

Reassessing the Role of Alternative Manure Management in California's Methane Reduction Strategy



CalCAN
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To produce this analysis, authors consulted with dairy industry advisors and dairy producers. CalCAN greatly appreciates all who took the time to provide valuable input and assistance with the drafting of this analysis.

Cover image: Year-around compost pack barn funded by the Alternative Manure Management Program

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EXECUTIVE SUMMARY

California's Alternative Manure Management Program (AMMP) supports dairy and livestock operations by reducing liquid and anaerobic manure management through practices that can achieve significant methane reductions and simultaneous improvements in various other environmental and agronomic outcomes. Facilitating wider adoption of alternative manure management practices is a highly effective way for the state to make progress towards multiple climate and environmental targets and requirements. However, as this report details, the state has not fully analyzed the multi-benefit role of AMMP practices or considered how coordinated interagency planning and increased support could maximize the program's impact.

The California Air Resources Board's (CARB's) 2022 [*Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target*](#)¹ projected that alternative manure management practices could make only a small contribution to California's methane reduction goals. While CARB's analysis recognized the general benefits of AMMP, it concluded that most of the state's methane reduction targets would be achieved through anaerobic digesters and enteric methane strategies.

This report proposes scenarios where alternative manure management could play a larger and more strategic role in meeting the state's methane, water quality, healthy soils, and organic transition targets. To conduct our analysis and our support claims, we draw upon scientific literature; technical and policy reports; state agency data; and interviews and collaboration with dairy producers, dairy industry technical assistance providers, and other relevant experts. While we do not attempt to create the in-depth modeling of AMMP practices that would be needed for a fuller understanding, we call on the relevant state agencies to conduct this analysis in partnership with external experts.

¹ California Air Resources Board. (2022). *Analysis of progress toward achieving the 2030 dairy and livestock sector methane emissions target*. <https://ww2.arb.ca.gov/resources/documents/dairy-livestock-sb1383-analysis>

KEY FINDINGS

- **The AMMP scenarios in CARB’s 2022 analysis do not capture the potential role alternative manure management practices could play in achieving California’s methane targets. Section 2 of this report discusses the opportunities and limitations for updating the data, metrics, and methodologies used for AMMP in the 2022 analysis.** Further, the 2022 analysis assumes various trends limiting potential reductions, but new data, research, and state policies warrant revisiting those assumptions and considering more ambitious scenarios. Section 2 also identifies ways the state could enhance AMMP impacts.
- **If 50–75 percent of California’s dairy industry adopted alternative manure management practices, methane reductions could approach the additional 4.4 million metric tons of carbon dioxide equivalent (MMTCO₂e) needed to meet SB 1383 (Lara, 2016) targets.** These scenarios apply the same methodology as CARB’s 2022 analysis used for enteric methane strategies. These scenarios are not predictions or based on current trends. Instead, they help illustrate the upper limits of possible alternative manure management reductions. (See Section 3.)
- **Using updated calculations, AMMP is the fourth most cost-effective California Climate Investments program tracked by CARB.** CARB’s cost-effectiveness analysis underestimates AMMP by making an unjustified assumption of a five-year project lifespan for AMMP projects. Evidence from producer surveys and technical assistance providers suggests that most AMMP projects last beyond five years, and a ten-year calculation is likely appropriate. (See Section 4.)
- **Alternative manure management offers key co-benefits that support broader state targets related to water quality, healthy soils, and organic transition.** The co-benefits of alternative manure management could play a vital role in meeting various state targets and regulatory requirements beyond methane reductions, for example, helping dairies comply with the State Water Board’s Draft Dairy Order by reducing nitrogen loading, or supplying compost needed to meet the state’s organic transition and healthy soil practice targets set by AB 1757 (Garcia, 2022). (See Section 5.)

POLICY RECOMMENDATIONS

Based on our analysis and findings, we offer the following recommendations to CARB and the California Department of Food and Agriculture (CDFA) to fully understand and realize the potential of alternative manure management and to enhance AMMP's effectiveness, scalability, and integration into broader environmental mandates.

Improve Cross-Agency Modeling and Planning

- Establish an interagency task force including CARB, CDFA, the State Water Resources Control Board, California Department of Resources Recycling and Recovery (CalRecycle), and relevant external experts to reassess the full potential of AMMP and related practices. This group should coordinate scenario modeling that accounts for methane, nitrogen, water quality, and soil health impacts.

Update Modeling Assumptions and Program Evaluations

- CARB should update AMMP's project lifespan assumptions to 10 years to align with the Dairy Digester Research and Development Program (DDRDP).
- CDFA should conduct a survey of AMMP recipients with completed projects, i.e., those who have passed the five years of required reporting to CDFA, to assess the persistence rate of different AMMP practices.

Update Emission Reductions Reporting Metrics While Improving Equitable Access

- Require manure emissions inventories in manure methane programs to apply to the facility's full herd, not just the portion of the herd within the project boundary.
- Utilize per-animal and full-facility reduction metrics for program evaluation and modeling.
- Prioritize full-facility percent reduction and per-animal reduction in the ranking of AMMP applications during project selection. This is a more size- and type-neutral approach than using per-project reductions.

Increase Support for Expanded Adoption and Stacked Practices

- CARB should update the AMMP calculator to (1) allow applicants to report more than one primary practice, and (2) allow projects to specify when they apply different practices to different portions of the facility.
- Direct technical assistance providers to stack funding for AMMP with federal and other sources to allow more projects to implement multiple practices.

Address Technical, Regulatory, and Knowledge Barriers to Practices

- Increase CDFA funding for AMMP pre-application and post-award technical assistance, including design, permitting, composting support and funding to train new AMMP technical assistance providers.
- Implement an efficient and effective process for approving manure composting projects, drawing on the findings and recommendations outlined in reports from Sustainable Conservation and the Manure Recycling and Innovative Products Task Force
- Invest in research and market infrastructure to address barriers to alternative manure management practices, including potential new and emerging technologies that can help achieve high methane reductions and/or co-benefits.

CONCLUSION

The state must revisit its modeling of alternative manure management to reflect the full potential of these practices in reducing methane and delivering environmental co-benefits. This effort should be a multi-agency collaboration between CARB, the State Water Resources Control Board, CalRecycle, CDFA, other relevant agencies, and a stakeholder group of experts that includes those with experience in modeling manure management's methane, water quality, and air quality impacts as well as other related topics such as soil health and organic agriculture. A more comprehensive, collaborative, and scenario-driven analysis will provide a stronger foundation for policy decisions, funding allocations, and future program design.

1. Introduction

A. Background

CARB estimates livestock emit approximately 70 percent of California's agricultural sector greenhouse gases (GHGs). Livestock emissions in the state peaked in 2012 at 23.9 million metric tons of carbon dioxide equivalent (MMT CO_2e) and have decreased by 3.0 MMT CO_2e (12.6 percent) to 20.9 MMT CO_2e as of 2022,² partially due to a decrease in total livestock population and partially due to the implementation of methane reduction techniques. Livestock emissions are almost entirely methane (CH_4) generated from enteric fermentation and manure management. CARB calculates that livestock generate more than half of the state's total CH_4 emissions, mostly coming from dairy operations. In 2016, SB 1383 (Lara) established Short-Lived Climate Pollution (SLCP) reduction targets and required CARB to implement a Short-Lived Climate Pollutant Reduction Strategy to achieve these targets. For the dairy and livestock sector, CARB has set the target at 9.0 MMT CO_2e below 2013 levels.

The Dairy Digester Research and Development Program (DDRDP), created in 2015, was initially the state's sole strategy for reducing methane emissions associated with dairy production. This program funds anaerobic digester projects that capture and use biogas.

In 2017, SB 859 acknowledged that a diversity of dairy methane management practices, including anaerobic digesters and non-digester strategies, could effectively reduce greenhouse gas emissions. The non-digester strategies named in the bill included scrape conversion, open solar drying and composting of manure on-site. CDFA created the Alternative Manure Management Program (AMMP), which funds these practices, as well as others, to reduce volatile solids entering anaerobic conditions conducive to methane formation. Alternative manure management practices include flush-to-scrape conversion, solid-liquid separation with solar drying or composting, and increased time on pasture. In 2023, the U.S. Department of Agriculture (USDA) Advancing Markets for Producers (formerly known as Partnerships for Climate Smart Commodities) created an opportunity for the California Dairy Research Foundation (CDRF) to collaborate with CDFA to launch the [Dairy Plus Program](#) to implement practices that reduce both methane emissions and nitrogen surplus at dairies.

B. CARB's 2022 Report

In 2022 (as required under SB 1383), CARB released a report, [Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target](#), that projected that, without additional funding, the dairy and livestock sector would reach just over half of the reductions in annual methane emissions necessary to achieve the target by 2030. Their analysis in Table 1 (copied below from the 2022 report) shows that most of the reductions so far have come from anaerobic digesters and decreases in total herd populations,³ while a much smaller reduction has come from AMMP. After accounting for reduced herd populations, CARB projected that the state must reduce an additional 4.4 MMT CO_2e from manure management and enteric sources to hit the 2030 targets.

² California Air Resources Board (CARB). (2024). *California greenhouse gas emissions from 2000 to 2022: Trends of emissions and other indicators*. https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_2022_ghg_inventory_trends.pdf

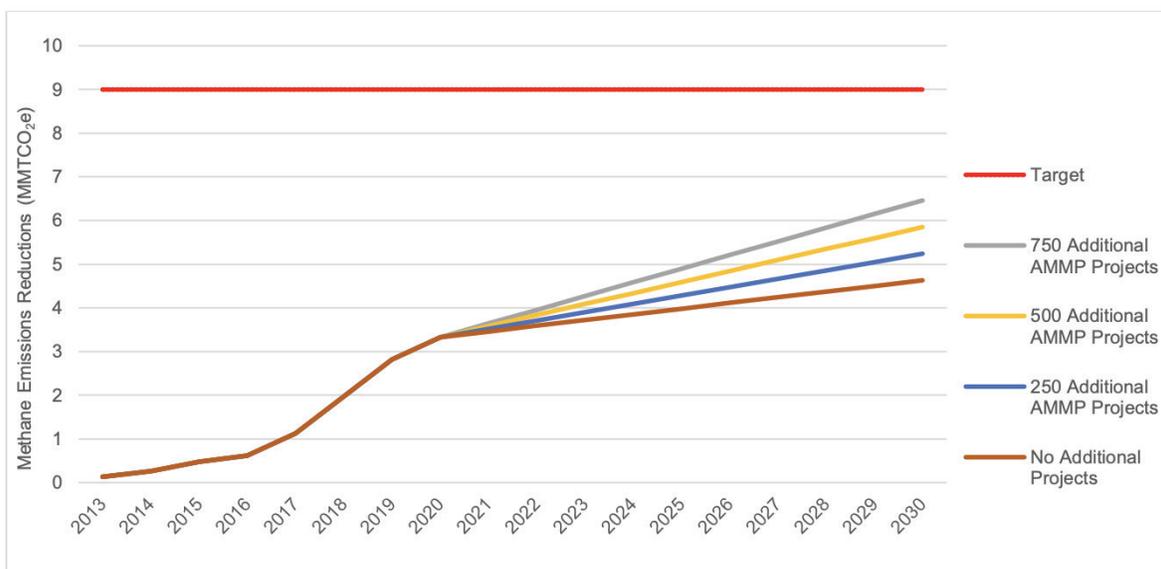
³ Reductions in total herd populations within the borders of California may or may not represent actual reductions in U.S. dairy herd emissions; it may simply represent movement of dairies and/or cows out of state, which may be a case of leakage rather than an actual reduction in global emissions.

Table 1: CARB’s Estimated California Dairy and Livestock Methane Emissions Reduction by the End of 2022

Reduction Type		Number of Projects Funded through FY 2019-20	Expected Emissions Reductions Through 2022 (MMTCO ₂ e)
Population Change		Not Applicable	1.3
Anaerobic Digester	State-funded (DDRDP)	118	1.8
	Privately funded	5	0.1
Alternative Manure Management Practices	State-funded (AMMP)	115	0.2
	Privately funded	40	0.1
Total		278	3.5

Figure A is CARB’s 2022 projection of the additional methane reduction potential of AMMP through 2030. CARB projected that funding an extra 750 AMMP projects would lead to California falling short of reaching the 2030 methane reduction goals set by SB 1383. The projection led CARB to conclude that alternative manure management practices alone cannot achieve methane reduction targets and that methane digesters and enteric strategies would be necessary to achieve SB 1383 goals.⁴

Figure A: CARB’s 2022 Projected Annual Dairy and Livestock Sector Methane Emissions Reductions through 2030 Resulting from Implementing Additional AMMP Projects



⁴ On page 13 of its 2022 analysis, CARB writes, “Based on this approach, at least 210 anaerobic digestion and 210 alternative manure management projects are necessary to achieve the remaining 4.4 MMTCO₂e in methane emissions reductions. However, future project types may vary depending upon available incentives and operator preference. If only dairy digester projects were implemented—which are about 10 times as effective at reducing emissions than alternative manure management projects—over 230 projects would be necessary to achieve this level of emissions reductions. With respect to alternative manure management practices, based on currently funded projects and reduction trends observed to date, staff’s analysis indicates that the state would be unable to achieve the 2030 dairy and livestock sector target through deployment of alternative manure management practices alone.”

CARB's methodology for creating Figure A was to take the total reported annual methane reduction of all the AMMP projects funded by CDFA to that point, divide that total by the number of projects to get an average, and multiply that average by 250, 500, and 750.⁵ In this report, we show that this methodology did not fully account for the methane reduction potential of alternative manure management practices, and we propose a different approach.

CARB also calculated the cost-effectiveness of AMMP and DDRDP in its 2022 report and used those calculations to inform various incentive funding scenarios. In calculating the cost-effectiveness of those two programs, CARB assumed that AMMP projects would have half the lifespan of DDRDP projects (five years rather than ten). Newer research and observations do not support the assumption that AMMP project lifespans are only five years, and this report presents updated AMMP cost-effectiveness calculations to reflect a ten-year project lifespan.

C. Overview of Analysis and Findings in This Report

This report is organized as follows:

[Section 2](#) reviews available AMMP program data on methane reductions; practice-specific technical documents; other recent data and publications; and relevant policy developments. It highlights opportunities to build on existing state analysis and to strengthen AMMP implementation, tracking, and evaluation.

[Section 3](#) creates scenarios for alternative manure management practices using the same methodology that CARB's 2022 report applied to enteric solutions, showing that widespread adoption of alternative manure management practices across the industry could play a significant role in methane reduction.

[Section 4](#) shows that CARB uses a ten-year lifespan projection for DDRDP projects to calculate total emissions reductions and cost-effectiveness but only uses a five-year lifespan projection for AMMP. This section shows that those assumptions are not justified and that newer research and observations support longer AMMP projections. Section 4 makes a new calculation for AMMP cost-effectiveness.

[Section 5](#) explores how the co-benefits of alternative manure management practices could drive increased interest in funding. The practices could play a vital role in meeting the new water quality requirements outlined in the Draft Dairy Order (October 2024) and producing the compost needed for the state to achieve organic agriculture transition and soil health targets. This section outlines scenarios of compost production potential through alternative manure management practices and calls for more in-depth scenario modeling of all co-benefits.

⁵ The methane emissions reductions of AMMP projects are estimated using the CARB AMMP calculator, which CARB has developed and updated throughout the existence of AMMP based on scientific literature, the Intergovernmental Panel on Climate Change (IPCC) livestock protocol, and feedback and input from experts.

2. Opportunities To Update Data, Metrics, and Methodologies in AMMP Projection Scenarios

CARB's 2022 report projected AMMP's future methane reductions by multiplying current average project reductions by hypothetical future project counts (250, 500, and 750), assuming continued reduction trends. While these projections provide a helpful baseline, and conservative assessments using existing averages are understandable, this section will show why reassessments with different methodologies and data are needed, and why it is necessary to revisit CARB's 2022 conclusion that alternative manure management can only play a minor role in meeting California's methane reduction targets.

This section analyzes the factors that have shaped variation in AMMP project outcomes and demonstrates that average reductions are the product of policy and funding decisions and implementation dynamics, not inherent limitations in the practices themselves. Section 2A examines sources of variation across AMMP projects, including differences in herd size, housing types, number of new practices implemented, use of matching funds, and use of emerging technologies. It also highlights limitations in the current AMMP calculator that affect reported outcomes.

Section 2B explores how shifts in incentives, program design, and regulatory drivers, such as new water quality mandates, could shape future implementation and methane reductions. Together, these analyses point to the need for CARB to adopt a more dynamic, scenario-based approach.

CARB's 2022 analysis used AMMP and DDRDP data from the agency's California Climate Investments (CCI) Database of Implemented GGRF Projects obtained in December 2020. Our report analyzed more recent AMMP data from the CCI Database, AMMP⁶ and DDRDP⁷ datasets for projects funded up to the 2023 application period,⁸ and additional aggregated and anonymized AMMP and DDRDP summary data obtained directly from CDFA (see [supporting data summary](#)). We obtained the herd size data from the [California Dairy and Livestock Database](#), which was made publicly available for the first time in August 2024.⁹

The emissions reduction estimates from these datasets all come from AMMP and DDRDP project applications and may not represent the real-life emissions reductions, which are unknown without extensive monitoring. AMMP project applicants use CARB's AMMP Benefits Calculator Tool (AMMP calculator) to estimate baseline and post-project methane emissions.¹⁰ It is important to note that some manure management experts dispute aspects of the calculator.¹¹ Methane reduction rates can vary based on conditions, and improper management can lessen reduction rates. However, the purpose of this analysis is not to call the underlying data into question, but rather, to suggest more robust and accurate analysis of that data.

⁶ California Department of Food and Agriculture. (2025). *Alternative Manure Management Program incentive project-level data* [Dataset]. https://www.cdfa.ca.gov/oefi/AMMP/docs/AMMP_Project_Level_Data.pdf

⁷ California Department of Food and Agriculture. (2025). *Dairy Digester Research and Development Program project-level data* [Dataset]. https://www.cdfa.ca.gov/oefi/DDRDP/docs/DDRDP_Project_Level_Data.pdf

⁸ In April 2025, CDFA announced the awardees from the 2024 project application period, but at time of publication had not yet incorporated the 2024 projects into the publicly available full project-level data sheets for each program.

⁹ California Air Resources Board. (2024). *California dairy and livestock database facility herd size table v1.0.0* [Dataset]. https://ww2.arb.ca.gov/sites/default/files/20248/CADD_Facility%20Herd%20Size_v1.0.0.csv

¹⁰ Calculator can be downloaded from CARB's webpage here: https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/cdfa_ddrdp_finalcalculatortool_7-19-2024.xlsx.

¹¹ See, for example, the discussion on incorporating bedding and recycled manure into mechanical separator calculations in Chapter 3 of [Research and Technical Analysis to Support and Improve the Alternative Manure Management Program Quantification Methodology](#).

A. Wide Variance in AMMP Project Outcomes Reflects Differences in Baseline Emissions, Practice Implementation, and Program Design

CARB’s 2022 analysis projections of AMMP’s future potential assume that the program’s average methane reductions per project will remain relatively static. But as this section shows, average project-level reductions are not a fixed attribute of the practices themselves; they are the outcome of multiple variations across projects: baseline emissions, housing and herd types, the number and type of practices adopted, and how fully each practice is implemented within a dairy. These variations reflect both the flexibility and limitations of data, metrics, and methodologies that have been used to assess AMMP.

To highlight the large difference in per-project reductions, Table 2 shows that the top 10 percent of projects average over 5,600 metric tons of carbon dioxide equivalent (MTCO₂e) in annual reductions, more than three times the overall program average of 1,679 MTCO₂e. The bottom 10 percent of projects average just 194 MTCO₂e.

The table in Appendix 1 provides project-level data, including herd size and descriptive notes, for a sample of high- and low-performing AMMP projects.¹²

Table 2. Differences in Methane Reductions Across AMMP Projects (MTCO₂e)

Group	Average Annual CH ₄ Reduction (MTCO ₂ e)
Top 10% of Projects	5,660
Overall Program Average	1,679
Bottom 10% of Projects	194

Table 3 updates CARB’s 2022 report methodology with the latest CDFA project-level data by calculating the overall average methane reduction for all AMMP projects and each of the top three most popular AMMP practices.¹³ As in CARB’s 2022 report, flush-to-scrape is the practice with the highest average reduction, achieving nearly twice the average for all practices. Multiplying the average reduction of each category by 250, 500, and 750 projects allows for comparison with CARB’s 2022 projections (see Table 1 and Figure A of this report). This disaggregation shows how the program’s future impact could vary depending on the mix of practices supported. While the type of management practice explains some of the variation, baseline emissions, herd size and composition, scope implementation, and stacking of practices also drive outcomes.

¹² Names of sample dairies have been removed and replaced with a numerical identification.

¹³ As done by CARB on p. 17 of the 2022 analysis.

Table 3: Estimated Annual Methane Reduction Potential of AMMP Projects by Practice through 2023 (MT CO₂e)

Number of Projects	All Practice Average	Compost Bedded Pack	Solid Separation	Flush-to-Scrape
1 (average)	1679	1516	1573	2965
250	419,750	378,955	393,250	741,250
500	839,500	757,911	786,500	1,482,500
750	1,259,250	1,136,866	1,179,750	2,223,750

i. AMMP Projects Have Lower Baseline Emissions than DDRDP

AMMP project emissions are calculated from an estimate of the volume of total volatile solids entering a lagoon through the manure stream before and after the implementation of the AMMP project. Logically, operations and projects with lower starting total volatile solids entering lagoons have less potential to reduce emissions. AMMP was created in part to provide an option for California’s small and medium-sized, organic, and pasture-based dairies where installing a digester with assistance from DDRDP may not have been economically feasible or practical for their style of manure management.

Though data limitations preclude definitive conclusions, the participation of these operations in AMMP likely brings down the average per-project reductions when compared to DDRDP. Thus, AMMP projections and assessments prioritizing per-project emissions can disadvantage many smaller, organic, and pasture-based operations. CARB acknowledges the important role AMMP plays in reaching these operations, so it is worth pursuing other approaches to scenario modeling, such as per-cow reductions, that more accurately assess relative reductions on small and mid-sized farms.

Smaller operations have smaller manure streams and thus less potential for methane reduction. According to data provided by CDFA for projects funded through the 2023 application period (see [supporting data summary](#)), the average number of livestock per project is 1,786 for AMMP and 6,209 for DDRDP. These averages refer to the number of livestock included within project boundaries rather than the total size of the operation.

**AMMP Calculator and Available Project Data
Prevent More Accurate Assessments**

AMMP projects do not require applicants to report methane reductions as a percentage of the facilities’ total herd emissions. Projects are only evaluated based on the portion of the herd and manure stream covered by the grant-funded practice. This limits the analysis of methane reduction differences.

Proposal: Require applicants to complete an emissions inventory for the facility’s entire herd and estimate project-level reductions as a share of that baseline. This would allow more consistent evaluation across dairies of different sizes and support more strategic funding decisions.

Proposal: Update the AMMP calculator to allow applicants to include more than one practice and adjust for which practices are applied to different portions of an operation.

Pasture-based dairies typically report very low baseline emissions under CARB's Quantification Methodology (QM) because cows on pasture deposit manure directly onto fields without anaerobic storage. This significantly limits the methane reduction potential that can be credited through AMMP, even if the farm adds infrastructure to manage manure during seasonal confinement or in specific areas of the operation.

Similarly, projects with high numbers of heifers, dry cows, or open lots of lactating cows will have lower baseline emissions. CARB's QM calculates 70 percent of manure from animals in open lots is deposited on land, with only 30 percent requiring collection. By contrast, the QM calculates that lactating cows housed in free stalls deposit 80 percent of their manure on concrete surfaces that feed into anaerobic storage. Additionally, heifers and dry cows produce less manure per day than milking cows. Thus, there is a lower methane reduction potential for any project involving large numbers of heifers, dry cows, or lactating cows in open lot corrals.

Availability of Additional Metrics Would Enable More Equitable and Comprehensive Evaluation of Methane Reductions

Because AMMP serves a wide range of dairy sizes and facility types, project-level reductions alone are not adequate for analyzing program effectiveness. Including other metrics, such as methane reduction per animal or as a percentage reduced from total operation baseline emissions, may allow for a fairer, more complete project comparison and overall program analysis.

While the latter would require substantial additions to AMMP's application requirements and Benefits Calculator, applicants already calculate per-animal reductions for the herd within the project's boundary. Per-animal assessments help identify high-impact projects across different operation scales and avoid biasing funding toward large herds with inherently higher absolute emissions. Per-animal metrics could also help identify particularly cost-effective or well-designed projects, even when total reductions are modest.

Proposal: CDFA and CARB should publish per-animal reduction values (for both the project herd and the total operation herd) for AMMP and DDRDP projects and incorporate per-animal and other metrics into scenario modeling.

ii. Project Implementation Further Shapes Reductions

Table 4 illustrates that AMMP projects report substantial differences in percent effectiveness, even for the same practice and baseline emissions. Table 4 uses data reported in AMMP applications and shows the lowest, highest, and average percentage reductions reported for the three most common AMMP practices.¹⁴

¹⁴ There is one listed project with 0 percent methane. The project's description proposes replacing a low-functioning outdated separator system with a new separator to allow for a significant increase of solids removal. In reality, this project likely did achieve methane reductions, but the AMMP calculator was not able to account for the reduced efficiency of the outdated separator, so the application showed equal starting and ending separation rates. Currently, the AMMP calculator has an option to adjust for baseline separators with degraded efficiency, but this option was added more recently. This example gives more evidence of the unreliability of relying on the averages of self-reported data of past AMMP projects to calculate future scenarios.

Table 4: AMMP project manure management CH₄ emissions reduction from baseline (2019-2023; only for animals in project boundary)

Primary practice	Lowest % reduction	Highest % reduction	Average % reduction
Solid separation	0%	87%	26%
Compost-bedded pack barn	28%	92%	69%
Flush-to-scrape	24%	85%	62%

Projects can stack practices to achieve greater methane reductions. For example, two dairies of the same size might each receive AMMP funding to install a sloped screen separator. One may install it across a manure stream containing multiple flushed free stalls, while another may install it on one free stall. Some projects also combine multiple types of practices, like flush-to-scrape conversion with a separator, while others install only one piece of equipment. The scope and manner of implementation can play a major role in project outcomes.

As an example of stacking practices, Dairy #32 in Appendix 1 is the AMMP project with the highest reported annual emissions reductions (11,118 MTCO₂e) as of 2023. Dairy #32 used AMMP to convert from a flush to a vacuum scrape system and installed two solid separators to allow for drying and composting of the vacuumed slurry. With a herd size of 4,500, Dairy #32 reported an 83 percent reduction in CH₄ emissions.

Differences in existing site layout, drainage, equipment access, and the capacity for the operation to match grant funding can influence how efficiently a project can use an AMMP grant. The Small Dairy Climate Change Research report commissioned for CDFA confirms this, documenting how physical and financial constraints affect implementation scope and technology adoption.¹⁵

Overall, AMMP’s flexibility enables participation from a broader range of dairies than DDRDP, but it also results in substantial variation in practice combinations and implementation levels. This diversity is not a flaw, but a defining feature of the program, and one that complicates comparisons with more uniform strategies like digesters. Scenario modeling of AMMP could explore policy and funding scenarios that facilitate more dairies stacking AMMP practices and achieving higher methane reductions.

iii. Advanced Technologies Show Higher Performance and Merit Broader Consideration

In its 2022 analysis, CARB acknowledged the potential for higher methane emission reductions through wider adoption of “advanced” manure management practices, but did not include this possibility in its AMMP scenarios or assessment. Many of these advanced practices need California field trials to prove viability and/or lack general methane reduction data from non-biased sources. The Dairy Plus Program is supporting some of these advanced manure practices (Table 5), and the USDA grant that funds the program is also funding monitoring and evaluation. As this data becomes available in the near future, it may be appropriate to incorporate these options into future projection scenarios.

AMMP first included vermifiltration and advanced solid separation practices, including using flocculants and/or bead filters, in its 2022 grant round and has supported weeping walls since the start of the program. However,

¹⁵ Mullinax, D., Meyer, D., & Sumner, D. (2020). *An economic evaluation of strategies for methane emission reduction effectiveness and appropriateness in small and large California dairies*. CDFA. https://www.cdfa.ca.gov/oefi/research/docs/CDFA_SmallDairyResearch_FINAL_Report.pdf

due to the introduction of the Dairy Plus Program in 2023, AMMP does not yet have funded examples of advanced solid separation practices, as applicants opted to leverage the increased funding through the Dairy Plus Program for these more extensive and expensive technologies.

For example, one vermifiltration project was awarded an AMMP grant in 2022 but chose to decline the grant to pursue additional funding through the Dairy Plus Program in 2023. That project had an estimated reduction of 7,813 MTCO₂e annually, which is over four times higher than the AMMP average for all practices. Other examples of past AMMP projects that installed weeping walls are listed in Appendix 1. These include Dairy #22 and #27, which are among the AMMP projects with the highest reported methane reduction rates and cost-effectiveness.

Table 5 uses CDFA’s reported data on the Dairy Plus AMMP track [list of awarded practices](#).¹⁶ Table 5 shows that funding 750 Dairy Plus-style projects could yield approximately 3.7 MMTCO₂e in reductions, approaching the 4.4 MMTCO₂e in additional reductions that CARB estimated the dairy and livestock sector would need to achieve by 2030. These projections may not reflect realistic scenarios, but they highlight the importance of incorporating advanced manure management practices into comprehensive scenario modeling.

Table 5: Projections from Dairy Plus (AMMP track) Project Reductions MMT CO₂e.

Number of Projects	All Practice Average	Vermifiltration	Weeping Wall	Advanced Separation
1	4,939	5,706	4,584	3,967
250	1,234,804	1,426,500	1,146,000	991,713
500	2,469,500	2,853,000	2,292,000	1,983,425
750	3,704,250	4,279,500	3,438,000	2,975,250

There are also other emerging advanced manure management practices that are not currently supported by AMMP, but that may merit future support. For example, recent research suggests that broader inclusion of practices like biochar-composting should be considered in AMMP scenario modeling. In a trial on a California dairy, researchers found that co-composting with wood-derived biochar reduced methane emissions by 58 percent, volatile organic compounds by 61 percent, hydrogen sulfide by 67 percent, and nitric oxide by 70 percent due to biochar’s porous structure and oxygen-enhancing properties that suppress anaerobic conditions during the thermophilic composting phase.¹⁷

Another study found methane reductions up to 80 percent in peak stages, though nitrous oxide responses varied based on biochar properties. Researchers also modeled scenarios in which California dairies that are already operating digesters with solid separators replace manure stockpiling with biochar-composting. They found that this combination could improve statewide CH₄ mitigation by 29 percent.¹⁸

¹⁶ California Department of Food and Agriculture. (2025). *2023 Dairy Plus Program (AMMP track) projects selected for awareness of funds* [Dataset]. https://www.cdffa.ca.gov/oefi/dairyplus/docs/2023_DairyPlusAMMP_ProjectsAwarded.pdf

¹⁷ Harrison, B. P., Moo, Z., Perez-Agredano, E., Gao, S., Zhang, X., & Ryals, R. (2024). Biochar-composting substantially reduces methane and air pollutant emissions from dairy manure. *Environmental Research Letters*, 19(1), 014081. <https://doi.org/10.1088/1748-9326/ad1ad2>

¹⁸ Harrison, B. P., Gao, S., Thao, T., Gonzales, M. L., Williams, K. L., Scott, N., Hale, L., Ghezzehei, T., Diaz, G., & Ryals, R. A. (2024). Methane and nitrous oxide emissions during biochar-composting are driven by biochar application rate and aggregate formation. *GCB Bioenergy*, 16(1), e13121. <https://doi.org/10.1111/gcbb/13121>

CDFa previously excluded biochar from AMMP eligibility on the grounds that its benefits were limited to soil carbon sequestration, but these recent field-scale studies show it can directly reduce methane during composting.¹⁹ This evidence may support reconsideration of composting with biochar as an eligible manure treatment and/or storage practice for separated or scrape-collected solids.

There may be limitations to the widespread adoption of these newer practices. Vermifiltration can generate large volumes of compostable solids that may exceed a dairy's handling capacity, and scaling these systems remains a logistical and regulatory challenge. Advanced solid separation systems leave behind nutrient-rich effluent that requires careful storage or application.²⁰

B. Assessing Future Potential: How AMMP's Impact Could Grow Under Evolving Conditions

More in-depth scenario modeling is needed to fully assess the potential role of AMMP in achieving California's methane targets. Such modeling would allow policymakers to test the impact of different policies and program designs and consider scenarios where alternative manure management practices achieve significantly larger methane reductions than projected in CARB's 2022 analysis.

This section justifies consideration of such scenarios by outlining some examples of factors that could increase methane reductions from AMMP-supported practices: (1) expanded program funding that enables practice stacking and implementation across larger portions of the herd; (2) greater producer demand and state interest in funding to meet water quality regulations, environmental justice outcomes, and organic transition and healthy soil practice targets; and (3) increases in average project effectiveness through prioritization and technical assistance. Together, these shifts would allow AMMP and related initiatives to scale beyond historical averages and play a larger role in meeting California's methane reduction targets.

i. Expanded Adoption Through Increased Funding

One key factor that has shaped the scale of AMMP adoption and the emissions reductions achieved to date is limits in program funding and overall incentives for alternative management. Increased funding would allow for more widespread access and for more dairies to increase practice stacking and implementation.

CDFa has regularly received more eligible applications than it can fund every year. As noted by an AMMP technical assistance provider, in many Northern California counties, producers who were initially enthusiastic have stopped applying after repeated unsuccessful attempts, believing the odds are too low to justify the effort. In contrast, they reported that AMMP technical assistance in Sonoma and Marin counties has ensured more steady applications and helped deliver highly effective AMMP projects that have drastically improved the local watershed. However, many in the region are still discouraged from applying because of the high chance of rejection.

AMMP's funding cap, currently \$750,000 per project and one project per operation, may help reach more dairies while demand is greater than funding availability. However, there are dairies interested in implementing multiple AMMP practices if they had access to more support. Growing awareness of the benefits of alternative management could lead to sufficient state, federal, or private funding to support

¹⁹ See CDFa AMMP New Management Practices Proposals Public Comments on Recommendations and Final Determination: https://www.cdfa.ca.gov/oefi/ammp/docs/ammp_newpractices_final2021.pdf.

²⁰ Zubair, M., Wang S., Zhang P., Ye, J., Liang, J., Nabi, M., Zhou, Z., Tao, X., Chen, N., Sun, K., Xiao, J., & Cai, Y. (2020) Biological nutrient removal and recovery from solid and liquid livestock manure: Recent advance and perspective. *Bioresource Technology*, 301 <https://doi.org/10.1016/j.biortech.2020.122823>

widespread adoption and more practices per operation, and more advanced technologies and systems that can achieve higher reductions practices.

Lack of Funding Limits Per-Dairy Reduction Potential

Producer interest in more comprehensive implementation is already evident. A Cal Poly evaluation found that 91 percent of AMMP recipients were somewhat or strongly likely to reapply. AMMP technical assistance providers and CalCAN have also heard directly from producers interested in expanding their projects.

For example, CalCAN spoke with a dairy producer from Stanislaus County and one from San Joaquin County who have received AMMP support to install manure separators, have seen substantial benefits, and want to secure additional funding. However, they cannot reapply to AMMP and have not been able to access other funds yet. In another example, CalCAN spoke with a Merced County dairy producer who used AMMP to install a compost-bedded pack barn and reported they would apply again, if possible, to install a manure separator on their remaining free stall.

In many cases, the barrier is not interest, but funding. These missed opportunities suggest that many dairies would achieve greater emissions reductions and other environmental co-benefits if they had access to adequate support.

Proposal: Expand permitted activities in CDFA’s Climate Smart Agriculture Technical Assistance Program (TAP) to allow technical assistance providers to assist producers with federal programs. This would allow TAPs to work with producers to stack AMMP with federal funds and maximize practice adoption.

More strategic coordination between state and federal funding streams could also help AMMP projects scale more effectively. Some AMMP awardees have successfully secured USDA Environmental Quality Incentives Program (EQIP) grants to expand their projects beyond what CDFA funds alone could support. Aligning timelines, simplifying application processes, and increasing technical assistance could help more producers stack AMMP with federal programs. Ongoing efforts at the federal level could secure additional support for alternative manure management practices.²¹

ii. Increased Demand for AMMP Co-Benefits to Meet Water Quality Targets and Other State Goals

As will be discussed in Section 5, AMMP practices can play an important role in meeting water quality requirements on dairies and in producing the compost needed to achieve the state’s targets for organic acreage transition and healthy soils practice adoption.

If the State Water Board’s Draft Dairy Order (October 2024) is finalized as proposed, a large number of dairy producers will need to significantly increase the export of manure off-dairy to comply with the new nitrogen regulations. Exporting more manure will require increased adoption of dry manure management, especially with composting, and dairy industry representatives contributing to this report assess that increased support for alternative manure management practices will be vital to ensure the industry can comply.

²¹ Read more about related federal legislation here: <https://calclimateag.org/currentcampaigns/cows-act/>.

Similarly, a University of California convening of experts found that AMMP could help address environmental justice–centered concerns around greater concentration of herds and associated local water and air quality impacts. Their final report, titled *Ahead of the Herd*, noted this in the context of the AB 32 (Nuñez, 2006) and SB 197 (E. Garcia, 2016) requirements that state GHG emission reduction efforts prioritize communities that are disproportionately impacted by climate change and public health threats.

At the same time, California has set ambitious goals to expand compost use statewide. The Nature-Based Solutions Climate Targets, established by AB 1757, (Garcia, 2022), call for transitioning 20 percent of cropland to organic management by 2045 and implementing healthy soil practices on an additional 3.1 million acres by 2045. Both objectives rely on a significantly increased compost supply. AMMP-supported manure composting could help fill that gap.

Furthermore, some AMMP producers we interviewed report reduced fertilizer costs due to the use of compost produced on-farm. This was especially important when fertilizer prices surged in 2021. Fertilizer prices have come down from the peak in 2022 but remain high, and producers continue to seek alternatives. Pastured AMMP dairies have also reported improved forage quality from compost applications and the ability to extend the grazing season by a couple of weeks.

Both the state and producers may become more interested in alternative manure management as a strategy that simultaneously meets methane targets and other environmental and agronomic goals, increasing support and demand, and thus potentially increasing the overall future methane reductions the approach can achieve. A deeper discussion of these water and compost-related co-benefits follows in Section 5.

iii. Increasing Average Project Effectiveness

AMMP’s reported methane reductions per project vary widely due to differences in practice selection, implementation scope, infrastructure constraints, and herd characteristics. While this variation reflects the program’s flexibility and accessibility, it also means that some funded projects deliver significantly higher reductions than others. However, there may be opportunities to improve the future average methane reduction effectiveness of AMMP without compromising access for smaller or pasture-based dairies. Scenario modeling should take these possibilities into account.

Proposed Avenues for Improving AMMP Effectiveness

Proposal: More technical assistance and project design support could help applicants implement practices more comprehensively across their herds or combine multiple strategies for larger reductions.

Proposal: As sufficient data is available, fund increased implementation of newer practices with high reduction rates, such as advanced separation systems, vermifiltration, and manure composting with biochar. Increasing the viability of these practices would also require addressing barriers outside of the scope of AMMP, including streamlining regulations of manure composting, ensuring demand for compost, and creating biochar supply chains.

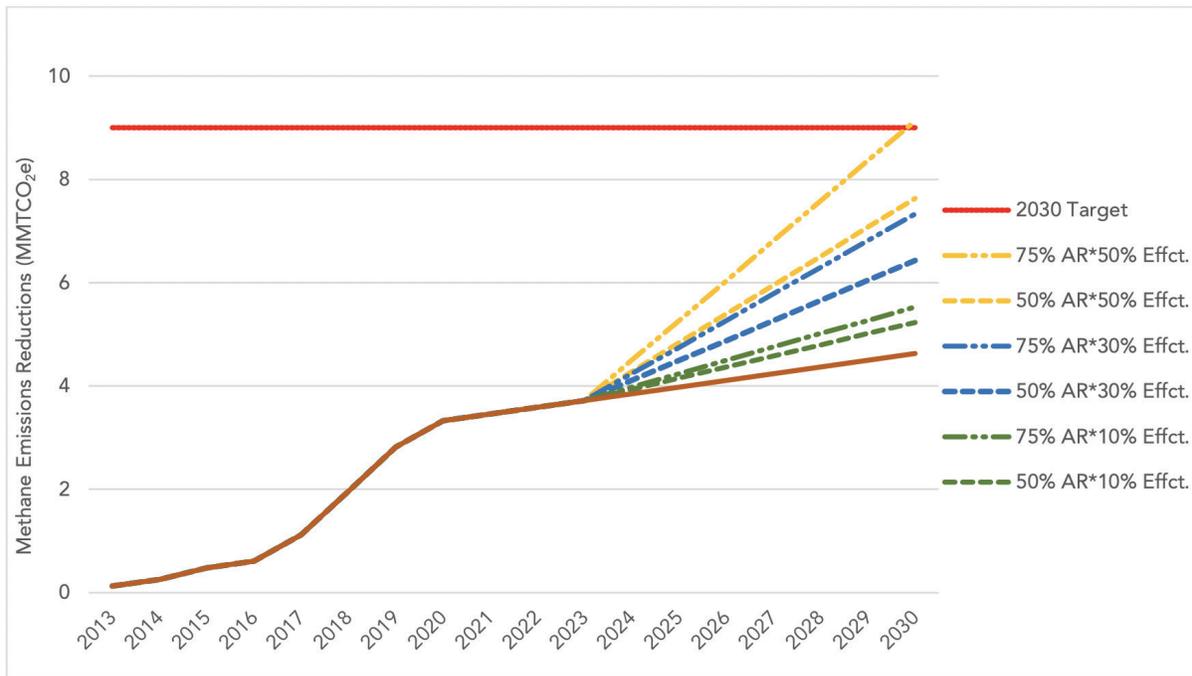
3. AMMP Practice Scenario Modeling For Methane Reduction

The assessment of AMMP in CARB’s 2022 analysis, based on projecting future methane reductions from current averages, helps us to understand conservative scenarios. However, the same 2022 analysis produced scenario projections where enteric methane feed additives would play a significant role in meeting the state’s 2030 target of 40 percent methane reductions, despite considerable uncertainty and implementation barriers to enteric practices. Given the wide accessibility of different manure management practices across different types of dairies, this section argues that AMMP practice projections can use similar assumptions as projections for enteric projects.

A. Comparisons with Enteric Feed Additives Scenarios

Figure B shows CARB’s projections of possible enteric methane reductions from feed additives under different efficacies and adoption rates. CARB’s 2022 analysis (Finding 1-5) concluded that “the dairy and livestock sector may fall short of the 2030 methane target absent an enteric strategy and sufficient public funds.” To reach this conclusion, CARB projected that the industry could implement feed additives with 30 percent enteric methane mitigation potential across 75 percent of the ruminant herds in California by 2030, with a linear adoption rate of roughly 11 percent per year starting in 2024.

Figure B: From CARB’s 2022 report (p. 24)—Projected Annual California Dairy and Livestock Sector Enteric Methane Emissions Reductions Through 2030 Under Various Feed Additive Adoption Rates (AR) and Methane Mitigation Effectiveness (Effect.).



As of early 2025, the Food and Drug Administration (FDA) has approved only one product, 3-NOP, as a feed additive that can make enteric methane reduction marketing claims. It achieves average reductions of 20 to 40 percent,²² is not certified for use by organic dairy and livestock producers, and it has uncertain consumer acceptance.²³ There are other products that are FDA-approved for use as livestock feed

²² California Air Resources Board (CARB). (2024). *California greenhouse gas emissions from 2000 to 2022: Trends of emissions and other indicators*. https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_2022_ghg_inventory_trends.pdf

²³ See recent consumer backlash against milk from dairies using 3-NOP in the UK: <https://www.euronews.com/green/2024/12/03/burping-cows-bovaer-and-boycotts-the-anti-methane-additive-thats-taking-social-media-by-st>.

additives but are not FDA-approved for methane reduction claims.²⁴ In late 2024, CDFA approved Blue Ocean Barns' red seaweed (*Asparagopsis*) additive, which has shown average reductions of 52 percent and up to 90 percent in trials, but it is not yet FDA approved, and the feasibility and environmental impacts of large-scale production remain uncertain.²⁵ Researchers have also identified enteric methane reductions using various other biological materials, including a California study that showed that feeding dairy cows grape pomace from the state's wine industry reduces methane by 10 to 11 percent.²⁶

Achieving the scenarios presented by CARB in Figure B of a 75 percent adoption rate is ambitious: to achieve 75 percent herd adoption by 2030, 3-NOP would currently need to supply most of the market, potentially supplemented by other products. Although some studies show improvements in feed efficiency with 3-NOP, others do not, and one projection found savings are unlikely to offset costs fully.²⁷

For instance, one study found that cost neutrality would require payments of \$0.21 to \$0.42 per cow per day, and an average of \$128,000 per year for a dairy with 1,000 milking cows.²⁸ Another study found that CO₂e needs to be priced at \$109 per metric tonne to maintain a neutral net return from 3-NOP supplementation.²⁹ Considering these ambitious adoption scenarios for enteric strategies helps CARB and the state with planning and policy. Similarly, consideration of ambitious scenarios for AMMP is important for planning for state goals and targets.

B. Determining Scenarios

We applied the scenario-based approach from CARB's enteric analysis to alternative manure management. Table 6 presents scenarios that assume the adoption of alternative manure management practices across 50 or 75 percent of the California dairy sector and anaerobic manure emissions with average methane reduction rates of 25, 40, 60, or 75 percent.

Applying alternative manure management practices to 50 or 75 percent of the dairy industry's manure streams is a significant divergence from current trends but may be possible with facilitative funding and policy conditions, as discussed in Section 2B. The justification for each of the methane reduction rates is as follows, and uses averages calculated from CDFA data for AMMP projects 2019–2023.

- **25 percent** represents the lower bound. Using CDFA data on 2019–2023 AMMP reductions from baseline manure emissions (for animals in the project boundary), 25 percent is the approximate average reduction for solid separation projects, the AMMP practice category with the lowest average reduction rate.
- **40 percent** represents the approximate overall average percent reduction rate across all practices in the CDFA data.³⁰

²⁴ California Air Resources Board (CARB). (2024). *California greenhouse gas emissions from 2000 to 2022: Trends of emissions and other indicators*. https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_20reductions_A_California22_ghg_inventory_trends.pdf feed additives feed additives

²⁵ Deelen, B. G. van. (2022, June 14). Feeding cows seaweed reduces their methane emissions, but California farms are a long way from scaling up the practice. *Inside Climate News*. <https://insideclimatenews.org/news/14062022/cow-seaweed-methane/>

²⁶ Akter, A., Li, X., Grey, E., Wang, S.C., & Kebreab, E. (2025) Grape pomace supplementation reduced methane emissions and improved milk quality in lactating dairy cows. *Journal of Dairy Science*, 108(3), 2468–2480. <https://www.sciencedirect.com/science/article/pii/S0022030224014164>

²⁷ Martins, L. F., Maigaard, M., Johansen, M., Lund, P., Ma, X., Niu, M., & Hristov, A. N. (2025). Lactational performance effects of 3-nitrooxypropanol supplementation to dairy cows: A meta-regression. *Journal of Dairy Science*, 108(2), 1538–1553. <https://www.sciencedirect.com/science/article/pii/S0022030225000219#cesec60>

²⁸ Pupo, M. R., Ferraretto, L. F., & Nicholson, C. F. (2025). Effects of feeding 3-nitrooxypropanol for methane emissions reduction on income over feed costs in the United States. *Journal of Dairy Science*, 108(5), 5061–5075. <https://www.sciencedirect.com/science/article/pii/S0022030225001456>

²⁹ Martins, L. F., Maigaard, M., Johansen, M., Lund, P., Ma, X., Niu, M., & Hristov, A. N. (2025). Lactational performance effects of 3-nitrooxypropanol supplementation to dairy cows: A meta-regression. *Journal of Dairy Science*, 108(2), 1551. <https://www.sciencedirect.com/science/article/pii/S00220302>

³⁰ Rounded down from the actual average of 41 percent. See Reduction Estimates AMMP 2019 to Present.xlsx.

- **60 percent** represents a calculation of the average reductions of the top 10 percent most effective projects in the CDFA data, weighted according to the number of projects funded in each practice category.³¹
- **75 percent** represents an aspirational goal. The non-weighted average of the top 10 percent most effective AMMP projects is 83 percent. These projects are mostly compost-bedded pack barns on herds sized 1 to 1,000, suggesting an unrealistic goal for industry-wide adoption. However, considering the emerging advanced manure management technologies and the various scenarios discussed in Section 2 of increased demand and support for alternative manure management, the 75 percent scenario is worth considering.

All scenarios assume an 8.0 MMTCO₂e baseline based on CARB’s reported 2022 CH₄ emissions³² from the manure stream of California’s dairy cattle that use “wet” management practices.³³

Table 6. Projected Annual California Dairy Manure CH₄ Emissions (MMTCO₂e) Reductions Under Various Alternative Manure Management Practice Adoption Rates and Average Per Project Methane Reduction Rates

AMMP Practice Adoption Rate Across California’s Current Anaerobic Manure Stream	25% Average Reduction Effectiveness	40% Reduction Effectiveness	60% Reduction Effectiveness	75% Reduction Effectiveness
50%	1.0	1.6	2.4	3.0
75%	1.5	2.4	3.6	4.5

C. Analysis of AMMP Practice Scenarios

CARB’s 2022 analysis estimated that an additional 4.4 MMTCO₂e of methane reductions are needed from the dairy and livestock sector to meet the state’s SB 1383 goal by 2030. In Table 6, one scenario exceeds that target: the 75 percent adoption rate of AMMP practices with 75 percent average reduction effectiveness. All these scenarios project alternative manure management playing a significantly larger role in emissions reductions than the 2022 CARB analysis.

It is important to emphasize that these scenarios do not represent projections of current trends, but instead project possible policy, funding, and implementation conditions, such as those discussed in Section 2. This reapplication of CARB’s 2022 methodology for enteric feed additives scenarios shows how similar modeling assumptions could be applied to AMMP to ensure consistency across strategies.

Our findings differ notably from those presented in the 2020 CDFA-funded *Small Dairy Climate Change Research Report*, primarily due to differences in underlying assumptions, methodologies, and the scope of scenarios modeled. The authors of that report created significantly more in-depth scenarios for

³¹ The CDFA dataset includes 115 total projects, 73 solid separation projects, 34 compost-bedded pack barn projects, and 8 flush-to-scrape projects. Here, we rounded up from the actual weighted average of 59.8 percent.

³² California Air Resources Board. (2024). *Current California GHG emission inventory data* [Dataset]. <https://ww2.arb.ca.gov/ghg-inventory-data#data>

³³ To calculate the emissions of the wet manure stream, we used the sum emissions of the following categories in CARB’s Scoping Plan” data set of the GHG Inventory: dairy cows with anaerobic lagoons or anaerobic digesters and dairy cows and dairy heifers heifers with liquid/slurry management. We rounded down from actual total of 8.01 MMTCO₂e. Dataset used found here as of July 25, 2025: https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-ghg_inventory_scopingplan_all_00-22.xlsx.

alternative manure management than CARB or this report. They employed a more conservative feasibility-oriented methodology that projected adoption scenarios based on anticipated ongoing dairy industry consolidation; on the lack of adoption of some of the advanced practices discussed in our analysis; and on the continuation of incentive, economic, and policy structures that favor digesters over AMMP practices.

4. Cost-Effectiveness of AMMP

In their 2022 analysis, CARB calculated the cost-benefit of AMMP and DDRDP on page 17. In Table 7, we updated that analysis with the most recent project-level data and expanded on it.

Table 7: Estimated Cost-Effectiveness of California Dairy and Livestock Methane Emissions Reductions through 2022

Program	State Investments (\$/MTCO ₂ e)	Private Investment (\$/MTCO ₂ e)	Total Investment (\$/MTCO ₂ e)
DDRDP (10 years)	\$9	\$20	\$29
AMMP (5 years)	\$74	\$16	\$90
AMMP (10 years)	\$37	\$8	\$45
Top 10% most effective AMMP (10 years)	\$14	\$5	\$19

CARB calculates the total methane emission reduction for DDRDP using a ten-year lifespan and calculates the emission reduction for AMMP using a five-year lifespan. CARB estimated the shorter predicted average for AMMP at the beginning of the program based on external stakeholder input that some AMMP technologies may break down after five years.

AMMP has now been implemented for more than five years, and there have not been widespread reports of people abandoning AMMP practices. A recent CalPoly evaluation of CDFA Climate Smart Agriculture Programs found that 93 percent of the funded AMMP practices were maintained by the surveyed producers, with a 100 percent persistence rate for flush-to-scrape systems, a 96 percent persistence rate for solid separation systems, and an 86 percent persistence rate for compost-bedded pack barns.³⁴ Additionally, AMMP technical assistance providers have reported that dairies opt to repair separators when they break down because separators save costs by reducing bedding, slurry transportation, and/or fertilizer purchases.³⁵

As shown in Table 7, when looking at AMMP CH₄ projections using a ten-year lifespan rather than a five-year lifespan, AMMP’s cost-effectiveness improves significantly, especially when accounting for private investment. Using the updated 10-year calculator for AMMP, the program rises to the fourth most cost-

³⁴ Babin, N., Tan, J., Radulski, B., & Church, S.P. (2024). *Evaluation of the California Department of Food and Agriculture’s Climate-Smart Incentive Programs*. California Polytechnic State University. <https://www.cdffa.ca.gov/oefi/efasap/docs/2024/CalPoly-CDFAstakeholders-CSA-Program-Assessment-July2024.pdf>

³⁵ Karle, B. *Costs and benefits of alternative manure management practices*. University of California. https://www.cdffa.ca.gov/oars/research/docs/Final_Report_costs_benefits.pdf

effective California Climate Investments program tracked by CARB on the basis of dollars per MTCO₂e reduced.³⁶ If CARB determines that more evidence is needed to update the AMMP QM, a survey of AMMP recipients and industry technical assistance providers can determine the average life expectancy of an AMMP project, keeping open the possibility of assigning different averages for different practices and technologies.³⁷

5. Modeling AMMP Co-Benefits

Alternative manure management offers key co-benefits that support broader state goals and targets beyond methane reduction: helping dairies comply with the State Water Board’s Draft Dairy Order by reducing nitrogen loading and supplying compost needed to meet the state’s organic transition and healthy soil practice targets set AB 1757 (Garcia, 2022). If there is increased demand and support for AMMP practice co-benefits, this could in turn increase adoption and methane reductions. A more integrated modeling approach would better reflect the role of these practices in meeting intersecting state mandates and help the state better plan to achieve those mandates.

A. Water Quality Benefits

AMMP practices offer significant potential to mitigate dairy-related nitrogen pollution, a primary driver of groundwater contamination in California’s dairy regions. As the Draft Dairy Order ratchets up regulatory requirements, it may increase demand from dairy producers for AMMP-supported practices that facilitate nutrient export and water quality compliance. While the Draft Dairy Order does not require or promote these practices explicitly, its emphasis on limiting land application of manure and encouraging off-site nutrient removal makes AMMP-supported methods increasingly relevant. This reinforces the need for CARB to coordinate with the State Water Board to model how AMMP can help meet not just climate goals, but water quality mandates as well.

i. Nitrogen Pollution and Dairy Groundwater Impacts

The Central Valley Dairy Representative Monitoring Program (CVDRMP) report found that groundwater beneath dairy operations in the Central Valley consistently exceeds water quality objectives for nitrates. Monitoring data from 2012–2018 across 42 dairies found nitrate concentrations surpassing regulatory thresholds at all sites, with about 94 percent of nitrate losses attributable to overapplication of liquid manure and wastewater on forage crops. As CVDRMP notes, nitrogen surpluses at the whole-farm level are the primary cause of excessive land application, and achieving water quality targets will require expanded off-site nutrient export. However, most manure on California dairies is stored and handled in liquid form, which is difficult and costly to transport. The CVDRMP report notes explicitly that the liquid fraction of manure is “almost never exported off-site due to the difficulty of doing so.”³⁸

³⁶ California Climate Investments. (2024). *2024 mid-year data update*. <https://ww2.arb.ca.gov/sites/default/files/2024-12/2024-CCI-Mid-Year-Update.pdf>

³⁷ Another related consideration is the risk that some AMMP-funded improvements may not persist for the full project life assumed in cost-effectiveness estimates if a dairy exits the industry. Small and mid-sized dairies have been closing at a high rate in California and nationally, reflecting ongoing economic pressures and broader market and policy shifts, and the trend may continue. This does not change the recommendation: a targeted survey of past AMMP projects could help estimate the typical longevity of funded practices and support more evidence-based project-life assumptions.

³⁸ Cativiela, J.P., Angermann T., & Dunham T. (2019). *Summary representative monitoring report*. Central Valley Dairy Representative Monitoring Program (CVDRMP). <https://leadershipcounsel.org/wp-content/uploads/2019/10/Dairy-report.pdf>

ii. Regulatory Context: State Water Board Draft Dairy Order (October 2024)

The Draft Dairy Order proposes a comprehensive framework for regulating nitrogen discharges to groundwater from dairy operations. It emphasizes numeric nitrogen application limits based on groundwater protection standards and requires whole-farm nitrogen accounting and phased compliance schedules. While the Order does not explicitly endorse alternative management or composting, it does reference nutrient export and alternative uses of manure as necessary when application would exceed agronomic rates. It also acknowledges composting as a potential strategy, citing its benefits and the barriers to adoption, such as air quality permitting and cost constraints, identified by CVDRPM's report.³⁹

In general, management systems that allow for more dry handling of manure can help reduce the risk of nutrient leaching by making manure solids easier to transport. The CVDRMP report emphasizes that composting stabilizes nitrogen, converting it into organic forms less prone to leaching and runoff. Composting also addresses pathogen concerns and weed seeds, enhancing the market value of manure solids and supporting nutrient export off-site. Yet composting also involves important economic and regulatory considerations, such as additional operational costs, air permitting challenges, and emissions of volatile organic compounds (VOCs) and ammonia.⁴⁰

Transitioning from wet (flush-lagoon) systems to dry manure handling can significantly reduce nitrogen loading to groundwater. Dry management systems, such as solid-liquid separation technologies, reduce nutrient leaching risk by enhancing the export potential of manure solids due to easier transport and improved marketability.⁴¹

AMMP and Water Quality Improvements in the North Coast

For this report, CalCAN interviewed a dairy industry advisor that has collected unpublished preliminary data showing alternative manure management practices are improving the health of a watershed located between Sonoma and Marin counties.

In the watershed, three projects have received funding through both AMMP and partnership funds, and a fourth was supported solely by partnership funds. Each project involved the construction of new housing, either compost-bedded pack barns or free stalls with scrape or vacuum systems, for animals that were previously kept on open dry lots. These animals typically generate approximately 1.6 cubic feet of solid and liquid manure per day, amounting to about 1,760 cubic feet annually per animal. Given an average of 25 wet weather days per year in the region, these projects collectively prevent around 40,000 to 50,000 cubic feet of manure from becoming runoff, instead capturing and redirecting nutrients for on-farm use through dried manure and compost. Preliminary data collection show improvements in nitrogen and phosphorus levels in the watershed.

³⁹ California State Water Resources Control Board. (October 2024). *Draft Order WQ 2024-00xx*. https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/r5-2013-0122/a2283bdrftordr.pdf

⁴⁰ Cativiela, J.P., Angermann T., Dunham T. *Summary representative monitoring report*. (2019). Central Valley Dairy Representative Monitoring Program (CVDRMP). <https://leadershipcounsel.org/wp-content/uploads/2019/10/Dairy-report.pdf>

⁴¹ Kaffka, S., Williams, R., Marvinney, E., & Smith, C. (2022). *Manure nutrient recovery, removal, and reuse on California dairies*. California Department of Food and Agriculture. https://www.cdffa.ca.gov/oefi/research/docs/cbc_manure_nutrient_report.pdf

iii. Advanced Nutrient Management Technologies

A CDFA funded report found some advanced manure treatment technologies present promising opportunities for enhanced nutrient removal and recovery:

- **Advanced Separators with Flocculants:** The Trident Nutrient Recovery System significantly reduces soluble nutrients, reducing the nitrogen (organic nitrogen and nearly all the ammoniac nitrogen) in the liquid effluent by about half and reducing up to 90 percent of the phosphorus.⁴²
- **Vermifiltration:** BioFiltro vermifiltration removes 80 to 90 percent of the volatile solids from flushed dairy wastewater, producing a finished compost of retained solids and worm castings. The remaining liquid effluent has reduced nitrogen by 40 to 90 percent and phosphorus by 20 to 80 percent. Though effectiveness varies significantly based on management, this technology can be a highly effective approach for producing compost and managing nutrients.⁴³

For these two practices, the USDA grant supporting the Dairy Plus Program is funding University of California researchers to collect on-dairy data on changes in nitrogen and salt surpluses. This monitoring and evaluation will help assess how the practices contribute to California's water quality goals.

iv. Water Quality Conclusions and Recommendations

Although there are economic and regulatory hurdles to implementation, alternative manure management practices offer significant benefits by stabilizing and exporting nutrients, thus protecting groundwater. AMMP helps dairies shift away from liquid manure that is difficult to export, opening up new pathways to reduce whole-farm nitrogen surpluses and limit overapplication. As the state adopts stricter regulatory requirements under the Draft Dairy Order, demand for these practices may increase. CARB should collaborate with the State Water Board and other agencies to assess how AMMP-supported practices can help meet water quality mandates and should adjust its methane reduction modeling to account for these co-benefits and the potential for broader adoption of AMMP practices.

B. Compost Production, Soil Health, and Soil Carbon Sequestration

California has established ambitious climate and agricultural targets that underscore the critical role of compost in enhancing soil health and sequestering carbon. The 2024 Nature-Based Solutions (NBS) Climate Targets, mandated by AB 1757, set forth goals to transition 10 percent of the state's annual and perennial croplands to organic management by 2030, increasing to 20 percent by 2045 (approximately 1.9 million acres),⁴⁴ and to adopt healthy soil practices on 140,000 new acres each year starting in 2030. Achieving these targets necessitates a substantial increase in the compost supply, as compost application is a cornerstone of both organic farming and soil health initiatives.⁴⁵

Alternative manure management can play an essential role in bridging this compost supply gap. Utilizing manure-derived compost addresses multiple objectives: reducing greenhouse gas emissions from dry storage, enhancing soil carbon sequestration, and supplying the compost necessary for the state's organic agriculture expansion and soil health improvement efforts. Incorporating the co-benefits of compost production into future scenario modeling of alternative manure management practices will allow a more

⁴² Kaffka, S., Williams, R., Marvinney, E., & Smith, C. (2022). *Manure nutrient recovery, removal, and reuse on California dairies*. California Department of Food and CDFA-funded Agriculture. https://www.cdfa.ca.gov/oefi/research/docs/cbc_manure_nutrient_report.pdf

⁴³ Kaffka, S., Williams, R., Marvinney, E., & Smith, C. (2022). *Manure nutrient recovery, removal, and reuse on California dairies*. California Department of Food and Agriculture. https://www.cdfa.ca.gov/oefi/research/docs/cbc_manure_nutrient_report.pdf

⁴⁴ The 2024 California NBS Climate Targets report estimates there are 9.8 million acres of cropland. See California's [Nature-Based Solutions Climate Targets](#), p. 15.

⁴⁵ Administration of Governor Gavin Newsom. (2024). *California's nature-based solutions climate targets: As required by Assembly Bill 1757 (2022)*, C. Garcia. <https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Californias-NBS-Climate-Targets-2024.pdf>

comprehensive understanding of how the practices can simultaneously help meet the state’s methane reduction and NBS climate targets.

We created the scenarios in Table 8 to illustrate that alternative manure management practices can play a significant role in meeting the compost needs of the state. These are basic scenarios that show that the state should pursue in-depth modeling to best inform planning.

Table 8: Estimated Statewide Finished Compost Production from Dairy Manure Under AMMP Industry-wide Adoption and Solids Separation Scenarios

Practice Adoption Rate Across CA Dairy Industry	25% Manure Volatile Solids Diverted Towards Composting	40% Manure Volatile Solids Diverted Towards Composting	60% Manure Volatile Solids Diverted Towards Composting	75% Manure Volatile Solids Diverted Towards Composting
50%	1.2 million tons	1.9 million tons	2.9 million tons	3.6 million tons
75%	1.8 million tons	2.9 million tons	4.3 million tons	5.4 million tons

To create Table 8, we mimicked the methodology we applied to methane reduction scenarios in Section 3 and Table 6. The “Practice Adoption Rate” in Table 8 represents scenarios where California dairies adopt alternative manure management practices across 50 percent and 75 percent of the industry’s entire anaerobically managed wet manure stream. See Section 3B for an explanation of why we used the 25, 40, 60, and 75 percent rates. We assumed a starting point of 37.2 million tons of manure annually based on CDFA and USDA estimates of approximately 1.7 million dairy cows statewide and an average manure output of 120 pounds per cow per day. Lastly, to find the final tons of compost produced, we accounted for the loss of mass through the composting process by multiplying the diverted volatile solids by 25.7 percent, approximately the same rate that CARB uses in the AMMP calculator.⁴⁶

The full formula for calculating the tons of compost reported in Table 8 is as follows: 37.2 million tons (California annual dairy manure) × adoption rate × separation effectiveness × 0.257 (to account for average loss of mass through composting process).

The scenarios in Table 8 show that alternative manure management could produce a large portion of the compost needed to meet California’s organic transition and soil health objectives. As discussed in Section 3, these high adoption rates are ambitious but help illustrate what might be possible under facilitative funding, economic, and policy conditions.

This potential for increasing compost supply and application is especially relevant in dairy-producing regions, where proximity to compost sources could reduce transportation costs and barriers to use. Importantly, AMMP’s methane reductions are also supplemented by the soil carbon sequestration and climate benefits of applying this compost, and these benefits are not currently accounted for in CARB’s modeling. Including these benefits in future projections would offer a more accurate picture of AMMP’s potential role in helping California meet its interrelated methane, soil health, and organic agriculture goals.

⁴⁶ The AMMP calculator multiplies the mass of solids composted by 0.256854 to estimate the mass of the final compost produced. More specifically, the AMMP calculator multiplies the total volatile solids sent to compost feedstock by a 0.39 conversion factor and a 0.6586 factor to convert from dry tons to wet tons.

6. Policy Recommendations: Expanding the Role of AMMP to Meet Climate, Water, and Soil Health Goals

AMMP is already achieving meaningful methane reductions and delivering environmental co-benefits. However, this analysis shows that current modeling underrepresents the potential role that alternative manure management practices can play in meeting California's agricultural climate targets and regulatory requirements. Further, strategic reforms could enhance AMMP's effectiveness, scalability, and integration into broader environmental mandates.

To fully realize and understand the potential of alternative manure management, we propose the following recommendations, informed by our analysis, stakeholder input, and complementary literature.

Policy Recommendations

Based on our analysis and findings, we offer the following recommendations to CARB and the California Department of Food and Agriculture (CDFA) to fully understand and realize the potential of alternative manure management and to enhance AMMP's effectiveness, scalability, and integration into broader environmental mandates.

Improve Cross-Agency Modeling and Planning

- Establish an interagency task force including CARB, CDFA, the State Water Resources Control Board, California Department of Resources Recycling and Recovery (CalRecycle), and relevant external experts to reassess the full potential of AMMP and related practices. This group should coordinate scenario modeling that accounts for methane, nitrogen, water quality, and soil health impacts.

Update Modeling Assumptions and Program Evaluations

- CARB should update AMMP's project lifespan assumptions to 10 years to align with the Dairy Digester Research and Development Program (DDRDP).
- CDFA should conduct a survey of AMMP recipients with completed projects, i.e., those who have passed the five years of required reporting to CDFA, to assess the persistence rate of different AMMP practices.

Update Emission Reductions Reporting Metrics While Improving Equitable Access

- Require manure emissions inventories in manure methane programs to apply to the facility's full herd, not just the portion of the herd within the project boundary.
- Utilize per-animal and full-facility reduction metrics for program evaluation and modeling.
- Prioritize full-facility percent reduction and per-animal reduction in the ranking of AMMP applications during project selection. This is a more size- and type-neutral approach than using per-project reductions.

Increase Support for Expanded Adoption and Stacked Practices

- CARB should update the AMMP calculator to (1) allow applicants to report more than one primary practice, and (2) allow projects to specify when they apply different practices to different portions of the facility.

- Direct technical assistance providers to stack funding for AMMP with federal and other sources to allow more projects to implement multiple practices.

Address Technical, Regulatory, and Knowledge Barriers to Practices

- Increase CDFA funding for AMMP pre-application and post-award technical assistance, including design, permitting, composting support and funding to train new AMMP technical assistance providers.
- Implement an efficient and effective process for approving manure composting projects, drawing on the findings and recommendations outlined in reports from Sustainable Conservation and the Manure Recycling and Innovative Products Task Force
- Invest in research and market infrastructure to address barriers to alternative manure management practices, including potential new and emerging technologies that can help achieve high methane reductions and/or co-benefits.

7. Conclusion

The state must revisit its modeling of alternative manure management to reflect the full potential of these practices in reducing methane and delivering environmental co-benefits. This effort should be a multi-agency collaboration between CARB, the State Water Resources Control Board, CalRecycle, CDFA, other relevant agencies, and a stakeholder group of experts that includes those with experience in modeling manure management's methane, water quality, and air quality impacts as well as other related topics such as soil health and organic agriculture. A more comprehensive, collaborative, and scenario-driven analysis will provide a stronger foundation for policy decisions, funding allocations, and future program design.

Appendix 1: Sample AMMP Projects Included in Analysis

Appendix 1 provides a table of selected AMMP projects used to illustrate the range of project types, herd sizes, and estimated methane reductions discussed in this report.

This appendix is a CalCAN-compiled analytical dataset based on publicly available CDFA and CARB project-level data, supplemented with additional variables derived by CalCAN for analytical purposes (including estimated herd size). The dataset reflects information available as of January 2025 and is provided in read-only form for transparency.

[Appendix 1: Sample AMMP Projects \(online data appendix\)](#)

Appendix 2: AMMP Practice Separation Rates

To understand the effectiveness of AMMP practices, we can also look at the standard rates that CARB uses in the AMMP calculator. The following are the rates at which CARB’s calculator assumes that each practice keeps volatile solids out of anaerobic manure lagoons.

Weeping wall	65%
Stationary screen	30%
Vibrating screen	15%
Screw press	25%
Centrifuge	50%
Roller drum	25%
Belt press/screen	50%
Polymer (flocculants)	80% (on top of the separator used)
Full Flush-to-scrape	90%
Compost-bedded pack barn	90%
Aerated vermicomposting system	90%

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