MONITORING WELL INSTALLATION COMPLETION REPORT

PHASE 2 REPRESENTATIVE MONITORING PROGRAM

EXISTING MILK COW DAIRIES – CENTRAL VALLEY, CALIFORNIA

Prepared for

Central Valley Dairy Representative Monitoring Program

November 15, 2013

LUHDORFF AND SCALMANINI, CONSULTING ENGINEERS
WOODLAND, CA

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This document is the finalized version of the November 15, 2013 *Monitoring Well Installation Completion Report* including non-substantive revisions for typography and clarity.

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Introduction

This Monitoring Well Installation Completion Report (MWICR) has been prepared by Luhdorff and Scalmanini, Consulting Engineers (LSCE) on behalf of the Central Valley Dairy Representative Monitoring Program (CVDRMP) to satisfy requirements for the documentation of monitoring well installations set forth in Revised Monitoring and Reporting Program (CVRWQCB, 2011), which was recently reissued in Reissued General Order R5-2013-0122 (CVRWQCB, 2013).

Specifically, the MWICR was prepared to document completion of the well installation project described in the Phase 2 Representative Monitoring Program Workplan Public Review Draft (Workplan) (LSCE, 2012a)[1] and its Addendum (LSCE, 2012b). The CVRWQCB conditionally approved the Workplan/Addendum on August 27, 2012.

The Workplan provides detailed discussion of the rationale supporting the concept of representative monitoring. The Workplan also discusses pertinent dairy farm site conditions as related to monitoring well design, the well drilling program, data collection, and data interpretation. Specifically, the following design criteria pertain to the recharge-dominated hydrologic system in irrigated agriculture and the absence of an identifiable plume (i.e., the ubiquitous occurrence of nitrate and other salt concentrations in shallow groundwater)[2]:

1. Representative Monitoring Program (RMP) monitoring wells that are located downgradient of a management unit (MU) are constructed with the objective to intercept groundwater that originates under the targeted MU only.
2. Groundwater sampling at the water table[3] is intended to avoid mixing of (younger) groundwater originating under the MU with (older) groundwater from source areas upgradient of the targeted MU.

The above criteria were met by installing nested wells (i.e., two well casings with relatively short well screens located at different depth intervals, and constructed in one bore hole). This design allows for sampling of the uppermost zone of first encountered groundwater and the same source area over the range of groundwater level fluctuations[4] as estimated in the project pre-design phase.

Field work was concluded on October 2, 2013 with the last wellhead survey. The regulatory reporting deadline for this MWICR is 45 days after completion of field activities, i.e., November 16, 2013.

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[1] Finalized without changes June 28, 2013.
[2] These conditions differ from those encountered at regulated units such as underground storage tanks, mining operations, refineries, dry cleaners, and landfills, where traditional site assessment and groundwater monitoring is implemented. Specifically, these regulated units are designed to minimize infiltration and deep percolation (e.g., by using asphalt or concrete surfaces and plastic liners) and to identify the magnitude and extent of contaminants of concern in the subsurface that are not commonly encountered in groundwater (i.e., a plume can be identified).
[3] Groundwater samples are retrieved from the upper few feet of the groundwater column. Samples are retrieved from the shallowest nested well that has sufficient water.
[4] In addition, this design is suitable for the installation of shorter screen lengths, which helps avoid potential groundwater quality bias due to vertical flow components in the wells. When screens were installed in differentiable water-bearing zones, bentonite seals were placed against a formation of low hydraulic conductivity to avoid hydraulic cross-communication of these zones through the well structure. When screens were installed in the same water-bearing zone, a bentonite seal was still installed between the screen intervals to impede vertical flow in the annular space around the well casings.

Drilling and Monitoring Well Installation

The Workplan/Addendum proposed the installation of monitoring wells at 12 dairies. This MWICR documents the installation of monitoring wells at 11 dairies (**Table 1** and **Figure 1**). In sum, 5 wells were installed with a single casing in the borehole, and 50 monitoring wells were installed at 25 nested monitoring well locations (at each nested well location, two well casings were installed in a single borehole) (**Attachment 1**). Legal arrangements between two of these dairies and CVDRMP could not be finalized in time for the drilling program. At one dairy, where no well installations had initially been planned, it was decided to abandon one of the pre-existing wells (DUR-MW5) due to its damaged wellhead[5]. DUR-MW5 was filled with cement slurry using the tremie method. Two replacement wells were constructed in a nested borehole in the neighboring corral (DUR-MW10s and MW10d). Monitoring wells at the other dairies were installed as planned or with non-substantive modifications (e.g., change of the side of a road or intersection corner).

Single-casing monitoring wells were installed at Brentwood Farms, MTSJ Dairy, and Manuel and Alda Lawrence Dairy. Specifically, BRE-MW2s and MW2d were installed as a well pair because heaving formation materials prevented the installation of the shallow well screen in the same borehole. At MTS-MW2 and MW3, thin shallow water-bearing zones were identified during drilling, which were separated by approximately 30 feet of unsaturated material before a deeper water-bearing zone was encountered. A shallow water-bearing zone was not encountered at MTS-MW1, and this well was constructed as a single casing well. The Manual and Alda Lawrence Dairy is underlain by a known, shallow perched zone, and its 6 pre-existing wells are all completed within this zone. The additional wells installed at this site (MAL-MW7 and MW8) were installed in the same zone (10-30 feet in depth).

Drilling and construction services were provided by Cascade Drilling, L.P. (State Contractor's License C-57 No. 938110). The first monitoring well was installed Tuesday September 25, 2012, and the last monitoring well was installed Monday October 22, 2012. The wells were drilled and installed with two CME-75 rigs. One of the sites necessitated a limited-access rig due to overhead utilities (RIC-MW7).

Eight-inch diameter test holes were drilled using the hollow stem auger method. The inside diameter of the 5-foot auger flights was 4.25 inches. Discrete samples were retrieved every 5 feet using ASTM D1586-11 "Standard Penetration Test and Split-Barrel Sampling of Soils". ASTM describes this procedure to drive "a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler". The split-barrel sampler has standardized outside and inside diameters of 2 and 1.5 inches, respectively. The chamber for soil collection was 18 inches in length. Therefore, the maximum core length was 18 inches. Cores of less than 18 inches length can occur in non-cohesive soils (i.e., the soil sample falls out of the open shoe while pulling the split-barrel out of the borehole), due to refusal (i.e., the sampler cannot be advanced 18 inches), or blockage (e.g., large rock fragments blocking the opening; or excessively high friction preventing the sample from sliding through the full length of the chamber). In addition to the retrieval of the split-barrel sample, drill cuttings were continuously observed as they surfaced from the rotation of the auger-column.

[5] DUR-MW5 was located in one of the corrals. This well had been sheared off at ground level, it had no protective well housing, and the well pad was deteriorated.

Subsurface materials were sampled, described and logged in the field by LSCE geologists, including two Geologists in Training) under the direct supervision of Scott Lewis (California Professional Geologist 7876) and Till Angermann (California Professional Geologist 7789).

Upon reaching target depth, samples were reviewed and the monitoring well designs were finalized. The 8-inch augers were retrieved and the test hole was reamed to 12 inches, prior to the installation of nested wells. Twelve-inch augers were used in combination with 13.25-inch diameter drill bits. The drill bit was equipped with a wooden plug to prevent drill cuttings from entering the drill pipe. The inside diameter of the auger column was 8.25 inches.

Prior to installation, well construction materials were laid out on a tarp next to the borehole, the auger plug was punched out, and the deepest casing of the nested monitoring well was installed inside of the auger. The auger served as a tremie pipe for the annular materials such that the level of the annular material in the pipe was maintained above the bottom of the auger. Installation of well casing through the auger also ensures a minimum distance between the well casing and the borehole wall. After placement of the lower sand pack, a bentonite seal was placed. After the first one to two feet of the upper sand pack were placed, the shallow well casing was installed inside of the auger to the top of the sand pack. Subsequently, the first of two spacers was installed on the end cap of the shallow well by lowering it over the shallow and deep well casings simultaneously on a disposable cotton thread[6]. The upper sand pack was then completed, a second spacer was installed (just above the shallow well screen), the fine sand transition seal was placed, and then the neat cement surface seal was placed. The installation process was the same for single-casing wells with the exception that they were installed in their 8-inch test holes (i.e., without reaming to 12 inches).

In addition to the above, the monitoring wells share the following specifications:

- 2-inch diameter Schedule 40 PVC ASTM F-480-88A threaded, blank casing (2.375 inch outside diameter)
- 2-inch diameter Schedule 40 PVC ASTM F-480-88A threaded, screened casing (2.375 inch outer diameter) with 0.030-inch slot size
- Threaded PVC end caps (with slot in the bottom to prevent stagnant water from collecting in the cap)
- Sand pack # 8 sand (Silica Resources Industries)
- Bentonite chip seal between deep and shallow screen
- Fine sand transition seal between the top of the shallow screen and the surface seal
- Neat cement grout for surface seals
- Steel-reinforced, round (5 feet diameter) concrete surface pads (12 inches thick, approximately 6 inches below and 6 inches above ground)
- Vented PVC slip caps

[6] Cascade Drilling, L.P. fabricated spacers consisting of two 5-inch long pieces of steel pipe (2.5 inches inside diameter) welded together with a small steel plate such that the two steel pipes were parallel to each other. These spacers provided 2.0 inches separation between the shallow and deep well casings.

Most of the wells were completed with 8-inch diameter steel surface monuments equipped with steel lids and padlocks. Where space permitted, wellheads were protected with 4 bollards (4-inch diameter steel pipe filled with concrete). Alternatively, flexible reflective delineators were used for visibility, especially in conjunction with flush-mounted, subsurface traffic valve boxes.

Monitoring well construction information is detailed in **Table 2**. Scaled as-built construction drawings and lithologic logs are provided in **Attachment 2**. The logs indicate the depth intervals where split-barrel samples were retrieved, blow counts for every 6 inches that the sampler was advanced (e.g., 7/9/12), the length of the recovered soil core in inches, the soil classification according to the Unified Soil Classification System (USCS), the Munsell color system, and additional description of subsurface materials. The logs identify lithologic changes observed within soil cores with solid horizontal lines. Lithologic changes between two soil cores are depicted with dashed lines. The driller's daily work reports are provided in **Attachment 3**. Construction information of the pre-existing monitoring wells that were incorporated in the RMP network of wells is detailed in **Table 3**.

Well Development, Wellhead Improvements and Survey

Monitoring wells were initially developed by LSCE staff 2 to 10 days after installation using heavy bailers to identify potential problems with wells (such as the presence of cement grout in the well casing) and to remove the majority of settled sediment from the well bottoms. Following the initial development, Del-Tech Geotechnical Support, Inc. completed well development using stainless steel bailers, air lifting, surge blocks, submersible pumps, inertial and centrifugal pumps, as applicable. Chemicals were not used in the well development activities. In addition to the newly installed wells, the pre-existing monitoring wells that were incorporated into the program were also developed. Well development was concluded prior to the first monitoring campaign in 2013.

The wells were developed until they produced water free of sand and with the goal to achieve turbidity values of 50 NTUs or less. As shown in **Table** 4, the turbidity goal proved too ambitious in many cases. This table provides a summary of well development information for the newly installed and pre-existing monitoring wells. The table includes depth-to-water readings, amount of sediment and water removed from the well casings during Del-Tech's development, and measurements of water quality indicator parameters during the polishing phase of the development when the wells were pumped at variable rates. Several of the pre-existing shallow monitoring wells were dry and, therefore, were not developed or not fully developed[7]. In many of these cases, it was still possible to remove some accumulated sediment from the well bottoms. These wells may be developed at a later date should groundwater levels rise. Purged water was spread on the ground at a sufficient distance to avoid the potential for purge water to re-enter the well during the development. Del-Tech's well development documentation is provided in **Attachment 4**.

[7] The University of California Davis purposefully installed many of these wells (i.e., LON-MW1A, 2A, 3A, 4A, 5A, 6A, 7A; ZZI-MW1A, 2A, 3A, 3AA, 5A, 6A, 7A, 9A; and DLF-MW4A, 5A, 6A) above first encountered groundwater for research purposes. These wells were installed in their own borehole as part of well clusters (including nested wells) that also include wells targeting first encountered groundwater and deeper zones. Wells that are installed above first encountered groundwater provide a means to continue monitoring the uppermost zone of first encountered groundwater if groundwater level rises were to occur in the future.

The wellheads of pre-existing monitoring wells that were incorporated into the program were improved where necessary. These improvements included new and enlarged concrete pads, bollards, flexible delineators, conversion from subsurface vaults to steel stick-up monuments, clear well identification with stainless steel placards, paint, and new locks.

Wellhead surveys were conducted by Precision Surveying in the North Area, EPIC Land Surveying, Inc. in the Central Area, and James Winton & Associates in the South Area. Surveys were conducted on the newly constructed wells and on the pre-existing wells that were incorporated in the RMP network of wells (**Attachment 5**). Attachment 5 also includes the original survey reports from three Phase 1 RMP dairies where pre-existing wells were incorporated in the RMP network of wells[8]. Field work was concluded on October 2, 2013 with the last wellhead survey on the Genasci Dairy.

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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[8] These wells were surveyed in December 2012 and the survey reports were provided in Attachment B2 of the *Year 1 RMP Annual Report (2012), Phase 1*, Part III of IV [LSCE, April 1, 2013]. However, this MWICR provides the original (wet stamped/signed) surveyor's reports.