

Chino Basin Recycled Water Recharge Program

Start-Up Protocol Plan for Turner Basins



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and



February 20, 2006



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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 drinking water 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 Program (WEI, 1999). Figure 1 shows the groundwater recharge and imported water facilities in the Chino Basin. This report presents the protocols that IEUA will implement to initiate recycled water use for groundwater recharge in Turner Basins.

Turner Basins are in Chino Basin Management Zone 2 and are approximately 2,000 feet north of Interstate 10 within the City of Ontario. The Turner Basins are roughly bounded by 4th Street to the north, Archibald Avenue to the east, Inland Empire Boulevard to the south and Cucamonga Creek channel to the west. Surrounding land use is mixed residential, light industrial and open space. The Turner Basins consist of a cluster of four adjacent excavations individually referred to as Turner 1, Turner 2, Turner 3, and Turner 4.

The Turner Basins were modified under the Chino Basin Facilities Improvement Project following the release of the Chino Basin Phase I Recycled Water Recharge Project Title 22 Engineering Report (CH2MHill, 2003). The original Turner 1 was divided into two recharge basins, now referred to as Turner 1 and Turner 2. The original Turner 2, 3 and 4 were also modified and are now referred to as Turner 3 and Turner 4 (Figure 2).

The infiltration rate¹ and recharge area for each Turner Basin are shown in the adjacent table. These measurements can be used to approximate recharge rates² and flow delivery rates for each basin.

Basin Name	Recharge Area (acres)	Infiltration Rate (feet/day)	Recharge Rate (af/day)	Delivery Rate (cfs)
Turner 1	6.7	0.5	3.33	1.68
Turner 2	2.2	0.5	1.08	0.55
Turner 3	2.1	0.5	1.04	0.52
Turner 4	6.0	0.5	2.99	1.51

Prior to recycled water recharge in the Turner Basins, a period of continuous diluent water will be delivered to purge the underlying sediments of stagnated water, thus ensuring more consistent water quality analyses once recharge using recycled water is initiated. Turner 3 and 4 are currently undergoing maintenance activities while Turner 1 and 2 are receiving diluent water. As such, the initial recycled water delivery for Turner 3 and 4 may be delayed from the initial recycled water delivery to Turner 1 and 2. However, only one start-up report will be prepared for all four cells.

¹ Infiltration rate is defined here as the rate at which water enters the ground through the basin bottom and side wall surfaces. Infiltration rate is typically reported in units of feet per day and measured by a timed change in the basin water level while basin inflow is not occurring.

² Recharge rate is defined here as the volume of water that can be recharged in a basin over a period of time (e.g. acre-feet per day), also commonly expressed as a flow delivery rate (cubic feet per second) over 24 hours. Recharge rate is generally a basin's infiltration rate multiplied by a basin's average wetted area.

Diluent water will be local runoff, stormwater, or a mixture of local runoff and imported water. Continuous local runoff of 0.5 to 1.5 cubic feet per second (cfs) occurs to Turner Basins from Cucamonga Creek and Deer Creek. Deer Creek is also used to convey recycled water to Turner Basins from an upstream pipeline turnout. Recycled water delivered to Deer Creek mixes with local runoff as it flows to Turner Basins. All water delivered to Turner Basins from Deer Creek enters through a drop inlet structure in the channel bottom. Due to the water deliver mechanism, recycled water cannot be delivered to Turner Basins without commingling with local runoff. Storm water may enter the Turner Basins from Cucamonga Creek, Deer Creek, and from the overflow of upstream storm water retention basins in Guasti Park.

The Turner Basins have two lysimeter clusters; one cluster in Turner 1 and one cluster in Turner 4. Each cluster consists of individual lysimeters set at 5, 10, and 15 feet, two at 25 feet, and one at 35 feet below the cell floor. Groundwater monitoring wells T-1 and T-2 are approximately 55 feet down gradient of Turner 1 and Turner 4, respectively. Lysimeter and well monitoring are part of the recycled water recharge permit. All surface water, well water, and lysimeter water monitoring procedures referenced herein are consistent with those discussed in the draft Operations, Maintenance, and Monitoring Plan (WEI, 2005).

The Turner Basins are scheduled to begin receiving recycled water in the first quarter of 2006. Due to basin maintenance schedules, the Turner 3 and 4 recycled water initiation schedule may be a month behind Turner 1 and 2.

2. Start-Up Protocol Plan Organization

This Start-Up Protocol Plan for the recycled water recharge program at Turner Basins is comprised of the following sections:

1. Introduction
 2. Start-Up Protocol Plan Organization
 3. Objectives
 4. Regulatory Requirements
 5. Start-Up Protocols
 - 5.1. Protocol 1 – Institute DHS-Recommended Laboratory Protocol for Analysis of TOC at Low Levels for Groundwater Recharge Reuse Projects
 - 5.2. Protocol 2 – Install Lysimeters
 - 5.3. Protocol 3 – Recharge with Diluent Water
 - 5.4. Protocol 4 – Recharge with Recycled Water
 - 5.5. Protocol 5 – Collect Lysimeter Samples
 - 5.6. Protocol 6 – Develop TOC Removal Rate
 - 5.7. Protocol 7 - Develop RWC Determination
 - 5.8. Protocol 8 - Develop Draft Start-Up Report
 6. References
- Appendix A. Detailed Methodology for Lysimeter Installation
- Appendix B. Sample Handling Protocols



3. Objectives

The objectives of the start-up period are to establish the physical characteristics of the vadose zone, including infiltration rates, percolation³ rates, and removal rates of Total Organic Carbon (TOC) and total nitrogen (TN) through soil-aquifer treatment (SAT) for both recycled water and diluent water. These characteristics will be used to establish a recycled water contribution (RWC) driven by the TOC removal rate for recycled water, and to develop a sampling regime for future monitoring of recycled water recharge. Although the recycled water recharge permit includes an initial program RWC limit of 20%, it also requires RWC to vary to a lower percentage based on less efficient TOC removal rates. As discussed in Section 5.7 of this report, IEUA's recharge facilities have been significantly improved to enhance recharge from historical levels and have demonstrated TOC removal to concentrations just below 2.0 mg/L. Based on the observed basin performance, IEUA is pursuing a RWC that can vary up or down based on a formula that is water quality driven. As allowed by the draft recharge regulations (DHS, 2004) and IEUA's recycled water recharge permit, this formula can produce a RWC higher than 20% with executive approval by the Regional Board Water Quality Control Board (Regional Board) and Department Health Services (DHS). The formula is based on the running average of recycled water TOC concentrations measured in the compliance lysimeter. IEUA proposes to allow the RWC to be determined and limited by the water quality driven formula and documented TOC results, up to the limit established by DHS in the draft recharge regulations. The RWC established for Turner Basins would be subject to the acceptance by the Regional Board and DHS of the Start-Up Report documenting the start-up period activities, and would be subject to annual reporting and re-evaluation.

Electrical conductivity (EC) has been very useful at other recharge sites in the Chino Basin (Banana and Hickory Basins) to identify the presence of recycled water, diluent water, and mixtures of the two⁴. Due to that success, IEUA will use EC as a natural tracer⁵ to differentiate diluent water from recycled water at Turner Basins. Changes in EC at the lysimeter and surface water will therefore be used to estimate percolation rates and when water at the lysimeters is predominantly of recycled water origin.

A start-up period report will be prepared at the close of the start-up period and will include recommendations for a first year monitoring plan that will be used to measure compliance with the permit (e.g. the optimum lysimeter depth and sample locations) and a generalized method of tracking recharge water in the vadose zone. The report will include recommendations for the initial RWC based on the observed SAT efficiency and the TOC concentration at the compliance lysimeter.

4. Regulatory Requirements

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

³ Percolation rate is defined here as the rate at which water flows predominately in a vertical direction downward through the unsaturated zone towards the groundwater table. Percolation rate is typically reported in units of feet per day and measured by a timed change in well water levels due to a change in basin operations or a timed change in water chemistry at a well or lysimeter from the recharge of different source waters.

⁴ Recycled water distributed to other recharge basins (Banana and Hickory) have consistently had EC greater than 660 mg/L, while diluent water (storm and import) have consistently had EC lower than 400 mg/L.

⁵ A natural tracer is a constituent or group of constituents that occur naturally in either or both the recycled water and diluent water. Significant differences in concentrations of the trace in each water source can be used as a chemical signature to show when either water source is present at each of the lysimeter depths.



- 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. Start-Up Protocols

The start-up protocols for recycled water recharge are described in this section and include the following:

- Protocol 1 – Institute DHS-Recommended Laboratory Protocol for Analysis of TOC at Low Levels for Groundwater Recharge Reuse Projects
- Protocol 2 – Install Lysimeters
- Protocol 3 – Recharge with Diluent Water
- Protocol 4 – Recharge with Recycled Water
- Protocol 5 – Collect Lysimeter Samples
- Protocol 6 – Develop TOC Removal Rate
- Protocol 7 - Develop RWC Determination
- Protocol 8 - Develop Draft Start-Up Report

The activities described in protocols 1 through 3 will occur prior to the introduction of recycled water and do not impact the duration of the start-up period. Protocol 4 will comprise the start-up period. Protocol 5 will occur during both Protocol 3 and Protocol 4. Protocol 6, 7, and 8 will be completed immediately following the start-up period.

5.1 Protocol 1 – Institute DHS-Recommended Laboratory Protocol for Analysis of TOC at Low Levels for Groundwater Recharge Reuse Projects

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

- 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.

5.2 Protocol 2 – Install Lysimeters

IEUA has installed lysimeter clusters within Turner 1 and Turner 4 (Figure 2) per the detailed protocols outlined in Appendix A. A lysimeter consists of a porous cup installed in unsaturated sediments that can be used to pull water from unsaturated material using a vacuum, and thus collect samples of downward moving recharge water above the groundwater table. Each cluster consists of individual lysimeters set at approximately 5, 10, 15, two at 25, and 35 feet below the cell floor. Two lysimeters are installed at 25 feet to allow sufficient sample to be collected at this depth should it later be selected as the compliance point. At both Turner Basin 1 and 4, a 35-foot deep lysimeter was installed to evaluate the potential for additional SAT with depth. During installation of the lysimeters, the exact locations and depths were determined by a Professional Geologist to provide appropriate placement of the lysimeter cup within vadose zone sediments likely to be transmitting recharge water. Following the startup period, the lysimeter with the most representative results will be used to demonstrate SAT efficiency.

An essential requirement for lysimeter functionality is that the lysimeter backfill material be relatively fine-grained such that a vacuum applied to the lysimeter will extend sufficient distance into the formation allowing soil water to be drawn into the porous cup. Silica flour is commonly used for this fine-grained material. However, since literature studies have shown that commercial silica flour commonly used for this purpose may contain low concentrations of trace metals, IEUA has instead used native backfill material that has been sieved to be finer-grained than the surrounding formation material. However, since the native backfill material from the bottom of a recharge basin may have elevated levels of organic carbon, the following backfill installation, sampling and testing procedures have been implemented to limit and identify baseline concentrations of any parameters of concern.

At the Turner Basin lysimeter sites, a trench was excavated to a depth of about 6 feet below the bottom of the cell (below the biologically active layer that forms at the surface of the soil). A volume of soil that is 50 percent greater than that expected to be needed for backfill material was first sieved with a No. 10 US Standard sieve (2-millimeter openings) to remove large-grained sediments and then stockpiled on the site in a clean 55-gallon drum or equivalent container. Three representative samples of this sieved native material were sent to an analytical laboratory for a leaching test (*e.g.*, TCLP or WET). These samples were analyzed for TOC, nitrate, nitrite, total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), trace metals, and boron.



5.3 Protocol 3 – Recharge with Diluent Water

Turner Basins will be recharged with diluent water (stormwater, local runoff, and/or imported water) for a few weeks prior to the beginning of the start-up period to flush the vadose zone and impart a readily identified diluent water signature to soil moisture under the site. The diluent recharge duration will be based on approximately three consecutive weeks of lysimeter EC samples approximating that of the delivered diluent water. This brief period of diluent recharge will be reported in the Start-Up Report. Establishing a baseline diluent water signature of EC will allow the estimation of percolation rates based on the arrival of recycled water to the lysimeters. Recharge with diluent water will also allow for the evaluation of TOC removal rates from the diluent water. TOC removal rate estimation is discussed later in Section 5.6. The TOC removal rate will be later compared with the TOC removal rate from recycled water. Ultimately the TOC removal rate from recycled water will be used to establish the compliance RWC following the start-up period.

The quality of the delivered diluent water will be evaluated through sampling and analysis. Grab samples of diluent water in the recharge basins will be collected a minimum of once per week during pre-start up activities. These samples will be analyzed for TOC, nitrate, nitrite, TKN, TDS and EC. EC will be used to differentiate diluent water (local runoff, storm water, and imported water) from recycled water.

During diluent water recharge, IEUA will measure delivered volumes, initial recharge rates, and initial infiltration rates. Initial estimates will be made for recharge and infiltration rates as these values may change during the course of the start-up period due to natural processes. IEUA will measure and record water level data over time at a sufficient frequency to allow for estimating recharge rates and infiltration rates. A relatively steady water level will indicate a stable rate for metered diluent water originating as imported water. A rising water level will be used to calculate the capture of diluent water originating as local runoff or storm flow. Declining water levels during periods of no inflow will be used to estimate infiltration rates. The capture of diluent water will be based on metered inflow, infiltration rates, water level changes, and basin geometry. Turner Basins are equipped with pressure transducers to facilitate these estimates. Imported water is metered at the point of import water purchase.

5.4 Protocol 4 – Recharge with Recycled Water

IEUA will begin recharging recycled water after a period of recharge with diluent water. The introduction of recycled water marks the beginning of the start-up period. During the start-up period, recycled water delivery will not last longer than 180 days for any single cell of Turner Basins. Should the start-up period of recycled water recharge be interrupted by stormwater recharge or an operational inability to delivery recycled water, IEUA will discuss the interruption with DHS and the Regional Board and request an extension of the start-up period. This will allow IEUA to evaluate SAT of recycled water uninfluenced by the interruption event.

To the extent possible, only recycled water will be recharged during the start-up period. For the Turner Basins, recycled water is delivered through Deer Creek, which contains persistence local runoff at about 1 cubic feet per second. As mixing of recycled water with this local runoff is unavoidable for Turner Basins, IEUA will conduct weekly sampling, analyses, and flow rate estimates of the local runoff during recycled water delivery. Local runoff will be sampled upstream of the delivery point of recycled water into Deer Creek. Local runoff samples will be analyzed for TOC, nitrate, nitrite, TKN, and EC.

Recycled water and lysimeter grab samples will be collected on the same dates according to the Monitoring and Reporting Program No. R8-2005-0033 (Requirement IV). With this Start-



up Protocol Plan, IEUA is recommending weekly sampling for nitrogen species than, rather than the twice weekly sampling listed in the recycled water recharge permit. This recommendation is based on the exceptional quality demonstrated for IEUA recycled water (generally less than 4 mg/L TN where less than 10 mg/L TN is permitted). TOC will remain as weekly sampling during the start-up period and be contemporaneous with TN sampling.

Recycled water will be collected either as a surface water sample or as a representative distribution system sample, and analyzed for TOC, nitrate, nitrite, TKN, EC, and TDS. When the start-up period occurs during storm season (October 15 through April 15), sampling and analyses for TOC may occur twice per week to collect additional data following a storm which may have created a blend of diluent and recycled water in the basins and in the subsurface. Additional sampling will identify when predominately recycled water is at the lysimeter. IEUA intends to use EC as a natural tracer or chemical indicator to differentiate diluent water (storm water, local runoff, and imported water) from recycled water. Recycled water has a notably higher EC than these diluent water sources.

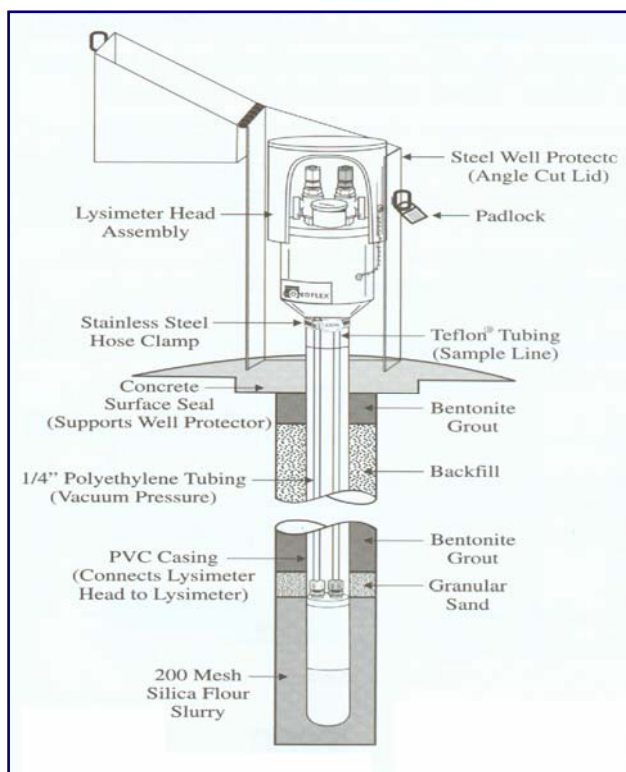
5.5 Protocol 5 – Collect Lysimeter Samples

Prior to sample collection, sampling technicians will be trained on the care, maintenance, and sampling procedures for the lysimeters, as recommended by the manufacturer of the lysimeter components. A diagram of the lysimeter components is shown in this section. All lysimeters in a cluster will be sampled during the start-up protocol.

Lysimeter sampling consists of a four -step process occurring over a 24-hour period. These sampling steps (lysimeter purging, lysimeter charging, lysimeter discharging, and basin sampling) are described in the following subsections.

5.5.1 Lysimeter Purging

To increase sample integrity, each lysimeter must be purged of any fluid remaining in the lysimeter and sample tubing prior to sampling. To purge the lysimeter, both ball valves are opened and a portable reversible vacuum pump is connected to the polyethylene vacuum/pressure tube and a positive pressure is applied. This process will clear any water that has entered the system between sampling events. When all water evacuates the Teflon sampling tube, purging is complete and the sampling ball valve is closed.



5.5.2 Lysimeter Charging

Charging the lysimeter and tubing with a vacuum is necessary to draw water through the porous stainless steel and into the lysimeter. Leaving the pump connected to the 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 then closed and the vacuum pump is turned off. The lysimeter will remain charged at a negative pressure for 24 hours.

5.5.3 Lysimeter Discharging

Sample collection occurs during lysimeter discharging. Discharging the lysimeter water is achieved by pressurizing the lysimeter and tubing until the sample is brought to the surface. The sampling technician inserts the sampling tube into a clean, labeled sample bottle. The lysimeter is then purged, as described in Section 5.5.1. When all water has been purged, power off the pump and close both valves. Lysimeter water samples will be handled under Chain-of-Custody procedures.

5.5.4 Basin Sampling

The sampling technician will collect a surface water grab sample adjacent to the lysimeter cluster on the same day and approximately the same time that the lysimeter samples are collected. If there are two lysimeter clusters at one basin site, a surface water sample will be taken near each cluster, and these samples will not be composited. The naming convention for water samples will be YYYYMMDD-Basin-Cell-Sampling Point or a similarly appropriate naming convention utilized by the laboratory. Samples will be handled in accordance with standard protocols, as described in Appendix B.

5.6 Protocol 6 – Establish the TOC Removal Rate

The efficiency of SAT in removing TOC will be determined from a running 20-sample average at the compliance point lysimeter. The 20 samples may not necessarily be consecutive. Samples used to calculate the running average will include only those lysimeter samples that are determined to be of predominately recycled water origin based on EC and are not influenced by TOC of stormwater or periods of basin inoperation. TOC removal rates will be established using the following equation:

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

where TOC_{SW} is a running average TOC concentration in mg/L of the recycled water (source water) delivered to the basin and TOC_{LYS} is the running average TOC concentration in the compliance point lysimeter. TOC_{Loss} will be expressed as a percent reduction.

Although permitted TN concentrations are being met in the discharge system from IEUA reclamation plants, TN removal rates will also be established during the start-up period using the following equation:

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

where TN_{SW} is a running average total nitrogen concentration in mg/L of the recycled water (source water) delivered to the basin and TN_{LYS} is the running average TN concentration in the compliance point lysimeter. TN_{Loss} will be expressed as a percent reduction. TN removal efficiency will be shown to further demonstrate SAT removal and is not used in the establishing a RWC.



5.7 Protocol 7 – Establish the Initial 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:”

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

This water quality driven derivation of $RWC_{COMPLIANCE}$ ⁶ indicates that with very low TOC concentrations, RWC may be as high as permitted in the draft recharge regulations or as allowed administratively by the Regional Board and DHS. Based on demonstrated performance of TOC removal at Banana and Hickory Basins to levels as low as 2.00 mg/L, IEUA is pursuing the use of this water quality based formula in establishing $RWC_{COMPLIANCE}$ following the start-up period for Turner Basins. IEUA's Phase 1 recycled water recharge permit provides for a maximum $RWC_{COMPLIANCE}$ of 20%, which allows a maximum $TOC_{AVERAGE}$ of 2.50 mg/L. Should the demonstrated $TOC_{AVERAGE}$ be less than 2.50 mg/L, then the $RWC_{COMPLIANCE}$ would be greater than 20%. Likewise, should the demonstrated $TOC_{AVERAGE}$ be greater than 2.50 mg/L then the $RWC_{COMPLIANCE}$ would be less than 20% as calculated from the formula. TOC removal rates at a basin will be reevaluated at the end of one year of recycled water recharge and may be used to support changes in $RWC_{COMPLIANCE}$ in subsequent years.

Following the start-up period and monthly thereafter, IEUA will estimate its RWC_{ACTUAL} based on a 60-month historical running average of historical diluent water volume recharged and recycled water volume recharged using the following formula:

$$RWC_{actual} = \frac{RW_{average}}{DW_{average} + RW_{average}}$$

At the end of the start-up period, the RWC_{ACTUAL} may be greater than the water quality based $RWC_{COMPLIANCE}$. IEUA may exceed the maximum volume requirements to maintain $RWC_{COMPLIANCE}$ to demonstrate SAT efficiency in a recharge basin with little to no historical recharge of diluent water. IEUA will bring the RWC_{ACTUAL} to be at or below the $RWC_{COMPLIANCE}$ within the first 60 months of recycled water recharge by preparing and implementing a RWC Management Plan. IEUA has dramatically improved recharge basin performance over historical levels by installing imported water sources and by routinely cleaning clogging materials from the recharge basin bottoms. As demonstrated at Hickory Basin in the two months prior to initiating recycled water recharge, IEUA was able to add in two months a volume of diluent water to the improved basin that was similar to the volume recharged over the previous two years in the unimproved basin.

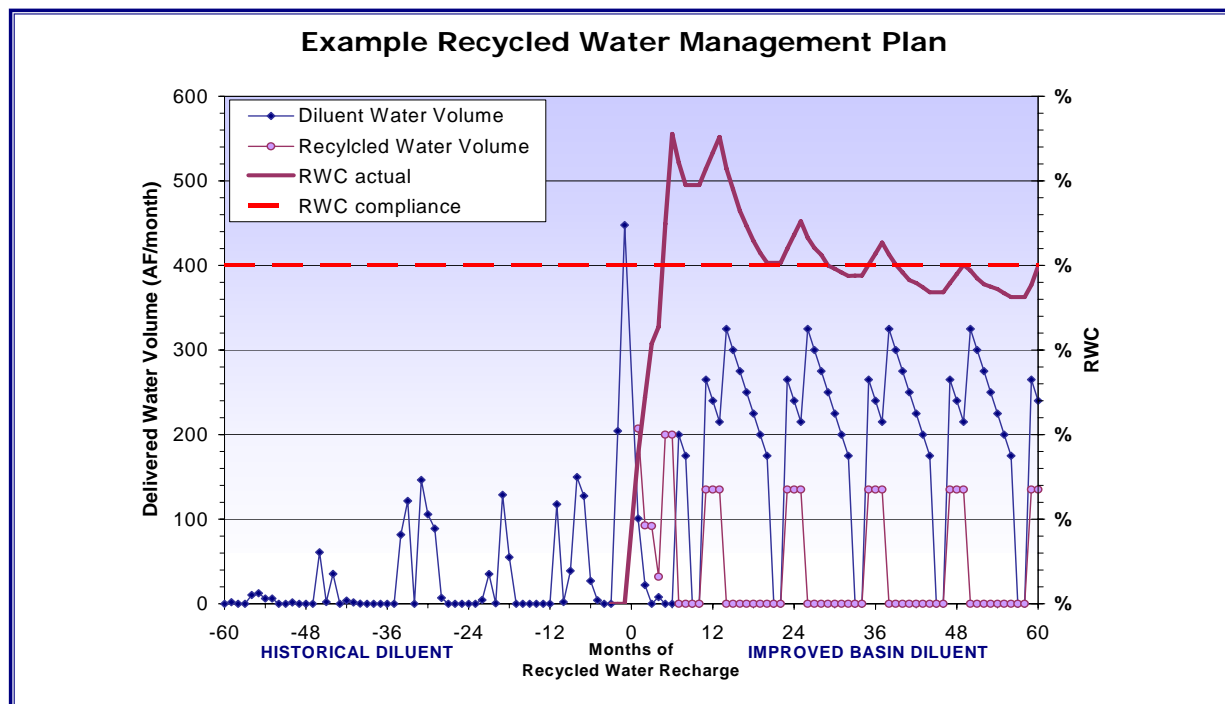
As part of the start-up period report and subsequent annual reports, IEUA will prepare a RWC Management Plan that looks forward in time to estimate RWC_{ACTUAL} based on anticipated IEUA recharge operations over the first 60 months of recycled water recharge. To assure $RWC_{COMPLIANCE}$ is met at 60 months, the RWC Management Plan will be updated annually to identify diluent water needs compared to past basin recharge performance. As suggested by the accompanying example graph of a RWC Management Plan, the plan will be based on IEUA's operational experience with diluent water availability and the periodic variations in basin recharge rates due to basin clogging and subsequent basin maintenance.

⁶ For clarification of the RWC purpose, IEUA will use the term $RWC_{compliance}$ in lieu of $RWC_{average}$



With a RWC Management Plan, IEUA will meet $RWC_{COMPLIANCE}$ at the 60th month of recycled water recharge.

During and following the start-up period, IEUA will maintain a time-series graph to track RWC_{ACTUAL} in relationship to the $RWC_{COMPLIANCE}$. The graph (not shown here) will include the TOC sampling results for surface water and the compliance point lysimeter, the 20-week running average TOC ($TOC_{AVERAGE}$) for the compliance point, and a horizontal line indicating the maximum $TOC_{AVERAGE}$ allowable with the identified $RWC_{COMPLIANCE}$.



5.8 Protocol 8 – Develop Start-Up Report

Following the end of the start-up period, IEUA will prepare a Start-Up Report for Turner Basins. The report will be submitted to the Regional Board and DHS approximately 60 days following the end of recycled water delivery to the Turner Basins. This time will allow laboratory analyses to be completed and data evaluation to be conducted for samples collected near the end of the start-up period. If Turner Basins 3 and 4 are delayed in receiving recycled water due to scheduled maintenance activities, then the start-up report for the Turner Basins will be submitted following the conclusion of necessary recycled water delivery to these two cells. The Start-Up Report will contain the following sections:

1. Introduction
2. Lysimeter Installation
3. Recharge Rates
4. Compliance Point Lysimeter Selection
5. Start-Up Period Recharge Operations
6. Determination of TOC Removal Rates



7. Determination of TOC Limit and Initial 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.

5.8.1 Introduction

This section will describe the Recycled Water Recharge Program and the subject recharge basin, including a location map for the subject recharge basin.

5.8.2 Lysimeter Installation

This section will describe the field work 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 and 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 cluster. Boring logs completed by a Professional Geologist will be included in an appendix.

5.8.3 Recharge Rates

Calculated recharge, infiltration, and percolation rates 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.

5.8.4 Compliance Point Lysimeter Selection

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

- Tables and time-series graphs of diluent water chemistry (surface water samples)
- Tables and time-series graphs of recycled water chemistry (representative distribution system and/or surface water samples)
- Tables and time-series graphs of recharge water chemistry (lysimeter samples)

Lysimeter water quality data will be reviewed to determine which lysimeters reflect recharge water chemistry most closely. As supported by lysimeter data, the deepest lysimeter that reflects recharge water chemistry would be selected as the compliance point to document SAT efficiency with depth on the removal of TOC and nitrogen. This section will also include a discussion and recommendation for which lysimeter at the Turner Basins is most appropriate for continued monitoring during the subsequent year of recycled recharge.



5.8.5 Start-Up Period Recharge Operations

This section will include a discussion of the start-up period recharge operations and duration, including water source volumes delivered and estimates of recharge rates, infiltration rates, and percolation rates. The section will discuss the general approach used for tracking the various sources 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. Estimates of transit times to various monitoring points will be determined. Plots of EC, TN, and TOC concentrations versus depth below grade will be provided, as will be time-series plots of EC, TN, and TOC.

This section will include a discussion of the water quality trends observed in relationship with the recharge operations of the basins. The trends will be used to explain observed percolation rates, trends in TOC reduction at the lysimeters, and evaluation of the minimum time necessary to establish consistent TOC reduction.

5.8.6 Establish TOC Removal Rates

This section will describe the data and process used to establish the TOC removal rate for the basin, which will generally utilize the process described in Section 5.6. TOC removal rate will be based on comparison of the recycled water delivered to the basin and the TOC of samples from the compliance lysimeter. This section will also describe the use of EC as a natural tracer to determine which lysimeter samples are of predominately recycled water origin. Only these samples will be used in evaluating TOC removal rates.

5.8.7 Establish Initial RWC

This section will describe the process used to establish the $RWC_{INITIAL}$ and will generally utilize the process described in Section 5.7. $RWC_{INITIAL}$ will be based on the sampling and analyses from the compliance lysimeter and from the limits and water quality driven formula provided in the draft recharge regulations. The RWC is described as initial as it is subject to administrative approval and review by the Regional Board and DHS. This section will also describe the annually updated RWC Management Plan that will be used to ensure compliance with the established RWC is met within a 60-month period following the initial delivery of recycled water.

5.8.8 First Year Monitoring Plan

IEUA will implement a First Year Monitoring Plan following the guidelines of the Monitoring and Reporting Program (Regional Board, 2005b). This section of the Start-Up Report will discuss IEUA recommendations for the First Year Monitoring Plan. It will also contain an identification of the compliance lysimeters and sampling locations for representative recycled water samples. For basins with more than one lysimeter cluster, the plan will indicate which clusters will contain the compliance lysimeters.

The goal of the monitoring plan will be to collect samples when the recharge basin is actively recharging recycled water and for a short period following the halt of recycled water recharge. Samples will not necessarily be collected when the basin is dry or undergoing maintenance or recharging only diluent water. The first year monitoring plan will provide recommended methods for monitoring recharge water that is predominantly of recycled water origin at the compliance point lysimeter. If necessary, discussion on the need for tracers other than EC will also be provided.

It is anticipated that the sampling will be according to the following schedule:



Monitoring Program for Recycled Water Recharge

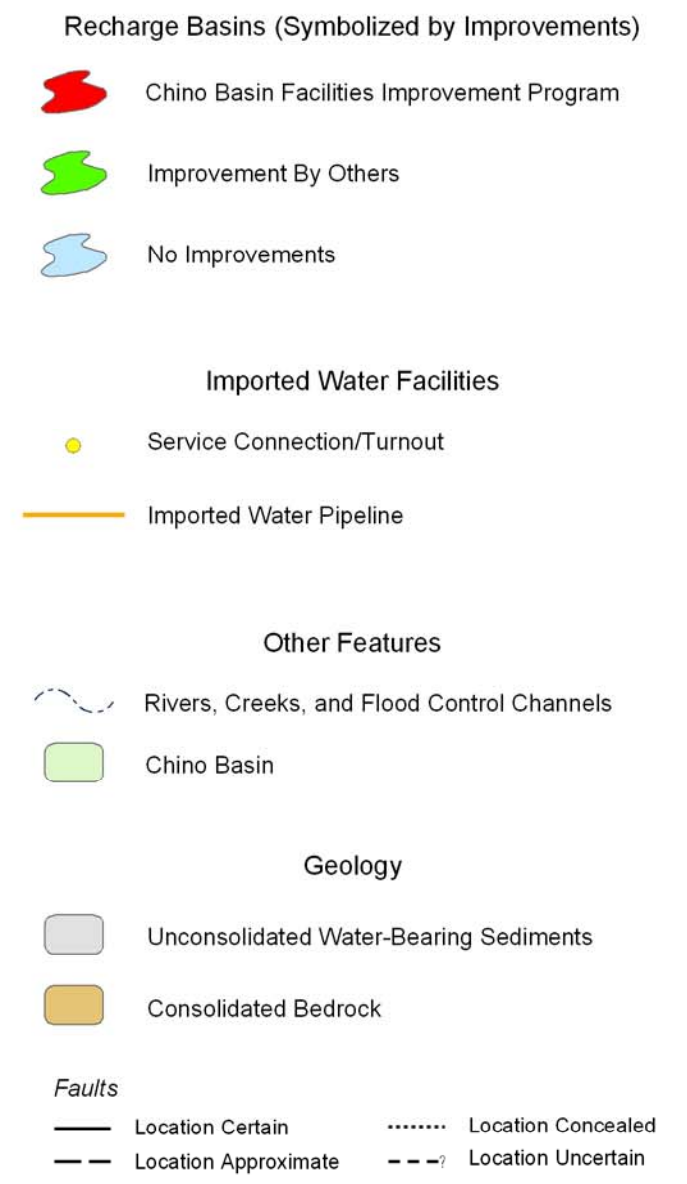
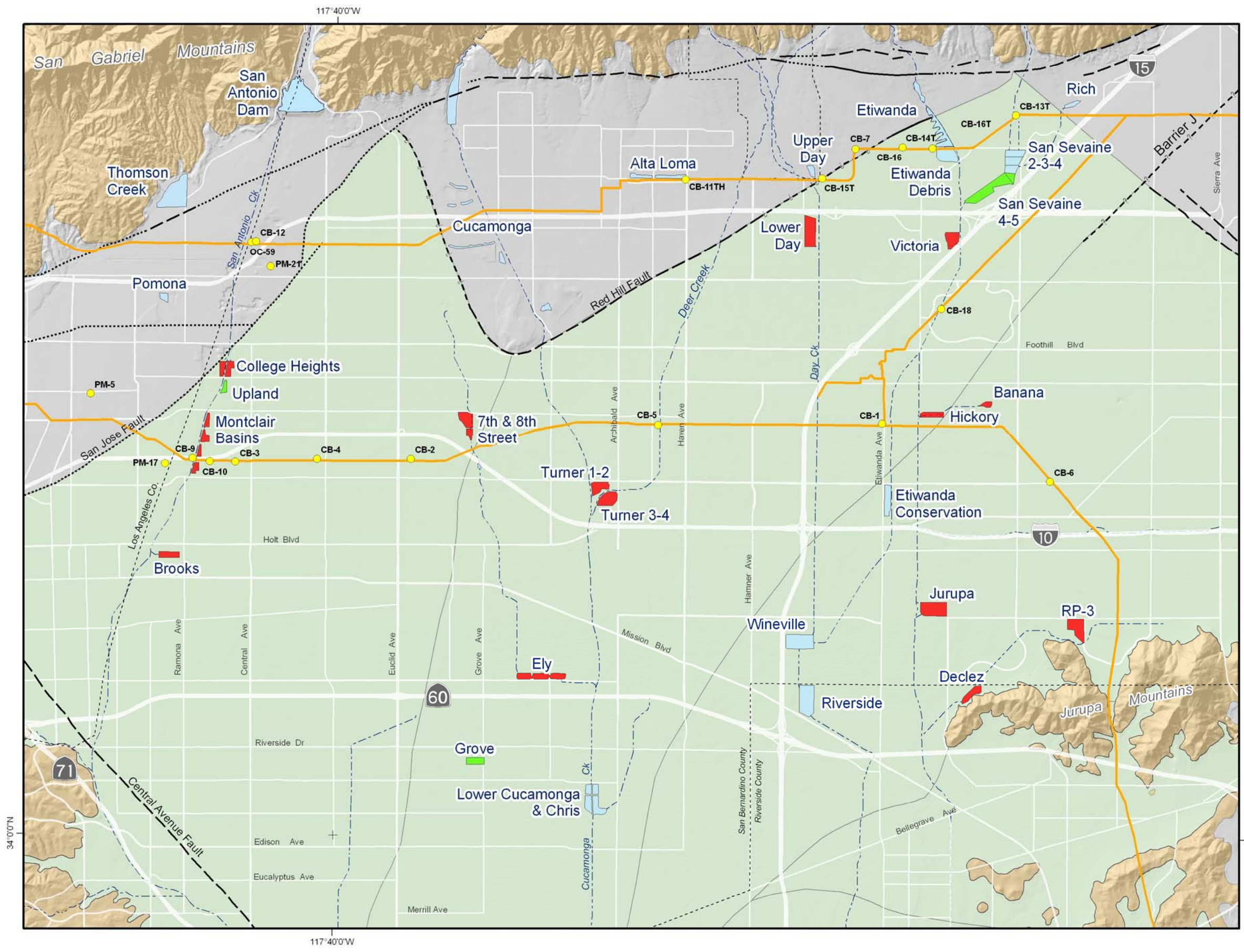
Parameter	Sample Station	Units	Type of Sample	Minimum Frequency
TOC	Lysimeter	mg/L	Grab	Weekly
Total Nitrogen	Lysimeter	mg/L	Grab	Weekly
Total Inorganic Nitrogen	Lysimeter	mg/L	Grab	Weekly
Nitrate-Nitrogen	Lysimeter	mg/L	Grab	Weekly
Nitrite, Ammonia, and Organic Nitrogen	Lysimeter	mg/L	Grab	Weekly
Nitrite-Nitrogen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

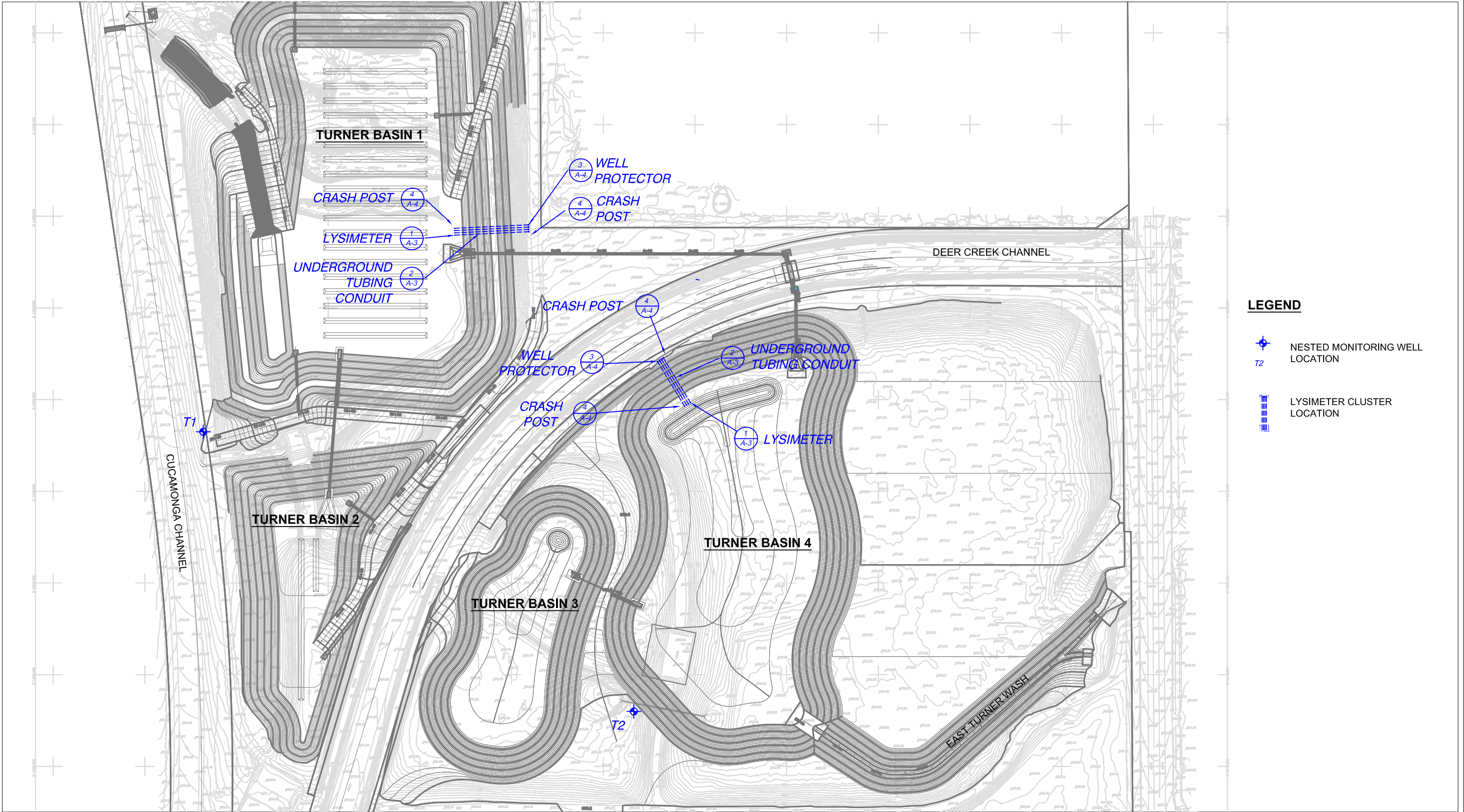
IEUA recommends a less frequent sampling of nitrogen species than listed in its recycled water recharge permit, due to the exceptional quality demonstrated for IEUA recycled water (generally less than 4 mg/L where less than 10 mg/L is permitted). IEUA recommends weekly nitrogen sampling at the lysimeter rather than twice weekly.

6. References


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- 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. Phase I Chino Basin Recycled Water Groundwater Recharge Project, Title 22 Engineering Report, prepared for Inland Empire Utilities Agency. November 2003.
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<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.
- Wildermuth Environmental, Inc., 1999. Optimum Basin Management Program, Phase I Report, prepared for Chino Basin Watermaster. August 19, 1999.
- Wildermuth Environmental, Inc., 2005. Chino Basin Recharge Facilities Operations Procedures, Administrative Draft No. 3. June 2005.









LEGEND


 NESTED MONITORING WELL LOCATION
T2

 LYSIMETER CLUSTER LOCATION

Scale 1:2400

0 200' 400'

 North

Underground Service Alert					REVISIONS		
 Call: TOLL FREE 1-800 227-2600 TWO WORKING DAYS BEFORE YOU DIG					NO.	DATE	INITIAL
					DESCRIPTION:	APPROVED/DATE	
DESIGNED:					DRAWN:		CHECKED:

 WILDERMUTH™
ENVIRONMENTAL INC.

 Inland Empire
UTILITIES AGENCY™

REVIEWED BY: AEM
DRAWN BY: WEL
START DATE: 02/16/05

TURNER BASINS

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 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 be 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.

