QUALITY ASSURANCE (ATTACHMENT 8)

INTRODUCTION

This attachment describes the standard procedures that OCWD will follow for the project. These procedures are grouped into the following categories:

- Well construction procedures
- Water quality sampling procedures
- Water quality analysis procedures

This attachment also describes the preliminary data quality objectives for the project.

These procedures, data quality objectives, and related details will be described in detail in a Quality Assurance / Quality Control Plan (QA/QC Plan) that will be prepared for the project.

OCWD makes sure that all field and laboratory personnel are fully trained before performing any study or project-related activities. Minimum personnel requirements are established to assure that field and laboratory personnel performing the work meet the adequate qualifications and sufficient training to do the task correctly. Training includes familiarity and understanding of the standard operating procedures (SOP) and planning documents such as QA project plan (QAPP). Detailed written and verbal directions are provided to field and laboratory personnel working under direct supervision. Manuals that include SOP protocols, media recipes, reliable sources of reagents, safety manuals, and references are available to all field and laboratory staff for their use.

OCWD's training program for assuring personnel qualifications include the following activities:

- Participation in in-house training sessions (i.e., on-the-job, short-term) as appropriate to their job functions to assist staff in adapting to changes in technology, methodology, and/or regulatory requirements. Such training includes on-the-job training (observing the task, performing the task with and without direct supervision) and short-term training (instruction for new staff or current staff who have been assigned new responsibilities or needing a refresher and/or retraining course);
- Demonstration of competence for those procedures and tests based on SOPs and other training materials; and
- Demonstration of proficiency in QA/QC procedures (e.g., initial demonstration of capability, performance evaluation samples,

interlaboratory QA samples, precision and accuracy) as they apply to specific tasks which staff is responsible for.

DATA QUALITY OBJECTIVES

The following preliminary data quality objectives have been identified for the Sunset Gap Seawater Intrusion Assessment:

- Data will be collected to:
  - Identify the occurrence, direction and rate of movement of saline groundwater in the Sunset Gap
  - Determine the salinity concentration in specific aquifers in the Sunset Gap
  - Provide a baseline from which future salinity changes can be measured
  - Provide data needed to evaluate the feasibility of seawater intrusion control alternatives in the Sunset Gap
- All water quality samples will be collected by OCWD staff and analyzed in OCWD's state-certified laboratory according to EPA approved standard methods.
- Groundwater elevation and groundwater quality data will be reviewed and entered into OCWD's data management system
- Well drilling shall be overseen by a California Professional Geologist and a California Certified Hydrogeologist.
- Well drilling shall be conducted by a water well driller licensed by the State of California (C-57 license).

WELL CONSTRUCTION PROCEDURES

In general, drilling and construction activities will be performed on a 24-hour basis. An OCWD inspector will be on site during critical drilling and construction activities. The OCWD on-site Inspector will work under the direction of the Project Field Geologist and Project Manager, who is a Professional Geologist and Certified Hydrogeologist in California. The following sub-tasks provide an outline of the responsibilities of the on-site Inspector.

INSPECTION TASKS FOR WELL CONSTRUCTION

The work effort is divided into the following inspection sub-tasks:

Sub-Task 1 - Project Set-up

Sub-Task 2 - Conductor Casing Installation

Sub-Task 3 - Pilot Borehole Drilling

Sub-Task 4 - Geophysical Logging

Sub-Task 5 - Borehole Wiper Pass

Sub-Task 6 - Caliper Logging

Sub-Task 7 - Casing Installation

Sub-Task 8 - Gravel Pack and Seal Installation

Sub-Task 9 - Cement Seal Installation

Sub-Task 10 - Well Development

Sub-Task 11 - Site Clean-up & Vault Installation

Sub-Task 12 - Prepare Well Construction Report

Sub-Task 1 – Project Set-up

The Inspector shall review and become familiar with all contract documents for this project. Since the proposed wells are on the NWSSB, all inspectors are required to obtain a temporary access badge from the Department of Navy.

Sub-Task 2 – Conductor Casing Installation

The Inspector shall be on site during the drilling and installation of the conductor casing. The purpose of the conductor casing is to provide near-surface borehole stability. The Inspector shall ensure that representative formation samples are collected from the conductor borehole on 5-foot intervals. The Inspector shall also log cuttings from the borehole using the Wentworth Scale soil particle size descriptions. The Inspector shall check and measure all casing on site and ensure that the contractor is using proper installation techniques.

Sub-Task 3 – Pilot Borehole Drilling

The Inspector shall be on site during the drilling of the pilot borehole. During drilling, the Inspector shall ensure that representative formation samples are collected on minimum 5-foot intervals. Other responsibilities shall include, but not be limited to:

- Testing of Drilling Fluid Properties – Ensure that the drilling fluid is tested per the contract documents for the specified parameters, e.g., density and viscosity, and on the specified intervals.
- Mud Pit Cleaning – Ensure that the contractor is cleaning the mud pits on a regular interval.
- Sample Collection – Ensure that samples are collected at the correct depth and are representative of each five-foot interval.
- Lithologic Logging – The Inspector shall develop a lithologic log of each borehole and shall describe the formation samples using the Wentworth Scale for grain size, Munsel soil color, and estimated percentage of soils types, as well as sorting, roundness, and sphericity. Other notable properties such as clay plasticity, shell fragments, wood fragments, etc, shall be included in the lithologic log.
- Drift Surveys – The Inspector shall witness the completion of each drift survey to be collected on 100-foot intervals to ensure straightness of the borehole. The Inspector shall obtain each completed drift target for OCWD.
- Check Contractor's Drill Pipe Tally – The Inspector shall ensure that the contractor is measuring and recording each drill pipe used. In addition, the Inspector shall verify that the contractor's pipe tally is correct.

Lithologic logging shall be completed by preparing documentation using lithologic logging forms that contain columns as follows:

COLUMN 1 – DEPTH

Write the depth in feet below ground surface of the bottom of the interval sampled. In the example provided, row number 1 indicates a sample from 0 to 1 feet and row number 2 indicates a sample from 1 to 5 feet. Row number 12 indicates a sample collected from 43 to 46 feet.

COLUMN 2 – SAND/GRAVEL CONTENT

Indicate the estimated percentage of sand and gravel contained in the sample using dots for sand and circles for gravel. The sub columns are divided in 10% increments. A dot or circle in each sub column indicates 10%. 5% is indicated by drawing a line splitting the sub column in half. Mark dots and circles neatly so it is evident which marks are dots and which marks are circles. The sample described in row 18 contains 55% sand and 45% gravel. Note that the 5% of sand and 5% of gravel are indicated by drawing a line cutting the sub column in half and placing a dot on one side of the line and a circle on the other side of the line.

COLUMN 3 – PERCENT CLAY

Indicate the estimated percentage of clay by simply writing the percentage in the box provided. A sample containing 0% clay will have nothing written in this box. A sample containing trace clay will have “TR” or “tr” written in this box.

COLUMN 4 – PERCENT SILT

Indicate the percentage of silt by simply writing the percentage in the box provided. A sample containing 0% silt will have nothing written in this box. A sample containing trace silt will have “TR” or “tr” written in this box.

Content for sand, gravel, clay, and silt should total to 100%.

COLUMN 5 – SAND/GRAVEL SIZE

Indicate the estimated grain-size range of the sample collected. The <1/16 mm sub column is for clay only. If there is no clay in the sample, then the <1/16 mm sub column should be left blank. Draw a clear line from the smallest grain size through the largest grain size observed in the sample to indicate the range. Row 9 contains sand and gravel up to 32 mm. If a percentage of gravel is indicated in column 2, then the range must go up to at least 2 – 4 mm as this is the smallest gravel size.

COLUMN 6 – SORTING

Indicate the sorting of the sample using a check mark or X. Check no more than two boxes. A range is acceptable. Row 9 indicates a sample that is very poorly to poorly sorted.

COLUMN 7 – ROUNDNESS

Indicate the general roundness of the sand and gravel using a check mark or X. The roundness is a measure of the sharpness of the grain corners. A range is acceptable. Row 9 indicates that the grains in that sample are very angular to subrounded.

COLUMN 8 – SPHERICITY

Indicate the overall sphericity of the sand and gravel contained in the sample. A range is acceptable.

COLUMN 9 – MUNSELL COLOR NAME

Indicate the Munsell color name as indicated in the Munsell soil color chart. Row 9 indicates a Munsell color of light olive brown. It is OK to abbreviate as these boxes are small. Some examples of acceptable abbreviations are:

Light – lt
Brown – brn
Olive – olv
Very – vy

<u>COLUMN 10 – MUNSELL COLOR DESCRIPTION</u>

Indicate the Munsell color description as indicated in the Munsell soil color chart. Row 9 indicates a Munsell color of 2.5Y/5/3 (light olive brown).

<u>COLUMN 11 – NOTES</u>

List any observed sample characteristics that are not included in Columns 1 through 10.

1. Fossils (i.e. shells)
2. Plant/root/wood fragments
3. Mineralogy
4. Organic material (e.g., peat)
5. Odor
6. Weathering/alteration
7. Clay plasticity and stiffness
8. Cementation
9. Moisture

List any note worthy field observations

1. Blow count (if applicable when collecting driven samples)
2. Hard drilling
3. Rig chatter
4. Loss of drilling fluid
5. Start/end drilling operations
6. Total depth of borehole

Sub-Task 4 – Geophysical Logging

The Inspector shall be on site to witness geophysical logging of each pilot borehole.

Sub-Task 5 – Borehole Wiper Pass

The Inspector shall be on site during the wiper pass and shall ensure that the required drilling fluid properties are maintained and to verify the drill pipe tally.

Sub-Task 6 – Caliper Logging

The Inspector shall be on site to witness the caliper survey prior to well construction. In addition, the Inspector shall review the completed caliper log and insure that the correct volume of back-fill material is installed during well construction (Sub-task 8).

Sub-Task 7 – Casing Installation

The Inspector shall be on site during well casing and screen installation. It is the contractor's responsibility to measure each casing and screen joint. The Inspector shall ensure that the contractor is measuring all casing and is completing the necessary tally. In addition, the Inspector shall verify that the contractor's casing tally is accurate. In addition, the Inspector shall ensure that all screen intervals, gravel pack, and seals are constructed according to the final well design. During well construction, the Inspector shall complete a hand-drawn well diagram showing depths of conductor casing, blank well casing, screen intervals, zone seal intervals, gravel pack intervals, and the sanitary cement seal interval.

Sub-Task 8 – Gravel Pack and Seal Installation

The Inspector shall be on site during the installation of the gravel pack and zone seals. The purpose of the gravel pack is to minimize entrance of formation sediment into the well screen during water sampling. The purpose of the zone seals is to hydraulically isolate (at least to the extent of hydraulic separation of adjacent aquitards) individual aquifer intervals for water level and water quality analysis. The Inspector is responsible for:

- <u>Construction Tremie Pipe Tally</u> – The Inspector shall take an accurate count of all construction tremie pipe on site prior to gravel and seal placement. The Inspector shall also ensure that the contractor is measuring and recording all tremie pipe installed in the borehole. In addition, the Inspector shall verify that the contractor's pipe tally is correct.
- <u>Back-Fill Volumes</u> – The Inspector shall calculate and record borehole and back-fill volumes to ensure that the gravel and seal material is not bridging during installation
- <u>Well Diagram</u> – During well construction, the Inspector shall complete the necessary well diagram as described in Sub-Task 7.

Sub-Task 9 – Cement Seal Installation

The Inspector shall be on site during installation of the cement seal. All delivery receipts shall be obtained by the Inspector for OCWD.

Sub-Task 10 – Well Development

The Inspector shall be on site during well development and shall ensure that the proper development techniques are employed by the contractor. Through out development, the Inspector shall measure and record the following, but not limited to:

1. Static and Pumping Water Levels
2. Airline and Pump Setting Depths
3. Discharge Rates
4. Field parameters of discharge including: pH, TDS, EC, temperature, & settleable solids
5. Installation and operation of equipment

Sub-Task 11 – Site Clean-up and Vault Installation

The Inspector shall conduct daily site walks during site clean-up and direct the contractor as necessary. The Inspector shall be on site during vault installation to ensure that the surface completion is done per the contract documents.

Sub-Task 12 – Well Construction Report

Upon completion of the project, the Inspector and Project Field Geologist shall prepare a draft Well Construction Report. The Project Manager and Technical Advisor shall review and finalize the report. The report shall contain, but not be limited to the following sections.

1. Introduction
2. Construction Activities Description (by Sub-Task)
3. Figures
    a. Location Map(s)
    b. Final As-Built Well Diagrams (8.5 x 11)
    c. Surface Completion As-Built (plan and side view showing casing orientation relative to north)
    d. Final As-Built Well Diagram with Lithologic Logs and Geophysical Logs (11 x 17)
4. Appendices
    a. Permits
    b. Lithologic Logs
    c. Geophysical Logs
    d. Field Reports

e. Contractor's Daily Logs
f. Development Records
g. Water Quality Sample Results
h. Photo Log (if applicable)

Field Reporting

The Inspector shall record and document all important site-specific information for each shift. Important site-specific information shall include, but not be limited to:

1. Personnel entering and leaving the site
2. Telephone conversations regarding site activities
3. Start and stop times of major events
4. Depths, volumes, rates, and pressures

WATER QUALITY SAMPLE COLLECTION PROCEDURES

This description provides basic guidelines and procedures used by OCWD personnel for water quality monitoring of groundwater, surface water, and treatment processes. These basic guidelines are the minimum requirements and may be modified to meet specific regulatory requirements, local environmental conditions, or focused studies. Proficiency with the use and operation of monitoring equipment and first-hand knowledge of the watershed form the core of the sample collection and data evaluation process.

BACKGROUND:

OCWD collects thousands of samples every year for a variety of monitoring programs related to drinking water, seawater intrusion, surface water, and water quality from monitoring and production wells located throughout the Orange County Groundwater Basin and selected locations in the upper Santa Ana River Watershed. As a basis, OCWD staff employs sampling protocols used by United States Geological Survey (USGS), Environmental Protection Agency (EPA), and the California Department of Public Health (CDPH). Staff go through an extensive training process, with a senior and/or experienced staff member, occurring over a 6-month to 1-year period to gain appropriate and specific knowledge about (1) OCWD's monitoring programs, (2) sample collection procedures following EPA and CDPH approved methods, industry standards and District expectations, (3) operation, calibration, and maintenance of all field sampling equipment related to each specific monitoring program, (4) individual sampling station site-specific characteristics to conduct sampling activities, (5) documentation protocols (i.e., chain-of-custody, field notebook, etc.), and (6) traffic control set-up and safety awareness. Emphasis is placed on high quality assurance and quality control (QA/QC) for all protocols and procedures for each activity related to field measurements and documentation, sample collection, storage, transport and delivery of samples to a state certified analyzing laboratory.

PROCEDURES:

The objective of OCWD's water quality monitoring program is to collect a "representative" sample of the ambient water source (e.g., groundwater, surface water, etc.). To meet this objective, Water Quality Department (WQ) staff must prepare in advance by gathering data on the groundwater well location or surface water site. Information such as site conditions and access, well construction details, historical water quality data if available, groundwater monitoring well pumping and purge characteristics, production well operational period, required sampling procedure and sampling equipment for the location, test methods for analysis, and sample handling procedures are known before arriving at the site. Samples are collected as specified by the EPA (e.g., method 524.2 for volatile organic compounds), CDPH, or other approved methods dependent on the type of analysis.

Staff prepares for field work and sample collection the day prior to the sampling event. Sampling equipment (field log books, meters, coolers, pumps, etc), laboratory prepared sample bottles, bottle labels, and corresponding paperwork are prepared ahead of time so that sampling teams may arrive at the field sites early, and return back to the laboratory with ample time for sample receiving and processing. Prior to leaving to the field site, field meters are calibrated in the WQ Laboratory the same day as the sampling event unless protocol requires meters be calibrated in the field.

The day of the sampling event, staff will load up equipment and sample collection materials and proceed to the sample site(s). Once at site(s), staff will set up and use proper sampling method procedures to collect samples and perform field work. Specific sampling methods and procedures will be used depending on the samples requested and type of source water to be sampled (e.g., groundwater, surface water, etc.). Staff will complete assigned field sampling, store and transport samples in a cooler with sample bottles surrounded by blue ice or double bagged ice, and deliver samples to the designated state certified laboratory for sample analysis.

Field log books, chain of custodies (COC), and well purge forms are used to record sample site information, field activities, and ambient conditions. Field readings such as electrical conductivity (EC), pH, temperature, dissolved oxygen, oxidation reduction potential (ORP), depth, well purge rates, etc., are recorded for sampling site using a calibrated multi-parameter field meter and/or other field instrument. Static or pumping depth to groundwater is recorded using a water level measuring tape or depth sounder. All sampling methods employed are dependent on site-specific conditions and requirements such as water quality objectives and site accessibility.

OCWD places the highest priority on safety in all field assignments. Staff will wear required personal protection equipment (gloves, safety glasses, traffic control vests, etc.) at all times and at all sites. Detailed standard operating procedures (SOP) are written for a diverse set of WQ Department sampling activities, equipment maintenance, decontamination procedures, data processing, etc. SOPs are routinely reviewed and revised to be current with modernized sampling techniques and new programs.

Standard Operating Procedure - Submersible Pump Sampling

Purpose

The Submersible Pump Sampling SOP was created specifically for the field personnel of the WQ Department to (1) increase staff knowledge of the OCWD's groundwater monitoring programs using a submersible pump and ancillary equipment to collect samples, (2) aid in staff preparation for submersible pump sampling activities, (3) provide methods which promote consistent and reliable water quality results, and (4) ensure safe operation of all equipment used during submersible pump monitoring activities.

This document will inform field personnel of pertinent information related to submersible pump sampling preparation, proper water quality sample collection, and safe handling/operation of submersible pump sampling equipment.

The information contained in this document has been adapted from various water quality sampling protocols and publications along with experience obtained from staff members of the WQ Department.

<u>Submersible Pump Monitoring Programs</u>

The WQ Department monitors many different groundwater locations in order to protect the quality of Orange County's groundwater. Submersible pump sampling at OCWD encompasses several water quality monitoring programs managed by the WQ Department. These programs include, but are not limited to, the Forebay VOC Program (FBVOC), the North Basin Groundwater Protection Project (NBGPP), the Talbert Barrier Seawater Injection Monitoring Program (TBQ23), the Santa Ana River Monitoring Program (SARMON), the El Toro Marine Corps Air Station TCE investigation (MCASTCE), the South Basin Groundwater Protection Project (SBGPP), and the Groundwater Replenishment System Monitoring Program (GWRS).

The equipment used in these programs consists of several different submersible pump assemblies that can be lowered into monitoring wells either mechanically or manually. The two types of submersible pumps used by the WQ Department are both manufactured by the Grundfos Pumps Corporation. The smaller pump, referred to as the Rediflo2 or MP1, is controlled using a variable frequency drive (VFD) to allow for variable pumping rates and is used mostly for two-inch well casings. The larger pump, referred to as SQ or SQE pump, will pump at greater rates and is used primarily for all well casings four inches or greater in diameter. The WQ Department has created or adapted many types of submersible pump monitoring equipment to fit the ever-changing needs of the diverse monitoring programs managed by the department. Several specialized sampling trucks and equipment are used to perform sampling using submersible pumps in our monitoring programs.

> **Dedicated Pumps:** One of the primary methods of pumping and purging monitoring wells is through dedicated pumps. These pumps are dedicated to the well casing and installed at appropriate depths determined by an OCWD hydrogeologist. No portable pumps need to be used at these wells. ***See Figure 1.***
>
> **Port-A-Reels:** Another important and versatile piece of equipment used in the submersible pump sampling program is the AMS Port-A-Reel. This is a hydraulically operated hose reel that can be used to get hard to reach

monitoring wells or when use of the sampling truck is not possible. ***See Figure 2.***

Pumps (MP1 and SQ): The port-a-reels require the use of a generator for power and may be equipped with either a Rediflo2 (MP1) Grundfos pump or a SQ Grundfos pump. The WQ Department maintains several port-a-reel systems with both the smaller Rediflo2 pumps as well as the larger SQ pumps to ensure coverage of any monitoring need. ***See Figures 3a and 3b.***

TK900 Well Management Truck (T-98): The primary truck used to sample many monitoring wells is the TK900 Well Management Truck or "T-98." This truck is equipped with a PTO driven generator and hydraulic system that operates an extendable boom and two hose reels. Two SQ pumps are attached to the hose reels for pumping well casings with a diameter of four inches or greater. This truck can also provide treatment of discharged water via granular activated carbon (GAC) treatment vessels. ***See Figure 4.***

Customized Utility Box Trucks: The WQ Department has three customized box trucks used for a variety of sampling programs requiring use of submersible pumps. The port-a-reel system will often be used in conjunction with a specialized utility (box) truck that is capable of providing power through an integrated generator as well as providing treatment of discharged water via granular activated carbon (GAC) treatment vessels. Staff will use lift-gates installed on each truck to safely load and unload the port-a-reels. ***See Figure 5.***

Monitoring Program Spreadsheets

The WQ Department uses specialized water quality program spreadsheets to organize and schedule sampling events. One of the most common monitoring programs associated with submersible pump sampling is the Forebay Volatile Organic Compound (VOC) Monitoring Program (FBVOC). Water Quality staff will refer to the Weekly Water Quality Sampling Schedule, as well as the FBVOC spreadsheet, for information needed to sample monitoring wells. The spreadsheet will be updated regularly with the wells "due" during that given month. Pertinent information such as samples required, well depth, and historical contaminant concentration, along with any special concerns or comments about a well, can also be found on this spreadsheet. At the end of each day, staff is required to highlight the wells completed in blue to prevent duplicate sampling of that well by other staff during the next FBVOC sampling event. Completed well purge sheets are placed in the appropriate location to be reviewed for quality assurance and completeness prior to filing in the well archive folders.

The Talbert Barrier Seawater Injection (Q23) monitoring program also uses a spreadsheet to organize and schedule sampling. This spreadsheet will have all relevant information listed and includes comments about the well location, well characteristics, and any treatment requirements. The spreadsheet must be filled-out at the end of each day to ensure that well sampling can be tracked. Since this program only occurs twice a year, the spreadsheet will be completed and made available with current information several weeks in advance to the beginning of the winter or summer sampling events.

Submersible Pump Sampling Procedures

The following step-by-step procedure is the basic process used by all Water Quality personnel when assigned to the task of sampling a monitoring well with any type of submersible pump. These procedures, if followed properly, provide a general structure that is safe and will ensure appropriate and consistent sampling protocols.

1. Review the WQ Weekly Sampling Schedule along with the corresponding spreadsheet for that monitoring program on the H: drive to determine the wells assigned and to obtain information about the historical water quality data and any treatment requirements. Before pumping any well, it is the sampler's responsibility to check the WRMS database to determine contaminant levels and whether carbon treatment is necessary.

2. After it has been determined whether or not carbon treatment is needed, the appropriate sample bottle labels and chain of custody forms can be created.

3. When carbon treatment is needed, you need to take carbon treatment samples (CRB) and equipment blank samples (EB). EB are collected at the end of equipment decon activity to document and track the effectiveness of the carbon treatment to remove contaminants treated to non-detect levels. All CRB and EB samples require three 40 ml vials when testing for VOC's.

4. Gather all samples bottles and prepare a cooler for sample storage and preservation. It is best to account for all bottles needed and then properly store bottles in the cooler for transport.

5. Collect equipment for required field measurements. For all submersible sampling, a Hydrolab is used to measure all required field parameters such as electrical conductivity, pH, temperature, dissolved oxygen, and the oxidation/reduction potential (ORP). The Hydrolab must first be calibrated using the instructions explained in detail in the field meter (Hydrolab) section of the Standard Operating Procedures Manual.

6. Depending on the wells to be sampled on a day and the number of personnel assigned to sample sites requiring use of submersible pump equipment, samples will be obtained from the monitoring well using an installed (dedicated) pump, port-a-reel system, or the T-98 well management system truck.

7. Review and double-check all equipment required for the wells to be sampled and ensure that everything needed for that day is in the sampling truck.

8. Double-check gasoline levels in all generators and trucks along with oil levels (use disposable gloves to avoid hydrocarbon contamination on hands). After samples have been submitted to the lab, WQ Staff are required to fill gasoline in trucks or generators for the next person's use. Completing fueling tasks at the end of day prevents possible organic contamination in water samples (i.e., false positive) by avoiding same day fueling/sampling and saves time for the next person's use.

9. The on-site well purge activities will depend on the well casing diameter. OCWD Water Quality staff will purge a minimum of 3.5 well volumes to ensure ambient groundwater conditions are represented at the time of sample collection.

10. All WQ Department staff will complete the WQ Department well purge sheet during any well sampling activity. The purge sheet is completed with all necessary information related the monitoring well to be sampled such as well ID, date, samplers, type of pump, etc. The purge sheet provides a "Well Purge Volume Calculation" section to determine the appropriate volume of water to purge from a monitoring well in order to meet the minimum 3.5 well volume requirement.

11. To ensure an accurate purge volume calculation, WQ staff will obtain a water level measurement using an electronic water level indicator before beginning to purge the monitoring well.

12. A flow rate will also be obtained using a flow meter or by accurately timing the rate of flow using a container marked with known volumes.

13. All field readings will be noted on the purge sheet (see Submersible Sampling Field Readings section) and the completed purge sheets will be reviewed by the program manager and then filed in the appropriate purge sheet binders located in the OCWD WQ Department Library area.

14. If the monitoring well water is known to contain contaminants, WQ staff will perform treatment of the purged water using the GAC treatment system currently in use. All necessary CRB samples will be collected for QA/QC purposes.

15. The WL indicator (WL Tape) and submersible pumping equipment will be cleaned/decontaminated, as needed, in between sample sites. Immediately after using equipment, staff will rinse the equipment with "decon" water from the FV carbon treatment location. Following the rinse, staff will use a non-phosphate detergent (Liquinox) to scrub the portion of the equipment that has contacted the well water. To remove the detergent wash, a thorough rinse with "decon" water will be performed to remove all detergent residue from the equipment (*USGS Field Manual*).

16. If necessary, the submersible pump and hose assembly will be decontaminated through a carbon treatment recirculation. The recirculation of "decon" water through the GAC treatment vessel will ensure removal of all contaminates from internal equipment surfaces. All necessary EB samples will be collected for QA/QC purposes.

Submersible Pump Sampling Field Readings

Recording the field parameters at a groundwater monitoring well is as important as taking the samples themselves. Field readings of electrical conductivity (EC), pH, temperature (Temp), dissolved oxygen (DO), and oxidation and reduction potential (ORP) are measured of the purged groundwater and recorded on the well purge sheet.

Calibration of the Hydrolab Quanta field instrument is performed at the beginning of each day. Field data is recorded on a monitoring well purge sheet during the purging of a submersible pump monitoring well. The purge sheet is used to document all relevant comments and observations while purging a monitoring well using a submersible pump. Field readings are taken at start up and at regular intervals during the purging of the well and document characteristics of the water being purged. These field readings can also show when a well has been purged completely and the water characteristics stabilize. WQ Department staff will purge the required 3.5 well volumes and upon completion of the purge, ensure that all field parameters have stabilized to ambient groundwater conditions. Purging of the monitoring well continues until the field measurements for EC, temperature and pH are stabilized before sample collection.

Standard Operating Procedure For Decontamination Procedures for Submersible Pump and Sampling Hose

This document outlines procedures for cleaning a submersible pump and sampling hose used to collect groundwater monitoring well samples. Decontamination of the inner surfaces of the submersible pump and sampling hose will be performed after every groundwater sampling event. OCWD WQ personnel will inspect all outer sections of the sampling hose that enter the well casing to determine if a more thorough decontamination of the hose that entered the well casing is necessary.

OCWD WQ personnel will conduct a thorough decontamination of the inner surfaces of the submersible pump and sampling hose. This procedure will be performed using a recirculation of “decon water” through the pump and hose then back through a carbon treatment vessel using granular activated carbon (GAC). The “decon water” will be City of Fountain Valley tap water that has been treated through granular activated carbon. The decon water has been tested by the OCWD Advanced Water Quality Assurance Laboratory to show that it is consistently “organic-free.” Following the re-circulation OCWD WQ personnel will collect appropriate QA/QC samples, equipment blanks (EB’s), after a sufficient recirculation sequence has been performed. A typical re-circulation will take approximately 15 to 30 minutes depending on the degree of contamination detected in the groundwater monitoring well sampled.

OCWD WQ personnel will perform the equipment decontamination procedure after completing the sampling of a groundwater monitoring well. After decontamination, all equipment will be stored in a designated area that is free of all possible contamination sources until the next groundwater sampling activity.

Submersible Pump and Sampling Hose Decontamination Procedure

Items/Equipment Needed:

-Submersible Pump/Sampling Hose

-OCWD Carbon Treatment Vessel (GAC)

-Discharge Hose

-Full Water Tank of Treated “Decon Water”

-Pump “Decon Tube”

Following the use of a portable submersible pump and sampling hose to collect samples from a groundwater monitoring well:

1. Prepare a contaminant-free area for cleaning the pump and sampling hose
2. Place the submersible pump into the “decon tube”
3. Connect a discharge hose to the water tank and fill the “decon tube” with treated decon water for recirculation

4. Connect discharge hose from pump / sampling hose to carbon treatment vessel
5. Connect discharge hose to carbon treatment vessel and place in “decon tube” to complete “recirculation loop”
6. Begin pumping treated decon water from the “decon tube” through the re-circulation loop consisting of the submersible pump, sampling hose, discharge hose, carbon treatment vessel, and back to the “decon tube”
7. Ensure proper decon length from 15 to 30 minutes depending on the last known contaminant levels in the most recent groundwater monitoring well sampled
8. Collect equipment blank samples to ensure proper QA/QC has been accomplished.

STANDARD OPERATING PROCEDURE - Field Log Books

Field log books are legal documents. As field observations are recorded, they become part of the permanent record of the sample.

PROCEDURES:

Label the exterior of your field book with your full name, the date of the first field event recorded, and end date with the last field event recorded. Field log books should be used until all pages are full with field events and notes. Hard bound field log books are preferred, however, if a spiral bound field log book is used - you must number the pages before the first use.

No pages may be removed from the field log book. Permanent ink must be used to record data. If any written error is made, then a single line must be drawn through the written error and initialed. Do not completely cross-out or black-out the error.

Documenting site conditions and legible penmanship is imperative for all field site visits and/or reconnaissance.

Data to be recorded in the field book:

- Date (MM/DD/YYYY)
- Weather Conditions
- Site Arrival Time
- Samplers (List your initials on each field event entry. If you are not alone, list all samplers initials)
- All Sample Site Names/IDs or site descriptions

- Time of Sample collection for each site
- All Field Readings:
  - *Electrical Conductivity*
  - *pH*
  - *Temperature*
  - *Dissolved Oxygen*
  - *Free/Total Chlorine results*
  - *ORP*
  - *Depth (for surface water samples)*
- If you are using another means to record field data such as a purge form, then note in your field book that all field data is recorded on corresponding form (i.e.; "See Purge Form for all Field Data").
- Note Equipment Blanks (EB), Site Blanks (SB), and Travel Blanks (TB) if taken
- Note any special QA/QC samples if taken
- Note Method of collection
- Test Series collected at each site (i.e.; 524, 507, PHARMA, 14DIOX, CLO4, GENLVLI)
- Unusual site conditions such as odors, unusual materials located near well, new plumbing on discharge, etc.
- Other miscellaneous notes on something you think may have an affect on the sample (i.e.; clear, color, aerated)
- Site Departure Time
- Note: If you are sampling with other personnel, you may log all the above details in only one field book, but you must reference this in your field book (i.e.; "Sample event details are located in Jim Smith's Field Log Book for 01-14-2012). However, you must still have the basic Sample Event information entered in your log book including Sample Date, Sampler(s) Initials, and all Sample Site Names. This is important so that Field Log Books can be cross referenced. It is also a good idea to include site arrival and departure times.

WATER QUALITY ANALYSIS PROCEDURES

Water quality analyses for the project will be completed at OCWD's state-certified laboratory in Fountain Valley, CA.

The following attachments describe the qualifications and experience of OCWD's laboratory.

Attachment A – Laboratory Certification

Attachment B – Certificate of OCWD's accredited fields of testing

Attachment C – Performance Testing Certificate

The water quality analysis conducted in OCWD's laboratory are conducted in accordance with OCWD's Laboratory Quality Assurance Manual. The analytical methods used are based on Standard Methods for the Examination of Water and Wastewater (American Water Works Association, 2012).

The water samples collected for the study will be analyzed for the following constituents:

- Volatile organic compounds (VOCs) by EPA Method 524.2
- OCWD parameter group OCR-1, which includes the following constituents and EPA Methods as shown below:

ORANGE COUNTY WATER DISTRICT
PARAMETER GROUP LIST
SORTED BY PARAMETER GROUP ABBREVIATION

Parameter Group ID: 266 **Abbreviation:** OCR-I
Name: LAB TEST SERIES OCR-I
Description:

Abbreviation	Name	Units	Method	Default Text Result	RDL
ALKPHE	Alkalinity-Phenolphthalein	mg/L	2320B		1.000
Br	Bromide	mg/L	X1-300.0		0.100
CO3Ca	Carbonate (as CaCO3)	mg/L	2320B		1.000
Ca	Calcium	mg/L	X200.7		0.100
Cl	Chloride	mg/L	X1-300.0		0.500
DOC	Dissolved Organic Carbon	mg/L	5310C		0.050
EC	Electrical Conductivity	um/cm	2510B		1.000
HCO3Ca	Bicarbonate (as CaCO3)	mg/L	2320B		1.000
K	Potassium	mg/L	X200.7		0.100
Mg	Magnesium	mg/L	X200.7		0.100
NH3-N	Ammonia Nitrogen	mg/L	4500NH3H		0.100
NO2-N	Nitrite Nitrogen	mg/L	4500NO3F		0.002
NO3-N	Nitrate Nitrogen	mg/L	X1-300.0		0.100
Na	Sodium	mg/L	X200.7		0.100
OHCa	Hydroxide (as CaCO3)	mg/L	2320B		1.000
ORG-N	Organic Nitrogen	mg/L	X1-351.2		0.100
PO4-P	Phosphate Phosphorus (orthophosphate)	mg/L	365.1		0.010
SO4	Sulfate	mg/L	X1-300.0		0.500
TDS	Total Dissolved Solids	mg/L	2540C		1.000
TKN	Total Kjeldahl Nitrogen	mg/L	X1-351.2		0.200
TOC	Total Organic Carbon (Unfiltered)	mg/L	5310C		0.050
TOTALK	Total Alkalinity (as CaCO3)	mg/L	2320B		1.000
TOTANI	Total Anions	meq/L	1030F		
TOTCAT	Total Cations	meq/L	1030F		
TOTHRD	Total Hardness (as CaCO3)	mg/L	X200.7		1.000
TURB	Turbidity	NTU	2130B		0.100
UV/TOC	UV Absorbance/TOC (unfiltered) ratio	L/mg-cm	5910B		
UVAB	Ultraviolet (absorbance)	1/cm	5910B		
pH	pH	UNITS	4500H+B		

QUALIFICATIONS OF OCWD STAFF

Resumes of key OCWD staff listed on the organization chart in the Work Plan are included in Attachment D.

REFERENCES

Orange County Water District. Main Laboratory Quality Assurance Manual. November 2011.

American Water Works Association. Standard Methods for the Examination of Water and Wastewater. 22nd Edition. May 2012.

Attachment A – Laboratory Certification

CDPH California Department of Public Health

CALIFORNIA STATE

ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM BRANCH

CERTIFICATE OF ENVIRONMENTAL ACCREDITATION

Is hereby granted to

Orange County Water District

Advanced Water Quality Assurance Laboratory

18700 Ward Street

Fountain Valley, CA 92708-6930

Scope of the certificate is limited to the
"Fields of Testing"
which accompany this Certificate.

Continued accredited status depends on successful completion of on-site, proficiency testing studies, and payment of applicable fees.

This Certificate is granted in accordance with provisions of Section 100825, et seq. of the Health and Safety Code.

Certificate No.: **1114**

Expiration Date: **02/28/2014**

Effective Date: **03/01/2012**

Richmond, California
subject to forfeiture or revocation

Fred Choske for
George C. Kulasingam, Ph.D., Chief
Environmental Laboratory Accreditation Program Branch

Attachment B – Certificate of OCWD's accredited fields of testing

Orange County Water District
Advanced Water Quality Assurance Laboratory
18700 Ward Street
Fountain Valley, CA 92708
Phone: (714) 378-3254

Certificate No.: 1114
Renew Date: 2/29/2012

Field of Testing: 101 - Microbiology of Drinking Water

101.010	001	Heterotrophic Bacteria	SM9215B
101.020	001	Total Coliform	SM9221A,B
101.021	001	Fecal Coliform	SM9221E (MTF/EC)
101.050	001	Total Coliform	SM9222A,B,C
101.051	001	Fecal Coliform	SM9221E (MF/EC)
101.060	002	Total Coliform	SM9223
101.060	003	E. coli	SM9223
101.120	001	Total Coliform (Enumeration)	SM9221A,B,C
101.130	001	Fecal Coliform (Enumeration)	SM9221E (MTF/EC)
101.140	001	Total Coliform (Enumeration)	SM9222A,B,C
101.150	001	Fecal Coliform (Enumeration)	SM9222D
101.160	001	Total Coliform (Enumeration)	SM9223

Field of Testing: 102 - Inorganic Chemistry of Drinking Water

102.030	001	Bromide	EPA 300.0
102.030	003	Chloride	EPA 300.0
102.030	005	Fluoride	EPA 300.0
102.030	006	Nitrate	EPA 300.0
102.030	007	Nitrite	EPA 300.0
102.030	008	Phosphate, Ortho	EPA 300.0
102.030	010	Sulfate	EPA 300.0
102.040	001	Bromide	EPA 300.1
102.040	002	Chlorite	EPA 300.1
102.040	003	Chlorate	EPA 300.1
102.040	004	Bromate	EPA 300.1
102.045	001	Perchlorate	EPA 314.0
102.050	001	Cyanide	EPA 335.4
102.070	001	Phosphate, Ortho	EPA 365.1
102.100	001	Alkalinity	SM2320B
102.120	001	Hardness	SM2340B
102.130	001	Conductivity	SM2510B
102.140	001	Total Dissolved Solids	SM2540C
102.234	001	Nitrite	SM4500-NO3 F
102.234	002	Nitrate	SM4500-NO3 F
102.262	001	Total Organic Carbon	SM5310C
102.263	001	DOC	SM5310C

102.270	001	Surfactants	SM5540C
102.280	001	UV254	SM5910B
102.520	001	Calcium	EPA 200.7
102.520	002	Magnesium	EPA 200.7
102.520	003	Potassium	EPA 200.7
102.520	005	Sodium	EPA 200.7
102.520	006	Hardness (calc.)	EPA 200.7
102.542	002	Silica	SM4500-SiO2 C
102.549	002	Chlorine, Free, Combined, Total	SM4500-Cl D
102.550	002	Chlorine, Free, Combined, Total	SM4500-Cl F
102.564	001	Cyanide	Quickchem 10-204-00-1-X

Field of Testing: 103 - Toxic Chemical Elements of Drinking Water

103.130	007	Chromium	EPA 200.7
103.130	009	Iron	EPA 200.7
103.130	018	Boron	EPA 200.7
103.140	001	Aluminum	EPA 200.8
103.140	002	Antimony	EPA 200.8
103.140	003	Arsenic	EPA 200.8
103.140	004	Barium	EPA 200.8
103.140	005	Beryllium	EPA 200.8
103.140	006	Cadmium	EPA 200.8
103.140	007	Chromium	EPA 200.8
103.140	008	Copper	EPA 200.8
103.140	009	Lead	EPA 200.8
103.140	010	Manganese	EPA 200.8
103.140	011	Mercury	EPA 200.8
103.140	012	Nickel	EPA 200.8
103.140	013	Selenium	EPA 200.8
103.140	014	Silver	EPA 200.8
103.140	015	Thallium	EPA 200.8
103.140	016	Zinc	EPA 200.8
103.140	018	Vanadium	EPA 200.8
103.310	001	Chromium (VI)	EPA 218.6

Field of Testing: 104 - Volatile Organic Chemistry of Drinking Water

104.030	001	1,2-Dibromoethane	EPA 504.1
104.030	002	1,2-Dibromo-3-chloropropane	EPA 504.1
104.030	003	1,2,3-Trichloropropane	EPA 504.1
104.035	001	1,2,3-Trichloropropane	SRL 524M-TCP
104.040	000	Volatile Organic Compounds	EPA 524.2
104.040	001	Benzene	EPA 524.2
104.040	007	n-Butylbenzene	EPA 524.2
104.040	008	sec-Butylbenzene	EPA 524.2
104.040	009	tert-Butylbenzene	EPA 524.2

104.040	010	Carbon Tetrachloride	EPA 524.2
104.040	011	Chlorobenzene	EPA 524.2
104.040	015	2-Chlorotoluene	EPA 524.2
104.040	016	4-Chlorotoluene	EPA 524.2
104.040	019	1,3-Dichlorobenzene	EPA 524.2
104.040	020	1,2-Dichlorobenzene	EPA 524.2
104.040	021	1,4-Dichlorobenzene	EPA 524.2
104.040	022	Dichlorodifluoromethane	EPA 524.2
104.040	023	1,1-Dichloroethane	EPA 524.2
104.040	024	1,2-Dichloroethane	EPA 524.2
104.040	025	1,1-Dichloroethene	EPA 524.2
104.040	026	cis-1,2-Dichloroethene	EPA 524.2
104.040	027	trans-1,2-Dichloroethene	EPA 524.2
104.040	028	Dichloromethane	EPA 524.2
104.040	029	1,2-Dichloropropane	EPA 524.2
104.040	033	cis-1,3-Dichloropropene	EPA 524.2
104.040	034	trans-1,3-Dichloropropene	EPA 524.2
104.040	035	Ethylbenzene	EPA 524.2
104.040	037	Isopropylbenzene	EPA 524.2
104.040	039	Naphthalene	EPA 524.2
104.040	041	N-propylbenzene	EPA 524.2
104.040	042	Styrene	EPA 524.2
104.040	044	1,1,2,2-Tetrachloroethane	EPA 524.2
104.040	045	Tetrachloroethene	EPA 524.2
104.040	046	Toluene	EPA 524.2
104.040	048	1,2,4-Trichlorobenzene	EPA 524.2
104.040	049	1,1,1-Trichloroethane	EPA 524.2
104.040	050	1,1,2-Trichloroethane	EPA 524.2
104.040	051	Trichloroethene	EPA 524.2
104.040	052	Trichlorofluoromethane	EPA 524.2
104.040	054	1,2,4-Trimethylbenzene	EPA 524.2
104.040	055	1,3,5-Trimethylbenzene	EPA 524.2
104.040	056	Vinyl Chloride	EPA 524.2
104.040	057	Xylenes, Total	EPA 524.2
104.045	001	Bromodichloromethane	EPA 524.2
104.045	002	Bromoform	EPA 524.2
104.045	003	Chloroform	EPA 524.2
104.045	004	Dibromochloromethane	EPA 524.2
104.045	005	Trihalomethanes	EPA 524.2
104.050	002	Methyl tert-butyl Ether (MTBE)	EPA 524.2
104.050	004	tert-Amyl Methyl Ether (TAME)	EPA 524.2
104.050	005	Ethyl tert-butyl Ether (ETBE)	EPA 524.2
104.050	006	Trichlorotrifluoroethane	EPA 524.2

104.050	007	tert-Butyl Alcohol (TBA)	EPA 524.2
104.050	008	Carbon Disulfide	EPA 524.2
104.050	009	Methyl Isobutyl Ketone	EPA 524.2

Field of Testing: 105 - Semi-volatile Organic Chemistry of Drinking Water

105.030	000	N-, P- Pesticides	EPA 507
105.030	001	Alachlor	EPA 507
105.030	002	Atrazine	EPA 507
105.030	007	Molinate	EPA 507
105.030	009	Simazine	EPA 507
105.030	010	Thiobencarb	EPA 507
105.040	000	Chlorinated Pesticides	EPA 508
105.040	003	Chlordane (total)	EPA 508
105.040	007	Endrin	EPA 508
105.040	008	Heptachlor	EPA 508
105.040	009	Heptachlor Epoxide	EPA 508
105.040	010	Hexachlorobenzene	EPA 508
105.040	011	Hexachlorocyclopentadiene	EPA 508
105.040	012	Lindane	EPA 508
105.040	013	Methoxychlor	EPA 508
105.040	015	Toxaphene	EPA 508
105.040	016	PCBs as Aroclors (screen)	EPA 508
105.083	001	2,4-D	EPA 515.4
105.083	002	Dinoseb	EPA 515.4
105.083	003	Pentachlorophenol	EPA 515.4
105.083	004	Picloram	EPA 515.4
105.083	005	2,4,5-TP	EPA 515.4
105.083	006	Dalapon	EPA 515.4
105.083	007	Bentazon	EPA 515.4
105.083	008	Dicamba	EPA 515.4
105.083	009	Chlorinated Acids	EPA 515.4
105.090	001	Alachlor	EPA 525.2
105.090	003	Atrazine	EPA 525.2
105.090	004	Benzo(a)pyrene	EPA 525.2
105.090	006	Chlordane	EPA 525.2
105.090	008	Di(2-ethylhexyl) Adipate	EPA 525.2
105.090	009	Di(2-ethylhexyl) Phthalate	EPA 525.2
105.090	013	Endrin	EPA 525.2
105.090	014	Heptachlor	EPA 525.2
105.090	015	Heptachlor Epoxide	EPA 525.2
105.090	016	Hexachlorobenzene	EPA 525.2
105.090	017	Hexachlorocyclopentadiene	EPA 525.2
105.090	018	Lindane	EPA 525.2
105.090	019	Methoxychlor	EPA 525.2

105.090	022	Molinate	EPA 525.2
105.090	023	Pentachlorophenol	EPA 525.2
105.090	025	Simazine	EPA 525.2
105.090	028	Thiobencarb	EPA 525.2
105.090	029	Polynuclear Aromatic Hydrocarbons	EPA 525.2
105.090	030	Adipates	EPA 525.2
105.090	031	Phthalates	EPA 525.2
105.090	032	Other Extractables	EPA 525.2
105.101	001	Carbofuran	EPA 531.2
105.101	002	Oxamyl	EPA 531.2
105.101	003	Aldicarb	EPA 531.2
105.101	004	Aldicarb Sulfone	EPA 531.2
105.101	005	Aldicarb Sulfoxide	EPA 531.2
105.101	006	Carbaryl	EPA 531.2
105.101	007	3-Hydroxycarbofuran	EPA 531.2
105.101	008	Methomyl	EPA 531.2
105.120	001	Glyphosate	EPA 547
105.140	001	Endothall	EPA 548.1
105.150	001	Diquat	EPA 549.2
105.161	000	Polynuclear Aromatic Hydrocarbons	EPA 550.1
105.161	001	Benzo(a)pyrene	EPA 550.1
105.170	031	Disinfection Byproducts	EPA 551.1
105.200	001	Bromoacetic Acid	EPA 552.2
105.200	003	Chloroacetic Acid	EPA 552.2
105.200	004	Dalapon	EPA 552.2
105.200	005	Dibromoacetic Acid	EPA 552.2
105.200	006	Dichloroacetic Acid	EPA 552.2
105.200	007	Trichloroacetic Acid	EPA 552.2
105.200	008	Haloacetic Acids (HAA5)	EPA 552.2

Field of Testing: 107 - Microbiology of Wastewater

107.010	001	Heterotrophic Bacteria	SM9215B
107.020	001	Total Coliform	SM9221B
107.040	001	Fecal Coliform	SM9221C,E (MTF/EC)
107.060	001	Total Coliform	SM9222B
107.080	001	Fecal Coliform	SM9222D

Field of Testing: 108 - Inorganic Chemistry of Wastewater

108.090	001	Residue, Volatile	EPA 160.4
108.112	001	Boron	EPA 200.7
108.112	002	Calcium	EPA 200.7
108.112	003	Hardness (calc.)	EPA 200.7
108.112	004	Magnesium	EPA 200.7
108.112	005	Potassium	EPA 200.7
108.112	007	Sodium	EPA 200.7

108.120	001	Bromide	EPA 300.0
108.120	002	Chloride	EPA 300.0
108.120	003	Fluoride	EPA 300.0
108.120	004	Nitrate	EPA 300.0
108.120	005	Nitrite	EPA 300.0
108.120	006	Nitrate-nitrite	EPA 300.0
108.120	007	Phosphate, Ortho	EPA 300.0
108.120	008	Sulfate	EPA 300.0
108.183	001	Cyanide, Total	EPA 335.4
108.211	001	Kjeldahl Nitrogen	EPA 351.2
108.260	001	Phosphate, Ortho	EPA 365.1
108.390	001	Turbidity	SM2130B
108.410	001	Alkalinity	SM2320B
108.420	001	Hardness (calc.)	SM2340B
108.430	001	Conductivity	SM2510B
108.440	001	Residue, Total	SM2540B
108.441	001	Residue, Filterable	SM2540C
108.442	001	Residue, Non-filterable	SM2540D
108.443	001	Residue, Settleable	SM2540F
108.462	001	Chlorine	SM4500-Cl D
108.464	001	Chlorine	SM4500-Cl F
108.470	001	Cyanide, Manual Distillation	SM4500-CN C
108.480	001	Fluoride	SM4500-F C
108.490	001	pH	SM4500-H+ B
108.498	001	Ammonia	SM4500-NH3 H (18th)
108.522	001	Nitrate-nitrite	SM4500-NO3 F
108.522	002	Nitrite	SM4500-NO3 F
108.523	001	Nitrate calc.	SM4500-NO3 F
108.551	001	Silica	SM4500-SiO2 C (20th)
108.580	001	Sulfide	SM4500-S= D
108.611	001	Total Organic Carbon	SM5310C
108.640	001	Surfactants	SM5540C
108.660	001	Chemical Oxygen Demand	HACH8000
108.926	001	Cyanide	Quickchem 10-204-00-1-X

Field of Testing: 109 - Toxic Chemical Elements of Wastewater

109.010	009	Chromium	EPA 200.7
109.010	012	Iron	EPA 200.7
109.010	026	Vanadium	EPA 200.7
109.020	001	Aluminum	EPA 200.8
109.020	002	Antimony	EPA 200.8
109.020	003	Arsenic	EPA 200.8
109.020	004	Barium	EPA 200.8
109.020	005	Beryllium	EPA 200.8

109.020	006	Cadmium	EPA 200.8
109.020	008	Cobalt	EPA 200.8
109.020	009	Copper	EPA 200.8
109.020	010	Lead	EPA 200.8
109.020	011	Manganese	EPA 200.8
109.020	012	Molybdenum	EPA 200.8
109.020	013	Nickel	EPA 200.8
109.020	014	Selenium	EPA 200.8
109.020	015	Silver	EPA 200.8
109.020	016	Thallium	EPA 200.8
109.020	018	Zinc	EPA 200.8
109.104	001	Chromium (VI)	EPA 218.6

Attachment C – Performance Testing Certificate

Certificate of Quality

This certifies that

Orange County Water District

has successfully completed

Proficiency Testing for 2011 with an Acceptance Rate of 100.00%

Presented by

RTC

Laramie, WY

on ***January 04, 2012***

R.T. CORP.
CORPORATE
SEAL
1988
WYOMING

Jennifer Jones
Proficiency Testing Coordinator

RT1143

Attachment D – Resumes of OCWD Staff

David L. Mark, R.G., C.HG.

Principal Hydrogeologist, Orange County Water District
Fountain Valley, CA

Mr. Mark has over 25 years experience managing and conducting soil and groundwater impact assessments; remediation feasibility studies; soil and groundwater remediation; technical support for environmental liability actions and allocation; private and municipal groundwater supply projects; production well rehabilitation; reclaimed water/groundwater recharge projects; seawater intrusion projects, technical support for establishing groundwater rights; well installation, sampling, and testing; groundwater flow and solute-transport modeling; landfill investigations; detection monitoring programs for surface impoundments; community relations; environmental impact reports; and land-use feasibility investigations.

Mr. Mark's primary responsibilities with the Orange County Water District (OCWD) are serving as project manager for the North Basin Groundwater Protection Project (NBGPP) and the Alamitos Sea Water Intrusion Barrier Project. The NBGPP involves containing regional plumes of volatile organic compounds in groundwater that cover approximately 10 square miles. Mr. Mark also provides technical support for OCWD's litigation to recover costs for implementing the project.

Mr. Mark has also served as a part-time instructor for two courses: The Remedial Investigation and Feasibility Study Process, and Managing Environmental Projects. These courses were part of an environmental certificate program offered through University of California, Irvine Extension.

Education

M.S., Geology (Hydrogeology), San Diego State University (1987)
B.S., Geology, California State University, Northridge (1983)
B.A., Earth Science, California State University, Northridge (1979)

Professional Registrations

California Professional Geologist (No. 4485)
California Certified Hydrogeologist (No. HG 46)

Representative Projects

Environmental

CERCLA/SARA

Served as Site Manager for the oversight of the Remedial Design and Remedial Action (RD/RA) for the Puente Valley Operable Unit of the San Gabriel Basin. This project involves providing technical oversight for EPA during pre-design investigation and analysis, and RD/RA activities conducted by Potentially Responsible Parties (PRPs). The remedy involves groundwater containment (pump and treat) and monitoring at the mouth of Puente Valley to prevent groundwater contaminated with volatile organic compounds (VOCs), 1,4-dioxane, and perchlorate in Puente Valley from further impacting potable water supplies in the San Gabriel Basin. Have also provided technical support to EPA for negotiations with PRPs and allocation assessment. This has involved working directly with EPA and Department of Justice attorneys, and active participation in PRP negotiations. This has also involved working with the Los Angeles Regional Water Quality Control Board (RWQCB) who has been tasked with identifying PRPs and mandating facility-specific remedial actions (i.e., in contrast to the regional remedy under the purview of EPA).

Was the project manager and lead hydrogeologist for the remedial investigation and feasibility study (RI/FS) of the Thomas Ranch Site in Corona, California. Four 0.1- to 0.6-acre ponds that contain waste material (sludge) from the refining of high-octane aviation fuel during World War II are located on the property. The waste material is very acidic and contains benzene and organic sulfur compounds (thiophenes). Groundwater has been impacted by the waste material. Responsibilities included project management and technical oversight of tasks that involved evaluating existing data; developing a project database; preparing an RI report, Baseline Health Risk Assessment, and FS; technical support to the Federal Deposit Insurance Corporation (FDIC) for their preparation of a remedial action plan (RAP); and community relations support during the public review period.

Served as project manager for the Marine Corps Base, Camp Pendleton RI/FS. The project involved preparing project plans; investigating soil and groundwater at numerous hazardous waste sites and landfills; evaluating potential impacts to aquifers that provide the Base's potable water supply; establishing and implementing a computerized database; conducting human health and ecological risk assessments; developing and evaluating remedial alternatives; preparing RI and FS reports; and providing community relations support to the Base. Was responsible for overall project management; technical oversight; and interface with the Navy; Camp Pendleton; and numerous federal, state, and local agencies. Also gave numerous presentations at briefings and public meetings.

Managed specific tasks and the overall project for the San Gabriel Basin RI/FS in Los Angeles County, California. Responsibilities included project and task management; monitoring well installation and sampling, including the installation, testing, and sampling of 800-foot-deep monitoring well clusters and multiport wells; spinner logging and depth-specific sampling of production wells; aquifer testing; hydrogeologic and groundwater quality evaluations; water resource planning; numerical modeling of groundwater flow and contaminant transport; preparation of feasibility studies; and community relations support.

RCRA

Was the senior technical reviewer for the Resource, Conservation, and Recovery Act (RCRA) Facility Assessment (RFA) of Marine Corps Base Camp Pendleton in California.

The RFA included the preliminary review, visual site inspection, and sampling visit for approximately 400 solid waste management units and areas of concern.

General Site Investigations
Provided senior technical review, strategy development, and liaison with the RWQCB for soil and groundwater assessments, remediation, and redevelopment at an active aerospace facility in Torrance, California. With the installation of vapor barriers, site redevelopment was conducted concurrent with further soil and groundwater assessment and remediation (soil vapor extraction). Soil and groundwater at this site are impacted with VOCs and 1,4-dioxane.

Provided senior technical review and approach development for groundwater investigation and remediation at Air Force Plant 42 in Palmdale, California. This site include numerous specific locations under investigation for past releases of VOCs. Helped develop and secure regulatory agency (RWQCB and DTSC) approval for implementing a groundwater re-circulation cell with in-situ chemical oxidation as a means to remediate the site and to address previous and potential future impacts to nearby production wells.

For a large aerospace company in Southern California, served as project manager for the development of a work plan to investigate the extent of the Redlands Plume, a regional plume of VOCs in the eastern end of the Bunker Hill Groundwater Basin, San Bernardino County, California. Successfully negotiated approval of that work plan with the Santa Ana Regional Water Quality Control Board.

Was the project manager for a hydrogeologic assessment of the potential impact of expanded gravel mining operations along Lytle Creek in San Bernardino County. Numerous water supply wells are located adjacent to the gravel mine. The hydrogeologic assessment evaluated potential impacts to those water supply wells. The assessment also supported the permitting process for expanding the mine.

Served as the project manager and principal investigator for preparing the work plan, conducting the field investigation (soil sampling), evaluating results, and preparing a Site Inspection (SI) report for three locations at Naval Weapons Station in Fallbrook, California, with stockpiles of leaking napalm bombs. Also presented the results of the SI at a briefing with Navy personnel, and state and county officials.

Landfills
Provided senior technical review and oversight for the evaluation and control of landfill gas migrating near residences constructed adjacent to Coyote Canyon Landfill in Orange County. This involved a detailed evaluation of the complex local geology (fractured, faulted, and folded sedimentary bedrock), and developing an understanding of the landfill gas migration pathways.

Served as project manager for the investigation of Box Canyon, Las Pulgas, and San Onofre Landfills on Marine Corps Base Camp Pendleton. These projects involved preparing a work plan and sampling and analysis plan; installing, aquifer testing, and sampling several monitoring well clusters to evaluate potential groundwater impacts; collecting air samples at an elementary school and residences located adjacent to Box Canyon landfill; and evaluating and reporting results of the field investigations.

Underground and Aboveground Storage Tank Services
Was the principal investigator and author for an underground tank management plan for 15 tanks at Wastewater Reclamation Plants 1 and 2 for the County Sanitation Districts of Orange County.

Served as project manager for the site assessment (soil and groundwater) of several underground and aboveground tank sites at Marine Corps Base Camp Pendleton.

Surface Impoundments/California Administrative Code Title 23
Was the project hydrogeologist for developing statistically based detection monitoring programs for surface impoundments at two solar-powered electric generating plants in the Mojave Desert in California. Unique hydrogeologic conditions at each generating station necessitated the development of different statistical evaluation procedures, which were approved by the California Regional Water Quality Control Board, Lahontan Region.

Remediation
Currently the project manager for the NBGPP which involves the containment of groundwater contaminated with VOCs in the Forebay of the Orange County Groundwater Basin. Extensive VOC contamination has impacted several drinking water wells in the City of Fullerton, and is threatening potable wells in the City of Anaheim. The project involves constructing extraction wells, a centralized treatment plant, injection wells, and miles of pipelines. The expected groundwater extraction rate is approximately 3,000 gallons per minute.

Provided technical review and oversight of the design of groundwater extraction and treatment systems for the mouth of Puente Valley, as discussed above under CERCLA/SARA projects.

Managed the evaluation of an existing groundwater extraction and treatment system, and a soil vapor extraction and treatment system at a former manufacturing facility in the City of Industry, California. The purpose of this evaluation was to determine the most cost-effective means of operating these systems while proceeding to site closure in a reasonable time frame. This evaluation is resulting in the operation of the remediation systems in a more cost-effective manner, and the shutdown of several soil vapor and groundwater extraction wells.

Served as project manager for the design of a soil vapor extraction system under an existing warehouse in Los Angeles County. This building was constructed over parts of a former manufactured gas plant and chemical processing plant.

Water Resources

Production Well Installation and Maintenance
Served as the project manager and senior technical reviewer for the installation of several production wells for Eastern Municipal Water District in eastern Riverside County, California. These well will supply brackish groundwater to a desalination plant. The treated water will be used for potable water supply.

Provided senior technical review for the installation of several extraction wells in the Palmdale-Landcaster area for Los Angeles County Department of Public Works. Production well installation has included depth-specific sampling to support construction of the wells in a manner that minimizes impacts from nitrate.

Served as project manager and lead hydrogeologist for the installation of a large-capacity municipal production well for Prescott Valley Water District. The well is 1,200 feet deep and has a sustained operating capacity of 3,000-gallons per minute. This well was installed under a very tight schedule due to water shortages in the Town of Prescott Valley, Arizona. The project received the National Ground Water Association's Outstanding Projects Commendation Award.

Conducted rehabilitation and testing of idle production wells in Owens Dry Lake, Owens Valley, California. Evaluated the potential use of these wells for temporary water supply.

For a manufacturing client in the San Gabriel Valley, evaluated the condition of their production well field, rehabilitated 6 wells, and developed an operating plan to minimize groundwater production costs.

Provided technical review of proposed well construction (i.e., well materials and screened interval) for several production wells in Southern California, including Corona, South El Monte, Long Beach, and Pico Rivera.

Was the field hydrogeologist for the installation and testing of an 800-foot-deep, 3,000-gpm municipal water production well for the City of Santa Ana.

Water Resource Development

Currently serving as project manager for the Alamitos Seawater Intrusion Barrier along the Orange/Los Angeles County line. This project involves continuously injecting water via a line of injection wells to prevent continued seawater intrusion through the Alamitos gap. Additional barrier expansion is currently being planned and implemented.

Provided confidential technical support to attorneys to establish water rights and develop groundwater yield and storage projects in groundwater basins in Southern California. Groundwater development projects include producing and treating poor quality native groundwater, enhancing natural recharge through physical controls, and conjunctive use projects using imported water and recycled water, including aquifer storage and recharge (ASR).

Working jointly for the City of Downey and the California Department of Transportation (CALTRANS), served as Task Manager for the evaluation of groundwater conditions and dewatering operations on the Interstate105 Freeway (I-105) in Downey. This evaluation supported a feasibility study for the beneficial re-use of groundwater produced by the dewatering of the I-105 Freeway.

Conducted a hydrogeologic assessment of a proposed groundwater development project in the San Bernardino Mountains. The assessment included evaluating available groundwater resources, and potential impact of extracting groundwater for sale to a water bottling company. The hydrogeologic assessment was used to support an Environmental Impact Report for a Conditional Use Permit to extract and export the groundwater.

California Environmental Quality Act/National Environmental Policy Act

Was the project manager and principal investigator for environmental impact reports/ statements for proposed residential, commercial, and industrial developments; municipal projects; redevelopment funds; and general plan amendments. Project locations include Los Angeles, Ventura, Santa Barbara, and Kern Counties.

Community Relations

Served as the primary presenter at numerous public meetings; project manager for the preparation of numerous fact sheets; and project manager for the preparation and implementation of Community Relations Plans for National Priorities List (NPL) sites and a State Superfund site, all in Southern California.

Publications

Sun, Kerang, Dolegowski, John, and Mark, David. "Delineation of Well Capture Zones in Complex 3-D Aquifer Systems," *proceedings of the National Groundwater Association Groundwater Exposition*, Las Vegas, NV. 2004.

Mark, David L., Bohrnerud, A., Rowland, K., and Nolan, C. "Impact of Butadiene Production at a Former Manufactured Gas Plant," *Proceedings of the Gas Technology Institute's Site Remediation Technologies & Environmental Management Practices in the Utility Industry Conference*. Orlando, Florida. 2000.

Mark, David L., L. A. Holm, and N. L. Ziemba. "Application of the Observational Method to an Operable Unit Feasibility Study-A Case Study," *Proceedings of the 10th National HMCRI Conference-Superfund '89, Washington, D.C.* 1989.

Mark, David L. "An Evaluation of Potential Saltwater Intrusion in the Ocotillo-Coyote Wells Groundwater Basin, Imperial County, County." M.S. Thesis, San Diego State University. 1987.

Mark, David L., D. S. Williams, and D. Huntley. "Application of Dipole-Dipole Resistivity Surveys to a Hydrogeologic Investigation," *Proceedings of the Surface and Borehole Geophysical Methods and Groundwater Instrumentation Conference* sponsored by the National Water Well Association. Denver, Colorado. 1986.

Roy L. Herndon

Chief Hydrogeologist, Orange County Water District

Fountain Valley, CA

Mr. Herndon has over 25 years professional experience in hydrogeologic investigations pertaining to environmental and water supply projects. These projects include the delineation of groundwater contaminant plumes over several miles long, characterization of hydrogeologic systems ranging from one-acre sites to the 300-square-mile Orange County groundwater basin, evaluation and control of sea water intrusion, and design of groundwater recharge and extraction systems for water supply and contamination remediation, respectively.

Mr. Herndon manages the Hydrogeology Department at the Orange County Water District and has directed hydrogeologic studies that have collectively entailed the construction of over 150 monitoring wells, 50 of which exceed 1,000 feet in depth. He is responsible for overseeing all departmental activities including the construction of a basin-wide numerical groundwater flow model, development of a comprehensive data management and geographic information system, and design/construction of multidepth monitoring wells and municipal water wells. Mr. Herndon acts as a liaison to state and local regulatory staff in reviewing technical reports submitted by parties performing subsurface environmental investigations. He has given numerous presentations to professional, regulatory, and industrial organizations, served as guest lecturer to university classes, and has been a continuing education program course instructor at the University of California, Irvine.

EDUCATION

M.S., Hydrology and Water Resources (1985), University of Arizona, Tucson
B.A., Geology (1982), Colorado College, Colorado Springs

PROFESSIONAL REGISTRATIONS

California Professional Geologist No. 4817
California Certified Hydrogeologist No. 113

EMPLOYMENT HISTORY

1992 - present:	Chief Hydrogeologist, Orange County Water District
1988 - 1992:	Project Hydrogeologist, Orange County Water District
1985 - 1988:	Project Hydrogeologist, Harding Lawson Associates

ACTIVITIES/MEMBERSHIPS

Chairman, Orange County Well Standards Advisory Board
Director, Groundwater Resources Association of California
Member, Santa Ana River Watermaster
Member, Alamitos Seawater Barrier Joint Management Committee
Member, South Coast Geological Society
Member, MCAS El Toro Restoration Advisory Board

REPRESENTATIVE PROJECTS

Sea Water Intrusion Evaluation/Control

Talbert Seawater Barrier Expansion – Directed design and construction of 21 new multi-depth injection wells to more than double the capacity of the barrier to 30-40 mgd. Source water is highly-treated recycled water from OCWD's Groundwater Replenishment System.

Talbert Seawater Barrier Well Rehabilitation - Evaluated causes of declining injection rates of 81 individual injection wells in operation since 1975. Developed and implemented several programs to mitigate corrosion holes in casing, clogging of perforations and gravel pack, and leakage of injection water to ground surface. Programs included installing casing liners, permeation and jet grouting around casings, and chemical/mechanical well development techniques.

Talbert Gap Groundwater Model - Managed development of groundwater flow model of multi-aquifer system within the Talbert Gap, through which sea water can intrude the Orange County groundwater basin. Model was used to estimate impacts to the existing injection well barrier due to proposed additional pumping by city of Newport Beach.

Alamitos Sea Water Barrier Expansion - Determined that additional injection wells were necessary to stop further sea water intrusion around and through the existing network of 35 injection wells spanning the Alamitos Gap between Los Angeles and Orange counties. Nine additional injection wells and three multi-depth monitoring wells were constructed in 1999-2000.

Alamitos Barrier Reclamation Project - Technically reviewed hydrogeologic portion of feasibility study to convert 50% of the injection water to reclaimed water. Regulatory guidelines required that travel times and percentages of injection water be estimated at municipal-supply wells in proximity to the barrier.

Artificial Recharge/Hydrogeologic Characterization

Orange County Water District Recharge Facilities - Developed conceptual hydrogeologic model of region surrounding the 1,000-acre surface spreading facilities; sited and designed five 1,000-foot multidepth and over 20 shallow monitoring wells to evaluate recharge mounding potential and effective depth of recharge in vicinity of basins; examined numerous borehole lithologic and geophysical logs, well and basin hydrographs to assess potential loss of vadose zone and clogging of spreading basins.

Santa Ana River Water Quality and Health Study - Manager of hydrogeologic characterization portion of $10 million study to delineate flow paths and travel times of groundwater from point of recharge to point of extraction at nearby production wells; developed and implemented an ongoing isotopic tracer study with Lawrence Livermore National Laboratory to "label" and track recharge water following percolation at OCWD's Anaheim spreading basins.

Orange County Water Reclamation Project [later known as the Groundwater Replenishment System] Feasibility Study - Prepared hydrogeologic portion of feasibility study report describing the percolation capacity of the OCWD recharge facilities and piezometric and water quality characteristics of the underlying aquifers in the city of Anaheim; evaluated the potential for recharging up to 100,000 acre-feet of reclaimed water at these facilities.

Artificial Recharge Feasibility Study, Butler Valley, Arizona - Conducted hydrogeologic investigation of remote desert basin, located along Central Arizona Project aqueduct, to evaluate its potential as a conjunctive-use storage basin; supervised construction of two 600-foot deep monitoring wells; performed aquifer testing and analysis; assisted with seismic and gravity surveys; constructed numerical flow model to estimate maximum basin storage potential.

Regional TCE/TDS/Nitrate Groundwater Contamination Investigation - Managed three-year investigation to determine source and extent of groundwater containing TCE, TDS, and nitrates in Irvine Subbasin; designed/supervised construction of twelve monitoring wells ranging from 150 to 1,300 feet deep; prepared two reports documenting evidence and rationale for conclusion of MCAS El Toro as the source of a four-mile-long TCE plume, resulting in Superfund designation of site.

North Basin Groundwater Protection Project - Directing ongoing remediation project (est. $45 million capital) to clean up chlorinated VOC contamination over a 5-square mile area; sited, directed construction of 5 extraction wells and 50+ monitoring wells.

Groundwater Numerical Modeling

Orange County Groundwater Basin Management - Directed development and transient calibration of numerical flow model (MODFLOW) of 300-square mile basin; model contains over 40,000 active cells and was successfully used to evaluate mounding potential beneath Anaheim Forebay recharge facilities under increasing recharge conditions and effects of shifting future groundwater production inland to lessen recharge mounding potential and reduce drawdown in coastal areas of the basin.

Irvine Desalter Project - Developed numerical flow model (MODFLOW/MODPATH) of Irvine subbasin used to design layout of 7.5-mgd production well field as part of a $45 million (capital) combined water supply/groundwater remediation facility to remove groundwater containing elevated TDS, nitrate, and TCE.

Oak Creek Canyon Water Supply Evaluation - Managed project to determine safe yield of small groundwater basin near Tehachapi, California for cement plant operations; designed and supervised construction and pump testing of two water wells; developed conceptual hydrogeologic and numerical flow models (MODFLOW) to evaluate maximum yield of basin.

Groundwater Salinity Investigation, Laughlin, Nevada - Developed groundwater flow and solute transport model (PLASM/Random Walk) to evaluate the effectiveness of an extraction system to contain a high-salinity groundwater plume at a power generating plant; supervised construction of multidepth monitoring wells to delineate extent of saline plume.

Data Management

OCWD Water Resources Management System - Managed design and construction of integrated database, GIS, CAD, and modeling software that stores and retrieves historical geologic, well construction, water level, water quality, and groundwater production data; system originally developed in client-server (DOS-UNIX) and converted to Windows; directed 20-year effort (ongoing) to compile, organize, code, and key-enter/digitize hundreds of thousands of paper records of geologic/water resources data.

PUBLICATIONS

Herndon, R.L., and Bonsangue, J.D., *Hydrogeology of Orange County Groundwater Basin -- An Updated Overview*, in Geology of the Orange County Region, Southern California, Field Trip Guide Book No. 33, John Bonsangue and Robert Lemmer ed., South Coast Geological Society, Inc., 2006.

Clark, J.F., Hudson, G.B., Davisson, M.L., Woodside, G., Herndon, R., *Geochemical Imaging of Flow Near an Artificial Recharge Facility, Orange County, California*, Ground Water, Vol. 42, No. 2, March-April 2004.

Herndon, R.L., Woodside, G.D., Davisson, M.L., Hudson, G.B., *Use of Isotopes to Estimate Groundwater Age and Flow Path*, Southwest Hydrology, Vol. 2, No. 1, January/February 2003.

Grebbien, V., Ide, C., and Herndon, R., *Alternatives to Adjudications – The OCWD Model*, presented by V. Grebbien at CLE California Water Law Conference, Irvine, CA, October, 2002.

Gamlin, J.D., Clark, J.F., Woodside, G., Herndon, R., *Large-Scale Tracing of Ground Water with Sulfur Hexafluoride*, Jour. of Environ. Engr., February 2001.

Davisson, M.L., Hudson, G.B., Esser, B.K., Ekwurzel, B., Herndon, R.L., *Tracing and Age-Dating Recycled Waste Water Recharge for Potable Reuse in a Seawater Injection Barrier, Southern California, USA*, International Atomic Energy Agency, International Symposium on Isotope Techniques in Water Resources Development and Management, Vienna, 10-14 May, 1999. IAEA-SM-361/36

Davisson, M.L., Hudson, G.B., Moran, J., Niemeyer, S., Herndon, R., *Isotope Tracer Approaches for Characterizing Artificial Recharge and Demonstrating Regulatory Compliance,* Annual UC Water Reuse Research Conference, Monterey, CA, June 1998.

Davisson, M.L., Hudson, G.B., Herndon, R., Niemeyer, S., Beiriger, J., *Report on the Feasibility of Using Isotopes to Source and Age-Date Groundwater in Orange County Water District's Forebay Region, Orange County, California*, Lawrence Livermore National Laboratory ref. #UCRL-ID-123953, May 1996.

Crook, J., Herndon, R.L., Wehner, M.P., and Rigby, M.G., *Studies to Determine the Effects of Injecting 100 Percent Reclaimed Water from Water Factory 21*, Proceedings of Annual Water Environment Federation Conference, Miami, FL, 1995.

Herndon, R.L., *Hydrogeology of Orange County Groundwater Basin -- An Overview*, in The Regressive Pleistocene Shoreline, Coastal Southern California, Annual Field Trip Guide Book No. 20, Edward G. Heath and W. Lavon Lewis ed., South Coast Geological Society, Inc., 1992.

PRESENTATIONS

Winning the Battle Against Seawater Intrusion with Recycled Water, National Ground Water Association Annual Water Summit, Garden Grove, CA, May 2012.

Geophysical Mapping Saltwater Intrusion in the Sunset Gap, Groundwater Resources Association Geophysics Symposium, Santa Ana, CA, May 2010.

The Orange County Groundwater Basin: A Resource Worth Protecting, National Research Council committee meeting on "Future Options for Management in the Nation's Subsurface Remediation Effort," Irvine, CA, May 2010.

Large-Scale Aquifer Replenishment and Seawater Intrusion Control Using Recycled Water in Californi, International Workshop on Artificial Recharge for Groundwater Management, sponsored by International Water Resources Association (Spanish Chapter) and Instituto Geologico y Minero de Espana, Mallorca, Spain, October 2009.

Challenging but Well Worth It – Developing Recycled Water Supplies in Orange County, Association of Environmental and Engineering Geologists, South Lake Tahoe, NV, September 2009.

The Battle to Provide Clean Water to a Growing Population, California State University Fullerton Colleagues Colloquium, Fullerton, CA, April 2009.

Cleaning Up Someone Else's Plume -- Orange County Water District's North Basin Groundwater Protection Project, California Geological Symposium, Sacramento, CA, May 2008.

Infrastructure Building for Groundwater Management, Groundwater Resources Association Annual Conference, Sacramento, CA, September 2007.

Geochemical Imaging of Flow Near an Artificial Recharge Facility, Orange County, California, Groundwater Resources Association High Resolution Symposium, Long Beach, CA, November 2006.

Recycled Water: Conveying the Message to Non-Water Experts, presented as part of a colloquium series hosted by U.C. Berkeley's Water Resources Archives, May 2006.

Two Years Down the Road of Sustainable Groundwater Pumping, presented at Groundwater Resources Association Conference, Pasadena, CA, September 2005.

Well, Is There Water or Not? OCWD's 12-Step Program to Recover from Drought, presented for Gen. Mgr. Virginia Grebbien at Groundwater Resources Association Annual Conference, Rohnert Park, CA, September 2004.

How Much Can We Pump? Identifying and Overcoming the Limiting Factors of the Orange County Groundwater Basin, presented at Association of Ground Water Scientists and Engineers Annual Conference, Orlando, FL, December 2003.

Building and Managing a Network of Over 200 Monitoring Wells in Orange County, presented at Water Education Foundation/Association of Groundwater Agencies conference, Ontario, CA, April 2002.

35 Years of Controlling Seawater Intrusion in Orange County, California, presented at Georgia Geological Survey workshop on seawater intrusion, Savannah, GA, September 2001.

Orange County's Groundwater: A Resource Worth Protecting, presented at the California Environmental Law Conference, Yosemite, October 1999.

Hydrogeologic Aspects of Recharging 250,000+ af/year in Orange County, presented at the American Ground Water Trust Workshop "The Latest on Artificial Recharge," Scottsdale, AZ, September 1999.

Measuring Success of Source Water Protection in Orange County, California, presented at Source Water Assessment and Protection 98 conference, Dallas, TX, 1998.

Orange County Water District's Hydrogeology and Modeling Objectives, presented at WateReuse Association of California Groundwater Recharge Workshop, Newport Beach, CA, 1997.

An Update on Groundwater Contamination in Orange County – Chlorinated Compounds and MTBE, presented at Groundwater Resources Association Conference, Costa Mesa, CA, 1996.

Orange County Water District Groundwater Management Plan: Water Quality and Hydrogeologic Perspectives, presented to ASCE North American Water Environment Congress, Anaheim, CA, 1996.

Hydrogeology of Alamitos Gap, Los Angeles and Orange County, California, presented at Association of Engineering Geologists/Groundwater Resources Association annual meeting, Sacramento, CA, 1995.

Orange County's Groundwater -- A Resource Worth Protecting, presented to Orange County Chamber of Commerce environmental workshop, Irvine, CA, 1993.

Hydrogeologic Evolution of the Orange County Groundwater Basin, presented at American Association of Petroleum Geologists Cordilleran Section annual meeting, Long Beach, CA, 1993.

El Toro TCE Investigation, presented to Association of Hazardous Materials Professionals, Anaheim, CA, 1991.

Chlorinated VOC Investigation in Anaheim, California, presented to Association of Engineering Geologists, southern California region, Montebello, CA, 1991.

TECHNICAL ADVISORY PANELS

AB303 Grant Program – Served on TAP for California Department of Water Resources to review and comment on grant program structure and subsequent proposals submitted for funding of groundwater monitoring and data management projects throughout the state.

Dana Point Desalination Project – Served on TAP to review and comment on proposed alternatives to construct a slant subsurface extraction well beneath the beach and near-shore seafloor for a potential future seawater desalination project to supply south Orange County, California.

Elsinore Valley Groundwater Management Plan – Served on TAP to review and comment on a groundwater management plan prepared for the Elsinore Valley Municipal Water District.

Georgia Seawater Intrusion – Served on TAP for state of Georgia to review existing seawater intrusion conditions between Hilton Head, South Carolina to Brunswick County, Georgia and recommend potential control alternatives.

Des Moines, Iowa ASR Project – Served on TAP for U.S. EPA-funded feasibility study of aquifer storage and recovery project using existing 2,000-foot wells.

David M. Field
Hydrogeologist, Orange County Water District
Fountain Valley, CA

Mr. Field has over 12 years professional experience managing well installation projects pertaining to environmental and water supply projects. The projects include drilling, construction and development of monitoring, production, and injection wells. Mr. Field has served as Field Supervisor and Site Geologist during a number of well construction projects. Responsibilities included drafting technical specifications, conducting preconstruction meetings, collecting representative formation samples, geologic logging of formation samples, geophysical log interpretation, well design, formation sieve analysis, well construction, and well development. In addition, Mr Field has experience with drilling methods such as reverse rotary, direct mud rotary, air rotary casing hammer, rotary sonic, cable tool, and hollow stem auger.

EDUCATION

B.S., Geological Sciences (2001), California State University, Fullerton

EMPLOYMENT HISTORY

2005 - present:	Hydrogeologist, Orange County Water District
2004 - 2005:	Staff Geohydrologist, Geoscience Support Services Incorporated
2002 - 2005:	Staff Hydrogeologist, URS Corporation
1999 – 2002:	Hydrogeology Intern, Orange County Water District

REPRESENTATIVE ROTARY DRILLING EXPERIENCE

Mid-Basin Injection Well Project (2012) – Drilling, construction, and development of 2 nested monitoring wells and one treated water injection well located in Fountain Valley, California. The wells ranged in depth from 1,150 and 1,200 feet below ground surface for the two monitoring wells and 1,220 feet below ground surface for the injection well.

Sunset Gap Monitoring Well Installation Project (2011) – Drilling, construction, and development of 2 nested monitoring wells located on the Naval Weapons Station Seal Beach, California. The well depths were 590 and 605 feet below ground surface.

North Basin Groundwater Protection Project Monitoring Wells (2007) – Drilling, construction, and development of 15 monitoring wells located in Fullerton, California. The wells ranged in depth from 150 to 350 feet below ground surface.

North Basin Groundwater Protection Project Extraction Wells (2007) – Drilling, construction, and development of 5 extraction wells located in Fullerton, California. The wells ranged in depth from 200 to 310 feet below ground surface.

Nested Monitoring Well OCWD-M44 Installation Project (2007)) – Drilling construction, and development of 1 nested monitoring well located in Costa Mesa, California. The well depth was 500 feet below ground surface.

Municipal Water Well Installation Projects (2004-2005) – Drilling, construction, and development of multiple municipal water wells (15) located in southern California. The wells ranged in depth from 1,000 to 2,000 feet below ground surface.

San Bernardino Valley Municipal Water District 10-Wells Project (2002) – Drilling and construction, and development of 13 nested monitoring wells located in San Bernardino, California. The wells ranged in depth from 300 to 1,500 feet below ground surface.

North Basin Groundwater Protection Project Monitoring Wells (2001) – Drilling construction, and development of 17 monitoring wells located in Fullerton, California. The wells ranged in depth from 150 to 350 feet below ground surface.

Nested Monitoring Well OCWD-M42 Installation Project (2001)) – Drilling construction, and development of 1 nested monitoring well located in Huntington Beach, California. The well depth was 638 feet below ground surface.

Patrick Versluis
Principal Environmental Specialist, Orange County Water District
Fountain Valley, CA

EXPERIENCE:

Principal Environmental Specialist

Dec. 2002 - Present

Orange County Water District Fountain Valley, CA

- Weekly scheduling and coordination of Water Quality Department monitoring tasks.
- Responsible for Storm water NPDES permit requirements such as Storm Water Pollution Prevention Plan creation, Annual Reporting to RWQCB, and all storm water quality monitoring requirements.
- Water Quality Department Project Manager for many research and emerging contaminant studies. Manage a microbial pathogen study in San Bernardino County involving several outside agencies as well as internal researchers. Continue to lead a bacteriophage study of surface and groundwater locations throughout the Orange County groundwater basin. Work with the laboratory personnel to collect and analyze sample for many emerging pharmaceuticals.
- Water Quality Department Project Manager for VOC monitoring and sampling program throughout Orange County groundwater basin. Ensure staff compliance with NPDES permit regulating the dewatering of contaminated groundwater monitoring wells.
- Water Quality monitoring of surface and groundwater sites throughout the Santa Ana River watershed. Represent OCWD and interact with various city, state, and federal agencies while performing water quality monitoring assignments.
- Review water quality sample results for accuracy and compliance with all established EPA drinking water regulations.
- Review applications for new hires and attend interviews to select new Environmental Specialists. Supervise the training of new employees and assist in development of Standard Operating Procedures.

Program Coordinator

Sept. 2001 – Dec. 2002 **Ocean Institute**
Dana Point, CA

- Supervise and coordinate outdoor science education programs with up to 8 staff and up to 80 students and teachers.
- Develop and evaluate new educational activities involving ocean and terrestrial sciences.
- Evaluate employee performance, provide staff instruction, and discuss all observations to program director.
- Instruct students in various biological, chemical, physical scientific investigations of the marine and terrestrial ecosystems.
- Teach water quality and marine mammal observation aboard a research vessel to students from third grade to community college courses.

Environmental Intern

June 2000 – Sept. 2000 **Geosyntec Consultants** Huntington Beach, CA

- Assisted project engineer on large DDT contaminated ocean sediment capping project involving the US EPA and US Army Corps of Engineers.
- Responsible for field interaction with various agency representatives and collecting all field data from dredge and cap operations.
- Performed review of environmental project documents and data organization. Created GIS maps of project site above and below ocean surface.

Research Technician

Oct. 1999 – June 2001 **Dynamac Corporation** Corvallis, OR

- Assisted in laboratory prep activities and data collection for Oregon forest health study.
- Responsible for processing of samples taken from EPA designated forest sites in the Cascade mountain range.
- Performed various tasks such as sorting, weighing, and grinding of forest floor and canopy samples.
- Coordinated sample prep and analysis with EPA contractors and EPA scientists.

EDUCATION:

California State University Long Beach, CA **In Progress**
- Master of Public Administration

Saddleback College Mission Viejo, CA **May 2010**
- Supervisor Skills Certifications (Part I and Part II)

California State University Fullerton, CA **August 2004**
- Master of Science in Environmental Studies

Oregon State University Corvallis, OR **June 2001**
- Bachelor of Science in Environmental Science

Lee Yoo

Laboratory Director, Orange County Water District
Fountain Valley, CA

Education:

Oregon State University, Food Science & Technology/Biochemistry MS. 1984

Seoul National University, Agricultural Chemistry. BS. 1978

Technical Training:

1/2002-8/3/2002 - Waters Connections School Operation & Maintenance of ZQ LC/MS 2002

Relevant Experience:

4/1986 – 5/1989S Supervisor, Analytical Chemistry, Michelson Laboratories, City of Commerce, CA

6/1989-1/1995 Orange County Water District, Chemist

1/1995-1/2002 Orange County Water District, Senior Chemist

1/2002-3/2012 Orange County Water District, Chemist Supervisor

4/2012 to present Orange County Water District, Laboratory Director

I have worked for the Orange County Water District (OCWD) since 1989, both as the organic section's supervisor and as the laboratory director. Before coming to the District I worked at Michelson Laboratories, an chemical and environmental contract laboratory, within the HPLC, GC & GC/MS sections. It is essential for the Orange County Water District's Advanced Water Quality Assurance Laboratory to work closely with the Department of Public Health and the Environmental Laboratory Accreditation Program.

Over several years, our laboratory has grown from a staff of seven to over twenty-eight dedicated professionals. We have tried to develop our technical staff as a cohesive team, able to address analytical challenges. We have enjoyed organizing laboratory processes to ensure efficient sample processing and quality assurances. OCWD's laboratory provides data on both drinking water and wastewater samples for a variety of projects and regulations. Our laboratory has been a leader on many analytical issues: MTBE, chromium VI, perchlorate, 1,4-dioxane and NDMA. We have worked closely with the CDPH on many of these emerging issues, investigating issues like pharmaceuticals and endocrine disrupting target analysis. We have recently completed an investigation with MWD into three water sources: State Project Water, Colorado River, and the Santa Ana River system; on the detection and fate of specific low-level pharmaceuticals and endocrine disrupting compounds.

Our laboratory supported a Performance Evaluation Study with CDPH (Dr. Kusum Perera) on the analysis of N-Nitrosodimethylamine. This data was presented at the AWWA's Water Quality and Technology Conference several years ago. The application of analytical technology to address these emerging issues and the quality control requirements needed to ensure reliable regulatory data is critical to our lab's operations. We have enjoyed an excellent working relationship with CDPH and ELAP's staff members. Communication with ELAP staff has always been a critical need for our laboratory; this information has allowed us to grow in a positive direction. We have benefited from each on-site audit conducted by ELAP staff.