

Representative Groundwater Monitoring for Dairy Best Management Practices

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Final Technical Report

The examination of the characteristics of first-encountered groundwater is coupled with examinations of dairy operations and management practices, particularly as related to nutrient and salt management, to facilitate the evaluation of cause-and-effect relationships between subsurface loading of nutrients and salts, and groundwater conditions.

Background

The Year 1 Annual Report (Luhdorff and Scalmanini Consulting Engineers [LSCE], April 1, 2013) was CVDRMP's first annual report and pertained to the first 18 dairies in Stanislaus and Merced Counties that were incorporated into the Representative Monitoring Program (RMP). That report encompassed the groundwater data collection effort in calendar year 2012 and related dairy operations information spanning from planting of summer crops 2011 to harvest of summer crops 2012. In January 2013, the RMP monitoring effort was expanded to a total of 42 dairies (i.e., 24 dairies were added); since then, over 400 monitoring wells from Tehama County in the north to Kern County in the south are included in the RMP. The Year 2 Report (LSCE, April 1, 2014) presented and discussed the cumulative data collected from January 2012 through December 2013, including related dairy operations information through the harvest of the 2013 summer crops.

The Year 2 Report includes over 200 pages of text and discussion, approximately 4,500 figures and maps, and 350 pages of tables. The Year 1 and Year 2 Annual Reports are incorporated in this Final Report by reference. This final technical report is structured as follows:

1. Summary of cumulative findings with respect to management practices and their ability to protect groundwater quality
2. Recommendations for prioritized development of improved management practices
3. Work plan and schedule for refining and delivering final recommendations for management practices

Summary of cumulative findings with respect to management practices and their ability to protect groundwater quality

In its second year, data collection continued to demonstrate that the well network is performing as designed. The RMP has generated a very comprehensive data set that provides important and insightful information with respect to groundwater levels and chemistry, and field-scale nutrient/salt accounting, and how these relate to site-specific hydrology, farm operations, and management. Much of what has been learned so far provides preliminary confirmation of previous research by the University of

California¹. Specifically, RMP observations confirm that first-encountered groundwater is affected by historical and/or current dairy farming practices and suggest that the application of fertilizer (manure and/or commercial fertilizer) to crops is a major contributing source. Effects on groundwater nitrate concentrations appear to be pronounced in areas with sandy soils, but such effects were also recorded in other soil types. Furthermore, automated, high-frequency groundwater elevation data acquisition efforts that commenced in summer 2013 document, for the first time, clear groundwater elevation, temperature and salinity responses to individual irrigation events, thus, making the connection between surface processes and groundwater effects.

As indicated in the Year 1 Annual Report, CVDRMP started a systematic field program to quantify seepage rates from working liquid manure storage lagoons in November 2013. CVDRMP used a tested and proven water balance method in conjunction with a mechanistic data-supported evaporation model to quantify seepage rates with quantified statistical confidence. Results are reported in the sub-millimeter range and, due to their sensitivity to evaporative losses, high confidence in results can only be achieved in the winter time. The initial results collected from eight lagoons that were constructed as earthen basins without engineered clay liners, in a variety of soils ranging from sandy to clay-rich, indicate that most lagoons perform within NRCS performance standards.

Key findings that inform future actions are as follows:

- ❑ Based on the goal that drinking water human health standards be maintained even in first-encountered groundwater, use of the current practices and previous practices so far has not returned first-encountered groundwater to a condition that meets required standards.
- ❑ To improve groundwater quality, additional time and in all likelihood, improved management practices will be needed.
- ❑ The cumulative data record specific to the RMP, preliminary analysis of comparative subsurface loading rates, and other research including the Central Valley (Harter et al., 2012) strongly suggest that cropped fields are by far the largest contributor to subsurface emissions of nutrients and salts.

With respect to specific management practices, the following observations are made:

- ❑ Existing irrigation systems including conveyance facilities generally do not support accurate measurement of irrigation depths. The same limitation applies to the field application of liquid manure.
- ❑ Good nutrient management of organic sources (i.e., manure) is difficult due to the uncertainty of plant nutrient availability.
- ❑ Existing recommendations and requirements for sampling procedures and data collection do not always support or even increase the farmer's knowledge of field-scale nutrient budgets.
- ❑ Farmers are not always knowledgeable about their crops' nutritional needs and how they vary over the course of the growing season.

¹ Harter et al., 2001a, 2001b, 2002a, 2002b, and 2006; Mathews et al., 2001; Van der Schans et al., 2009.

Recommendations for prioritized development of improved management practices

It is recommended that resources focus on the development of improved field-scale nutrient and irrigation water management. Specifically, improved matching of plant nutrient and water needs to the supply is needed. The estimation of all applied nutrients and removed nutrients over a period of years on a field scale is thought to play a critical role in this effort. In order to do this, the quality of field-scale nutrient budgets needs to increase. On-farm infrastructure improvements will play a role in this effort such as improved conveyance systems that allow delivery and measurement of flow to individual fields. Sampling protocols (e.g., for nutrient content in liquid manure and the harvest) will need to be reviewed, updated, changed, or newly developed. A critical component will be outreach, education and training to increase farmers' knowledge base and also the level of service provided by agricultural professionals and consultants. In parallel track, additional lagoon seepage measurements should be performed in conjunction with other exploratory tools to gain a more representative sample of tested lagoons and increase our knowledge base to support future decisions about the fate of earthen lagoons. This effort should include the exploration of alternatives to lagoon closure and synthetic lining such as in-situ reactive barriers to reduce the nutrient load, pump-and-recycle and pump-and-fertilize, diversion of nutrients to composting, and others.

Work plan and schedule for refining and delivering final recommendations for management practices

CVDRMP is presently in the process of developing a 5-year project plan (2015-2019) that emphasizes transfer of knowledge and cooperative long-term relationships between trained professionals and dairy farmers. The project includes independent evaluation of as-is farm conditions and identification of farm specific modifications and practices, an implementation phase, and development of metrics to analyze the effects on subsurface emissions, long-term monitoring, uninterrupted communication between trained professionals and farmers, and outreach to the broader dairy community. CVDRMP seeks to partner with NRCS through the new Resources Conservation Partnership Program (RCPP).

CVDRMP is also preparing for lagoon subsurface hydrogeologic investigations at 12 monitored member dairies in fall 2014 and the continuation of lagoon seepage testing in winter 2014/15. Based on information collected in these work efforts, CVDRMP plans to develop a work plan that more comprehensively addresses the fate of dairy lagoons by spring 2015.

Per the schedule set forth in the Dairy General Order, final recommendations are to be prepared and submitted to the Central Valley Regional Water Quality Control Board by 2019.

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