Attachment 2

Phase 1 RMP Workplan; excluding its Attachment 1, the *Report of Results – Delineation of an Area for the Design and Initiation of a Representative Groundwater Monitoring Network for Existing Milk Cow Dairies, Central Valley, CA* (LSCE, 2010)

MONITORING AND REPORTING WORKPLAN

AND

MONITORING WELL INSTALLATION AND SAMPLING PLAN

PHASE 1:

INITIATION OF REPRESENTATIVE GROUNDWATER MONITORING NETWORK DESIGN &

MONITORING PROGRAM

EXISTING MILK COW DAIRIES – STANISLAUS AND MERCED COUNTIES, CALIFORNIA

FINAL

Prepared for

Central Valley Dairy Representative Monitoring Program

January 11, 2012

LUHDORFF AND SCALMANINI, CONSULTING ENGINEERS
WOODLAND, CA

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This document is the finalized version of the June 16, 2011 *Public Review Draft* without changes. The *Public Review Draft* was conditionally approved by the Executive Officer September 9, 2011.

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Table of Content

Table of Content 1
Tables, Figures, and Attachments 3
Acronyms 4
1 Executive Summary 5
1.1 Area Selection for Phase 1 RMP Initiation 5
1.2 Selection of Phase 1 Dairy Farms 6
1.3 Representativeness of the Representative Groundwater Monitoring Effort 6
1.4 Groundwater Monitoring on Dairies 7
1.5 Proposed Phase 1 Network of Dedicated Monitoring Wells 8
1.6 Monitoring and Reporting 8
1.7 Future Activities 9
2 Introduction 10
3 CVDRMP's Sustainable Dairy Farming Plan 12
3.1 RMP Administration 12
3.2 Groundwater Technical Advisory Committee 12
3.3 Multidisciplinary Advisory Committee 12
3.4 Stakeholder Input and External Review 13
4 Purpose and Scope 14
5 Representative Groundwater Monitoring Program 15
5.1 Framework 15
5.2 Additional Data Collection 16
5.3 Key Features 17
5.4 Area Selection for Monitoring Well Network 17
5.5 Selection of Initial Dairy Farms 18
5.5.1 Key Parameters 18
5.5.1.1 Physical Parameters – Manure Application Areas 20
5.5.1.2 Physical Parameters – Corrals 20
5.5.1.3 Physical Parameters – Liquid Manure Storage Ponds 21
5.5.1.4 Physical Parameters – Discussion 22
5.5.1.5 Dairy Farm Infrastructure and Operational Characteristics 22
5.5.2 Monitoring Well Siting and Other Considerations 23
5.6 Rationale for the Proportional Distribution of Monitoring Wells 23
5.7 Extrapolation of Monitoring Results to Non-Monitored Dairies 24
5.8 Refinement of Representative Groundwater Monitoring Program 25
5.9 Expansion of Representative Groundwater Monitoring Program 25
6 Proposed Phase 1 Representative Monitoring Well Network 26
7 Monitoring Well Construction 27
7.1 Monitoring Well Design 27
7.2 Monitoring Well Development 27
7.3 Wellhead Survey 28
8 Groundwater Sampling 29
8.1 Sampling Procedures and Instrumentation 29
8.1.1 Groundwater Level Measurements 29

8.1.2 Purging Protocol 29
8.1.2.1 Instrumentation 29
8.1.2.2 Calibration 30
8.1.2.3 Decontamination 30
8.2 Sample Handling and Recordation 30
8.3 Quality Assurance Procedures 30
8.3.1 Field Quality Control 30
8.3.2 Laboratory Quality Control 30
8.3.3 Review of Laboratory Data Reports 31

9 Groundwater Monitoring Program 32

9.1 Groundwater Levels 32
9.2 Groundwater Quality 32
9.2.1 Initial Sampling 32
9.2.2 Expanded Sampling 32
9.2.3 Quarterly Sampling 32
9.2.4 Annual Sampling 32

10 Reporting 33

10.1 Monitoring Well Installation Completion Report 33
10.2 Annual Reporting 33
10.3 Summary Report 34

11 Schedule 35

11.1 Estimated Schedule for Monitoring Well Construction and Reporting 35
11.2 Proposed Schedule for Other Elements of the RMP 35
11.3 Proposed Schedule for RMP Refinement and Expansion 35

12 References 36

Tables, Figures, and Attachments

Table 1 Dairy Farm Selection for Monitoring Well Installation
Table 2 Physical Parameter Types for Dairy Farm Selection by Management Unit
Table 3 Dairy Farm Herd Size, Manure Application Area, and Whole Farm Nitrogen Balance
Table 4 Number and Distribution of Monitoring Wells
Table 5 Construction Details of Existing Monitoring Wells
Table 6 Groundwater Quality Monitoring Program and Laboratory Analyses
Table 7 Laboratory Methods and Reporting Limits

Figure 1 Location Map – Phase 1 Selected Dairy Farms, Representative Groundwater Monitoring Program
Figure 2 Index Map – Phase 1 Selected Dairy Farms, Representative Groundwater Monitoring Program
Figure 3 Albert Mendes Dairy – Proposed Monitoring Well Locations
Figure 4 Robert Gioletti and Sons Dairy – Proposed Monitoring Well Locations
Figure 5 Index Map for Frank J. Gomes #1 and Anchor J. Dairies
Figure 6 Frank J. Gomes Dairy #1 – Proposed Monitoring Well Locations
Figure 7 Anchor J. Dairy – Proposed Monitoring Well Locations
Figure 8 P. and L. Souza Dairy – Proposed Monitoring Well Locations
Figure 9 Paul Caetano Dairy – Proposed Monitoring Well Locations
Figure 10 Bettencourt and Marson Dairy – Proposed Monitoring Well Locations
Figure 11 Gallo Cattle Company, Bear Creek Dairy – Proposed Monitoring Well Locations
Figure 12 Index Map for Gallo Cattle Company, Cottonwood and Santa Rita Dairies
Figure 13 Gallo Cattle Company, Cottonwood Dairy – Proposed Monitoring Well Locations
Figure 14 Gallo Cattle Company, Santa Rita Dairy – Proposed Monitoring Well Locations
Figure 15 Moonshine Dairy – Proposed Monitoring Well Locations
Figure 16 Antone L. Gomes and Sons Dairy – Proposed Monitoring Well Locations
Figure 17 Frank J. Gomes Dairy #2 – Proposed Monitoring Well Locations
Figure 18 Tony L. Lopes Dairy LP – Proposed Monitoring Well Locations
Figure 19 Correia Family Dairy – Proposed Monitoring Well Locations
Figure 20 Jose Nunes and John Machado Dairies – Proposed Monitoring Well Locations
Figure 21 Godinho Dairy – Proposed Monitoring Well Locations
Figure 22 Typical Nested Groundwater Monitoring Well Profile
Figure 23 Typical Groundwater Monitoring Well Profile
Figure 24 Typical Surface Completion Detail

Attachment 1 Report of Results – Delineation of an Area for the Design and Initiation of a Representative Groundwater Monitoring Network for Existing Milk Cow Dairies, Central Valley, CA. Luhdorff and Scalmanini, Consulting Engineers (August 31, 2010)
Attachment 2 Construction Details of Existing Monitoring Wells
Attachment 3 Example field sheet for groundwater sampling

Acronyms

ASTM	American Society for Testing and Materials
COC	chain of custody
CVDRMP	Central Valley Dairy Representative Monitoring Program
CVHM	Central Valley Hydrologic Model
CVRWQCB	Central Valley Regional Water Quality Control Board (CVRWQCB)
DWR	California Department of Water Resources
GTAC	Groundwater Technical Advisory Committee
LSCE	Luhdorff and Scalmanini, Consulting Engineers
MAC	Multidisciplinary Advisory Committee
MCL	Maximum Contaminant Level
MRP	Monitoring and Reporting Program
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
SDFP	Sustainable dairy farming plan
QA	quality assurance
QC	quality control
RMP	Representative Groundwater Monitoring Program
TDS	total dissolved solids
TID	Turlock Irrigation District
TKN	Total Kjeldahl Nitrogen
UCCE	University of California Cooperative Extension
USCS	Unified Soil Classification System

1 Executive Summary

This document was prepared for the Central Valley Dairy Representative Monitoring Program (CVDRMP), and in response to the Central Valley Regional Water Quality Control Board's (CVRWQCB) *Waste Discharge Requirements General Order No. R5-2007-0035 for Existing Milk Cow Dairies* (General Order) and its revised Monitoring and Reporting Program (revised General Order MRP). The CVDRMP is a coalition of more than 960 member dairies formed in 2010 to conduct and manage a Representative Monitoring Program. CVDRMP is a non-profit California corporation managed by a 12-member board of directors to administer the Representative Groundwater Monitoring Program (RMP). CVDRMP is presently in the process of creating a comprehensive sustainable dairy farming plan (SDFP). Components of the SDFP provide for rigorous peer review of RMP data collection, analyses, and interpretations, by two technical advisory committees, stakeholder input, and ongoing identification of research, extension and consulting needs, and funding sources necessary to support those needs. The CVDRMP also proposes to implement the RMP in a minimum of two phases with ongoing refinement as the program proceeds.

- Phase 1 RMP refers to the initiation of a network of dedicated monitoring wells in Stanislaus and Merced Counties, and associated comprehensive data collection, analysis, and reporting. The document herein is referred to as the Phase 1 RMP Workplan.
- Phase 2 RMP refers to the geographic expansion of the RMP to all San Joaquin Valley Counties, and selected counties in the Sacramento Valley, where dairy farming occurs. Phase 2 will be addressed in a separate Phase 2 Workplan.

The goal of the RMP is to identify dairy farm practices protective of groundwater quality (including practices currently employed in response to the General Order) using a data collection and analysis effort that targets a subset of Central Valley dairy farms. This Phase 1 RMP Workplan aims to satisfy the regulatory requirements for both the Monitoring and Reporting Workplan and the Monitoring Well Installation and Sampling Plan identified in the revised General Order MRP.

1.1 Area Selection for Phase 1 RMP Initiation

Luhdorff and Scalmanini, Consulting Engineers (LSCE) evaluated dairy farm characteristics along with environmental parameters to determine the area most sensitive to dairy management practices in the *Report of Results* (LSCE, 2010). This area was selected based on delineation of those areas in the Central Valley where high groundwater nitrogen and salt concentrations are thought to be substantially attributable to dairy operations and where changes in water quality are most likely to be detected quickly due to adoption of management practices required by the General Order. The analysis included comparison of key information such as relative dairy farm/milk cow densities and other historical livestock operations data, historical average depths to groundwater, soil permeability, historical recharge to groundwater, observed historical groundwater nitrate and total dissolved solids (TDS) concentrations, and whole farm nitrogen balances submitted to the CVRWQCB in response to the General Order. Based on the above criteria, the *Report of Results* recommended that the representative groundwater monitoring be initiated in Stanislaus and Merced Counties (i.e., from the Stanislaus River in the north and the Chowchilla River in the south) between the San Joaquin River and Highway 99. This area is referred to as the high priority area, and is characterized by predominantly coarse-grained, highly permeable soils, and shallow depth to groundwater.

The high priority area will facilitate understanding of the causal link between groundwater quality changes (as observed with the network of dedicated monitoring wells) in response to modifications to dairy management practices. The shorter the response time the sooner conclusions can be drawn from the data, and the higher the confidence in the identified linkage between management practices and groundwater quality trends. To increase the representativeness of the Phase 1 data collection effort, the Phase 1 RMP Workplan also includes dairy farms west of the San Joaquin River in an area of shallow groundwater and clay-rich, low permeability soils.

1.2 Selection of Phase 1 Dairy Farms

There are two key components involved in the transfer of nutrients and salts from the land surface to underlying soil and groundwater, specifically, the rate of deep percolation and constituent concentrations of the infiltrate. Accordingly, surface processes (including management practices) in combination with soil properties in the very shallow zone (e.g., the crop root zone of manure application areas) are important factors for groundwater quality analysis and interpretation. The relationship between these factors and the extrapolation of results from the RMP to non-monitored dairy farms is described below.

Physical Parameters

Physical parameters (e.g., soil texture, depth to groundwater, irrigation depth, manure and fertilizer application, and crop type and rotation) directly support the analysis and interpretation of groundwater quality data and the extrapolation of results from the RMP to non-monitored dairy farms. These parameters are key to the representativeness of the RMP, and dairy farms were selected accordingly for participation in the Phase 1 RMP.

Dairy Farm Infrastructure and Operational Characteristics

In contrast to physical parameters, dairy farm infrastructure and operational characteristics (e.g., dairy farm size; number of lactating milk cows, dry cows, heifers, calves, and bulls; and the relationship between annual manure exports and imports of synthetic fertilizers) do not have direct bearing on the analysis and interpretation of groundwater quality data, because they do not provide information on actual subsurface loading rates. Dairy farm characteristics were considered to assemble an initial group of dairy farms that is intended to be sufficiently representative of a cross section of typical dairy farms and a wide range of typical operational management practices for purposes of initiating the Phase 1 RMP. Therefore, from an infrastructure and operational standpoint, non-monitored dairies exhibiting similar characteristics are expected to be able to implement similar management practices that are determined to result in groundwater quality improvements on monitored farms. As such, the diversity of these parameters in the group of monitored dairy farms is key to the implementability of identified management practices on non-monitored dairy farms. It is expected that through the process of RMP refinement, initial data gaps will be identified and addressed during Phase 2.

Other Important Considerations

Only CVDRMP member dairy farms were considered because these farms are contractually bound to permit groundwater monitoring to occur on their property as part of the RMP. After reviewing the CVRWQCB's files, aerial photography was used to identify potential candidate farms. The owners/operators of these dairy farms were informed by mail, and also follow-up phone calls, that their dairy farms had been selected as a potential site to install RMP monitoring wells. These owners/operators were invited to an informational meeting on April 8, 2011 to introduce them to the RMP, the CVDRMP board of directors, and next steps. At the meeting, 23 site visits were scheduled.

Prior to the site visits, major selection criteria were the size and geometry of dairies' management units with regard to the inferred, prevailing regional groundwater flow direction. For example:

- Large management units are favorable to groundwater monitoring efforts on dairy farms.
- The geometry of the management unit should be such that the expected source area for the to-be-constructed monitoring well(s) would take full advantage of the management unit's extent.
- Clear separation between management units.

1.3 Representativeness of the Representative Groundwater Monitoring Effort

The ability to extrapolate monitoring results from dairy farms monitored under the RMP to non-monitored dairy farms rests on the selection of physical parameters that directly support the analysis and interpretation of groundwater quality data. For example, dairy practices on coarse-grained/sandy soils over shallow groundwater that result in groundwater quality improvements beneath cropped manure application fields that are part of the RMP are expected to produce similar results beneath non-monitored fields of similar soil types in areas of similar precipitation patterns. The same rationale applies to corrals and liquid manure storage ponds.

Since increased depths to groundwater and increased seasonal variability of groundwater level elevations do not exert control on subsurface salt loading rates, Phase 1 and subsequent phase results will also be applicable to areas with these characteristics without necessitating additional data collection efforts. Although response times between dairy management practices (and associated changing nutrient and salt loading characteristics) and potential groundwater quality changes in areas of deep first encountered groundwater will be significantly prolonged, there remains a potential for long-term impact and also improvement related to modified practices. Additionally, data analysis and interpretation in such areas are exacerbated by the difficulty to delineate (with a reasonable degree of confidence) contributing source areas and, ultimately, establish a causal link between groundwater quality results and the range of management practices by management unit. Consequently, measures to avoid groundwater quality impacts would likely not occur in these areas for a potentially very long time unless a proactive approach is taken via extrapolation of RMP results.

1.4 Groundwater Monitoring on Dairies

Groundwater monitoring efforts will target the uppermost zone of first encountered groundwater beneath three distinct management units, i.e., the liquid manure storage ponds, corrals, and manure applied forage fields.

There are two significant differences between traditional groundwater monitoring of regulated units and groundwater monitoring on dairy farms:

- Traditional regulated units are designed to not recharge groundwater, whereas irrigated agriculture depends on sufficient leaching of salt residue beyond the crop root zone to avoid increasing soil salinity and associated soil degradation and crop losses (and some recharge is also expected from corrals and liquid manure storage ponds). In the case of dairy farms, groundwater samples retrieved from both upgradient and downgradient monitoring wells will not originate from the same source areas but from different source areas.
- Typically, constituents of concern related to traditional regulated units are not commonly found in natural groundwater systems (e.g., petroleum products), and a detection in a downgradient well provides evidence that the regulated unit leaks (given that this constituent is not detected in the upgradient well). This is in contrast to irrigated agriculture, where constituents of concern (i.e., mainly nitrate and other salts) are ubiquitous in groundwater systems.

RMP Monitoring Well Design, Data Collection, and Data Interpretation

The circumstances under which groundwater monitoring is conducted in areas of irrigated agriculture have the following implications for monitoring well design, data collection, and data interpretation:

- RMP monitoring wells positioned downgradient of a management unit are aimed to be constructed such that they intercept groundwater, which originates under that targeted management unit, only.
- Groundwater sampling should occur in the upper few feet of the groundwater column to avoid mixing of (younger) groundwater originating under the targeted management unit with (older) groundwater from source areas upgradient of the targeted management unit.
- As a corollary to the above, the concept of comparing downgradient to upgradient groundwater quality as a means to determine potential groundwater degradation loses its utility in recharge-dominated systems.

The Phase 1 RMP attempts to address the above design challenges using a two-pronged approach:

- The Phase 1 RMP areas are characterized by very shallow groundwater. Also, irrigation water needs in most of these areas are largely satisfied with surface water deliveries from local water purveyors. This translates into less agricultural demands on groundwater resources and less pumping-induced seasonal groundwater level fluctuations.

- Most monitoring wells will be constructed as nested wells (i.e., two well casings with relatively short well screens located at different depth intervals, constructed in one bore hole).

Nested Monitoring Well Design

The nested monitoring well design planned for most of the Phase 1 sites provides monitoring facilities that:

- address uncertainty regarding the extent of the upgradient area contributing flow to the well (i.e., the source area);
- is less vulnerable to seasonal and longer-term groundwater level fluctuations than single-completion monitoring wells;
- is suitable for the installation of shorter screen lengths (e.g., 5-15 feet), which helps avoid potential groundwater quality bias due to vertical flow components in the wells; and
- can be used for chemical groundwater profiling including isotopic groundwater age dating.

The proposed nested design also (i) increases data quality and the confidence in analysis and interpretations, (ii) increases the flexibility for analytical approaches, and (iii) avoids or decreases the need for potential future well replacements, for example, as a result of groundwater level declines causing a well to go "dry".

1.5 Proposed Phase 1 Network of Dedicated Monitoring Wells

This Phase 1 RMP Workplan proposes a network of 135 dedicated monitoring well locations distributed over 18 dairy farms in Stanislaus and Merced Counties, and associated comprehensive data collection, analysis, and reporting. Eighteen (18) of the proposed monitoring wells already exist and wells at 117 locations are proposed for installation. Eighty-six (86) monitoring well locations are distributed over 10 dairy farms located in the high priority area. Forty-nine (49) monitoring well locations are distributed over 8 dairy farms located in the area west of the San Joaquin River in Stanislaus and Merced Counties.

Most of these wells will be installed as nested wells (i.e., two wells of different depth and construction installed in one borehole). Therefore, the proposed 135 monitoring well locations actually symbolize a much larger number of individual monitoring facilities (possibly upwards of 200). However, for ease of communication, each well location is referred to as one well herein, regardless of whether or not it will be completed as a nested well.

1.6 Monitoring and Reporting

The monitoring activities proposed herein exceed requirements of the revised General Order MRP. This includes high frequency groundwater level measurements to evaluate potentially important seasonal intricacies of groundwater flow conditions, and comprehensive baseline sampling, subsequent quarterly sampling for a reduced set of constituents, and annual sampling for an expanded set of constituents.

A Monitoring Well Installation Completion Report will be prepared in compliance with Item C, Attachment A of the revised General Order MRP.

RMP Annual Reports will be prepared in compliance with the revised General Order MRP and applicable Standard Provisions and Reporting Requirements of the General Order, and in accordance with the goal of the RMP. The reports will present cumulative groundwater level and quality data collected to date and utilize tables and figures to communicate the dairies' layout and infrastructure, monitoring results, pertinent observations, and data trends. The reports will provide geologic/lithologic conceptualization of the shallow subsurface, hydrogeologic analysis (e.g., groundwater level hydrographs, groundwater level contour maps, groundwater quality data, trend analyses, and statistical analyses) and comparative evaluations in view of variable land uses and dairy operations. Further, the reports will present and evaluate any information pertinent to the operation and management of the specific investigated dairy management units. Analytical tools may include statistical procedures such as:

- cluster analysis to assess the *a priori* hypothesis of differences in groundwater quality between management units;

- assessment of statistical sample distributions and spatial and temporal autocorrelations between groundwater samples to aid, for example, in the delineation of appropriate analytical approaches, sampling frequencies, and placement of additional monitoring wells;
- statistical intervals such as upper tolerance bounds or prediction intervals with associated confidence levels;
- concentration averaging specific to management unit and comparison against recharge and loading estimates;
- farm-scale averaging to assess overall farm performance; and
- group comparisons using, for example, analysis of variance (parametric or nonparametric).

1.7 Future Activities

CVRWQCB approval of this Phase 1 RMP Workplan will trigger several activities.

Within 3 months:

- Complete Phase 1 RMP well installation

Within 6 months:

- Advisory committees to CVDRMP (i.e., the Groundwater Technical Advisory Committee and the Multidisciplinary Advisory Committee) will be formed.
- Initiate a dialogue with the CVRWQCB regarding the overall scope of the Phase 2 RMP and cooperatively work with the advisory committees on the details to be incorporated in the Phase 2 RMP Workplan.
- A public stakeholder meeting will be held (location, time and agenda to be coordinated with CVRWQCB staff).

Ongoing Activities:

- ongoing data analysis and interpretation
- annual reporting
- RMP refinement (i.e., continuous improvement of the work effort, for example, via identification of data gaps)

A Summary Report (as described in the revised General Order MRP) will be prepared within 6 years of initiating Phase 1 sampling activities to provide a comprehensive synthesis of RMP monitoring activities (Phase 1 and subsequent phases), results, and findings related to dairy management practices historically and currently employed by the monitored dairy farms, the effects of those practices on groundwater quality, and observed groundwater quality trends in response to modified practices during the first 6 years of the program.

The Summary Report is intended to serve as a technical basis for evidence-based regulatory decision-making. In this capacity, the Summary Report will analyze and discuss the effectiveness of dairy management practices and provide information that will be applicable to both monitored and non-monitored dairy farms.

2 Introduction

This document was prepared for the Central Valley Dairy Representative Monitoring Program (CVDRMP), the administrative body managing the Representative Groundwater Monitoring Program (RMP). It is referred to as the Phase 1 RMP Workplan and aims to satisfy the regulatory requirements for both the Monitoring and Reporting Workplan and the Monitoring Well Installation and Sampling Plan identified in the revised General Order MRP. Phase 1 RMP refers to the initiation of a network of dedicated monitoring wells in Stanislaus and Merced Counties, and associated comprehensive data collection, analysis, and reporting. Phase 2 RMP refers to the geographic expansion of the RMP to all San Joaquin Valley Counties, and selected counties in the Sacramento Valley, where dairy farming occurs.

CVDRMP is presently in the process of creating a comprehensive sustainable dairy farming plan (SDFP). Components of this plan provide for rigorous peer review of RMP data collection, analyses, and interpretations, by two technical advisory committees, stakeholder input, and ongoing identification of research, extension and consulting needs, and funding sources necessary to support those needs.

Background

On May 3, 2007, the Central Valley Regional Water Quality Control Board (CVRWQCB) adopted *Waste Discharge Requirements General Order No. R5-2007-0035 for Existing Milk Cow Dairies* (General Order) (CVRWQCB, 2007). The General Order defines an existing milk cow dairy as a dairy that (i) was operating as of October 17, 2005, (ii) filed a complete Report of Waste Discharge in response to the CVRWQCB's August 8, 2005 Report of Waste Discharge Request Letter, and (iii) has not expanded since October 17, 2005 (i.e., its herd size has not increased by more than 15%). The General Order regulates waste discharges to land at the majority of 1,429 existing dairies[1] of all sizes and imposes significantly more stringent requirements than in the past.

Relative to groundwater monitoring, the General Order and its accompanying Monitoring and Reporting Program (MRP) specify two requirements: (1) monitoring of domestic and agricultural supply wells at dairies, and (2) additional groundwater monitoring. The latter requirement is presently implemented by the Executive Officer by ordering individual dairies to install monitoring wells ("site-by-site approach"). However, the General Order also authorizes the Executive Officer to approve alternative monitoring methods. The Information Sheet (page IS-8) states:

> "In the future, the Executive Officer or Central Valley Water Board may determine that a proposed alternative method of environmental monitoring is appropriate to determine if groundwater protection is being achieved. One suggested alternative has been to allow regional groundwater monitoring as a substitute for groundwater monitoring at individual dairies. Any proposed alternative will require sufficient details for consideration by either the Executive Officer or Central Valley Water Board. The Executive Officer or the Central Valley Water Board must issue a monitoring and reporting program order for any alternative environmental monitoring."

To further the development of an alternative environmental monitoring method, Dairy Cares (www.dairycares.com) submitted a proposal on October 5, 2009 (Dairy Cares, 2009) to the CVRWQCB Executive Officer for the development of a collaborative plan that would allow a representative groundwater monitoring approach to satisfy the additional groundwater monitoring requirements in lieu of the site-by-site approach of the General Order MRP.

At the February 4, 2010 stakeholder meeting held at the CVRWQCB's offices in Rancho Cordova, Luhdorff and Scalmanini, Consulting Engineers (LSCE) presented an initial outline of the representative groundwater monitoring approach, which was developed based on a regional monitoring approach proposed by Dr. Thomas Harter of the University of California Cooperative Extension (UCCE) in September 2008 (Harter, 2008). The monitoring approach was discussed in greater detail at the March 9, 2010 meeting of the CVRWQCB's Groundwater Advisory Workgroup, also held at the CVRWQCB's offices in Rancho Cordova.

[1] As of January 2010 (personal communication with J.P. Cativiela, Dairy Cares, April 2, 2010).

Concurrently, LSCE evaluated dairy farm characteristics along with environmental parameters to determine the area most sensitive to dairy management practices in the *Report of Results* (LSCE, 2010; **Attachment 1**). This area (which is the primary focus in this document) was selected for initiating the RMP based on delineation of those areas in the Central Valley where high groundwater nitrogen and salt concentrations are thought to be substantially attributable to dairy operations and where changes in water quality are most likely to be detected quickly due to adoption of management practices required by the General Order. The analysis included comparison of key information such as relative dairy farm/milk cow densities and other historical livestock operations data, historical average depths to groundwater, soil permeability, historical recharge to groundwater, observed historical groundwater nitrate and total dissolved solids (TDS) concentrations, and whole farm nitrogen balances submitted to the CVRWQCB in response to the General Order. This work effort recommended that the representative groundwater monitoring be initiated in Stanislaus and Merced Counties (i.e., from the Stanislaus River in the north and the Chowchilla River in the south) between the San Joaquin River and Highway 99 (this area is referred to as the high priority area). Results of this work effort were presented at the April 5, 2010 stakeholder meeting held at the CVRWQCB's offices in Rancho Cordova.

Subsequently, two concurrent work efforts ensued. One was the formation of an administrative body to manage the RMP. This occurred on May 17, 2010 with the founding of the CVDRMP. The other effort concerned the modification of the MRP to provide regulatory support for the RMP. The revised General Order MRP was issued by the Central Valley Executive Officer on February 23, 2011 (CVRWQCB, 2011).

3 CVDRMP's Sustainable Dairy Farming Plan

CVDRMP is presently in the process of creating a comprehensive sustainable dairy farming plan (SDFP). The SDFP is tentatively composed of the following components:

- Phase 1 – Initiation of the RMP including a detailed network of dedicated monitoring wells located in Stanislaus and Merced Counties;
- Phase 2 – Geographic expansion of the RMP to include dairy farms in all counties in the San Joaquin Valley plus some dairies between Sacramento and Tehama Counties in the Sacramento Valley;
- formation of a Groundwater Technical Advisory Committee;
- formation of a Multidisciplinary Advisory Committee;
- stakeholder input and external review; and
- ongoing identification of research, extension and consulting needs (and funding sources necessary to support those needs) to ensure dairy practices are protective of water quality.

A detailed description of the Phase 1 RMP is presented in this Phase 1 RMP Workplan. This Phase 1 RMP Workplan also conceptually outlines Phase 2 by (i) quantifying its overall scope (i.e., general location and number of participating dairy farms) and (ii) providing a time table to develop a detailed Phase 2 RMP Workplan. The remaining SDFP components are outlined below.

3.1 RMP Administration

The CVDRMP is a coalition of more than 960 member dairies formed in 2010 to conduct and manage a Representative Monitoring Program. CVDRMP is a non-profit California corporation managed by a 12-member board of directors to administer the RMP. CVDRMP was officially formed on May 17, 2010, following a series of more informal scoping and planning meetings. Important duties for the board of directors in the near term are:

- solicitation of membership in the program from dairy operators/owners and collection and management of membership fees (962 members as of May 20, 2011);
- submission of an acceptable Phase 1 RMP Workplan to the CVRWQCB; and
- upon CVRWQCB approval of this Phase 1 RMP Workplan, selection and hiring of personnel to drill and install monitoring wells, collect groundwater level and quality data, compile, organize, analyze, and interpret data, and prepare annual monitoring reports.

3.2 Groundwater Technical Advisory Committee

The purpose of the Groundwater Technical Advisory Committee (GTAC) is to ensure adequacy of the RMP data collection effort, soundness of analytical tools, and interpretations. The GTAC will be formed within 6 months of CVRWQCB approval of this Phase 1 RMP Workplan. It is envisioned that this committee will include, for example, hydrologists, statisticians with experience in environmental applications relevant to this work effort, members of the University of California Cooperative Extension Hydrology Program, dairy farm representatives, and CVRWQCB staff and additional professionals as determined appropriate by CVDRMP. Members of the GTAC will be asked to critically review and formally comment on draft annual reports before their finalization. The GTAC review and comment process is to facilitate delivery of comprehensive work products (particularly Annual Reports) submitted to the CVRWQCB for its review, comment, and ultimate approval.

3.3 Multidisciplinary Advisory Committee

The MAC will be formed within 6 months of CVRWQCB approval of this Phase 1 RMP Workplan. It is envisioned that this committee will include professionals providing background in agronomy, economy, animal nutrition, irrigation, plant biology, hydrology, and civil engineering (with emphasis on liquid manure storage pond design, pond liners and covers, wastewater treatment, and digester technology), members of the University of California Cooperative Extension Hydrology Program, dairy farm representatives, and CVRWQCB staff, and others as deemed appropriate by CVDRMP.

The purpose of the Multidisciplinary Advisory Committee (MAC) is to:

- Aid in the compilation of a list of existing management practices, which will be used in the refinement of the RMP and affect both the extrapolation of RMP findings to non-monitored facilities and the expansion of the RMP;
- identify innovative methodologies[2], approaches, and analytical tools (e.g., whole farm nitrogen use efficiency modeling, modeling of nitrogen and salt movement in the root zone, and groundwater modeling) to support the RMP and its goals;
- review and evaluate results from implemented methodologies, approaches, and analytical tools;
- identify potential research needs; and
- identify potential solutions in response to findings of the RMP[3].

3.4 Stakeholder Input and External Review

Public stakeholder meetings will be held on a semi-annual basis starting upon approval of this Phase 1 RMP Workplan. The purpose of these stakeholder meetings will be to:

- inform stakeholder groups of the progress and development of the RMP and the overarching SDFP;
- inform stakeholder groups on key findings of the RMP that are presented in Annual Reports;
- provide a platform to discuss findings and answer questions on the SDFP; and
- provide a platform for public input and external review from interested parties.

[2] An example of a promising methodology to assess the seepage rate of working liquid manure storage ponds was identified as part of a systematic literature review (LSCE, 2008). A demonstration project including the application of this methodology to five liquid manure storage ponds in winter 2010/11 in conjunction with an outreach program has been funded by the U.S. Department of Agriculture (USDA) and California Department of Food and Agriculture/Dairy Cares and is presently being carried out. Results from this demonstration project will be submitted to the MAC for critical review and comment.

[3] It is fully expected that such developed management practices will be relevant to both CVDRMP member dairy farms and also to non-member dairy farms.

4 Purpose and Scope

The purpose of this Phase 1 RMP Workplan is to seek CVRWQCB approval to proceed with the implementation of the RMP. Specifically, this document aims to satisfy the regulatory requirements for both the Monitoring and Reporting Workplan and the Monitoring Well Installation and Sampling Plan identified in the revised General Order MRP. The remainder of this document is structured as follows:

- *Section 5* provides detailed discussions of RMP components and underlying rationale controlling the design of the Phase 1 well network. This includes:
  - *Section 5.1* – a discussion of similarities and differences between traditional groundwater monitoring for regulatory compliance and groundwater monitoring in irrigated agricultural settings,
  - *Section 5.2* – a description of anticipated data collection efforts the RMP will pursue to facilitate interpretation of groundwater quality trends beneath management units,
  - *Section 5.3* – key features of the RMP,
  - *Section 5.4* – a summary of how the high priority area was identified,
  - *Section 5.5* – a discussion of key parameters used in the selection of dairy farms,
  - *Section 5.6* – the rationale for the proportional distribution of proposed monitoring wells,
  - *Section 5.7* – the rationale for extrapolating monitoring results to non-monitored dairy farms,
  - *Section 5.8* – the process of ongoing RMP refinement, which aims to improve the representativeness and overall performance of the RMP, and
  - *Section 5.9* – the process of Phase 2 expansion of the RMP.
- *Sections 6-8* present information for the Monitoring Well Installation and Sampling Plan portion of the Phase 1 RMP Workplan, i.e., detailed information on proposed well locations, preliminary well design, well development, wellhead surveying, and groundwater sampling procedures.
- *Sections 9* and *10* present a detailed monitoring and reporting program that exceeds requirements set forth in the General Order.
- *Section 11* proposes a schedule for the installation of the monitoring well network described herein through the submittal of a Monitoring Well Installation Completion Report to the CVRWQCB. It also provides a conceptual process schedule, including timelines for the creation of technical advisory committees, RMP refinement, and RMP expansion (Phase 2).
- *Section 11* – References

5 Representative Groundwater Monitoring Program

The goal of the RMP is to identify dairy farm practices protective of groundwater quality using a data collection effort that targets a subset of Central Valley dairy farms. To reach this goal, the RMP aims to:

- examine current groundwater conditions and how they relate to historical dairy management practices and recent changes to those practices; and
- generate results and recommendations for additional changes to waste management and utilization practices that are applicable beyond areas of monitored dairies (to non-monitored dairies).

5.1 Framework

Nearly the entire acreage of a typical Central Valley dairy constitutes a potential source of manure-related waste discharge, including the corrals or exercise yards, the freestalls with their flush lanes, underground waste conveyance facilities, solid and liquid waste storage facilities, areas for manure drying and feed storage, and all crop land receiving manure applications, including elaborate irrigation and drainage systems of pipes, canals, and ditches. In addition, the adjacency of different management units (with different loading characteristics) and the large size of dairies (i.e., hundreds to sometimes thousands of acres) makes groundwater monitoring, as the sole means to enforce compliance with water quality objectives, ineffective and very expensive. Many dairies apply manure and commercial fertilizer to grow feed for their animals on 10 to 20 or more individual fields. Crop types, cropping patterns (including crop rotations within a year and year-to-year), irrigation practices, manure application rates, and other variables may vary substantially from field to field. Highly variable application rates may also occur within individual fields. While many of these fields are adjacent to each other, many fields may also be distant from the production area[4]. There may also be significant changes from year to year, as land leases expire and new land is acquired. In light of the inherent complexity of dairy operations and their sheer geographic extent, groundwater monitoring can feasibly occur only on a small fraction of the manure application areas and other management units. In an effort to respond to the challenges outlined above, the Phase 1 RMP was developed and includes an extensive groundwater monitoring network consisting of new and existing dedicated monitoring wells.

For the purposes of extensive groundwater quality research, California dairy farms have previously been conceptualized to consist of three main management units, the land application areas, corrals, and liquid manure holding ponds (CVRWQCB, 2007; Harter et al., 2001a; Harter, 2008; van der Schans et al., 2009). These management units have been documented to exhibit distinctly different subsurface loading characteristics and are often large enough to support targeted groundwater quality monitoring. Therefore, this concept has been incorporated into the RMP.

It is useful to compare traditional groundwater monitoring of regulated units (e.g., underground storage tanks, mining operations, refineries, dry cleaners, and landfills) to groundwater monitoring on dairy farms. In either case, the monitoring effort targets the uppermost zone of first encountered groundwater, i.e., the shallowest existing groundwater. However, there are two significant differences with important implications regarding monitoring well design, data collection, and data interpretation.

1. Traditional regulated units are designed to not recharge groundwater. This is accomplished by roofing, asphalt and concrete surfaces, synthetic liners, and possibly leachate collection systems. As a result, monitoring wells placed upgradient and downgradient of the unit may have an essentially identical source area (i.e., the area which supplies groundwater to the well). Under this traditional concept, the comparison of upgradient (i.e., ambient or background) groundwater quality to downgradient groundwater quality is critical in the determination of potential groundwater degradation. In contrast, irrigated agriculture depends on sufficient leaching of salt residue beyond the crop root zone to avoid increasing soil salinity and associated soil degradation and crop losses. In this case, samples retrieved from both upgradient and downgradient monitoring wells will not originate from essentially identical source areas but from completely different source areas. In this scenario, the emphasis for purposes of the assessment of potential impact to groundwater quality is now shifted to the downgradient well.

[4] The production area encompasses the actual dairy facility where animals are bred, housed, and fed including support infrastructure such as barns, feed and waste handling and storage facilities, and the milk barn.

2. Typically, constituents of concern related to traditional regulated units are not commonly found in natural groundwater systems (e.g., petroleum products, volatile or aromatic organics, pesticides, and other chemicals), or not in as high of concentrations (e.g., heavy metals). This has important implications regarding groundwater quality interpretation. For example, if a groundwater sample retrieved from a monitoring well downgradient of a gas station in an urban/industrial setting shows any detection of benzene (regardless of how small it might be), and the upgradient well has no such detections, it is determined that the unit is leaking. The fact that the leachate is much diluted has no effect on the conclusion that the unit leaks. If, however, the upgradient well shows similar benzene concentrations, this conclusion is not warranted (i.e., following the paradigm of "no groundwater quality change"). This is in contrast to irrigated agriculture in general and dairy farms in particular, where constituents of concern (i.e., mainly nitrate and other salts) are ubiquitous in groundwater systems[5]. In this case, the traditional concept provides an unsatisfactory interpretation, because a given nitrate or salt concentration in a downgradient monitoring well could be the result of any number of (i) management unit subsurface loading rates, (ii) upgradient subsurface loading rates, and (iii) proportional representations of both management unit and upgradient contributions.

The above has the following implications for monitoring well design, data collection, and data interpretation:

- RMP monitoring wells positioned downgradient of a management unit are aimed to be constructed such that they intercept groundwater which originates under that targeted management unit, only.
- Groundwater sampling should occur in the upper few feet of the groundwater column (i.e., shorter well intake screen) to avoid mixing of (younger) groundwater originating under the targeted management unit with (older) groundwater from source areas upgradient of the targeted management unit.
- As a corollary to the above, the concept of comparing downgradient to upgradient groundwater quality as a means to determine potential groundwater degradation loses its utility in recharge-dominated systems.

The above also highlights the challenge of installing monitoring wells for purposes of the RMP or likewise, the regulatory site-by-site approach on dairy farms. The monitoring effort needs to focus on the upper few feet of the groundwater column. Since the well screen (for groundwater intake) is placed according to field observations during drilling (i.e., lithology, initial and equilibrated groundwater levels), even moderately fluctuating groundwater levels (i.e., seasonal or longer-term fluctuations) have the potential to render a monitoring well useless. Longer well screens (commonly used in domestic and agricultural supply wells) would address this issue. However, this is counter to the needs for above *Item 1*.

The Phase 1 RMP attempts to address the above design challenges using a two-pronged approach.

1. The Phase 1 RMP areas are characterized by very shallow groundwater. Also, irrigation water needs in most of these areas are largely satisfied with surface water deliveries from local water purveyors. This translates into less agricultural demands on groundwater resources and less pumping-induced seasonal groundwater level fluctuations.
2. Most monitoring wells will be constructed as nested wells (i.e., two well casings with relatively short well screens located at different depth intervals, constructed in one bore hole).

5.2 Additional Data Collection

In addition to the collection of groundwater level and quality data, the RMP will pursue other data collection efforts necessary to interpret groundwater quality trends beneath management units. Specifically, information currently submitted to the CVRWQCB in response to the General Order will be complemented by additional data to fully analyze and interpret current groundwater quality and also quality changes beneath manure application areas, corrals, and liquid manure storage ponds. For these management units, detailed study and recordation of on-farm practices will be necessary. For example, in the case of the manure application areas, results from tile drain water analyses will be

[5] This may be different in the vicinity of liquid manure storage ponds where ammonium has been documented in some monitoring wells.

included in the evaluation. Also, more detailed tracking of irrigation water, manure, and fertilizer applications in relation to crop demands specific to crop type and species/sub-species (trade name if genetically engineered) will be collected to more effectively interpret groundwater quality. In the case of corrals, more detailed tracking of corral conditions and management (e.g., soil type, methods/degree of soil compaction, slope and drainage, observations of precipitation ponding, animal hours spent on the corral, frequency of manure scraping) will be collected to more effectively interpret groundwater quality. In the case of liquid manure storage ponds, more detailed tracking of pond conditions and management (e.g., waste depth, nutrient and salt concentrations, berm conditions, periodic draining and sediment removal) will be collected to more effectively interpret groundwater quality.

The data collection effort described above will commence upon CVRWQCB approval of this Phase 1 RMP Workplan. This effort will likely involve consultants that already routinely provide services to the dairy farms regarding the collection and compilation of information in response to the General Order. Data collection efforts will be refined as potential data gaps or redundancies are identified.

5.3 Key Features

The following are key features of the RMP:

- monitoring effort focused on three distinct management units (i.e., crop fields, corrals, and liquid manure storage ponds);
- individual well design based on local predominant gradients, hydraulic conductivities in the shallow groundwater zone, and estimated recharge rates;
- network of monitoring facilities encompassing many dairies (group approach);
- systematic development of a comprehensive data set;
- centralized data collection and compilation;
- uniform quality assurance (QA) and control (QC);
- comprehensive data analysis and evaluation;
- rigorous peer review by Groundwater Technical Advisory Committee (GTAC);
- rigorous peer review and independent work by Multidisciplinary Advisory Committee (MAC); and
- comprehensive reporting.

Fundamentally, the RMP monitoring well network is more comprehensive than the traditional site-by-site monitoring well networks and groundwater investigations at individual dairy farms, because the RMP network optimizes well installation efforts and emphasizes the systematic development of a comprehensive data set. Through this integrative approach, the total number of monitoring wells and their relative distribution over application areas, corrals, and liquid manure storage ponds is determined by balancing the need for a sufficiently large data set to capture the existing variability within management units and between dairies with the expected variability of groundwater quality changes in response to future modifications to current management practices.

5.4 Area Selection for Monitoring Well Network

It is critical to the success of the RMP that a causal link be established between groundwater quality changes (as observed with the network of dedicated monitoring wells) in response to modifications to dairy management practices. The shorter the response time the sooner conclusions can be drawn from the data, and the higher the confidence in the identified linkage between management practices and groundwater quality trends. Therefore, the emphasis for the Phase 1 RMP implementation was placed on an area of high aquifer sensitivity (i.e., highly permeable soils and shallow depth to groundwater), as summarized below.

In the northern San Joaquin Valley, the area in Stanislaus County between the San Joaquin River and Highway 99, and extending south into Merced County, emerged as an area of very high dairy farm density and milk cow density (**Attachment 1**). These two counties have consistently had the second and third largest overall herd size while other livestock operations have been comparatively minor. Based on the California Department of Water Resources (DWR) depth-to-groundwater contour maps and the U.S. Geological Survey's Central Valley Hydrologic Model (CVHM) (Faunt, 2009) groundwater level output, the above Stanislaus/Merced dairy farm area overlies very shallow groundwater (i.e., <20 feet, below ground surface). Soil data indicate a prevalence of high permeability soils in this

area, and CVHM groundwater recharge estimates for this area indicate moderate to moderately high annual recharge. Greatly elevated groundwater nitrate-N concentrations occur in this area, and an overall increase of nitrate-N concentrations is apparent since the 1980s. According to CVRWQCB files, the results from the recent (2007-2008) dairy-specific nitrate monitoring also show elevated groundwater nitrate concentrations in this area. Lastly, Stanislaus and Merced Counties are characterized by relatively high N-balances in comparison to other San Joaquin Valley dairy farms.

In the southern San Joaquin Valley, the area west and east of Highway 99 in Kings and Tulare Counties also emerged as an area of very high dairy farm density and milk cow density (**Attachment 1**). Tulare County has always had the largest herd size (1.8 times larger than Merced County's herd size in 2005) and has experienced substantial growth of the milk cow population over the last two decades while other livestock operations have been very minor. Kings County has also experienced large increases in cow population and ranks fourth in terms of its herd size; other livestock operations have been very minor. Based on the DWR depth-to-groundwater contour maps and the CVHM groundwater level output, the depth to groundwater beneath the Tulare/Kings dairy farm cluster is deeper and more heterogeneous (ranging mainly from 40 to 80 feet, bgs) than beneath the high density dairy farm area in Stanislaus and northern Merced Counties, with shallower groundwater beneath dairies near the Tulare lakebed and substantially deeper groundwater south of Tule River. CVHM recharge estimates for this area indicate predominantly high annual recharge. These model results are consistent with the prevalence of high permeability soils in this area. The area of low permeability soils west of Highway 99 in Tulare County also roughly corresponds to deeper water levels. Groundwater nitrate-N concentrations from the 1990s compared to those from the 2000s indicate an increasing trend. This increase occurred during a time when the herd size in Tulare County more than doubled. The results from the recent (2007-2008) dairy-specific nitrate monitoring also indicate elevated nitrate-N concentrations in this area. Lastly, N-balances in this area are similar to the rest of the San Joaquin Valley.

Only 3 percent of the Central Valley milk cow population resides in the Sacramento Valley, cow populations have remained fairly stable in the Sacramento Valley, and milk cows constitute a comparatively small proportion of all livestock. Contours of equal depth to groundwater in the unconfined aquifer of the Sacramento Valley were not available from DWR. Based on CVHM groundwater level output only, dairies in Sacramento County and most other places in the Sacramento Valley are situated on very shallow groundwater. However, the recent maximum nitrate-N concentrations in agricultural and domestic wells located on dairy farms in the Sacramento Valley are predominantly below the Maximum Contaminant Level (MCL).

The prevalence of high permeability soils in combination with very shallow depths to groundwater, high nitrate-N concentrations, and relatively high N-balances present favorable baseline conditions, as future changes in field and dairy management practices are likely to positively affect groundwater quality more rapidly than in other regions. Therefore, this region was recommended as the high priority area to initiate the representative groundwater monitoring program approach. To increase the representativeness of the Phase 1 data collection effort, the Phase 1 RMP Workplan is comprised of dairy farms located in both the high priority area and west of the San Joaquin River in an area of shallow groundwater and clay-rich, low permeability soils (**Table 1**, **Figure 1**).

5.5 Selection of Initial Dairy Farms

5.5.1 Key Parameters

The selection of dairy farms for the initiation of the RMP was based on two types of parameters:

- physical parameters that control subsurface loading; and
- dairy farm infrastructure and operational characteristics.

The subsurface loading rate is determined by the product of its two components, the rate of deep percolation (i.e., the amount of infiltrated water reaching first encountered groundwater) and the constituent concentration of the infiltrate. It is a chemical flux that describes a particular management unit's performance. This concept is applicable to any management unit, and is described in more detail by management unit in *Sections 5.5.1.1 – 5.5.1.3* and further discussed in *Section 5.5.1.4*.

Physical parameters directly support the analysis and interpretation of groundwater quality data and the extrapolation of results from the RMP to non-monitored dairy farms. As such, these parameters are key to the representativeness of the RMP. Some physical parameters are largely independent of dairy operational decisions and management, and they cannot be readily changed by individual dairy farm practices. These parameters are referred to as "static" in this context (**Table 2**). Examples are soil texture (i.e., the proportional grain size distribution of soil particles) and precipitation. The overall depth to groundwater is also a physical parameter, which is largely independent of individual farmers' dairy operational decisions and management[6]. However, the depth to groundwater does not control subsurface loading, it merely affects the travel time of the infiltrate through the unsaturated zone and, thus, exerts control on the response time between surface processes and groundwater quality responses[7]. Similarly, the age of an existing management unit does not control subsurface loading. However, knowledge of the age of an existing management unit may aid in the evaluation of the lag time between commencement of operation and downgradient groundwater quality effects.

Other parameters are subject to change. The irrigation rate and duration, fertilizer application, and crop type are examples of parameters important in relation to manure application areas. Examples for corrals are ground surface slope (to provide drainage), degree of compaction, and maintenance thereof. Examples for liquid manure storage ponds are ultimately (and most directly) seepage rate and constituent concentrations (i.e., the components of the chemical flux). These parameters can be addressed via management practices; therefore, they are referred to as "dynamic" in this context.

To establish basic parameters that have bearing on the direct analysis and interpretation of groundwater quality data and the extrapolation of results from the RMP to non-monitored dairy farms, it is useful to recognize and focus on the two components involved in subsurface loading, i.e., the rate of deep percolation and constituent concentration of the infiltrate. From this, it is clear that surface processes (including management practices) in combination with soil properties in the very shallow zone (e.g., the crop root zone of manure application areas) are key elements for groundwater quality analysis and interpretation.

In contrast to physical parameters, dairy farm infrastructure and operational characteristics do not have direct bearing on the analysis and interpretation of groundwater quality data, because they do not provide information on actual subsurface loading rates. Dairy farm characteristics used to assemble an initial group of dairy farms that is intended to be representative of a cross section of typical dairy farms and a wide range of typical operational management practices are discussed in *Section 5.5.1.5*. Examples include (i) the dairy farm size, (ii) number of lactating milk cows, dry cows, heifers, calves, and bulls, and (iii) the relationship between annual manure exports and imports of synthetic fertilizers. Specifically, dairy farm size (including the total cropping area available for manure application) in absolute terms or in relation to the total number of animals on the farm does not provide an indication of actual nitrogen and salt application rates occurring on particular forage fields. Similarly, the relationship between annual manure exports and imports of synthetic fertilizers is not sufficient to explain any particular constituent concentration in a groundwater sample obtained from a particular monitoring well.

Dairy farm characteristics were considered to assemble an initial group of dairy farms that is intended to be sufficiently representative of a cross section of typical dairy farms and a wide range of typical operational management practices for purposes of initiating the Phase 1 RMP. Therefore, from an infrastructure and operational standpoint, non-monitored dairies exhibiting similar characteristics are expected to be able to implement similar management practices that are determined to result in groundwater quality improvements on monitored farms. As such, the diversity of these parameters in the group of monitored dairy farms is key to the implementability of identified management practices on

[6] It is recognized that irrigated agriculture can and does affect groundwater levels on a regional scale.

[7] In the case of nitrogen components, reactive transport such as denitrification may also play a significant role in some localized subsurface environments (particularly in clay-rich soils), although denitrification rates may overall be less significant, even in deep vadose zone environments, than previously hypothesized (Harter et al., 2006). This is a very active field of research, and estimates of denitrification rates usable for consideration in the selection of dairy farms are currently not available. Similarly, sorption and desorption processes were not considered in this context, as quantification of these do not relate to actual subsurface loading (but merely to constituent fate and transport rates once introduced to the subsurface).

non-monitored dairy farms. However, it is fully expected that through the process of RMP refinement, initial data gaps will be identified and addressed during Phase 2 (and possibly later phases) and also the activities of the GTAC and MAC.

5.5.1.1 Physical Parameters – Manure Application Areas

For purposes of interpreting groundwater quality beneath cropped manure application areas, the primary focus is on soil texture, irrigation and precipitation, and the application rate and fate of nutrients. Soil texture, and particularly its clay content, relates to the infiltration rate and its rate of change during individual irrigation and precipitation events (and consecutive events). For example, soil properties in conjunction with the rate of irrigation application (e.g., in a furrow irrigated system) relate to the spatial variability of deep percolation losses along the furrow profile. Irrigation types (e.g., furrow, flood, impact or micro sprinkler) and practices (e.g., rate of irrigation application, timing and duration of irrigation events) are often chosen to complement particular soil types. Likewise, the frequency and rate of fertilizer applications to satisfy a particular crop's demand depends, in part, on the soil. Precipitation, while typically not a major contributor to deep percolation beneath crop fields in the San Joaquin Valley, poses a complicating variable to the farmer, as it can affect decisions relating to the timing of sowing, planting, harvest, irrigation, and manure/fertilizer applications. In addition, it can potentially cause unwanted flushing of the root zone. Since the long-term sustainability of irrigated agriculture depends on the flushing of excess salts below the root zone (to prevent a detrimental accumulation of salts), it becomes apparent that the interaction between the soil, irrigation and precipitation, and manure/fertilizer application is key to the interpretation of groundwater quality beneath cropped manure application fields.

Farming practices on coarse-grained/sandy soils and fine-grained/clay-rich soils that result in groundwater quality improvements beneath cropped manure application fields that are part of the RMP are expected to produce similar results on non-monitored fields of similar soil types in areas of similar precipitation patterns. Consequently, for purposes of selecting dairy farms (and particularly the associated manure application areas) for the initiation of the RMP, the primary focus was on soil texture and precipitation. Specifically, regarding static physical parameters, the emphasis was to initiate a large data set related to application fields on coarse-grained soils and on fine-grained soils in an area of shallow groundwater occurrence and similar annual precipitation. In terms of dynamic physical parameters, Phase 1 dairy farms were selected to include forage crops typical for the industry (e.g., corn, oats, alfalfa, sudan, pasture, and wheat) as well as two less typical, yet not insignificant crops (e.g., almonds). Likewise, the initial dairy farm group employs typical irrigation practices for their forage crops, namely flood and furrow irrigation. Lastly, crop fertilization occurs by use of synthetic fertilizers, and both liquid and dry manure.

5.5.1.2 Physical Parameters – Corrals

Corrals are designed (or should be designed) to minimize infiltration and deep percolation. For purposes of interpreting groundwater quality beneath corrals, the primary focus is on soil texture, precipitation, and the rate and fate of nitrogen and salt excretions onto the corral surface. Naturally, these parameters are very similar to parameters discussed for the application areas, because the fundamental components (i.e., liquid and chemical flux) that control subsurface loading are the same. The liquid flux is largely determined by soil texture and precipitation, and it can be reduced by management practices such as compaction of the soil and sloping of the corral surface to provide positive drainage and reduce pooling of water during the rainy season[8]. The mass input (i.e., the excretion rate) can be controlled by management practices relating to the total amount, rate, and timing of nitrogen and salt excretions. The fate of excretions can be controlled by the frequency and timing of manure removal (e.g., via scraping).

Management practices (as outlined above) on coarse-grained/sandy corrals and fine-grained/clay-rich corrals that result in groundwater quality improvements beneath corrals that are part of the RMP are expected to produce similar results on non-monitored corrals of similar soil types in areas of similar precipitation patterns. Consequently, for purposes of selecting dairy farms (and particularly the associated corrals) for the initiation of the RMP, the primary focus was on soil texture and precipitation. Specifically, regarding static physical parameters, the emphasis was to initiate a large

[8] Good maintenance to of a sloped corral surface during the rainy season is important in order to reduce pooling and infiltration, but may be difficult to achieve, for example, in saturated clay-rich soils. This highlights the importance to continuously monitor corral surface conditions.

data set related to corrals on coarse-grained soils and fine-grained soils in an area of shallow groundwater occurrence and similar annual precipitation. In terms of dynamic physical parameters, dairy farmers are currently implementing practices as prescribed in the General Order but reliable, quantitative information was not available for this work effort. For example, dry manure may be scraped from corrals several times a year, followed by some grading and compaction effort. However, the degree of drainage from corral surfaces during the rainy season may vary widely between dairies as the soft, organics-rich soil is constantly turned over and worked into the ground by the cows. Actual rainy season maintenance efforts appear important to understanding potential recharge from corrals; and regular visual observations may prove to be the most useful tool to evaluate these efforts in the future. Site visits were used to select a group of Phase 1 RMP Workplan dairy farms, including corrals with very thick manure cover and others with well-scraped and graded surfaces.

5.5.1.3 Physical Parameters – Liquid Manure Storage Ponds

Similar to corrals, liquid manure storage ponds are designed (or should be designed) to minimize infiltration and deep percolation (referred to as seepage in the context of ponds). For purposes of interpreting groundwater quality beneath ponds, the primary focus is on soil texture, pond seepage, and the nitrogen and salt concentrations in the waste liquor near the bottom of the pond. Again, these parameters are very similar to parameters discussed for the application areas and corrals, because the fundamental components (i.e., liquid and chemical flux) that control subsurface loading are the same. Site-specific information on pond seepage is currently not available and information on the chemical composition is very sparse. The latter is also highly variable depending on the amount of dilution with fresh flush water and can vary considerably between seasons as affected by direct precipitation. Soil texture appears to not typically control the seepage rate of liquid manure storage ponds (especially not those filled with cow manure) that are operated as anaerobic basins in all but the most extreme cases (e.g., gravel deposits or macro fissures in limestone) (LSCE, 2008). However, the presence of clay beneath such ponds has been found to significantly affect the movement of ammonium in the subsurface; and ion exchange processes involving clay minerals can significantly affect groundwater quality (LSCE, 2008).

Management practices pertaining to ponds that are operated as anaerobic basins are essentially limited to the maintenance of the berms and a steady waste depth, and the degree of solids separation. Waste depth and the solids content may relate to the chemical environment in the vertical waste profile. Information on the solids content in the ponds is currently very sparse. However, CVRWQCB files often identify settling basins and mechanical solids separators.

Management practices (as outlined above) pertaining to ponds on coarse-grained/sandy soils and fine-grained/clay-rich soils that result in groundwater quality improvements beneath ponds that are part of the RMP are expected to produce similar results beneath non-monitored ponds on similar soil types. Consequently, for purposes of selecting dairy farms (and particularly the associated liquid manure storage ponds) for Phase 1 of the RMP, the primary focus was on soil texture. A secondary focus was on precipitation, as it can relate to seasonal differences of the chemical composition of the waste liquor. Specifically, regarding static physical parameters, the emphasis was to initiate a large data set related to ponds on coarse-grained soils and fine-grained soils in an area of shallow groundwater occurrence and similar annual precipitation. Additional emphasis was placed on older liquid manure storage ponds such as to favor ponds with a history of nitrogen and salt loading. In terms of dynamic physical parameters, Phase 1 RMP dairy farms were selected to include the most typically encountered pond system where liquid manure passes through one or more settling basins prior to entering the main storage pond[9]. Some of the selected dairy farms utilize mechanical solids separators in addition to settling basins. Others operate a mechanical separator with a single liquid manure storage pond. Solids removal from settling basins occurs mostly via scooping off the dry top layer but may also include more complete drying and/or deeper excavation. Solids from the main storage ponds are removed either via agitation and pumping, or excavation, or may not yet have been necessary at the time of the site visit. Phase 1 RMP Workplan dairy farms were selected to include earthen liquid manure storage facilities ranging in depth from 4 to over 20 feet. These facilities were constructed prior to 2007, and many are older than 10 years.

[9] During site visits and direct communication with dairy farmers, it was found that this system is not always strictly operated in series, but also in parallel or switched back and forth (i.e., one settling basin is used until full while the other is dried out).

5.5.1.4 Physical Parameters – Discussion

Physical parameters directly support the analysis and interpretation of groundwater quality data and the extrapolation of results from the RMP (Phase 1 and subsequent phase(s)) to non-monitored dairy farms. As such, these parameters are key to the representativeness of the RMP.

Future changes in field and management practices are likely to positively affect groundwater quality more rapidly in areas of coarse-grained/sandy soils and shallow groundwater depths than in any other areas. Practices specific to management units in these conditions that result in groundwater quality improvements on dairy farms that are part of the RMP are expected to produce similar results beneath non-monitored dairy farms that operate in similar conditions including similar precipitation patterns. Consequently, for purposes of selecting dairy farms for the initiation of the RMP, the primary focus was on static physical parameters, including soil texture, depth to groundwater, and precipitation. Specifically, the emphasis was to initially generate a large data set for an area of coarse-grained/sandy soils, shallow groundwater, and moderate precipitation (e.g., about 7 to 10 inches annual precipitation, which applies to most dairy farms in the San Joaquin Valley). This is consistent with conditions in the high priority area (i.e., the area in Stanislaus and Merced Counties from the Stanislaus River in the north and the Chowchilla River in the south, between the San Joaquin River and Highway 99). In addition, the Phase 1 RMP Workplan includes several dairy farms west of the San Joaquin River (outside of the high priority area), where groundwater also occurs at shallow depths and annual precipitation is similar, but soils are predominantly fine-textured (e.g., clay loams and clays). These dairies were selected to broaden the initial range of hydrogeologic conditions and potential dairy management practices investigated within the Phase 1 RMP well network.

For the selection of corrals and liquid manure storage ponds, additional emphasis was placed on older management units such as to favor those with a history of nitrogen and salt loading. In an effort to obtain improved pond construction documentation, some younger liquid manure storage ponds were also selected.

5.5.1.5 Dairy Farm Infrastructure and Operational Characteristics

As discussed in *Section 5.6.1*, dairy farm infrastructure and operational characteristics do not have direct bearing on the analysis and interpretation of groundwater quality data, because they do not provide information on actual subsurface loading rates. However, they were invoked to assemble an initial group of dairy farms that is intended to be representative of a cross section of typical dairy farms and a wide range of typical operational management practices for purposes of initiating the RMP. Therefore, from an infrastructure and operational standpoint, non-monitored dairies exhibiting similar characteristics are expected to be able to implement similar management practices that are determined to result in groundwater quality improvements on monitored farms. As such, the diversity of these parameters in the group of monitored dairy farms is key to the implementability of identified management practices on non-monitored dairy farms. The following is a list of characteristics exhibited by the selected initial group of dairy farms for the Phase 1 RMP:

- distinct management units (corrals, liquid manure holding ponds, land application areas);
- dairy farm size ranges from approximately 550 to 5,500 mature milk cows;
- animal housing occurs to approximately equal portions under roofed areas (freestalls) and open lots;
- additional infrastructure includes separate areas for heifers, calves, dry cows, bulls, and sick animals; milk barn; loading docks and roads; hay and commodity barns; outside silage storage; manure drying/stacking areas; farm equipment yards and machine shops; residential housing; ditches and underground pipelines; and tailwater recovery systems;
- mature milk cows constitute approximately half of all animals on the dairy farms;
- predominant waste management via flush lanes but also substantial manure drying;
- proportion and absolute volume of manure exports vary widely between dairies;
- the overall size of the land application areas vary widely between dairies and is not correlated to the number of animals; and
- reported whole farm nitrogen-balances range from less than 1.00 to over 3.00.

A summary of herd sizes, manure application areas, and whole farm nitrogen balances for dairy farms that were selected to be part of the Phase 1 RMP network is presented in **Table 3**. The information shown in this table was

obtained from files that were submitted by dairy farm owners/operators to the CVRWQCB to maintain compliance with the General Order. It is recognized that these data are not flawless (e.g., inaccuracies in the computation on the whole farm nitrogen balance are not uncommon). During the site visits, information regarding irrigation methods, crop types and rotations, field ownership or expiring leases, plans for new infrastructure, liquid manure storage facility operation, and other miscellaneous items as they arose out of individual discussions, was gathered. Since the overall diversity of the initial group of dairies is important to the success of the Phase 1 RMP, not the combination of individual characteristics on any one dairy farm, it is expected that any potential biases in the initial group of dairy farms (to be identified via continued interaction with dairy farmers and analyses in the first annual report) will be readily addressed as the monitoring network will be expanded. For example, dry scrape and pasture dairies were considered but ultimately not included in Phase 1, because they constitute a very small fraction of all Central Valley dairies. Their inclusion will be considered again during the process of refinement and the Phase 2 RMP expansion.

5.5.2 Monitoring Well Siting and Other Considerations

Only CVDRMP member dairy farms were considered because these farms are contractually bound to permit groundwater monitoring to occur on their property as part of the RMP. After reviewing the CVRWQCB's files, aerial photography was used to identify potential candidate farms. The owners/operators of these dairy farms were informed by mail, and also follow-up phone calls, that their dairy farm had been selected as a potential site to install RMP monitoring wells. The owners/operators of these dairy farms were informed by mail, and also follow-up phone calls, that their dairy farms had been selected as a potential site to install RMP monitoring wells. These owners/operators were invited to an informational meeting on April 8, 2011 to introduce them to the RMP, the CVDRMP board of directors, and next steps. At the meeting, 23 site visits were scheduled.

Prior to the site visits, major selection criteria were the size and geometry of dairies' management units with regard to the inferred, prevailing regional groundwater flow direction. For example:

- Large management units are favorable to groundwater monitoring efforts on dairy farms.
- The geometry of the management unit should be such that the expected source area for the to-be-constructed monitoring well(s) would take full advantage of the management unit's extent.
- Clear separation between management units.

An example of a less favorable condition is the existence of a management unit of potentially high infiltration located upgradient of a management unit of potentially small infiltration (e.g., a large liquid manure storage pond upgradient of a small corral).

Site visits and communication with dairy farmers were invaluable in the effort to place the proposed monitoring wells. In many cases, locations that appeared promising based on the inspection of aerial photography proved to be not usable. Examples were:

- Unstable road conditions – many of the field roads are simple dirt paths, tentative in nature and subject to being plowed-over and modified during the seasons.
- Open areas next to liquid manure storage ponds that are periodically used for excavators and trucks during solids removal.

Underground facilities (e.g., irrigation and flush water pipes, tailwater recovery systems, residential sewer systems, and gas and telephone lines) put substantial constraints on monitoring well placement. In many cases, the most promising location for a monitoring well was directly under above-ground telephone or power lines. As a result, and due to rough field conditions, many wells will need to be installed using specialized limited-access equipment.

5.6 Rationale for the Proportional Distribution of Monitoring Wells

The total number of monitoring wells and their relative distribution over application areas, corrals, and liquid manure storage ponds was determined by balancing the need for a sufficiently large data set to capture the existing variability

within management units and between dairies with the expected variability of groundwater quality changes in response to future modifications to current management practices.

Land Application Area

The land application area constitutes by far the largest proportion of a dairy and has been shown to be the largest contributor to subsurface loading of salts and fertilizers (van der Schans et al., 2009). In addition, the land application areas provide the most promising opportunity to control leaching of excess salts and fertilizer through a variety of potential management adjustments, including methods of application, application rate and timing, irrigation practices, crop types and cropping patterns, installation of tile drains, and return water recycling systems (Mathews et al., 2001; Harter et al., 2001b). As a result, the overall groundwater quality responses to management modifications are expected to be most diverse in the land application areas.

Corrals

In comparison to field management, dairy corral management offers less flexibility. Open-lot corrals do not feature animal housing with impermeable floors and manure removal systems, but they may have simple shade structures. Management of these corrals may include the frequency of manure removal (scraping) and its timing in relation to dry and wet seasons, and overall maintenance of the surface to provide positive drainage and reduce infiltration. Many corrals are associated with freestalls (i.e., roofed animal housing with concrete floors and manure removal systems) where animals spend most of their day.

Liquid Manure Storage Ponds

Management of liquid manure storage ponds offers relatively little flexibility for the dairy farmer. Probably the single most important management tool for unlined and earthen-lined ponds is to minimize seasonal stage elevation changes and to always maintain a minimum liquid depth. This ensures the maintenance of anaerobic conditions in the manure liquor and helps keep non-organic nitrogen in the form of ammonium, which sorbs to clay particles in the subsurface. In contrast, oxidizing conditions in the manure liquor support conversion of ammonium to nitrate, which is highly mobile in groundwater systems.

In accordance with the above observations, the largest proportion of monitoring facilities in the proposed representative groundwater monitoring well network is dedicated to land application areas.

5.7 Extrapolation of Monitoring Results to Non-Monitored Dairies

The ability to extrapolate monitoring results from dairy farms monitored under the RMP to non-monitored dairy farms rests on the selection of physical parameters that directly support the analysis and interpretation of groundwater quality data. For example, dairy practices on coarse-grained/sandy soils over shallow groundwater that result in groundwater quality improvements beneath cropped manure application fields that are part of the RMP are expected to produce similar results beneath non-monitored fields of similar soil types in areas of similar precipitation patterns. The same rationale applies to corrals and liquid manure storage ponds.

Notably, increased depths to groundwater and increased seasonal variability of groundwater level elevations do not exert control on subsurface salt loading rates. Consequently, Phase 1 and subsequent phase results will also be applicable to areas with these characteristics without necessitating additional data collection efforts. Although response times between dairy management practices (and associated changing nutrient and salt loading characteristics) and potential groundwater quality changes in areas of deep first encountered groundwater will be significantly prolonged, there remains a potential for long-term impact and also improvement related to modified practices. Additionally, data analysis and interpretation in such areas are exacerbated by the difficulty to delineate (with a reasonable degree of confidence) contributing source areas and, ultimately, establish a causal link between groundwater quality results and the range of management practices by management unit. Consequently, measures to avoid groundwater quality impacts would likely not occur in these areas for a potentially very long time unless a proactive approach is taken via extrapolation of RMP results.

5.8 Refinement of Representative Groundwater Monitoring Program

This Phase 1 RMP Workplan proposes to install an initial network of monitoring wells on a group of dairy farms to initiate the RMP. The RMP will be assessed on an annual basis and dynamically modified through a process of peer review, input from technical advisory committees (GTAC and MAC), and stakeholder input. Input requested from reviewers will, for example, pertain to:

- any technical aspects of the RMP Annual Reports (e.g., monitoring well locations and construction, selection of dairy farms, sampling protocol, any data collection and compilation efforts, analyses, interpretations, and recommendations);
- identification of potential solutions in response to findings of the RMP (Phase 1 and subsequent phase(s));
- identification of innovative methodologies, approaches, and analytical tools;
- review and evaluation of results from implemented methodologies, approaches, and analytical tools; and
- identification of potential research needs, and most generally, the ability of the RMP to reach its goals.

5.9 Expansion of Representative Groundwater Monitoring Program

The Phase 2 RMP Workplan will expand the RMP to include a total of 50-100 dairies. Three distinct components of the Phase 2 RMP expansion are identified:

- *High Priority Area* The well network will be expanded in the high priority area (i.e., the primary focus of the initial Phase 1 RMP; the area defined by the Stanislaus River in the north, the Chowchilla River in the south, the San Joaquin River in the west, and Highway 99 in the east).
- *West Side Expansion* The well network will be expanded in the area west of the San Joaquin River in Stanislaus and Merced Counties (i.e., a secondary focus of the initial Phase 1 RMP), which is characterized by fine-grained/clay-rich soils and the occurrence of shallow groundwater.
- *Central Valley Coverage* The well network will be expanded to include dairy farms in all San Joaquin Valley counties plus dairy farms between Sacramento and Tehama Counties in the Sacramento Valley. This effort will include a survey of dairy farms that already conduct groundwater monitoring to assess their potential to effectively contribute to Central Valley wide groundwater evaluation beneath dairies and their associated management units.

Additional expansion of the monitoring network and program will continue to be evaluated, under consideration of the input from the advisory committees, in regulatory annual monitoring reports; and will depend, most generally, on the success of the RMP.

6 Proposed Phase 1 Representative Monitoring Well Network

The proposed Phase 1 dedicated monitoring well network consists of 18 dairy farms and 135 dedicated monitoring well locations (**Table 4**, **Figure 2**). 18 of these monitoring wells already exist (**Attachment 2**), and 117 are proposed for installation. Most of these wells will be installed as nested wells (with possible exceptions being very large irrigated forage fields). This means that most proposed locations for monitoring well installation will actually have two wells of different depth and construction installed in one borehole. However, for ease of communication, each well location is referred to as one well regardless of whether or not it will be completed as a nested well). 86 of these monitoring wells are distributed over 10 dairy farms located in the high priority area characterized by predominantly sandy coarse-textured permeable soils and shallow groundwater occurrence (the depth to groundwater is commonly less than 20 feet below ground surface and often less than 5 feet below ground surface). Regionally, shallow groundwater flow directions range from southwest to northwest. This was supported via anecdotal evidence in conversations with dairy farmers and confirmed with site specific groundwater elevation data where available. 49 monitoring wells are distributed over 8 dairy farms located in the area west of the San Joaquin River in Stanislaus and Merced Counties characterized by clay-rich, low-permeability soils and shallow groundwater (similar to the high priority area). Regionally, shallow groundwater flow directions range from southeast to northeast. This was supported via anecdotal evidence in conversations with dairy farmers and confirmed with site specific groundwater elevation data where available.

Monitoring well locations were identified in cooperation with dairy farmers during site visits carried out from April 11 to May 6, 2011 (**Figures 3** to **21**), and final locations will be identified during the well drilling permit process.

Existing production area infrastructure (e.g., existing water wells, corrals, shade structures, hay and milk barns, silage storage areas, liquid manure storage areas, and settling basins) was compiled from annual dairy reports and is included in these figures. All selected dairy farms have monitoring wells proposed near a liquid manure storage pond. In the high priority area, the selected dairy farms have monitoring wells distributed over all three target management units. On the west side, the number of CVDRMP member dairies is rather limited and, as a result, the availability of favorable monitoring conditions is similarly limited. As a result, the corrals of one dairy farm and the fields of two dairy farms are not monitored in that area.

7 Monitoring Well Construction

Well construction in Stanislaus County is permitted through the Stanislaus County Department of Environmental Resources, Office of Environmental Health. A qualified California licensed professional well drilling contractor (C-57 license) will be selected through a competitive screening process. The drilling contractor will be responsible for adherence to trade-specific health and safety measures during drilling, installation, and site cleanup. In addition, a safety meeting will be held in the field before commencing work; local emergency telephone numbers and directions to the nearest medical facilities will be distributed.

In accordance with the expected shallow completion of the monitoring wells and unconsolidated nature of subsurface materials in the project area, direct push and/or auger methods will be employed for the advancement of the boreholes. The machinery will be sized commensurate to the tasks. Drilling and construction oversight will be provided by a licensed California professional geologist or professional civil engineer with experience in the water well construction business or under the direct supervision of such a professional.

Subsurface materials will be described and logged in the field by a California professional geologist or under his/her direct supervision. Subsurface materials will be sampled at least every 5 feet and at the terminus of the boreholes. The description of the samples will follow the American Society for Testing and Materials (ASTM) Unified Soil Classification System (USCS). Material samples will be archived for a minimum of one year from the date of retrieval.

7.1 Monitoring Well Design

Monitoring wells will be constructed such that the well screen intersects the uppermost zone of first encountered groundwater. Consequently, the final monitoring well design (e.g., total well depth, depth and length of the well screen, depth of the transition seal, depth and length of the surface seal) will be determined based on field observations made during drilling (e.g., depth to first encountered groundwater and type of subsurface materials). Most monitoring wells will be constructed as nested wells (i.e., two well casings with well screens located at different depth intervals, constructed in one borehole (**Figure 22**). This design provides a monitoring facility that:

- addresses uncertainty regarding the extent of the upgradient area contributing flow to the well (i.e., the source area);
- is less vulnerable to seasonal and longer-term groundwater level fluctuations than single-completion monitoring wells;
- is suitable for the installation of shorter screen lengths (e.g., 5-15 feet), which helps avoid potential groundwater quality bias due to vertical flow components in the wells; and
- can be used for chemical groundwater profiling including isotopic groundwater age dating.

The proposed nested design also (i) increases data quality and the confidence in analysis and interpretations, (ii) increases the flexibility for analytical approaches, and (iii) avoids or decreases the need for potential future well replacements, for example, as a result of groundwater level declines causing a well to go “dry”. An alternative single well construction profile is shown in **Figure 23**. Figures **22** and **23** show a traffic valve box for below-grade completion. However, such construction is planned for only two locations (NUN-MW3 and 4), where the newly poured concrete feed lane provides a better location than the steep escarpment leading into the adjacent field to the east. A more typical surface completion with casing stick-up and bollards is shown in **Figure 24**. Other options for surface completions include flexible posts with reflective sheeting or the use of a 1.5 to 2-feet section of 4 to 6-feet diameter prefabricated concrete pipe such as used in the construction of manholes to protect the wellhead. The actual configuration of the surface completion will be determined prior to drilling based on local conditions surrounding the well location and communication/consensus with the appropriate party (i.e., property owner and/or dairy farm operator).

7.2 Monitoring Well Development

The monitoring wells will be developed as the drilling program progresses and the last monitoring well will be developed within two weeks of its installation.

The purpose of well development is to remove drilling fluids and to develop the gravel pack and aquifer to ensure that proper groundwater samples can be obtained from the monitoring facility. Since the proposed drilling methods do not utilize drilling fluids, the overall monitoring well development efforts are expected to be relatively straightforward.

Monitoring wells will be initially bailed to remove any fill that may have accumulated in the well casing during installation. The gravel envelope will be cleaned of fluids, cake, and substances that would impair the flow of water into the well and the quality thereof. Cleaning will be accomplished by surging and pumping opposite the screen interval until the gravel has been cleaned and consolidated. The pumping operations will be conducted until the screen section is fully developed and the well discharges clean groundwater. Fill that may have accumulated in the well casing during development will be removed using bailing or pumping methods.

The development will continue until the well produces water free of sand and the following turbidity guidelines can be achieved:

- For monitoring wells that produce less than 2 gpm, a turbidity of 10 NTU within two casing volumes of purging.
- For monitoring wells that produce at least 2 gpm, a turbidity of 5 NTU within two casing volumes of purging.

It is recognized that the limited yield, typical for small diameter monitoring wells, can substantially affect the progress and overall success of well development. Ultimately, the professional overseeing the well development will decide when well development efforts will be terminated based on the logged progress in the field.

7.3 Wellhead Survey

A California licensed professional (licensed land surveyor or civil engineer with land surveying experience) will be selected through a competitive screening process. To ensure adequate measurement accuracy and precision, the horizontal and vertical position of the top of the well casings of the new monitoring wells will be determined in accordance with the National Oceanic and Atmospheric Administration's (NOAA) *National Geodetic Survey User Guidelines for Single Base Real Time GNSS Positioning* (Henning, 2010) using a professional-grade global navigation satellite system. Wellhead elevations will be determined with an accuracy of 0.01 foot and their horizontal position will be determined with an accuracy of 0.02 foot.

8 Groundwater Sampling

This section describes guidelines for:

- the retrieval of groundwater level measurements and groundwater quality samples from dedicated groundwater monitoring wells;
- purging protocol;
- instrumentation and its calibration and decontamination;
- sample handling and recordation; and
- quality assurance procedures.

8.1 Sampling Procedures and Instrumentation

The sampling procedures will comply with the provisions set forth in the General Order.

8.1.1 Groundwater Level Measurements

Prior to sampling a monitoring well, the static water level is measured. An electric sounder is used to measure the depth to groundwater from a specified reference point (usually the top of the well casing). Wellhead reference points will be marked to provide consistency between measurements. Measurements are recorded to the nearest 0.01 foot. The static water level in conjunction with well construction information is used to calculate the volume of water in the well. This information is used to determine the minimum volume of water to be purged prior to sample collection.

8.1.2 Purging Protocol

Monitoring wells are be purged and sampled using a portable submersible sampling pump. A discharge hose is attached to the top of the pump assembly through which purge water is discharged. Smaller-diameter tubing for sample collection is also attached to the top of the pump assembly. Discharge and sample collection tubings are attached to a manifold and are isolated from each other by a check valve.

Monitoring wells are purged of at least three wet casing volumes and until indicator parameters have stabilized prior to sample retrieval. Stabilization is defined as three consecutive readings at 5-minute intervals where parameters do not vary by more than 5 percent. Purged groundwater is disposed of by spreading it on the ground at a reasonable distance from the sampled well to avoid the potential for purge water to enter the well casing again during the purging process.

The following indicator parameters are monitored during the well purging:

- temperature (°C)
- pH (standard pH-units)
- electrical conductivity (µS/cm)
- dissolved oxygen (percent saturation)
- oxygen reduction potential (mV)
- turbidity (NTU)

Visual (color, occurrence of solids), olfactory (odor) and other observations (e.g., wellhead conditions, well access, ground conditions, weather) are noted as appropriate.

8.1.2.1 Instrumentation

The following equipment is used during purging and sampling activities:

- purging: submersible pump with discharge hose[10]
- sample retrieval: clean food-grade polyethylene tubing (to bypass the discharge hose)
- depth-to-water: *Durham Geo Slope Indicator* electrical sounder (or similar)
- pH, temperature, electrical conductivity: *YSI* instrumentation (Model 63) (or similar)
- turbidity: *Orbeco-Hellige* Model 966 portable turbidity meter (or similar)

[10] Alternatively, it may be elected to use an inertial pump, peristaltic pump, or comparable equipment.

- dissolved oxygen: *YSI* instrumentation (Model 55) (or similar)
- oxygen reduction potential: *Oakton ORPTestr* (or similar)

8.1.2.2 Calibration

Field calibration of instrumentation is conducted following the manufacturer's instructions and standard solutions prior to a sampling event and once on every day of the event. The thermometer is factory calibrated and is not field calibrated.

8.1.2.3 Decontamination

The pump assembly and discharge hosing will be thoroughly flushed with tap water between well visits. If additional analyses are incorporated into the program in the future (e.g., microbial analyses, volatile organic compounds, low-level metal analyses, pharmaceuticals, or isotopic speciation), decontamination procedures will be appropriately adjusted to include, for example:

- use of new sampling hose between each well,
- purging of the pump with a dilute Clorox© solution and subsequent rinsing with clean tap water,
- washing the portion of the electrical sounder that has entered a well with a dilute Clorox© solution and subsequent rinsing with tap water, and
- double bagging procedures.

8.2 Sample Handling and Recordation

After completion of purging activities, groundwater quality samples are filtered in the field to remove turbidity and collected in laboratory-supplied bottles with or without preservative (depending on analyses to be conducted) without headspace. Bottles are labeled with laboratory-supplied labels, immediately placed on ice, and kept in a dark ice chest (at 4 °C) until delivered to the laboratory. Samples are delivered to a laboratory certified through the State of California (Department of Health Services Environmental Laboratory Accreditation Program) with the proper chain-of-custody documentation within the required holding time. A chain-of-custody (COC) form is used to record sample identification numbers, type of samples (matrix), date and time of collection, and analytical tests requested. In addition, times, dates, and individuals who had possession of the samples are documented to record sample custody.

A field sheet is used to document equipment calibration, water level measurements, well purging activities, and the measurement of indicator parameters; an example is provided in **Attachment 3**.

8.3 Quality Assurance Procedures

Quality assurance (QA) is an overall management plan used to guarantee the integrity of data collected by the monitoring program. This includes the discussed guidelines for groundwater level measurements, purging protocol, and sample handling and recordation. Quality control (QC) is a component of QA that includes analytical measurements used to evaluate the quality of the data. A brief discussion of field QC is followed by a discussion of laboratory QC requirements.

8.3.1 Field Quality Control

"Blind" duplicate field samples are collected to monitor the precision of the field sampling process and to assess laboratory performance. Blind duplicates are collected from at least 5 percent (1 in 20) of the total number of sample locations. The true identity of the duplicate sample is not noted on the COC form, rather a unique identifier is provided. The identities of the blind duplicate samples are recorded in the field sheet, but the sampling locations of the blind field duplicates will not be revealed to the laboratory.

8.3.2 Laboratory Quality Control

Quality assurance and quality control samples (e.g., spiked samples, blank samples, duplicates) are employed by the laboratory to document the laboratory performance. Results of this testing are provided with each laboratory report.

8.3.3 Review of Laboratory Data Reports

Data validation includes a data completeness check of each laboratory analytical report. Specifically, this review includes:

- review of data package completeness (ensuring that required QC and analytical results are provided);
- review of the required reporting summary forms to determine if the QC requirements were met and to determine the effect of exceeded QC requirements on the precision, accuracy, and sensitivity of the data;
- review of the overall data package to determine if contractual requirements were met; and
- review of additional QA/QC parameters to determine technical usability of the data.

In addition, the data validation includes a comprehensive review of the following QA/QC parameters:

- holding times (to assess potential for degradation that will affect accuracy);
- blanks (to assess potential laboratory contamination);
- matrix spikes/matrix spike duplicates and laboratory control samples (to assess accuracy of the methods and precision of the method relative to the specific sample matrix);
- internal standards (to assess method accuracy and sensitivity);
- compound reporting limits and method detection limits; and
- field duplicate relative percent differences.

9 Groundwater Monitoring Program

This section discusses the proposed monitoring program for the representative groundwater monitoring approach. The monitoring program consists of groundwater level and quality sampling and exceeds monitoring requirements set forth in the General Order. The groundwater level monitoring is proposed to be initially conducted at a relatively high frequency to evaluate potentially important seasonal intricacies of groundwater flow conditions. The proposed groundwater quality monitoring consists of comprehensive baseline sampling, subsequent quarterly sampling for a reduced set of constituents, and annual sampling for an expanded set of constituents.

9.1 Groundwater Levels

Depth-to-water measurements will be obtained on a monthly schedule from the monitoring wells in the network for a period of 2 years following well installation. After 24 monthly water level measurements, the data collection frequency will be reduced to a quarterly schedule if, upon review of the water level data record, such reduced collection frequency is adequate to meet the goals of the RMP. Groundwater level measurements will be coordinated by area within the region in order to collect data over a relatively short time period (i.e., within days rather than weeks).

9.2 Groundwater Quality

Groundwater samples will be regularly retrieved from the network locations. However, at a given location of a nested well, a groundwater sample will only be retrieved from the well casing that intersects the uppermost portion of first encountered groundwater. For example, if the screen of well casing “a” is 60 percent below the groundwater table and the screen of well casing “b” is 100 percent below the groundwater table, then a sample will be retrieved from well casing “a”.

Additional analytical testing will be performed on an ad-hoc basis as needs are identified. For example, some chemical profiling in a subset of nested wells will begin in the first year of monitoring to complement the regulatory monitoring effort. Monitoring frequencies and laboratory analytical testing are summarized in **Table 5**. Analytical methods and reporting limits are summarized in **Table 6**. The scope of monitoring frequencies and laboratory analytical testing will be annually evaluated and modified, as needed, through a process of ongoing RMP refinement.

9.2.1 Initial Sampling

The first groundwater quality samples will be retrieved within one month of the completion of well development. Samples will be laboratory analyzed for total dissolved solids (TDS), nitrate, and ammonia (i.e., identical to quarterly sampling).

9.2.2 Expanded Sampling

During the second groundwater sampling campaign, samples will be laboratory analyzed for general minerals (i.e., sodium, potassium, magnesium, calcium, chloride, sulfate, alkalinity suite (bicarbonate, carbonate, and hydroxide alkalinity), phosphate, and TDS), nitrate, nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN).

9.2.3 Quarterly Sampling

Groundwater quality samples will be retrieved on a quarterly schedule (e.g., November, February, May, August) from the monitoring wells in the network. These samples will be laboratory analyzed for TDS, nitrate, and ammonia.

9.2.4 Annual Sampling

An expanded suite of constituents will be analyzed during the annual sampling event (scheduled for the third quarter sampling event), including the same general mineral suite as used during the second monitoring campaign and select nitrogen components. Nitrite analysis will not be repeated in wells where samples were previously reported as below the reporting limit or otherwise negligibly small. Similarly, TKN analysis will not be repeated in wells where the comparison of TKN and ammonia results indicates that organic nitrogen concentrations are negligibly small in groundwater.

10 Reporting

10.1 Monitoring Well Installation Completion Report

A Monitoring Well Installation Completion Report will be prepared in compliance with Item C, Attachment A of the General Order's MRP, including:

- detailed location and site maps;
- narrative and chronology of pertinent field activities;
- identification of contractors, geologists, engineers, and other key personnel;
- description of drilling methods;
- detailed monitoring well information (planned and actual locations, as-built drawings);
- driller's logs and lithologic logs;
- depth-to-groundwater measurements;
- field notes;
- monitoring well construction summary table;
- records and results of the well development and well survey;
- purging records and indicator parameter measurements; and
- laboratory data reports.

10.2 Annual Reporting

RMP Annual Reports will be prepared in compliance with the revised General Order MRP and applicable Standard Provisions and Reporting Requirements of the General Order, and in accordance with the goal of the RMP. The reports will present cumulative groundwater level and quality data collected to date and utilize tables and figures to communicate the dairies' layout and infrastructure, monitoring results, pertinent observations, and data trends. The reports will provide geologic/lithologic conceptualization of the shallow subsurface, hydrogeologic analysis (e.g., groundwater level hydrographs, groundwater level contour maps, groundwater quality data, trend analyses, and statistical analyses) and comparative evaluations in view of variable land uses and dairy operations. Further, the reports will present and evaluate any information pertinent to the operation and management of the specific investigated dairy management units. Analytical tools may include statistical procedures such as:

- cluster analysis to assess the *a priori* hypothesis of differences in groundwater quality between management units;
- assessment of statistical sample distributions and spatial and temporal autocorrelations between groundwater samples to aid, for example, in the delineation of appropriate analytical approaches, sampling frequencies, and placement of additional monitoring wells;
- statistical intervals such as upper tolerance bounds or prediction intervals with associated confidence levels;
- concentration averaging specific to management unit and comparison against recharge and loading estimates;
- farm-scale averaging to assess overall farm performance; and
- group comparisons using, for example, analysis of variance (parametric or nonparametric).

In accordance with the goal of the RMP and based on the cumulative data record, the Phase 1 RMP Annual Report (and reports for subsequent phases) will assess current groundwater conditions and how they relate to historical operations, as possible. The Phase 1 RMP Annual Report and following RMP Annual Reports will assess how dynamically changing dairy management practices (e.g., in response to regulatory requirements specified in the General Order) affect groundwater quality trends.

Subsequent RMP Annual Reports will supplement the data record and are expected to strengthen statistical and interpretive analyses and confidence in conclusions. Following the rationale formulated in *Section 5.7*, results generated and conclusions drawn from a relatively small subset of dairy farms will be adequate to formulate management practices that are relevant and applicable to a much larger number of dairy farms throughout the Central Valley. The MAC will delineate management practices in response to findings communicated in RMP Annual Reports

and evaluate their technical and economic feasibility. Subsequent implementation of management practices by the RMP will ultimately show whether they are protective of groundwater quality.

10.3 Summary Report

A Summary Report will be prepared within 6 years of initiating Phase 1 sampling activities to provide a comprehensive synthesis of the RMP monitoring activities (Phase 1 and subsequent phases), results, and findings related to dairy management practices historically and currently employed by the monitored dairy farms, the effects of those practices on groundwater quality, and observed groundwater quality trends in response to modified practices during the first 6 years of the program. Similar to the RMP Annual Reports, the Summary Report will be prepared in compliance with the revised General Order MRP and applicable Standard Provisions and Reporting Requirements of the General Order, and in accordance with the goal of the RMP. The Summary Report will include the same components as the RMP Annual Reports, complemented by additional analyses of groundwater conditions and trends in relation to historical and/or modified management practices.

The Summary Report is intended to serve as a technical basis for evidence-based regulatory decision making. In this capacity, the Summary Report will analyze and discuss the effectiveness of dairy management practices and provide information that will be applicable to both monitored and non-monitored dairy farms.

11 Schedule

11.1 Estimated Schedule for Monitoring Well Construction and Reporting

It is the intent of the CVDRMP to start the Phase 1 RMP well installation in August 2011, complete the installation within 3 months and submit the Monitoring Well Installation Completion Report within 2 months following conclusion of the installation project.

11.2 Proposed Schedule for Other Elements of the RMP

Formation of:

Groundwater Technical Advisory Committee	within 6 months of Phase 1 RMP Workplan approval
Multidisciplinary Advisory Committee	within 6 months of Phase 1 RMP Workplan approval
Stakeholder Input/External Review	semi-annually upon CVRWQCB approval of Phase 1 RMP Workplan

11.3 Proposed Schedule for RMP Refinement and Expansion

Begin Phase 2 RMP Workplan Development	within 6 months of Phase 1 RMP Workplan approval. Initiate a dialogue with the CVRWQCB regarding the overall scope of the Phase 2 RMP and cooperatively work with the advisory committees on the details to be incorporated in the Phase 2 RMP Workplan.
RMP Refinement	following release of the first Phase 1 RMP Annual Report and annually thereafter, as needed
Phase 2 Implementation	Following immediately upon CVRWQCB approval of Phase 2 RMP Workplan
Subsequent Phase(s)	as needed, pending Phase 2 results and findings and activities of GTAC and/or MAC

The refinement and expansion of the RMP will occur on a continuous basis through the preparation of the milestone 6-year Summary Report. As peer review and collaboration with a multidisciplinary group of experts (GTAC and MAC) will continue throughout the duration of the RMP, it is expected that dynamic changes will continue to be implemented after the submittal of the Summary Report. Therefore, the mechanisms for RMP refinement and expansion will continue to operate throughout the duration of the RMP.

12 References

Central Valley Regional Water Quality Control Board. **2007**. *Waste Discharge Requirements General Order No. R5-2007-0035 for Existing Milk Cow Dairies*. May 3, 2007.

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Tables

Table 1
Dairy Farm Selection for Monitoring Well Installation
Phase 1 Representative Groundwater Monitoring Workplan

Dairy Farm	Address	City, State, Zip Code	Facility Detail
East Side			
Albert Mendes Dairy	1100 Ruble Rd	Crows Landing, CA 95313	Figure 3
Anchor J. Dairy	24507 First Ave	Stevinson, CA 95374	Figures 5 and 7
Bettencourt and Marson Dairy	18128 American Ave	Hilmar, CA 95324	Figure 10
Frank J. Gomes Dairy #1	5301 N. DeAngelis Road	Stevinson, CA 95374-9726	Figures 5 and 6
Gallo Cattle Company Bear Creek	15751 W. Hwy. 140	Livingston, CA 95334	Figure 11
Gallo Cattle Company Cottonwood	10561 Hwy. 140	Atwater, CA 95301	Figures 12 and 13
Gallo Cattle Company Santa Rita	91 S. Bert Crane	Atwater, CA 95301	Figures 12 and 14
P. & L. Souza Dairy	20633 Crane Ave	Hilmar, CA 95324	Figure 8
Paul Caetano Dairy	9436 Griffith Ave	Delhi, CA 95315	Figure 9
Robert Gioletti and Sons Dairy	118 N. Blaker Road	Turlock, CA 95380	Figure 4
West Side			
Antone L. Gomes and Sons Dairy	515 E. Stuhr Rd	Newman, CA 95360	Figure 16
Correia Family Dairy Farms	26380 W. Fahey Rd	Gustine, CA 95322	Figure 19
Frank J. Gomes Dairy #2	890 Kniebes Rd	Gustine, CA 95322	Figure 17
Godinho Dairy	12710 S. Wilson Rd	Los Banos, CA 93635	Figure 21
John Machado Dairy	22495 W. China Camp	Los Banos, CA 93635	Figure 20
Jose Nunes Dairy	22484 W. China Camp Rd.	Los Banos, CA 93635	Figure 20
Moonshine Dairy	22922 Kilburn Rd	Crows Landing, CA 95313	Figure 15
Tony L. Lopes Dairy LP	27500 Bunker Road	Gustine, CA 95322	Figure 18

Table 2
Physical Parameter Types for Dairy Farm Selection by Management Unit
Phase 1 Representative Groundwater Monitoring Workplan

	Physical Parameter (1)	
Management Unit	Static	Dynamic
Manure Application Area	Soil Texture Precipitation Depth to Groundwater (2)	Irrigation Manure and Fertilizer Application Crop Type and Rotation
Corral	Soil Texture Precipitation Depth to Groundwater (2) Age (2)	Slope, Soil Compaction, Maintenance Rate of Manure Excretion Rate of Manure Removal
Liquid Manure Storage Pond	Soil Texture Precipitation Depth to Groundwater (2) Age (2)	Waste Depth Solids Content Chemistry Seepage Rate

(1) Static: Existing conditions that are not readily changed by individual dairy farm practices; Dynamic: Items that can be addressed by dairy farm practices specific to management unit.
(2) These parameters do not control subsurface loading, but are important considerations with respect to groundwater quality analysis as affected by travel time of nitrogen components and salt in the subsurface.

Table 3
Dairy Farm Herd Size, Manure Application Area, and Whole Farm Nitrogen Balance
Phase 1 Representative Groundwater Monitoring Workplan

Dairy Farm	Maximum Number of Animals (head)			Animal Housing (head)		Manure Application Area (acres)	Whole Farm Nitrogen Balance
	Mature Milk Cows	Other (1)	Total	Freestall	Open Lot		
East Side							
Albert Mendes Dairy	1,700	1,450	3,150	1,700	1,450	379	1.67
Anchor J. Dairy	2,600	500	3,100	2,600	500	4,456	0.79
Bettencourt and Marson Dairy	1,244	1,104	2,348	1,244	1,104	649	1.32
Frank J. Gomes Dairy #1	1,250	1,680	2,930	1,250	1,680	252	2.32
Gallo Cattle Company Bear Creek	3,955	6,706	10,661	5,456	5,205	3,115	1.56
Gallo Cattle Company Cottonwood	5,500	687	6,187	0	6,187	1,463	1.63
Gallo Cattle Company Santa Rita	3,200	459	3,659	0	3,659	**tbd**	1.04
P. & L. Souza Dairy	457	630	1,087	**tbd**	**tbd**	426	1.06
Paul Caetano Dairy	640	280	920	**tbd**	**tbd**	120	2.40
Robert Gioletti and Sons Dairy	2,000	650	2,650	2,000	400	1,600	0.84
West Side							
Antone L. Gomes and Sons Dairy	520	563	1,083	671	412	150	2.28
Correia Family Dairy Farms	850	1,349	2,199	1,080	1,119	137	3.87
Frank J. Gomes Dairy #2	2,300	2,750	5,050	3,775	1,275	582	2.46
Godinho Dairy	1,258	1,140	2,398	1,490	908	492	1.60
John Machado Dairy	760	500	1,260	760	500	282	1.66
Jose Nunes Dairy	1,200	1,400	2,600	1,380	1,220	1,053	1.59
Moonshine Dairy	2,000	1,950	3,950	2,400	1,550	425	1.15
Tony L. Lopes Dairy LP	2,175	2,293	4,468	2,175	2,293	919	1.62

Data from most recent available Annual Dairy Report (i.e., calendar year 2009) at the time of February 2011 file review.
tbd = to be determined
(1) Dry cows, bred heifers (15-24 months), heifers (7-14 months), and calves (<6 months).

Table 4
Number and Distribution of Monitoring Wells
Phase 1 Representative Groundwater Monitoring Workplan

	Dedicated Shallow Monitoring Well Locations (1)					
				Assigned To (2)		
Dairy Farm	Existing	New	Total	Pond	Corral	Field
East Side						
Albert Mendes Dairy	-	7	**7**	2	3	2
Anchor J. Dairy	4	5	**9**	4	2	3
Bettencourt and Marson Dairy	-	8	**8**	1	3	4
Frank J. Gomes Dairy #1	-	9	**9**	1	2	6
Gallo Cattle Company Bear Creek	-	8	**8**	1	3	4
Gallo Cattle Company Cottonwood	10	4	**14**	2	3	9
Gallo Cattle Company Santa Rita	-	10	**10**	3	3	4
P & L Souza Dairy	-	7	**7**	2	3	2
Paul Caetano Dairy	-	6	**6**	1	3	2
Robert Gioletti and Sons Dairy	-	8	**8**	2	3	3
West Side						
Antone L. Gomes and Sons Dairy	-	6	**6**	1	3	2
Correia Family Dairy Farms	-	5	**5**	1	4	0
Frank J. Gomes Dairy #2	-	6	**6**	1	2	3
Godinho Dairy	-	7	**7**	1	2	4
John Machado Dairy	-	5	**5**	2	0	3
Jose Nunes Dairy	-	4	**4**	1	3	0
Moonshine Dairy	4	4	**8**	2	3	3
Tony L. Lopes Dairy LP	-	8	**8**	2	3	3
		Total	135	30	48	57

(1) Strictly speaking, this table enumerates well locations, not wells. Most of the proposed new dedicated monitoring facilities will be constructed as nested wells with two individual wells completed in one borehole. As a result, the total number of new monitoring wells will be approaching or exceeding 200.

(2) The assignment indicates the management unit targeted for groundwater quality assessment. All wells are used for hydraulic control. Many wells serve multiple purposes (e.g., downgradient hydraulic control/groundwater quality from application field and upgradient hydraulic control for corral).

Table 5
Groundwater Quality Monitoring Program and Laboratory Analyses
Phase 1 Representative Groundwater Monitoring Workplan

Quarter (1)	Sampling Event	Laboratory Analyses
Year 1 Q1	initial sampling	TDS, nitrate, ammonia
Year 1 Q2	**expanded sampling**	general minerals, nitrate, nitrite, ammonia, TKN
Year 1 Q3	quarterly	TDS, nitrate, ammonia
Year 1 Q4	quarterly	TDS, nitrate, ammonia
Year 2 Q1	quarterly	TDS, nitrate, ammonia
Year 2 Q2	quarterly	TDS, nitrate, ammonia
Year 2 Q3	**annual**	general minerals, nitrate, nitrite, ammonia, TKN (2)

General Minerals = sodium, potassium, magnesium, calcium, chloride, sulfate, alkalinity suite (bicarbonate, carbonate, and hydroxide alkalinity), phosphate, total dissolved solids.
TKN = total Kjeldahl nitrogen (sum of ammonia and organic nitrogen)
TDS = total dissolved solids
ammonia = sum of ammonium and ammonia
(1) Generic quarters are given for purposes of demonstration.
(2) Nitrite analysis will not be conducted in wells where baseline sampling indicate concentrations below the reporting limit or otherwise negligibly small concentrations. TKN analysis will not be conducted in wells where the comparison of TKN and ammonia baseline results indicate negligibly small organic nitrogen concentrations in groundwater.

Table 6
Laboratory Methods and Reporting Limits
Phase 1 Representative Groundwater Monitoring Workplan

Constituent	Analytical Method	Reporting Limit (mg/L)
Sodium	EPA 200.7	1.0
Potassium	EPA 200.7	1.0
Magnesium	EPA 200.7	1.0
Calcium	EPA 200.7	1.0
Chloride	EPA 300.0	0.5
Sulfate	EPA 300.0	1.0
Bicarbonate (as CaCO3)	SM2310B	5.0
Carbonate (as CaCO3)	SM2310B	5.0
Hydroxide (as CaCO3)	SM2310B	5.0
Phosphate (as PO4)	SM4500-PE	0.15
Total Dissolved Solids	SM2540C	10
Nitrate-N	EPA 300.0	0.5
Nitrite-N	EPA 300.0	0.4
Ammonia-N	EPA 350.2 or SM4500-NH3C	0.1
Total Kjeldahl Nitrogen-N	EPA 351.3 or SM4500-NH3C	0.2

Figures

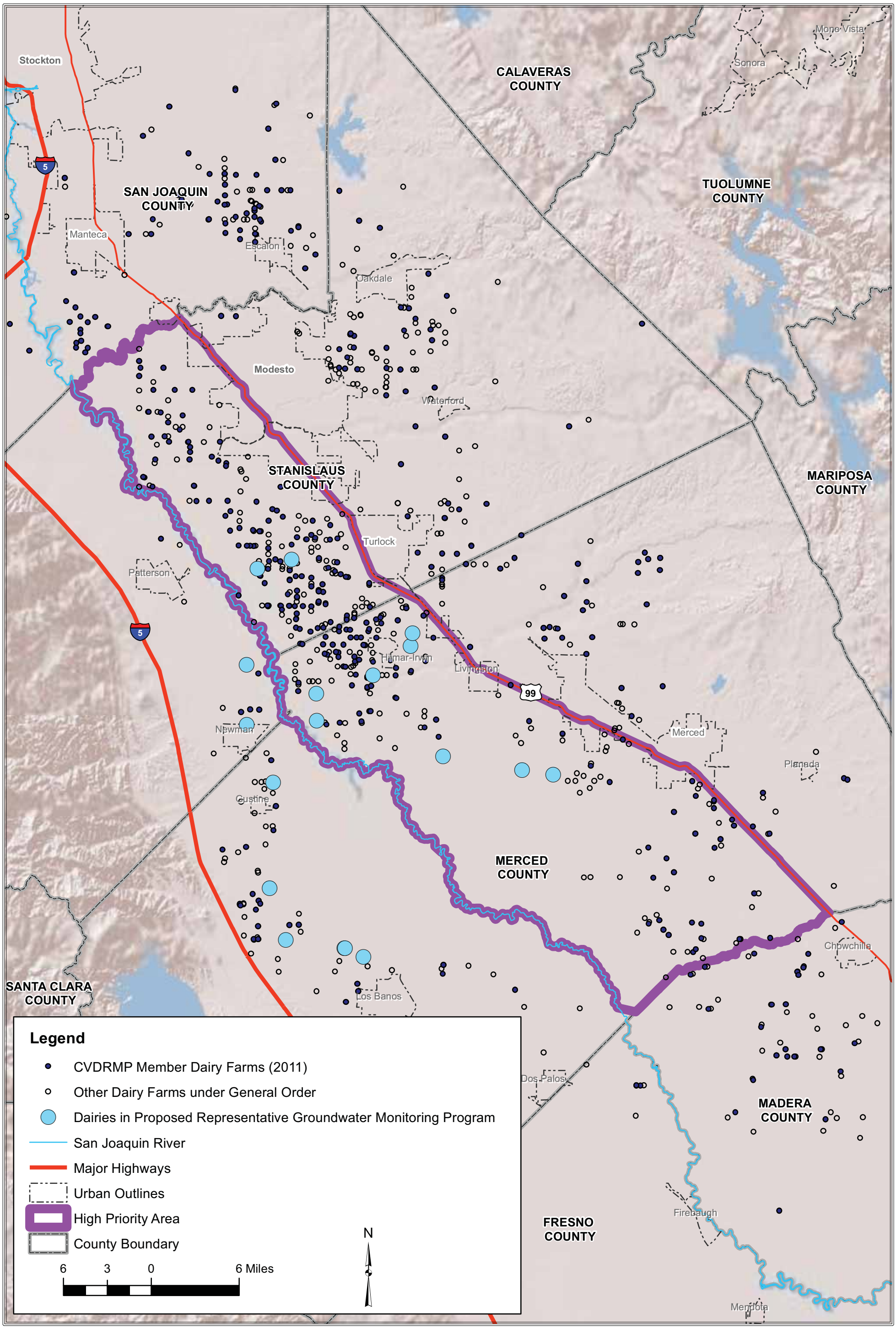

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Figure 1
Location Map - Selected Dairy Farms
Phase 1 Representative Groundwater Monitoring Program

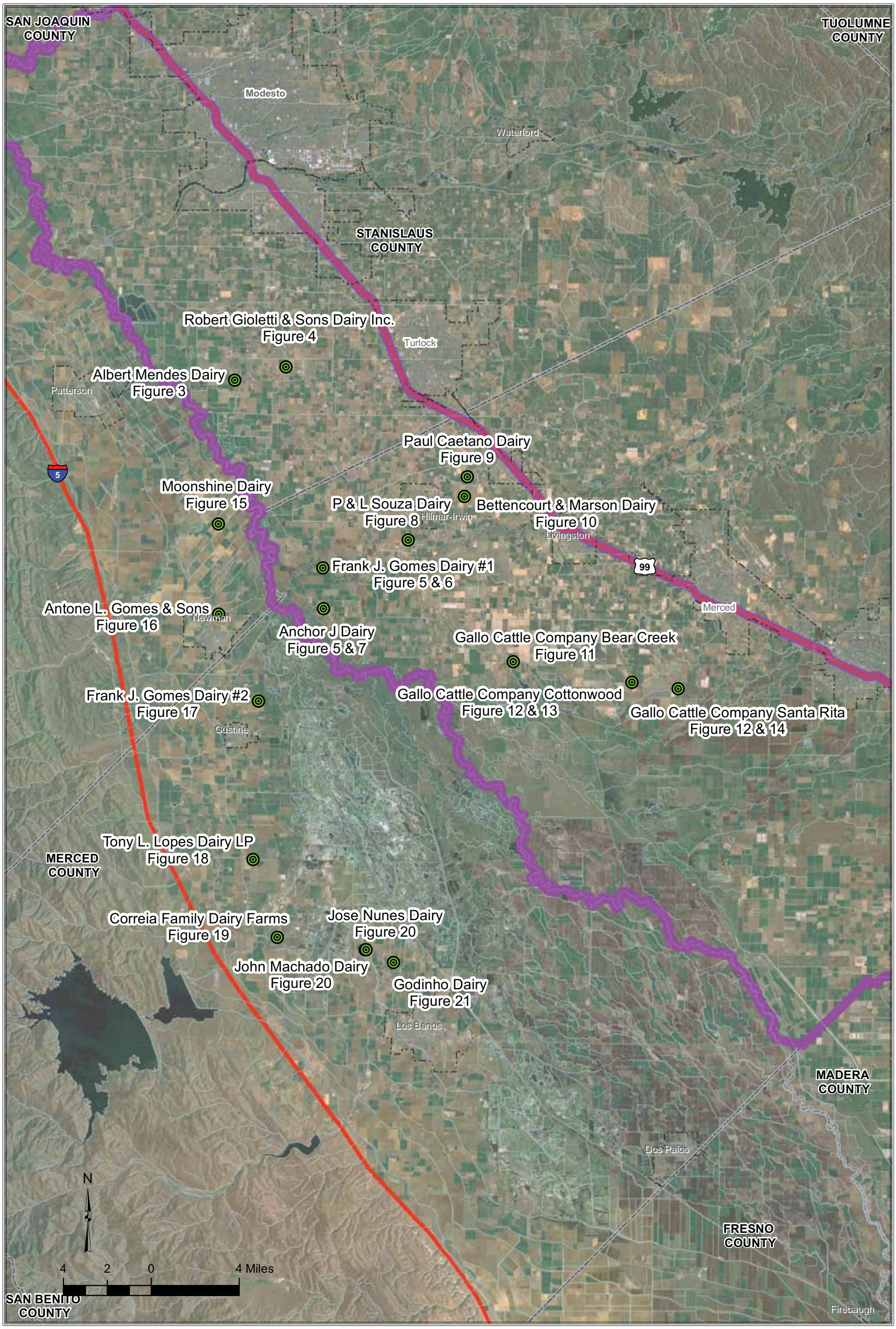

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Figure 2
Index Map - Selected Dairy Farms
Phase 1 Representative Groundwater Monitoring Program

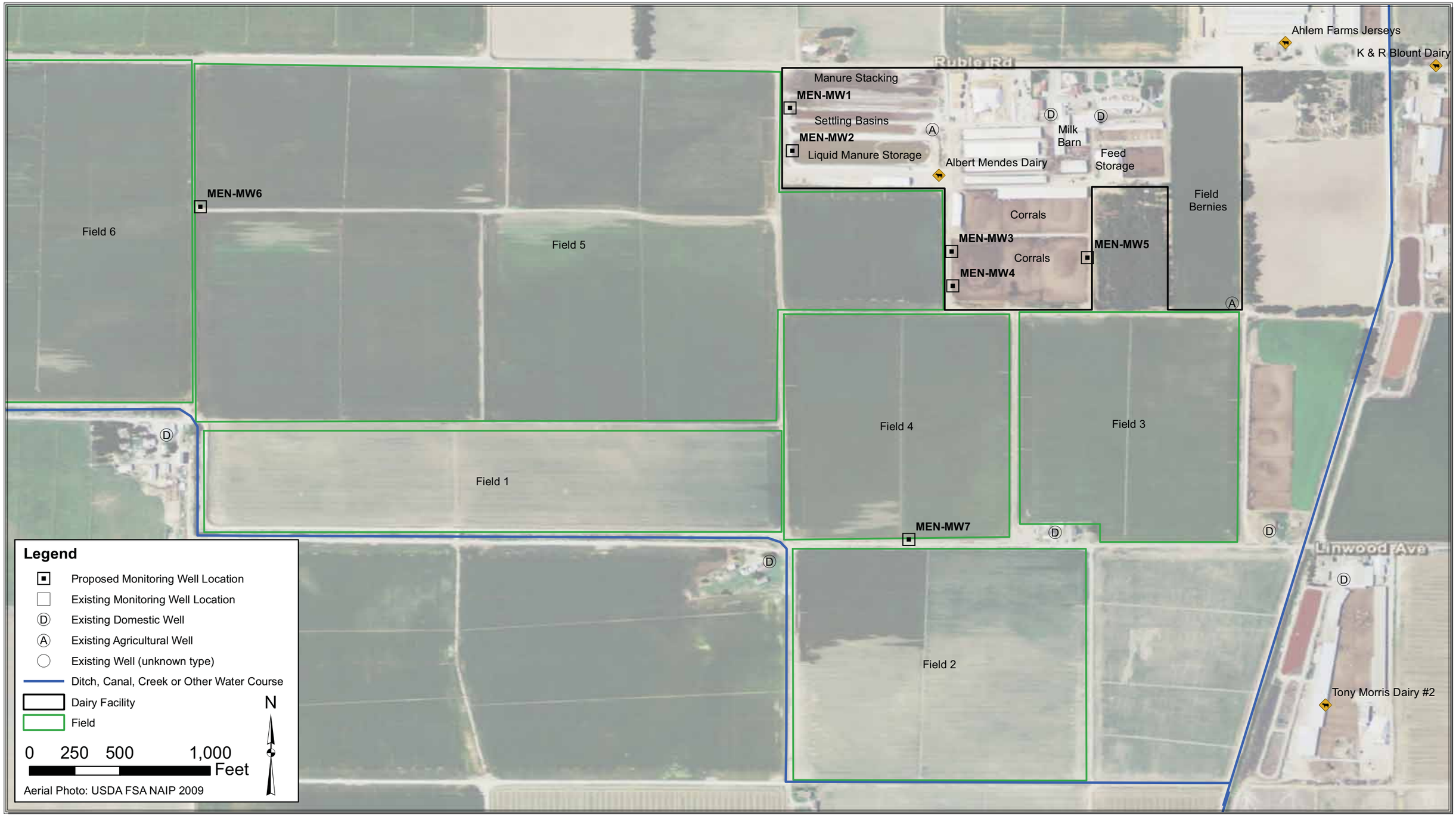

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Figure 3
Albert Mendes Dairy
Proposed Monitoring Well Locations

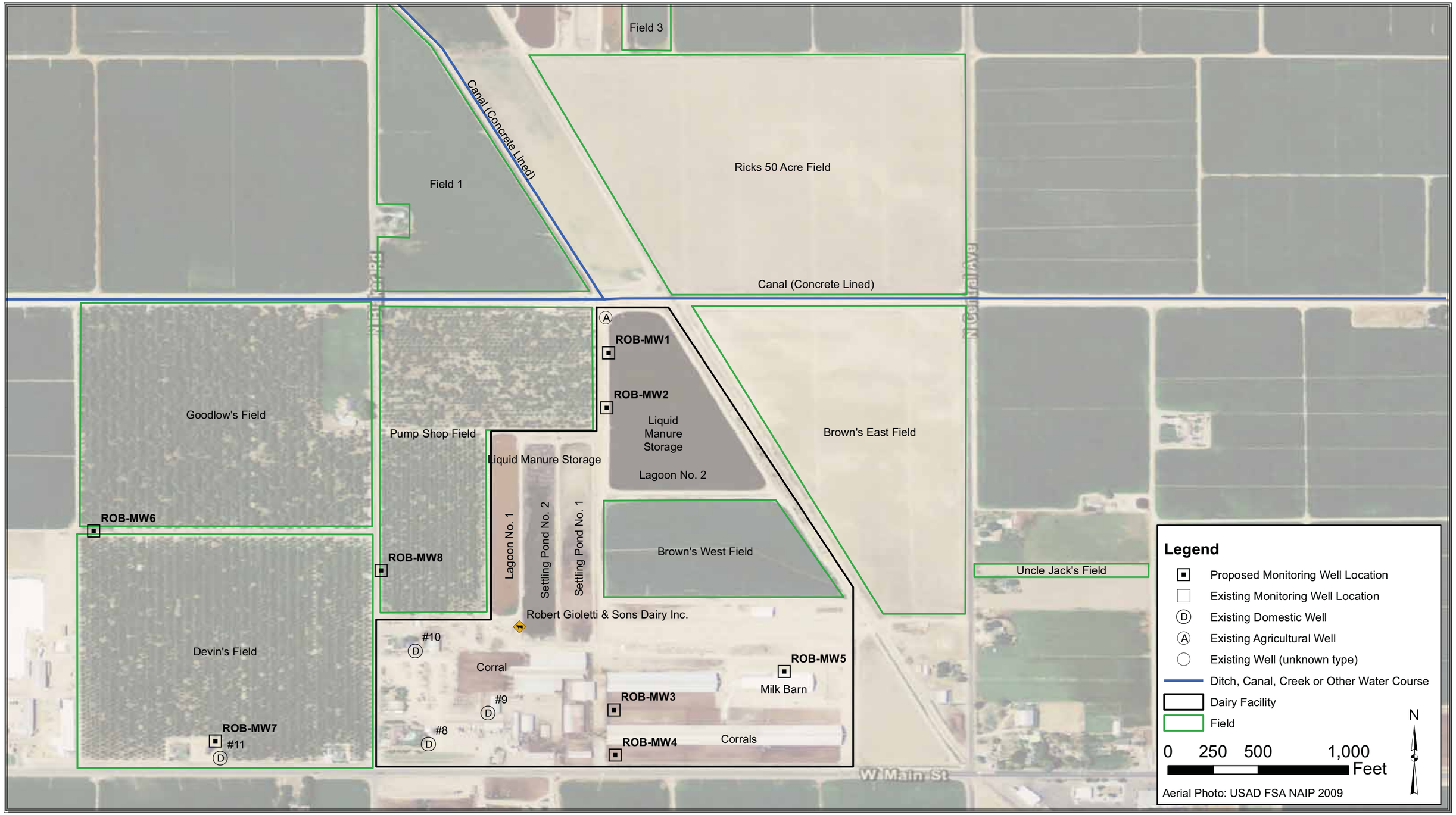

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Figure 4
Robert Gioletti and Sons Dairy
Proposed Monitoring Well Locations

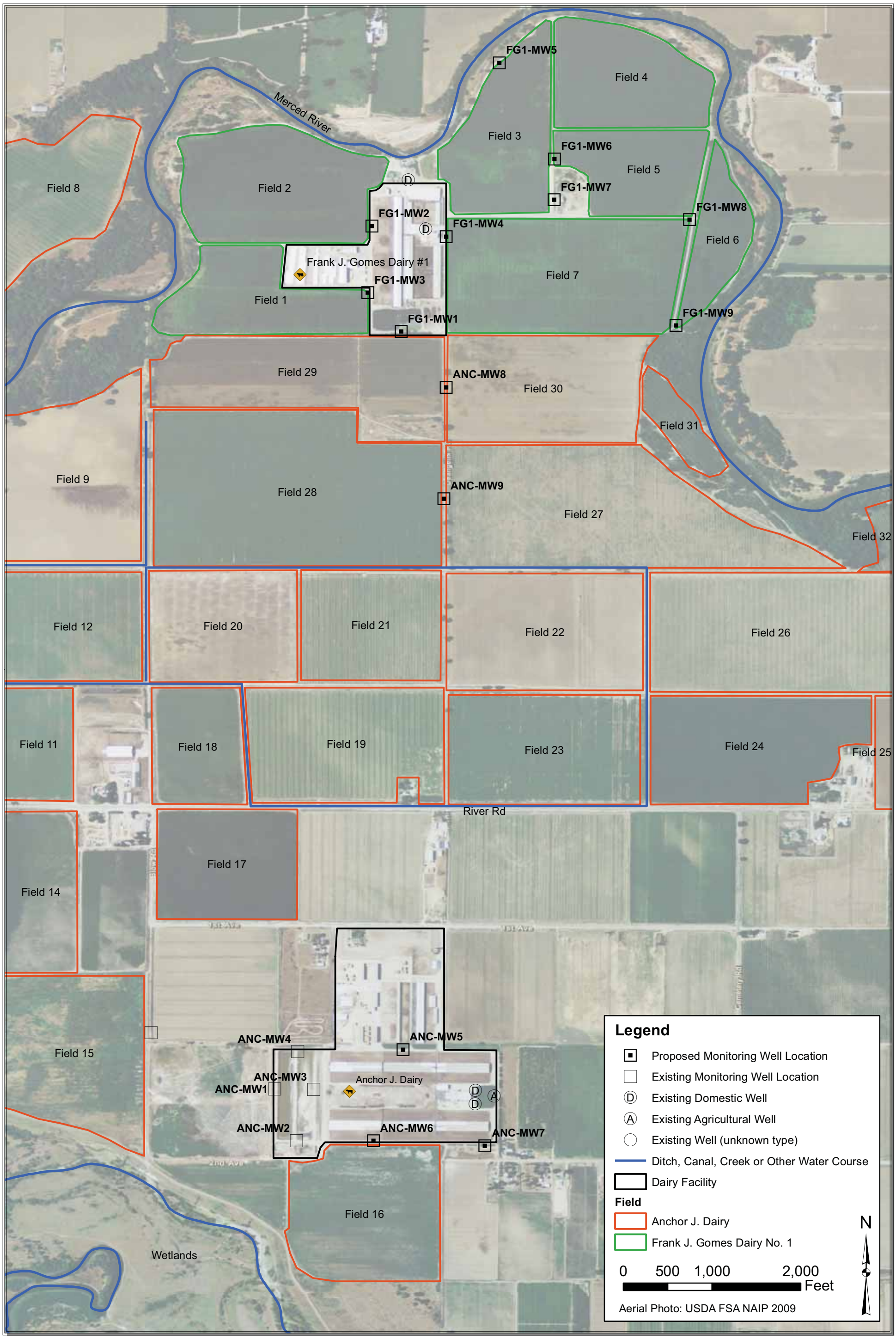

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Figure 5
Index Map for Frank J. Gomes # 1 and Anchor J. Dairies

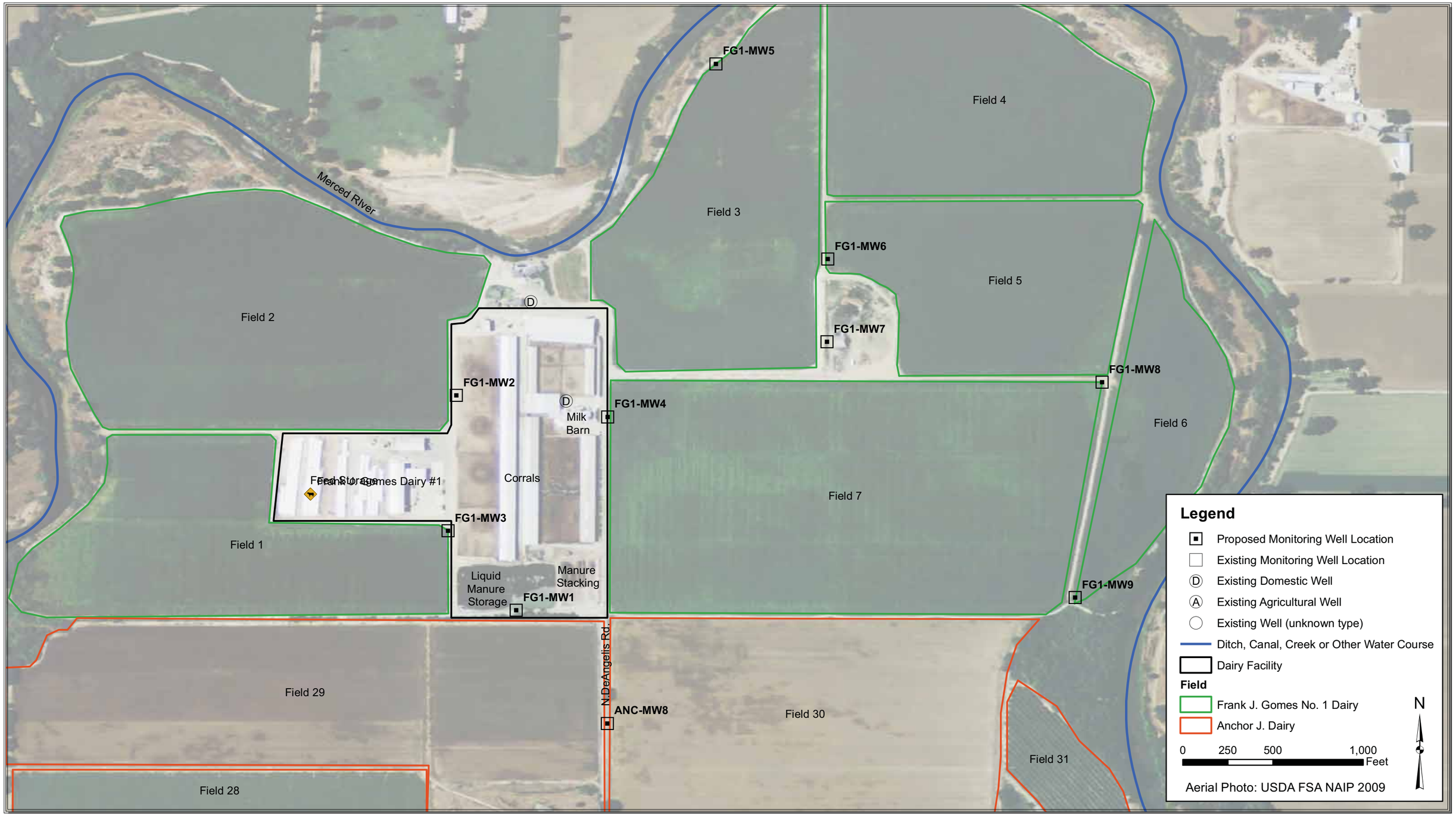

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Figure 6
Frank J. Gomes Dairy # 1
Proposed Monitoring Well Locations

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Figure 7
Anchor J. Dairy
Proposed Monitoring Well Locations

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Figure 8
P. and L. Souza Dairy
Proposed Monitoring Well Locations

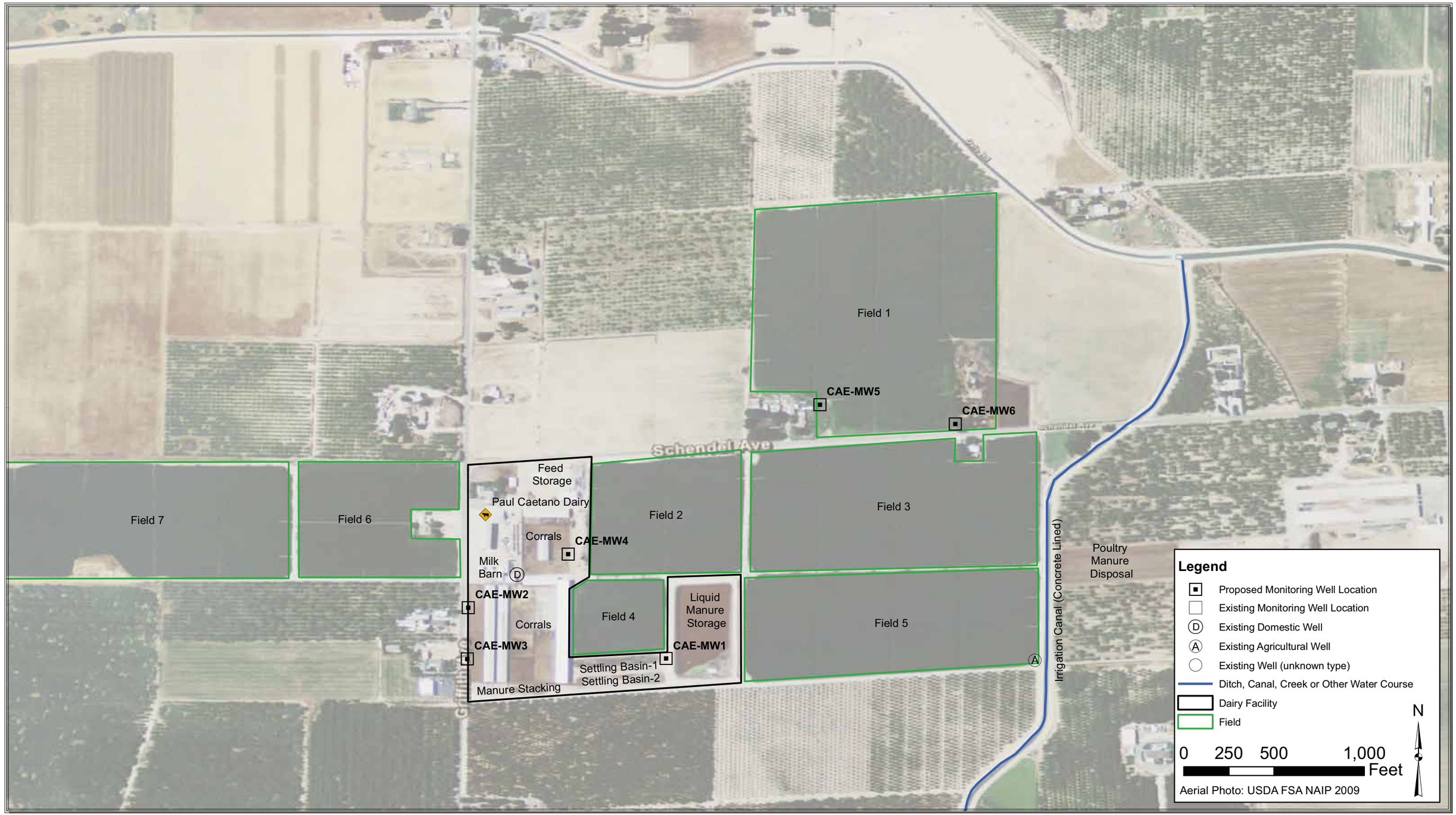

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Figure 9
Paul Caetano Dairy
Proposed Monitoring Well Locations

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Figure 10
Bettencourt and Marson Dairy
Proposed Monitoring Well Locations

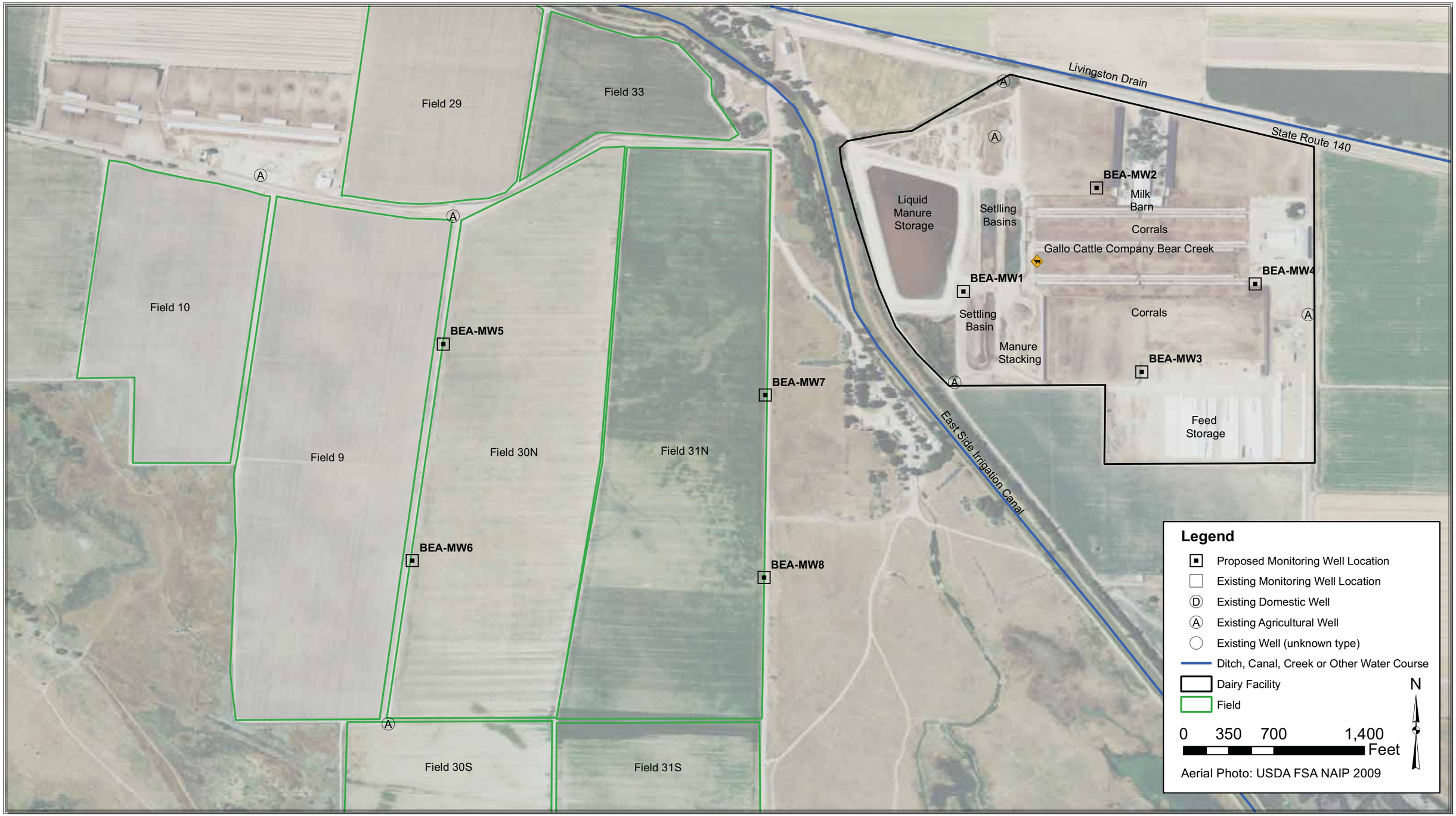

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Figure 11
Gallo Cattle Company, Bear Creek Dairy
Proposed Monitoring Well Locations

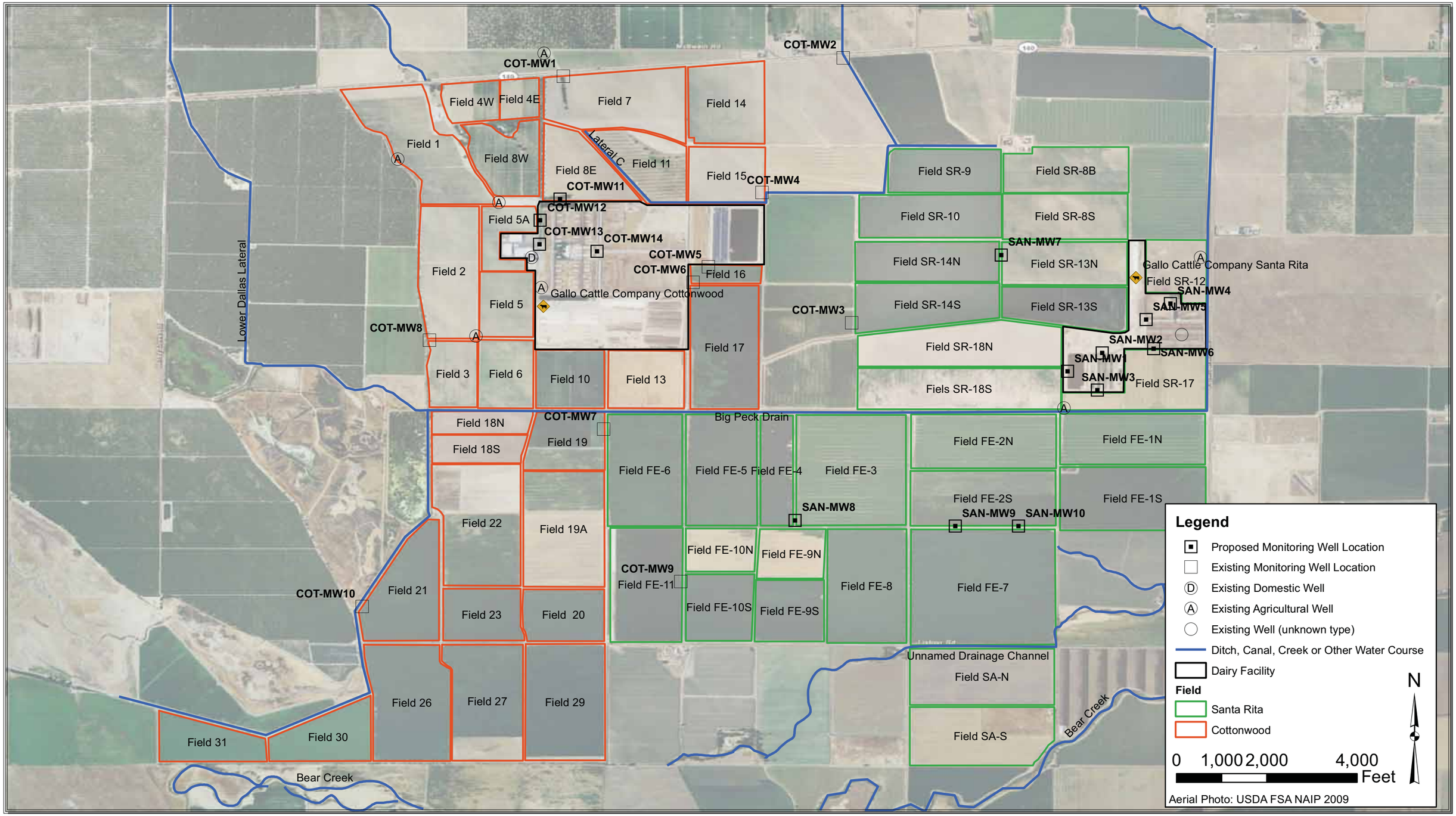

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Figure 12
Index Map for Gallo Cattle Company, Cottonwood and Santa Rita Dairies

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Figure 13
Gallo Cattle Company, Cottonwood Dairy
Proposed Monitoring Well Locations

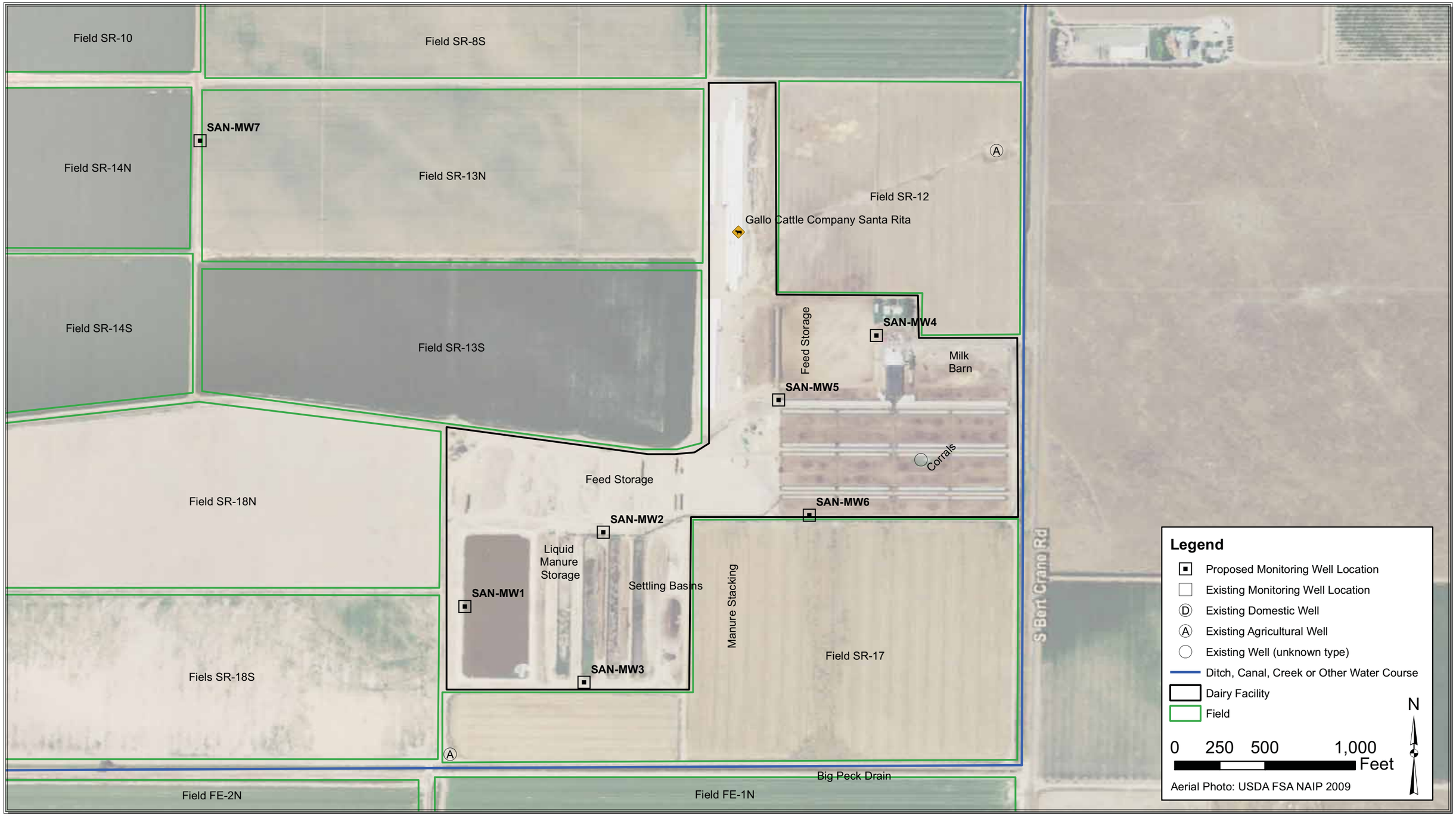

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Figure 14
Gallo Cattle Company, Santa Rita Dairy
Proposed Monitoring Well Locations

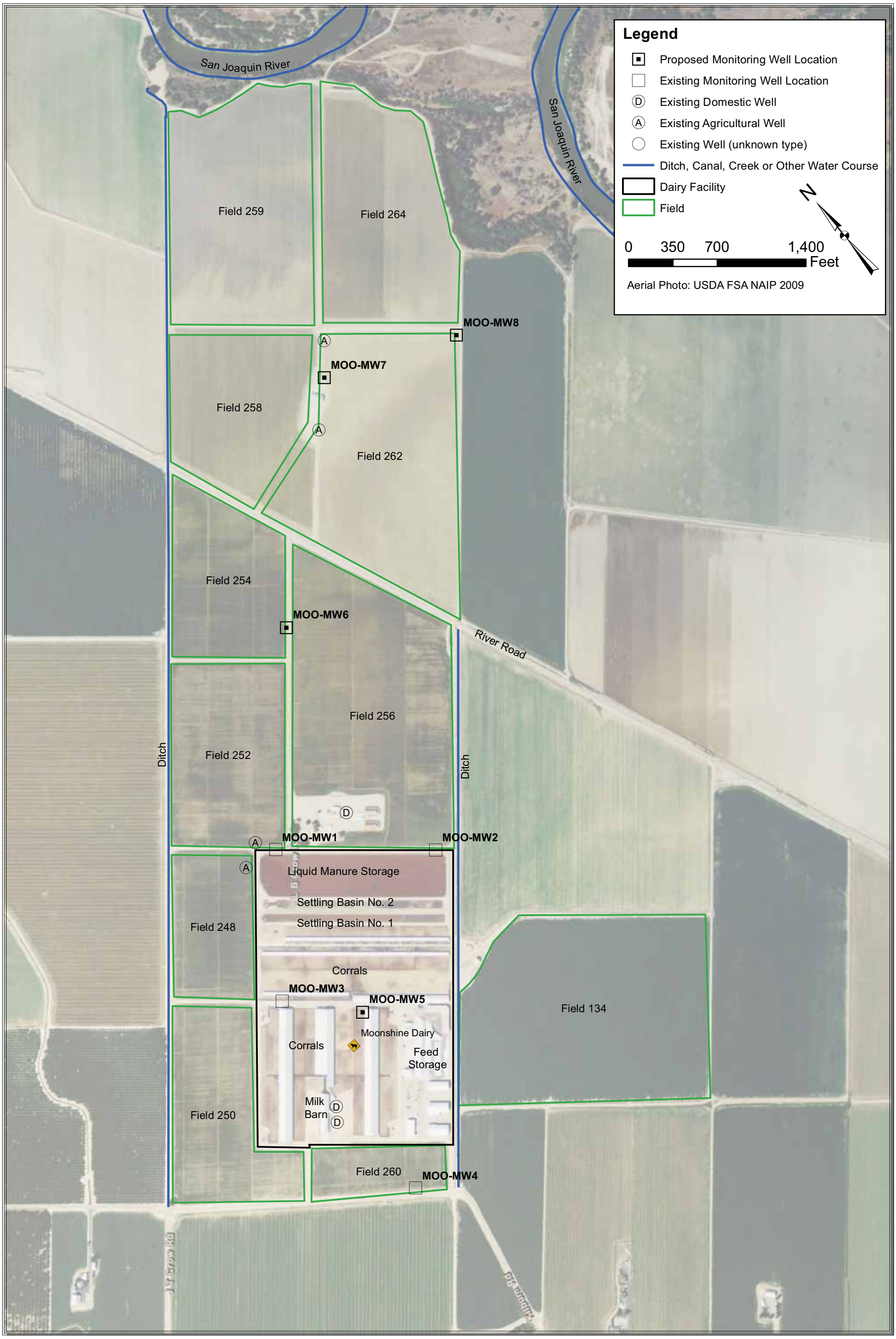

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Figure 15
Moonshine Dairy
Proposed Monitoring Well Locations

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Figure 16
Antone L. Gomes and Sons Dairy
Proposed Monitoring Well Locations

File: GIS/Jeanette/Jeanette 5.2.2011

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Figure 17
Frank J. Gomes Dairy #2
Proposed Monitoring Well Locations

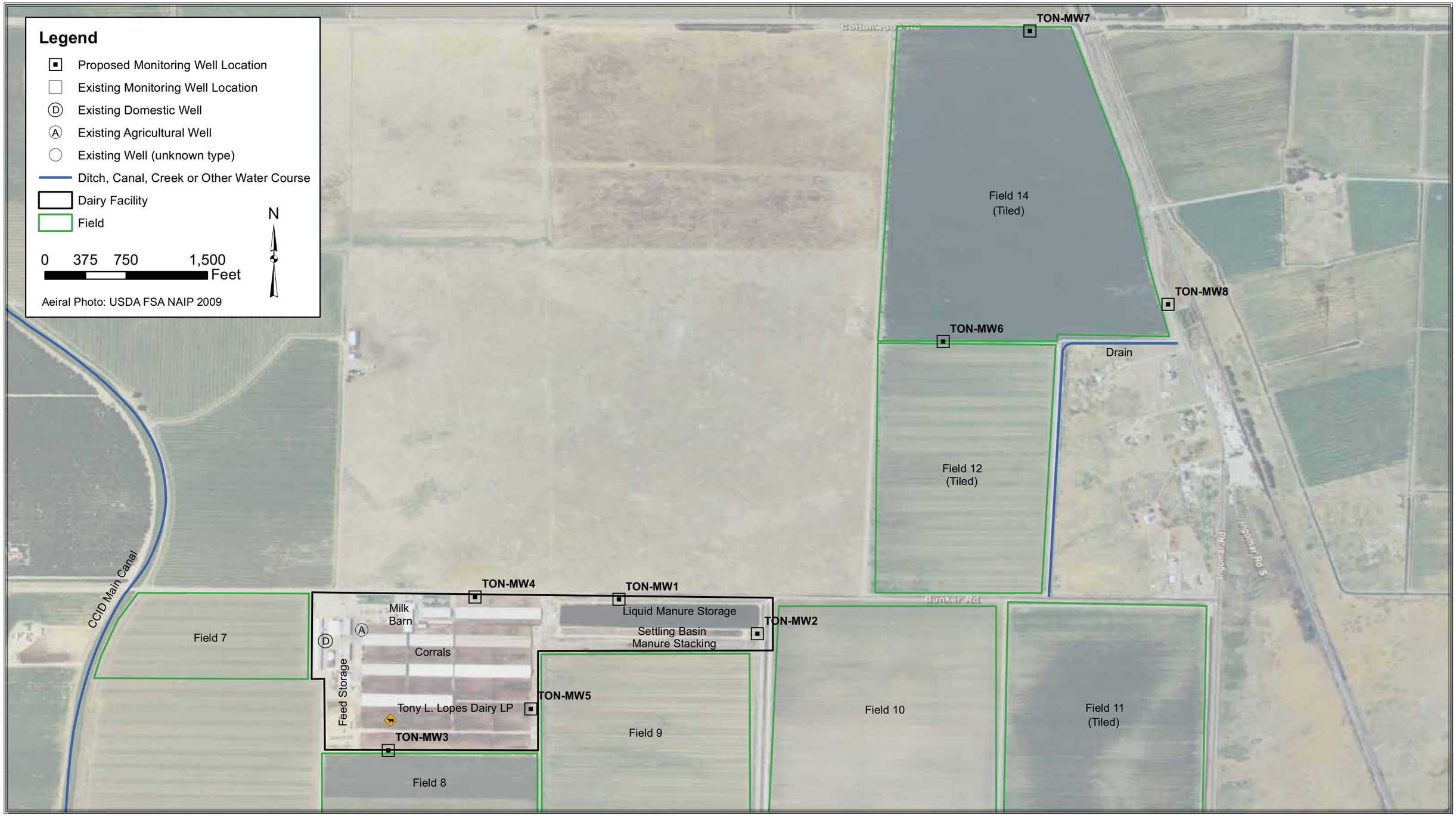

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Figure 18
Tony L. Lopes Dairy LP
Proposed Monitoring Well Locations

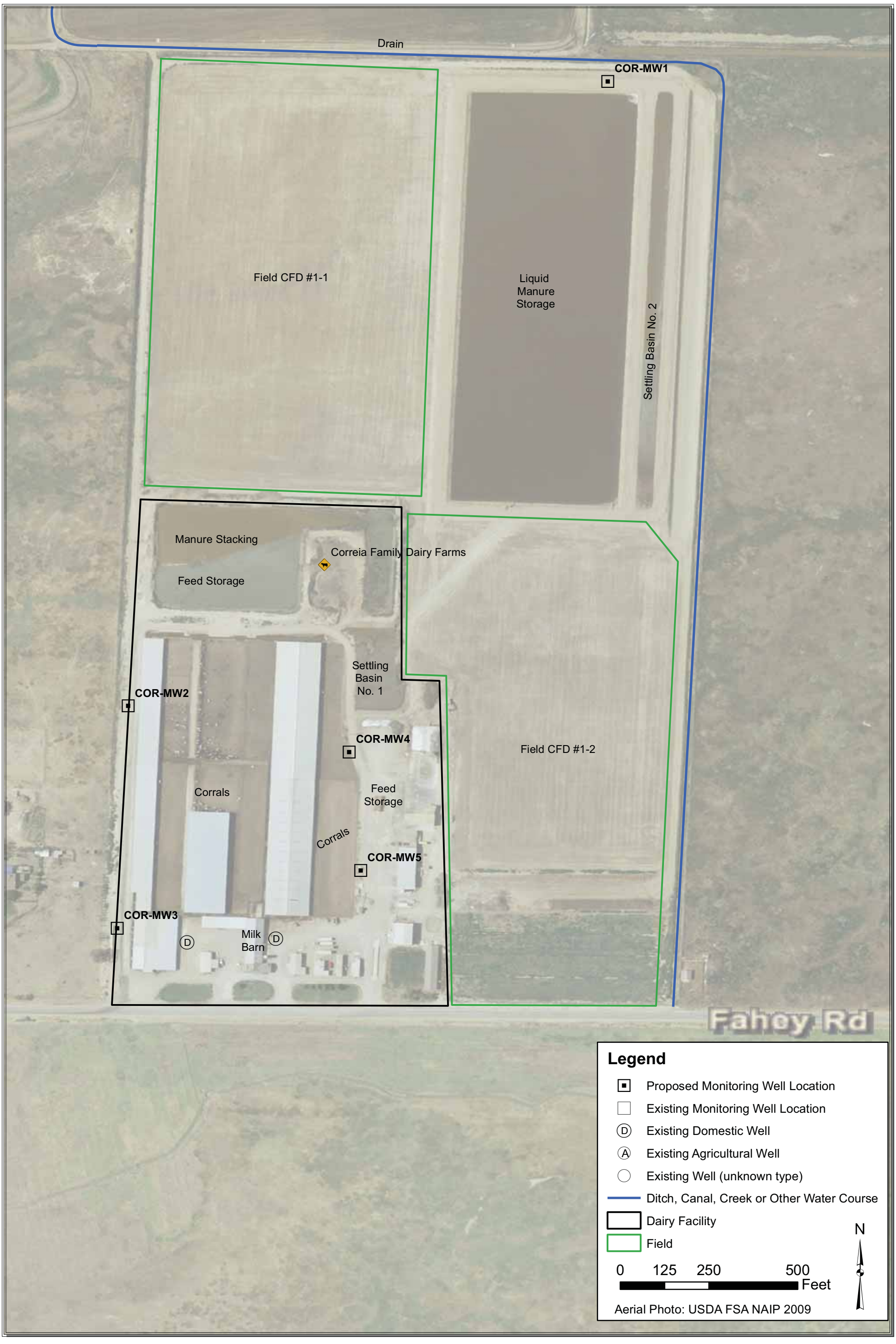

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Figure 19
Correia Family Dairy
Proposed Monitoring Well Locations

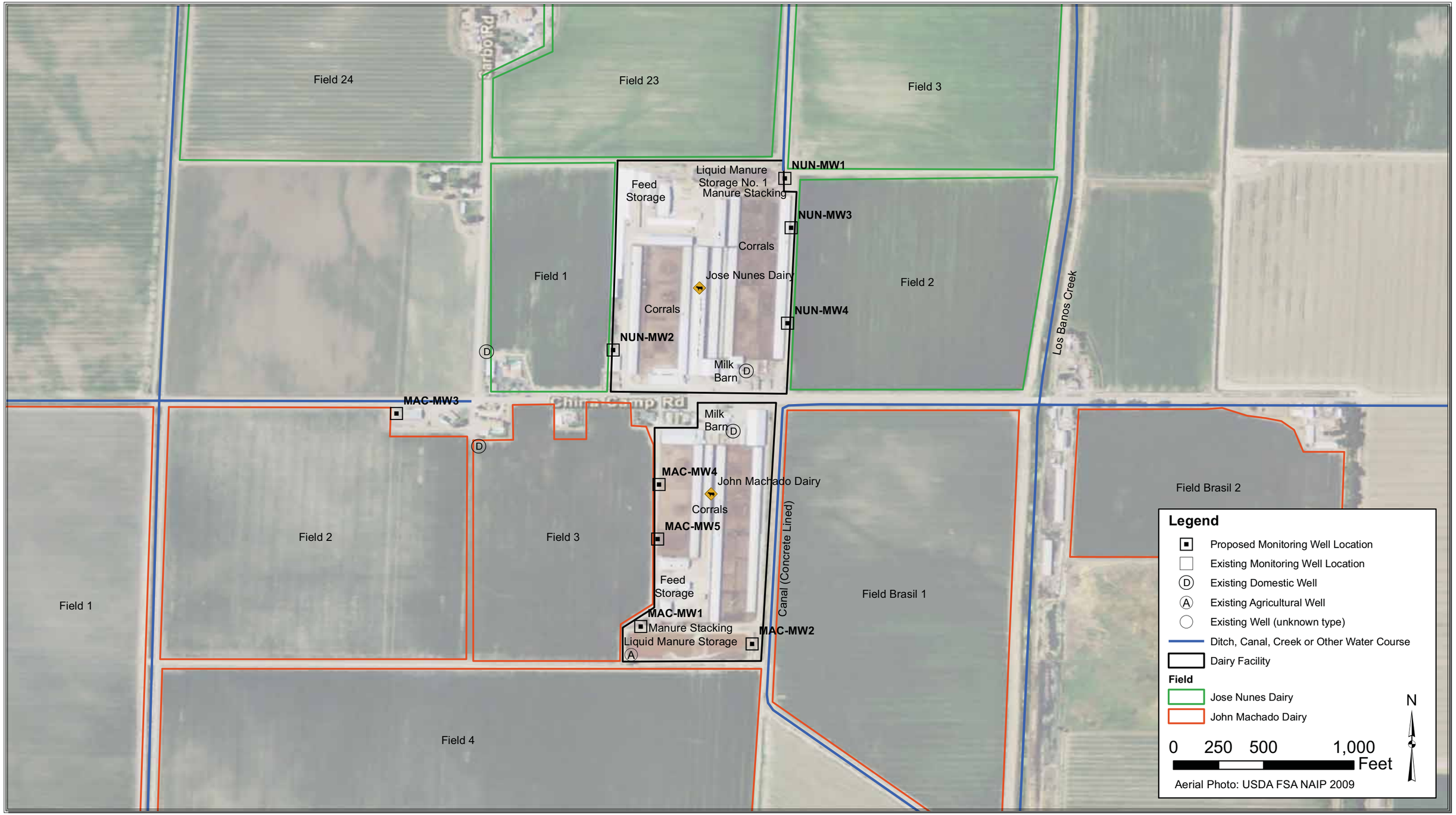

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Figure 20
Jose Nunes and John Machado Dairies
Proposed Monitoring Well Locations

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Figure 21
Godinho Dairy
Proposed Monitoring Well Locations

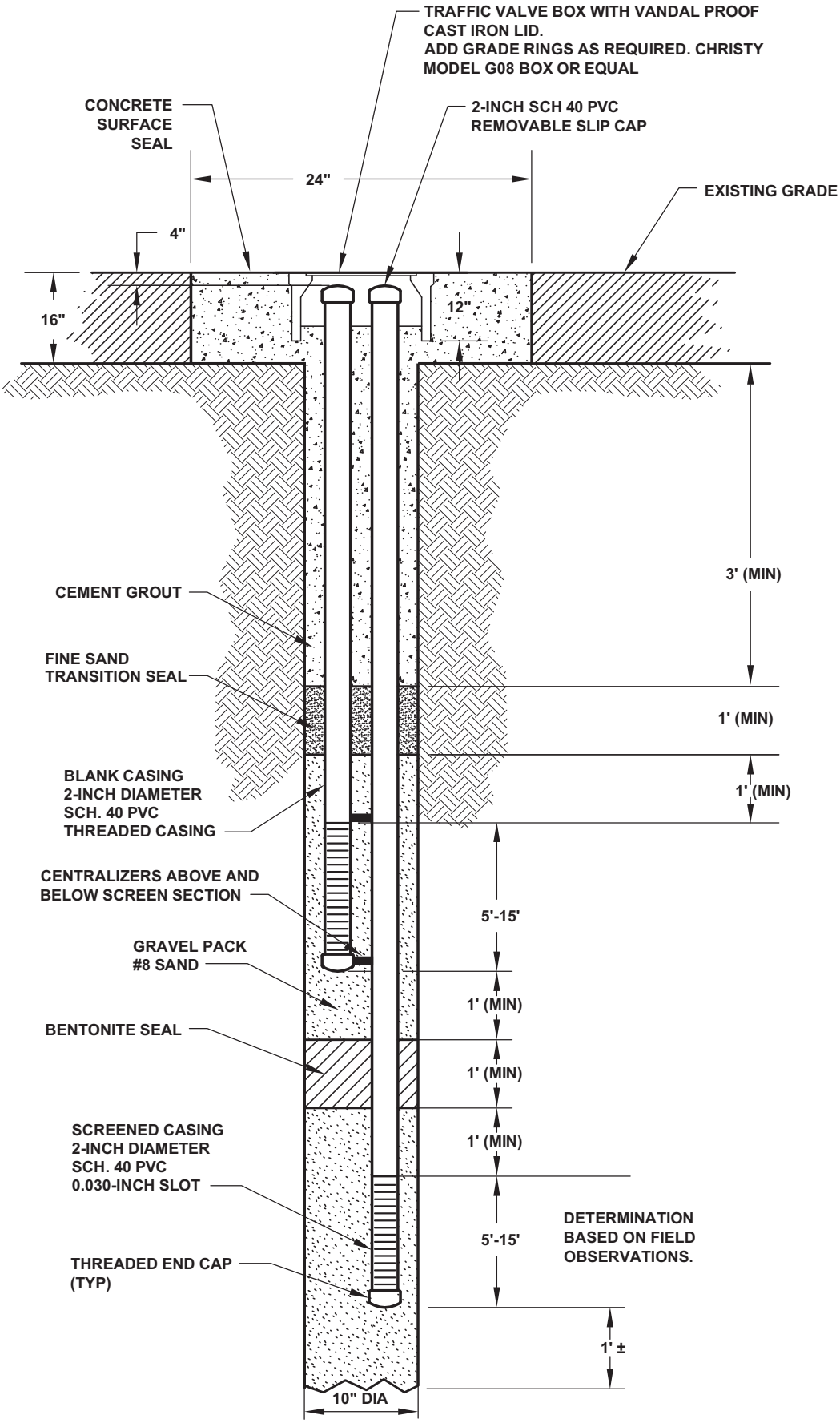

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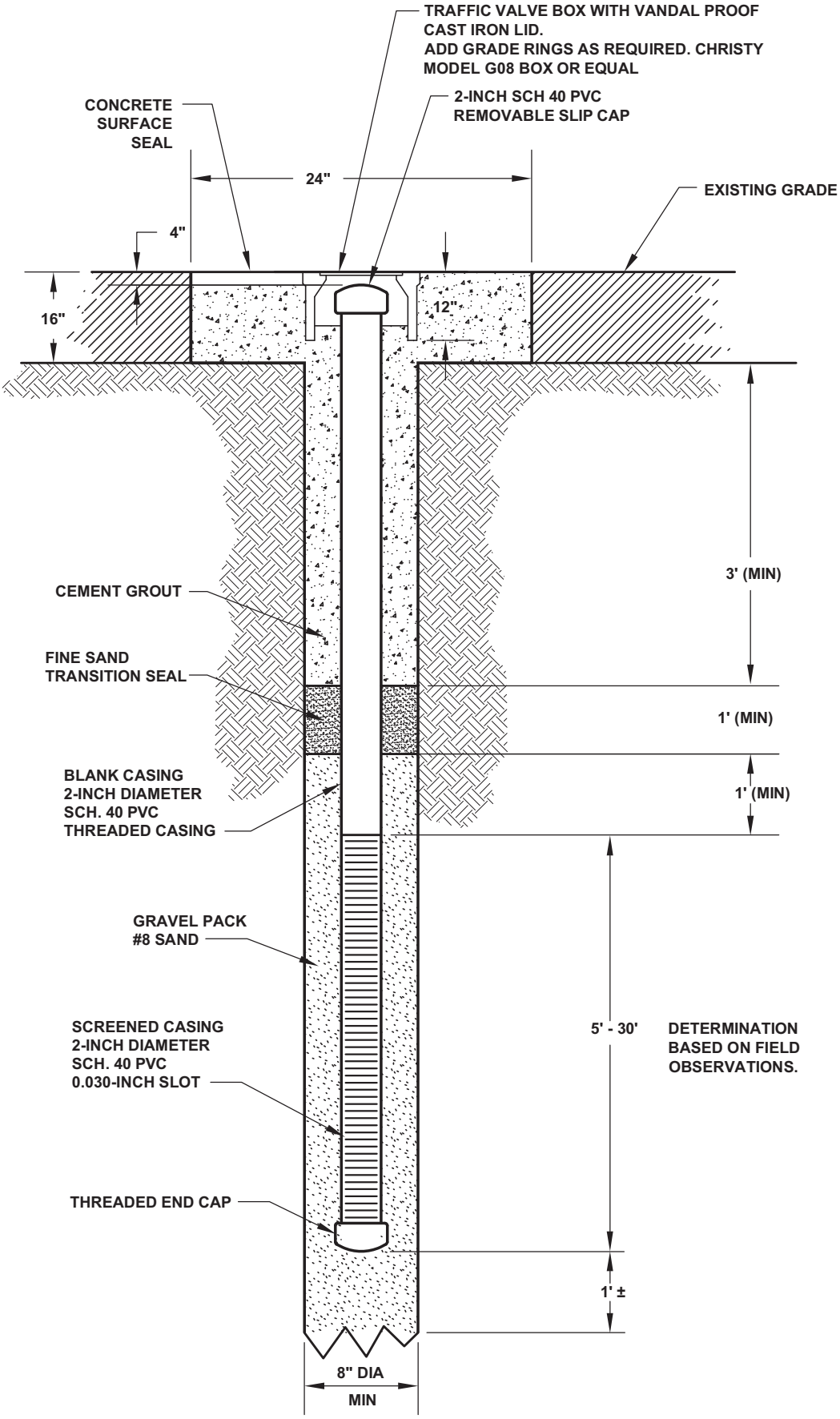
Figure 22
Typical Nested Groundwater Monitoring Well Profile



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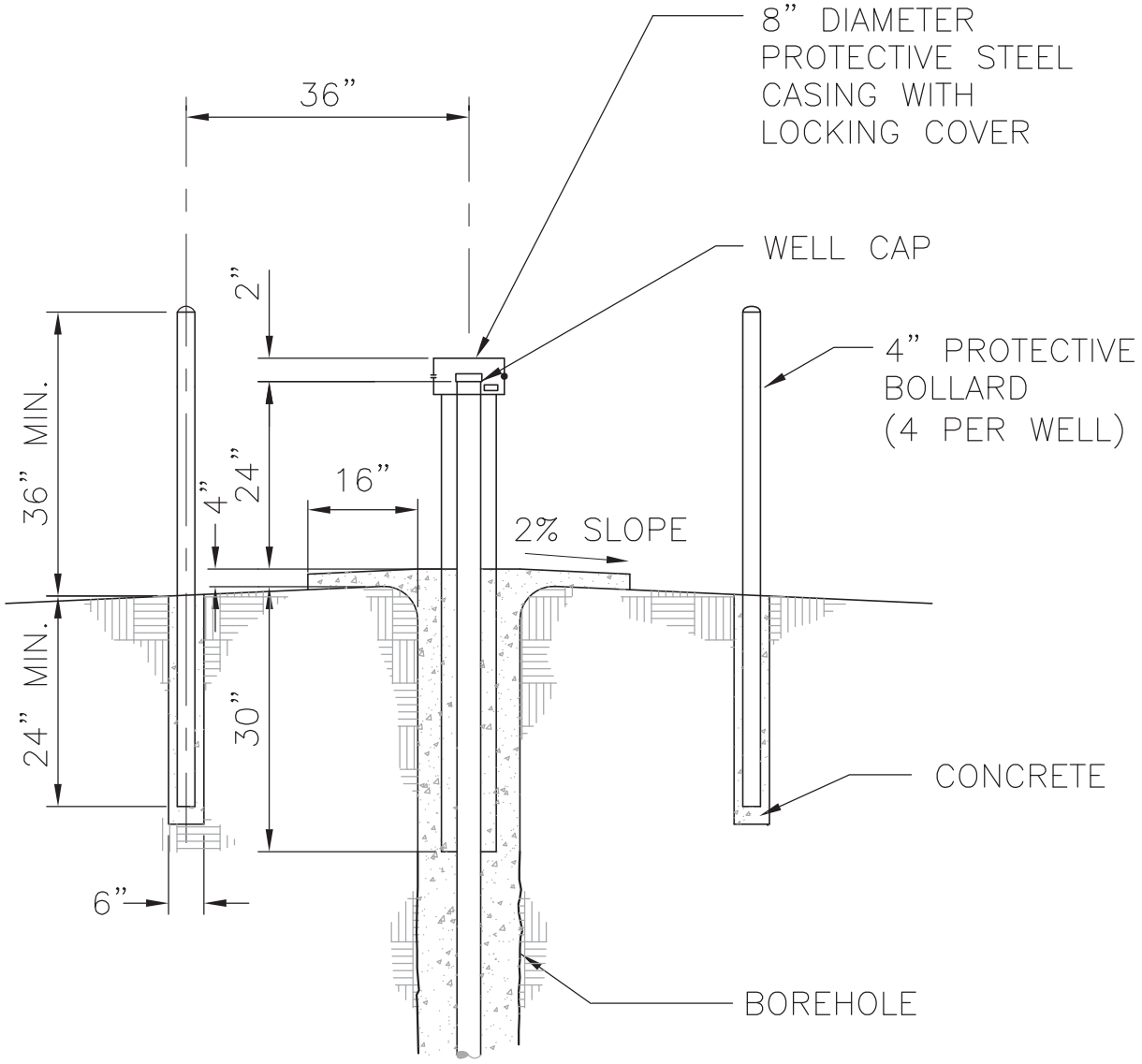
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure 23
Typical Groundwater Monitoring Well Profile



NOTE:

DIMENSIONS OF CONCRETE
PAD SUBJECT TO
LOCAL REQUIREMENTS.

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Figure 24
Typical Above Grade
Surface Completion Detail

Attachment 1

Report of Results – Delineation of an Area for the Design and Initiation of a Representative Groundwater Monitoring Network for Existing Milk Cow Dairies, Central Valley, CA.

Removed for purposes of this attachment to the Phase 2 RMP Workplan

Attachment 2

Construction Details of Existing Monitoring Wells

Attachment 2
Construction Details of Existing Monitoring Wells
Phase 1 Representative Groundwater Monitoring Workplan

Well Identification	Total Well Depth (feet below ground surface)	Screened Interval (feet below ground surface)	Casing Diameter (inch)	Casing Material	Reference Point Elevation (feet, above mean sea level)
East Side					
ANC-MW1	24	tbd	2	PVC	tbd
ANC-MW2	35	tbd	2	PVC	tbd
ANC-MW3	25	tbd	2	PVC	tbd
ANC-MW4	33	tbd	2	PVC	tbd
COT-MW-1	30	15-30	2	PVC	113.99
COT-MW-2	35	20-35	2	PVC	115.37
COT-MW-3	30	15-30	2	PVC	112.78
COT-MW-4	25	10-25	2	PVC	112.48
COT-MW-5	23	8-23	2	PVC	109.67
COT-MW-6	23	8-23	2	PVC	109.22
COT-MW-7	25	10-25	2	PVC	108.36
COT-MW-8	22	12-22	2	PVC	107.47
COT-MW-9	25	10-25	2	PVC	107.88
COT-MW-10	10	10-20	2	PVC	103.17
West Side					
MOO-MW1	25	5-25	4	PVC	75.58
MOO-MW2	29	9-29	4	PVC	73.01
MOO-MW3	25	5-25	4	PVC	72.05
MOO-MW4	25	5-25	4	PVC	74.28

tbd = to be determined

Attachment 3

Example field sheet for groundwater sampling

Field Purge Data (Monitoring Wells)

Client	Date	Project No.
Project	Measured/Collected by (Initial)	

Well ID	Total Well Depth (ft)	Casing Diameter (in)	PVC / Steel
Static DTW (ft)	Standing Water Column (ft)		
Standing Water Column (ft) x 0.16 (for 2" casing); 0.37 (for 3" casing); 0.65 (for 4" casing); 1.0 (for 5" casing); 1.5 (for 6" casing); 2.6 (for 8" casing) = Wet Casing Volume, Vc (gal)			3 Vc (gal)

Clock Time	Pumping Time (min)	Flow Rate (gpm)	Cumulative Flow (gal)	DTW (ft)	Temp (°F / °C)	pH	Spec. Cond. temp. comp. to 25 °C (µS/cm)	Turbidity (NTU)	DO (mg/L)	ORP (milliVolt)	Observations (e.g., color, odor)

Notes / Water Sample Collection (number of bottles and sample I.D.)

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Attachment 3

"Table 6. Additional Groundwater Monitoring" (Excerpt from *Revised Monitoring and Reporting Program Order No. R5-2007-0035 General Order for Existing Milk Cow Dairies*. February 23, 2011)

Table 6. ADDITIONAL GROUNDWATER MONITORING
Monitoring Wells Quarterly[1]: Measurement of the depth to groundwater from a surveyed reference point to the nearest 0.01 foot in each monitoring well. Semi-annually: Field measurements of electrical conductivity, temperature, and pH. Laboratory analyses for nitrate and ammonia. Within six months of well construction and every two years thereafter: Laboratory analyses for general minerals (calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, and chloride).

[1] After two years of quarterly depth to groundwater measurements, the discharger may request reduction of frequency of depth to groundwater measurements to semi-annually upon demonstration there are no seasonal impacts to groundwater levels.

9. Groundwater samples from monitoring wells shall be collected as specified in the approved Monitoring Well Installation and Sampling Plan (MWISP).

10. The Discharger shall submit to the Executive officer an annual assessment of the groundwater monitoring data due 1 July of each year. The annual assessment may be attached to the annual report required in Section C of the MRP. The annual assessment shall include a tabulated summary of all analytical data collected to date including analytical lab reports for data collected during the past year. The assessment shall include an evaluation of the groundwater monitoring program's adequacy to assess compliance with the Order, including whether the data provided is representative of conditions upgradient and downgradient wastewater management area, production area and land application area of the dairy facility. The assessment shall also include and evaluation of the groundwater monitoring data collected to date with a description of the statistical or non-statistical methods used. The assessment must use methods approved by the Executive Officer. If the Discharger determines that the analytical methods required by this MRP are insufficient to identify whether site activities are impacting groundwater quality, the annual assessment must address Item II.11 below and employ the needed analyses during future monitoring events.

11. If the monitoring parameters required by this MRP are insufficient to identify whether site activities are impacting groundwater quality, the Discharger must employ all reasonable chemical analyses to differentiate the source of the particular constituent. This includes, but is not limited to, analyses for a wider array of constituents and chemical isotopes.

12. Within six years of initiating sampling activities, the Discharger shall submit to the Executive Officer a summary report presenting a detailed assessment of the monitoring data to evaluate whether site activities associated with operation of the wastewater retention system, corrals, or land application areas have impacted groundwater quality. This summary report can be required at an earlier date if evaluation by the Discharger or Central Valley Water Board staff indicates that the