: a) reduced quality of self-  
1263 reported compliance data; b) use of data by external parties for purposes unrelated to ILRP  
1264 compliance; and c) visits to farm locations without the consent of growers, such as for  
1265 agricultural theft, recruitment for participation in unrelated projects, or any targeting of  
1266 growers based on crops, markets, agricultural practices, or demographic characteristics.

1267 4. The public has expressed interest in understanding whether poorly performing fields are  
1268 large or small. The Expert Panel finds that the degree of anonymity sought by the growers is  
1269 adequately and justifiably protected by not disclosing the specific acreage associated with  
1270 individual field or APN parcel entries. But the Expert Panel understands the need to gauge  
1271 the impact of individual entities not properly performing. We therefore propose that public-  
1272 facing reporting tables add a column that identifies the size of the individual field / APN  
1273 parcel as a categorical characteristic. The categories should be determined at a regional

- 1274 level. For illustrative purposes, the Panel suggests using the following categories to  
 1275 categorize individual field or APN level data:
- 1276 ○ <1 acre, 1 to < 10 acres, 10 to < 100 acres, 100 to < 500 acres, 500 to <1,000  
 1277 acres, >1,000 acres;
  - 1278 or alternatively a breakdown into the following, more detailed categories,  
 1279 bounded by:
    - 1280 ○ 0-25 acres, 50 acres, 100 acres, 200 acres, 400 acres, 800 acres, 1600 acres,  
 1281 3200 acres, >3200 acres; these categories bracket the size of quarter-quarter-  
 1282 quarter sections (10 acres), quarter-quarter sections (40 acres), quarter section  
 1283 (160 acres), section (640 acres), two to five sections (3200 acres), more than 5  
 1284 sections (more than 5 square miles, > 3200 acres)
- 1285 5. We recommend that the reports add simplified information on the predominant soil series  
 1286 (e.g., coarse vs. fine grained soils, well- or poorly drained, with or without hardpan,  
 1287 saline/sodic issues). As most fields or APNs will contain multiple soil series, only the most  
 1288 dominant two or three need to be reported with an indication of the total percent (to the  
 1289 nearest 10%) of the field or APN covered by these series. It is not practical for growers to  
 1290 report separately for various soil series within a field/orchard. Information about the soil  
 1291 series other than the name of the soil series is provided by public agencies and need not be  
 1292 reported by the grower.
- 1293 6. To meet public interest in understanding and auditing reported data, the Panel recommends  
 1294 that the following additional (electronic, i.e., MS Excel-compatible) summary table be  
 1295 prepared by Region (or major sub-region or coalition), which lists, *for each crop or cropping*  
 1296 *system* (multiple crops per year) the following variables, with one table row per crop or  
 1297 cropping system and one table column for each variable:
- 1298 ● Area information:
    - 1299 ○ Total acres
  - 1300 ● Annual water budget information:
    - 1301 ○ Average precipitation volume
    - 1302 ○ Average irrigation volume
    - 1303 ○ Average ET volume
    - 1304 ○ Average runoff volume
    - 1305 ○ Average recharge volume
  - 1306 ● Annual N reporting information: Separate columns for the average, 5<sup>th</sup>, 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>,  
 1307 75<sup>th</sup>, 90<sup>th</sup>, and 95<sup>th</sup> percentile of
    - 1308 ○ INMP N applied (where N applied is clearly defined, separated by synthetic and  
 1309 organic fertilizer, organic amendments, manure, etc.)
    - 1310 ○ Average INMP N removed (in regions where N removed is clearly defined) or yield  
 1311 plus yield-to-N conversion factor
    - 1312 ○ Any other N mass balance terms reported by growers

- 1313 • Additionally, in regions where soil-crop models (e.g., SWAT) are used: Modeled annual
- 1314 N budget information – separate columns for the average, 5<sup>th</sup>, 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup>,
- 1315 and 95<sup>th</sup> percentile of:
  - 1316 ○ Nitrogen applied (all sources and, separately, by major source)
  - 1317 ○ Nitrogen from atmospheric deposition
  - 1318 ○ Nitrogen from fixation
  - 1319 ○ Nitrogen removed from field
  - 1320 ○ Nitrogen added to permanent woody tissue (tree, vine)
  - 1321 ○ Nitrogen in runoff
  - 1322 ○ Nitrogen subject to atmospheric losses (denitrification, volatilization)
  - 1323 ○ Change in soil organic matter N content

1324 In all of the above, the average and percentiles are understood to be computed on an *area*

1325 basis and reported *by crop or cropping system*.

- 1326 7. We recommend that the State Water Resources Control Board, in collaboration with CDFA,
- 1327 the Farm Bureau, and third parties develop a standardized table of commodity names, crop
- 1328 type names, crop groups and crop group names.
- 1329 8. In addition, associated reports summarize annual and multi-year place-based and crop-
- 1330 based data, which is appropriate and desirable. Clearly defined protocols for computing
- 1331 multi-year rolling statistics (mean, median, percentile distribution) must accompany these
- 1332 reports. Also see recommendation 6 above for a minimum set of summary information to be
- 1333 provided.
- 1334 9. With these tables (plus the recommended improvements), the third parties and Regional
- 1335 Water Boards provide a transparent dataset that is available to the public for further analysis
- 1336 and review. The Expert Panel suggests that this level of detail in reporting may be an
- 1337 appropriate requirement to set for all California agricultural regions (with either the first or
- 1338 second variant approach identified above).

1339

1340 *Question 5b. Is the INMP data that is being reported, including the format for that data reporting,*

1341 *effective for the Water Board to assess reductions in nitrogen discharges to groundwater and*

1342 *improvements in management practices, both on an individual grower basis and an overall*

1343 *basis? Is the data capable of being used to confirm that follow up actions are being*

1344 *appropriately prioritized (e.g., by distinguishing between overapplication on large farms vs.*

1345 *overapplication on small farms)?*

- 1346
- 1347 10. With the modifications discussed above, the INMP data that is being reported can achieve
- 1348 the objectives mentioned in Question 5b.

1349

1350 *Question 5c. What improvements should be made (if any) to data collection, reporting practices*

1351 *and quality assurance procedures?*

1352 *Question 5d. Order WQ 2018-0002 directs Regional Boards to periodically audit the Third*

1353 *Party's anonymous INMP records by spot checking that the field-level A and yield data reported*

1354 *is being accurately transcribed and converted into A/R and A-R in the data tables submitted to*  
1355 *the Board. For the INMP data being collected through anonymous identifiers, what level of*  
1356 *auditing is necessary to ensure the data that's submitted can be relied upon? Are there any*  
1357 *improvements that can be made to ensure the data is accurate and reliable?*

1358

1359 **The Panel makes several recommendations including standardization of protocols that**  
1360 **growers use to produce and document their INMP data; some validation against larger**  
1361 **regional and statewide datasets, including the CDFA fertilizer sales database and**  
1362 **comparison to measured shallow groundwater data.**

1363 11. The Panel recommends developing standardized documentation requirements on how  
1364 growers arrived at the reported amount of N applied to crops/fields, the proportion of N  
1365 mineralized from organic fertilizer and compost, and how they measure the harvested  
1366 product. The use of records and invoices that can be traced to the amount of N applied to a  
1367 crop/field would help coalitions better understand the quantity of N applied.

1368 12. Effective verification and auditing processes should be evaluated to ensure reductions in A-  
1369 R are validated and enduring.

1370 13. The Panel is fundamentally concerned, but currently not sufficiently familiar with processes  
1371 and challenges associated with a secure independent verification of reported values for the  
1372 amount of applied fertilizer (synthetic or organic) or the amount of N applied with soil  
1373 amendments or reported yield values.

1374 14. During the first 2-3 years of data collection, many errors and mistakes are made and need to  
1375 be corrected. Audits during this period should not result in enforcement actions. After this  
1376 initial phase, the level of auditing primarily depends on the quality of the data. When and  
1377 where most datasets audited have errors, a higher level of auditing may be warranted.

1378 15. As a regulatory agency, the Water Board is certainly more experienced in determining the  
1379 level of auditing required than the Expert Panel. The question about the level of auditing  
1380 needs to be answered by the State and Regional Waterboards.

1381 16. If a specific mistake is detected in one dataset, it is likely that other datasets contain similar  
1382 mistakes. Therefore, it is important that the results of audits are shared with the third parties,  
1383 so that they can work with growers to improve the quality of the data.

1384 17. Over the next five to ten years, a comprehensive comparison and assessment of fertilizer  
1385 sales (for synthetic commercial fertilizer, reported to CDFA) in California against ILRP-  
1386 reported statewide fertilizer application rates may provide a large-scale verification of ILRP-  
1387 reported fertilizer application data. For illustrative purposes, an example for such a  
1388 calculation is given under Additional Consideration 2. The Panel understands that a county  
1389 level or even regional level comparison of fertilizer sales to INMP reported fertilizer use may  
1390 be more difficult than a statewide comparison due to cross-county movement of county  
1391 fertilizer sales but may yield useful information with diligent analysis.

1392 18. Another important form of verification is the assessment of nitrate discharge from the  
1393 landscape via measured groundwater nitrate concentrations (see Additional Consideration  
1394 3).

1395

1396

1397 **Additional Considerations**

1398 1. *INMP Summary Reports*

1399 Requirements for the INMP Template and INMP Summary Report are described in  
1400 Attachment B MRP section VI.B in Order R5-2012-0116-11 (RWB Central Valley, 2021):

1401 Irrigation and Nitrogen Management Plan (INMP) and INMP Summary Report Templates

1402 • Should the Third-Party choose to develop a Nitrogen Management Plan Template per  
1403 the Third-Party or Group Option outlined in section VIII.D.2 of the Order, the following  
1404 provisions apply.

1405 • The Third-Party shall develop a template or web-based information system to gather  
1406 Irrigation and Nitrogen Management Plan and Summary Report information from  
1407 Members for each parcel enrolled. The goal of the template is to gather information  
1408 needed to calculate A-R and the A/R ratio. At a minimum, the INMP template must be  
1409 designed to collect the following information:

1410 1. Crop year

1411 2. Owner/Manager name

1412 3. Whether Member was identified as an outlier for AR data in previous year

1413 4. Irrigation management practices implemented

1414 5. Nitrogen management practices implemented to minimize leaching past the root  
1415 zone

1416 6. Assessor Parcel Number (APN)

1417 7. Field identification number

1418 8. Acreage

1419 9. Residual N in soil

1420 10. Crop type

1421 11. Crop production units

1422 12. Crop age (permanent crops)

1423 13. Total acreage

1424 14. Irrigation method

1425 15. Crop evapotranspiration (estimated)

1426 16. Anticipated crop irrigation

1427 17. Irrigation water N concentration

1428 18. Projected yield (if appropriate to crop type)

1429 19. Nitrogen recommended

1430 20. Nitrogen applied in irrigation water

1431 21. Applied fertilizers (products with guaranteed nutrient content)

1432 22. Applied organic soil amendments (compost and manure where nutrient content is not  
1433 guaranteed)

1434 23. Total N applied

1435 24. Primary and secondary crop harvest yield

1436 25. Plan certification information

1437 2. *Example calculation comparing fertilizer sales in California with ILRP-reported statewide*  
1438 *fertilizer application rates*

1439 The total acreage for which “GWP values” were reported in Region 5 for 2022 was 4.4  
1440 million acres. The sum of N fertilizer applied to these acres, as reported in the INMPs was  
1441 270,000 tons. For the same year, Region 3 reports a median of 165 lb N/ac synthetic  
1442 fertilizer applied to 344,000 ranch acres, a total of 28,000 tons. Between the two regions, the  
1443 reported fertilizer application on 4.8 million acres of irrigated lands is 300,000 tons.  
1444 Assuming that this were to represent approximately two-thirds of California irrigated lands  
1445 and assuming that the remaining one-third were to use similar levels of fertilizer, the total  
1446 estimated “reported” fertilizer application is on the order of 450,000 tons. According to the  
1447 California Nitrogen Assessment (2016), urban (mostly turfgrass) synthetic fertilizer use is  
1448 60,000 tons, and fertilizer use in environmental horticulture is 50,000 tons, suggesting a total  
1449 synthetic fertilizer use in California of approximately 560,000 tons. Yet, the reported  
1450 statewide N fertilizer sales tonnage for 2022 was 700,000 tons (2021: 770,000 tons, 2023:  
1451 835,000 tons). The question arises whether this is a reasonable agreement between  
1452 reported, aggregated fertilizer application rates and reported fertilizer sales, given potential  
1453 exports of sales to other states and given other fertilizer uses. The assessment would need  
1454 to include an analysis to determine whether and to which degree fertilizer sales are a valid  
1455 measure for fertilizer use in crop production statewide or at a regional scale.

1456

1457 3. *Assessment of nitrate discharge from the landscape via measured groundwater nitrate*  
1458 *concentrations*

1459 Another important form of verification that the committee recommend to be used at the  
1460 appropriate time – at least in the intermediate (10-20 year) term - is the assessment of  
1461 nitrate discharge from the landscape via measured groundwater nitrate concentrations, e.g.,  
1462 using the methodology developed by Ransom et al. (2018), possibly at a finer scale and  
1463 simultaneously using a groundwater age assessment.

1464 Using such an analysis, the verification would consist of determining whether INMP reported  
1465 values, adjusted for land use and management practice changes since the time of N  
1466 discharge, and accounting for denitrification in the groundwater system, are consistent with  
1467 estimated groundwater nitrate-derived loading rates.

1468 In separate work, Ransom et al. (2017) found a stronger link between mid-1970s land use  
1469 and groundwater nitrate in the 2000s, than between 1990 land use and groundwater nitrate  
1470 in the 2000s, suggesting that – at the Central Valley scale – an audit of this kind is useful  
1471 mostly for validating loading rate estimates some three decades earlier. Follow-up research  
1472 can identify wells with much younger groundwater age to perhaps pursue a similar analysis  
1473 sooner than 30 years from now. The younger age of the well water would thus provide more  
1474 recent N leaching estimates.

1475

1476 4. *Other topics relevant to Question 5 are discussed under different questions:*

1477 • Inputs included in A and outputs included in R (Questions 3, 4 and 7)

- 1478 • How these reporting requirements may be best handled for very small, diversified  
1479 farmers (Question 8)
- 1480 • Potential exceptions and alternatives to these reporting requirements (Question 9)

1481  
1482

#### 1483 4.6. “Synthetic Fertilizer” - Response to Question 6

##### 1484 Question

1485 *The 2021 Central Coast Ag Order established nitrogen application limits (AFER) based on*  
1486 *percentiles of known grower practices in the region and considered the California Fertilization*  
1487 *Guidelines on the California Department of Food and Agriculture website: California Crop*  
1488 *Fertilization Guidelines. This approach was remanded in the Central Coast Ag Petition Order. Is*  
1489 *using AFER in this manner an appropriate metric for interim limits to protect groundwater? If*  
1490 *yes, what should those limits be?*

1491

##### 1492 Response and Recommendations

1493 **AFER targets/limits have questionable benefits. Therefore, the Expert Panel concludes that**  
1494 **the focus should be on determining targets/limits for A and A-R. Instead of developing**  
1495 **crop specific AFER targets/limits, resources are better used to determine crop specific**  
1496 **removal N, crop N uptake curves, and for grower outreach on practices to improve N use**  
1497 **efficiency.**

- 1498 1. In addition to synthetic fertilizers (AFER), N Applied (A) includes inputs from organic fertilizers  
1499 (A<sub>ORG</sub>), composts (A<sub>COMP</sub>), and irrigation water (A<sub>IRR</sub>). Targets/limits on AFER do not account  
1500 for contributions of these other inputs of N, as well as the relationship to N removed (R).  
1501 Therefore, AFER alone provides an incomplete assessment of the risk of N losses.
- 1502 2. Although imposing targets/limits on AFER could prevent excessive fertilizer N applications,  
1503 these targets/limits would potentially be redundant of targets/limits set for A-R or A metrics.  
1504 Excessive AFER values would also likely result in high A and A-R values that exceed targets.  
1505 In addition, having targets/limits for AFER and A or A-R may confuse growers as to which  
1506 metric to consider when developing and implementing nutrient management plans. While  
1507 reported AFER values may be a useful tool to report back to growers when comparing them  
1508 with AFER values for the same crop grown in the same region, supporting growers in better  
1509 understanding A-R or A values should have priority.
- 1510 3. The 2021 Central Coast Ag Order provided AFER limits for only six crops. Determining AFER  
1511 limits for a majority of crops grown in California would require a major effort by agronomists  
1512 and agricultural researchers. Recommended N fertilizer rates would need to be developed  
1513 for many more crop types grown in California. Existing California Crop Fertilization  
1514 Guidelines published by CDFA-FREP are for a limited number of crops and were not  
1515 developed for regulatory purposes.

1516  
1517  
1518

1519 **4.7. “Beyond A and R in the N Cycle, Part 2” - Response to Question 7**

1520 **Question**

1521 *The 2021 Central Coast Ag Order included discount factors to A (compost [ACOMP], organic*  
1522 *fertilizer [AORG]), additional components of R (RSCAVENGE, RTREAT, and ROTHER), and*  
1523 *excluding nitrogen in irrigation water from the calculation of total nitrogen applied in compliance*  
1524 *pathways.*

1525 *Are the discount factors and additional components of R included in the 2021 Central Coast Ag*  
1526 *Order’s compliance pathways appropriate measurements to include in A and R calculations*  
1527 *when measuring the potential to discharge nitrogen to groundwater?*

1528

1529

1530 **Response and Recommendations**

1531 *Question 7A. Does including the discount factors allow for a full accounting of the nitrogen that*  
1532 *has the potential to discharge to groundwater?*

1533

1534 **Regions 3 and 5 use different strategies to determine nitrate loss from the cropping**  
1535 **system that can potentially leach to groundwater. Both approaches have advantages and**  
1536 **disadvantages. In Region 3 the A-R metric is used and the discount factors and credits**  
1537 **are used in the A-R calculation to increase its precision. In Region 5 N discharge is**  
1538 **measured using CV-SWAT simulation model in conjunction with grower INMP. Neither**  
1539 **approach is exact but provides a practical approach to estimating nitrate-N losses in an**  
1540 **achievable method.**

1541 *Region 3 Procedure:*

1542 1. The inputs for INMP reporting required for growers are similar to Region 5 (total applied  
1543 water, crop evapotranspiration [ETc], fertilizer N, amendment N, etc.) but the methodologies  
1544 used in compliance pathways for targets/limits in Region 3 represent a best attempt, with  
1545 current knowledge of the N cycle, to estimate nitrate-N leaching losses from complex soil  
1546 and agricultural production systems using a ranch-scale N mass balance approach. Not  
1547 included in the estimates are mineralizable N in soil organic matter, atmospheric deposition,  
1548 mineralization of organic fertilizer after week 12 and of compost after year 1, mineralization  
1549 of cover crops and plant residues re-worked into the soil of the field, and, in case of  
1550 Compliance Pathways 2 and 3, nitrate in irrigation water is not accounted for (see Additional  
1551 Considerations 1). In addition, the compliance pathways do not include atmospheric losses  
1552 of N due to denitrification and volatilization. However, the discounts and credits make use of  
1553 rigorous scientific knowledge about N in soils developed since the first Expert Panel to  
1554 update and make the A-R calculation as precise as possible.

1555 2. The discount factors and credits used in Ag Order 4.0 are appropriate and are practical  
1556 policy measures that reflect a combination of:

1557 i. Updated knowledge about complex N processes in soils,

1558 ii. Practicability of N measurement and accounting needs,

1559 iii. policy incentives toward more use of, cover crops, high carbon organic amendments,  
1560 and irrigation water nitrate as sources of crop fertilization, and

- 1561           iv.     discount factors for organic amendments and fertilizers are included to more  
1562                 accurately estimate N mineralized based on the C:N ratio of these inputs.
- 1563     3.     As a result, the Expert Panel supports and encourages the incentives provided by the  
1564           inclusion of the discounts and credits in the compliance pathways used to calculate the A-R  
1565           metric. In addition, the Panel has proposed additional updates to existing discounts and  
1566           credits.

1567

1568     *Region 5 Procedure:*

- 1569     4.     In the Central Valley, “values” of N discharge are “measured” using CV-SWAT in  
1570           conjunction with grower INMP reports which include commercial fertilizer,  
1571           compost/amendment N, organic fertilizer, available soil N, and irrigation water N. The East  
1572           San Joaquin Valley order also allows for discounts for compost and organic amendments:  
1573           “The applied organic soil amendments include compost and manure and should be  
1574           reported as the amount of N *available to the plant during the growing period* in pounds per  
1575           acre.” [emphasis added here by the Panel]. In Region 5 these discounted amounts of N  
1576           included in the ILRP are estimated by growers. The Central Coast Ag Order 4.0 went one  
1577           step further by providing growers with guidelines to determine plant-available N from  
1578           organic fertilizers and amendments. Given the complexity of estimating N mineralization,  
1579           guidelines on how to estimate plant-available N should be provided to growers.
- 1580     5.     Removed N (R) includes harvested N, and a list of N efficiency practices  
1581           (<https://www.esjcoalition.org/pdf/INMPWorksheet.pdf>).
- 1582     6.     In the Central Valley, these INMP records are then compared to a large library of CV-SWAT  
1583           simulation runs that further consider the following factors:
- 1584           i.     The crop N coefficient to convert harvested yield to N removed from the field and N  
1585                 uptake into woody mass
- 1586           ii.    Soil-, climate-, and management-specific denitrification
- 1587           iii.   Soil-water budget (including irrigation and ET)
- 1588           iv.    Irrigation and nutrient management practices
- 1589           Values of N discharge to groundwater, aggregated to the township-crop level are then  
1590           compiled using the CV-SWAT Rootzone Library. At the core of this process is an automated  
1591           matching of the INMP-reported N inputs from fertilizer, compost, organic materials, and  
1592           irrigation water nitrate, and of the INMP-reported harvested N to find the closest matching  
1593           specific run from the CV-SWAT rootzone library for the specific soil, climate, and crop of the  
1594           specific field in the INMP report.
- 1595     7.     For its practical implementation, the Region 5 approach to estimate N discharge to  
1596           groundwater – like the Region 3 approach - necessarily relies on simplifications/generic  
1597           assumptions and is subject to significant uncertainty relative to actual complex N processes  
1598           at the field scale (see Chapter 6 of this report for more details on the procedure).

1599

1600

1601

1602 *Question 7b. Will including these additional components of R result in valid and comparable A/R*  
1603 *and A-R values between different growers?*

1604

1605 **The inclusion of additional R components increases the precision of the estimate of the**  
1606 **amount of soil nitrate in the soil that is at risk for leaching. It is important to note that not**  
1607 **all practices that receive a credit on the R side of the equation result in removal of nitrate**  
1608 **from the parcel. Cover crops for example may result in a transfer of residual soil nitrate**  
1609 **from one growing season to the following growing season. The procedure used to**  
1610 **estimate the amount of N that is removed from a parcel should result in valid and**  
1611 **comparable A-R calculations between growers.**

1612 8. The additional R components included in Ag Order 4.0 increase the accuracy of the estimate  
1613 of applied N that is potentially at risk for leaching to groundwater. The results of the A-R  
1614 calculation should result in valid and comparable values between growers. They are an  
1615 attempt to calculate the actual levels of N discharge for an individual grower and when used  
1616 by all growers they should yield valid estimates for each grower. The following points  
1617 illustrate the value that they bring to the A-R calculation.

1618 9. The  $R_{SCAVENGE}$  component included in Ag Order 4.0 provides a way to estimate the amount  
1619 of residual soil nitrate that is not at risk for leaching during the winter fallow by implementing  
1620 practices such as the use of cover crops or immobilization of N by adding high carbon  
1621 amendments. These practices do not result in a removal of N from the system but rather  
1622 serve as a transfer of the residual soil nitrate from one growing season to the subsequent  
1623 growing season by means of sequestering the N in cover crop biomass, as well as by  
1624 immobilization of residual nitrate by the soil microbial community stimulated to grow with the  
1625 addition of labile carbon to the soil. In each of these practices a portion of the “scavenged” N  
1626 can be re-mineralized during the following growing season and can be utilized by growing  
1627 crops. Ag Order 4.0 provided a credit for 97% of the N contained in over wintered cover  
1628 crops (Oct/Nov to Feb/March) on the R side of the equation. To obtain the N credit, these  
1629 cover crops must meet biomass and C:N ratio criteria. This credit acknowledges the  
1630 important role that cover crops play in reducing nitrate leaching during the winter fallow  
1631 season when winter rains potentially leach residual soil nitrate to groundwater (Jackson, et  
1632 al, 1993). It should be mentioned that the most important aspect of the winter cover crop is  
1633 the time frame that it is grown. To receive a credit, the cover crop should be grown for a  
1634 portion of or for the entire winter fallow season (e.g. November to March). The other criteria  
1635 recommended in Ag Order 4.0 (e.g. C:N ratio and biomass production) do not affect the  
1636 amount of residual soil nitrate that is not at risk for leaching during the winter; the total  
1637 amount of N taken up by the cover crop is the essential criteria for this practice. Ag Order  
1638 4.0 also provided a 30 lb N/acre credit for the use of high carbon amendments which supply  
1639 labile carbon to stimulate the soil microbial community of decomposers to temporarily  
1640 immobilize soil nitrate (Smith et al, 2024; Muramoto et al., 2025). The use of winter cover  
1641 crops and high-carbon amendments prevent nitrate losses during the winter fallow when  
1642 residual soil nitrate is most at risk for leaching due to winter rain events. Providing a N  
1643 removal credit for these practices not only provides an invaluable practice to reduce nitrate  
1644 leaching but it also provides an incentive for growers to implement these practices which  
1645 have a multitude of other benefits to the operation, soil health and the environment.

- 1646 10.  $R_{\text{SCAVENGE}}$  should be expanded to include other cover crop strategies that have been shown  
1647 to reduce nitrate leaching during the winter fallow. These strategies include:
- 1648 i. Due to high land rents and scheduling constraints, the use of over-wintered cover  
1649 crops can only be used on a small percentage of growers' acreage. As a result, some  
1650 growers on the Central Coast utilize fall-grown cover crops which are typically planted  
1651 August-September and incorporated into the soil October-November. This strategy  
1652 leaves the soil available for early plantings of crops. The portion of cover crop N  
1653 (recalcitrant N) that is not mineralized during the winter should receive a credit  
1654 because it is not at risk for N leaching during the winter. Studies have been conducted  
1655 that indicate a modest credit can be awarded for the use of this cover crop strategy  
1656 (Geisseler, et al, 2025). However, further studies are planned that will provide  
1657 additional data to determine if greater credits for this practice can be granted. In  
1658 addition, studies need to be conducted to select for cover crop varieties that achieve a  
1659 higher C:N ratio during the short time frame during which fall grown cover crops are  
1660 produced.
  - 1661 ii. Growers and researchers are experimenting with additional winter cover crop  
1662 strategies. They can be lumped together under the term "low-residue cover crops".  
1663 Examples of these cover crop strategies include the following:
    - 1664 a) Growing cover crops on beds and terminating them before they produce too much  
1665 residue, which will allow rapid incorporation using minimal tillage in the spring and  
1666 rapid access to the field for planting crops. The total quantity of N in the cover  
1667 crop biomass or at least the quantity of cover crop biomass N that is not  
1668 mineralized during the following cropping season (recalcitrant cover crop N)  
1669 should receive a credit.
    - 1670 b) Planting summer adapted cover crop species in the fall which produce a modest  
1671 amount of cover crop biomass before cold weather inhibits their growth. These  
1672 cover crops may also be incorporated using minimal tillage techniques to facilitate  
1673 rapid planting of subsequent cash crops. These strategies would result in only a  
1674 modest N credit as compared to traditional over wintered cover crops. However,  
1675 the amount of N that is contained in low-residue cover crops are deserving of a  
1676 credit because they scavenge N during the winter and safeguard it in a non-  
1677 leachable form during the rainy season.
    - 1678 c) Other strategies under development that demonstrate effective reductions in  
1679 nitrate leaching should be considered by Regional Water Quality Control Boards  
1680 for credits in the A-R calculation in the future.
  - 1681 iii. Winter cover crop mixtures of legumes (i.e., pea, vetch, fava bean) and non-legumes  
1682 (i.e. cereals and mustards) combine the N scavenging ability of the non-legume with  
1683 the N fixing ability of the legume (Ranells and Wagger, 1997; Thorup-Kristensen et al.,  
1684 2003). These cover crop mixes are an important cover crop strategy employed by  
1685 organic and small-scale growers in California. Meta analyses have shown that cover  
1686 crop mixes of legumes and non-legumes were as effective as non-legumes at reducing  
1687 nitrate leaching (Nouri et al., 2022; Thapa et al., 2018). This may seem counter  
1688 intuitive, because legumes fix N from the air; however, legumes fix less N when  
1689 residual soil nitrate is high, and in turn, scavenge soil nitrate. A long-term, systems

1690 evaluation with winter cover crops in rotation with intensive vegetable production in  
1691 Salinas found that N scavenging by a legume-rye mixture was similar to scavenging by  
1692 non-legume cover crops of rye or mustard (Brennan and Boyd, 2012; White et al.  
1693 2022). Based on these studies, there is sufficient evidence of N scavenging by legume  
1694 and non-legume cover crop mixes and that Regional Water Quality Control Boards can  
1695 consider providing a N scavenging credit for N uptake by the non-legume component  
1696 of winter cover crop mixtures of legumes and non-legumes.

1697 iv. There are research efforts that are currently not yet ready to be implemented by  
1698 growers to reduce nitrate leaching. But if Regional Water Quality Control Boards are  
1699 presented with sound research of strategies that sequester/immobilize residual soil  
1700 nitrate during the winter fallow they should be encouraged to consider their inclusion  
1701 as credits in water quality regulatory actions.

1702 v. In the future, the amount of N scavenged by cover crops that becomes available to the  
1703 subsequent cash crop will be better understood. The re-release of this N to the  
1704 subsequent crop needs further investigation to know how much it may affect the  
1705 calculation of future-crop A-R values. The use of soil nitrate quick tests to guide  
1706 fertilization of crops is currently the best management practice to account for N  
1707 mineralized from cover crop biomass (see Chapter 5.1, Bullet 1). However, while  
1708 Region 3 provides credit to cover crops, the approach currently does not provide  
1709 incentives to the grower of the next crop to reduce  $A_{FER}$  in response to cover crop N  
1710 mineralization. In Region 5, cover crop N scavenging and subsequent re-release is not  
1711 captured by grower reports or the model framework used to report values of nitrate  
1712 discharge. Research is needed on how to effectively incorporate these complexities  
1713 into a regulatory framework.

1714 11. In some regions of the state, tile drains capture drainage water that might otherwise be at  
1715 risk for leaching.  $R_{TREAT}$  was included in Ag Order 4.0 to account for the quantity of nitrate-N  
1716 that is removed using denitrification bioreactors or other technologies. This technology is  
1717 also utilized for the treatment of surface waters from nursery operations.

1718 12. The  $R_{OTHER}$  component is a holding place for the development of future technologies that  
1719 can reduce nitrate leaching.

1720 13. In the presence of significant denitrification such as what may occur in wet clayey soils, the  
1721 A-R calculation may overestimate actual nitrate losses to groundwater. Therefore,  $R_{GASEOUS}$   
1722  $LOSS$  is proposed here to include the quantity of nitrate-N that is denitrified or volatilized from  
1723 agricultural fields during the production season. The levels of denitrification are likely to vary  
1724 depending on temperatures, irrigation method, fertilizer type and application method, soil  
1725 type, etc. and levels of denitrification in various regions and production systems need to be  
1726 better outlined with robust data sets to better guide the implementation of this credit. In  
1727 addition, studies need to recognize that nitrous oxide is only one of the gas components of  
1728 denitrification. A significant portion of the gas may be in the  $N_2$  form which is not easily  
1729 measured.  $R_{GASEOUS LOSS}$  should be introduced alongside  $A_{DEPOSITION}$ , which accounts for  
1730 atmospheric deposition of N. It is a small quantity of N and is included to improve the  
1731 accuracy of the calculation.

1732

1733 *Question 7c. What are ways to incentivize the use of compost, organic fertilizers, cover crops,*  
1734 *other treatments, etc., that properly account for these practices in the calculations of the*  
1735 *potential to discharge nitrogen to groundwater (e.g., A/R and A-R)?*

1736

1737 **The N in organic materials are mineralized from labile and recalcitrant fractions of the**  
1738 **material. The labile fraction becomes available in the time frame of the crop cycle. The**  
1739 **recalcitrant fraction becomes available after the crop cycle over a period of months and**  
1740 **years (it becomes part of the background N that mineralizes from soil organic matter).**  
1741 **Recent research has documented the amount of labile N that mineralizes from composts**  
1742 **and organic fertilizers during the timeframe of the crop cycle. Providing a credit to the**  
1743 **labile fraction of N from compost and organic fertilizers does not penalize growers for all**  
1744 **N in these materials and incentivizes their use.**

1745 14. The credits provided in Ag Order 4.0 for compost, organic fertilizers and cover crops  
1746 provided tangible incentives for growers to utilize these practices. Interviews with growers in  
1747 Region 3 indicated that following the adoption of Ag Order 4.0 the use of cover crops  
1748 increased. Prior to the adoption of Ag Order 4.0, the use of cover crops hovered around 5%  
1749 of the vegetable production acreage for many years. Since the adoption of Ag Order 4.0,  
1750 some growers have indicated that their use of winter cover crops has increased 2-3 times  
1751 than in previous years. The use of fall-grown cover crops (described above) also increased.  
1752 Providing credits for the use of cover crops and immobilization strategies expands the model  
1753 of A-R developed by the First Expert Panel. It will be critical for Regional Boards, as  
1754 appropriate, to include the R factors discussed above in their A-R evaluations because it  
1755 makes measurements of leaching more precise but also provides a tangible incentive for the  
1756 use of these critical water quality and soil health improving practices.

1757 15. The A factors for the use of organic N fertilizer ( $A_{ORG}$ ) were modified based on the expected  
1758 level of N mineralization of the organic fertilizer over the growing season (Lazicki et al.,  
1759 2020). The reason is that not all N in organic amendments is readily plant available, nor is it  
1760 readily leachable from the system. The rate and amount of N that mineralizes over a given  
1761 period of time from organic fertilizers is largely driven by the C:N ratio of the material. Other  
1762 factors such as temperature, moisture, and microbial community structure and abundance,  
1763 also influence the rate and amount of N that mineralizes and is available to the plant, and  
1764 that is retained or lost from the system. Given the complex forms of N that comprise organic  
1765 fertilizers and the delayed availability of leachable and bioavailable N, it is important to  
1766 accurately reflect the quantity of N that is mineralized during the growing season and that  
1767 benefits the crop. Organic materials are comprised of labile and recalcitrant fractions of N  
1768 that mineralize at distinct rates (Chen et al, 2024). The labile fraction releases in a matter of  
1769 days/weeks and the recalcitrant fraction releases over a period of months/years. The non-  
1770 mineralized fraction of organic fertilizers is not leachable and remains in complex molecules  
1771 in the soil and contributes to the background levels of nitrate-N as it mineralizes from soil  
1772 organic matter over time. Background levels of nitrate-N are accounted for during the  
1773 growing season by measuring levels of residual soil nitrate-N and accounting for this source  
1774 of N by reducing levels of applied fertilizer N as appropriate. The data provided by Lazicki et  
1775 al. (2020) provides a guide for accounting for the labile fraction of N from organic fertilizers  
1776 and the amount mineralized over 12 weeks and serves as an estimate (discount factor) that

- 1777 can be used on the A side of the A-R metric. In summary, it provides greater precision in  
1778 accounting for the amount of N provided by organic fertilizers.
- 1779 16. The A discount factors for the use of compost ( $A_{COMP}$ ) were based on its C:N ratio and  
1780 expected rate of mineralization of N from the material (Hartz, et al., 2000; Lazicki, 2020;  
1781 Gravuer, 2016). The compost follows the same N dynamics described above for organic  
1782 fertilizers. The estimates of mineralization provide a measure of expected levels of  
1783 mineralization from these materials over a year given their C:N ratios.
- 1784 17. Organic farmers rely heavily on N inputs from organic fertilizers and amendments such as  
1785 compost. Conventional growers also apply organic amendments to improve soil health and  
1786 growing conditions for their crops. The difference between the total quantity of N contained  
1787 in organic fertilizers and compost and the actual amount that becomes plant-available could  
1788 discourage the use of these materials if the entire quantity of N was included on the A side  
1789 of the A-R metric. However, the quantity of N that mineralizes over the 12 weeks of the crop  
1790 cycle as estimated by Lazicki et al. (2020) provides a more precise estimate of the amount  
1791 of N that becomes available to the crop during the growing season. Beyond the 12 weeks of  
1792 the crop cycle, the release of N from organic fertilizers is slow and it becomes  
1793 indistinguishable from the N made available from soil organic matter. The recalcitrant N  
1794 made available from organic amendments, compost and soil organic matter can be  
1795 measured in future crops by use of nitrate quick tests. As mentioned above, these discounts  
1796 provide a realistic estimate of the quantity of mineral N expected to be released from applied  
1797 organic materials and do not penalize growers for the use of these soil amendments.  
1798 Adoption of these discount factors prevents the unattended consequence of disincentivizing  
1799 the use of these materials.
- 1800 18. The use of nitrate testing to guide fertilization practices during the growing season is a  
1801 critical practice to reduce fertilizer applications on the A side of the equation. It is a critical  
1802 keystone practice to reduce loading of nitrate in the rootzone of crops while still providing for  
1803 the needs of the crop. Cover crops have an upper limit of how much N they can absorb. If  
1804 fertilizer practices can be made more efficient and the amount of residual soil nitrate  
1805 minimized at the end of the growing season, then the cover crop can sequester a greater  
1806 proportion of residual nitrate found in the soil at the start of the rainy winter fallow period. It  
1807 should be acknowledged that the unharvested residue of vegetable crops frequently  
1808 contains substantial amounts of N that will mineralize additional residual soil nitrate-N after  
1809 harvest; this reality further emphasizes the critical role that cover crops play as a means of  
1810 taking up and sequestering this nitrate and the need for incentivizing this practice as much  
1811 as possible.

1812

1813 *Question 7d. Is incentivizing the use of nitrogen in irrigation water by excluding it from the*  
1814 *calculation of total nitrogen applied the most appropriate approach for accounting for and*  
1815 *controlling potential discharges to groundwater and reducing the overall concentrations of*  
1816 *nitrates in groundwater?*

1817

### 1818 **Response and recommendations**

1819 **Analysis of the various A-R compliance pathways proposed in Ag Order 4.0 suggests**  
1820 **that they encourage the use of N in irrigation water (pump and fertilize) by requiring**

1821 **growers to credit only an amount that is available for plant uptake. However, to avoid**  
1822 **confusion, the Panel suggests streamlining the three compliance pathways into one**  
1823 **pathway, as proposed below. For example, Pathway 2 of Ag Order 4.0 would potentially**  
1824 **conflict with targets/limits set below 200 lb/acre (see discussion below). For purposes of**  
1825 **modeling and estimating potential N loading to the aquifer growers also could be**  
1826 **required to report all the N applied from irrigation water but these values may not**  
1827 **necessarily be used for compliance with A-R targets/limits (see response to Question 1).**

1828 19. Nitrogen concentration values in water used for irrigation of crops in California can range  
1829 from less than 1 to greater than 80 ppm N. Concentrations can vary among regions and  
1830 among water sources. However, some of the highest concentrations are found in  
1831 groundwater that have been impacted by leaching of nitrate from fertilizer and animal  
1832 manures applied to agricultural land.

1833 20. The Panel supports the fundamental principle of “pump and fertilize”. Clearly, the more that  
1834 synthetic or organic fertilizer can be replaced by N in irrigation water, the better. Irrigation  
1835 and fertilizer management practices should take full advantage of nitrate in irrigation water.  
1836 Utilizing nitrate in irrigation water to the maximum possible extent should always be  
1837 encouraged, whether through education, incentives, or regulation.

1838 21. Field research trials clearly demonstrated that N in irrigation water is plant available and can  
1839 substitute for a portion of fertilizer N (Cahn et al., 2015, 2017; Smith and Cahn, 2019).

1840 22. Crediting N in irrigation water when developing and implementing INMPs would help reduce  
1841 the application of other sources of N ( $A_{FER}$ ,  $A_{COMP}$ ,  $A_{ORG}$ ) thereby reducing N loading to  
1842 groundwater. However, many growers still need to gain confidence that they can reliably  
1843 credit N in irrigation water when developing fertilizer budgets for their crops. Regional Water  
1844 Quality Control Boards are encouraged to facilitate and encourage educational outreach to  
1845 growers and work with universities to establish on-farm demonstration field trials showing  
1846 the effective use of nitrate in the irrigation water for crop production.

1847 23. Although requiring growers to report and credit all the N applied in the total amount of  
1848 irrigation water applied to crops would provide an accurate estimate of N loading to the  
1849 aquifer, it would likely cause growers to avoid using these water sources for irrigating their  
1850 crops in order to achieve proposed discharge A-R targets/limits set by the Regional Water  
1851 Quality Control Boards, due to the difference in the amount of water taken up by the crop  
1852 and the total that is applied to the crop (see below). This would reduce the efficacy of a  
1853 pump and fertilize approach.

1854 24. The Expert Panel recommends that regulations that include  $A_{IRR}$  for calculation of  
1855 targets/limits consider the practical limitations that growers face when using irrigation water  
1856 as a source of N for their crops:

1857 1. Early in the season much of the irrigation water applied for germination or transplant  
1858 establishment of annual crops or short season vegetables is during the period of low  
1859 transpiration and N uptake and mostly drains below the root zone.

1860 2. Irrigation water is frequently applied before the crop is planted to moisten the soil for bed  
1861 preparation, germinate weeds, and to leach salts that have accumulated near the soil  
1862 surface. Applying a leaching fraction of water which, by definition, drains below the  
1863 rootzone is necessary when growing salt sensitive crops such as lettuce and  
1864 strawberries and thereby does not provide N to the crop.

- 1865 3. In addition to nitrate, irrigation water may have a high concentration of salt and therefore  
1866 extra water (maintenance leaching) would be needed to prevent salt from building up in  
1867 the rootzone during the growing season.
- 1868 4. Extra water is often required to offset limitations in application uniformity of the irrigation  
1869 system and would also cause drainage below the root zone.
- 1870 5. The efficiency of plant roots to uptake nutrients from soil solution is less than 100%.
- 1871 6. Growers often irrigate crops using multiple sources of water which complicates  
1872 determining how much N is available to the crop from the irrigation water.
- 1873 25.  $A_{IRR}$  in Ag Order 4.0 is calculated based on the volume equal to  $ET_c$  or the volume of water  
1874 applied by irrigation, whichever is smaller. The assumption is that the N in the  
1875 evapotranspired volume is the amount that a crop takes up during the season and discounts  
1876 extra water needed for soil preparation, salt leaching, and for offsetting non-uniformity of the  
1877 of the irrigation system and other inefficiencies. In the case of winter planted crops, and  
1878 some tree and vineyard crops, the volume of irrigation water applied over the season may  
1879 be less than the evapotranspiration volume since a portion of the crop water use may be  
1880 supplied by rainfall.
- 1881 26. For purposes of modeling and estimating potential N loading to the aquifer, growers could  
1882 additionally be required to report N in the total irrigation water applied but this amount of N  
1883 would not be used for compliance with A-R targets/limits.
- 1884 27. Ag Order 4.0 Table C.1-3 presents three compliance pathways for growers to meet  
1885 targets/limits (see Additional Considerations 1). These pathways were developed to  
1886 encourage growers to credit N in irrigation water in their nutrient management plans, which  
1887 would lead to less use of fertilizer N. Pathway 1 includes  $A_{IRR}$  where  $A_{IRR}$  is calculated as lb  
1888 of N/acre applied in irrigation water using the formula:  $A_{IRR} \text{ (lb N/acre)} = \text{N concentration}$   
1889  $\text{ (ppm N) of the irrigation water} \times \text{Crop ET or applied water volume (inches)} \times 0.227$   
1890 conversion factor.
- 1891 28. Pathways 2 and 3 were included for situations when the nitrate concentration in irrigation  
1892 water is too high for crops to fully utilize all the applied N. For example, in lettuce which  
1893 usually takes up 120 to 135 pounds of N per crop-acre, if the irrigation water had a nitrate  
1894 concentration of 80 ppm N and seasonal  $ET_c$  was 8 inches, then total N that would need to  
1895 be credited from the irrigation water (145 lb of N per acre) would be greater than crop  
1896 uptake. Also, even when very high nitrate water is used for irrigation, fertilizer N is typically  
1897 needed early in the season for the crop to develop its root system and become sufficiently  
1898 established to utilize nitrate-N in the water. Pathway 2 allows a grower to apply fertilizer N in  
1899 an amount equal to the N removed in the harvested crop. Pathway 3 caps the maximum  
1900 amount of N in irrigation water that growers need to credit in their INMP to 200 lb  
1901 N/acre/year by reducing the targets/limits by 200 lb N/acre. These two pathways  
1902 unnecessarily complicate calculations and are recommended to be simplified (see below).
- 1903 29. Table 2 shows three scenarios using water with high nitrate concentrations for growing 2  
1904 crops of lettuce per year. In all scenarios the assumed removed N (R) for 2 crops of lettuce  
1905 per year is 125 lb N/acre (62.5 lb of N per crop of lettuce) and crop ET equals 7 inches per  
1906 lettuce crop. In Scenario 1, R is less than  $A_{IRR}$ . In Scenario 2, R is less than  $A_{IRR}$  and  $A_{IRR}$  is  
1907 greater than 200 lb N/acre. In Scenario 3, R is greater than  $A_{IRR}$ . Table 3 outlines which  
1908 pathways in Ag Order 4.0 would allow the most applied N from the fertilizer, compost, and

1909 organic fertilizer for targets/limits set at 300, 200, and 100 lb N/acre. This could lead to a  
1910 “race to the top” of applying the most N possible, rather than what is needed for a healthy  
1911 crop and to meet targets/limits.  
1912  
1913

1914 **Table 2:** Three scenarios using water with high nitrate concentrations for growing 2 crops of  
 1915 lettuce per year. For each crop harvest removal (R) equals 62.5 lb N/acre  
 1916

	<u>Scenario 1</u>	<u>Scenario 2</u>	<u>Scenario 3</u>
	R < A <sub>IRR</sub>	R < A <sub>IRR</sub> A <sub>IRR</sub> > 200 lb N/ac	R > A <sub>IRR</sub>
Nitrate concentration of irrigation water	47 ppm N	71 ppm N	31 ppm N
Crop ET	7 inches	7 inches	7 inches
A <sub>IRR</sub> * per crop	75 lb N/acre	112.5 lb N/acre	50 lb N/acre
Seasonal A <sub>IRR</sub> (2 crops per year)	150 lb N/acre	225 lb N/acre	100 lb N/acre
N removal (R) per year	125 lb N/acre	125 lb N/acre	125 lb N/acre

1917 \* calculated using the equation: lb N/acre = N concentration (ppm N) x ETc (inches) x 0.227  
 1918

1919 **Table 3:** Maximum rate of nitrogen that could be applied from synthetic fertilizer (A<sub>FER</sub>),  
 1920 compost (A<sub>COMP</sub>), and organic fertilizer (A<sub>ORG</sub>) to comply with A-R targets/limits of 300, 200,  
 1921 and 100 lb N/acre/year through the three pathways in Ag Order 4.0 (Table C.1-3; see  
 1922 additional considerations) for scenarios summarized in Table 2.  
 1923

Target	Scenario 1 R < A <sub>IRR</sub> A <sub>IRR</sub> = 150 A <sub>(FER+COMP+ORG)</sub>			Scenario 2 R < A <sub>IRR</sub> , 200 < A <sub>IRR</sub> A <sub>IRR</sub> = 225 A <sub>(FER+COMP+ORG)</sub>			Scenario 3 R > A <sub>IRR</sub> A <sub>IRR</sub> = 100 A <sub>(FER+COMP+ORG)</sub>		
	Path 1	Path 2	Path 3	Path 1	Path 2	Path 3	Path 1	Path 2	Path 3
300	275	125	275	200	125	225	325	125	325
200	175	125	175	100	125	125	225	125	225
100	75	125	75	0	125	25	125	125	125
Potential N loading at 100 lb/ac target	100	150	100	100	225	125	100	100	100

1924 \* Units are in lb N/ac

1925 \*  = Pathways that allow highest A<sub>(FER+COMP+ORG)</sub> for A given target

1926 \*R = 125 lb N/ac in Scenarios 1, 2 & 3

1927

1928

- 1929 30. In situations where  $A_{IRR}$  is greater than 200 lb N/acre/year, Pathway 3 would allow the most  
1930 N to be applied at targets/limits greater than 200 lb N/acre. Pathway 2 would allow the most  
1931 N to be applied if targets/limits are reduced to less than R ( $< 125$  lb N/acre in these  
1932 scenarios). In fact, the existence of Pathway 2 means that targets/limits could never be less  
1933 than  $A_{IRR} + R$ , which essentially sets the minimum amount of N that can be applied from  
1934 sources other than irrigation water equal to R.
- 1935 31. The Expert Panel recommends streamlining the compliance pathways. Pathway 1 is  
1936 recommended but the total N in irrigation water that growers are responsible for crediting in  
1937 their nutrient management plans should be capped to 200 lb N/acre/year or equal to total  
1938 crop N removal over the year. The option to use total crop N removal in place of 200  
1939 lb/acre/year is for situations where the total N taken up and removed by the crop(s) is less  
1940 than 200 lb N/acre/year.
- 1941 32. Potentially the cap of 200 lb N/acre/year from  $A_{IRR}$  could be increased in the future as  
1942 growers gain more experience in crediting N in irrigation water in their nutrient budgets. The  
1943 minimum target can be set at a value greater than R such as  $A_{IRR} + R$  or another value so  
1944 that pathway 2 is also not needed.
- 1945

1946 **Additional Considerations**

1947 1. Compliance Pathways (Table C.1-3 in Ag Order 4.0 pg. 52)

**Table C.1-3. Compliance Dates for Nitrogen Discharge Targets and Limits**

<b>Compliance Pathway 1</b> $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) + A_{IRR} - R =$	<b>Compliance Date</b>		
	Target	500	12/31/2023
	Target	400	12/31/2025
	Limit	300	12/31/2027
	Limit	200	12/31/2031
	Limit	150	12/31/2036
	Limit	100	12/31/2041
OR			
<b>Compliance Pathway 2</b> $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) = R$	<b>Compliance Date</b>		
	Target	A = R	12/31/2023
	Target	A = R	12/31/2025
	Limit	A = R	12/31/2027
	Limit	A = R	12/31/2031
	Limit	A = R	12/31/2036
	Limit	A = R	12/31/2041
OR			
<b>Compliance Pathway 3</b> $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) - R =$	<b>Compliance Date</b>		
	Target	300	12/31/2023
	Target	200	12/31/2025
	Limit	100	12/31/2027
	Limit	0	12/31/2031
	Limit	-50	12/31/2036
	Limit	-100	12/31/2041
Limit	-150	12/31/2051	

1948

1949

1950

1951 **4.8. “Small/Diversified Farms” - Response to Question 8**

1952 **Question**

1953 *Is there enough data and scientific research to conclude that small and/or small diversified*  
 1954 *farms are operated in a fundamentally different manner that results in a reduced water quality*  
 1955 *impact compared to larger farms, on a per acre basis? If yes, what criteria could be used to*  
 1956 *identify the operations that have reduced water quality impacts?*

1957

1958 **Background, Terminology and Concepts**

1959 The category of “small farms” in California agriculture encompasses a variety of cropping  
 1960 systems. These can include small-acreage monoculture farms producing one of California’s  
 1961 major commodities; small acreages of monoculture niche and emerging crops such as jujube,

1962 agave, daikon, moringa, dragon fruit, or lemongrass; and small-scale diversified farms, which  
1963 can range from a few to many niche and mainstream crops rotated through several production  
1964 seasons within the year and can include mixed crop-livestock systems. Below, we describe  
1965 three main categories of small farms in California, noting that this is an oversimplification, as  
1966 they may relate to broader patterns in nutrient management practices. We also describe  
1967 container-grown nursery production practices in California as a fourth category with low nitrate  
1968 impact.

1969

1970 **Response and recommendations**

1971 **Nutrient management practices can be substantially different on small-scale diversified**  
1972 **farms compared to larger farms. We recommend a category such as “reduced-risk small**  
1973 **farms” that could be defined as meeting a number of identified criteria associated with**  
1974 **lower risk for nitrate leaching. Small-scale diversified production systems in California**  
1975 **also include container-grown nursery production operating in a substantially different**  
1976 **manner than field grown crops.**

1977 *A. Small-acreage monocultures of major California commodities*

1978 1. Major commodities in California such as grapes, almonds, pistachios, walnuts, citrus,  
1979 lettuce, and strawberries are cultivated on a range of acreages and can include small,  
1980 medium, and large farms. We are not aware of any data indicating that small-acreage farms  
1981 of major California commodities under conventional production methods have substantially  
1982 different nutrient management practices than larger farms of the same commodities. Small-  
1983 acreage farms producing major commodities may have very similar practices to large-  
1984 acreage farms and can be connected to the same networks for supplies, services, and  
1985 equipment, and they may sell into the same market channels for national and international  
1986 wholesale markets. These types of small farms may be independently owned and operated,  
1987 or they may be owned by larger corporations, with similar management across multiple  
1988 properties. Some small-acreage monocultures also sell to direct-to-consumer market  
1989 channels such as farmers markets, farm-to-institution procurement, or retail outlets, but we  
1990 are not aware of data that suggest differences in nutrient management practices based on  
1991 these factors.

1992 2. While nutrient management practices undoubtedly vary from one operator to the next, these  
1993 small-acreage farms are unlikely to demonstrate a reduced water quality impact based on  
1994 acreage alone. However, this category also includes small farms that can reduce their water  
1995 quality impacts through some of the factors described in Section C below. For example,  
1996 many small-acreage certified organic farms or regenerative farms producing major  
1997 California commodities use soil conservation practices and organic soil amendments that  
1998 are associated with a reduced risk of nitrate leaching to groundwater. Also, the Panel notes  
1999 that the regulatory burden for small-acreage commodity farms can be higher than for larger  
2000 farms, especially when an individual operator is responsible for all regulatory reporting and  
2001 compliance across multiple regulatory programs.

2002

2003 *B. Small-acreage plots of niche or emerging crops*

2004 3. Outside of major California commodities, minor crops, niche crops, and emerging crops are  
2005 grown on small acreages. These crops may be marketed to diverse cultural communities,

2006 such as specialty Asian vegetables and herbs, and/or represent new economic  
2007 opportunities for California growers, such as agave. Research-based fertilizer  
2008 recommendations specific to California may be unavailable for many of these crops, as well  
2009 as N removal coefficients and information on current nutrient management practices. For  
2010 this category of small farm, further research is needed to understand whether there are  
2011 specific nutrient management practices that might result in a reduced water quality impact.  
2012 One metric to consider is the percentage of total acreage of minor or niche crops in a  
2013 reporting area. If certain crops represent a very low percentage of total irrigated acres, it  
2014 may be more effective to focus on research and education and adopt alternate reporting  
2015 requirements until fertilizer recommendations and N removal coefficients are available.  
2016 Also, as for category A, these small farms can reduce their water quality impact through  
2017 additional beneficial practices.

2018

2019 *C. Small-scale diversified farms*

2020 4. Small-scale diversified farms in California are defined here as having multiple crops on  
2021 small acreages, with more than two crops per acre (SWRCB, 2018), for a maximum of 80  
2022 acres (DWR, 2025). This definition attempts to distinguish between farms with a few crops  
2023 where nutrient management practices are specific to each crop, and highly diversified farms  
2024 with many crops where nutrient management practices have more of a whole-farm  
2025 approach. Crop diversification is often driven by direct-to-consumer markets, such as  
2026 farmers markets, community supported agriculture (CSA), direct-to-restaurant sales, and  
2027 roadside stands. Crop mixtures can include both mainstream commodities and minor or  
2028 niche crops, as well as livestock that may be integrated with crop production or separate.  
2029 While reporting of N applied on a whole-farm basis is relatively straightforward for these  
2030 farms, calculation of N removed is extremely challenging for multiple small plots of a large  
2031 variety of different crops, multiple sales channels, some use of harvested produce for family  
2032 consumption, and staggered plantings through multiple seasons. These difficulties are part  
2033 of the justification for the current alternate reporting requirements for small and diversified  
2034 farms outlined in the Eastern San Joaquin River Watershed Agricultural Order (SWRCB,  
2035 2018).

2036 5. Nutrient management practices can be substantially different on small-scale diversified  
2037 farms compared to larger farms. However, it is difficult to generalize due to the variety of  
2038 crops, production practices, available labor and capital, and access to financial and  
2039 technical resources. The factors below are associated with lower risk for nitrate leaching to  
2040 groundwater:

2041 i. Strategy of building soil organic matter long-term, for example through incorporating  
2042 crop residues, planting cover crops, and using organic amendments, not exceeding  
2043 recommended rates

2044 ii. Planting of winter cover crops that scavenge excess N

2045 iii. Rotation with N -scavenging crops, when residual soil N is accounted for in  
2046 determining fertilizer application rates

2047 iv. Low-input production systems, usually related to limited financial resources

2048 v. Efficient irrigation with drip systems, especially for more shallow-rooted crops

- 2049 vi. Use of frequent soil, water, and/or plant tissue testing for in-season nutrient
- 2050 management planning
- 2051 vii. Demonstration of low residual nitrate in the soil profile at the end of the cropping
- 2052 season, for example through soil testing after harvest
- 2053 viii. Quality standards associated with reduced application rates of N fertilizer
- 2054 ix. Diversified farms representing a small percentage of irrigated acres in an area
- 2055 x. Locations with infrequent and limited rainfall

2056 6. We recommend a category such as “reduced-risk small farms” that could be defined as  
 2057 meeting a number of the criteria above: for example, small-scale diversified farms meeting  
 2058 a selected minimum number of the ten criteria. This could be combined with alternate  
 2059 reporting requirements, technical assistance with monitoring soil and plant N levels, and  
 2060 education. The alternate reporting requirements currently allowed in the Eastern San  
 2061 Joaquin River Watershed Agricultural Order and implemented by the Kings River Water  
 2062 Quality Coalition provide an example of tailoring requirements to be appropriate to small-  
 2063 scale diversified farming systems. Alternate reporting could focus on N applied, with  
 2064 simplified reporting forms allowing whole-farm reporting of N applied for a diverse mixture of  
 2065 crops. Defining a reduced-risk category can help focus compliance efforts where they are  
 2066 most impactful and provide pathways for meaningful engagement of small-scale diversified  
 2067 farms in protecting water quality.

2068 7. For small farms that do not qualify for a reduced risk category the Panel recommends  
 2069 developing a simplified INMP reporting method such as outlined in the Eastern San Joaquin  
 2070 River Watershed Agricultural Order (SWRCB, 2018). Developing average values and  
 2071 ranges for A and R for diversified small farms, or at a minimum reporting only A and  
 2072 indicating BMPs used, could greatly reduce the regulatory burden for these growers.

2073

2074 *D. Container-Grown Nurseries*

2075 8. The Panel was presented with data that showed nurseries are operated in a significantly  
 2076 different manner than field grown crops. The majority of these nurseries produce a highly  
 2077 diverse mixture of ornamental species planted in containers with minimal leaching to  
 2078 groundwater. For example, one study conducted in Southern California found that only  
 2079 about 3% of N applied to nurseries infiltrates to soil below the bed, while up to 61% of the N  
 2080 input is retained in the plant shoots and substrate (Pitton et al., 2022).

2081 9. Comparing N applied and N removed in nurseries is substantially different from farming  
 2082 operations because the soil substrate leaves the nursery when purchased by the consumer,  
 2083 and ornamental plants usually do not have a harvested product. While nurseries can easily  
 2084 report on N applications, N removal coefficients are not available for most ornamental  
 2085 species. While more research is conducted to determine if reporting R is suitable for the  
 2086 nursery industry. Development of an alternative pathway for reporting should be explored  
 2087 (see response to Question 9).

2088 10. Implementation of best management practices could qualify operators to have reduced  
 2089 regulatory reporting. For example, denitrification bioreactors, lining of retention ponds and  
 2090 drainage ditches, and reuse of drainage water for irrigation are practices that could be  
 2091 implemented to greatly reduce or eliminate the discharge of N.

2092 **Additional Considerations**

- 2093 1. The practices above can also apply to larger farms. It may be useful to explore a reduced-  
2094 risk category independent of farm size, based on practices that protect water quality.
- 2095 2. The discussion above is focused on reduced risk of water quality impacts, in response to  
2096 Question 8. To support a long-term sustainable ILRP as outlined in Questions 1 and 2, a  
2097 category of “reduced-risk small farms” could be implemented in conjunction with education,  
2098 technical assistance, and alternate reporting requirements where appropriate. Efforts  
2099 should be made to effectively involve small-scale and diversified farms in meaningful efforts  
2100 to protect regional groundwater quality that correspond to the complexity of their production  
2101 systems and maximize opportunities to prevent nitrate leaching.
- 2102 3. The Panel noted that the regulatory burden of ILRP reporting for all of the categories of  
2103 small farms described above is greater than for larger farms. We recommend consideration  
2104 of the recommendations from the California Department of Food and Agriculture (CDFA)  
2105 Regulatory Alignment Study that are relevant to reducing regulatory burdens for small-  
2106 scale, diversified, and socially disadvantaged farmers.

2107

2108

2109 **4.9. “Exceptions and Alternatives” - Response to Question 9**

2110 **Question**

2111 *As summarized in footnote 33 of the Central Coast Ag Water Quality Order, the Eastern San*  
2112 *Joaquin Water Quality Order contains exemptions from its precedential nitrogen management*  
2113 *requirements for growers whose nitrogen-related practices do not impact water quality, and also*  
2114 *gives the regional boards the discretion to allow additional time or alternative methods for three*  
2115 *categories of growers to submit their R data. Is there enough data and scientific research that*  
2116 *would support any other exceptions to, or alternative methods for complying with, the*  
2117 *precedential nitrogen management requirements in the Eastern San Joaquin Water Quality*  
2118 *Order or any nitrogen-related limits or other requirements recommended by the Expert Panel?*

2119

2120 **Overview and Background**

- 2121 • SWRCB staff provided additional information on “footnote 33”, which Question 9 refers to  
2122 (see Additional Information below). In summary, footnote 33 identifies target groups among  
2123 irrigated land owners for which State Water Board Order WQ 2018-0002 is not precedential  
2124 (rice growers in the Central Valley region) or for which regional water boards were given  
2125 discretion to apply alternative requirements (areas with limited N impact, diversified socially  
2126 disadvantaged growers, and growers who do not operate more than 20 acres and grow no  
2127 fewer than an average of two different crops per acre).
- 2128 • The answer to Question 8 discusses exceptions and alternative approaches specifically for  
2129 highly diversified growers.
- 2130 • The Panel was otherwise not presented with any data, nor is the committee sufficiently  
2131 familiar with or aware of data that would allow the Panel to identify specific exceptions or  
2132 specific alternative approaches to the said Order.

- 2133 • In Region 3, guidance is provided to individual growers on the information, data, and  
2134 analysis that must be included in an exemption application (California Water Boards Central  
2135 Coast - R3., 2024).
- 2136 • In Region 5, significant data collection (including field work, soil sampling, groundwater  
2137 monitoring), research, analysis, and assessment were completed by the Rice Coalition to  
2138 demonstrate that the risk of nitrate leaching is minimal, leading to a very different reporting  
2139 structure.
- 2140 • The approach taken in Region 5 with the Rice Coalition provides a potential template for  
2141 other major agricultural sectors or for other regions. For expediency, it may be useful for  
2142 SWRCB or RWBs to clearly identify the data and analysis needed by growers, regions,  
2143 commodities, or coalitions to identify regions or agricultural industries that may allow for  
2144 significantly different – lower – reporting requirements due to demonstrated low risk of  
2145 nitrate pollution. It is expected that such an assessment may require significant amount of  
2146 new data collection, research, data analysis, and assessment.

2147

2148 **Response and Recommendations**

2149 **The Panel finds several cropping systems to be potential candidates for some form of**  
2150 **exception or alternative compliance pathways, but further research is needed to make**  
2151 **more specific recommendations: wine-grape vineyards, alfalfa, clover-pasture, nursery**  
2152 **and floral industry, and some organic and regenerative farms/farming practices. Already,**  
2153 **pathways exist for regions with no or low groundwater use to develop such exceptions**  
2154 **or alternative compliance pathways.**

2155 1. The Panel finds that, among the major agricultural industries, the following may be potential  
2156 candidates for such an assessment pending additional research, findings, and policy  
2157 decisions:

2158 1.1. Wine-grape vineyards, in some regions, may currently have practices that minimally  
2159 affect groundwater. For example, public comments to the Expert Panel have noted that  
2160 wine-grape vineyards managing for high quality wine-grapes are associated with lower  
2161 rates of applied N. When combined with practices reducing the risk of nitrate leaching,  
2162 such as building soil organic matter and efficient irrigation, these systems could have  
2163 minimal effects on groundwater quality. However, the Panel also understands that there  
2164 are significant grower-to-grower differences as well as regional differences. Vineyards in  
2165 some regions, for example those in the coastal regions (Kurtural et al., 2020), tend to  
2166 focus more on lower yields and higher quality associated with lower N applications,  
2167 while southern San Joaquin Valley vineyards tend to focus more on higher yields  
2168 (Zhuang et al., 2019). While reporting data on A and R are not yet available from coastal  
2169 vineyards, regional differences exist within the San Joaquin Valley. For example, in the  
2170 Kings River Water Quality Coalition area, there were more than 630 wine-grape  
2171 vineyards in 2023. A<sub>FER</sub> ranged from 0 to 205 lb/ac, A from 0 to 245 lb/ac and A-R from -  
2172 81 to 208 lb/ac. By contrast, in 2024 the San Joaquin County and Delta Water Quality  
2173 Coalition reported 2,175 wine-grape management units delineated by APNs, with A<sub>FER</sub>  
2174 ranging from 0 to 100 lb/ac, A from 0 to 121 lb/ac, and A-R from -68 to 87 lb/ac.

2175 An alternative compliance approach may require a strict limit for applied fertilizer  
2176 applications on wine-grapes compatible with current practices limiting N applications to

2177 ensure high wine-grape quality. One possibility could be to define a low-risk category  
2178 based on a set of factors associated with reduced risk of nitrate leaching, such as:

- 2179 a) participation in an existing certification program that includes measurement and  
2180 recording of applied N, such as the Certified California Sustainable Winegrowing  
2181 (CCSW; <https://californiasustainablewine.com/learn>) program or the Sustainability in  
2182 Practice (SIP; <https://app.sipcertified.org/preview/docs>) certification, and/or  
2183 limitations on the use of synthetic fertilizers, such as the Guardian Vital program  
2184 (<https://liderescampesinas.org/guardian-vital/>);
- 2185 b) a documented production focus on high wine-grape quality rather than yield,  
2186 associated with lower rates of applied N;
- 2187 c) use of cover crops that scavenge N or otherwise limit leaching to groundwater;
- 2188 d) use of organic soil amendments that build soil organic matter long-term, not  
2189 exceeding recommended rates;
- 2190 e) documented use of petiole testing for nutrient management planning to maintain N  
2191 levels in plant tissue consistent with high wine-grape quality;
- 2192 f) efficient irrigation minimizing movement of irrigation water below the root zone;
- 2193 g) demonstration of low residual nitrate in the soil profile at the end of the cropping  
2194 season, for example through soil testing after harvest;
- 2195 h) location in groundwater basins not impacted by nitrate contamination.

2196

2197 1.2. Alfalfa, as a long-established leguminous crop managed with minimal N fertilizer and  
2198 characterized by frequent harvests, consistently exports substantial quantities of N from  
2199 the field. Field-based research conducted under commercial low-desert production  
2200 conditions demonstrates that growers generally apply very low amounts of N to alfalfa  
2201 (often none), and that alfalfa harvest removal commonly amounts to several hundred  
2202 pounds of N per acre per year. Alfalfa exhibits the highest harvested N removal among  
2203 major crops. Field research further shows that nitrate-N in the upper 2 ft of soils under  
2204 alfalfa cultivation ranges from non-detectable to no more than 4 mg N/L. These  
2205 characteristics indicate a low potential for residual soil N accumulation and nitrate  
2206 leaching and support consideration of alfalfa for significantly reduced N ILRP reporting  
2207 requirements.

2208 1.3. Non-fertilized pasture systems warrant consideration under the same N regulatory  
2209 exception framework, based on comparable N balance characteristics and typical  
2210 management practices. Clover pastures, for example, are dominated by leguminous  
2211 species that rely primarily on biological N fixation, resulting in low dependence on  
2212 external N inputs relative to non-leguminous forage and pasture systems. Under typical  
2213 pasture management, N fertilizer application to clover-based pastures is limited or non-  
2214 existent, while N uptake and removal occur continuously through grazing and/or forage  
2215 harvest. Consequently, the applied minus removed N (A–R) for these systems is  
2216 generally expected to remain below the 50 lb N/ac threshold used within the regulatory  
2217 framework to indicate potential N management concern. Consistent with the treatment  
2218 proposed for alfalfa, clover-based and other pastures with no external N inputs (except  
2219 animal traffic) therefore represent a low-risk N management category with respect to

2220 excess N loading and nitrate leaching when managed according to standard agronomic  
2221 practices. Accordingly, it is scientifically appropriate and consistent with existing N  
2222 program rationale to extend the same exception/alternative approach consideration to  
2223 clover-dominated and unfertilized (but with animal traffic) pasture systems, aligned with  
2224 the criteria applied to alfalfa cropping systems. Region 5 already carries this exception:  
2225 "The requirement for an Irrigation and N Management Plan does not apply to irrigated  
2226 pasture with no external N inputs, or to parcels that are operated exclusively as a  
2227 managed wetland and are enrolled in this Order (either voluntarily or at the direction of  
2228 the Central Valley Water Board)." (RWB Central Valey, 2021, p. 34).

2229 1.4. Considering and exploring alternative approaches for alfalfa and non-fertilized pasture  
2230 systems would make most sense where these are permanent crops, with no or only  
2231 short, intermittent low N intensity rotations. Alternative approaches for alfalfa and non-  
2232 fertilized pasture may require low targets/limits on A or on A-R or both, thus requiring  
2233 reporting in some form. This may include, if and where appropriate, local GSAs  
2234 monitoring nitrate in groundwater as a "backstop" thus justifying an exception to further  
2235 reporting until/unless significant indication is available for broader impact on  
2236 groundwater nitrate (i.e., more than isolated individual farm incidents).

2237 1.5. Nursery and floral industry production systems have challenges with measuring R.  
2238 Appropriate, affordable, and effective monitoring systems to inform on actual or  
2239 potential groundwater nitrate impacts exist and may be used for compliance.

2240 Relevant from a hydrogeological perspective, the California nursery and floral industry  
2241 stands out from other agricultural production systems by its small footprint relative to  
2242 other agricultural industries: It covers less than 150,000 acres (about 2800 operations  
2243 averaging 50 acres per operation) producing \$4 billion in sales (Carman, 2020). Given  
2244 their size, the focus of research must be on understanding N fluxes at the scale of  
2245 individual operations or clusters of operations, i.e., considering understanding the total  
2246 N fluxes at a scale of not less than 40-80 acres. For reasons explained in Chapter 6  
2247 (Modeling Consideration), more granular accounting requirements would unlikely be  
2248 useful or needed to control groundwater nitrate impacts.

2249 Based on data presented to the Panel, we recommend consideration of alternate  
2250 reporting methods for nurseries, given the difficulty in accurately computing R for a  
2251 large variety of ornamental species grown in containers that leave the nursery for sale.  
2252 Identification of outliers based on A, use of lined capturing ponds and ditches for runoff  
2253 water, efficient irrigation practices, discharge monitoring, and adherence to and use of  
2254 best management practices already promoted by the industry and UC Cooperative  
2255 Extension can be part of an alternative reporting approach. The final determination on  
2256 how to proceed should be left to individual regions.

2257 1.6. Some organic farms and, in the future, perhaps some farms with demonstrable  
2258 regenerative farming practices (For definitions see:  
2259 <https://www.cdffa.ca.gov/RegenerativeAg/>) may have low nitrate leaching, particularly in  
2260 low N demanding crops. Since nutrient management practices vary across different  
2261 approaches to organic certification, it may be useful to define specific organic and  
2262 regenerative nutrient management practices associated with low nitrate leaching rather  
2263 than relying on organic certification alone as a defining category. Input substitution with  
2264 organic-approved fertilizer products more immediately soluble in water when applied

2265 may be less associated with reduced nitrate leaching. By contrast, integrated use of  
2266 multiple organic soil amendments such as carbon rich organic fertilizers, cover crops,  
2267 compost, biochar, and similar materials with the goal of building soil organic matter over  
2268 time may be associated with slower release of available N. Reporting of N applied can  
2269 be complex for these types of operations given the multiple organic sources of N, each  
2270 with different mineralization rates, and the continuous interaction of multiple biotic and  
2271 abiotic processes within soil ecosystems that often contain high microbial diversity.  
2272 Some possible categories to describe this type of farming operation may already exist:  
2273 for example, CCOF's "Regenerative Organic" certification ([https://www.ccof.org/organic-](https://www.ccof.org/organic-certification-services/regenerative-organic-certified/)  
2274 [certification-services/regenerative-organic-certified/](https://www.ccof.org/organic-certification-services/regenerative-organic-certified/); [https://regenorganic.org/wp-](https://regenorganic.org/wp-content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf)  
2275 [content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf](https://regenorganic.org/wp-content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf)) requires self-  
2276 produced or regionally available organic amendments, maintenance of vegetative cover,  
2277 crop rotation including cover crops or green manures, and minimal soil disturbance and  
2278 prohibits use of anaerobic liquid manure from concentrated animal feeding operations.  
2279 However, relevant studies on the impact of different types of organic farming systems  
2280 on groundwater quality are currently lacking; similarly, studies on appropriate  
2281 measurement and monitoring and on appropriate best management practices in organic  
2282 farming systems that specifically demonstrate reduction of risk for groundwater nitrate  
2283 pollution are also lacking. The scale of organic farming systems is over an order of  
2284 magnitude larger than that of the nursery and floral production industry, with about 1.8  
2285 million acres of agricultural lands are in organic farming systems producing \$12 billion in  
2286 in sales (CDFA, 2025b). Within the organic farming industry – and by extension –  
2287 among growers that have adopted regenerative practices, a large number of very small  
2288 producers (< 40-80 acres) exist to which the discussion on small and diversified farming  
2289 system (Response to Question 8) applies. Smaller-scale, diversified organic farms  
2290 using soil health and/or regenerative practices such as those supported by CDFA's  
2291 Healthy Soils Program (HSP) could be considered for alternative reporting structures  
2292 that both fit the complexity of their organic soil amendments and recognize practices  
2293 that contribute to protecting water quality.

2294 2. In regions where there is no current and no reasonably foreseeable future groundwater use  
2295 for domestic, municipal, commercial, irrigation, public supply, or groundwater dependent  
2296 ecosystem purposes, the Panel recommends consideration of alternative compliance  
2297 pathways. In such settings, conventional groundwater monitoring requirements are unlikely  
2298 to provide meaningful additional groundwater protection. The Imperial Valley is an example  
2299 of this condition, given the absence of active or planned beneficial groundwater uses and  
2300 the lack of groundwater dependent ecosystems. The Panel understands both, the  
2301 unparalleled burden to agriculture (lack of wells to be used for monitoring, requiring costly  
2302 installation of an entire network of monitoring wells, whereas other regions have relied 100%  
2303 on already existing wells for monitoring) and the Regional Board's concern that the lack of  
2304 groundwater quality characterization does not equate to the resource not being impacted or  
2305 not being usable in the future. The Panel encourages all parties to collaborate on the need  
2306 to characterize basin-wide water quality conditions, possibly with significant help from  
2307 federal, state, or other grants, as prequel to setting appropriate standards.

2308 3. The alternate reporting requirements referenced in Footnote 33 to Order WQ 2023-0081  
2309 authorized small-scale diversified farms to initially report A values only but gave the regional  
2310 water boards discretion to determine when or how R values should be reported. While

2311 reporting R should be a goal whenever feasible, some systems described above are unlikely  
2312 to be able to report meaningful R values that could be used effectively for compliance. This  
2313 includes small-scale diversified farms with multiple rotated, staggered crops and direct  
2314 market outlets and container-grown nurseries. For these types of operations, it may be more  
2315 effective to develop alternate compliance pathways that effectively use A or other methods  
2316 as long-term solutions. Also, reporting of A on a whole farm basis should be considered for  
2317 small-scale diversified farms for which increased data precision is unlikely to be gained  
2318 through reporting on a per-crop basis. We recommend that alternate compliance pathways  
2319 of this type be established in standard reporting for long-term compliance procedures rather  
2320 than using temporary exceptions.

2321 4. The goal of exceptions and alternative compliance methods must be to arrive at  
2322 substantially less costly, yet clearly defined reporting requirements that engage growers with  
2323 meaningful connections between reporting and implementation of practices that benefit  
2324 water quality. This includes reporting requirements for individual growers and reporting  
2325 requirements generated at the industry coalition or other regional level on behalf of  
2326 industry/region members. The reduced reporting requirements are only possible, when and  
2327 where such exceptions and alternative compliance methods do not lead to increased  
2328 groundwater pollution risk.

2329

### 2330 Additional Considerations

2331 • Presenters at the Panel meetings and Panel members collated resources and studies in  
2332 support of the above-mentioned potential exceptions and alternative approaches, which are  
2333 listed in Appendix D.

2334

#### 2335 • Footnote 33

2336 Footnote 33 in Order WQ 2023-0081 reads as follows (emphases added by Thomas  
2337 Harter): “33 See id. at fn. 92, pp. 34, 40-41. The irrigation and nitrogen management  
2338 requirements in State Water Board Order WQ 2018-0002 are not precedential for rice  
2339 growers in the Central Valley region, growers who never apply nitrogen to their fields, and  
2340 growers who demonstrate that the nitrogen applied to their fields does not percolate below  
2341 the root zone in an amount that could impact groundwater and does not migrate to surface  
2342 water through discharges, including drainage, runoff, or sediment erosion.

2343 • In addition, the regional water boards were given the discretion to apply alternative  
2344 requirements to some or all growers in the following categories: (1) growers who operate in  
2345 **areas with limited nitrogen impacts, have minimal nitrogen inputs, and have**  
2346 **difficulty measuring crop yield** (e.g., some growers who operate irrigated pastures), (2)  
2347 **diversified socially disadvantaged growers** who do not operate more than 45 acres,  
2348 have annual sales less than \$350,000, and grow no fewer than an average of two different  
2349 crops per acre, and (3) **other growers who do not operate more than 20 acres** and grow  
2350 no fewer than an average of **two different crops per acre**. The final three categories of  
2351 growers are required to report their A values, but the regional water boards were given the  
2352 discretion to determine when or how these growers will report their R values. We take this  
2353 opportunity to reiterate to the regional water boards that **these are currently the only**  
2354 **authorized exceptions to our precedential direction in Order WQ 2018-0002**. Based on

2355 comments we received from the third party, we expect that the Central Coast Water Board  
2356 will, on remand, consider using this discretion as appropriate. We also encourage the  
2357 Central Coast Water Board to work closely with the third party to develop targeted  
2358 education in appropriate languages for reporting A prior to revising the General WDRs on  
2359 remand.”

2360

2361 • Reference to footnote 92 is from ESJ ORDER WQ 2018-0002:

2362 “92. In the Central Valley region, the **rice growers** are the only commodity group issued its  
2363 own set of agricultural waste discharge requirements. (Central Valley Water Board Order  
2364 No. R5-2014-0032, available at:  
2365 [https://www.waterboards.ca.gov/centralvalley/board\\_decisions/adopted\\_orders/general\\_ords/r5-2014-0032.pdf](https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2014-0032.pdf) (as of Jan. 31, 2018).) Those waste discharge requirements specify a  
2366 **rice-specific nitrogen management plan** that takes into account the low potential for  
2367 nitrogen discharges due to rice’s unique cultural growing practices. Review of the rice-  
2368 specific nitrogen management plan is outside of the scope of these proceedings. **The**  
2369 **irrigation and nitrogen management requirements in this order accordingly are not**  
2370 **precedential for rice growers.”**  
2371

2372

2373 Updates by Expert Panel:

- 2374 • Footnote 33 is included in Order WQ 2023-0081, which can be accessed online at  
2375 [https://www.waterboards.ca.gov/public\\_notices/petitions/water\\_quality/docs/2023/wqo20](https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/2023/wqo2023-0081.pdf)  
2376 [23-0081.pdf](https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/2023/wqo2023-0081.pdf) (Accessed 01/16/2026)
- 2377 • The order for Sacramento Valley rice growers is now available at:  
2378 [https://www.waterboards.ca.gov/rwqcb5/board\\_decisions/adopted\\_orders/general\\_order](https://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/general_order_s/r5-2014-0032-03.pdf)  
2379 [s/r5-2014-0032-03.pdf](https://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/general_order_s/r5-2014-0032-03.pdf) (Accessed 01/16/2026)

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## 5. Additional Recommendations

### 5.1. Recommendations for Effective Irrigation and Nitrogen Management Practices

- Conduct comprehensive soil and plant testing to guide N fertilizer application. The use of pre-plant and in-season soil nitrate testing to determine residual soil nitrate-N in the root zone prior to N fertilizer applications is a cornerstone practice for improving the efficiency of applied N. The quantity of residual soil nitrate can vary depending on prior crop residues, residual fertilizer, soil texture, and the impact of excess irrigation or rainfall. Soil nitrate quick tests provide information to determine if there is sufficient residual soil nitrate available in order to reduce the amount of supplemental fertilizer needed to achieve optimal crop yields. Soil nitrate quick tests help growers to track N availability under changing soil conditions that affect nitrate availability such as irrigation and crop growth stage. Plant tissue testing, though not a substitute for soil testing, can also be used to confirm soil-based indicators. Integrating soil nitrate measurements and plant tissue analysis enables timely fertilizer adjustments that improve N use efficiency, sustain crop productivity, and minimize environmental losses.
- Adopt integrated irrigation scheduling supported by decision tools and soil moisture sensing to improve water and N use efficiency. Implement irrigation scheduling practices that align water applications with ETc demand using decision-support tools such as CropManage ([cropmanage.ucanr.edu](http://cropmanage.ucanr.edu)), which integrate weather-based ET estimates, crop growth stage, and soil characteristics. Complement ET-based scheduling with in-field moisture sensing to directly monitor root zone water status and verify that irrigation events replenish soil moisture without exceeding field capacity. This combined approach allows growers to adjust irrigation timing and duration in response to both atmospheric demand and soil conditions, reducing excess deep percolation. By maintaining soil moisture within an optimal range for crop uptake, these practices also improve the synchronization of irrigation and N applications, limit nitrate transport below the root zone, and enhance overall N use efficiency throughout the growing season.
- Improve irrigation water delivery systems through targeted upgrades and automation to reduce deep percolation and nitrate leaching. Enhancing irrigation system performance is a foundational strategy for improving both water use efficiency and N retention in the root zone. Adoption of modern irrigation technologies such as upgraded drip or sprinkler components, pressure regulation, and automated control systems can substantially improve distribution uniformity and ensure that applied water is delivered more evenly across the field. Improved irrigation system uniformity reduces localized over irrigation, which is a primary driver of deep percolation and nitrate transport below the active root zone. Automation and real time control enable precise irrigation timing and application volumes that better match crop water demand and soil infiltration capacity, particularly during periods of high evapotranspiration or variable field conditions. These improvements allow growers to apply smaller and more frequent irrigation events with greater accuracy, thereby minimizing excess drainage, reducing nitrate leaching risk, and enhancing overall water and N use efficiency while maintaining or improving crop productivity.

- 2423 • Account for nitrate contributions from irrigation water using ETc-based N accounting.  
2424 Quantify N supplied through irrigation water by combining measured irrigation water nitrate  
2425 concentrations with the volume of irrigation water consumed by the crop, as represented by  
2426 ETc. As opposed to the total quantity of water applied to the crop, ETc provides a direct  
2427 basis for estimating nitrate-N that can be taken up by the crop from the root zone, which  
2428 allows for accurate accounting of N in irrigation water that is available for plant use.  
2429 Depending on the concentration of nitrate-N in the irrigation water, fertilizer application  
2430 rates can be reduced accordingly. Effectively utilizing nitrate-N in the irrigation water can  
2431 improve N use efficiency and reduce the potential for nitrate accumulation and movement  
2432 below the root zone during the growing season.
- 2433 • Follow crop-specific N fertilization guidelines where available, based on regionally relevant  
2434 research. Fertilizer application guidelines for a number of crops are available on the CDFA  
2435 Fertilizer Research and Education Program (FREP) website  
2436 (<https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/>). These guidelines are based  
2437 on replicated field trials that evaluate crop N demand, yield response, and N use efficiency  
2438 under local soil, climate, and management conditions. Where formal guidelines are not  
2439 available, growers should rely on the best available research (from University of California  
2440 Cooperative Extension and other sources) and on-farm evaluations. Use of soil nitrate  
2441 testing (see above) should be used to make final fertilizer application decisions based on  
2442 real time levels of residual soil nitrate that can substitute for fertilizer N.
- 2443 • Utilize cover crops during fallow periods to reduce nitrate leaching and improve N retention.  
2444 Cover crops are a non-cash crop grown during the winter fallow when residual soil nitrate is  
2445 at risk for leaching by uncontrolled rain events. The use of cover crops is a key practice to  
2446 capture residual soil nitrate present at the end of the growing season and safeguard it until  
2447 the following growing season. All cover crop strategies, winter grown, fall grown and low-  
2448 residue cover crops, take up residual soil nitrate remaining after harvest and temporarily  
2449 sequester it their biomass or recalcitrant crop residue and maintain it in the root zone.  
2450 When appropriately managed, cover crops provide an effective biological strategy to  
2451 reduce nitrate leaching risk, enhance N cycling, and support long-term soil health without  
2452 compromising production goals.
- 2453 • Apply high carbon organic amendments during winter fallow to reduce nitrate leaching  
2454 through microbial immobilization. Application of labile forms of high carbon organic  
2455 amendments (C:N > 30:1) such as finely ground (< ¼ inch particles) almond shells  
2456 stimulates soil microbes to temporarily immobilize residual soil nitrate. Immobilization  
2457 temporarily reduces the pool of soil nitrate vulnerable to leaching. This practice can be  
2458 easily adopted by growers because it can be substituted for typical fall applications of  
2459 compost. Research has shown that on average this practice can sequester 30 lb N/ac or  
2460 more.
- 2461 • Incorporate N scavenging rotational cash crops to reduce residual soil nitrate losses.  
2462 Integrate rotational cash crops with high N uptake capacity into cropping systems to  
2463 effectively utilize residual soil nitrate remaining within the soil profile following harvest of the  
2464 primary crop. Crops such as broccoli and other long season cole crops root three feet or  
2465 deeper and can scavenge residual soil nitrate at these deeper soil levels than shallower  
2466 rooted crops such as lettuce or spinach cannot access. As a result, nitrate scavenging  
2467 crops typically need less fertilizer than they take up over the growing season. Selection of

2468 appropriate crop species and rotation sequences should be based on rooting depth, N  
2469 uptake efficiency, and compatibility with existing management practices. When strategically  
2470 incorporated, N scavenging rotational crops improve whole system N use efficiency,  
2471 enhance nutrient cycling, and reduce the risk of nitrate movement below the root zone.

2472 • Select crop varieties with higher N use efficiency to improve productivity and reduce nitrate  
2473 losses. High N use efficiency is defined as the ability to produce greater yield per unit of N  
2474 applied. Varieties with improved N uptake efficiency, internal N utilization, or partitioning to  
2475 economic yield are better able to convert available N into biomass and yield, reducing N  
2476 fertilizer needs. Nitrogen use efficient varieties are not widely available for many  
2477 commodities but should be considered as they become available from seed companies.

2478 • Adopt enhanced efficiency fertilizer technologies to improve N use efficiency and reduce  
2479 nitrate leaching. Utilize enhanced efficiency fertilizer products, including controlled release  
2480 fertilizers and nitrification inhibitors, to better synchronize N availability with crop uptake  
2481 patterns. The goal of controlled release fertilizers is to regulate the release of plant  
2482 available N, through physical or chemical mechanisms, during the slow and exponential  
2483 phases of crop N uptake. Nitrification inhibitors slow the conversion of ammonium to nitrate,  
2484 thereby decreasing the formation of highly mobile nitrate and prolonging N retention in the  
2485 root zone. By limiting the accumulation of nitrate during periods of low crop demand and  
2486 high leaching potential, these technologies improve N use efficiency and reduce N losses  
2487 below the root zone. When integrated with appropriate irrigation management and rate  
2488 selection, enhanced efficiency fertilizers can be an effective tool for improving nutrient  
2489 management while maintaining crop yield and quality.

2490 • Implement denitrification bioreactors where appropriate to reduce nitrate losses from  
2491 agricultural drainage. Denitrification is the reduction of nitrate by microbes under anaerobic  
2492 conditions to nitrous oxide and dinitrogen gas. Denitrification bioreactors facilitate the  
2493 growth of anaerobic denitrifying microorganisms fed with carbon-based media to denitrify  
2494 nitrate rich waters. They can be used to treat tile drainage or other agricultural runoff and  
2495 reduce the load of nitrate in the water. The level of denitrification depends on the initial  
2496 quantity of nitrate in the water, the water temperature, the quantity of available labile carbon  
2497 and the amount of time the water dwells in the reactor. When appropriately designed and  
2498 managed, denitrification bioreactors provide a targeted, downstream approach to  
2499 complement in field nutrient and irrigation management practices and further reduce off-site  
2500 nitrate impacts.

2501 • Explore emerging and novel technologies as complementary strategies for reducing N  
2502 losses. Evaluate the potential of emerging and novel N management technologies,  
2503 including microbial inoculants designed to enhance biological N fixation within plant tissues  
2504 and microbial based products intended to improve crop N use efficiency. These approaches  
2505 aim to increase the proportion of plant N demand met through biological processes or to  
2506 improve N uptake and assimilation efficiency, thereby reducing reliance on synthetic  
2507 fertilizer inputs. Microbial stimulants may also influence rhizosphere processes that  
2508 enhance N availability and retention in forms more accessible to crops. While research on  
2509 these technologies is ongoing and performance can be variable across crops, soils, and  
2510 environments, they represent promising complementary tools that may support more  
2511 efficient N cycling. When used alongside established irrigation and fertilizer management

2512 practices, emerging biological technologies have the potential to contribute to reduced N  
2513 losses and improved overall nutrient stewardship.

- 2514 • Variable-rate N application is an effective management practice for improving N use  
2515 efficiency in irrigated agricultural systems while reducing the risk of nitrate losses to  
2516 groundwater. By adjusting N rates spatially and temporally to better match crop demand,  
2517 soil variability, and yield potential within a field, variable-rate approaches help minimize  
2518 over-application in areas with lower uptake capacity and reduce residual N that is  
2519 vulnerable to leaching under irrigation. The effectiveness of this practice is enhanced when  
2520 supported by available technologies such as precision fertilizer applicators, GPS-guided  
2521 equipment, yield monitors, soil and crop sensors, remote sensing, and decision-support  
2522 tools that integrate field history and irrigation performance. When combined with  
2523 appropriate irrigation scheduling and uniform water application, variable-rate N  
2524 management can significantly reduce N losses during periods of low crop uptake while  
2525 maintaining productivity. Adoption of this practice depends on crop type, irrigation system,  
2526 equipment access, and technical support, and therefore should be encouraged through  
2527 flexible, outcomes-based regulatory frameworks that recognize site-specific conditions  
2528 rather than prescriptive requirements. Overall, variable-rate N application represents a  
2529 practical, technology-enabled pathway to improved nutrient stewardship and water quality  
2530 protection in irrigated lands.

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2532 **5.2. Outreach, Research, Evaluation and Implementation Needs**

2533 **Outreach and Technical Assistance**

- 2534 • An extensive education effort should be conducted to help growers utilize best management  
2535 practices and improve N use efficiency to make rapid progress toward ratcheting down the  
2536 values of the selected metric with the goal of improving water quality. Incentives can be  
2537 offered by the Regional Boards/coalitions and consequences can result from continued  
2538 exceedances.
- 2539 • Specifically, technical assistance for reducing N applied includes:
- 2540 ○ Frequent irrigation water testing ahead of crop fertilization should be conducted by  
2541 growers with support from technical assistance programs. Help with accounting for  
2542 nitrate-N in irrigation water to reduce fertilizer applications accordingly and efficiently  
2543 irrigating to reduce nitrate leaching during the growing season should be provided by  
2544 technical assistance providers.
- 2545 ○ Judicious use of residual soil nitrate testing at the beginning and during the cropping  
2546 season to guide fertilizer applications and use of efficient irrigation practices should be  
2547 incentivized through technical assistance programs.
- 2548 ○ Utilization of crop fertilization guidelines such as those provided by the CDFA FREP  
2549 program or other similar programs (e.g. UCANR, local farm advisers) and adjusting  
2550 fertilizer rates according to these research-based recommendations.
- 2551 • For increasing N removed, technical assistance needs include:
- 2552 ○ Implementation of practices that are new to a grower, such as cover crop management,  
2553 fertilizer technologies, or high carbon amendments.

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2555 **Research**

- 2556 • Research is needed to develop N removal coefficients for crops that do not have existing  
2557 data. For some commodities (e.g. cut flowers with a large number of varieties and types),  
2558 removal coefficients of representative commodities may be used in lieu of specific  
2559 coefficients. Establishment of removal coefficients may include research trials in addition to  
2560 literature reviews from regions with similar soils and climates. Ultimately, each cropping  
2561 system should move towards developing the means to estimate A-R values.
- 2562 • Research is needed to understand N uptake patterns of crops that currently do not have  
2563 existing data. These curves can be used by growers to better match fertilizer applications to  
2564 crop requirements.
- 2565 • Research needs to include evaluating which crops/operations pose a risk of nitrate leaching  
2566 and if there is a need for them to be subject to ILRP regulations.
- 2567 • A preliminary, but by no means exhaustive list of specific cropping systems that need  
2568 research include nursery systems (many regions), diverse orchard/nursery operations  
2569 (Regions 8 and 9), pasture systems with animal traffic and limited input of synthetic fertilizer,  
2570 small diversified organic or conventional operations (many regions), or cut flower operations.
- 2571 ○ For small-acreage plots of niche or emerging crops, further research is needed to  
2572 understand whether there are specific nutrient management practices that might result in

- 2573 a reduced water quality impact. Research is needed to determine average values and  
2574 ranges for N applied in diversified systems such as mixed vegetable production that  
2575 could provide an alternate method of identifying outliers in systems where calculating N  
2576 removed is difficult. If certain crops represent a very low percentage of total irrigated  
2577 acres, it may be more effective to focus on research and education and adopt alternate  
2578 reporting requirements until fertilizer recommendations and N removal coefficients are  
2579 available. It may be useful to explore a reduced-risk category independent of farm size,  
2580 based on practices that protect water quality. Research-based fertilizer  
2581 recommendations specific to California may be unavailable for many of these crops.
- 2582 ○ Further, research to determine average values and ranges for N applied in diversified  
2583 systems such as mixed vegetable production could provide an alternate method of  
2584 identifying outliers in systems where calculating N removed is difficult.
  - 2585 ○ Nursery and floral industry production systems have challenges with measuring R and  
2586 may have limited groundwater nitrate impact. Research is needed to understand the  
2587 operation of nurseries in other parts of California outside of Southern California  
2588 operations and to determine if reporting R is suitable for the nursery industry. Evaluation  
2589 of practice-based enforcement for container nurseries should be explored. However, the  
2590 Panel does not consider N removal coefficients for container-grown nursery species a  
2591 high priority for research, as the soil containing both the plant and any available N is  
2592 transported off the nursery property. Container-grown nurseries can easily report on N  
2593 applications while more research is conducted to determine if reporting R is suitable.  
2594 Additional research on understanding N pathways out of the nursery (surface runoff,  
2595 groundwater leaching, atmospheric losses), which may depend on the timing, form,  
2596 amount, and place of N application, is needed. There is also a need to evaluate the  
2597 amount of N removed in container stock and sites with non-permeable surfaces.
  - 2598 ○ Research on whether risk of N leaching is different in (long-term) regenerative and  
2599 organic farming systems is needed to understand if and under what conditions these are  
2600 effective systems of management that are beneficial to water quality while maintaining  
2601 profitability.
  - 2602 ● Research is needed to fully understand the elements of N transformation rates including  
2603 atmospheric losses by denitrification and volatilization and how they should be considered in  
2604 the A-R calculation. Characterize denitrification rates across different climates, soils,  
2605 management systems, high carbon amendments, etc. In addition, studies need to recognize  
2606 that nitrous oxide is only one of the gas components of denitrification. A significant portion of  
2607 the gas may be in the N<sub>2</sub> form which is not easily measured. This area of research must  
2608 include mapping and understanding denitrification dynamics in the deeper vadose zone and  
2609 in aquifer systems underlying agricultural regions of the state.
  - 2610 ● Research into the socioeconomic (e.g. land tenure) and market driven factors that allow  
2611 operations to meet the operational benchmark. Given farmers are operating in a large socio-  
2612 ecological system, other actors (e.g. wholesale buyers) could be considered when creating  
2613 a regulatory program that supports targets/limits “that are protective of groundwater quality  
2614 and support a long-term sustainable Irrigated Lands Regulatory Program.”
  - 2615 ● Research to support the use of SWAT (or similar soil-crop models) and groundwater models  
2616 elsewhere (outside of the Central Valley).

- 2617 • Research projects that can assist in determining the agronomic feasibility of targets/limits.
- 2618 • Research into specific practices to reduce A-R values should include:
  - 2619 ○ Development of new technology for improving N use efficiency by crops, increasing N
  - 2620 removal, and contributing to reducing A-R values in challenging cropping systems. New
  - 2621 technologies may include N fertilizer technologies (controlled release fertilizers and
  - 2622 nitrification inhibitors), microbial inoculants, improved irrigation efficiency technologies
  - 2623 that reduce risk of deep percolation of water during the growing season, more N efficient
  - 2624 crop varieties, and emerging technologies to increase immobilization during the winter
  - 2625 fallow such as high carbon amendments.
  - 2626 ○ Evaluations of emerging/existing N fertilizer technologies that improve N use efficiency
  - 2627 should be conducted, such as stimulation of microbial N fixation in plants.
  - 2628 ○ Assessment and evaluation of irrigation water N uptake into crops including
  - 2629 development of best irrigation and nutrient management practices to minimize N
  - 2630 leaching to groundwater under various levels of irrigation water N. This work would also
  - 2631 lead to improved understanding of N discharge levels that can be achieved when
  - 2632 irrigation water N significantly exceeds plant N uptake capacity during some or all of the
  - 2633 growing season (see response to Question 7d).
  - 2634 ○ A significant expansion of comprehensive groundwater-agriculture field research sites
  - 2635 where the most promising water and nutrient management can be tested under real
  - 2636 world conditions for their actual impact to first encountered groundwater; and where
  - 2637 existing methods for estimating nitrate discharge to groundwater (N mass balance, soil-
  - 2638 water-crop models, etc) can be evaluated and validated. These field sites would
  - 2639 encompass a single field, orchard, or vineyard, be equipped with a groundwater
  - 2640 monitoring well network (with at least 10 monitoring wells) that effectively monitors the
  - 2641 recharge water quality coming from the site and with instrumentation to track the details
  - 2642 of water and N movement into and out of the soil-plant system of the site across all
  - 2643 pathways – land surface, atmosphere, soil, deep vadose zone, and into groundwater.
  - 2644 The site would be sufficiently large to ensure that the source area of the monitoring
  - 2645 network predominantly or exclusively reflects recharge coming directly from the site,
  - 2646 typically several tens to a few hundred acres. At a minimum, such a research program
  - 2647 would include one to three such sites in each of the major cropping systems of a region
  - 2648 and in one or two organic/regenerative farming systems, at geographically most
  - 2649 vulnerable locations (shallow water table, coarser soils, absence of extensive clay
  - 2650 layers), and be conducted over at least 10 years at each site.
  - 2651 ○ Continued evaluation of cover crops and other end-of-growing season practices that
  - 2652 reduce the load of residual soil nitrate during winter fallow (e.g. high carbon
  - 2653 amendments).
    - 2654 ▪ Growers and researchers are experimenting with additional winter cover crop
    - 2655 strategies. They can be lumped together under the term, “low-residue cover crops”.
    - 2656 Examples of these cover crop strategies include growing cover crops on beds and
    - 2657 killing them before they produce too much residue, which will allow rapid
    - 2658 incorporation using minimal tillage in the spring and rapid access to the field for
    - 2659 planting crops.

- 2660           ▪ The effectiveness of fall grown cover crops at reducing nitrate leaching and the  
2661           appropriate credit amount they should receive in the order.
- 2662           ▪ Studies need to be conducted to select for cover crop varieties that achieve a higher  
2663           C:N ratio during the short time frame that fall grown cover crops are produced.
- 2664           ▪ Determine the amount of N mineralized from cover crop residues during the growth  
2665           of the next crop and how  $A_{FER}$  can be reduced in response to cover crop N  
2666           mineralization.
- 2667           ○ Expanding/optimizing the role of rotational cash crops in utilizing residual soil nitrate  
2668           (scavenging cash crops) thereby reducing nitrate leaching.
- 2669           ○ Further field research studies evaluating the use of residual soil nitrate in lieu of fertilizer  
2670           N is needed to help growers effectively use this source of N and thereby reduce N  
2671           fertilizer use when appropriate.

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2673   **Evaluation and Implementation**

- 2674   • Targets/limits should be addressed on a local/regional basis. The diversity of agricultural  
2675   production systems in the state makes it impossible to impose a one-size-fits-all approach to  
2676   the regulatory process.
- 2677   • A thorough evaluation of the unique cropping systems of each region of the state needs to  
2678   be conducted to evaluate to what extent they pose a N leaching risk.
  - 2679           ○ In the case of small farms, diversified operations, and others, one metric to consider as  
2680           to whether they have to report is the percentage of total acreage of minor or niche crops  
2681           in a reporting area. If certain crops represent a very low percentage of total irrigated  
2682           acres, it may be more effective to focus on research and education and adopt alternate  
2683           reporting requirements until fertilizer recommendations and N removal coefficients are  
2684           available.
- 2685   • Identify and designate nitrate vulnerability zones as seen in the case of the EU nitrate  
2686   directive and in the CV-ILRP and CV-SALTS programs and look at implementation of buffer  
2687   zones around community wells.
- 2688   • It may be useful to explore a reduced-risk category independent of farm size, based on  
2689   practices that protect water quality.
- 2690   • Funding for increased research on new and useful BMPs as well as technical assistance  
2691   and education to help growers adopt BMPs will be needed to reach compliance with  
2692   whatever targets/limits are set.
- 2693   • Regional boards, as appropriate, could include incentives for water quality and soil health  
2694   improving practices that focus on reduced N applied or increased N removed. Many of these  
2695   practices are discussed in Question 7c.
- 2696   • The Panel noted that the regulatory burden of ILRP reporting for all of the categories of  
2697   small farms described in Question 8 is greater than for larger farms. We recommend  
2698   consideration of the recommendations from the California Department of Food and  
2699   Agriculture (CDFA) Regulatory Alignment Study that are relevant to reducing regulatory  
2700   burdens for small-scale, diversified, and socially disadvantaged farmers.

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- Currently, the fees paid by growers to their coalition are based on the acreage. The fees could be adjusted to reflect A-R values: Growers with low A-R values would pay less per acre while growers with A-R values that are above the operational benchmark and that are high compared to the A-R values of other growers who grow the same crop in the region would pay a higher fee per acre. Such a fee structure would reward growers who already achieve low A-R values, while it would provide a financial incentive for growers with high A-R values to improve N management in their crops. The structure of such fees and their evolution over time must consider that ultimately, all growers would be meeting required targets/limits, thus lessening/removing the need for built-in incentives. For example, incentive-based fees may have an expiration date. Whether A-R linked fees are introduced and how they are structured would need to be determined by individual coalitions.
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- Effective verification and auditing processes should be conducted to ensure reductions in A-R are validated and enduring. As a regulatory agency, the Waterboard has certainly more experience in determining the level of auditing required than the Expert Panel, and therefore we leave it up to the State and Regional Waterboards to determine the framework and frequency of auditing.
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- As new, scientifically based practices that reduce A-R are developed, regional boards should be able to adopt them into their orders without having to go through the time-consuming, rigorous process of convening an advisory panel. However, some kind of expedited peer-reviewed process of the suggested practices should be conducted by an objective third party (i.e. researchers, UCCE).

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## 6. Using Models to Assess Well Nitrate Contamination Risks from Agriculture

### 6.1. Why Do We Need Models?

In many regions of California, wells are contaminated with nitrate or at risk of being contaminated with nitrate, i.e. of having nitrate-N concentrations above MCL of 10 mg/L. Most domestic wells are not actually measured for nitrate; hence we only know the risk that they are contaminated (SWRCB, 2026). For food, feed, fiber, and biofuel production, agriculture depends on N fertilizer, some of which leaches to groundwater in form of nitrate (Chapter 1). Nitrate contaminated recharge to groundwater then travels through the aquifer and eventually -years, decades, or centuries later - turns out in a well, a stream, or is taken up by plants in groundwater-dependent ecosystems, unless natural attenuation processes in the aquifer remove nitrate prior to that time.

Under California’s Porter-Cologne Water Quality Control Act (SWRCB, 2025), individual landowners are responsible for any pollution caused to well water. How do we know how, how much, where and when agricultural activities impact well water quality either in general, or more specifically those of individual landowners?

One way to make that linkage is to do extensive monitoring along the pathway between the suspected source and the contaminated well – taking soil and vadose zone measurements under the source and installing monitoring wells between the source and the contaminated well to measure the plume of contamination. Variants of this approach are common where the source is small (a spill, leak, pond, or even a landfill) and isolated from other sources (a so-called “point-source”) and where pollution in the recharge under source may be one or several orders of magnitude above regulatory water quality targets/limits.

When multiple sources are suspected, a second way to establish the link between source and contaminated well is a forensic analysis – identifying a water quality pattern unique to the source that is also present in the contaminated well. This is also a not uncommon approach in identifying primary responsible parties for the cleanup of point-source pollution (aquifer remediation). Forensic tools can also provide direct chemical evidence of agriculturally sourced nitrate in the water of nitrate contaminated wells (e.g. Ransom et al., 2016).

Finally, models are used to track pollution from a groundwater contamination source to contaminated wells. **The term “model” is here employed in the broadest sense**, referring to any type of mathematical representation of pollution sources and of water and N fluxes. This includes water and N mass balance models (however simple or complex) and all kinds of farm management, soil and groundwater assessment tools, from simple analytical equations useful in spreadsheets, to very complex numerical models. These models are used to represent – to various degrees of detail and accuracy - management practices and processes at and within the pollution source and the physics and chemistry of pollutant fate and transport in soils, deep vadose zones, in groundwater, around and inside wells, at the groundwater-surface water interface and in streams, lakes, and oceans. The advantage of models is that they are less expensive than monitoring wells, pose less risk to additional contamination from improper monitoring well construction, and may be useful to predict future outcomes under different, more protective source control management.

2765 In the case of agricultural nitrate contamination of wells, it is impractical and far too expensive to  
2766 use field observations to track nitrate from all potential sources to all potentially polluted wells or  
2767 streams, due to the nonpoint-source nature of nitrate pollution. Forensic tools provide important  
2768 general evidence of source contributions to well and stream pollution but are not suitable for  
2769 understanding more precisely how agricultural practices need to be improved to avoid well (or  
2770 stream) nitrate contamination.

2771 Hence, models are a critical component of assessing the outcomes of agricultural practices on  
2772 well (and stream) water quality. In fact, most scientific assessments of the prominent role of  
2773 irrigated agricultural land use as a prevalent source of nitrate contamination in domestic and  
2774 public supply wells rely on models. But these models in turn are supported by extensive field  
2775 data, measurements, and well-proven scientific concepts. Absent of easily available direct  
2776 observation of “contamination plumes”, models provide the scientifically, technically, and  
2777 economically most useful framework, which links (limited) observation data and science into a  
2778 tool useful for quantitative understanding of irrigated land’s impact on nitrate in domestic and  
2779 public supply wells.

2780 Chapter 6.2 lays out the conceptual linkage between irrigated lands and wells. This provides a  
2781 foundation for understanding at which spatial scales and time scales we need to understand  
2782 nitrate leaching from irrigated lands to assess well water quality impacts. It then discusses a  
2783 very simplified “model” to quantitatively link the nitrate MCL with agricultural N losses to  
2784 groundwater (Chapter 6.3). It provides an overview of the various models already used in the  
2785 state’s ILRP programs (Chapter 6.4) and lists and compares measurements provided by  
2786 growers and others in support of these models (Chapter 6.5).

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2788 **6.2. *Polluted Wells and Agriculture – How are They Linked? Source Area***  
2789 ***of Wells and Mixing in Wells to Identify Time and Spatial Scale***  
2790 ***Relevant to Assessing Groundwater Quality Impacts:***

2791 *Source:* Nitrate in groundwater is a nonpoint source pollutant, discharged from across the  
2792 landscape. In irrigated agricultural regions, N discharge is typically in the range from 1 to 100,  
2793 sometimes several hundred pounds per acre per year.

2794 *Wells:* Individual domestic, public, or irrigation supply wells pump groundwater that was  
2795 recharged at an earlier time in the “source area” of the well. In the well, water from across the  
2796 source area is mixed. The impact of N management on a well therefore reflects the overall  
2797 impact from across the source area. Hence, the size of the source area is relevant to N  
2798 management to meet groundwater quality objectives.

2799 *Source Area Size:* Over the long-term, the size of the source area is related to long-term  
2800 average pumping rate and the seasonal and interannual fluctuations of the groundwater flow  
2801 field. The size of the source area, however, is always such that the average recharge rate in the  
2802 source area equals the well's average discharge rate. As a rule of thumb, the source area tends  
2803 to be an elongated oval and, for small pumping rates, e.g., for a domestic well, the source area  
2804 is a very slender, exceedingly elongated oval area (Horn and Harter, 2009). Where source  
2805 areas overlap, they develop complex bifurcated shapes (Forster et al., 1997).

2806 Average recharge rates in California irrigated agriculture range from a few inches to  
2807 approximately one to two feet (one to two acre-feet per acre) per year. Hence, the source area

2808 of wells impacted by nitrate in irrigated areas of the Central Coast is typically on the order of 1-2  
2809 acres per gpm (gallons per minute) pumped, where the pump rate represents the annual  
2810 average (e.g., a well that pumps 1,000 gpm for six months but nothing otherwise has a nominal  
2811 annual average pumping rate of 500 gpm). For domestic wells (average pumping rate: 1gpm),  
2812 the source area will be small (1-2 acres, typically a few tens of feet wide, but hundreds of feet  
2813 long), for wells pumping 300 – 500 gpm (annual average), the source area will encompass 300 -  
2814 1000 acres (potentially about half to one mile wide and several miles long, e.g., Henri and  
2815 Harter, 2019). The presence of losing streams in the source area of a well may significantly  
2816 reduce the size of the source area, with the stream then being a major source of the well water.  
2817 Travel time to the well will vary – less for water recharged in the proximal part of the source  
2818 area, more for water recharged in the distal part of the source area. Based on Visser et al.  
2819 (2020), the average travel time in most wells subject to nitrate pollution is less than 40 years.  
2820 For larger production wells, some water is much older than 100 years (Henri and Harter, 2019).  
2821 Nitrate loading from across the source area will be mixed in the extraction well: Within each  
2822 well, water of younger and older ages is mixing, typically ranging from less than half of the mean  
2823 age to more than twice the mean age measured in a well (Henri and Harter, 2019). Even in  
2824 short-screened, shallow domestic wells, the age mixing within the well will be on the order of at  
2825 least four to ten years and often much more (Figure 4 in Henri et al., 2026).  
2826 Given the above information, it is reasonable to set the minimum area over which the nitrate  
2827 discharge-relevant information is evaluated for purposes of assessing risk and setting target  
2828 compliance to an area, within which the heterogeneity of N loading does not matter due to the  
2829 mixing in wells. To protect domestic wells, knowledge of (spatially averaged) N loading at a  
2830 scale no less than 10 acres (quarter-quarter-quarter section) to 40 acres (quarter-quarter-  
2831 section) is reasonable. This is relevant especially to small, diversified farms.  
2832 Similarly, given the age mixing that inevitably occurs in a well, a full understanding of the total N  
2833 fluxes at the 10-acre to 40-acre scale (or larger) over the course of a moving three-year window  
2834 is sufficient to assess the risk for groundwater contamination to most individual wells. To  
2835 understand risk to wells, there is no need for finer spatial or temporal resolution, unless needed  
2836 for other purposes (e.g., to assess individual landowner contributions where individual  
2837 ownership is a small acreage).  
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### 2839 ***6.3. What Needs to Be Done in the Agricultural Landscape to Protect*** 2840 ***Wells from Nitrate Contamination?***

2841 The relevant compliance level for protecting wells used for drinking water purposes is the  
2842 drinking water standard or MCL for nitrate-N, 10 mg/L. With the most simple “model” to link  
2843 agricultural sources to well contamination, this number can be converted to N losses from the  
2844 landscape if the recharge rate is known: For example, where the source area of a well is  
2845 exclusively irrigated agricultural land, and assuming groundwater recharge is 1 ac·ft/ac per year  
2846 (typical in the Central Valley), the loss of 27 lb N/ac per year of nitrate-N in that 1 ac·ft of  
2847 recharge is exactly equal to the MCL. For a recharge rate of 2 acre-feet per acre per year, N  
2848 losses of 54 lb per acre per year yield a recharge concentration equal to the MCL. For a  
2849 recharge rate of 0.5 acre-feet per acre per year, 14 lb N losses result in recharge nitrate  
2850 concentrations at the MCL, etc. In practice, the value used in the Central Valley is 31 lb

2851 N/acre/year (based on levels of recharge and denitrification) and the Central Coast RWB Ag  
2852 Order 4.0 limit of 50 lb N/acre/year is explicitly based on greater levels of groundwater recharge  
2853 in that region. In this report, these values are referred to as “operational benchmarks”.

2854 Based on the discussion in Chapter 6.2, we point out that larger recharge rates yield  
2855 proportionally smaller (shorter) source areas, while smaller recharge rates yield proportionally  
2856 larger (longer) source areas. The longer the source area, the more diverse is the land use within  
2857 the source area and the more likely it is that the well source areas are not entirely covered by  
2858 irrigated land production. Importantly, it also increases the likelihood that some source water is  
2859 from a nearby (losing) stream (or leaky irrigation canal), which provides significant dilution of the  
2860 nitrate signal from the irrigated lands within the source area. In that case, the MCL would not be  
2861 reached unless much more than 27 lb N/acre/year is leached. In other words, a limit higher than  
2862 27 lb N/acre/year would still be protective of well water quality. Furthermore, to the degree that  
2863 denitrification occurs between the source area and the well, a limit that is higher than 27 lb  
2864 N/acre/year will be protective of groundwater quality.

2865 Limits “that are protective of groundwater quality and support a long-term sustainable Irrigated  
2866 Lands Regulatory Program” require that the need for groundwater protection is balanced with  
2867 the economic cost to landowners/operators for the proper nutrient management. The Expert  
2868 Panel was not presented with sufficient evidence to consider economic cost to implement  
2869 specific practices, let alone specific practices that may successfully protect groundwater quality  
2870 in the above rigorous manner.

2871 Given the complexity of how water quality in wells is impacted by agriculture (diverse land use,  
2872 impact of streams, potential denitrification) and the need for economic sustainability (not  
2873 considered by the Panel), the Panel finds that it lacks the scientific basis to recommend region-,  
2874 sub-region (area), or crop-specific limits “that are protective of groundwater quality and support  
2875 a long-term sustainable Irrigated Lands Regulatory Program”. Instead, both final targets/limits  
2876 (Question 1) and interim targets/limits (Question 2) best include further modeling insights that  
2877 account for the above-mentioned mixing, denitrification, and other N cycling processes that  
2878 impact the leaching of nitrate from the root zone, the recharge of nitrate to groundwater, and the  
2879 transport of nitrate to wells (Question 3). We therefore support the efforts currently undertaken  
2880 in Regions 3 and 5, which do just that: they use more complex models to account for some of  
2881 these processes.

2882

#### 2883 ***6.4. Models Currently Used in the ILRP***

2884 Both, Region 3 and Region 5 use models (as defined in Chapter 6.1) rather than intensive  
2885 groundwater flow path monitoring between sources and wells to estimate the discharge of  
2886 nitrate from agricultural land to groundwater considering the degree to which such discharge will  
2887 impact drinking water consumption from domestic or public supply wells.

2888 The difference in the choice of the modeling framework between the two regions reflect  
2889 differences in the regulatory philosophy between the two regions. It is beyond the scope of this  
2890 Expert Panel to judge these regulatory, administrative tool choices. From the testimony heard  
2891 and based on the discussions among Panel members, some key differences can be  
2892 summarized as follows:

<b>Attribute</b>	<b>Region 3</b>	<b>Region 5</b>
Grower representation	In Region 3, few growers directly report to the RWB, while most utilize the services of Preservation Inc. for reporting.	In region 5, individual growers are members of water quality coalitions. Growers report to their coalition. The coalition represents the grower vis-à-vis the RWB.
Primary data collection and processing	RWB	Coalition
Anonymity	None	Anonymous, subject to third-party audits and right of RWB to see non-anonymous data collected by the coalition
Primary party to affect changes in grower practices	RWB, by direct communication with growers, supported by third-party organizations	Coalition, by direct communication with growers, supported by third-party organizations
Spatial scale at which targets/limits apply	Grower	Township
Spatial diversification of targets/limits	None – all growers have the same targets/limits	Each township has a different target; moreover, coalitions and growers have flexibility over exactly what targets/limits apply to individual growers, reflecting aquifer, soil, and production conditions unique to growers.
Incentivizes use of cover crops and high-nitrate well water	Yes	No
Intended use of the model	Primary: Incentivize growers to adopt best management practices  Secondary: Estimate N discharge to groundwater,	Primary: Estimate sub-field scale nitrate leaching from the root zone and determine township-scale targets that are protective of groundwater quality in wells, given the mix of land use, climate, soil properties, aquifer properties, and groundwater nitrate transport dynamics.  Secondary: inform coalitions and experts so that they can translate results into grower recommendations on what practices must be adopted to achieve targets.

2894 Given these differences in the administrative approach to the ILRP regulation, Regions 3 and 5  
2895 chose distinctly different modeling approaches: Region 3 relies on a N mass balance model of  
2896 individual fields. This N mass balance is directly tied to target/limits and incorporates elements  
2897 that incentivize good agricultural practices including use of regenerative and organic farming  
2898 methods (Chapter 1). Furthermore, Region 3 does not include a groundwater model and instead  
2899 employs the approach outlined in Chapter 6.3 above to justify a final limit of 50 lb N/ac/yr for the  
2900 N discharge computed from the N mass balance model. In contrast, Region 5 coalitions rely on  
2901 a set of numerical models that represent sub-field scale processes of the soil-water-plant  
2902 continuum, the deep vadose zone, and of groundwater flow and transport.

2903 Soil-crop, vadose zone, and hydrogeological models (such as those employed in Region 5) can  
2904 be used to estimate the factors that affect nitrate leaching to groundwater, including natural  
2905 recharge from clean water, aquifer geology, denitrification processes, and mix of crop types at  
2906 the sub-field / soil series scale across large landscapes to determine current risks to  
2907 groundwater from legacy activities and estimate future nitrate risk reduction from improved  
2908 management practices. The models can be applied to different size areas - from farm to  
2909 watershed scale. Some level of field validation should also be conducted to assure that the  
2910 employed simulation models provide accurate estimates of nitrate loading to groundwater.

2911 Region 5 is using the model CV-SWAT to determine nitrate leaching from the root zone based  
2912 on grower's reported A and R, and the CV-NPSAT framework to assess impacts of N discharge  
2913 on groundwater nitrate concentrations at a township scale. Root zone models, such as CV-  
2914 SWAT can be used to track site specific soil N transformations based on climate, soil, crop, and  
2915 irrigation and nutrient management practices. These transformations are not captured by A-R,  
2916 such as N mineralization or denitrification (similar but not the same as the "discount factors" in  
2917 Region 3).

2918 By coupling a soil-crop-water model like CV-SWAT to a hydrogeological model (e.g. CV-  
2919 NPSAT), the current and future impacts of changes in A, R, and soil processes on groundwater  
2920 nitrate concentrations can be estimated. Specifically, outcomes in domestic, public, and  
2921 irrigation water supplies are predicted. These simulation models are based on the principles of  
2922 water and N mass balance and fully track all water and N fluxes, thus providing an improved  
2923 estimate of N discharge, including N concentration in recharge to groundwater.

2924 The use of these water and N simulation tools is especially relevant in regions where the travel  
2925 time of water and nitrate from the root zone to groundwater is on the order of a decade or longer  
2926 and in regions where significant mixing of groundwater with recharge from streams, from  
2927 managed aquifer recharge operations, or from non-irrigated lands occur. In these situations,  
2928 simulation models allow for determination of how current or future improvements in A-R will  
2929 impact groundwater nitrate concentrations over time. They allow for a more comprehensive  
2930 assessment and prioritization of potential management practices and land use measures on  
2931 groundwater quality.

2932 By way of this modeling process, Region 5 estimates N discharge to groundwater and their  
2933 impacts on individual well water quality across all Central Valley wells. Coalitions use this  
2934 information and member-specific INMP summary reports in the work with their members to  
2935 develop individual farm improvements.

2936 This use of computer modeling is very appropriate and may be chosen as an approach by other  
2937 regions, but it is recognized that this approach may not be appropriate for all regions.

2938 For its practical implementation, the Region 5 approach to estimate N discharge to groundwater  
2939 – like the Region 3 approach - necessarily relies on simplifications/generic assumptions and is  
2940 subject to significant uncertainty relative to actual complex N processes at the field scale. For  
2941 example:

- 2942 • CV-SWAT explicitly tracks N into and out of the soil organic matter pool, at the “HRU” or  
2943 field-soil series scale, over the 30-year simulation. However, there is no measurement  
2944 against which these changes in soil organic matter (usually small) are matched. Further,  
2945 representations of N in various organic matter pools have not been updated with our most  
2946 recent scientific understanding of organic N cycling, including the interaction with soil  
2947 minerals. Reported results from the CV-SWAT simulation focus on the average N fluxes  
2948 over the 30-year simulation only. While growers report the amount of soil N available at the  
2949 beginning of the season from this pool in their INMP reports, CV-SWAT does not take this  
2950 information into account in the matching of INMP reports to CV-SWAT rootzone library runs.
- 2951 • This, in effect, means that the release of N from soil incorporation of cover crops (or the  
2952 prior soil N uptake of cover crops), and the year-over-year carry-over of N from soil  
2953 amendments is not explicitly accounted for. Incorporation of these transformations and  
2954 inter-annual processes, as explained elsewhere in this report, is difficult due to a lack of  
2955 data, let alone site-specific data.
- 2956 • Denitrification and many other processes in the CV-SWAT model necessarily rely on expert  
2957 analysis and scientific findings at locations different from a grower’s specific field.

2958 The CV-SWAT approach is an appropriate method to address site-specific conditions to account  
2959 for the processes that Ag Order 4.0 addresses via region-wide, tabularized uniform discount  
2960 factors. To the degree that CV-SWAT reflects the complexity of the agricultural cropping system  
2961 with more detail than the discount factors in Ag Order 4.0, it may provide a better estimate of the  
2962 N discharge to groundwater than the “N discharge” equation in Ag Order 4.0 Compliance  
2963 Pathways. But it’s accuracy has limitations due to data availability and model structural  
2964 uncertainty, an issue also discussed by the first Ag Expert Panel.

2965

## 2966 *6.5. Measurements of N Cycle Components, and Who Can Best Measure* 2967 *What, at Which Spatial Scale and How Often, by Farm System*

2968 While the models used by Regions 3 and 5, and hence the basic definition of the compliance  
2969 pathways are very different, both regions rely on very similar data collection at the grower/farm  
2970 level. In other words, the measurements that go into each region’s model are actually very  
2971 similar.

2972 Region 5 (Central Valley) agricultural water quality coalitions collect and evaluate five-yearly  
2973 Farm Evaluations (FE) and annual INMP Summary Reports, which they receive from individual  
2974 growers. The coalitions analyze and work with the detailed field- and crop-based data obtained  
2975 from growers and provide summary information in annual reports to the CV RWB (“Annual  
2976 Management Practice Implementation and Nitrogen Application Report”). The information  
2977 provided by growers in the INMP Summary Report to a grower’s respective coalition includes  
2978 (here quoted from the Wetlands Water Quality Coalition Annual Report Appendix I 2023, p.2):

- 2979 • General Information (site location, crop, crop age, acres),

- 2980 • Nitrogen applied in pounds per acre split by application type (N in irrigation water,
- 2981 organic amendments, dry/liquid fertilizers, and foliar fertilizers),
- 2982 • Yield per acre,
- 2983 • Production unit (tons, pounds, bins, etc.),
- 2984 • Primary and secondary irrigation methods,
- 2985 • Irrigation efficiencies applied,
- 2986 • Nitrogen efficiencies applied,
- 2987 • Acknowledgment of receipt of outlier notification, and
- 2988 • INMP certification method

2989 Region 5 requires reporting of both annual and multi-year evaluations of both, A/R and A-R.  
 2990 However multi-year evaluations are only performed on specific APN parcels that meet the  
 2991 following criteria:

- 2992 • Nitrogen applied (A) was reported for three consecutive years
- 2993 • Nitrogen removed (R) could be calculated for three consecutive years
- 2994 • The parcel was reported on by the same membership for three consecutive years
- 2995 • The same specific crop was grown on the parcel for three consecutive years (orchards
- 2996 only when at full production age)
- 2997 • Yield to N conversion factors are available

2998 In the development of three-year averages, removed N is calculated by multiplying yield with a  
 2999 removal coefficient. While coefficients for many crops are based on recent data from California  
 3000 and can be considered representative, they can vary considerably from one field to another.  
 3001 Therefore, the A-R values calculated for individual fields are estimates and not exact values. All  
 3002 of the fields need to be included with a minimum number of exceptions when calculating rolling  
 3003 three-year averages. The approach currently used by some Central Valley coalitions to  
 3004 calculate three-year averages for the identification of outliers does not meet this criterion: Only  
 3005 fields where the same crop has been grown for three consecutive years by the same grower are  
 3006 included. Fields with a rotation of annual crops and fields that were managed by different  
 3007 growers during the three-year period are excluded. This approach would not be appropriate to  
 3008 calculate three-year average A-R values that are subsequently compared to targets/limits.

3009 Region 5 requires growers in areas subject to a Groundwater Quality Management Plan  
 3010 (GQMP) to submit a Management Practice Implementation Report (MPIR) to their respective  
 3011 coalition (SWRCB Order WQ 2018-0002).

3012 The tables submitted to the Boards of Region 5, 7, and 8 and available to the Panel include a  
 3013 summary of management practices.

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3151 Southern San Joaquin Valley. University of California Agriculture and Natural Resources;  
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- 3155

3156 **Appendix**

3157 *A. Second Agricultural Expert Panel Members*

3158

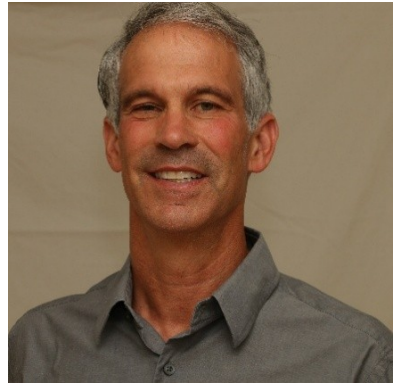
**Ngodoo Atume**, SGMA Technical Assistance for Small Farms Coordinator, UC Agriculture and Natural Resources (UC ANR)

Ngodoo Atume is a SGMA Small Farms Technical Assistance Coordinator at the University of California Agriculture and Natural Resources. Ngodoo works on groundwater policy in California primarily the implementation of the Sustainable Groundwater Management Act of 2014. She previously worked on the protection of drinking water communities under the Irrigated Lands Regulatory Program. She is interested in the equitable consideration and protection of groundwater users in California. Ngodoo has a bachelor's degree in Water Resources and Environmental Engineering and a master's degree in Sustainable Water Management.



**Michael Cahn**, UC Farm Advisor, Monterey, Santa Cruz, and San Benito Counties, (UC ANR)

Michael Cahn is an Irrigation and Water Resource Advisor for University of California, Cooperative Extension, based in Salinas CA. He received his B.S degree in Soil and Water Science from UC Davis, and Masters and Ph.D. degrees from Cornell University. He has worked for UC Cooperative Extension since 1995, first as a Vegetable and Row Crop Advisor in the Sacramento Valley, and since 2001 in his current position. His research and extension activities are focused on the areas of irrigation technology, water and nutrient management of vegetable and horticultural crops, protection of water quality, and food safety.



3159

**Ruth Dahlquist-Willard**, Interim Director of the University of California Sustainable Agriculture Research and Education Program (UC SAREP).

Ruth has led the recent reorganization of UC SAREP into an interdisciplinary program with the goal of addressing sustainability challenges across the food supply chain and integrating statewide efforts in food systems, organic agriculture, and small farms extension support. Ruth also served as a UCCE Small Farms and Specialty Crop Advisor in the Fresno area for ten years, where her extension program supported small-scale farmers from diverse communities through individual extension support, bilingual outreach and training, and research on small-acreage specialty crops, including studies on nitrogen uptake in niche vegetable and herb crops. Ruth holds a Ph.D. in Entomology from the University of Idaho and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE).



**Daniel Geisseler**, Cooperative Extension Specialist, UC Davis

Daniel Geisseler is a Cooperative Extension Specialist in the Department of Land, Air and Water Resources at UC Davis. Daniel's research and outreach focus on nutrient turnover and plant nutrition in agricultural systems. He is interested in the effects that different management practices have on nutrient use in California crops and how nutrient use efficiency can be improved, particularly with nitrogen. Daniel Geisseler has a PhD in Soil Science from UC Davis. He served as the chair of the Second Expert Panel.



**Thomas Harter**, Distinguished Professor and Professor of Cooperative Extension, UC Davis.

Thomas Harter holds the Nora S. Gustavsson Endowed Professorship for Groundwater Resources in Agriculture at the University of California, Davis. He maintains a unique research and extension program in agricultural groundwater hydrology developing novel understanding and solutions to address issues at the nexus of groundwater, the unsaturated zone, soils, and agriculture. His research group and their outreach/extension support focus on nonpoint-source pollution of groundwater, sustainable groundwater management, groundwater and vadose zone modeling, groundwater resources evaluation under uncertainty, groundwater-surface water interaction, and contaminant transport.



**Ali Montazar**, Irrigation and Water Management Advisor, Imperial County, UC ANR

Ali Montazar holds a Ph.D. in Water Science and Management and is currently an Irrigation and Water Management Farm Advisor with the University of California Cooperative Extension for Imperial, Riverside, and San Diego Counties. His research and extension efforts focus on irrigation management, sensor-based technologies, water conservation techniques and strategies, optimized irrigation and nitrogen practices, and salinity management.



**Richard Smith**, Emeritus Farm Advisor for Vegetable Crop Production and Weed Science, Monterey County, UC ANR

He worked for 38 years as a Vegetable Crop Farm Advisor working on crop production issues including nutrient management and plant nutrition. His research examined nutrient uptake by crops and strategies for improving nutrient use efficiency. Practices evaluated include the use of in-season nitrate testing to guide fertilizer applications and the role that cover crops and high carbon amendments play in reducing nitrate leaching during the winter fallow. He has an MS in Agronomy from UC Davis and retired in 2023.



**Hannah Waterhouse**, Assistant Professor of Agroecology and Watershed Ecology, UC Santa Cruz

Dr. Hannah Waterhouse is a soil biogeochemist interested in creating sustainable and resilient agroecosystems for healthy communities and watersheds. Her research is grounded in a coupled natural-human systems framework to develop socio-ecological relevant solutions for reducing nutrient loading from agricultural systems to the environment. To do so, she engages in participatory and on farm research focusing on how soil health management practices can leverage soil biogeochemical processes to beneficially influence nitrogen, carbon, and water cycling, and predicting outcomes of such practices at field to watershed scales. She leverages collaborations with rural sociologists, economists, and hydrologists to understand barriers and provide frameworks for holistically realizing sustainable and just agroecosystems. Hannah received her B.A. in Mathematics from Bryn Mawr College, as well as her Masters and PhD from UC Davis.



3161 **B. Charge Questions**

- 3162 1. Is there enough data and scientific research to set crop-specific nitrogen-related limits (e.g.,  
3163 A/R, A-R, or other limits) that are protective of groundwater quality and support a long-term  
3164 sustainable Irrigated Lands Regulatory Program? What metrics and methodology would be  
3165 used for developing those limits and what would the limits be? What additional data should  
3166 be collected and/or what additional research needs to be conducted to further support the  
3167 development of nitrogen-related limits that are protective of groundwater quality and support  
3168 a long-term sustainable Irrigated Lands Regulatory Program?
- 3169 2. Based on the data and scientific research that is currently available, what series of  
3170 increasingly protective interim nitrogen-related limits can be set now to ensure that all  
3171 growers make progress towards nitrogen-related limits that are protective of groundwater  
3172 quality and support a long-term sustainable Irrigated Lands Regulatory Program?
- 3173 3. Are there any scientific or technical considerations or advances related to the factors  
3174 discussed in the First Agricultural Expert Panel's 2014 Report that the State Water Board  
3175 should take into account in future policy decisions regarding implementation issues or the  
3176 direct enforceability of the nitrogen-related limits described above?
- 3177 4. Is A-R a scientifically appropriate metric to evaluate and quantify nitrogen discharges to  
3178 groundwater (either on its own or used in conjunction with A/R)? Are there any other  
3179 methods or metrics that could help quantify nitrogen discharges?
- 3180 5. The Eastern San Joaquin Water Quality Order includes additional aspects not specifically  
3181 recommended by the First Agricultural Expert Panel. For example, the Order requires the  
3182 submission of INMP summary tables.
- 3183 a) Are these tables, as they currently stand, an effective tool for evaluating A and R data?
- 3184 b) Is the INMP data that is being reported, including the format for that data reporting,  
3185 effective for the Water Board to assess reductions in nitrogen discharges to groundwater  
3186 and improvements in management practices, both on an individual grower basis and an  
3187 overall basis? Is the data capable of being used to confirm that follow up actions are  
3188 being appropriately prioritized (e.g., by distinguishing between overapplication on large  
3189 farms vs. overapplication on small farms)?
- 3190 c) What improvements should be made (if any) to data collection, reporting practices and  
3191 quality assurance procedures?
- 3192 d) Order WQ 2018-0002 directs Regional Boards to periodically audit the third party's  
3193 anonymous INMP records by spot checking that the field-level A and yield data reported  
3194 is being accurately transcribed and converted into A/R and A-R in the data tables  
3195 submitted to the Board. For the INMP data being collected through anonymous  
3196 identifiers, what level of auditing is necessary to ensure the data that's submitted can be  
3197 relied upon? Are there any improvements that can be made to ensure the data is  
3198 accurate and reliable?
- 3199 6. The 2021 Central Coast Ag Order established nitrogen application limits (AFER) based on  
3200 percentiles of known grower practices in the region and considered the California  
3201 Fertilization Guidelines on the California Department of Food and Agriculture website:  
3202 California Crop Fertilization Guidelines. This approach was remanded in the Central Coast

3203 Ag Petition Order. Is using AFER in this manner an appropriate metric for interim limits to  
3204 protect groundwater? If yes, what should those limits be?

3205 7. The 2021 Central Coast Ag Order included discount factors to A (compost [ACOMP], organic  
3206 fertilizer [AORG]), additional components of R (RSCAVENGE, RTREAT, and ROTHER), and  
3207 excluding nitrogen in irrigation water from the calculation of total nitrogen applied in  
3208 compliance pathways. Are the discount factors and additional components of R included in  
3209 the 2021 Central Coast Ag Order's compliance pathways appropriate measurements to  
3210 include in A and R calculations when measuring the potential to discharge nitrogen to  
3211 groundwater and, if so, are these applicable to use statewide?

3212 a) Does including the discount factors allow for a full accounting of the nitrogen that has the  
3213 potential to discharge to groundwater?

3214 b) Will including these additional components of R result in valid and comparable A/R and  
3215 A-R values between different growers?

3216 c) What are ways to incentivize the use of compost, organic fertilizers, cover crops, other  
3217 treatments, etc., that properly account for these practices in the calculations of the  
3218 potential to discharge nitrogen to groundwater (e.g., A/R and A-R)?

3219 d) Is incentivizing the use of nitrogen in irrigation water by excluding it from the calculation  
3220 of total nitrogen applied the most appropriate approach for accounting for and controlling  
3221 potential discharges to groundwater and reducing the overall concentrations of nitrates  
3222 in groundwater?

3223 8. Is there enough data and scientific research to conclude that small and/or small diversified  
3224 farms are operated in a fundamentally different manner that results in a reduced water  
3225 quality impact compared to larger farms, on a per acre basis? If yes, what criteria could be  
3226 used to identify the operations that have reduced water quality impacts?

3227 9. As summarized in footnote 33 of the Central Coast Ag Water Quality Order, the Eastern San  
3228 Joaquin Water Quality Order contains exemptions from its precedential nitrogen  
3229 management requirements for growers whose nitrogen-related practices do not impact  
3230 water quality, and also gives the regional boards the discretion to allow additional time or  
3231 alternative methods for three categories of growers to submit their R data. Is there enough  
3232 data and scientific research that would support any other exceptions to, or alternative  
3233 methods for complying with, the precedential nitrogen management requirements in the  
3234 Eastern San Joaquin Water Quality Order or any nitrogen-related limits or other  
3235 requirements recommended by the Expert Panel?

3236 *Footnote 33:* The irrigation and nitrogen management requirements in State Water Board  
3237 Order WQ 2018-0002 are not precedential for rice growers in the Central Valley region,  
3238 growers who never apply nitrogen to their fields, and growers who demonstrate that the  
3239 nitrogen applied to their fields does not percolate below the root zone in an amount that  
3240 could impact groundwater and does not migrate to surface water through discharges,  
3241 including drainage, runoff, or sediment erosion. In addition, the regional water boards were  
3242 given the discretion to apply alternative requirements to some or all growers in the following  
3243 categories: (1) growers who operate in areas with limited nitrogen impacts, have minimal  
3244 nitrogen inputs, and have difficulty measuring crop yield (e.g., some growers who operate  
3245 irrigated pastures), (2) diversified socially disadvantaged growers who do not operate more  
3246 than 45 acres, have annual sales less than \$350,000, and grow no fewer than an average of

3247 two different crops per acre, and (3) other growers who do not operate more than 20 acres  
3248 and grow no fewer than an average of two different crops per acre. The final three  
3249 categories of growers are required to report their A values, but the regional water boards  
3250 were given the discretion to determine when or how these growers will report their R values.  
3251 We take this opportunity to reiterate to the regional water boards that these are currently the  
3252 only authorized exceptions to our precedential direction in Order WQ 2018-0002. Based on  
3253 comments we received from the third party, we expect that the Central Coast Water Board  
3254 will, on remand, consider using this discretion as appropriate. We also encourage the  
3255 Central Coast Water Board to work closely with the third party to develop targeted education  
3256 in appropriate languages for reporting A prior to revising the General WDRs on remand.

3257

3258 ***C. Presentations Given at Expert Panel Meetings***

3259 List provided by Erica Kalve, SWQCB

3260

3261 **Plenary Sessions**

3262 August 8, 2025

3263 • Darrin Polhemus, State Water Resources Control Board: Overview of 2014 Expert Panel  
3264 Recommendations

3265 • Darrin Polhemus: Precedential Petition Order on Eastern San Joaquin General Waste  
3266 Discharge Requirements (WDR)

3267 • Eric Gillman, State Water Resources Control Board: State Water Board Order WQ-2023-  
3268 0081

3269 • Tess Dunham, Kahn Soares & Conway, LLP: Agricultural Perspective on Second Ag Expert  
3270 Panel

3271 • Abby Taylor-Silva, Kahn Soares & Conway, LLP: Central Coast Ag Partners' Insights on Key  
3272 Expert Panel Considerations

3273 • Kija Rivers, Community Water Center; Nat Kane, Environmental Law Foundation; Rosa  
3274 Carrillo Orozca, San Jerardo Cooperative: Considerations for the Expert Panel

3275 August 14, 2025

3276 • Dr. Enrique Salmon, California State University, East Bay: Indigenous Land Stewardship  
3277 and Food Systems

3278 • Kelsey Moore and Laleh Rastegarzadeh, State Water Resources Control Board: Statewide  
3279 Irrigated Lands Regulatory Program (ILRP) Program Nitrogen Data

3280 • Mary Hamilton and Elain Sahl, Central Coast Regional Water Quality Control Board:  
3281 Region 3 Data Analysis

3282 • Eric Warren, Central Valley Regional Water Quality Control Board: Region 5 Data Analysis

3283 • Amy Grove, San Diego Regional Water Quality Control Board: Region 9 Data Analysis

3284 • Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Central Coast Third-Party  
3285 Program Implementation

3286 • David Cory, Central Valley Salinity Coalition: Central Valley ILRP Data and Implementation

3287 • Melissa Turner, MLJ Environmental: Region 7 INMP Reporting and Groundwater Quality:  
3288 Challenges, Insights, and Progress

3289 • Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey,  
3290 Santa Clara University: Analysis of Central Valley and Central Coast Agricultural Fertilizer  
3291 and Shallow Groundwater Nitrate Data

3292 • Dr. Daniel Rath, Natural Resources Defense Council: Comparing Nitrogen Regulation  
3293 Globally and in California: Water Quality Impacts and Structure

3294

3295

3296 October 31, 2025

- 3297 • Secretary Karen Ross, Natalie Jacuzzi, and Scott Weeks, California Department of Food  
3298 and Agriculture: California Department of Food and Agriculture: Fertilizer Research and  
3299 Nutrient Management Support for Producers
- 3300 • Chief Deputy Director Karen Mogus, State Water Resources Control Board: Overview of  
3301 State Water Board Regulatory Processes and Procedures
- 3302 • Elaine Sahl, Central Coast Regional Water Quality Control Board: Central Coast (Region 3)  
3303 Ranch Level A – R Groundwater Quality
- 3304 • Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey,  
3305 Santa Clara University: Follow-Up Analysis of San Joaquin Valley (Region 5) Shallow  
3306 Groundwater Nitrate Data
- 3307 • Ramy Colfer, True Organic Products, Inc.: [No Title] Presentation on Organic Farming  
3308 Practices

3309

3310 **Public Listening Sessions (Presentations and Extended Public Comments)**

3311 October 1, 2025

- 3312 • Eric Morgan, Soil Health Lab, LLC: [No Title] Presentation on Cover Cropping
- 3313 • Elisha Wakefield, Los Angeles Regional Water Quality Control Board: Irrigated Agriculture in  
3314 the Los Angeles Region
- 3315 • Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Central Coast 3rd Party Group  
3316 Perspectives
- 3317 • Kenneth Miller, Formation Environmental: Response to: Scientific Literature Review  
3318 Questions Posed to the Upcoming Second Statewide Agricultural Expert Panel
- 3319 • Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey,  
3320 Santa Clara University: Follow-Up Analysis of Central Valley (Region 5) Agricultural Fertilizer  
3321 and Shallow Groundwater Nitrate Data
- 3322 • Eric B. Brennan, US Department of Agriculture, Agricultural Research Service: Why Nitrogen  
3323 Scavenging Credits for Non-legume, Winter Cover Crops are CRITICAL to Protect Water  
3324 Quality in California

3325 December 17, 2025

- 3326 • Margaret Champeny, State Water Resources Control Board: [No Title] Demonstration of the  
3327 Irrigated Lands Regulatory Program's INMP Summary Report Data Visualization Tool
- 3328 • Laleh Rastegarzadeh, State Water Resources Control Board: [No Title] Demonstration of  
3329 the 2025 ILRP and Nitrate Risk Map v2
- 3330 • Aaron Dillon, Plant California Alliance: Nursery Industry Perspective, Irrigated Lands  
3331 Regulatory Program – Second Statewide Agricultural Expert Panel
- 3332 • Danilu Jelderks and Christopher Hight, DRAM Agricultural Consulting, Inc.: Organic  
3333 Nitrogen Uptake and Fertility (Bettervia Farms Case Study)
- 3334 • Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Comments for Nitrogen  
3335 Expert Panel

3336 • Corrine Gibson, Leadership Counsel; Rosa Carrillo, San Jerardo Cooperative; Elias  
3337 Rodriguez, California Rural Legal Assistance, Inc.; Nathaniel Kane, Environmental Law  
3338 Foundation; Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; Dr. Iris Stewart  
3339 Frey, Santa Clara University; and Kija Rivers, Community Water Center: Recommendations  
3340 for the Expert Panel

3341 • Duncan MacEwan, PhD; Jay Noel, PhD; Steve Hatchett, PhD, ERA Economics: Economic  
3342 Analysis for the Irrigated Lands Regulatory Program

3343

## 3344 **Work Group Meetings**

### 3345 November 14, 2025

3346 • Eric Warren, Central Valley Regional Water Quality Control Board: Region 5 Data  
3347 Collection and Target Development

3348 • Ken Miller, Formation Environmental; and Tess Dunham, Kahn, Soares, and Conway:  
3349 Overview of Key Performance Metrics in the Central Valley ILRP

### 3350 December 5, 2025

3351 • Sierra Casteneda and Anna Gomez, Stanford University; and Eric Brennan, US  
3352 Department of Agriculture, Agricultural Research Service: Can non-legume fall-terminated  
3353 cover crops reduce nitrate-N leaching?

### 3354 December 12, 2025

3355 • Bruno J.L. Pitton, University of California Agriculture and Natural Resources: Nitrogen  
3356 Management in Nursery Production

3357 • Gerardo Spinelli, University of California Agriculture and Natural Resources: Runoff and  
3358 stormwater management practices for nurseries and greenhouses in San Diego and Los  
3359 Angeles

### 3360 January 7, 2026

3361 • Erik Porse and Divya Prakash, University of California Agriculture and Natural Resources:  
3362 Reported Nitrogen Application Rates Across Farm Sizes: Analyzing Data from the Central  
3363 Coast

3364 • Dr. Joji Muramoto, University of California Santa Cruz/University of California Agriculture  
3365 and Natural Resources: Immobilizing soil nitrate using high carbon amendments to reduce  
3366 nitrate leaching

### 3367 January 21, 2026

3368 • Stefanie Kortman, California State University Monterey Bay: Gaseous Nitrogen Losses  
3369 from Central Coast Specialty Crops

3370

3371 *D. Useful Information for Developing Exceptions and Alternative*  
3372 *Approaches*

3373 (these will eventually need to be sorted alphabetically and consistently formatted; these should  
3374 also include all presentations provided during the panel process that provide insights into these  
3375 systems – Thomas is working with SWRCB staff to help with an initial distribution of those  
3376 resources into the below as appropriate)

3377

3378 **On Winegrape Systems:**

3379 Kurtural, S.K., Stewart, D., Sumner, D.A. 2020. Sample costs to establish a vineyard and  
3380 produce winegrapes — North Coast Region, Napa County (Crush District 4). University of  
3381 California Agriculture and Natural Resources, Agricultural Issues Center, UC Davis.  
3382 [https://coststudyfiles.ucdavis.edu/uploads/cs\\_public/fe/24/fe24e27a-5c29-4cc3-a83c-](https://coststudyfiles.ucdavis.edu/uploads/cs_public/fe/24/fe24e27a-5c29-4cc3-a83c-63a31cd0c767/2020napawinegrape.pdf)  
3383 [63a31cd0c767/2020napawinegrape.pdf](https://coststudyfiles.ucdavis.edu/uploads/cs_public/fe/24/fe24e27a-5c29-4cc3-a83c-63a31cd0c767/2020napawinegrape.pdf)

3384 Note: demonstrates lower nitrogen application rates for Napa County winegrapes  
3385 compared to other regions.

3386 Zhuang, S., Fidelibus, M., Kurtural, S.K., Lund, K., Torres, G., Stewart, D., Sumner, D.A. 2019.  
3387 Sample costs to establish a vineyard and produce Cabernet Sauvignon winegrapes—  
3388 Southern San Joaquin Valley. University of California Agriculture and Natural Resources;  
3389 Agricultural Issues Center, University of California, Davis.  
3390 [https://coststudyfiles.ucdavis.edu/uploads/cs\\_public/2d/10/2d10450b-f265-45db-85d6-](https://coststudyfiles.ucdavis.edu/uploads/cs_public/2d/10/2d10450b-f265-45db-85d6-5b15a0fde6c0/19winegrapeessjvsouthcabernet.pdf)  
3391 [5b15a0fde6c0/19winegrapeessjvsouthcabernet.pdf](https://coststudyfiles.ucdavis.edu/uploads/cs_public/2d/10/2d10450b-f265-45db-85d6-5b15a0fde6c0/19winegrapeessjvsouthcabernet.pdf)

3392 Wine Institute Comments, submitted by the Wine Institute. 8/7/2026, and referenced at the  
3393 August 8<sup>th</sup> Kick-Off Plenary Meeting, Access via SWRCB Second Expert Panel FTP site.

3394

3395 **On Alfalfa and Clover-/Legume-based Pasture Systems:**

3396 Montazar, A. 2026. Alfalfa's regional value in the low desert: Field data document unmatched  
3397 nitrogen removal with minimal inputs. Agricultural Briefs, Vol. 29, Issue 1.

3398 Siskiyou County Flood Control and Water District Groundwater Sustainability Agency, Scott  
3399 Valley Groundwater Sustainability Plan, December 2021.

3400 *Note: demonstrates low nitrate impact in a basin with a century of alfalfa and pasture-system*  
3401 *agriculture.*

3402 Siskiyou County Flood Control and Water District Groundwater Sustainability Agency, Shasta  
3403 Valley Groundwater Sustainability Plan, 2021.

3404 *Note: demonstrates low nitrate impact in those parts of a groundwater basin with a long*  
3405 *history of alfalfa and pasture-system agriculture*

3406

3407 **On Nursery and Floral Industry Systems:**

3408 Pitton, B.J.L. 2025. Nitrogen management in nursery production. Presentation slides given at  
3409 the California Nursery Conference on September 10th, 2025, and referenced at the  
3410 October 1<sup>st</sup> Listening Session. Access via SWRCB Second Expert Panel FTP site.

3411

3412 **On Organic and Regenerative Farming Systems:**

3413 Brennan, E.B., Boyd, N.S., Smith, R.F., Foster, P. 2011. Comparison of rye and legume–rye  
3414 cover crop mixtures for vegetable production in California (Brennan et al). Agronomy  
3415 Journal, 103, 449-463. <https://doi.org/10.2134/agronj2010.0152>

3416 <https://access.onlinelibrary.wiley.com/doi/epdf/10.2134/agronj2010.0152>

3417 *Note: A 2-year study on organic farms in Salinas and Hollister that evaluated cover crop*  
3418 *population densities, ground cover, aboveground dry matter, and N content of rye and five*  
3419 *legume–rye mixtures.*

3420

3421 *E. Dissenting Opinions*

3422

3423 Some Regional Water Boards, and in some cases, the water quality coalitions working with their  
3424 Regional Water Boards, have provided information on their educational and outreach efforts to  
3425 date and, in some cases, on their planned educational and outreach activities. Instructions on  
3426 how to access the summary is available on [Second Statewide Agricultural Expert Panel -](#)  
3427 [Document Log](#).

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