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13 March 2014

Dane Johnson
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Central Valley Regional Water Quality Control Board
1685 E Street
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Subject: Phase 1 Work Plan for Subsurface Investigations at the Fee 34 Facility and Race Track Hill Area,
Valley Water Management Company, Edison Oil Field, California
K/J 1365027*00

Dear Mr. Johnson:

As promised, please find the attached Phase 1 Work Plan for Subsurface Investigations at the Fee 34 Facility and Race Track Hill Area. We apologize for this being submitted after the intended date earlier this week, but we took an additional few days to ensure that we provided a complete and suitable product for your review.

This Phase 1 Work Plan addresses the scope of work that we reviewed with you during our meeting in January, with modifications based on the comments we received, including the addition of a pond leak test procedure and deeper borings to provide additional characterization of lithology. The Phase 1 Work Plan also provides additional information required to describe our proposed approach, including detailed sampling and analysis plans, reporting requirements, and a schedule for undertaking the described activities. We have also selected a driller and a laboratory to assist with the proposed Phase 1 investigations as described in the attached document.

The plan incorporates many of the procedures outlined in the draft Cleanup and Abatement Orders but, for some aspects of these initial site investigations, we have proposed modifications. When we report the results of the Phase 1 investigations and discuss our findings with you, we will propose additional field investigations, if needed, and propose any necessary modifications to this initial Work Plan for use in future phases of investigation. We may also talk with you about the availability of a salinity variance or exception under the California Regional Water Quality Control Board, Central Valley Region's recently proposed program.

We have not incorporated the local area hydrogeologic characterization work that Dee Jaspar and Ken Schmidt are currently conducting. They have compiled available geologic and hydrogeologic information for the local area, but we intend to use our Phase 1 findings to plan their field work proposals. Their project work plan for field investigations and sampling will, therefore, be incorporated in the work plan for the next phase of work.

Please let us know how we can assist you in your review of this work plan.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

Stuart W. Childs

Stuart W. Childs, PhD
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Enclosure

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Phase 1 Work Plan for Subsurface Investigations at the Fee 34 Facility and Race Track Hill Area

Valley Water Management Company

13 March 2014

Prepared for

Valley Water Management Company
7500 Meany Ave.
Bakersfield, California 93308

K/J Project No. 1365027*00

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Section 1: Introduction

This Phase 1 Work Plan for Subsurface Investigations (Work Plan) has been prepared by Kennedy/Jenks Consultants (Kennedy/Jenks) for two Valley Water Management Company (VWMC) sites that serve the Edison Oilfield east of Bakersfield, California (Figure 1). The sites are:

Fee 34 Facility. This facility, also referred to as the C Plant, is an oilfield produced water treatment and storage facility approximately one mile northeast of the community of Edison. The Facility operates under California Regional Water Quality Control Board, Central Valley Region (RWQCB) Order Nos. 92-11037 and 92-110.

Race Track Hill Facility. This facility, located approximately 4 miles northeast of the Fee 34 Facility, receives treated oilfield produced water from the Fee 34 Facility and discharges the treated water to surface impoundments where the water is distributed to percolation/evaporation ponds or spray irrigation areas for evapotranspiration. The Race Track Hill Facility is regulated by RWQCB Resolution No. 58-349.

This document addresses the initial site investigation activities for characterizing vadose zone and shallow groundwater conditions beneath the Race Track Hill discharge area and the Fee 34 collection and oil separation facility. The investigations are referred to as Phase 1 investigations because these investigations are intended to provide an initial assessment of potential soil and groundwater impacts caused by site operations. Once the Phase 1 results are available, the data will be used to assess the conditions at and beneath the sites. As part of the assessment, proposals for receiving a regulatory exception to the otherwise applicable salinity requirements, or for additional site investigations and characterization activities will be provided to RWQCB staff for their review and comment.

VWMC is committed to conducting investigations of their sites in a timely manner and working cooperatively with RWQCB staff to address potential subsurface impacts from historical site operations. This Phase 1 Work Plan addresses the initial investigations only. If additional investigations are conducted, the Work Plan will be revised as needed.

1.1 Background

The following events evidenced a need for this work plan:

23 July 2013 - RWQCB letter to VWMC announcing its intent to update Waste Discharge Requirements for oilfield surface impoundments (RWQCB, 2013a).

9 October 2013 - VWMC and Kennedy/Jenks met with RWQCB staff and a representative of the State Water Quality Control Board legal staff.

10 October 2013 - VWMC received Notices of Violation (NOV) dated 9 October 2013 for the Edison Oilfield sites (RWQCB, 2013b, 2013c).

14 January 2014 - At VWMC's request, RWQCB staff met with VWMC and their consultants to discuss the first phase of site investigations proposed by VWMC. As a result of this meeting, the proposed scope was revised by incorporating the following:

- The initial scope, which proposed using soil borings to assess leakage from the lined surface impoundments was replaced by the use of climatological water balance leak test methods that have proven to be effective in recent work in the Central Valley (Luhdorff and Scalmanini. 2012. Technical Field Guide: Measuring Dairy Lagoon Seepage Using the Water Balance Method. Prepared for Western United Dairymen in cooperation with USDA-NRCS).

- The depth of the boring proposed adjacent to the unlined skimmed oil ponds was extended to approximately 200 feet below ground surface (bgs) to provide site-specific information for subsurface lithology. The use of the boring to evaluate movement of oilfield produced water beneath the ponds using both field and laboratory methods remains in the scope of work.

- If sufficient groundwater is encountered in a boring, a sample will be obtained to assess water quality and the boring may be used to install a 4-inch monitoring well.

- At the Race Track Hill site, two of the four borings will be used to install groundwater monitoring wells, if water is encountered within 150 feet of ground surface. This addition to the scope was suggested by Ken Schmidt to provide site-specific hydrogeologic information needed for the ongoing characterization of local area hydrogeology.

5 February 2014 - Draft Cleanup and Abatement Orders (CAOs) for each of the facilities were sent to VWMC for review and comment. The Work Plan presented here addresses most of the draft CAO requirements for a Work Plan but focuses initially on the Phase 1 investigation. This voluntary Work Plan approach is requested instead of the proposed CAOs, in an attempt to shorten the time before field work can commence and increase cooperation between VWMC and the RWQCB.

Section 2: Site Descriptions and Proposed Field Investigations

2.1 Fee 34 Facility

The Fee 34 Facility covers 3.4 acres (Assessor's Parcel Number 388-050-254) in the SW ¼ of the SW ¼ of Section 34, T29S, R29E, MDB&M). The general location of the Site is shown on Figure 1.

The Fee 34 Facility contains six surface impoundments (Figure 2). Produced water is transported to the facility by pipeline from various small, independent oil leases throughout the Edison oil field. Two gunite-lined ponds on the northeastern portion of the site are used in parallel to skim and separate crude oil from the produced water. Each of these ponds has a cell on the east that receives incoming water and provides initial oil separation. Water then flows through the skimming ponds to adjustable weirs on the west that discharge treated water into a larger lined pond (the shipping pond) on the west side of the property. The treated produced water is then pumped from this pond to the Race Track Hill site for disposal.

Crude oil removed from the skimming ponds is stored in two unlined skimmed oil recovery sumps in the central portion of the site. These sumps are netted and used for temporary storage before shipment offsite. In the southern portion of the site, there is one unlined and rarely utilized contingency impoundment for temporary storage of excess wastewater and stormwater.

Land around the Fee 34 Facility is used for agricultural production, primarily grapes. Many of the crops are irrigated with groundwater from local supply wells. In the Edison area, groundwater is reported to be approximately 350 to 400 feet bgs and flows to the southwest.

2.2 Race Track Hill Site

The Race Track Hill site consists of 338.4 acres (Assessor's Parcel Number 387-060-031) in the western half of Section 24, T29S, R29E, MDB&M. The Race Track Hill Facility is in an area of steep and rolling topography (Figure 3). The produced water flow from the Fee 34 site enters Race Track Hill at a netted pond at a higher elevation than the highest point where water can be applied on the site. As a result, distribution of all discharges on the site can be conducted via gravity.

There are 27 unlined surface impoundments used for produced water percolation and evaporation. The ponds lie along several existing drainageways that are generally dry except for the percolation ponds. In addition, there are 94 acres with sprinkler irrigation systems that are also used for land application. Salt tolerant local grasses and some shrubs take up water from the soil to meet their evapotranspiration requirements. On the color aerial photograph in Figure 3, the areas with irrigation and resulting increased vegetative growth are visible along the southeastern edge and north central portion of the site.

2.3 Proposed Phase 1 Field Investigations

Phase 1 investigations will provide an initial assessment of potential impacts of oilfield produced water on underlying soil and groundwater. In this work plan, soil borings, lined pond leak testing, and installation and sampling of monitoring wells are parts of the site investigations.

The proposed Phase 1 field investigations are summarized in Table 1. Additional details about the testing procedures are found in the next section. The initial activities at the Fee 34 site will be a) a deep soil boring to determine subsurface lithology and effects of produced water (see Figure 2), and b) leak testing of the lined ponds. At the Race Track Hill site, 4 borings will be advanced (see Figure 3). Two will be in a drainageway above the percolation ponds. Boring #1 will be in an irrigated area and Boring #2 will be in an adjacent unirrigated location. Two more borings will be completed at the base of the drainageways on Race Track Hill. Boring #3 will be at the base of the same drainage as the first two borings and Boring #4 will be along a dry drainageway in the northeast portion of the site. Depending on subsurface conditions observed during drilling, up to three wells may be installed in the boreholes.

The proposed Phase 1 investigations will also provide input to a general hydrogeologic investigation that be used to assess groundwater and lithologic conditions in the project area. This task is being conducted by Dee Jaspar and Associates and Ken Schmidt and Associates with assistance from RWQCB staff who have provided access to well logs in the project area as well as out of print publications with valuable hydrogeologic information. This current work is also a first phase of work to provide background hydrogeologic information. In the next phase of work, the Work Plan will be updated to incorporate the Jaspar-Schmidt characterization of hydrogeologic conditions at the Fee 34 and Race Track Hill sites.

Section 3: Field Activities

In this section, details of the planned field investigations are presented. In addition, plans for sampling procedures and analytical methods are provided.

3.1 Pre-Field Activities

Kennedy/Jenks will perform the following activities prior to commencing fieldwork.

- Prepare a site-specific Health and Safety Plan.
- Obtain soil boring and well installation permits from Kern County.
- Survey the proposed boring locations for potential location conflicts with subsurface utilities by performing a utility clearance check prior to drilling. The survey will be done by contacting USA Alert for utility clearance a minimum of two working days before the scheduled fieldwork. In addition, a private subsurface utility locating service will perform a search for underground utilities at the proposed drilling locations.
- Contract with a licensed drilling contractor to perform the fieldwork.
- Select an ELAP-certified laboratory to provide laboratory analytical services.

3.2 Fee 34 Facility - Leak Testing

Leak tests will be used to evaluate whether produced water may be seeping through the gunite lined ponds. The procedure to be used, Luhdorff and Scalmanini, 2012, makes use of precision monitoring of pond water levels at two locations and monitoring of microclimate variables required to calculate pond evaporation rate. An individual pond leak test will be conducted by eliminating inflows to the pond for a 5-day period. Water and microclimate data (rainfall, air temperature and relative humidity, wind speed and direction, and pond surface temperature) will be collected every 15 seconds and summarized, averaged, and stored every 30 minutes. Results will be evaluated based on the entire 5-day period and, in addition, for each night time period. Evaluation of leakage is most sensitive when evaporation is low.

In order to allow VWMC to maintain produced water flows during the leak testing procedure, separate tests will be run on the three ponds. For the two skimming ponds, one pond will remain in service while the other pond is isolated and tested. When the shipping pond is tested, additional storage or pumping capacity may be required so that the flows from the skimming ponds can be routed away from the shipping pond so that it can be isolated without process water inputs for a 5-day period.

Pond leakage will be calculated as

$$\text{Leakage} = \text{pond water level decline} - \text{evaporation} + \text{rainfall}$$

The method of Luhdorff and Scalmanini also provides an error estimate for the leak test calculation.

3.3 Soil Borings

3.3.1 Soil Boring Location and Depth– Fee 34 Facility

A soil boring will be advanced to assess potential impacts below the unlined skimmed oil sumps at the Fee 34 Facility. As any liquids migrating vertically downward will also disperse laterally, we propose a single boring installed between the two sumps (see Figure 2). The boring will be advanced until 200 feet depth is reached, or groundwater is encountered, whichever occurs first.

3.3.2 Soil Boring Locations and Depths – Race Track Hill

Subsurface sampling is required to assess potential impacts of the percolation/evaporation ponds as well as the irrigation areas at the site. A Phase 1 subsurface investigation is proposed for the central drainageway at Race Track Hill. This drainageway flows west to east and connects several of the largest percolation ponds. At the base of Race Track Hill, the central drainageway appears to connect with another dry drainageway along the eastern property boundary (Figure 3). Four soil borings will be completed at this site.

Borings in and near the irrigation areas. For the Phase 1 assessment, boring #1, in an irrigated area and boring #2 in an adjacent, unirrigated background location, will be completed (proposed locations are shown in Figure 3). Boring #2 in the background location will be advanced to a depth of 50 feet bgs or auger refusal, whichever is shallower. Boring #1 in the irrigation area will be advanced to a depth of up to 100 feet bgs to determine whether there is shallow groundwater in the local area.

Borings downgradient of the disposal ponds. For the Phase 1 investigation, two borings will be installed in downgradient locations near the eastern property boundary (see Figure 3) to evaluate lithology and identify evidence of lateral groundwater movement, perched groundwater, or local groundwater in the vicinity of the ponds.

Proposed boring #3 will be located at the lower end of the central drainage in the disposal area. This boring will be advanced to 50 feet bgs. Boring #4 will be completed along the ephemeral drainage along the eastern Race Track Hill property boundary. This drainage should intercept shallow groundwater from several of the drainages where the disposal ponds are located. This boring will be advanced to a maximum depth of 150 feet.

3.3.3 Soil Boring and Soil Sample Collection

The borings at both sites will be drilled using a hollow-stem auger drilling rig. Continuous core will be collected for lithologic determination. The soil produced during the drilling will be logged under the supervision of a professional geologist or engineer, in accordance with the Kennedy/Jenks' Standard Operating Guidelines (SOG) for Borehole Logging (attached as Appendix A). A flame ionization detector (FID) will be used to check for hydrocarbon vapors in the soil core and breathing zone during drilling.

At pre-selected sampling intervals a 6-inch long brass or stainless steel liner will be retained, labeled, sealed with Teflon tape and capped, and stored at 4 degrees Celsius until delivered under chain-of-custody to the laboratory. Samples will be named with the boring name, the letter "S" for soil, and the sample depth.

Upon completion of drilling and sampling, the soil borings will be filled with cement-bentonite grout extending continuously from the bottom to approximately 1-foot below ground surface. The grout will be pumped through tremie pipe as the augers are removed. Grouting will be done under observation or supervision of Kern County.

3.3.4 Soil Sample Depths and Laboratory Analyses

3.3.4.1 Fee 34 Facility

Samples for laboratory analysis will be collected at 5-foot intervals to a depth of 50 feet and at 10-foot intervals for the remainder of the boring. A maximum of 25 soil samples will be analyzed for pH, electrical conductivity (EC), boron, chloride, moisture content, and Total Petroleum Hydrocarbons as crude oil (TPHc) by a California ELAP-certified laboratory. Analytical methods are summarized in Table 2.

3.3.4.2 Race Track Hill - Borings in and near Irrigation Areas

Soil samples from the background boring #2 will be collected at 1 foot, 2 feet, 3 feet and 5 feet bgs, then at 5-foot intervals to the total depth of the boring. A maximum of 13 soil samples will be analyzed for pH, EC, boron, chloride, and TPHc.

Boring #1 within the irrigation area will be sampled in the same manner. For the 13 samples collected to a depth of 50 feet bgs, samples will be analyzed for pH, EC, boron, chloride, and TPHc. At depths below 50 feet bgs, samples will be collected every 10 feet and analyzed for pH, EC, boron, chloride, and TPHc.

3.3.4.3 Race Track Hill - Borings downgradient of Disposal Ponds

Soil samples from boring #3 located at the lower end of the central drainage in the disposal area will be collected every 5 feet and analyzed for pH, EC, chloride, and boron.

Soil samples from boring #4 in the ephemeral drainage along the eastern Race Track Hill property boundary will be collected every 5 feet to a depth at 50 feet bgs. From 50 feet bgs to the maximum depth of 150 feet bgs samples will be collected every 10 feet. Samples will be analyzed for pH, EC, boron, and chloride.

3.3.5 Reconnaissance Groundwater Sampling and Analysis

A reconnaissance groundwater sample will be collected from the Fee 34 Facility boring or any of the Race Track Hill borings, if groundwater is encountered during drilling.

If groundwater is encountered, the boring will be advanced approximately five feet below groundwater. New 2-inch diameter Schedule 40 (SCH40) polyvinyl chloride (PVC) casing will be inserted into the augers; the bottom 10 feet will be 0.010-inch machine-slotted screen and the remainder will be blank casing. Three to four feet of Cemex #2/12 or equivalent filter pack sand will be added to the annulus around the screen to assist in reducing turbidity.

The sample will then be collected using a disposable bailer and placed into laboratory-supplied containers of the appropriate size and with preservation chemicals as required. The groundwater samples will be analyzed for pH, EC, chloride, and boron. The water to be analyzed for boron will be field-filtered with a 0.45-micron filter prior to containerization. Samples will be stored at 4 degrees Celsius until delivered under chain-of-custody to the laboratory.

If the groundwater is not considered to be a constantly saturated zone, then the temporary well will be removed and the boring will be advanced to the planned depth with the planned soil sampling.

3.3.6 Well Installation

A permanent monitoring well may be installed in any borehole if the amount of water appears to be part of a constantly saturated zone or the underlying regional groundwater. The project geologists will evaluate whether the location and groundwater conditions justify installation of a monitoring well to allow ongoing monitoring of groundwater level and quality.

For locations where a well will be installed, the boring will be deepened to approximately 20 feet deeper than the encountered water depth, and reamed to a diameter to provide at least 2-inches of annular space around the well casing. The wells will be constructed in accordance with the SOG for Well Construction and Development (Appendix B).

Each well will be constructed of 4-inch diameter, PVC casing. The screened interval will consist of 20 feet of 0.010-inch slotted casing, or other appropriate slot size for the lithologies encountered, based on the lithologic log from the soil boring. A threaded end cap will be installed. The remainder of the well above the screened section will consist of flush-threaded, 4-inch diameter PVC blank casing. The deep well in the Fee 34 Facility area will be constructed of Schedule 80 (SCH80) PVC and other wells will be built with SCH40 PVC. Wells built at Race Track Hill will be constructed of 4-inch diameter SCH40 PVC, with the same annular materials. A schematic well diagram is shown on Figure 4.

A continuous filter pack will be placed in the annular space between the screened section and the wall of the boring. The filter pack will consist of washed packaged sand sized accordingly for the well screen slot size selected (#2/12 or equivalent for 0.010-inch slots). The filter pack will extend upwards from the bottom of the boring to one to two feet above the screened section. The well screen will be surged to settle the filter pack.

The well will be pre-developed after the filter pack is installed and surged and prior to the bentonite seal being installed. A three-to-five foot layer of protective hydrated bentonite clay pellets will be placed to minimize downward migration of the grout seal into the filter pack. After installing the upper bentonite seal, the well will be bailed until sediment is removed from the casing. A cement-bentonite grout will be placed so as to extend continuously from the top of the bentonite pellet layer to less than one foot below grade. A locking expansion cap and well-housing enclosure will be installed to control access to the well opening. Drill cuttings will be disposed of onsite. Well construction guidelines are presented in the SOG for Well Construction and Development (Appendix B).

3.3.7 Well Development

After waiting a minimum of 48 hours to allow curing of the grout and concrete, the monitoring well will be developed by bailing, surging, and pumping until the water removed from the well is relatively sediment-free, no further improvement in water quality is observed, or 10 casing volumes have been purged. Field parameters of pH, temperature, and conductivity will be recorded. Procedures are outlined in the SOG for Well Construction and Development (Appendix B).

The monitoring well will be allowed to recover for a minimum of 72 hours following well development, prior to monitoring and sampling.

3.3.8 Monitoring Well Groundwater Sampling and Analysis

An initial sampling of groundwater will be conducted from the monitoring wells no sooner than 72 hours after the newly installed monitoring well has been developed. Groundwater sampling will be in accordance with the SOG for Groundwater Sampling (Appendix C). Groundwater will be purged from the monitoring wells prior to sampling to obtain samples representative of aquifer conditions. The field parameters pH, temperature, and conductivity will be monitored during purging to document stabilization. The parameters will be measured in accordance with the SOG for Field Measurement of pH, Temperature, and Conductivity (Appendix D).

Samples will be collected in containers of the appropriate size and preservative provided by the laboratory. Laboratory analyses, containers, and hold times are summarized in Table 3. Water to be analyzed for metals will be field-filtered with a 0.45-micron filter prior to containment.

Following collection, groundwater samples will be analyzed by a state-certified laboratory. The laboratory will follow their normal turnaround time and internal quality assurance/quality control (QA/QC) procedures during the analysis.

3.3.9 Surveying

The location and well casing elevations of the new monitoring wells will be horizontally and vertically surveyed by a licensed land surveyor. The ground surface and top of well casing elevation will be surveyed to the nearest 0.01 foot relative to mean sea level. The ground surface and top of casing will be surveyed to the North American Vertical Datum (NAVD) 1988, relative to the nearest benchmark for the Site. The horizontal location of the new well will also be surveyed relative to the California Coordinate system to 0.1 foot precision.

3.3.10 Residuals Management

Residuals generated as a result of these activities are anticipated to include soil cuttings from the drilling activities, soil core not retained for soil sample analysis, decontamination water resulting from the drilling activities and development of the monitoring wells, and purge water from sampling of the monitoring wells.

If the upper soil is visually impacted with hydrocarbons, visually impacted soil and non-visually soil will be segregated into two different lined roll-off bins. The soil will be characterized and profiled prior to disposal either on or offsite in accordance with applicable regulations.

Water residuals will be contained at the work site and then pumped into the ponds.

3.3.11 Quality Assurance/Quality Control Procedures

Field QA/QC will include collection of one field duplicate sample during the first sampling event. The results of the duplicate sample will be compared to the primary sample for consistency. The laboratory will follow their standard internal QA/QC procedures during sample analysis, including elements such as analyzing method blanks and control spikes, where appropriate.

Analytical data received from the laboratory will be reviewed immediately upon receipt for completeness and consistency. Any discrepancies will be discussed with the laboratory and corrective measures will be taken if warranted.

Section 4: Phase 1 Site Investigation Report

For this Phase 1 investigation, Kennedy/Jenks will prepare a report summarizing and documenting the field activities at both the Fee 34 Facility and Race Track Hill area. The report will assess whether there are indications of produced water effects on soil or groundwater beneath the ponds, sumps, or irrigation areas and will provide recommendations for further investigation, as needed.

The report is intended to inform VWMC and the RWQCB in a timely manner about potential impacts and as anticipated by the draft CAOs. The contents of a preliminary draft of the report may be presented and discussed in a meeting with RWQCB staff to facilitate timely evaluation of the preliminary results and development of the scope for any further phases of investigation required, or whether a salinity exception is needed or warranted.

The report will provide the following information:

- Purpose of the Phase 1 investigation.
- Description of geologic/hydrogeologic conditions encountered during soil and/or groundwater sampling.
- Topographic site map showing facilities, well locations, and other major physical and man-made features.
- Drilling details, including soil boring logs and a narrative of field activities.
- Any well construction details, well development information, and surveying report.
- Data evaluation, interpretation of results, and recommendations for additional field investigations.
- Copies of laboratory reports and other project records.
- Recommended site investigations and analysis for the next phase of work at the Fee 34 and Race Track Hill sites, if any.
- Proposed schedule for site investigations and reporting (see below).

4.1 Proposed Implementation Schedule

The Phase 1 investigations will proceed in accordance with the following general timeline:

- The proposed field investigations will commence within 30 days of submittal of this Work Plan to the RWQCB.
- Within 45 days of completion of Phase 1 field activities, an initial written report on findings of the field investigation will be provided to RWQCB staff. This information may also be presented in a meeting with VWMC, its consultants, and RWQCB staff.

- Following review and comment on the Phase 1 results by RWQCB staff, a proposal and time schedule for additional site characterization will be submitted, as needed.

References

Central Valley Regional Water Quality Control Board (RWQCB, 2013a). Letter to Valley Water Management Company re: Intent to Update Waste Discharge Requirements for Oil Field Surface Impoundments. 23 July 2013.

Central Valley Regional Water Quality Control Board (RWQCB, 2013b). Notice of Violation. Inspection Report – Valley Water Management Company, Race Track Hill Facility, Edison, Kern County. 9 October 2013.

Central Valley Regional Water Quality Control Board (RWQCB, 2013c). Notice of Violation. Inspection Report – Valley Water Management Company, C-Plant Facility, Edison Oil Field, Kern County. 9 October 2013.

Luhdorff and Scalmanini. 2012. Technical Field Guide: Measuring Dairy Lagoon Seepage Using the Water Balance Method. Prepared for Western United Dairymen in cooperation with USDA-NRCS).

Tables

Table 1: Summary of Proposed Phase 1 Investigations

Field Activities	Observation/Samples/Measurements required	Analyses / Decisions
Fee 34 Facility (see Figure 2)		
Boring between skimmed oil ponds	Continuous core to assess lithology Soil sample every 5 feet to 50 feet, every 10 feet to 200 feet Grab sample of water, if encountered	Soil sample analyses: pH, EC, Boron, chloride, TPHc, FID Water sample analysis: pH, EC, Boron, chloride, TPHc Determine when boring depth is adequate
Install 4" well in boring	Water level and water quality monitoring	Determine if well installation is necessary
Leak testing of three lined ponds	Pond water level change with time Pond evaporation rate with time.	If one leak test demonstrates significant leakage (> 1e-6 cm/sec), then remaining ponds will not be tested
Race Track Hill (see Figure 3)		
Boring 1: irrigated area in drainage above upper percolation pond	Continuous core to assess lithology Soil sample every 5 feet to 50 feet, every 10 feet to 100 feet Grab sample of water, if encountered	Soil sample analyses: pH, EC, boron, chloride, TRPH, FID, calcium, magnesium, sodium, potassium, sulfate, bicarbonate, carbonate Water sample analysis: pH, EC, boron, chloride, TPHc
Install 4" well in boring	Water level and water quality monitoring	Determine if well installation is necessary
Boring 2: non-irrigated area adjacent to Boring 1	Continuous core to assess lithology Soil sample every 5 feet to 50 feet	Soil sample analyses: pH, EC, boron, chloride, TPHc, FID, calcium, magnesium, sodium, potassium, sulfate, bicarbonate, carbonate
Boring 3: at bottom of drainageway	Continuous core to assess lithology Soil sample every 5 feet to 50 feet Grab sample of water, if encountered	Soil sample analyses: pH, EC, boron, chloride, TPHc, FID Water sample analysis: pH, EC, boron, chloride, TPHc
Boring 4: Along East boundary of property	Continuous core to assess lithology Soil sample every 5 feet to 50 feet, every 10 feet to 150 feet Grab sample of water, if encountered	Soil sample analyses: pH, EC, boron, chloride, TPHc, FID Water sample analysis: pH, EC, boron, chloride, TPHc
Install 4" well in boring	Water level and water quality monitoring	Determine if well installation is necessary

Table 2: Soil Sample Test Methods

Constituent	Test Method[a]	Reporting Units[b]	Holding Time[c]
pH	SM9045-C	Units	7 days
Electrical Conductivity (EC)	EPA 120.1	dS/m	28 days
Chloride (Cl)	EPA 300.0	mg/kg	28 days
Boron (B)	EPA 6010B	mg/kg	6 months
Calcium (Ca)	EPA 6010B	mg/kg	6 months
	EPA 200.7 on Saturated Paste Extract	meq/l	
Magnesium (Mg)	EPA 6010B	mg/kg	6 months
	EPA 200.7 on Saturated Paste Extract	meq/l	
Sodium (Na)	EPA 6010B	mg/kg	6 months
	EPA 200.7 on Saturated Paste Extract	meq/l	
Potassium (K)	EPA 6010B	mg/kg	6 months
	EPA 200.7 on Saturated Paste Extract	meq/l	
Sulfate (SO_4)	EPA 300.0	mg/kg	28 days
Bicarbonate (HCO_3)	EPA 310.1	mg/kg	14 days
	EPA 310.1 on Saturated Paste Extract	meq/l	
Carbonate (CO_3)	EPA 310.1	mg/kg	14 days
	EPA 310.1 on Saturated Paste Extract	meq/l	
TPHc[d]	EPA 8015M	mg/kg	7 days

Notes:

(a) EPA = U.S. Environmental Protection Agency
SM = Standard Methods
(b) dS/m = deciSiemens per meter, mg/kg = milligrams per kilogram, meq/l = milliequivalents per liter
(c) All samples should be kept at 4 degrees Celsius from the time of collection until analysis.
(d) TPHc = Total Petroleum Hydrocarbons as Crude Oil

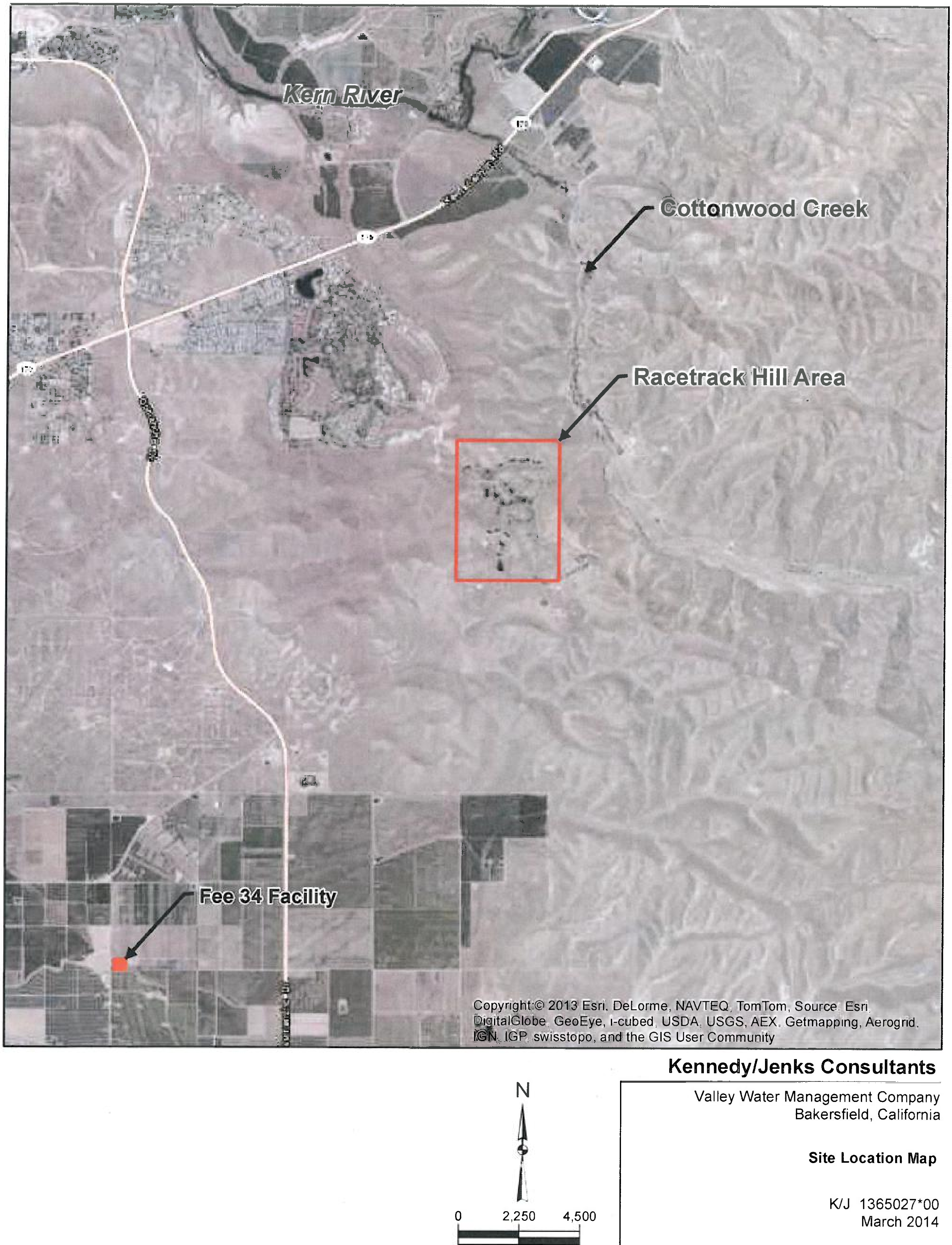
Table 3: Groundwater Sample Test Methods

Constituent	Test Method[(a)]	Reporting Limit	Container[(b)]	Sample Volume[(c)]	Preservative[(d)]	Holding Time[(e)]
pH	SM4500-HB	0.1 unit	P	250 ml	None	24 hours
Electrical Conductivity (EC)	EPA 120.1	1 (µmhos/cm[(f)] @ 25°C)	P	250 ml	None	28 days
Nitrate - Nitrogen (NO_3 as N)	EPA 300.0	0.1 mg/l[(g)]	P	250 ml	None	48 hours
Total Dissolved Solids (TDS)	SM2540C	10 mg/l	P	250 ml	None	7 days
Boron (B)	EPA 200.7	0.1 mg/l	P	250 ml	HNO_3 pH<2	6 months
Chloride (Cl)	EPA 300.0	0.2 mg/l	P	250 ml	None	28 days
Calcium (Ca)	EPA 200.7	0.5 mg/l	P	250 ml	HNO_3 pH<2	6 months
Magnesium (Mg)	EPA 200.7	0.5 mg/l	P	250 ml	HNO_3 pH<2	6 months
Sodium (Na)	EPA 200.7	0.5 mg/l	P	250 ml	HNO_3 pH<2	6 months
Potassium (K)	EPA 200.7	0.5 mg/l	P	250 ml	HNO_3 pH<2	6 months
Sulfate (SO_4)	EPA 300.0	5.0 mg/l	P	250 ml	None	28 days
Alkalinity as Carbonate (CO_3)	EPA 310.1	1.0 mg/l	P	250 ml	None	14 days
Alkalinity as Bicarbonate (HCO_3)	EPA 310.1	1.0 mg/l	P	250 ml	None	14 days
TPH-Crude Oil (TPHc)	EPA 8015B	0.1 mg/l	G	1000 ml	None	14 days
Fuel Finger Print (FFP)	EPA 8260	n/a	G	40ml	None	14 days
Benzene	EPA 8260	5 µg/l[(h)]	G	40 ml	HCl	14 days
Toluene	EPA 8260	5 µg/l	G	40 ml	HCl	14 days
Ethylbenzene	EPA 8260	5 µg/l	G	40 ml	HCl	14 days
Xylenes	EPA 8260	5 µg/l	G	40 ml	HCl	14 days

Notes:

(a) EPA = U.S. Environmental Protection Agency
SM = Standard Methods
(b) P = Polyethylene; G = Glass
(c) ml = milliliter
(d) HNO_3 pH<2 = nitric acid at pH 2 or less, HCl = hydrochloric acid.
(e) All samples should be kept at 4 degrees Celsius from the time of collection until analysis.
(f) µmho/cm = micromhos per centimeter
(g) mg/l = milligrams per liter
(h) µg/l = micrograms per liter

Figures



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Kennedy/Jenks Consultants

Valley Water Management Company
Bakersfield, California

Site Location Map

K/J 1365027*00
March 2014

Figure 1

Document Path: P:\IS-Proj\2013\1365027.00_Valley Water\Data\Figures\Figure 2_C Plant.mxd

Legend:

- Proposed Soil Boring Location

Notes:

1.) Fee 34 Facility Located at SW1/4 Section 34 T29S R29E WDB&M

N

0 100 200
Feet

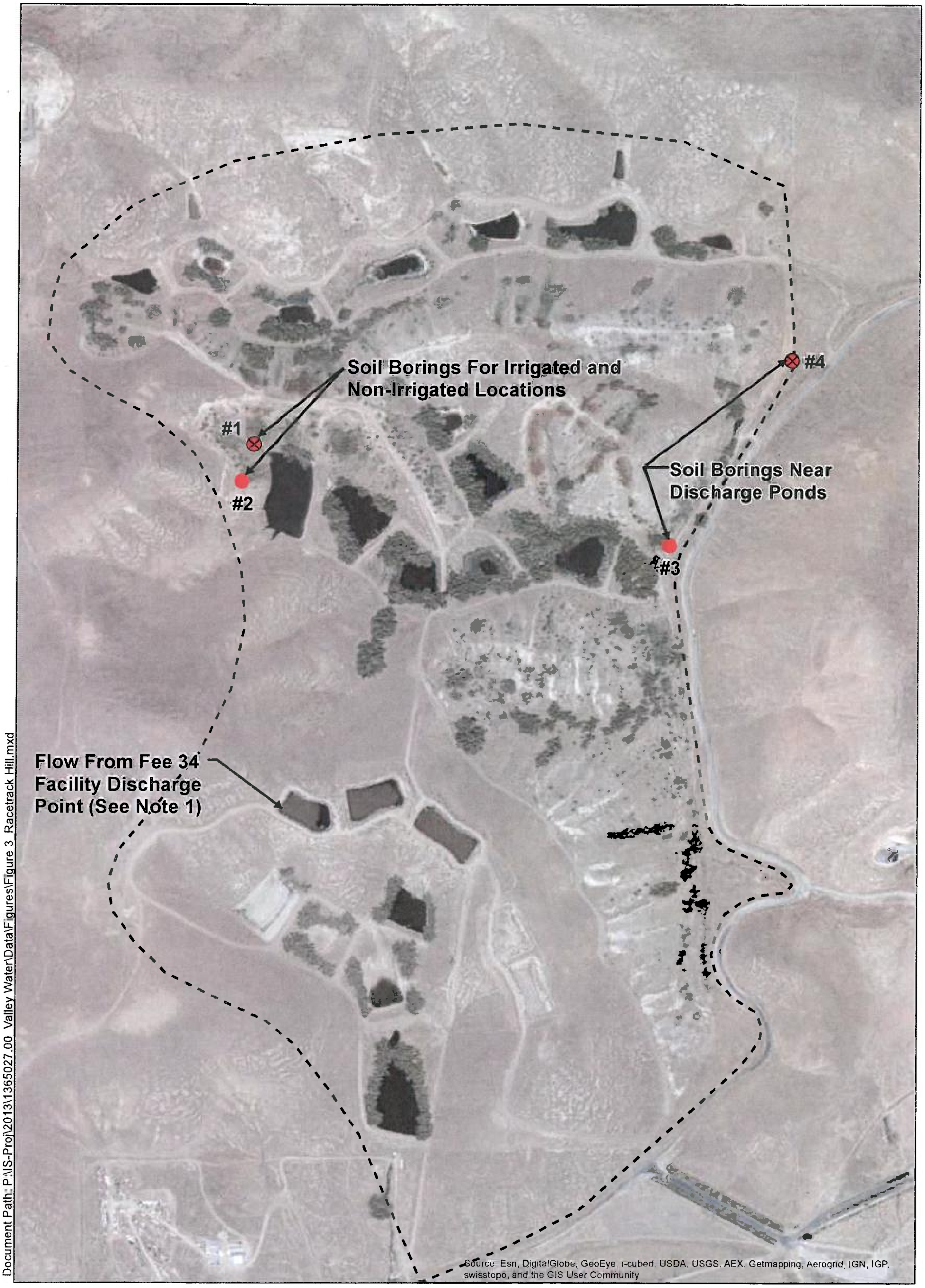
Kennedy/Jenks Consultants

Valley Water Management Company
Bakersfield, California

Fee 34 Facility Soil Boring Location

K/J 1365027*00
March 2014

Figure 2



Document Path: P:\IS-Proj\2013\1365027.00_Valley Water\Data\Figures\Figure 3_Racetrack Hill.mxd

Legend:

- Proposed Soil Boring Location
- Potential Monitoring Well Location

Notes:

1.) Flow from Fee 34 Facility is discharged to the pond shown on the map. This is the highest elevation pond, and all other ponds are fed by gravity.
2). Racetrack Hill Area is located at W1/2 Section 24 T27S R29E WDB&M.

N
0 200 400
Feet

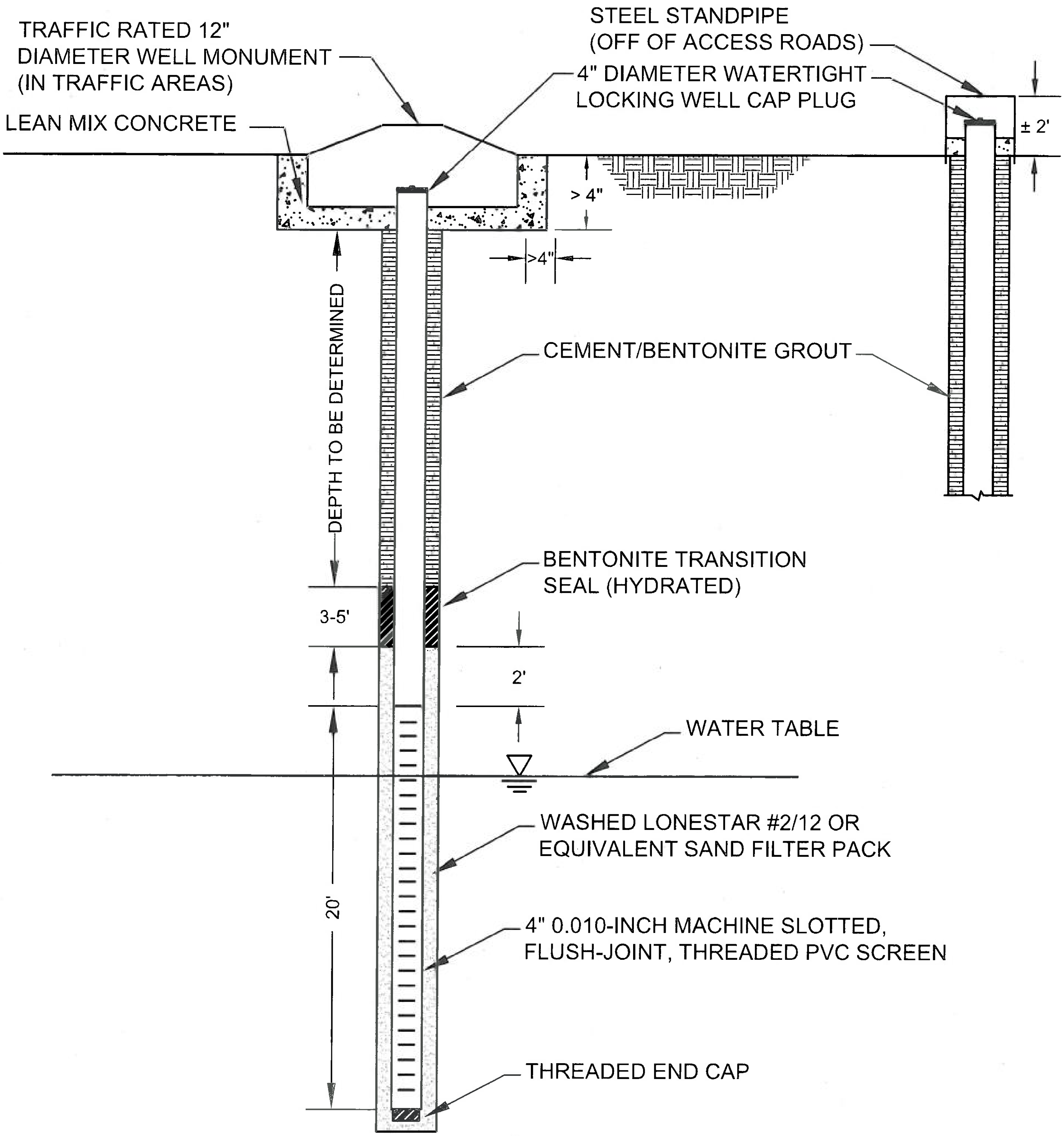
Kennedy/Jenks Consultants

Valley Water Management Company
Bakersfield, California

Racetrack Hill Borings

K/J 1365027*00
March 2014

Figure 3



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Kennedy/Jenks Consultants

Valley Water Management Company
Bakersfield, California

Proposed Monitoring Well Schematic Construction Details

K/J 1365027*00
March 2014

Figure 4

Appendix A

Standard Operating Guidelines – Borehole Logging

Appendix A: Standard Operating Guidelines – Borehole Logging

A.1 Introduction

This guideline describes procedures followed by Kennedy/Jenks Consultants personnel for classifying soils and for preparing borehole logs and other types of soil reports. It assists in obtaining uniform descriptions of soils encountered during borehole programs and enhances consistency among Kennedy/Jenks Consultants personnel and among projects.

Borehole logging is the systematic observation and recording of geologic and hydrogeologic information from subsurface borings and excavations. As adopted by Kennedy/Jenks Consultants, and in accordance with general practices followed by the profession, the Unified Soil Classification System (USCS) (ASTM D 2488-90) is used to identify, classify, and describe soils.

A.2 Recommended Minimum Requirements

Soil classification and borehole logging should be conducted by a geologist or another professional trained in the classification of soils.

A.3 Equipment

- Boring log forms (1st and 2nd sheet, K/J Form F-40.1, 40.2)
- Chain-of-custody forms/request for analysis forms
- USCS (ASTM D 2488-90) table and classification chart
- Soil color chart (i.e., Munsell)
- American Geological Institute (AGI) data sheets
- Graph paper
- Engineer's scale
- Previous project reports and boring logs
- Pocket knife or putty knife
- Hand lens
- Supply of clean water
- Dilute HCL
- Gloves (latex, nitrile as described in project health & safety plan)
- Personal protective clothing and equipment, as described in the project health & safety plan
- Sample containers (brass, steel or aluminum liners, plastic or glass jars)
- Decontamination equipment and supplies
- Aluminum foil, Teflon sheets, and paper towels

A.4 Typical Procedures

A.4.1 Soil Classification

Soils are typically logged in conjunction with advancing boreholes and sampling subsurface soils. Although the guideline focuses on classifying soil samples obtained from boreholes, this particular procedure also applies to soils and sediments collected using other techniques (e.g., post hole digger, scoop, Van Veen sampler, and backhoe).

The USCS categorizes soils into 15 basic groups, each with distinct geologic and engineering properties. The following steps are required to classify a soil sample:

1. Observe basic properties and characteristics of the soil. These include grain-size grading and distribution and influence of moisture on fine-grained soil.

2. Assign the soil a USCS classification and denote it by the standard group name and symbol.

3. Provide a written description to differentiate between soils in the same group, if necessary.

Many soils have characteristics that are not clearly associated with a specific soil group. These soils might be near the borderline between groups, based on either grain-size grading and distribution, or plasticity characteristics. In this case, assigning dual group names and symbols might be appropriate (e.g., GW/GC or ML/CL).

The three basic soil groups are:

1. **Coarse-Grained Soils** – For soils in this group, more than half of the material is larger than No. 200 sieve (0.074 mm).

2. **Fine-Grained Soils** – For soils in this group, one half or more of the material is smaller than No. 200 sieve (0.074 mm).

3. **Highly Organic Soils** – This group includes soils with high organic content, such as peat.

Note: No. 200 sieve is the smallest size that can be seen with the naked eye.

A.4.2 Classification of Coarse-Grained Soils

Coarse-grained soils are classified on the basis of:

1. Grain size and distribution

2. Quantity of fine-grained material (i.e., silt and clay)

3. Character of fine-grained material

Classification uses the following symbols:

Basic Symbols	Modifying Symbols
G - gravel	W - well graded
S - sand	P - poorly graded
	M - with silt fines
	C - with clay fines

The following are basic facts about coarse-grained soil classification:

- The basic symbol G is used if the estimated percentage of gravel is greater than that for sand. In contrast, the symbol S is used when the estimated percentage of sand is greater than the percentage of gravel.

- Gravels range in size from 3-inch to 0.25-inch (No. 4 sieve). Sands range in size from No. 4 sieve to No. 200 sieve. Use the grain size scale used by engineers (ASTM Standards D422-63 and D643-78) to further classify grain size as specified by the USCS.

  Note: This grain size scale differs from the Modified Wentworth Scale used in teaching most geologists. Also, it introduces a distinction between sorting and grading.

- The modifying symbol W indicates good representation of all particle sizes.
- The modifying symbol P indicates that there is a predominant excess or absence of particle sizes.
- The symbol W or P is only used when there is less than 15 percent fines in a sample.
- Modifying symbol M is used if fines have little or no plasticity (silty).
- Modifying symbol C is used if fines have low to high plasticity (clayey).
- The following rules apply for the written description of the soil group name:

Types of Soil	Rule
Sands and gravels (clean)	Less than 5 percent fines
Sands (or gravels) with fines	5 to 15 percent fines
Silty (or clayey) sands or gravels	Greater than 15 percent fines

- Other descriptive information includes:
  - Color
  - Maximum grain size
  - Composition of grains
  - Approximate percentage of gravel, sand, and fines (use a percentage estimation chart)

Modifiers	Description
Trace	Less than 5 percent
Few	5 to 10 percent
Little	15 to 25 percent
Some	30 to 45 percent
Mostly	50 to 100 percent

- Mineralogy
- Grain shape (round, subround, angular, subangular)
- Moisture (dry, moist, wet)
- Structure
- Organic material
- Odor

A.4.3 Classification of Fine-Grained Soils

Fine-grained soils are classified on the basis of:

1. Liquid limit

2. Plasticity

Classification uses the following symbols:

Basic Symbols	**Modifying Symbols**
M - silt	L - low liquid limit
C - clay	H - high liquid limit
O - organic	
Pt – peat	

The following are basic facts about fine-grained soil classification:

- The basic symbol M is used if the soil is mostly silt, while symbol C applies if it consists mostly of clay. Use of symbol O indicates that organic matter is present in an amount sufficient to influence soil properties. The symbol Pt indicates soil that consists mostly of organic material.

- Modifying symbols are based on the following hand tests conducted on a soil sample:

  - Dry strength (crushing resistance)

  - Dilatency (reaction to shaking)

  - Toughness (consistency near plastic limit)

- Soil designated ML has little or no plasticity and can be recognized by slight dry strength, quick dilatency, and slight toughness.

- CL indicates soil with slight to medium plasticity, which can be recognized by medium to high dry strength, very slow dilatency, and medium toughness.

- OL is used to describe a soil that is less plastic than CL soil and can be recognized by slight to medium dry strength, medium to slow dilatency, and slight toughness.

- MH soil has slight to medium plasticity and can be recognized by low dry strength, slow dilatency, and slight to medium toughness.

- Soil designated CH has high plasticity and is recognizable by its high dry strength, no dilatency, and high toughness.
- OH soil is less plastic than CH soil and can be recognized by medium to high dry strength, slow dilatency, and slight to medium toughness.
- Other descriptive information includes:
  - Color
  - Moisture
  - Consistency (very soft, soft, firm, hard, very hard)
  - Structure
  - Compactness (loose, dense) for silts
  - Cementation (uses hydrogen chloride)
  - Odor

A.5 References

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM D-2488-90.

Compton, R. R. 1962. *Manual of Field Geology*. New York: John Wiley & Sons, Inc.

U.S. Department of the Interior. 1989. *Earth Manual*. Washington, D.C.: Water and Power Resources Service.

"Grain Size Scale Used by Engineers", ASTM D422-63 and D643-78.

Boring & Well Construction Log **Kennedy/Jenks Consultants**

BORING LOCATION				**Boring/Well Name** ____	
DRILLING COMPANY	DRILLER			**Project Name** ____	
DRILLING METHOD (S)	DRILL BIT (S) SIZE:			**Project Number** ____	
ISOLATION CASING	FROM	TO	FT.	ELEVATION AND DATUM	TOTAL DEPTH
BLANK CASING	FROM	TO	FT.	DATE STARTED	DATE COMPLETED
PERFORATED CASING	FROM	TO	FT.	STATIC WATER ELEVATION	
SIZE AND TYPE OF FILTER PACK	FROM	TO	FT.	LOGGED BY	
SEAL	FROM	TO	FT.	SAMPLING METHODS	WELL COMPLETION ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT	FROM	TO	FT.		

SAMPLES			Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in.)						

F-40.1
(6-87) (3-88)

SHEET____ OF____

Boring & Well Construction Log **Kennedy/Jenks Consultants**

Project Name ____________ **Project Number** ____________ **Boring/Well Name** ____________

SAMPLES			Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in.)						

F-40.2
(6-87) (3-88)

SHEET______ OF______

Appendix B

Standard Operating Guidelines – Well Construction and Development

Appendix B: Standard Operating Guidelines – Well Construction and Development

B.1 Introduction

This guideline describes procedures used by Kennedy/Jenks Consultants personnel for well construction and development following completion of boring and soil sampling procedures (described in Standard Operating Guideline, Boring and Subsurface Soil Sampling).

B.2 Well Construction Materials

- 4-inch Schedule 40 or 80 PVC blank casing
- 4-inch Schedule 40 or 80 PVC slotted casing, of appropriate slot size
- 4-inch Schedule 40 or 80 PVC threaded and slip caps
- Hasp-locking standpipes
- Ground-level traffic-rated watertight well housing enclosure
- Locking expansion plugs
- Combination or key lock
- Filter pack sand
- Type I or II Portland cement
- Concrete
- Bentonite powder
- 0.25-inch bentonite pellets or chips.

B.3 Well Development Equipment

- 4-inch-diameter vented surge block
- Submersible pump (4-inch-diameter wells or larger)
- 55-gallon DOT-approved drums
- Teflon, stainless steel or PVC bailer
- Teflon-coated bailer retrieval wire

B.4 Typical Procedure

1. Following completion of selected borings, install the monitoring well casing through the center of the hollow stem auger, drive casing, or open boring. The monitoring well consists of a PVC Schedule 40 slotted well casing of appropriate diameter and a blank casing with a threaded bottom cap and a slip or threaded top cap or watertight expansion plug. The casing string must be held in tension during initial installation.

2. Place clean, well graded sand around the slotted section of the monitoring well to serve as the filter pack. The grade of sand is chosen on the basis of aquifer units encountered (refer to Standard Operating Guideline, Design of Filter Packs and Selection of Well Screens for Monitoring Wells). The filter pack is emplaced as the auger or temporary casing is removed from the boring.

3. Ensure that filter pack sand for the well extends to approximately 3 feet above the top of the screened interval.

4. If required in the well construction permit, notify the appropriate inspector prior to placing the well seal.

5. Place a 2- to 3-foot thick bentonite pellet seal above the sand pack, as the auger and/or casing is removed from the boring. If the seal is placed above the water table, the bentonite pellets must be hydrated with potable water prior to placement of the annular seal.

6. Fill the remainder of the annulus between the well casing and the borehole wall with cement/bentonite grout (with approximately 5 percent bentonite), neat cement grout, or a high-solids bentonite slurry (11 to 13 pounds per gallon), to a depth of approximately 1 foot below ground surface. If the water level is higher than the seal, use a tremie pipe to place the grout.

7. Install either a threaded cap or a locking watertight expansion plug on the monitoring well. Place a steel hasp-locking well housing over the top of the well and cement it into the annulus of the boring.

8. Place a traffic-rated precast concrete or steel well enclosure approximately 1 to 2 inches above grade, and cement it into place with concrete. Have a concrete apron constructed around the well housing enclosure to facilitate runoff.

9. For aboveground completion, ensure that the well casing extends approximately 2-3 feet above ground surface. Place an 8-inch diameter, hasp-locking steel well housing over the well. A typical well housing is 5 feet long, and should be place with approximately 3 feet above ground and 2 feet below ground. Dig a 4-inch wide, 12-inch deep annulus around the housing and place concrete in it. Traffic bollards can be installed around the well housing as necessary.

10. Repeat Steps 1 through 9 for all monitoring wells at site.

11. Following the curing of the grout (approximately 24 hours), each monitoring well is developed. Prior to development activities, measure the depth in each well to static water level and total casing depth.

12. During development of each well, ensure that field parameters and observations are recorded on a Kennedy/Jenks Consultants purge and sample form (attached). Information to be recorded includes, but is not limited to, the following items:

    Depth to water

    Development time and volume

    Development (flow) rate

    pH, temperature, specific conductivity, and turbidity

    Other observations, as appropriate (e.g., color, presence of odors, or sheen)

13. Develop each monitoring well until water of relatively low turbidity is removed from the casing.

14. When development of each well is discontinued, record the following field parameters/observations:

Depth to water

Temperature

pH

Specific conductance

Turbidity

Color

B.5 Investigation-Derived Wastes

Place groundwater produced by well development in appropriately labeled containers for disposition by the client. Kennedy/Jenks Consultants is available to assist the client with options for disposition of groundwater.

Appendix C

Standard Operating Guidelines – Groundwater Sampling

Appendix C: Standard Operating Guidelines – Groundwater Sampling

C.1 Introduction

This Standard Operating Guideline (SOG) provides the procedures typically followed by Kennedy/Jenks Consultants personnel during the collection of groundwater samples from monitoring wells. Groundwater sampling from temporary boreholes (e.g., grab groundwater samples collected from direct push borings) is not addressed by this SOG. This SOG provides guidance on procedures that are generally consistent with standard practices used in environmental sampling. Federal, state and/or local regulatory agencies may require groundwater sampling procedures that differ from those described in this SOG and/or may require additional procedures. As guidance, this SOG does not constitute a specification of requirements for groundwater sampling. Deviations from, and additions to, the procedures described herein may be appropriate based on project-specific sampling objectives, site-specific conditions, and/or regulatory requirements. The user of this SOG should modify the sampling procedures used, as appropriate, to conform to the project-specific requirements and then document such deviations from this SOG in the project-specific documentation of groundwater sampling activities.

This SOG does not address Quality Assurance/Quality Control (QA/QC) procedures for groundwater sampling in detail. While some general QA/QC procedures are addressed, project-specific QA/QC procedures should be developed and presented in a Quality Assurance Project Plan (QAPP), field sampling and analysis work plan, or other project- or activity-specific document.

This SOG contains the following sections:

- Field Equipment/Material
- Typical Procedures for Monitoring Well purging and Groundwater Sampling
- Stabilization Criteria for Adequacy of Monitoring Well Purging
- Quality Control Guidance
- Investigation-Derived Waste (IDW) Management
- References

C.2 Field Equipment/Materials

Material/equipment typically required for the collection of groundwater samples from monitoring wells may include:

- Electric water-level monitoring probe
- Bladder pump, peristaltic pump, pre-cleaned, disposable, 2- or 4-inch bailers with disposable cord, inertial pump, submersible pump, or other suitable apparatus for purging the well and sampling
- Flexible discharge tubing [polyethylene (PE), Teflon™, or similar]
- Purge water collection container

- Multi-parameter water quality meter (temperature, pH, specific conductance, redox potential)
- Flow-through cell
- Nitrocellulose filters (if conducting field filtering)
- Sample containers (laboratory-supplied) with appropriate preservatives
- Additional chemical preservatives (if necessary)
- Watch or stopwatch
- Sample labels, pens, field logbook, or other appropriate field forms (e.g., groundwater purge and sample forms, chain-of-custody forms), and access agreements and third-party sample receipts (if warranted)
- Previous purging and sampling data for monitoring wells to be sampled, including water levels, purging parameters, and laboratory analysis results.
- Monitoring well boring and construction log (including wellhead elevation survey and reference point information)
- Personnel and equipment decontamination supplies
- Sample shipping and packaging supplies
- Personal protective equipment as specified in the Health and Safety Plan (HASP).

C.3 Typical Procedures for Monitoring Well Purging and Groundwater Sampling

1. **Pre-Purging Data Collection and Purging Equipment Placement.** Record the data and information collected during this procedure on a groundwater purge and sample form. Perform the following prior to groundwater sampling:

    a. Calibrate the multi-parameter water quality meter, prior to beginning sampling and as necessary based on field conditions, in accordance with the instructions in the manufacturer's operation manual. Note that it may be appropriate to keep a written log of the calibration procedures and an instrument maintenance with the instrument.

    b. Examine the monitoring well to be sampled and associated protective surface enclosure for any structural damage, poorly fitting caps, and leaks into the inner casing. If notable conditions exist, they should be recorded on the sampling log for the well so that any necessary follow-up corrective actions can be planned and implemented.

    c. Record an initial measurement of the depth to water. Calculate the volume of water in the well casing if wetted-casing-volume-based purging is to be used to remove the so-called "stagnant water" from the well prior to sampling. The volume of water in the wetted well casing should be calculated using the formula: $V = (\pi r^2) \times L$ where r is one half of the inner diameter of the well casing/screen and L is the length of wetted casing/screen (calculated by subtracting the depth to water from the total well depth). Total well depth should not be measured at the start of a sampling event (due to the potential to cause turbidity). Measure the total well depth after sample collection. Note that some regulatory agencies require that the calculated "stagnant water" volume include the water contained in the pores space of the wetted portion of the monitoring well filter pack in addition to the casing/screen. If this is a requirement, it should be defined in the project-specific sampling requirements.

f. Submersible pump: place the pump intake at a depth approximate to the middle or just slightly below the middle of the well screen interval unless another position is justified based on site-specific conditions.

g. Pre-cleaned or disposable bailers. Note: The use of bailers for low-flow purging/sampling is not appropriate.

h. Another suitable purging/sampling device may be selected for use depending upon project requirements.

2. **Monitoring Well Purging and Sampling.** When purging of a monitoring well prior to sampling is appropriate and/or required, purge the well using either (a) wetted-casing-volume-based purging or (b) low-flow purging as described in the following sections. If a well exhibits evidence of slow recharge, or produces excessively silty water, etc., the well may need to be redeveloped.

   a. Wetted-casing-volume-based purging.

      (1) Establish a purging rate to pump or bail approximately three wetted-casing volumes of groundwater without dewatering the well.

      (2) If using a pump, set-up the discharge tubing, flow-through cell, water quality meter, and purge water collection container. If turbidity is measured, collect the sample for turbidity measurement after groundwater passes through the flow-through cell in the vial provided with the turbidity meter. If using a bailer, maintain a clean plastic container next to the well for collecting observation samples. Begin purging the well.

      (3) At the beginning of purging and periodically thereafter, record the following information and water quality parameters/observations on the groundwater purge and sample form: As guidance, field parameters may be measured after one purge volume is removed and every ½ purge volume thereafter.

      - Date and time
      - Purge volume and/or flow rate
      - Water depth
      - Temperature
      - pH
      - Specific conductance
      - Dissolved oxygen
      - Oxidation-reduction potential (ORP)
      - Other observations as appropriate (turbidity, color, presence of odors, sheen, etc).

      (4) Continue purging until water quality parameters have stabilized (refer to "Stabilization Criteria for Adequacy of Monitoring Well Purging" below) and/or a minimum of three wetted-casing volumes of water have been removed from the well. If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very

long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.

(5) Collect the sample in pre-cleaned sample containers suitable for the laboratory analyses to be performed.

(6) If sampling using a bailer, use a bottom-emptying device or other technique to avoid sample agitation. If the collected water is very turbid, or a bottom-emptying bailer is not used, properly transfer the water from the bailer into the appropriate sample containers. Be careful to avoid agitating the sample. When sampling for VOCs, turn the bottle upside down after filling the container to identify possible headspace. If bubbles are present, top off the sample container or resample.

3. **Field Filtering Groundwater Samples.** Groundwater sample filtering and/or preservation should be performed in accordance with the requirements of the analytical method being specified and any other project-specific requirements. For example, samples collected for dissolved metals are typically filtered using a 0.45 µm filter.

4. **Sample Collection Considerations.** When multiple analyses will be performed, collect the samples in order of decreasing sensitivity to volatilization (i.e., VOC samples first and metals last). When sampling for VOCs, turn the sample container upside down after filling to identify possible headspace. If bubbles are present, top off the sample bottle or resample (do not reuse bottles, especially if they have been pre-preserved by the vendor or laboratory). If possible, the pump should not be moved or turned off between purging and sampling; however, the pump may need to be turned off for a very brief period (as a practical matter) so field personnel can handle samples and minimize the potential for water to splash on the ground surface. The ground surface should be protected from incidental splashing, especially if water from the well would be considered a hazardous waste for disposal purposes.

5. **Monitoring Wells with Slow Recharge.** If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.

6. **Sample Container Filling and Shipping.** Fill the appropriate containers for the analyses to be requested and ensure that the required label information is completely and accurately filled in. Follow sampling packaging, shipping, and chain-of-custody procedures (see applicable SOG).

7. **Decontamination.** Follow personnel and equipment decontamination procedures (see applicable SOG).

C.4 Stabilization Criteria for Adequacy of Monitoring Well Purging

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EPA 2001) states that "with respect to groundwater chemistry, an adequate purge is achieved when pH, specific conductance, and temperature of groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Wells should be considered stable when the criteria listed in the following table have been met for pH, specific conductance, temperature, and turbidity. Attempts should also be made to stabilize ORP and dissolved oxygen.

Field Parameters	Stabilization Criteria for Three or More Consecutive Readings	Notes
pH	Difference between three or more consecutive readings is within ±0.2 units	–
Temperature	Difference between three or more consecutive readings is constant	–
Specific Conductance	Difference between three or more consecutive readings is within ±3%	–
Turbidity	Difference between three or more consecutive readings is within ±10% or three consecutive readings below 10 NTUs	Generally, turbidity is the last parameter to stabilize. Attempts should be made to achieve stabilization; however, this may not be possible. It should be noted that natural turbidity in groundwater may exceed 10 NTUs. If turbidity is greater than 50 NTU, redevelopment of the well may be warranted.
ORP	Difference between three or more consecutive readings is within ±20mV	Very sensitive. Attempts should be made to achieve stabilization; however, due to parameter sensitivity this may not be possible.
Dissolved Oxygen	Difference between three or more consecutive readings is within ±10% or ±0.2 milligrams per liter (mg/L), whichever is greater	Very sensitive. Attempts should be made to achieve stabilization, especially when collecting samples of VOC analysis; however, due to parameter sensitivity this may not be possible.

Attempts should be made to achieve the stabilization criteria. Because of geochemical heterogeneities in the subsurface environment, stabilization of field parameters during purging may not always be achievable. If field parameter measurements do not indicate stabilization, continued conventional purging may be required until a minimum of three wetted-casing volumes have been removed. During low-flow purging of a well containing a large volume of casing water, it may be practical to discontinue low-flow purging and proceed with sampling if field parameters have not stabilized within a reasonable period. This judgment must be made on a site-specific/project-specific basis.

C.5 Quality Control Guidance

Follow the quality control requirements specified in the Quality Assurance Project Plan (QAPP), project-specific field sampling and analysis work plan, and/or project-specific regulatory requirements, as applicable. The following may be used as guidelines.

Approximately one duplicate sample should be obtained for each sampling event or for each batch of samples (a batch is typically defined as 20 samples). Collect duplicate samples immediately after the original samples are collected. Purging is not performed between original sample collection and collection of duplicate samples. Original and duplicate samples are collected sequentially, without appreciable delay between collection cycles. Duplicate samples are to be submitted to the laboratory blind (i.e., not identified as a duplicate sample).

1. Typically, at least one type of field blank sample (rinsate or transfer) should be collected per day of water sampling. All field blank samples are to be collected, preserved, labeled, and treated like any other sample. Field blank samples are to be sent blind to the laboratory (i.e., not identified as a field blank). Record in the field notebook the collection of any blank sample (rinsate, transfer, trip). The types of field blank samples are discussed below.

    - Rinsate blank samples. If rinsate field blank samples are required, prepare the sample by pouring deionized water over, around, and through the various reusable sampling implements contacting a natural sample. Rinsate blanks need not be collected when dedicated sampling equipment is used for purging and sampling the well. Rinsate blank samples are to be analyzed for the same parameters as the environmental samples.

    - Transfer blank samples. Transfer blank samples are routinely prepared when no rinsate blank samples are collected. (The purpose of a transfer blank sample is to monitor for entrainment of contaminants into the sample from existing atmospheric conditions at the sampling location during the sample collection process.) A transfer blank sample is prepared by filling a sample container(s) with distilled or deionized water at a given sampling location. Transfer blank samples are to be analyzed for the same parameters as the environmental samples.

C.6 Investigation-Derived Waste (IDW) Management

Purge water is to be contained onsite in an appropriate labeled container for disposition by the client unless other project-specific procedures are defined. If the groundwater is not contaminated, e.g., water produced at a winery, it may be distributed on the ground near the well, in a manner that does not create a safety hazard. As a matter of practice, any waste, or potential waste, generated onsite, should remain onsite. Refer to the IDW SOG.

C.7 References

ASTM. 1999. Designation: D 6452 - 99. Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations. Copyright ASTM, West Conshocken, PA.

ASTM International. 2002. Designation D 6771 – 02. Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. Copyright ASTM International, West Conshocken, PA.

U.S. Environmental Protection Agency. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM)*. Dated November 2001. U.S. EPA Region 4.

Appendix D

Standard Operating Guidelines – Field Measurement of pH, Temperature, and Conductivity

Appendix D: Standard Operating Guidelines – Field Measurement of pH, Temperature, and Conductivity

D.1 Introduction

This guideline describes the procedure that will be used by Kennedy/Jenks Consultants personnel during performance of field pH, temperature, and electrical conductivity (EC) measurements.

D.2 Equipment

- Portable pH, temperature, and conductivity meter with potassium chloride (KCl) probe, temperature probe, and EC probe
- Extra KCl filling solution
- 50 ml plastic jar or other suitable container
- Squirt bottle and supply of deionized (DI) water
- pH 7, 10, and 4 buffer solutions
- EC solutions

D.3 Typical Procedures

1. Calibrate meter according to manufacturer's instructions. Prior to first measurement, check calibration against pH 7 buffer and again periodically over the course of the day, and recalibrate if the reading is more than 0.1 units from 7.

2. Use 50 ml plastic jar or other suitable containers for measurement readings. Rinse sample test container with sample water three times prior to measurement.

3. Immerse pH probe and temperature electrode in sample water. Gently stir sample for thorough mixing. Read and record pH to nearest 0.1 unit once pH reading has stabilized. Many pH meters possess an automatic feature which indicates final stabilized measurement.

4. Immerse the EC probe (if EC probe is not built into the same sonde as the pH probe) in the sample water. Repeat Step 3.

5. Rinse or bathe the probes with DI water or soak in DI water between measurements. Changing DI water bath between measurement stations increases accuracy of measurements.

D.4 Instrument Calibration – General Procedure

1. Calibrate pH meter in the field at the beginning of each day of field work and when the standard check is out of calibration.

2. Rinse pH and temperature probes in DI water.

3. Turn on meter and immerse pH and temperature probe in a pH 7 buffer solution. Calibrate meter to pH 7, allowing enough time for meter to stabilize.

4. Rinse pH and temperature probe with DI water.

5. Immerse pH and temperature probe in either a pH 4 or a pH 10 buffer solution, depending on whether expected pH of samples is above or below pH 7. If expected sample pH is above pH 7, use pH 10 solution for the second calibration. If expected sample pH is below pH 7, use pH 4 for the second calibration. Calibrate meter to second pH solution, allowing enough time for meter to stabilize.

6. Rinse pH and temperature probe with DI water.

7. Perform occasional rechecking of meter calibration to pH 7 calibration solution during usage. Repeat the calibration process (Steps 2-4) if value for final pH check is more than 0.1 units from pH 7.0.

8. Immerse the EC probe in EC solution of known conductivity. Calibrate according to manufacturer's instructions.

D.5 Maintenance

1. Store meter in case with pH electrode immersed in a pH 7 buffer solution.
2. Inspect pH and temperature probes for cracks and scratches.
3. Inspect pH probe for containing adequate amount of KCl solution. If amount is low, refill as needed.
4. Carry spare batteries and screwdriver in the meter case.
5. Carry a copy of the instruction manual with meter.