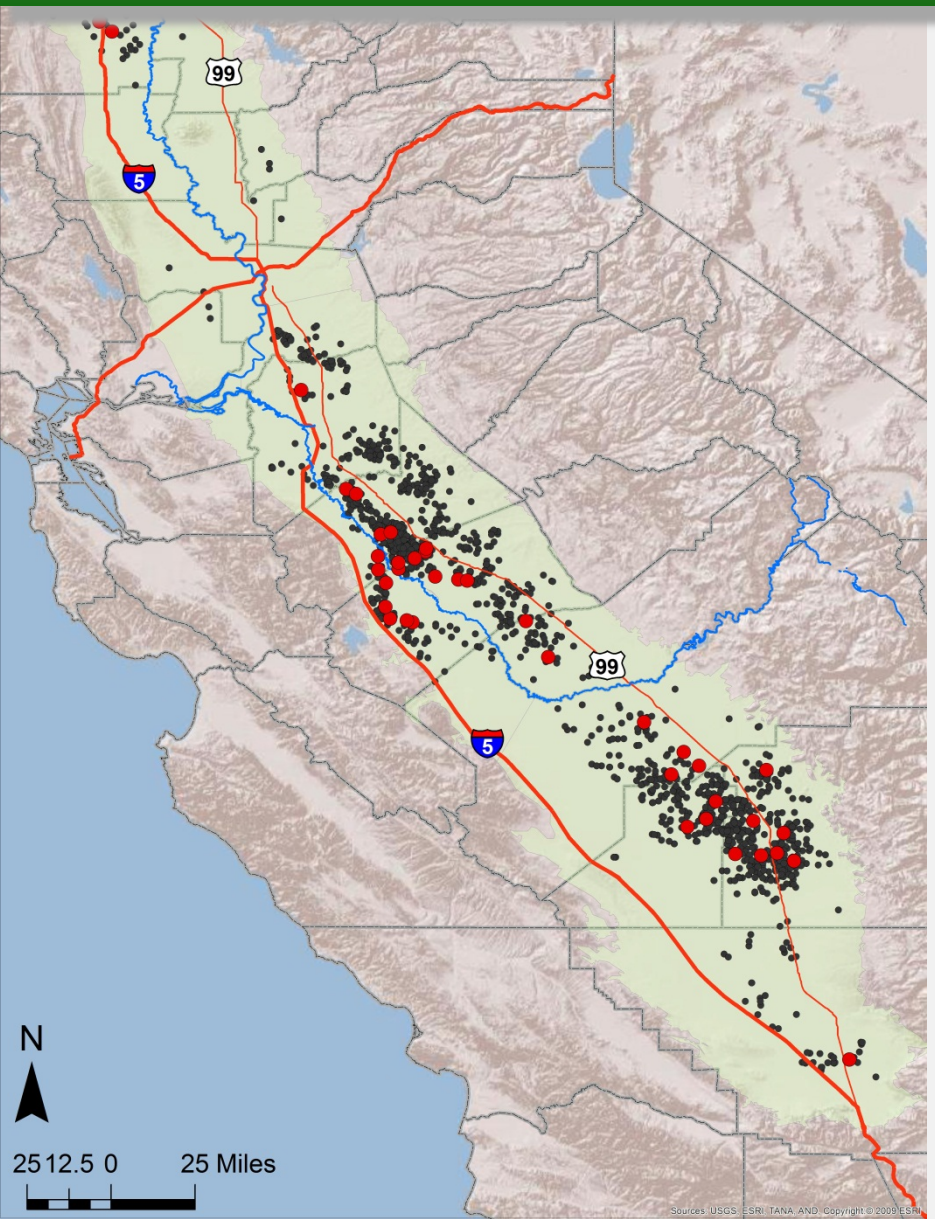
Central Valley Dairy Representative Monitoring Program – Status Update



Stakeholder Meeting

Central Valley Regional Water Quality Control Board

1685 “E” Street
Fresno, CA 93706

April 12, 2016

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Presentation Overview

1. Representative Monitoring Program Overview
2. Cumulative Groundwater Monitoring Results
3. Lagoon Investigations
   - Seepage results, mass loading, correlation to groundwater quality
   - Draft recommendations and workplan
4. Field Research Studies
5. Next Steps
6. Summary

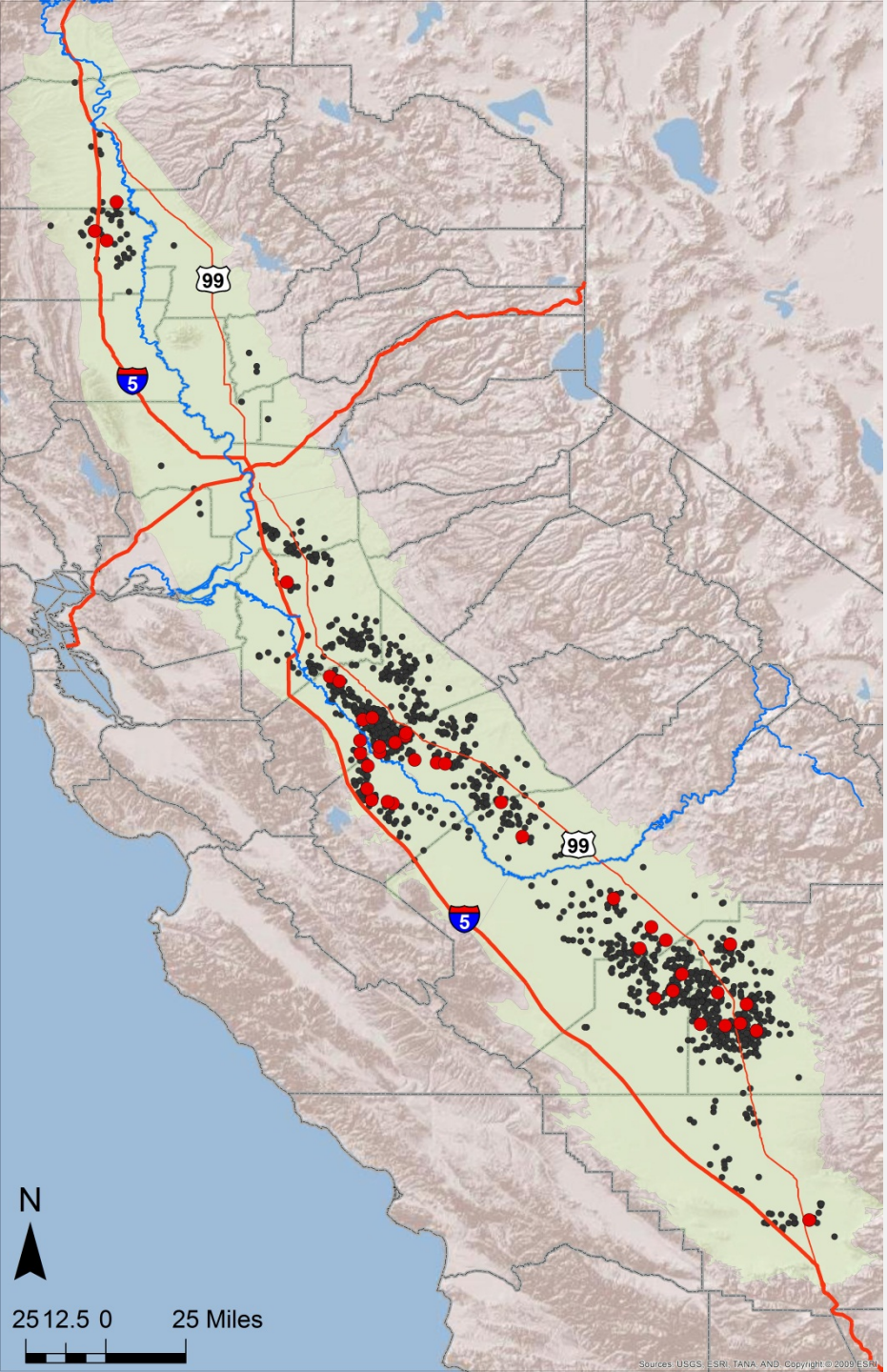
Representative Monitoring Program

- A regulatory compliance monitoring program
- An alternative to site-by-site monitoring of ~1,130 dairies
- Collects data on a subset of dairies representative of the industry and pertinent site conditions
- Tasked to identify dairy management practices that are protective of groundwater quality and those that are not
  - RWQCB: protective = meeting drinking water quality objectives; for nitrate as N, 10 mg/L
- Ultimately, will recommend improved practices for implementation on monitored and non-monitored dairies

2019 Summary Representative Monitoring Report

Pursuant to Reissued General Order

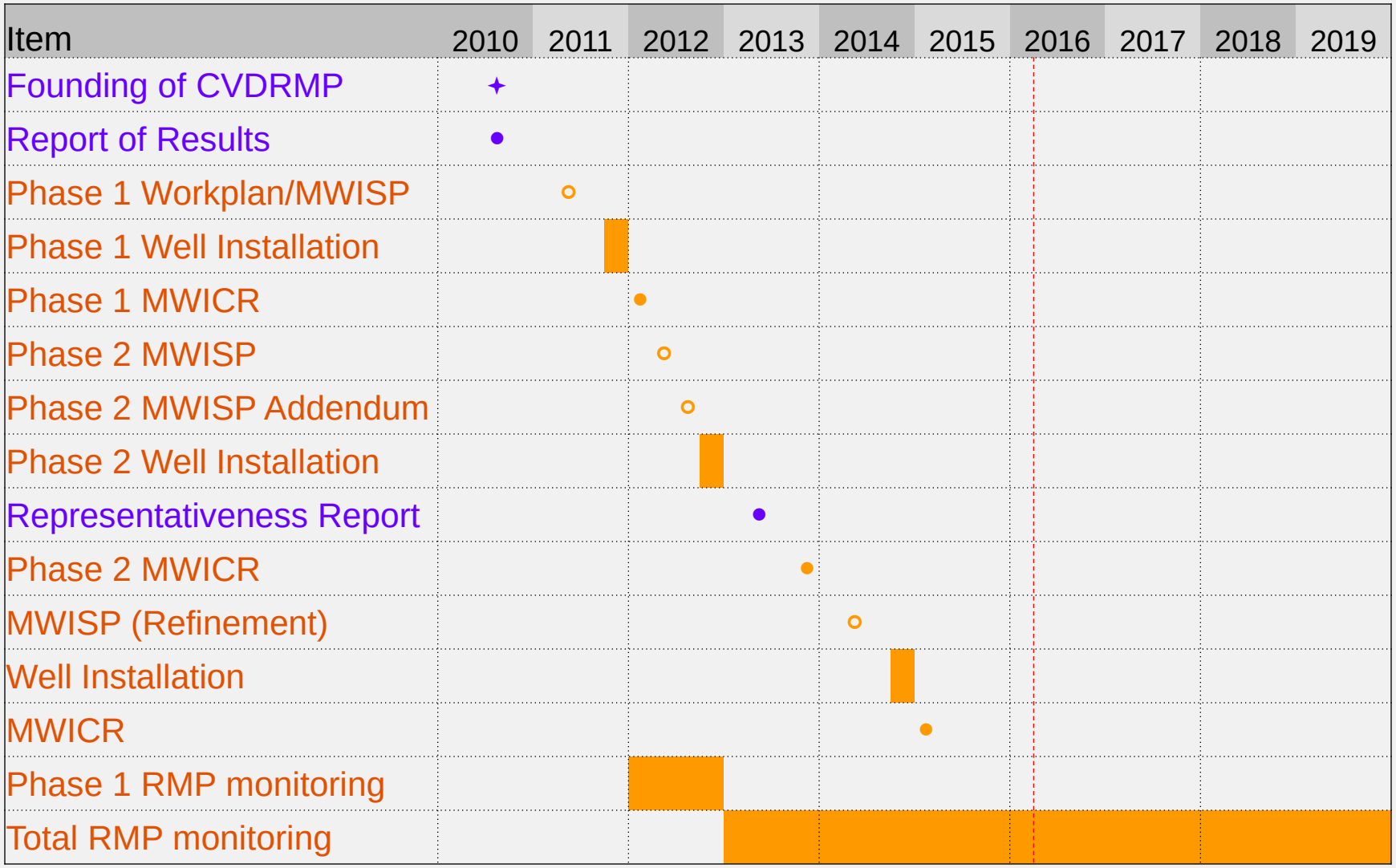
- Identify management practices that are protective of groundwater quality for the range of conditions found at dairies covered by the RMP
- Provide implementation schedules for practices that are as short as practicable, supported with appropriate technical or economic justification, not to exceed 10 years from SRMR approval



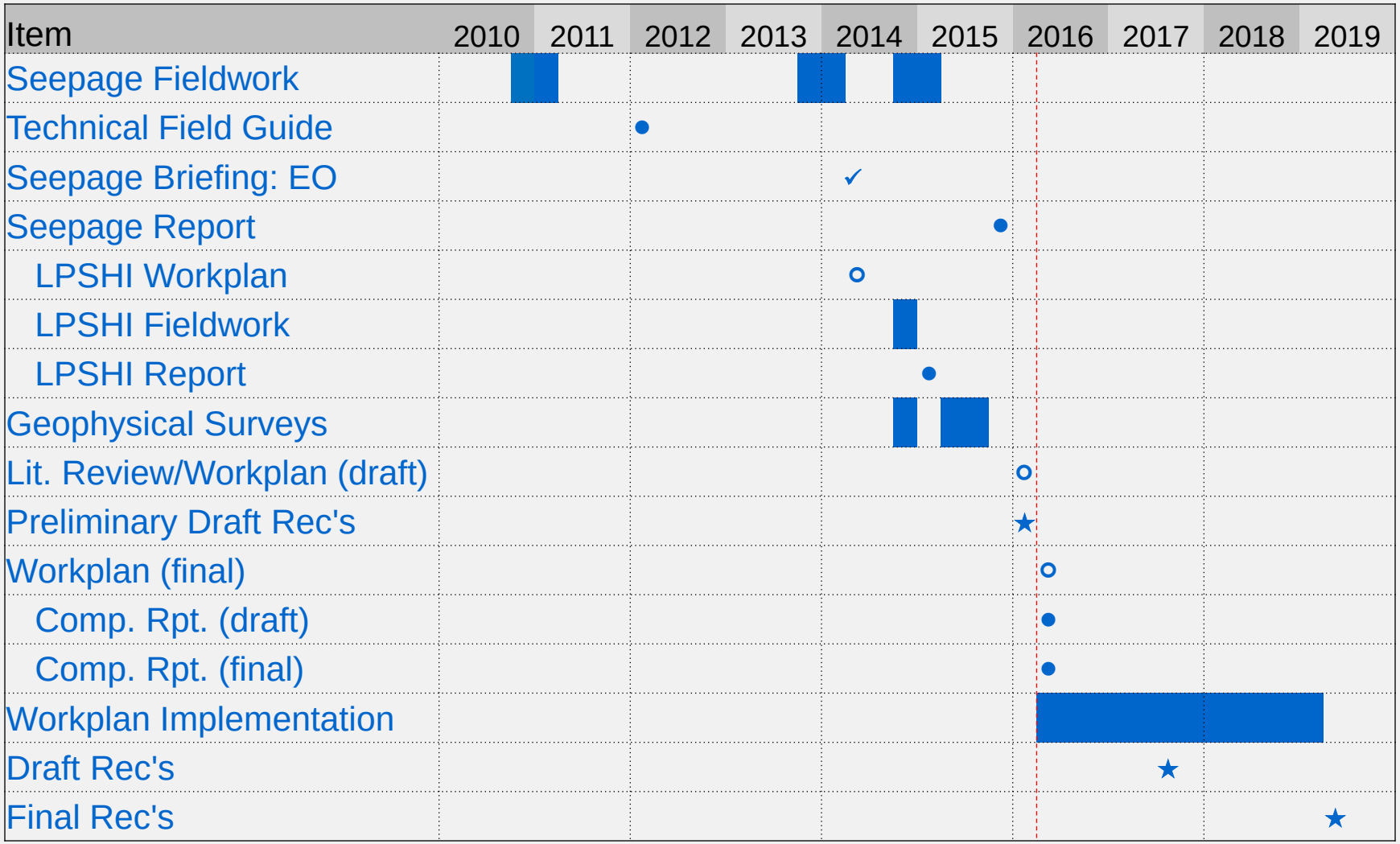
Basics

- 42 monitored dairies
- 443 dedicated monitoring wells at 279 well sites
- Phased approach started Jan. 2012 (18 dairies)
- Fully implemented Jan. 2013 (+24 dairies)
- Monthly GW level monitoring
- Groundwater quality monitoring
  - quarterly: 9 constituents
  - annual: 22 constituents
- >16,000 raw data points per year

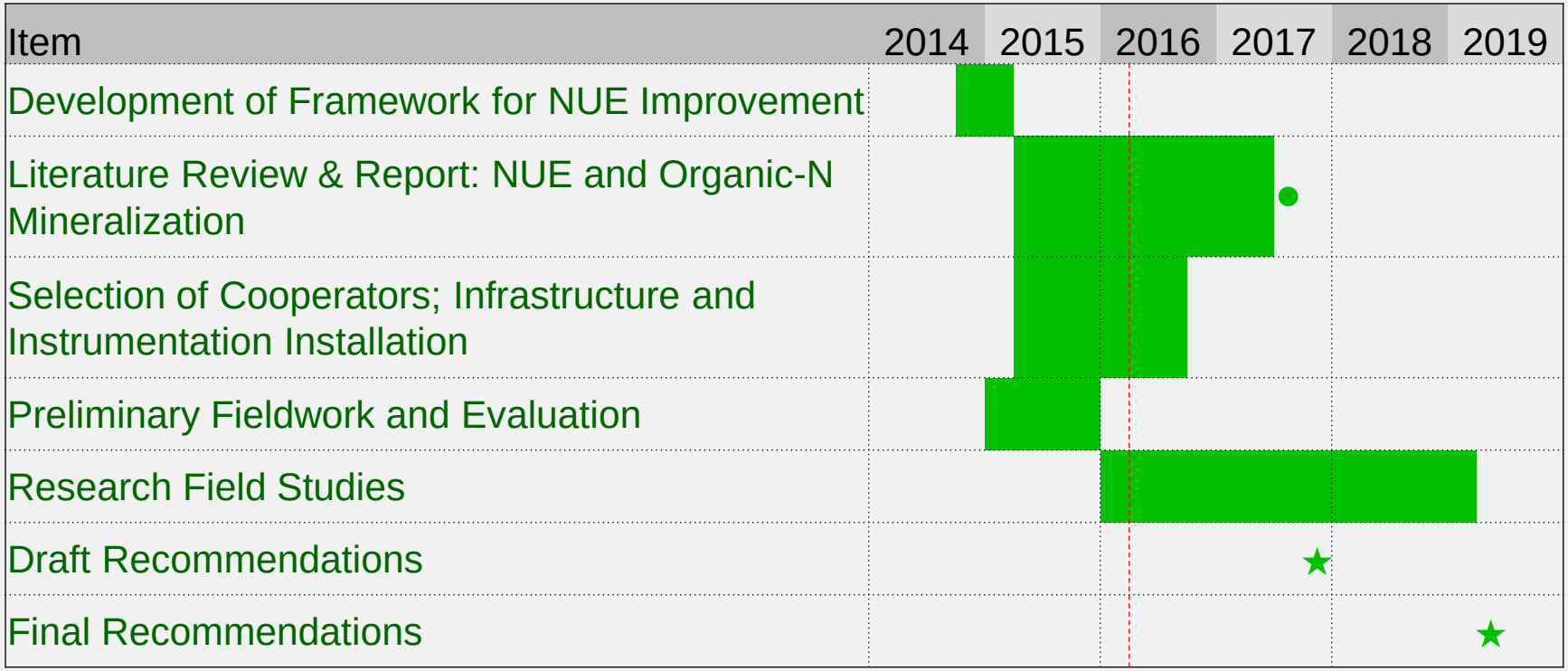
MW Installation and Monitoring Activities



Lagoon Investigations



Improving Nutrient Use Efficiency



Cumulative Groundwater Monitoring Results

1. Elevated NO_3 in groundwater beneath almost all monitored fields and animal housing
2. NO_3 (sandy soils) > NO_3 (clay soils)
3. Salinity (sandy soils) < salinity (clay soils)
4. Application of soil amendments on clay soils increases salinity
5. Cause-and-effect relationship between management practices and groundwater conditions weakens with increasing depth to groundwater
6. Dairymen receive quarterly groundwater quality data

Lagoon Investigations

Objective: *Generate a knowledge base to aid in evidence-based decision making regarding the fate of dairy lagoons*

Questions to answer

1. At what rates does lagoon liquor percolate and how does this compare to NRCS design seepage rates?
2. Are there significant seepage differences between lagoons (e.g., between sandy vs. clay-rich soils)?
3. How do lagoon loading rates to the subsurface compare to crop land loading rates?
4. How do loading rates compare to groundwater quality?
5. What is the extent of local impacts to groundwater quality?

Lagoon Investigation Fieldwork Matrix

Site/Lagoon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Water Balance Test			✓			✓			✓	✓	✓	✓			✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
LPSHI		✓	✓		✓		✓	✓	✓			✓	✓	✓	✓	✓	✓										
Monitoring Wells	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓			
Geophysical Survey	✓	✓	✓	✓	✓				✓		✓	✓			✓	✓	✓	✓									

- Minimal or no lagoon construction records
- Lagoon ages: <10 to ~50 years
- Lagoon depths: 8-30 feet
- Native materials: sand, loamy sand, sandy loam, loam, clay loam, silty clay

Summary of Mean Seepage Rates

- Mean = 1.1 mm d^{-1}
- Median = 0.7 mm d^{-1}
- Minimum = 0.0 mm d^{-1}
- Maximum = 2.9 mm d^{-1} (possible exposed gravel strata)
- Second highest = 2.2 mm d^{-1}
- No predictor variable

NRCS Design Seepage Rate
=
0.86 mm d^{-1}

Results are consistent with academic literature

- Seepage rates are moderated by the sealing effect of manure
- Seepage variance is small between sites
- A study in Kansas reported seepage rates from hog, cattle, and dairy lagoons ranging from 0.2 – 2.4 mm d^{-1} (n=20).

N-Loading Source	N-Loading Rate* [lbs ac^{-1} y^{-1}]	N-Mass Contribution** [tons y^{-1}]	Proportional N-Mass Contribution**
Prior to Targeted N-Management (Harter and Menke, 2005)			
Lagoon	1,045	180	**2.3%**
Cropland	570	7,700	97.7%
Improved N-Management on Cropland			
Lagoon	1,045	180	**3.5%**
Cropland	364	5,000	96.5%

* Within range of rates used in Harter et al. (2012).

**Based on 380 acres lagoons and 29,000 acres of manured fields on 41 CVDRMP-monitored dairies.

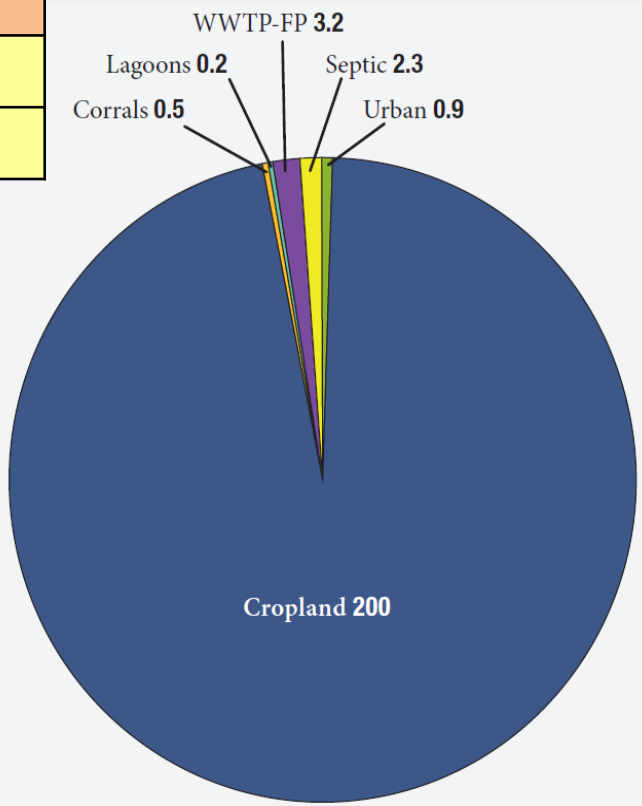


Figure ES-1. Estimated groundwater nitrate loading from major sources within the Tulare Lake Basin and Salinas Valley, in Gg nitrogen per year (1 Gg = 1,100 t).

From: Harter et al. (2012), *Addressing Nitrate in California's Drinking Water*

Geophysical Testing and Lagoon Perimeter Soil Coring

- Significant concentration decreases and oxidation over short distance between soil cores and monitoring wells (<100 feet)
- Groundwater constituent concentrations are non-unique with regard to lagoon seepage and N-mass loading
- Groundwater monitoring with respect to lagoon performance provides no information on the concentration of lagoon seepage, the seepage rate, overall subsurface mass loading rate, or the duration of the loading

Literature Review

- Main reference document: USDA NRCS Agricultural Waste Management Field Handbook (AWMFH)
- Lack of quantitative information indicating the effectiveness of existing management measures (MM); many MMs based on common sense
- Development of evidence that demonstrates further seepage reductions will be very difficult because seepage rates are already very small, limited precision of seepage testing
- Development of MMs will likely need to rely on qualitative reasoning more than quantitative evidence
- Weighing the (quantitative) cost of MMs against the perceived (qualitative) benefits is important

Draft Recommendations

Avoid oxidation of NH_4 to NO_3; damage of sludge layer

Do not:

- Use earthen, fully aerated storage lagoons and oxidation ditches unless data are provided documenting that this practice is protective of groundwater quality
- Completely dry storage lagoons in preparation for sludge removal unless data are provided documenting that this practice is protective of groundwater quality

Draft Recommendations

Avoid oxidation of NH_4 to NO_3

Do:

- Explore mechanisms to reduce periods of complete drying and exposure of cleaned-out SSBs to the atmosphere
- Develop practical guidance to limit subsurface N-emissions continuing after an earthen lagoon or SSB is decommissioned

Draft Recommendations

- Develop a third tier for the construction of new lagoons with a single synthetic membrane that does not require anti-degradation analysis and/or groundwater monitoring
- Allow continued use of existing earthen storage lagoons under certain circumstances

Soil Treatment of Lagoon Banks

Intends to reduce infiltration

Broadcasting of bentonite or soil dispersants; disking and repacking to reduce secondary porosity

Why is it of interest?

Banks have less developed sludge layer, are subject to desiccation, and have proportionally more seepage losses than lagoon floor; maybe possible without completely drying the lagoon

First step: Document current use on dairies, practicality, cost, effectiveness, safety issues

Synthetic Liners
Leak Detection and Seepage Testing

Conduct geoelectric leak detection surveys in conjunction with measurement of leachate removal and seepage testing

- What is the magnitude and range of whole-lagoon seepage rates from operational synthetic lined dairy lagoons, and can it be measured with the water balance method?
- How does the seepage rate relate to the size of identified leaks?

Partial Synthetic Liners for Banks

Investigate engineering feasibility of a liner apron

Address large area of lagoon with highest potential for seepage while maintaining traditional means of solids removal and reducing risk of whaling

Synthetic-lined Lagoons: Owner/Designer Survey

Document the effects on lagoon operations, maintenance, repair activities and expenditures

1. NO_3-N concentration in leachate under “optimal irrigation and nutrient management” in border check and furrow systems 10 – 55 mg/L
2. Precise nutrient management, while plausible in principle, may be problematic in full-scale production systems
3. Estimates AR-ratio of 1.4 – 1.65 based on hypothetical N- balance and computer simulations
4. Lack of literature on actually achieved AR-ratios on Central Valley dairies

CVDRMP Approach

Pursue a data-supported path to performance improvement of nutrient management with targeted research projects on select dairies

1. Demonstrate that the concept of the NUE is universally applicable, while actions to achieve improvements may differ from site to site
2. Document currently achieved NUEs under different conditions (as-is conditions)
3. Show the extent of improvement under different conditions
4. Document the level of effort and challenges associated with improvement under different conditions, including costs

CVDRMP Research Studies

1. Evaluate surface irrigation system (Distribution Uniformity, DU and, Irrigation Efficiency, IE).
2. Identify if/how DU/IE could be improved with the existing irrigation system.
3. Track nitrogen inputs, changes in soil storage, and harvest removal to compute NUE and leaching below the root zone.
4. Evaluate current N-application timing with crop need and identify if improvements to N-application timing and amount adjustments during the season can be made. Evaluate N-mineralization.

CVDRMP Research Studies

1. Collaborative effort with UC researchers
2. Preliminary 2015 studies helped experimental design
3. Four field sites in Merced, Madera, and Fresno counties. Data collection started with pre-plant soil sampling in April.
4. Two sites to be selected in Tulare/Kings/Kern counties. Data collection to start with pre-plant soil sampling in fall.
5. 2016/17: as-is conditions description/evaluation
6. 2017 and beyond: focus on improvements

Next Steps

1. Finalize and implement lagoon workplan
2. Finish and submit comprehensive lagoon performance report for review
3. Continue research studies and launch two more studies in fall 2016
4. Keep collaborative effort with LLNL (vadose zone residence times, groundwater age) on hold

CVDRMP continues to demonstrate by action

- Proactive, science-based, innovative, ***successful*** approaches and methods beyond GO-required monitoring

General Order's schedule is ambitious

- CVDRMP is on track to meet 2019 deadline for Summary Report
- Recommendations for management practices are being identified, vetted & solidified through field testing and MAC/GTAC discussions