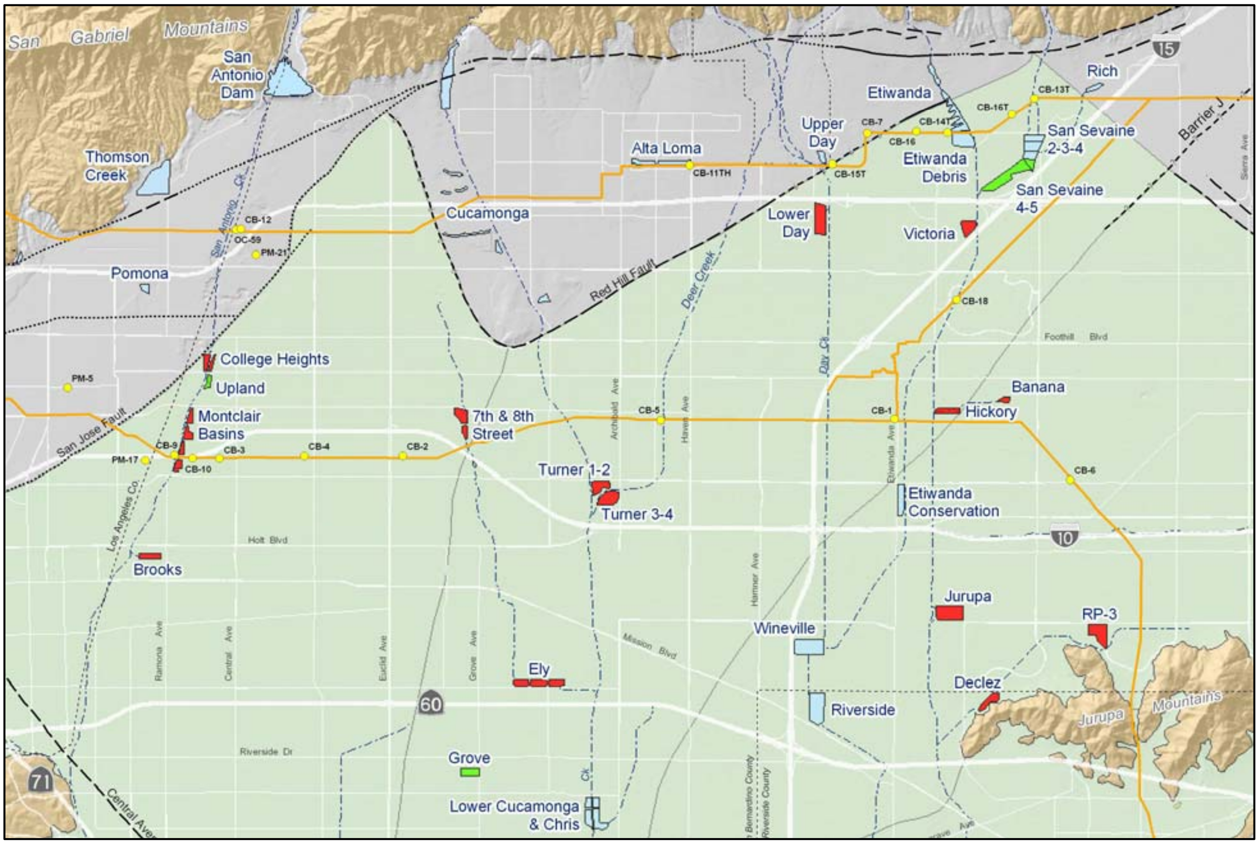
Chino Basin
Recycled Water Recharge Program

Start-Up Protocol Plan for Banana Basin



Prepared for:

Inland Empire Utilities Agency

Prepared by:

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Start-Up Protocol Plan for Banana Basin

1. Introduction

Inland Empire Utilities Agency (IEUA), Chino Basin Watermaster (Watermaster), Chino Basin Water Conservation District, and San Bernardino County Flood Control District jointly sponsor the Chino Basin Recycled Water Groundwater Recharge Program. This is a comprehensive water supply program to enhance water supply reliability and improve the quality of local drinking water wells throughout the Chino Groundwater Basin by increasing the recharge of stormwater, imported water and recycled water. This program is an integral part of Watermaster's Optimum Basin Management Plan (OBMP). Figure 1 shows the location of groundwater recharge and imported water facilities in Chino Basin.

Banana Basin is in Chino Basin Management Zone 3 and is approximately 3.3 miles northeast of the Interstate-15 and Insterstate-10 interchange, within the City of Fontana. It is west of Cherry Avenue; south of Whittram Avenue; north of California Speedway and east of Calabash Avenue. Surrounding land use is primarily industrial. Banana Basin has an effective recharge area of 6.2 acres and an estimated percolation rate of 2.0 feet per day (CH2MHill, 2003). Surface water from Banana Basin drains westerly into Hickory Basin through the West Fontana Channel. Diluent and recycled water deliveries to Banana Basin are described in detail in the Title 22 Engineering Report dated November 2003 (CH2MHill, 2003).

Banana Basin has one lysimeter cluster consisting of individual lysimeters set at 5, 10, 15 and two at 25 feet below the basin floor. In addition, one groundwater monitoring well, BH-1, is approximately 340 feet down gradient of Hickory Basin and will serve both Hickory and Banana Basin. Banana Basin is scheduled to begin receiving recycled water in July 2005. Start-up Protocols 1 through 4 have already been implemented for Banana Basin. All monitoring procedures referenced herein are consistent with those discussed in the draft Operations, Maintenance, and Monitoring Plan (OMMP).

2. Organization of this Start-Up Protocol Plan

The Start-Up Protocol Plan for the recycled water recharge program is comprised of the following sections:

1. Introduction
2. Organization of this Start-Up Protocol Plan
3. Objectives
4. Regulatory Requirements
5. Protocol 1 – Institute DHS-Recommended Laboratory Protocol for Analysis of Total Organic Carbon (TOC) at Low Levels for Groundwater Recharge Reuse Projects (GRRPs)
6. Protocol 2 – Recharge with Diluent Water Prior to Start-Up Period
7. Protocol 3 – Stockpile and Test Backfill Material
8. Protocol 4 – Install Lysimeters
9. Protocol 5 – Recharge with Recycled Water

3. Objectives

The objectives of the Start-Up Period are to establish site characteristics, including percolation rates, the physical characteristics of the vadose zone and soil aquifer treatment efficiency, and to establish a sampling regime, based on these characteristics, that is representative of recycled water following soil aquifer treatment. "Natural" tracers will be used to differentiate diluent water from recycled water and thereby estimate when the lysimeters are collecting water that is predominantly of recycled water origin. A "natural" tracer is a constituent or group of constituents that occur naturally in either or both the recycled water and diluent water that can be used as a chemical signature to show "breakthrough" of the recharge water at each of the lysimeter depths. The length of the Start-Up Period at each basin will be contingent on site characteristics, including percolation rates and recycled water transit time in the subsurface.

A Start-Up Period report will be prepared at the close of each Start-Up Period and will include recommendations for the optimum depths and locations for placement of lysimeters that will be used to measure compliance, and for a monitoring plan; and a generalized method to track recharge water in the vadose zone. The report will also include recommendations for the maximum average recycled water contribution (RWC) and corresponding total organic carbon (TOC) limit for the initial year of recharge operations.

4. Regulatory Requirements

This Recycled Water Groundwater Recharge Program being implemented by IEUA and Watermaster is subject to the following requirements:

- California Regional Water Quality Control Board, Santa Ana Region. Order No. R8-2005-0033. Water Recycling Requirements for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. Draft Order: April 2005.
- California Regional Water Quality Control Board, Santa Ana Region. Monitoring and Reporting Program No. R8-2005-0033 for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County.

5. Protocol 1 – Institute DHS-Recommended Laboratory Protocol for Analysis of Total Organic Carbon (TOC) at Low Levels for Groundwater Recharge Reuse Projects (GRRPs)

DHS (2003) recommends the following analytical method and protocols for analysis of total organic carbon (TOC) at low levels for Groundwater Recharge Reuse Projects (GRRPs):

- Method 5310C, listed in Standard Methods for the Examination of Water & Wastewater 20th Edition (1998), is the appropriate method for TOC analysis for the reclamation and recycling of municipal wastewater.
- A reporting level of 0.10 mg/L
- Precision and accuracy within +/-20%

In order to successfully use Standard Method 5310C for low-level measurements of TOC, DHS further recommends the following laboratory protocols be implemented:

1. Use only new or scrupulously cleaned auto-sampler vials.
2. If the auto-sampler vials are covered with septum caps, ensure that the septa are not touched with fingers. Use forceps to handle the septa.
3. Pre-rinse the auto-sampler vials with the sample before filling them.
4. Use a large enough sample aliquot for the analysis to achieve the required reporting limit of 0.10 mg/L.
5. Procure reagents and water that produce consistently low reagent blanks.
6. Use only peroxodisulfate reagent solutions that produce stable blank levels. Freshly prepared peroxodisulfate reagent solutions were found to produce higher blanks than solutions that were aged for several days. The decrease in the observed blank was most pronounced on the first day of use. The aging process and the reduction in blank levels can be accelerated by boiling the peroxodisulfate reagent for a short time period and then cooling it.

6. Protocol 2 – Recharge with Diluent Water Prior to Start-Up Period

Banana Basin will be recharged with diluent water – either stormwater or State Water Project (SWP) water – for a period of time prior to the commencement of the Start-Up Period to flush the vadose zone. The length of time will be determined by IEUA and will be reported in the Start-Up Report. Recharging with diluent water prior to recharging with recycled water will also filter any "noise" out of the system so that the breakthrough of recycled water in the lysimeters will be more readily discerned. The recharge with diluent water can occur before or after installation of the lysimeters. Surface water grab samples will be collected so that IEUA understands the chemistry of the diluent water being recharged.

6.1 Sample Diluent Surface Water

Grab samples of diluent water collected from the recharge basins should be collected twice per week during this phase of the pre-start up activities. These samples will be analyzed for TOC, nitrate, nitrite, total Kjeldahl nitrogen, total dissolved solids (TDS) and any other constituent that IEUA intends to use as a natural tracer or chemical signature to differentiate diluent water from recycled water. In the case of stormwater, TDS is likely sufficient. For SWP water, the constituent list may also include bromide, hardness, and boron.

6.2 Estimate Recharge and Percolation Rate

All of the Phase 1 and Phase 2 basins are equipped with pressure transducers. IEUA shall record water level data over time during this period at a frequency to be able to make an engineering estimate of the recharge and the percolation rate based on inflow, outflow, water levels, evaporation rate, and basin geometry.

7. Protocol 3 – Stockpile and Test Backfill Material

There is a potential for the introduction of contaminants into the borehole during the backfilling of material around the porous cup of the lysimeter. This backfill material should be relatively fine such that when a vacuum is applied to the lysimeter, it extends some distance into the formation so that soil water is drawn into the porous cup. Literature studies have shown that commercial silica flour commonly used for this purpose may contain low concentrations of trace metals, therefore IEUA will use a native backfill material. However, the native backfill material from the bottom of the recharge basin may have elevated levels of organic carbon. The following protocol will limit any contamination introduced in the borehole and will provide IEUA with an understanding of any contaminants that may be introduced.

A trench shall be excavated to a depth of about 2 meters below the bottom of the recharge basin (below the *schmutzdecke*, the biologically active layer that forms at the surface of the soil). A volume of soil that is 50 percent greater than expected to be needed for the backfill will be sieved with a No. 10 US Standard sieve (2-millimeter openings) to remove large-grained sediments and stockpiled on the site in a clean 55-gallon drum or equivalent.

Three representative sample of this material shall be sent to the analytical laboratory for a leaching test (*e.g.*, TCLP or WET). These samples would be analyzed for TOC, nitrate, nitrite, total Kjeldahl nitrogen, TDS, trace metals, and any other constituent that IEUA intends to use as a native tracer.

8. Protocol 4 – Install Lysimeters

IEUA shall test and install lysimeters at each basin per the detailed protocols outlined in Appendix A. (A lysimeter consists of a porous cup installed in unsaturated sediment that collects undiluted samples of recharge water prior to reaching the regional groundwater table.) One or two clusters of four lysimeters shall be installed at each recharge basin at locations and depths determined in the field during installation of the lysimeters by a licensed geologist. Each cluster shall include lysimeters completed at varying depths based on the recommendations of the licensed geologist to provide detailed vertical resolution in the upper part of the vadose zone. The most representative lysimeter results shall be used to demonstrate soil aquifer treatment efficiency.

9. Protocol 5 – Recharge with Recycled Water

IEUA shall begin recharging recycled water into the basin after installation of the lysimeters. To the extent possible, only recycled water will be recharged in the basins during the Start-Up Period. The introduction of recycled water marks the beginning of the “start-up” period, which shall not last longer than 180 days. All the activities described in Sections 5 through 8 are considered “pre-start-up.” Grab surface water and lysimeter samples will be collected at the same time according to the schedule described in the Monitoring and Reporting Program No. R8-2005-0033 (Requirement IV): twice per week for nitrogen species and weekly for TOC. These samples will be analyzed for TOC, nitrate, nitrite, total Kjeldahl nitrogen, TDS, and any other constituent that IEUA intends to use as a native tracer or chemical signature to differentiate diluent water from recycled water.

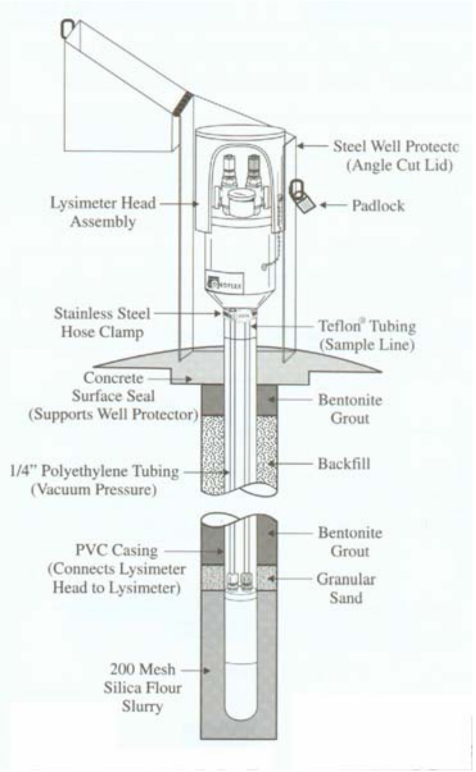
10. Protocol 6 – Collect Lysimeter Samples

IEUA’s staff will be trained on the care, maintenance, and sampling procedures of the lysimeters, as recommended by the manufacturer.

The sampling of each lysimeter consists of a three-step process that occurs over a 24-hour period.

10.1 Lysimeter Purging

To ensure the integrity of the samples, each lysimeter must be purged before sampled. Both ball valves are opened and the portable reversible vacuum pump is connected to the black polyethylene vacuum/pressure tube and a positive pressure is applied. This will clear any water that has entered the system between samplings. When no further condensation evacuates the Teflon sampling tube, the sampling ball valve is closed. A schematic diagram of the lysimeter head assembly is shown below:



10.2 Lysimeter Charging

Leaving the pump connected to the black polyethylene vacuum/pressure tube, the sampling technician switches the pump to the vacuum function and applies a vacuum until the pressure gauge reads approximately 20 psi (or as close as possible). The vacuum tube ball valve is closed and the vacuum pump is turned off. The lysimeter should remain charged at a negative pressure for 24 hours.

10.3 Lysimeter Discharge

The sampling technician inserts the sampling tube into a clean, labeled sample bottle. Attach the portable reversible pump to the black polyethylene vacuum/pressure tube, open both ball valves and apply a positive pressure. The lysimeter contents should be emptied into the bottle. When no more fluid is ejected, power off the pump and close both valves. Lysimeter water samples will be handled under Chain-of-Custody procedures.

10.4 Basin Sampling

The sampling technician will collect a surface water grab sample adjacent to each of the lysimeter nests on the same day and time that the lysimeters samples are collected. If there are two lysimeter nests, one surface sample will be taken near each nest and they will not be composited. The naming convention for these samples will be YYYYMMDD-Basin-Nest-Sampling Point or some other appropriate naming convention.

Samples will be handled in accordance with standard protocols, as described in Appendix B.

11. Protocol 7 – Develop Draft Start-Up Report

IEUA shall prepare and submit to the Regional Board and DHS a draft Start-Up Report. The draft Start-Up Report will contain the following sections:

1. Introduction
2. Lysimeter Installation
3. Recharge Rates
4. Compliance Point Lysimeter Selection
5. Determination of Start-Up Period
6. Determination of SAT Efficiency
7. Determination of TOC Limit and RWC
8. First Year Monitoring Plan
9. References

   Appendix A. Soil Boring Logs

   Appendix B. MS Access Database

   Appendix C. Lysimeter Schematic

The following subsections provide more detail on the text and deliverables that will be provided in the draft Start-Up Report.

11.1 Introduction

This section will describe the Recycled Water Recharge Program and the subject recharge basin, including a map showing the location of the recharge basin (*i.e.*, a site location map).

11.2 Lysimeter Installation

This section will describe the field work that was completed during the lysimeter installation. Any significant deviations from the installation protocols discussed in Appendix A will be addressed. This section will contain as-built drawings or maps showing the location and arrangement of the lysimeters in the basin, location of inlets, outlets, pressure transducers, *et cetera*. A discussion of the soil profile will be provided, along with a table that describes the depths of the lysimeters in each nest. Boring logs completed by a registered geologist will be included in an appendix.

11.3 Recharge Rates

Calculated recharge and percolation rates based on the recharge of diluent water will be included in this section. If there are previous estimates of recharge and percolation rates, they will be included and compared with the rates calculated during the Start-Up Period.

11.4 Compliance Point Lysimeter Selection

This section will included a discussion of how the tracers were selected (based on differences in chemical signatures of the recycled water and the diluent water) and how the tracers were used to demonstrate breakthrough of recycled water to the compliance point lysimeter. The section will include:

- Tables and time-series graphs of diluent water chemistry

- Tables and time-series graphs of recycled water chemistry (grab surface water samples)
- Tables and time-series graphs of recharge water chemistry (lysimeter samples)

The lysimeter sample water quality data will be reviewed to determine which lysimeter reflects recharge water chemistry most closely – this lysimeter would most likely be recommended as the compliance point lysimeter. If the data supports this, the deepest lysimeter that reflects recharge water chemistry would most likely be chosen as the compliance point lysimeter to maximize the effects of the soil aquifer treatment (SAT) on TOC and nitrogen removal.

11.5 Determination of Start-Up Period

This section will estimate the time required for the recharge water to reach the compliance point lysimeter, based on the tracer(s) used. Based on the selection of tracers and the results of the tracer studies, the report will discuss the general approach used for tracking the various types of water (stormwater, imported water, and recycled water) in the vadose zone, and how the tracking methods can be used to determine when the lysimeters are sampling water of recycled water origin. Also, estimates of transit times to various monitoring points will be determined. The tracer or tracers will be described and plots of the tracer, total nitrogen (TN), and TOC concentrations versus depth below grade will be provided. In addition, time series plots of the tracer, TN, and TOC will be provided. Based on the travel time of tracer, a Start-Up Period that is specific to each recharge basin will be determined. For example, if TDS was used as the tracer and "breakthrough" of recycled water at the compliance point lysimeter was measured to be two months, the Start-Up Period would be defined to be four months – which incorporates a factor of two to ensure that the recharge water sampled by the compliance point lysimeter is predominately recycled water in origin. Based on the date that recharge of recycled water began in a given basin, and the calculated Start-Up Period, a calendar date marking the end of the Start-Up Period will be specified in the Start-Up Report. This Start-Up Period shall not in any case exceed 180 days.

11.6 Determination of SAT Efficiency

The efficiency of the SAT in removing TOC and TN will be determined from individual samples, monthly averages, and 20-sample averages (for TOC) in both the recycled water discharged into the recharge basin and the compliance point lysimeter. Efficiencies will be calculated with the following equations:

$$TN_{Loss} = \frac{(TN_{SW} - TN_{LYS})}{TN_{SW}}$$

where TN_{SW} is the monthly average total nitrogen concentration in mg/L of the sampled surface water and TN_{LYS} is the monthly average total nitrogen concentration in the compliance point lysimeter. TN_{Loss} will be expressed as a percentage reduction.

$$TOC_{Loss} = \frac{(TOC_{SW} - TOC_{LYS})}{TOC_{SW}}$$

where TOC_{SW} is the monthly average total organic carbon concentration in mg/L of the sampled surface water and TOC_{LYS} is the monthly average total organic carbon concentration in the compliance point lysimeter. TOC_{Loss} will be expressed as a percentage reduction.

11.7 Determination of TOC Limit and RWC

The Recycled Water Quality Specification A.10 (Regional Board, 2005a) states, "At each recharge basin, the monthly average TOC concentration of the recycled water prior to reaching the regional groundwater table, shall not exceed the average TOC value calculated from the following formula:"

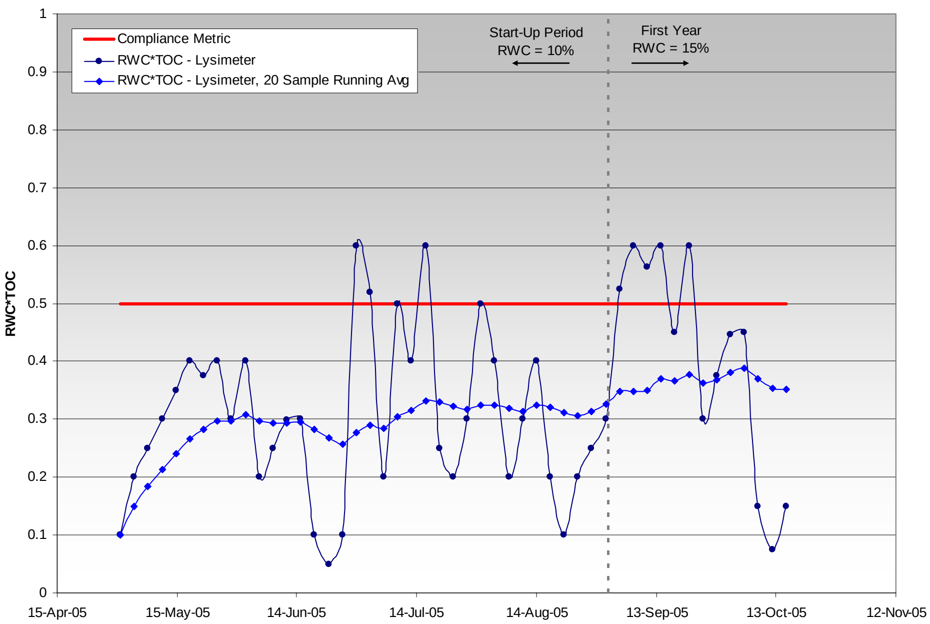
$$TOC_{average} = \frac{0.5mg/L}{RWC_{average}}$$

For example, if the average RWC during the Start-Up Period is 10 percent the initial TOC limit – during the Start-Up Period – for the compliance point lysimeter at the recharge basin will be 5 mg/L.

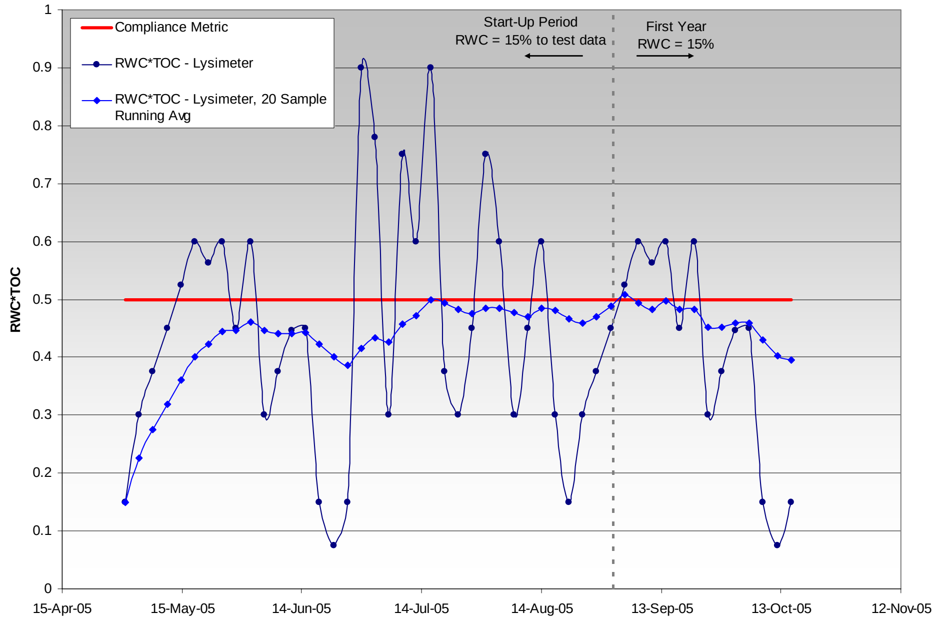
Performance will be determined by the rearranging the above formula to:

$$RWC_{average} \cdot TOC_{average} \leq 0.5mg/L$$

where the average TOC value is based on a running average of the 20 most recent samples. The performance metric, then, is always the product of $RWC_{average}$ and $TOC_{average}$. IEUA will develop a performance graph with the product of $RWC_{average}$ and $TOC_{average}$ on the y-axis and time on the x-axis. The graph would include the performance metric (a horizontal line at 0.5 mg/L), the product of $RWC_{average}$ and $TOC_{average}$ for the lysimeter samples, and the 20-sample running average of the sample data. The graph shown below illustrates what the performance graph would look like.



Once performance is demonstrated during the Start-Up Period (see first four months in the above example), IEUA will determine if the data warrant a higher RWC. IEUA will substitute the desired RWC for the initial RWC in the spreadsheet (*e.g.*, substitute 15 percent for 10 percent) to test the samples collected to-date to see: (i) if the data to date would be in compliance; and (ii) to determine if there are any trends in the data. As an example, the graph below show the same data, but using an RWC of 15 percent for the Start-Up Period.



In the example shown here, the data in the Start-Up Period would suggest that TOC compliance would be met with an RWC of 15 percent. Even though there are two excursions above the performance metric, the overall trend of the running average data is flat or downward. In this case, IEUA may elect to use an RWC for the first year of recharge operations, with a concomitant TOC limit of 3.3 mg/L (see above equations). Note that the RWC for the Start-Up Period would remain at 10 percent – using an RWC on those data was simply a test to determine the RWC going forward into the first year of operations.

11.8 First Year Monitoring Plan

IEUA will implement a monitoring program in accordance with the Monitoring and Reporting Program (MRP) (Regional Board, 2005b). In accordance with the tentative MRP, the lysimeters will be sampled according to the following schedule:

Monitoring Program for Recharged Water

Parameter	Sample Station	Units	Type of Sample	Minimum Frequency of Analysis
TOC	lysimeter	mg/L	Grab	Weekly
Total Nitrogen	lysimeter	mg/L	Grab	2/Week
Total Inorganic Nitrogen	lysimeter	mg/L	Grab	2/week
Nitrate-Nitrogen	lysimeter	mg/L	Grab	2/week
Nitrite, Ammonia, and Organic Nitrogen	lysimeter	mg/L	Grab	2/week
Nitrite-Nitrogen	lysimeter	mg/L	Grab	2/week

This section of the Start-Up Report will contain any special recommendations for properly obtaining representative samples from the lysimeters. The goal will be to collect samples when the recharge basin is actively recharging recycled water. Samples will not necessarily be collected when the basin is dry or undergoing maintenance or recharging only diluent water. The start-up testing will provide recommended methods for monitoring recharge water that is predominantly of recycled water origin at the compliance point lysimeters. Recommendations on the need for tracer studies will also be provided.

12. References

California Environmental Protection Agency. 1994. Representative Sampling of Ground Water for Hazardous Substance. Guidance Manual for Ground Water Investigations. Interim Final. June 1994.

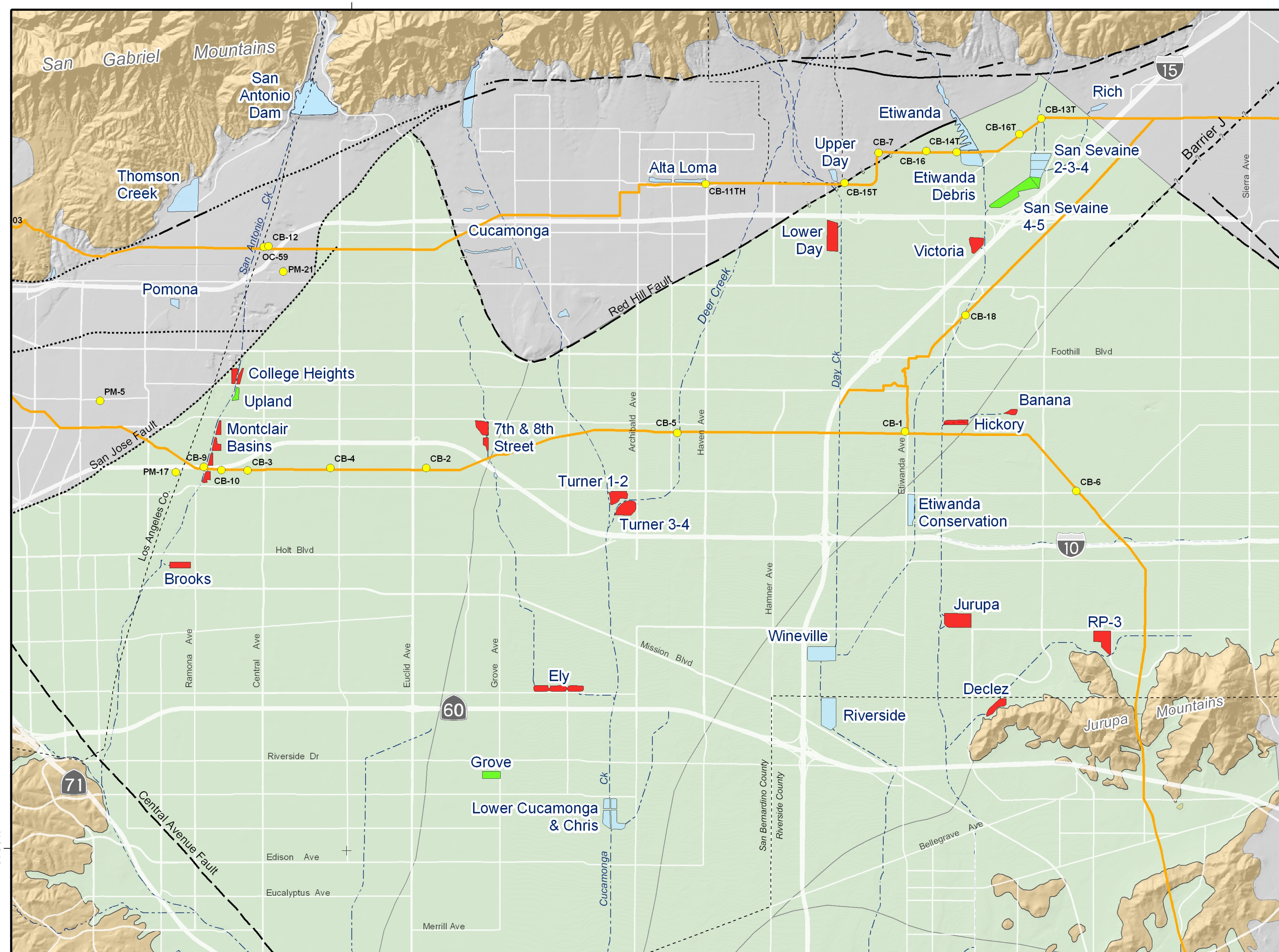
California Regional Water Quality Control Board, Santa Ana Region. 2005a. Order No. R8-2005-0033. Water Recycling Requirements for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. Draft Order: April 2005.

California Regional Water Quality Control Board, Santa Ana Region. 2005b. Monitoring and Reporting Program No. R8-2005-0033 for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County.

CH2MHill. 2003. Title 22 Engineering Report. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. November 2003.

DHS. 2003. Analysis of Total Organic Carbon (TOC) at Low Levels for Groundwater Recharge Reuse Projects (GRRPs). April 1, 2003. http://www.dhs.ca.gov/ps/ddwem/publications/waterrecycling/TOCinrecycledwater.pdf

US EPA. 1998. EPA Guidance for Quality Assurance Project Plans. EPA QA/G-5. Office of Research and Development. EPA/600/R-98/018. February 1998.



Recharge Basins (Symbolized by Improvements)

- Chino Basin Facilities Improvement Program
- Improvement By Others
- No Improvements

Imported Water Facilities

- Service Connection/Turnout
- Imported Water Pipeline

Other Features

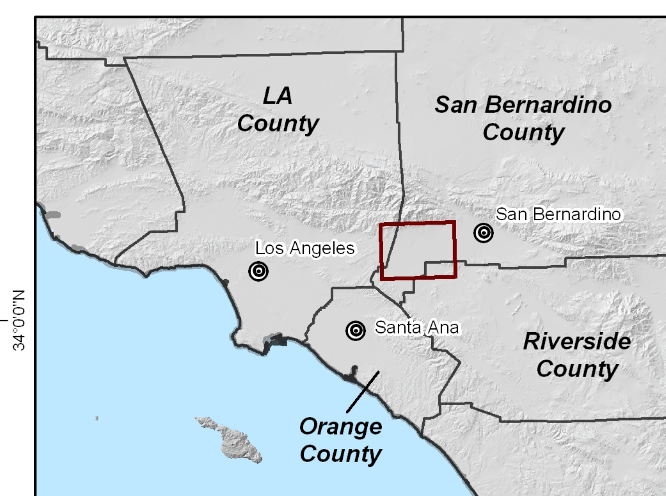
- Rivers, Creeks, and Flood Control Channels
- Chino Basin

Geology

- Unconsolidated Water-Bearing Sediments
- Consolidated Bedrock

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain



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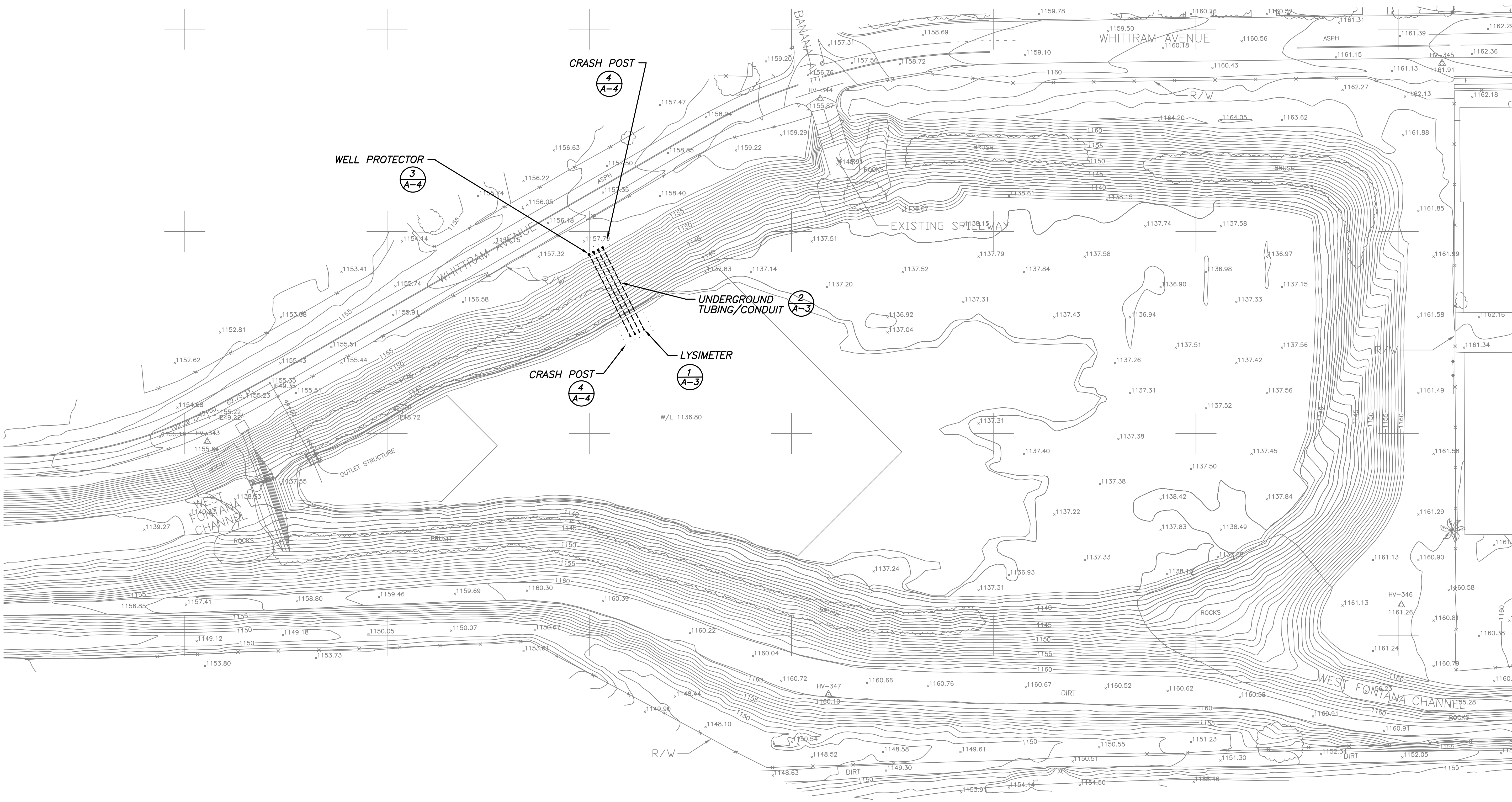
0 1 2 3 Miles
0 2 4 KM

Inland Empire UTILITIES AGENCY

State of the Basin Report -- 2004
Recharge Basin Monitoring

Groundwater Recharge and Imported Water Facilities

Figure 1



Scale: 1" = 100 FEET

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Inland Empire UTILITIES AGENCY

REVIEWED BY:	DRAWN BY:	START DATE:
AEM	WEL	06/08/05

BANANA BASIN

FIGURE 2

SHEET NO. 1 OF 1

Appendix A. Install Lysimeters

A.1 Lysimeter Assembly and Testing

All lysimeter units shall be assembled and pre-tested, prior to mobilization for field work to ensure that each unit functions properly. Each unit shall be assembled, tested for pressure leaks, and cleaned in accordance with manufacturer instructions. Each lysimeter will consist of a Model SW-070 2-inch OD dual-chamber stainless steel body equipped with two ¼-inch OD stainless steel nipples of different lengths and a stainless steel porous "cup" comprising the lower portion of the body. A ¼-inch OD black polyethylene tube is attached to the longer vacuum/pressure nipple and a ¼-inch OD clear Teflon™ tube is attached to the shorter sampling nipple with stainless steel unions.

After the unions have been tightened and the porous cup has been pre-soaked in distilled water, the unions, the welded nipple joints protruding through the top of the body, and the joint that mates the porous cup to the solid upper portion of the body will be tested for pressure leaks. A minimum pressure of 0.5 bars will be alternately applied to each tube while clamping the other tube shut. While under pressure, the lysimeter body, welded locations, and tubing unions will be submerged in distilled water to allow visual identification of leaks via the production of bubbles. If no bubbles are observed, the lysimeter assembly will be considered pressure-tight and will then be cleaned for installation in the field.

Each assembly will be cleaned by flushing internally with 70% isopropyl alcohol and rinsing with distilled water. Initially, a minimum vacuum of 0.5 bars will be applied to the vacuum/pressure tube while clamping the sampling tube shut and submerging the porous cup within the alcohol to draw it into the lysimeter body. The alcohol will then be evacuated from the lysimeter body by applying a minimum pressure of 0.5 bars to the vacuum/pressure tube and opening the sampling tube until the lysimeter body is emptied. The lysimeter body will then be rinsed internally four times with distilled water (a total of approximately 1 gallon) following the same procedure described above until the discharge does not contain any residual alcohol. After performing a final exterior rinse with distilled water, each lysimeter assembly (lysimeter body, tubes, and unions) will be inserted intact within a new plastic 55-gallon plastic bag and sealed pending installation in the field.

A.2 Borehole Drilling and Soil Sample Collection

A MARL 5T rubber-tracked hollow-stem auger drill rig and supporting equipment or similar will be used to drill the boreholes. Each lysimeter nest will consist of four individual lysimeter assemblies that will be installed to approximate depths of 5, 10, 15, and 25 feet below ground surface (bgs) in separate boreholes. The actual depths will be determined by a registered geologist. The boreholes will be drilled with an 8-inch nominal OD continuous flight augers. The 8-inch nominal OD will minimize the possibility of sand-locking between the lysimeter assemblies and the interior of the auger string during installation.

Each borehole will be drilled in one pass to the lysimeter installation depth, if possible. Relatively undisturbed soil samples will be collected from the 25-foot boring of each nest, from approximately 5, 10, 15, 20, and 25 feet bgs. Each soil sample will be collected with a 1.5-inch diameter California Modified Split-Spoon Sampler equipped with three (3) 6-inch long brass sample sleeves. The sampler will be driven to approximately 18 inches below borehole total depth using a rig-mounted pneumatic hammer or similar.

After driving the sampler, the split-spoon will be retrieved to the ground surface, opened, and the sample sleeves will be removed from the sampler. Both ends of sleeves will be lined with Teflon™ sheeting, sealed with tight-fitting plastic end caps, labeled, and stored in an ice-cooled chest pending chemical analysis. One sample from each depth material shall be sent to the analytical laboratory for a leaching test (*e.g.*, TCLP or WET). These samples would be analyzed for TOC, nitrate, nitrite, total Kjeldahl nitrogen, TDS, trace metals, and any other constituent that IEUA intends to use as a native tracer.

A.3 Lysimeter Installation

Lysimeter construction will proceed upon reaching total borehole depth. If the geologist observes that the borehole is stable enough, the lysimeters will be installed open-hole (without the auger string). However, the deeper lysimeters and any other where the borehole stability is questionable will be installed using the auger string as a precautionary measure. Upon reaching total borehole depth for the lysimeters installed with the auger string, the string will be raised approximately one foot from the bottom of the borehole prior to installation of any materials to prevent the lysimeter assembly from becoming wedged within the auger bit.

Just prior to lysimeter installation, the lysimeter assembly will be removed from its plastic bag and a 1.9-inch OD Schedule 40 polyvinyl chloride (PVC) flush-threaded extension casing will be threaded into the top of the lysimeter body after threading the vacuum/pressure and sampling tubes through the casing. The extension casing will be of sufficient length such that it would extend above the surrounding grade. Next, approximately 22 pounds (10 kilograms) of the slurry (silica flour or native backfill) will be installed within the bottom portion of the borehole to create an approximate 0.5- to 1.5-foot thick layer at the bottom of the borehole. After letting the slurry consolidate via dewatering, the lysimeter assembly will be lowered via the PVC extension casing and gently pressed into to the top of the slurry. Then approximately 22 pounds (10 kilograms) of slurry will be installed on top of the initial soil slurry layer such that it extends approximately 1.25 to 1.35 feet above the top of the porous cup.

A minimum 0.2-foot layer of Lonestar No. 3 granular sand and then a minimum 1.2-foot layer of 3/8-inch bentonite pellets will be successively installed on top of the native soil slurry to act as a filter following the installation of the neat cement seal. The pellets will be hydrated with distilled water to allow them to expand and create a tight seal. The neat cement grout shall conform to ASTM C150 “Standard Specifications for Portland Cement” Type II. The grout will be mixed in a 55-gallon barrel at a ratio of 7 gallons of fresh water to each 94-pound bag of dry cement, to which up to 3% by weight of bentonite powder will be added to reduce shrinkage during grout curing, and vigorously stirred with a motor-driven paddle. The grout seal will then be installed from the top of the bentonite pellet seal to approximately 2 feet bgs. The auger string used during the construction of the 25-foot lysimeters will be periodically raised during the installation of the grout seal. The PVC extension casing will be trimmed approximately 1 foot above the surrounding grade.

A.4 Lysimeter Trenching and Head Assembly

Upon installation of the lysimeter assemblies, the lysimeter tubes will be extended toward to the lysimeter head assembly locations that will be typically located on one of the basin’s berms. This will be accomplished by excavating a wide collector trench adjacent to each lysimeter nest, which will narrow to an approximate 18-inch wide trench that will extend up the surface of the berm to the location of the lysimeter head assemblies.

Each trench will be excavated to approximately 2 feet bgs with a four-wheel drive backhoe to facilitate the burial of the conduits protecting the paired tubes. After trenching is completed, the lysimeter extension casings will be cut off approximately 2 feet bgs and fitted with a curved 90-degree 1.9-inch OD Schedule 40 PVC elbow connector. Next, the paired tubes will be threaded through a 1.9-inch OD Schedule 40 PVC conduit that extends from the elbow to the lysimeter head assemblies via the narrow trench. An electric heater box may used to bend the conduit to fit the geometry within the trenches prior to threading the paired tubes through. After the conduits are labeled with the appropriate lysimeter information and secured at the lysimeter head assembly locations, an approximate 4-inch layer of imported sand/gravel will be installed within the trench and the conduits will be gently lifted on top of this layer prior to installing another 4-inch layer on top of it for protection and identification during potential future excavation.

The trenches will be backfilled to grade with the native soils that had been excavated, while jetting with fresh water to aid soil compaction. The backfill located adjacent to the lysimeters within the basin and the lysimeter head assemblies will be compacted with a gasoline-powered manually-operated soil compactor to prevent accidental damage, whereas the backfill within the remaining trench between these locations can be compacted with the backhoe by either driving over it where possible, or by striking the backfill with the backhoe bucket.

The assemblies will be secured in place within a single concrete block (one block per 4 head assemblies/nest) that will be aligned parallel with the edge of the berm. To create each single-pour concrete pad, a wooden form will be constructed about 2 feet from the edge of the berm that measured approximately 9.75 feet long, 1.5 feet across, and 1 foot high, with approximately 4 inches protruding above the surrounding grade. A structural concrete will be mixed onsite with an electric concrete mixer and poured into the forms. The locking metal well protectors will then be set into the concrete along 3-foot centers before it sets such that they extend approximately 2 feet above grade. The protectors will be installed such that the head assemblies are readily available to field personnel after the angle-cut lid has been opened. The lysimeter head assemblies will be secured within their well protectors with uniformly keyed locks.

A Monoflex head assembly, or equivalent, for each lysimeter will be installed within its own locking steel well protector. The head assembly consists of a vacuum pressure gauge, two ball valves, and two termination ports for the vacuum/pressure and sampling tubes leading to the corresponding lysimeter assembly. Each head assembly will be installed on top of the vertical 1.9-inch OD Schedule 40 PVC riser such that the head assembly is approximately 2.0 feet above the top of the berm. After installation of the head assemblies, each lysimeter will be pressure tested using the methods described in Section A.1, except that initial and residual pressures will be recorded for both lysimeter nests, after all valves had remained closed. After verifying that no significant leaks are present in any of the lysimeters, any residual fluid remaining from the testing/cleaning of the lysimeters (Section A.1) will be discharged from each lysimeter by applying pressure to each pressure/vacuum tube and leaving the paired sample tube open until all residual fluids, if any, had been discharged from the assembly.

A.5 Crash Post Installation

The nested lysimeters and lysimeter head assemblies will be protected against damage from vehicles and heavy equipment by concrete-filled crash posts. Each lysimeter nest will be encircled by several crash posts installed in a box-like array, with sufficient spacing to reduce hindrance with field activities, yet close enough (approximate 5-foot intervals) to prevent entry of vehicles. The lysimeter head assemblies will be partially encircled by a U-shaped array of crash posts with the open end aligned with the edge of the berm.

Each crash post consists of a 6-foot length of 4-inch diameter galvanized steel pipe that will be set into a 2-foot deep, 12-inch diameter hole such that it extends approximately 4 feet above grade. Structural concrete will be either mixed onsite in an electric concrete mixer or imported to the site. Each crash post will be filled with a rounded top, painted bright yellow, and fitted with reflective tape to increase its visibility and further reduce accidental impacts with vehicles and heavy equipment.

A.6 Lysimeter Borehole Logging

The field geologist will develop geologic logs based on cuttings and soil samples collected from the 25-foot boreholes drilled at each lysimeter nest. Soil sample characteristics will be described using the Unified Soil Classification System (USCS). Borehole logs will be reviewed and signed by a geologist registered with the State of California.

A.7 Handling of Extra Soils

All extra soils generated during borehole drilling and trenching that are not be used to backfill trenches will be spread over the bottom surface of the basin such that no hummocks (*i.e.*, vehicular, slip, trip, and fall hazards) are produced.

Appendix B. Sample Handling Protocols

The sample handling protocols will be in general accordance with the guidelines established in California EPA (1994) and US EPA (1998).

B.1 Sample Labeling, Handling, Packaging, and Shipping

Sample Labeling. Sample labels will be filled out with indelible ink and uniquely numbered. Lysimeter samples will be capped immediately following collection. Labels may be partially completed prior to sample collection. The date, time, sampler's initials, and the sample identification number should not be completed until the time of sample collection. At a minimum, each numbered label shall contain the following information:

- Project name;
- Project number;
- Lysimeter number (includes depth);
- Date and time of sample collection;
- Sampler's initial;
- Analyses required; and
- Preservatives (if applicable).

Sample Handling. Lysimeter samples will be collected in appropriate containers supplied by the analytical laboratory. Lysimeter samples will be placed on ice or a chemical ice substitute in a portable insulated cooler immediately following sample collection. Preservatives required for water samples will be added to the appropriate container by the laboratory prior to sample collection.

Sample Packaging. A completed chain-of-custody form for each cooler will be prepared and placed in a resealable plastic bag and taped to the inside of the cooler lid. Coolers will be wrapped with strapping tape at two locations to secure lids.

Sample Shipping. Collected samples will be delivered to the designated analytical laboratory by IEUA's staff or a bonded courier. Sample transportation will follow EPA and Department of Transportation (DOT) regulations.

B.2 Sample Documentation and Tracking

Sample Documentation. Documentation of observations and data acquired in the field will provide information on the acquisition of samples and a permanent record of field activities. The observations and data will be recorded with indelible ink in a permanently bound weatherproof field book with consecutively numbered pages and, if applicable, on field sampling data sheets.

The information in the field book will include the following as a minimum.

- Project name;
- Location of sample;
- Sampler's signature;
- Date and time of sample collection;
- Sample identification numbers and sample depth (if applicable);
- Description of samples (matrix sampled);

- Analysis to be performed;
- Number and volume of samples;
- Description of quality assurance/quality control (QA/QC) samples (if collected);
- Sample methods;
- Sample handling;
- Field observations; and
- Personnel and equipment present.

Changes or deletions in the field book should be lined out with a single strike mark, initialed and dated by person making change, and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the sample collector's memory. The person making the entry will sign each page of the field book. Anyone making entries in another person's field book will sign and date those entries.

Sample Tracking. During field sampling activities, traceability of the sample must be maintained from the time the samples are collected until laboratory data are issued. Information on the custody, transfer, handling, and shipping of samples will be recorded on a Chain-of-Custody (CoC) form. The CoC is a one-page form.

The sample handler will be responsible for initiating and filling out the CoC form. The sampler will sign the CoC when the sampler relinquishes the samples to anyone else, including the bonded courier. A CoC form will be completed for each cooler of samples collected daily, and will contain the following information:

- Sampler's signature and affiliation;
- Project number;
- Date and time of collection;
- Sample identification number;
- Sample type/matrix;
- Analyses requested;
- Number of containers;
- Person to contact regarding analyses;
- Signature of persons relinquishing custody, dates, and times;
- Signature of persons accepting custody, dates, and times (laboratory); and
- Method of shipment.

The person responsible for delivery of the samples to the laboratory will sign the CoC form and document the method shipment. Upon receipt at the laboratory, the person receiving the samples will sign the CoC form. Copies of the CoC forms and all custody documentation will be received and kept in the central files. The original CoC forms will remain with the samples until final disposition of the samples by the laboratory. The analytical laboratory will dispose of the samples in an appropriate manner 60 to 90 days after data reporting. After sample disposal, a copy of the original CoC will be sent to the Project Manager by the analytical laboratory to be incorporated into the central files.