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Final
Revised Field Sampling Plan
UC Davis Additional Field Investigations
LEHR/SCDS Environmental Restoration
Davis, California

AUGUST 1998
Job No. 00234-258-044

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UNIVERSITY OF CALIFORNIA, DAVIS

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December 9, 1998

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Federal Facilities Cleanup Office, Section I
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Ms. Susan Timm
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Ms. Lisa Brown
Department of Health Services
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Sacramento, CA 95814

Re: Distribution of the Final Revised FSP – UC Davis Additional Field Investigations – LEHR/SCDS Environmental Restoration

Dear Ms. Setian, Ms. Timm, Mr. Austin, and Ms. Brown:

Enclosed please find a copy(s) of the Final Revised Field Sampling Plan (FSP) for UC Davis Additional Field Investigations at the LEHR/SCDS Environmental Restoration in Davis, California. Wherever appropriate, RPM comments have been incorporated into this final document. An outline of the RPM comments and respective UC Davis responses is provided at the front of the FSP.

If you have any questions about the enclosed document, please call me at (530) 752-6041, or write me at the following address:

Environmental Health & Safety
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for Brian Oatman
LEHR/SCDS Project Manager

Attachments: Final Revised FSP – UC Davis Additional Field Investigations – LEHR/SCDS Environmental Restoration

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Comments o l Responses to Field Sampling Plan
Laboratory for Energy-Related Health Research, University of California, Davis, Solano County
Susan Timm, California Regional Water Quality Control Board, Central Valley Region

Item No.	Comment	Response
1	***Attachment A, Response to EPA Comment # 4.*** UCD proposes adding aquatic toxicity testing to the storm water and surface water monitoring programs. UCD says the test will be performed by EPA Method 600/4-90-D27F. This method is for acute aquatic toxicity. UCD should test chronic aquatic toxicity using EPA Method 600/4-91-002.	Chronic aquatic toxicity has been added to the surface water monitoring program. Initial tests were conducted with the spring surface water 1998 round conducted in May 1998. The surface water monitoring program has been modified to consists of multiple dilution tests to establish end-point concentrations for all three species. The chronic test uses 3 species: fathead minnow larvae, *Ceriodaphnia dubia*, and *Selenastrum capricornutum* Acute aquatic toxicity is more appropriate than chronic toxicity for monitoring stormwater discharges because of the nature of the discharge. Stormwater discharges from the site typically last for only a few hours and generally occur when the creek levels are high. Therefore, the organisms in the creek that are potentially exposed to stormwater discharges would experience the discharge in an acute exposure scenario; i.e., over a short period of time. Over several hours or days, the stormwater discharge would become mixed with the creek water, resulting in a chronic exposure scenario. Therefore, we propose to monitor stormwater discharge for acute toxicity and Putah Creek for chronic toxicity. The revised program is described in Sections 4.8 and 4.9 of the FSP.
	UCD discusses the detection limits with respect to aquatic water quality limits. It says detection limits for 17 parameters are above at least one aquatic water quality limit. I count 13, or 18 if total PCBs are separated into individual aroclors.	Detection limits have been updated for GEL. Table A has been corrected to indicate detection limits for 14 parameters are above at least one aquatic water quality limit.
	Several misspellings occur in the document; for example "achieve" is consistently misspelled. UCD should run spell check on the document before issuing the final.	Checked as requested.
2	***Page 4.2, Section 4.1.1 Waste Burial Holes.*** UCD proposes containment and/or partial or complete removal as possible remedial alternatives for the waste burial holes and states, "...the data gaps soil investigation in this area focused on collecting data to evaluate these alternatives and included a trenching and soil sampling program...." UCD needs to present the Remedial Project Managers (RPMS) with the investigation results including an analysis and evaluation of the data, any plans for further investigation, and a schedule with more detail than presented in the 5 February 1998 *Long Range Plan.* The schedule needs to include a process for public participation.	An Administrative Order on Consent (AOC) is currently being negotiated between the US EPA and UC Davis. The AOC will specify the plans and schedule for further investigation, completion of RI/FS documents, and a process for public participation consistent with CERCLA requirements.

3	***Page 4.2, Section 4.1.2 Eastern Trenches and Page 4.3, Section 4.1.3 Southern Trenches.*** UCD needs to submit to the RPMs a data summary and discussion of sampling results for the eastern trenches and southern trenches data gaps investigations. UCD lists crontonaldehyde as a constituent detected in the eastern trenches during previous investigations. I thought the reporting of this constituent was determined a laboratory error.	Eastern Trenches and Southern Trenches data have been transmitted. Further review of the data will be presented either in documents supporting Interim Removal Actions or in the RI/FS report. The detection of crotonaldehyde was erroneously reported and the reference has been removed from the FSP.
4	***Page 4.6, Section 4.4 Additional Hydrogeologic Investigation.*** In the first sentence of the last paragraph of this section, UCD should replace the "or" before "groundwater remedial activities" with "and".	Changed as requested.
5	***Page 4.9, Section 4.6 Off-site Monitoring Well Investigation.*** The title to this section should be "Off-site Groundwater Investigation".	Changed as requested.
6	***Pages 4.11 through 4.18, Section 4.7 Groundwater Monitoring, Section 4.8 Surface Water Monitoring, Section 4.9 Storm Water Runoff Monitoring and Section 4.10.*** Neighbor Well Monitoring Program UCD should include a water monitoring reporting schedule. Quarterly reports should be submitted within 90 days after the sampling events occur for groundwater and surface water. An Annual Water Monitoring Report (Annual Report) should be submitted by 1 April of each year following the monitoring year being reported. Since storm water sampling only occurs during the rainy season, the results of this sampling could be included in the second quarterly report.	Section 7.5 (Data Transmittals) has been revised as follows: "After analytical data have been validated using procedures described in the Revised QAPjP, the results will be submitted to site RPMs in quarterly water monitoring data transmittals within 90 days after the conclusion of sampling. The quarterly data transmittals will present water level data, summary tables of the analytical results, a summary of field methods and a summary of QA/QC procedures as described in the Revised QAPjP. "The annual report will present more detailed analysis of the monitoring results and statistical evaluation of identified impacts. The annual report will also include information regarding hydrogeologic parameters, including groundwater gradients and flow directions, established throughout the year. It is anticipated that the annual report will be prepared after the fall quarterly sampling results have been received, and will contain storm water runoff data from the previous rainy season. The annual report will be submitted to site RPMs by April 1 of the following year.
7	***Page 5.3, Section 5.3.3 Preliminary QC Data Evaluation.*** The discussion of relative percent difference (RPD) between a primary sample and duplicate sample is unclear. UCD states, "If the RPD values indicate a trend for a particular analyte or a particular sampling event, those data are flagged for possible corrective action." Does UCD mean that differences in results for these samples could indicate that the sampling procedures or laboratory procedures are causing invalid data results? What is meant by "possible corrective action"?	Use of RPD between primary and duplicate samples is more clearly described in Section 3.0 of the Revised QAPjP. For clarity, Section 5.3.3 has been removed from the FSP.

8	***Page 5.3, Section 5.4 Changes to Sample Analysis.*** UCD proposed recommending modifications to the monitoring programs in the Annual Report and implementing the modification (if approved) in the August monitoring round. In order to implement changes in August, UCD must submit the Annual Report by 1 April of the year following the monitoring being reported. Whether or not UCD is requesting modifications which require RPM approval, submitting the Annual Report in a timely fashion is essential for all parties involved to evaluate the monitoring network, monitoring frequency, analytes being monitoring, removal and remedial actions, changes in water quality, and changes in groundwater flow characteristics.	The Annual Report will be submitted by April 1 of each year. See response to RWQCB comment #6, above.
9	***Page 6.3, Section 6.4 Exploratory Trench Investigation.*** UCD lists criteria for selecting waste samples in exploratory trenches. UCD should list criteria for selecting soil samples in exploratory trenches. Also, UCD should address how it will determine the number of samples to be taken from waste material and from native soil.	Section revised as follows: "In addition to sampling wastes, soil samples will be collected below the base of trenches and landfill units. The soil samples will be collected from areas located below waste sample locations, or in discolored, stained soil to evaluate areas where material may be leaching out of waste. Soil samples will be collected as undisturbed drive samples, if possible, or from a backhoe bucket. Both disturbed and undisturbed samples must be capped and cooled immediately for analysis of volatile samples as described in SOP 10.
10	***Page 6.5, Section 6.5 Soil Borings.*** UCD proposes collecting soil samples below or adjacent to waste, every five feet. More frequent sampling may be necessary. Additional sampling locations should be decided in the field based on visual observations and field analyses.	Sentence revised as: "While drilling below or adjacent to waste, samples will be collected at least every five feet and more frequently if necessary, based on field observations and field measurements for VOCs and radioactivity."
11	***Pages 6.7 and 6.8, Section 6.9 Surface Water Monitoring Procedures.*** At the bottom of the page, UCD writes "Additionally, estimates of flow velocity in the South Fork of Putah Creek..... This is an incomplete sentence.	Sentence changed to: "Additionally, estimates of flow velocity in the South Fork of Putah Creek can be obtained by checking the nearest stream gauge monitored by Solano County Water Agency and obtaining the daily flow rate from the UC Davis wastewater treatment plant.
12	***Page 6.8, Section 6.10 Storm Water Sampling Procedures.*** The second paragraph in this section needs to be rewritten to clarify sample collection procedures.	Paragraph revised as follows: "Samples from location LS-1 will be collected out of the sump while it is receiving runoff and while the lift station pump is running. Grab samples for LS-1 will be collected directly into the proper sample container. Samples from locations LF-1 and LF-3 will be collected out of the culvert while it is receiving runoff. Grab samples for LF-1 and LF-3 will be collected directly into the sample containers or into disposable containers and transferred to the appropriate sample containers."

13	***Table 8, Sample Analyses-Water.*** As stated above, UCD needs to change the method for Aquatic Toxicity to EPA/600/4-91-002 for chronic aquatic toxicity analyses.	See response to RWQCB comment #1.
14	***Table 10, IRA Groundwater Analytical Parameters.*** UCD should explain why the table has "Parameters Groundwater Sample" and "Additional Parameters".	The following footnotes have been added to Table 10: 1. IRA Groundwater Analytical Parameters – Parameters analyzed for samples collected during the pumping phase of the IRA pumping test of extraction well EW2-1. 2. Parameter Groundwater Samples – Parameters analyzed for all pumping test samples from extraction and monitoring wells. 3. Additional Parameters – Parameters analyzed for extraction well samples only.

Item No.	Comment	Response
1	Laboratory Quality Assurance Plan The Laboratory's Quality Assurance Plans are referenced for providing specifics in the areas of accuracy and precision objectives, calibration procedures, and laboratory data reduction. General Engineering Laboratory (GEL) is certified in California to perform inorganic and organic chemistry for drinking water, but not for radiochemistry. Please provide the laboratory quality assurance plans for radiochemistry in soil and water for review.	GEL's radiochemistry division, Environmental Physics, Inc., is a certified California testing laboratory. See response to EPA comment #5.
2	Detection Limits. ***Table 7.1, Sample Analyses - Soil, pages 7.3-7.4, and Table 7.2, Sample Analyses - Water, pages 7.21-7.22.*** Please see comments four and five of the comment letter submitted by this Department for the *Revised Field Sampling Plan* dated February 9, 1998 (attached) as they are the same for the referenced tables above.	See response to DHS comment #4 for the Revised Field Sampling Plan dated February 9, 1998.
	In addition, please explain the change in analytical method for isotopic thorium, isotopic uranium, americium-241 and plutonium-241 from LAS 0108 and LAS 0178 in the *Revised Field Sampling Plan* to EPA 907.0 (M) in this document. There should be some consistency between the documents since they are to be used together.	References to analytical methods have been revised to be consistent between FSP and QAPjP documents.
3	Spike Samples. ***Section 9.2.4, Spike samples, page 9.4.*** The purpose for performing this quality control check is not indicated. Please include the purpose for using the matrix spike and spike duplicate sample in this section. Also, please explain what determines when it is "appropriate to the method" to collect and analyze this type of quality control samples.	The following sentence has been added to address MS/MSD analyses: "For some methods (e.g., TDS, alkalinity and hardness), spiking native samples is not appropriate. The referenced methods provide guidance on the appropriateness of performing MS/MSD analyses."

Item No.	Comment	Response
1	Air Monitoring. ***Section 5.2, Summary of Analyses, page 5. 1, first and second paragraphs.*** Table 9 is actually in regard to soil vapor. Please clarify if the reference for Table 9 as air monitoring information is correct. Please address the topic of air monitoring. There is no specific discussion of an air monitoring program although procedures for collecting air samples are included in Appendix A. Include whether air monitoring is performed routinely or during specific site activities.	The reference to Table 9 has been changed. Section 4.11 has been added to the Revised FSP as follows: "4.11 Air Monitoring "The baseline air monitoring program for the LEHR/SCDS described in Section 7.0 of the RI/FS Work Plan and Section 6.11 of Appendix A to the RI/FS Work Plan. Baseline air monitoring is currently being conducted by the DOE. Air monitoring during specific UC Davis field activities that have the potential to cause site contaminants to become airborne will be conducted as part of Health and Safety monitoring as described in the site Health and Safety Plan."
2	Field Measurements. ***Sections 6.9, Surface Water Monitoring Procedures, page 6.7; Section 6.10, Storm Water Sampling Procedures, page 6.8; Section 6.11, Neighbors' Well Sampling,. page 6.9; and Appendix A, Standard Operating Procedure 1.0, pages 7-8.*** Please identify the basis for collecting three sets of field measurements for surface and storm water monitoring and, in the case of the neighbors' groundwater wells, why only one set of a more limited number of measurements is required.	Text has been revised to require one set of measurements from storm water and surface water sample locations, and three sets of measurements from neighbors' groundwater wells. The three sets of readings for neighbors' well sampling will be collected to demonstrate stable field measurements.
	The section on groundwater monitoring indicates that the field measurements taken of purged water should stabilize prior to sampling, yet it is not required for the neighbors' groundwater well sampling. Please explain this discrepancy.	When possible, field measurements will be used to demonstrate consistent temperature, pH, and conductivity for neighbors' wells. However, due to the large flow rates of many wells (greater than 1,500 gpm), and as a courtesy to well owners, unnecessary and prolonged pumping will not be conducted based on field measurements.
3	Representative Sampling of Surface Waters. ***Sections 6.9, Surface Water Monitoring Procedures, pages 6.7 and 6.8.*** Please discuss the procedure for collection of surface water samples as it pertains to sample representativeness. Justify -the current method of collecting surface water (taking a grab sample from the shore of the creek) instead of other more representative methods, e.g., a sample composite over the cross section of the creek, a sample composite over time, a grab sample representative of a more open area, etc.	Surface water samples are collected as grab samples from the northern bank of Putah Creek because discharges from the site occur at the northern bank of Putah Creek. We propose to continue grab samples from these locations due to the relatively low and short-duration flows of storm water discharges to the creek from the site, and due to difficult access to Putah Creek in the vicinity of the site.

4	Detection Limits. ***Table 2, Sample Analyses - Soil.*** The detection limits need to be sufficiently low enough to distinguish contamination from background levels of contaminants of concern with a high level of confidence, e.g., less than 20% uncertainty. Current site background numbers established by the Department of Energy (DOE) show background levels of soil contaminants of concern below the proposed detection limits. Furthermore, the detection limits established for DOE areas of the site are orders of magnitude lower than the limits proposed in this document. The detection limits for gross alpha, gross beta, radium-226, carbon-14, and strontium-90 could be lower. Isotopic thorium and uranium are set at about what is normally seen in soil samples and should be lower. Americium-241, plutonium-241 and the gamma spectral analysis look high and could be lower.	Table 2 has been revised to reflect the best achievable detection limits by the contract laboratory, GEL. Method selection and determination of detection limits are described in Sections 7.1 and 7.2 of the QAPjP. See response to EPA comment #7.
	Table 8, Sample Analyses - Water. The EPA National Interim Primary Drinking Water Standards require the detection limit for gross alpha in drinking water be 1 pCi/L when screening for radium. This standard limit could be achieved. The detection limit for radium-226, americium-24 1, plutonium-241 and gamma spectroscopy look high and could be lower. The concern is that the use of higher detection limits may limit data usability in meeting the purpose and objectives outlined in Chapter 1.0 of this document. Primarily, the detection limits need to be low enough to see the levels that are present in the sample. Secondly, it is practical to achieve lower detection limits. Please justify the use of these proposed detection limits.	The Final EPA Drinking Water Standards (40 CFR141.15) require detection limits of 5 pCi/L for Ra-226/Ra-228 and gross alpha (including Ra-226) of 15 pCi/L. Table 8 has been revised to reflect the best achievable detection limits by the contract laboratory, GEL. Method selection and determination of detection limits are described in Sections 7.1 and 7.2 of the QAPjP. See response to EPA comment #7.
5	Carbon-14. ***Table 2, Sample Analyses - Soil.*** The method proposed to analyze for carbon-14 in soil is by liquid scintillation. Please provide a description of this analytical methodology.	Reference has been corrected to read EPA 520/5-84-006 for carbon-14. A closed distillation is performed to convert carbon compounds to CO_2, which is then precipitated in a $CaCl_2$ solution, and weighed prior to counting with a beta particle counter.

6	Analytical Parameters. ***Table 10, IRA Groundwater Analytical Parameters.*** Carbon-14 should be added to the list of analytical parameters for monitoring of the Groundwater Interim Removal Action (IRA) system, because of the presence of measurable quantities in on-site monitoring wells. The list provided in Table 10 does not appear to correspond with the analytical parameters proposed in the *Removal Action Workplan, Groundwater Interim Removal Action,* dated December 1997. Please explain this discrepancy.	Table 14 refers to samples collected during the IRA extraction well pumping test. See response to RWQCB comment #14.

Item No.	Comment	Response
General	The FSP includes most of the elements required by Regional guidance; however, a number of concerns have been identified, including the "back dated" planning documentation for some project activities that have been completed; discrepancies between information provided in the quality assurance project plan (QAPjP) and FSP regarding the laboratory contracted to perform analytical services for the project and the frequency of field duplicate collection, and insufficient rationale for the selection of analytical parameters. These concerns are included in Section 1 of this memorandum. The subject FSP includes information which addresses some of the concerns identified in the EPA memorandum dated March 19, 1998, a review of the QAPjP. These comments are addressed in Section II of this memorandum. The subject FSP cannot be approved by the Quality Assurance (QA) Office until the following comments are addressed	
Major Concerns		
1A	***Attachment A: Response to EPA Comment #4; Table A, Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters.*** The subject FSP includes responses to EPA comments. Attachment A, which addresses EPA Comment 4, includes Table A, a comparison of freshwater aquatic limits, contract required detection limits (CRDLs), and instrument or method detection limits (IDL or MDL, respectively). Attachment A indicates that the CRDLs provided in Table A are those specified in the contract between UC Davis and the current analytical laboratory, LAS Laboratories. However, it is the QA Office's understanding that LAS Laboratories is no longer in business, which suggests that some of the information in -the table may no longer be valid. CRDLs in Table A should be revised to reflect project needs, requiring the contract laboratory to achieve the levels required by the project.	Table A has been revised to reflect current detection limits and is attached to these responses.

1B	Given the low detection levels required for aquatic limits, it is recommended that the sampling be Performed using the "clean hands, dirty hands", which involves having the clean sampling containers double bagged and two persons performing the sampling, one person opening and closing the outer bag (dirty hands) and the other opening the inner bag and handling the sample container (clean hands). It is recommended that this technique be documented in the FSP.	Current sample handling methods are sufficient for the analytical methods identified in the Revised QAPjP and FSP. Should ultra-low detection limit methods be used at LEHR/SCDS (e.g., for mercury), special sample handling procedures may be necessary. SOP 2.0 has been revised to include a clean-hands/dirty-hands procedure.
2	***Section 4.5, Groundwater Interim Removal Action; Section 4.7, Groundwater Monitoring***. According to the FSP, some of the activities described by the revised FSP have been performed, and the revised FSP serves to document the planning after the fact. It is not completely clear what activities performed are documented by this revised FSP, e.g., according to Section 4.5, a groundwater interim removal action (IRA) was conducted during the fall of 1996, and Section 4.7 indicates that wells were installed in October and November 1997. Region 9 requires that planning documents be prepared and approved before field activities begin. The FSP should clearly state-which activities were performed before the sampling plan documentation was prepared.	The FSP was not revised to document planning after the fact, but was generated to document methods for UC Davis field activities at the site. In order to completely describe work conducted by UC Davis, work plans that were reviewed and approved by site RPMs for several field activities (Technical Memorandum/Work Plan for Pre-design Activities, Off-site Hydropunch Work Plan, Data Gaps Limited Field Investigation Work Plan) have been incorporated into the Revised FSP.
3A	***Section 5.1, Analytical Methods; Table 2, Sample Analyses Soil.*** A number of the methods cited in this section for soil analyses are water methods (e.g., the 300 and 900 series methods). There is no indication concerning whether and how samples are to be leached or the methods otherwise modified to accommodate the soil matrix. The text should discuss this issue and provide the necessary information.	This has been addressed in Table 7.1 of the QAPjP. See response to DHS comments #3A and #3B, which addresses soil preparation methods for general chemical analysis.
3B	Several of the methods cited in Table 2 are standard operating procedures (SOPS) from LAS Laboratories. Copies of the SOPs should be included with the FSP. Since LAS Laboratories is no longer in business, it may be necessary to cite or include alternative methods or SOPs from the new contract laboratory.	Table 2 has been updated to reflect current methods.
4	***Section 5.1, Analytical Methods; Table 2a, Soil Sample Analyses, Target Compound List (TCL) and Contract Required Quantitation Limits (CRQLS) for Organic Analyses.*** It is not clear why there is not a Table 2b covering inorganic analyses and the remaining parameters for which methods are listed in Table 2. If these parameters are not considered "Target Analytes" this should be clarified in Section 5.1 or these methods removed from Table 2.	Inorganic methods listed in Table 2 are already analyte-specific and require no additional detail. In contrast, organic analytical methods listed in Table 2 are for groups of organic chemicals and Table 2b has been included to document the parameter list for each referenced method.

5A	***Section 5.3.2, Quality Control Sampling; Section 6.12, Field Quality Assurance Sampling.*** Sections 5.3.2 and 6.12 specify blind duplicate collection at a frequency of five percent, while the QAPjP specifies a ten percent duplicate collection frequency. Region 9 recommends the collection of field duplicate samples at a frequency of ten percent. This discrepancy must be addressed.	Sections 5.3.2 and 6.12 have been corrected to indicate a 10-percent duplicate frequency.
5	Section 5.3.2 also indicates that equipment blanks will be analyzed for volatile organic compounds (VOCs). Equipment blanks should be analyzed for all target analytes.	Section 5.3.2 has been corrected to indicate that equipment blanks will be analyzed for all target analytes.
6	***Table 8, Sample Analyses, Water.*** Table 8 specifies filtration for analyses where filtration may not be appropriate. Analytical results determined from a filtrate passed through a 0.45 micron filter should be referred to as "dissolved", while analytical results determined from an unfiltered sample should be referred to as "total." The FSP should provide a rationale for the determination of dissolved or total fractions. Note that filtration *is* inappropriate for alkalinity and total dissolved solids (TDS). EPA methods specify that samples collected for alkalinity should not be altered in any way; TDS samples incorporate filtration in the analysis. Also, samples collected for total organic carbon (TOC) should not be filtered. Table 8 indicates that samples will be collected for "Phosphorous, all forms." If all forms, including total and dissolved are to be measured, samples for total reactive, total acid-hydrolyzable and total organic phosphorous samples must not be filtered, while samples for the dissolved forms must be. A discussion regarding dissolved and total fractions should be included to clarify this issue and the appropriate tables should be revised accordingly.	See response to EPA QAPjP comment Nos. 3D and 3E.
	It is not clear whether the designation "total chromium" in Tables 8 and 10 means that the sample should be collected and analyzed without filtration or whether the term "total chromium is meant to contrast with "hexavalent chromium."	Tables 8 and 10 will be changed to refer to "total dissolved chromium" instead of "total chromium."
Concerns		
1A	***General.*** The revised FSP identifies the analytical laboratory as LAS Laboratories, while the QAPjP identifies GEL and Air Toxics, Inc. as the analytical laboratories. This issue must be addressed. Note, as mentioned previously, LAS is no longer in operation.	FSP has been updated and refers to current methods.
1B	Although cited a number of times in the FSP, a health and safety plan (HSP) is not included with the FSP.	The reference to the Health and Safety Plan as Appendix C has been removed.

2	***Section 5.3.3, Preliminary QC Data Evaluation.*** Section 5.3.3 indicates that the relative percent difference (RPD) between an environmental sample and its duplicate will be compared, and if the RPD values indicate a trend for a particular analyte or particular sampling event, those data are flagged for possible corrective action. It is recommended that a specific criterion be established.	See response to RWQCB comment #7.
3	***Section 6.4, Exploratory Trench Investigation; Section 6.5, Soil Borings, Standard Operating procedure 10.0, Soil Sampling.*** It is advised that Region 9 is encouraging responsible parties to adopt methods which minimize the loss of volatile organic compounds' (VOCS) from soil samples, such as the use of methanol preservation, use of EPA Method 5035, or use of EnCore samplers. Although not required, these methods will provide a more accurate result for VOCS in soils since they minimize the off-gassing of VOCS.	Recommendation taken under consideration for future soil VOC investigations.
4	***Table 9, Sample Analyses-Soil Vapor.*** Table 9 specifies "TBD" for information regarding analytical methods, containers, reporting limits, sample handling, and holding times. This information should be provided in the final FSP.	Table 9 has been completed.
5	***Table 10, IRA Groundwater Analytical Parameters.*** Table 10 includes dissolved oxygen (DO). However, DO is not discussed in the text-of the FSP, nor is it included in other tables. It is recommended that information regarding DO be included in the tables and discussed in the text.	Dissolved oxygen has been added to Table 8 as a field parameter. Section 2.9 has been added to SOP 2.0 to describe the field measurement
Comments		
1A	***General.*** A number of incorrect citations are made in the *FSP* as follows (this list is not inclusive):	
1B	Section 4.7 references Table 4 for well construction details. This should be Table 3.	Corrected.
1C	Section 4.7 references Section 5.2 for field quality control (QC) requirements. This should be Section 5.3.	Corrected.
1D	Section 6.7, Hydropunch Sampling, references 8a. This should be Table 8.	Corrected.

Section II	The subject FSP includes information which addresses some of the concerns identified in the EPA memorandum dated March 19, 1998, which reviewed the QAPjP. However, most of the concerns identified in the QAPjP review are not addressed by information provided in the revised FSP. Concerns identified in the QAPjP review are presented in bold type and evaluations of whether the FSP information addresses the QAPjP concerns are presented in normal type. If information from the FSP is not applicable to a comment, it is noted with "NA."	

Major Concerns		
1A	***General.*** Although the EPA guidance document, QA/R-5, which is referenced above, is cited in the QAPjP, a number of elements required by QA/R-5 have not been addressed in the QAPjP. As stated in the QAPjP guidance, if a required element is not considered to be relevant to the project, this should be stated and a reason provided. Elements which need to be addressed or which require additional information include:	This general comment is specifically addressed in 1B through 1J.
1B	***The establishment of DQOs.*** The use of the seven-step DQO process is recommended. Without sample design information and information of the number of samples, where they will be collected, site goals, etc., it is not possible to assess DQOS. There is no indication that the seven step DQO process was utilized for the FSP.	Design of the specific sampling program is addressed in the RI/FS Work Plan and the FSP, along with information detailing the number of samples to be collected and their respective locations. Though not specifically referenced, the elements for the 7-step process were documented in the LEHR RI/FS Work Plan, and summarized in part in the Revised FSP and QAPjP, which serve as Appendices to the RI/FS Work Plan. The RI/FS Work Plan describes the site problem, boundaries, previously collected data and input, decision types, data uses and needs, data collection program design and approach. The Revised FSP and subsequent addenda update data collection activities, rationale and methods specific to UC Davis field activities. The Revised FSP specifies how UC Davis field activities will be conducted to obtain environmental data objectives and provides the operational plan for executing the general sample design described in the RI/F Work Plan. Section 1.3.7 of the QAPjP has been revised as follows: "Data Quality Objectives (DQOs) have been specified for each data collection activity, and the work will be conducted and documented in a manner whereby data collected are sufficient and of adequate quality for their intended uses (EPA, 1993). The process for establishing DQOs is detailed in "Guidance for Data Quality Objective Process" (EPA, 1994c). DQOs for this site specify the data type, quality, quantity, and uses needed to make decisions and are the basis for designing the data collection activities. The DQOs have been developed and are incorporated in the work plan rationale presented in the Final Draft RI/FS Work Plan. Some information has been updated in the Revised FSP to address changes in sample design, sample locations, sample numbers, and analytical methods The following reference has been added: "USEPA, 1994c, 'Guidance for the Data Quality Objectives Process: EPA/G-4, Washington, D.C., August."

1C	***Title and approval sheet.*** The FSP does not include an approval sheet.	A title and approval sheet has been included with this Final QAPjP.
1D	***Distribution list of persons and organizations who will receive copies of the approved plan and its revisions.*** The FSP cover letter includes a distribution list of persons and regulatory organizations to receive a copy of the revised FSP. However, a distribution list of all persons who should receive a copy of the finalized FSP is not included.	The final QAPjP and FSP will be distributed appropriately. This *draft* was not meant to be distributed outside the RPMs.
1E	***Problem definition/background, including sufficient background information to provide a historical perspective for the project including results from previous studies.*** This concern has been adequately addressed. The FSP includes summary background information in Section 2. However, it is recommended that the levels of contamination be included in the final FSP.	No response necessary.
1F	***Project/task description, including measurements that will be made, applicable regulatory criteria, and a schedule for the work to be performed.*** This concern has been partially addressed. The Attachment to the response to EPA comments includes regulatory criteria for aquatic environments. Table 4 of the FSP includes the groundwater monitoring schedule. However, it is recommended that a rationale for all measurements be included in the FSP or QAPjP.	Additional rationale for site parameters has been added to Table 1. Additional rationale for site analytical parameters is presented in Tables 5.1 (soil) and 6.1 (water) of the Final Draft RI/FS Work Plan. The Revised FSP is Appendix A to the RI/FS Work Plan.
1G	***Sampling process design, including the types and numbers of samples required, design of the sampling network, sampling locations and frequencies, sample matrices, measurement parameters of interest, and rationale for the design.*** This concern has been partially addressed in Sections 4 and 6. Further discussion regarding measurement parameters of interest should be provided.	See response to 1F.

1H	***Sampling methods requirements, including a description of procedures for collecting samples, decontamination procedures, and identification of support facilities.*** This concern has been partially addressed. Appendix A of the FSP includes standard operating procedures (SOPS) for sample collection and decontamination procedures. However, it is recommended that more detail be provided for sample preservation. It is also recommended that the "clean hands, dirty hands" technique be described in the FSP or a SOP and be utilized during sample collection for analytes with very low detection limits. (please refer to Major Concern No. 1B of Section 1.)	See response to US EPA Major Concern 1B of Section 1, above.
1I	***Inspection/acceptance requirements for supplies and consumables.*** Not applicable. ***Reconciliation with user requirements, describing how. the results obtained from the project or task will be reconciled with the results of the DQO Process.*** Not applicable.	The following sections have been added: "11.1 Standard Materials Standards used for calibration of both laboratory and field equipment, or to prepare samples, will be certified by NIST A2LA, or other equivalent source. The standards will be current. The expiration date will be established by the manufacturer, or based on chemical stability, the possibility of contamination, and environmental and storage conditions. Standards will be labeled with expiration dates. Expired standards will be discarded." "11.2 Supplies All supplies (e.g., bottles, equipment, reagents) will be inspected prior to their use in the field or laboratory. A current inventory and appropriate storage system will ensure their integrity prior to use. Efficiency and purity of supplies will be monitored through the use of standards and blank samples."
1J	***Reconciliation with user requirements, describing how the results obtained from the project or task will be reconciled with the results of the DQO process.*** Not applicable.	Chapters 3.0 and 12.0 of the QAPjP have been combined to clarify the reconciliation of the data.
2	***Section 1.3-6, Target compounds.*** ***Section 1.3.6 states that the rationale for the target compounds is provided in a revised FSP. The rationale for the choice of target compounds must also be stated in the QAPjP.*** This concern has been partially addressed in Section 4. It is recommended that a rationale for the choice of target compounds be expanded to include when dissolved or total analyses are to be performed.	A rationale for the choice of target compounds for any given field activity is addressed in the FSP and in Chapters 5.0 and 6.0 of the RI/FS Work Plan. A section summarizing method selection has been added to Chapter 7.0. See response to EPA comment #7. Except in the case of alkalinity (see response to EPA comment 3B on QAPjP), analyses will be conducted on filtered samples for dissolved inorganic constituents. Samples for organic constituents are not filtered.

3	***Section 1.3-7, Data Use.*** ***Section 1.3.7 states that DQOs are incorporated into the Remedial Investigation/Feasibility Study (RI/FS) FSP. At a minimum, a summary of the seven-step DQO process as outlined in EPA Guidance (QA/G-4) for each investigation should be included in the QAPjP.*** This information is not provided in the FSP.	Section 1.3.7 has been modified to include a description of the DQO process. See response to EPA comment #1B.
4	***Section 2, Project organization and Responsibilities.*** ***Section 2 describes the responsibilities of project management personnel. An organizational chart should be prepared to illustrate the organizational structure and indicate the lines of authority and communication among all project participants, including the role of the quality assurance manager (QAM). The organizational chart should illustrate the independence of the QA function for the project. The data users and any subcontractor relationships should also be depicted in the organizational chart.*** Not applicable.	An organization chart has been added to Section 2.0 of the QAPjP.
5	***Section 2.4, Laboratory.*** ***Section 2.4 identifies GEL in Charleston, South Carolina as the fixed laboratory for the project, except for soil gas analyses, which will be analyzed by Air Toxics, Inc. in Folsom, California. It is the reviewer's understanding that GEL may not be State of California certified for all parameters of interest to the program (radiochemical analyses in particular). It is also not clear to what extent this organization is familiar with the regular and low detection limit organic and inorganic statements of work (SOWs). It is recommended that quality assurance manuals for both GEL and Air Toxics be provided with the QAPjP, or at least relevant standard operating procedures (SOPs). Since some analyses have short holding times, e.g. a 24-hour-holding time for hexavalent chromium, the plan should indicate how the short holding times will be met by a laboratory in South Carolina. Additional laboratories should be identified if appropriate.*** Note that the FSP identifies a different laboratory, LAS.	Reference to GEL's radiochemistry division (Environmental Physics, Inc.) has been added to Section 2.4. Additionally, references to Quanterra Environmental Services located throughout the U.S. have been indicated as a secondary laboratory, and AQUA-Science located in Davis, California, which is performing toxicity testing. To clarify field custody procedures, the following statement has been added to Section 5.1: "For samples designated for short holding time analyses, sample shipment will occur by next-morning air courier services."

6	***Section 4.0, Sampling Procedures.*** ***Section 4.0 states that details of sample types, locations, analytes, and detailed procedures of sample collection are described in the "Revised Data Gaps Work Plan, Revised FSP, and SOPS. 11 These documents were not available for review with the QAPjP, and currently QA Office records indicate none of the original QA documents.-prepared for the LEHR site (including the RI/FS Work Plan and its QAPjP and FSP appendices and a soil gas FSP) have been approved. Although it is a judgement call concerning hoc much information from other documents should be included in or provided with the QAPjP, and the referencing of other site documents for this information may be appropriate, it would facilitate the review and approval process if the documents or information were also provided in some form. Review of the revised FSP would appear appropriate under any circumstance.*** This concern has been addressed by providing the FSP.	No response necessary.
7	***Table 7.1, Sample Analyses - Soil; Table 7.2, Sample Analyses - Water.*** ***The QAPjP should provide a rationale for the detection limits specified in the plan. The QAPjP indicates that the inorganic and organic CLP statements of Work (SOWs), ILM04 and OLM03, respectively, will be used for soil samples, and that the inorganic and organic low concentration CLP SOWS, ILCO2 and OLCO2, respectively, will be used for water samples. A rationale for the use of ILCO2 based on project needs should be provided. Regulatory limits such as maximum contaminant levels (MCLS) should be included in the discussion.*** This concern has been partially addressed. Attachment A includes low level detection limits required for aquatic studies.	The following sections have been added to Chapter 7.0 of the QAPjP: "7.1 Method Selection The selection of methods for a given field sampling program will be based on historical investigations, the end use of the data, and any regulated action levels for the respective analyte. Whenever possible, the most current version of the analytical method should be employed. Tables 7.1 and 7.2 reference the latest editions of historical methods employed for this site. The FSP identifies the methods upon which the sampling design is based.: "7.2 Detection Limits The Method Detection Limit (MDL) is the minimum concentration of an analyte or compound that can be measured with 99% confidence that the concentration is greater than zero. MDLs are established by the laboratory for each method, matrix, and analyte. MDLs are derived using the procedures described in 40 CFR136, Appendix B. EPA requires that MDLs be established on an annual basis. MDLs are used to determine the reporting limits listed in Tables 7.1 and 7.2. MDLs must be less than the applicable reporting limit for each target analyte or compound.
Other Concerns		

Comments .nd Responses to Quality Assurance Project Plan
LEHR/SCDS
David R. Taylor, Ph.D., US EPA

1A	***Table 1.2, Summary of Data Quality Objectives.*** ***Other than indicating whether data for a particular task is categorized as screening or definitive, the table contains no information regarding DQOS; the revised FSP is referenced.*** Not applicable.	The following sentence was added to Section 1.3 to clarify that Quality Assurance Objectives for the measurement data are provided in Chapter 3.0. Additionally, Chapter 3.0 has been revised to incorporate Chapter 12.0: "Quality assurance objectives have been established to assess the quality of the measurement data to serve its intended purpose to support the DQOs. These QAOs are discussed in Chapter 3.0."
1B	***The footnotes to Table 1.2 incorrectly reference Section 1.3.5, Groundwater Interim Removal Action for descriptions of definitive data and screening data. The correct reference is Section 1.3.8, Data Categories.*** Not applicable.	Reference has been corrected.
2A	***Table 3.1a, Quality Assurance Objectives for Soil Samples; Table 3.1b, Quality Assurance Objectives for Water Samples.*** ***The tables should be revised to reflect the appropriate calculations for precision and accuracy criteria, e.g. relative percent difference (RPD) for precision and percent recovery (%R) for accuracy.*** Not applicable.	The tables have been revised to more clearly define the precision and accuracy criteria for the measurement data. The calculations for precision and accuracy have been moved from Chapter 12.0 to Chapter 3.0.
2B	***It is recommended that Tables-3.la and 3.lb express the accuracy criteria as a range, e.g., 75-125%R.*** Not applicable.	The manner in which accuracy criteria are presented has been changed as recommended.
2C	***It is recommended that matrix spike/matrix spike duplicate (MS/MSD) accuracy and precision criteria be included. Currently all data quality indicators are based solely on results of laboratory control samples or quality control check samples. This minimizes the chances of any problems being noted with the data, but does not necessarily provide information which help assess the problems with site data which might affect decision making.*** Not applicable.	The acceptable ranges vary widely for MS/MSD with respect to matrix and analytical method. The evaluation of matrix spike data is discussed in Chapter 3.0 (previously Chapter 12.0) and in the data validation SOPs.

3A	***Table 7.1, Sample Analyses - Soil; Table 7.2, Sample Analyses - Water.*** ***Table 7.1 indicates that hexavalent chromium in soil will be determined using EPA Method 7196. EPA Method 7196 is a method for the determination of hexavalent chromium in water. The digestion method for the determination of hexavalent chromium in soils should be identified. If non-EPA or modified EPA methods will be used they should be described in the QAPjP.*** This deficiency also appears in Table 8 of the FSP.	Unless otherwise specified in the reference method (e.g., EPA 300.0), a soil/water ratio of approximately 1:1 will be used as an extraction method. This has been added to the footnote in Table 7.1.
3B	***Table 7.1 indicates that a number of general chemistry analyses will be performed on soil samples; however, the methods identified are methods for the determination of these analytes in aqueous samples. The extraction, digestion, or leaching procedures necessary to analyze soil samples for these analytes should be provided in the QAPjP.*** This deficiency also appears in Table 8 of the FSP.	See response to 3A.
3C	***Table 7.2 cites "SOP" for pH, EC [electrical conductivity, Temperature, Turbidity, and Eh analyses. A brief description of the procedures to be followed should be provided in lieu of providing method references or copies of the standard operating procedures (SOPs).*** This concern has been adequately addressed. SOPs are attached to the FSP as Appendix A.	No response necessary.
3D	***Table 7-2 indicates that samples collected for alkalinity should be-filtered. EPA Method 310.1 states that samples should not be filtered, diluted, concentrated, or altered. This discrepancy should be resolved.*** This error also appears in Table 8 of the FSP.	Filtering will no longer be conducted for alkalinity in water samples.
3E	***Table 7-2 indicates that samples collected for total dissolved solids (TDS) will be filtered. Filtration through a glass fiber filter is part of the analytical procedure. The sample should not be filtered before receipt by the laboratory.*** This error also appears in Table 8 of the FSP.	Field filtering with a 0.45-mm filter is consistent with the analytical method . Field filtering reduces the potential for changes in dissolved sample characteristics that could occur during sample shipment and the 7-day holding time.

4	***Section 8.3, Data Reporting.*** ***Section 8.3 should be revised to require that gas chromatography/ mass spectrometry (GC/MS) and GC magnetic tapes will be retained by the laboratory and made available to EPA upon request. Tape audits should be considered as part of the overall QA program for the site.*** Not applicable.	The following section has been added to Chapter 10.0 to address magnetic tape audits: "10.4 Magnetic Tape Audits "Magnetic tape audits involve the examination of the electronic media used in the analytical laboratory to collect, report, and store the data. These audits are performed to assess the authenticity of the data generated. It is required that all GC and GC/MS magnetic tapes will be retained by the laboratory, and upon formal request by the University, its contractors, or EPA, made available for review within seven business days.
5	***Section 9.0, Internal-Quality Control.*** ***The discussion in this section should be more detailed, both with respect to the QC practices of the laboratories, and with respect to the corrective action procedures to be taken if analyses are out of control. For example, the data quality indicators presented in Tables 3.la and 3.lb are based on LCS or QC check sample analyses, but these are not even mention in Section 9.0, and it is not immediately apparent these samples are available for all the methods.*** Not applicable.	Laboratory QC practices and corrective action procedures are described in the laboratory's QA Plan. These lab QA plans have been compiled in Volume II of the QAPjP and will be provided to EPA.
6A	***Section 9.2.3, Duplicates and Replicates.*** ***Section 9.2.3 states that field duplicates will be collected at ten percent frequency and references Table 1.2 for the "expected number of duplicate or replicate samples to be collected based on the proposed number of samples"; however, Table 1.2 does not provide an actual number, but also indicates that field duplicates will be collected at a frequency of 1/10. This discrepancy should be addressed.*** Sections 5.3.2 and 6.12 of the FSP indicate that field duplicates will be collected at a frequency of five percent. The two documents should specify a ten percent frequency.	The FSP has been corrected to reflect a 10% frequency for the collection of duplicate samples. The following sentence has been added to Section 9.2.3. "The planned number of field duplicates is included in the FSP."

6B	***There does not appear to be a provision for the analysis of duplicate samples. The CLP statement of work calls for the analysis of duplicates (rather than matrix spike duplicates) for metals. Duplicates are also recommended for other inorganic and general chemistry analyses and for the radiochemical analyses.*** Not applicable.	Duplicate analyses have been included in Section 9.3.
7	***Section 10.1, Audits.*** ***Section 10.1 does not address the use of performance evaluation (PE) samples. This section should be revised to discuss the submittal of PE samples, preferably as double blind samples, into the sample stream.*** Not applicable.	The following section has been added to the QAPjP to address performance evaluation samples. "10.3 Performance Evaluation Samples "Double blind performance evaluation (PE) samples may be submitted to the analytical laboratory during any site investigation. These samples may be of water or soil matrix, and are used to assess the accuracy of analytical procedures employed for a given sample set. Double blind PE samples will be prepared by Environmental Resource Standards, or similar supplier, and shipped from the field using a fictitious identification to the laboratory for analysis. "Double blind PE samples will be prepared using NIST and/or A2LA certified standards. The project-specific PE samples will contain known concentrations of the analytes of interest. Laboratory results will be evaluated against the original Certificates of Analyses for accuracy. Any failures will be directed to the laboratory for corrective action."

	Questions or comments regarding this review should be referred to David Taylor, EPA QA Program, at (415) 744-1497. Technical assistance for this review was provided by Douglas Lindelof, Lockheed Martin, Environmental Services Assistance Team Contract No. 68D60005, Work Assignment No. 9-98-2-5 and Technical Direction Form No. 9825005, Amendment 1.	

Item No.	Comment	Response
1	Since I was skeptical about UCD's new findings that no stormwater from the LEHR site entered the campus sanitary sewer system, I made several requests that UCD be required to monitor the flows in the sanitary sewer system leading from the LEHR site to verify that these flows did not change as a function of stormwater runoff events. To my knowledge, UCD did not publicly implement that program. However, now UCD is finally admitting again that some of the LEHR site stormwater does, in fact, enter the campus sanitary sewer system. This situation mandates that a full comprehensive monitoring program, including ammonia, be reinstated for UCD's so-called treated campus wastewaters that are discharged to Putah Creek in order to detect potential adverse impacts of LEHR site stormwater runoff.	The area within the site that drains to the UC Davis sanitary sewer consists of the 18,000-square-foot paved area at the former Co-60 field. Over the course of one 2-inch rainfall, this area would generate approximately 1.5% of the total daily wastewater treatment plant discharge. Over the course of one rainy season, the storm water total would be less than 0.15% of the plant discharge. Because this area makes up such a small portion of the site and does not drain any of the site waste disposal areas, a specific investigation of storm water runoff from this area and its contribution to wastewater treatment plant discharges it not warranted. A comprehensive monitoring program of treated campus wastewater is not within the scope of the LEHR/SCDS site restoration. As proposed in the FSP, winter surface water samples (including STPO) will be collected at the same time as rainy season storm water samples (see response to DSCSOC comment #17).
2	As discussed in previous correspondence, the issue is not just the adequacy of treatment of chemical constituents present in LEHR site stormwater runoff that is added to the campus sewer system, but also the influence of the additional flow which could impact the adequacy of performance of the campus wastewater treatment plant during stormwater runoff events. The increased flow could readily contribute to poor treatment for constituents derived from campus sources that, while not present in LEHR site stormwater runoff, are adverse to Putah Creek because of LEHR stormwater runoff impacts on the performance of the treatment plant.	See response to DSCSOC comment #1 and #17.
3	The RPMs need to revisit the issue of the adequacy of the monitoring of the campus wastewater treatment plant discharges to Putah Creek under stormwater runoff conditions. Specific sampling of the treatment plant effluent during stormwater runoff events must be part of the UCD Revised Field Sampling Plan.	See response to DSCSOC comment #17.
4	Page 2.5 states in the second paragraph, "Beginning with the 1996-1997 storm season, samples were collected from the drainage outlets for the lift station, landfill unit #1, and landfill unit #3." To my knowledge none of these data have been made available for review. While there has always been a problem with making LEHR site data available for review within an appropriate time after its development, UCD has become highly derelict in making its LEHR site monitoring data available for review. The RPMs should put UCD on notice that it must make available the quarterly data reports no later than three months after a quarter sampling period occurs.	1997 storm water data will be included in the 1997 Annual Report.

5	Page 4.5 under the Old Wastewater Treatment Plant states that data have been collected to investigate whether the sludge drying beds "...present a threat to groundwater." To my knowledge, the proposed study plan as well as the data from this investigation have not been made available for review. The issue of the Old Wastewater Treatment Plant pollution of groundwaters is an area that needs specific attention at a future RPM meeting.	Data collected for the Old Wastewater Treatment Plant sampling activities have been distributed.
6	Page 4.7, second paragraph, UCD persists with trying to give some credence to the 100 µg/L chloroform value. For years UCD has been trying to mislead the public into believing that 100 µg/L is a concentration that is suitable for drinking water. The regulatory agencies and DSCSOC have informed UCD that its approach in this regard is technically invalid and inappropriate.	The proposed California Toxics Rule Criteria for California Inland Surface Waters, and Ambient Water Quality Criteria for One-in-a-million Cancer Risk Estimate for Sources of Drinking Water, value of 5.7 µg/L will be referenced in future documents.
7	Page 4.7, last paragraph, the FSP uses the term "groundwater chemistry." This is inappropriate terminology. "Chemistry" refers to the thermodynamics and kinetics of the chemical reactions that occur in an aquatic system. UCD is not investigating any groundwater chemistry; it is simply measuring the some of the chemical constituents in the groundwaters. The proper terminology is "chemical characteristics."	Changed as requested.
8	Page 4.14, under Surface Water Monitoring, states, "Sampling will be conducted to evaluate the extent of site constituents of concern in the South Fork of Putah Creek, to identify potential water quality impacts from the site on Putah Creek, and to identify the potential for Putah Creek to impact groundwater. Aquatic toxicity testing has been initiated to directly assess potential acute ecological impacts to aquatic life in Putah Creek."	Chronic toxicity testing of surface and storm water samples has been added to the surface water and storm water monitoring programs. See response to RWQCB comment #1.

9	As discussed herein, the proposed monitoring program falls far short of achieving these stated objectives. Further, the stated objective of assessing "...potential acute ecological impacts to aquatic life in Putah Creek" is not adequate. As discussed previously and as required by regulation, the Clean Water Act and Central Valley Regional Water Control Board's Basin Plan do not restrict NPDES permitted dischargers, including stormwater dischargers, to only consider acute impacts of toxic chemicals. That approach was abandoned in the 1960s. Since 1972, the US water pollution control program for potentially toxic constituents focuses on protecting aquatic life from chronic toxicity. It has been known for over 30 years that some chemicals at concentrations 100 times less than that which causes acute toxicity can cause chronic toxicity to aquatic life. The US EPA has developed a battery of standard tests to assess chronic toxicity. UCD has been notified by the DSCSOC that it must do chronic toxicity testing of its stormwater runoff to Putah Creek and within Putah Creek in order to protect aquatic life within the Creek from chemicals that are adverse to aquatic life. The proposed restriction of toxicity testing to acute toxicity is another example of the L. Vanderhoef administration trying to do less than necessary to properly protect public health, surface and groundwater resources and the environment from UCD's management (mis-management) of its campus waste.	See response to RWQCB comment #1.
10	Page 4.14 in the last paragraph discusses the past flow conditions that existed in Putah Creek during the summer months, where at times Putah Creek at some locations essentially is 100% campus wastewaters. This presentation, however, does not discuss the fact that through a court order upstream water sources are now required to maintain a certain minimum flow in Putah Creek. This issue should be discussed, pointing out that this could be a significant factor in enhancing aquatic life beneficial uses, provided toxic discharges/conditions do not continue to prevail.	Surface water and storm water sampling will be conducted during the winter months, during times of discharge from the site.
11	Page 4.15, first paragraph, states that the analytical program for surface waters is presented in Table 5. Examination of Table 5, however, does not provide a reference to the specific parameters that are included in the various groups of chemicals to be determined. The same problem occurs with Table 6 with the stormwater runoff monitoring parameters. This information may be presented in Table 8 and 8a. This section needs to be re-written so it can be understood as to what will be done.	Cross referencing has been added to Tables 5 and 6 for clarity.
12	Page 4.15, third paragraph, mentions that flow "velocities" for Putah Creek were calculated using monthly flow totals. It is unclear why flow velocities are being determined unless the sampling program is adjusted based on the velocity of the Creek waters. It appears, however, that UCD has used incorrect terminology where flow velocity should be "discharge." This issue needs to be clarified.	Sentence rewritten as: "Previously, Putah Creek discharge in the vicinity of the site has been obtained from . . . ."

13	Page 4.15 states under Stormwater Runoff Monitoring that two storms for the LEHR site will be sampled each year. Monitoring only two storms a year of the LEHR site stormwater runoff is not adequate in light of the current information base that exists today and the significant disturbance of the LEHR site that will be occurring over the next few years associated with site remediation activities. The first storm of the season as well as an anticipated major runoff event that occurs in late fall, early winter should be monitored. An anticipated major runoff event that occurs in late December, early January and late January, early February should also be monitored. A storm that occurs in March and April and the late May storm that typically occurs should be monitored. The monitoring of the storm should not follow the approach that has occurred in the past where UCD personnel claimed that no stormwater ran off from the LEHR site in the ditch cut through the top of Landfill #3 based on a cursory visual inspection of this ditch between 9 and 10 a.m. on a rainy day. As was documented by photographs taken by DSCSOC that same day in the afternoon, appreciable stormwater from the LEHR site entered Putah Creek through this UCD so-called dry ditch.	Based on observations made during storm water sampling conducted for the 1996/1997 and 1997/1998 rainy seasons, early season rain storm events do not necessarily generate discharge to Putah Creek for site discharge locations. In fact, drainage ditches often serve as infiltration features until conditions are wet enough to produce discharge to Putah Creek. In addition, discharges to Putah Creek from the LF-1 and LF-3 locations do not necessarily occur during the same rain storm events, often requiring more than one storm event to complete "one" round of storm water monitoring. Based on these observations, and on the irregular nature of weather patterns, a sampling schedule based on calendar months and single storm events is not appropriate, and we propose to continue to monitor both LF-1 and LF-3 locations until one early season sample and one mid-season sample has been collected from both locations. Surface water samples will be collected during the first storm event that produces a storm water sample.
15	UCD must develop a credible stormwater runoff water quality monitoring program and stop this seat-of-the-pants, cursory approach for stormwater runoff water quality monitoring that it has been practicing at the LEHR site. Automatic sampling equipment is routinely used by NPDES stormwater permittees to monitor stormwater runoff. We cannot depend on the staff being present to take samples. This is the approach that should be adopted at the LEHR site.	Due to the highly irregular flows at both LF-1 and LF-3 sampling locations, and the handling requirements for LEHR analytes that require over 15 different sample containers, two different preservatives, and 8 gallons of water, auto sampling is not a practical solution to storm water sampling at the LEHR/SCDS site.
15	Page 4.16, first bulleted item, the word "diverts" should be changed to "transports."	Changed as requested.
16	Page 4.16, last paragraph, apparently indicates that the samples taken of the ditch that cuts through the top of Landfill #3 will be taken from a "spill pipe" located south of the north-south trending drainage ditch. The exact sampling location for this area should be clarified.	Sentence changed to: ". . . ; and at the north end of the spill pipe that transports runoff from the main north-south ditch to Putah Creek (designated LF-3).
17	As discussed above, an additional sampling point that should be used during stormwater runoff events is UCD's campus wastewater treatment plant discharge to Putah Creek. Since LEHR site stormwater enters the campus sanitary sewer system, it could readily carry LEHR site pollutants or help contribute to treatment plant operation problems due to elevated flows that are adverse to Putah Creek. The current stormwater runoff sampling program would not detect these problems. The sampling of the treatment plant effluent must include sampling at appropriate times to consider the lag between when the stormwater from LEHR reaches the treatment plant and when the wastewater containing this stormwater is discharged to Putah Creek. This will likely require at least three samples of the effluent taken over a period of several hours.	To correspond to storm water runoff, future surface water sampling events will be coordinated with the first flush and mid-season storm water events instead of with the quarterly groundwater monitoring events. The surface water sampling will continue to include sampling of the wastewater treatment plant outfall location (designated STPO), as well as a location further downstream of current location PCD. Section 4.8 has been modified accordingly. Surface water and storm water monitoring will not be conducted during the dry season because storm water runoff from the site does not occur during this period.

18	In addition to sampling the campus wastewater treatment plant discharges associated with stormwater runoff events, Putah Creek should be sampled at least twice during a stormwater runoff event, i.e. preferably early in the event and then several hours later at the upstream (PCU), downstream (PCD), and further downstream, such as where Mace Blvd. crosses Putah Creek, to detect potential problems associated with the combination of LEHR site stormwater runoff and upstream Putah Creek constituents. The sampling at the Mace Blvd. location must consider the travel time between the LEHR site and the sampling location so that the samples collected represent the mixture of LEHR site stormwater runoff with upstream Putah Creek water.	See response to DSCSOC comment #13.
19	It is important to note that the State Water Resources Control Board has adopted a policy that specifies that NPDES-permitted stormwater discharges cannot cause or contribute to water quality use impairments for the receiving waters for the stormwater runoff. The proper implementation of this policy requires comprehensive studies of receiving waters during and following runoff events.	No response necessary.
20	Page 4.17, first paragraph, states that two stormwater runoff events will be sampled per year. While, as discussed above, that approach might be suitable for a conventional stormwater runoff monitoring program, for a hazardous chemical site which is undergoing remediation that could include above ground storage of waste, monitoring two storms per year is inadequate. The above mentioned monitoring program should be implemented until the site has been stabilized after remediation, and it is possible to predict with a high degree of certainty the chemical characteristics of the stormwater runoff based on past sampling. At that time, the frequency of sampling can be decreased to one storm per season, i.e. fall, winter and spring.	Remediation of disposal areas is conducted at the site in the dry summer months, with excavated materials disposed off-site or stored in containers (steel drums or boxes). As a result, runoff conditions are most likely to change due to site activities between rainy seasons, not during the rainy season. As a result, the "first flush" sample event early in the rainy season will continue to provide worst-case data for runoff conditions at the LEHR/SCDS site.
21	Page 4.17, second paragraph, again mentions flow velocity. Does UCD mean flow velocity? If so, how does it plan to measure it? It appears that those who wrote this section are not familiar with flow measurements.	Changed to reference discharge.

22	This same paragraph states, "Aquatic toxicity testing will also be conducted on stormwater runoff samples for each of the three sampling locations and from both runoff sampling events." No toxicity measurements are planned of the mixture for the stormwater runoff from the LEHR site with Putah Creek water. As discussed in previous correspondence, there can readily be toxicity arising out of mixing LEHR site stormwater runoff-derived constituents with Putah Creek water-derived constituents that would not be detected by sampling each of them individually. A credible stormwater monitoring program for the impacts of LEHR site stormwater runoff-associated constituents must include sampling Putah Creek water at several locations downstream from LEHR in order to determine whether LEHR's stormwater runoff causes Putah Creek to become toxic. Further, the stormwater runoff toxicity test must be based on not just acute toxicity, but on chronic toxicity using the US EPA three species standard toxicity test. The proper test procedures has been defined by the US EPA as Lewis et al., "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms" (Environmental Monitoring Systems Laboratory, Cincinnati, OH; Environmental Research Laboratory, Duluth, MN; Region 4, Environmental Services Division, Athens, GA; Office of Water, Washington, D.C.; Environmental Monitoring Systems Laboratory, Cincinnati, OH; Office of Research and Development, US Environmental Protection Agency, Cincinnati, OH, 1994). The surface water monitoring of Putah Creek should include dry weather quarterly monitoring as well as stormwater runoff monitoring.	See response to RWQCB comment #1.
23	The SOP in Appendix A indicates that single grab samples will be taken. Evidently, no consideration is being given to first flush issues. Samples should be taken over the course of the runoff event and, if necessary, composited.	Discharges from locations LF-1 and LF-3 are not typically long-lived, and often pose the difficulty of collecting enough water for the proposed analytes.
24	Table 1 presents a list of Soil Analytical Parameters. One of the additional parameters is "anions." The anions that are analyzed as a soil parameter need to be specified with the proper reference given in the table so there is no ambiguity about what will be analyzed. This same problem occurs in Table 2 where water soluble anions are listed, but no specific listing is made of what parameters are being determined.	Table2 has been revised for clarity.
25	The total carbonate content of the soil samples should be determined to help characterize the geological matrix. The carbonate content of soils can influence the transport of a number of constituents.	Carbonate content analysis will be considered in future soil sampling investigations.
26	The soil samples and waste taken in areas where ashes could be present, such as associated with the landfills, should include dioxin analysis.	Dioxin analysis was included as part of the Data Gaps Limited Field Investigation.
27	Table 4 lists hexavalent chromium. It should also include total chromium. Again, the anions and cations should be specified. These same problems occur with Table 5 for surface water monitoring and Table 6.	Total dissolved chromium is included as part of metals analysis.

28	The groundwater sampling should include measurement of dissolved oxygen. Failure to make this measurement will serious hamper the ability to predict transport of some constituents. Measurements of this type can be readily accomplished with down bore hole instrumentation that is readily available.	Procedures for downhole measurements of dissolved oxygen have been added to SOP 2.0.
29	Table 8 lists hexavalent chromium and total chromium detection limits for water samples as 10 µg/L. As I pointed out previously, that concentration is not adequate for detecting potential problems associated with chromium species in aquatic systems. The detection limits for chromium must be decreased to 1 µg/L. Procedures are available for analysis of chromium at those levels.	The contract-required detection limit for hexavalent chromium is 10 µg/L; however, the current laboratory is estimating concentrations to the instrument detection limit of 4 µg/L. The contract-required detection limit for total dissolved chromium is 10 µg/L, but the laboratory is estimating concentrations to 1 µg/L when using the ICP-MS method.
30	The detection limit listed in Table 8 for mercury in water of 0.2 µg/L is too high. It is essential that the detection limit for mercury be decreased to less than 5 ng/L. This is the value that is predicted now to become the new US EPA water quality criterion for mercury in order to avoid excessive bioaccumulation. Procedures are available for analysis of mercury at that concentration.	See response to DSCSOC comment #44.
31	Table 8, detection limits for phosphorus of 1 mg/L is too high. Methods are readily available to determine soluble phosphorus at 5 µg/L P and total phosphorus at 10 µg/L P. These methods should be used.	Phosphorus is not a site constituent of concern, and is not currently included in the monitoring program. Please forward specific references to the methods suggested for possible future use.
32	The detection limit for nitrate of 0.1 mg/L N should be decreased by a factor of 10.	The contract-required reporting limit of 0.1 mg/L is sufficient, considering regional and background concentration of nitrate.
33	Table 8 indicates that chemical oxygen demand is continuing to be analyzed. This is a waste of time and money; it is not an interpretable value in this setting.	Chemical oxygen demand is not included in FSP Tables 4, 5, and 6.
34	Table 8 indicates that aquatic toxicity based on an EPA method which, based on the text, is an acute toxicity measurement, is to be used. That is not an appropriate procedure for this type of study. In previous discussions, but not in the revised sampling plan, UCD has mentioned that it plans to use adult trout for acute toxicity testing. At that time I voiced concern about this approach.	The acute toxicity method for UC Davis storm water and surface water samples uses fathead minnow larvae.
35	It appears now that UCD is attempting to deliberately make it difficult to find out what particular test procedures and organisms are being used by failing to provide the information in the proposed revised FSP.	See response to DSCSOC comment #34, above.
36	It also should be understood that if toxicity is found, then UCD will enter into a comprehensive TIE program to determine the cause of the toxicity and through a TRE, control the toxicity. These issues should be specified in the FSP.	Section 4.9.3 has been modified to describe the TIE program.

37	While the potential impacts of Putah Creek-associated constituents on groundwater quality are mentioned as an objective in monitoring Putah Creek, no information is provided on how this information is to be used. UCD should be required to immediately start to conduct extensive drilling along Putah Creek to sample groundwaters in the vicinity of the Creek to determine the full degree of pollution that has occurred due to UCD's inadequate treatment of its domestic wastewaters prior to discharge to Putah Creek.	Impacts resulting from wastewater treatment plant discharges are not within the scope of the LEHR/SCDS site restoration.
38	Table 10 lists the IRA Groundwater Analytical Parameters. I thought there was agreement that UCD would include TOC among these parameters. TOC must be one of the standard parameters analyzed. Chemical oxygen demand can be deleted from the list since it is not an interpretable parameter in this setting.	Table 10 refers to constituents analyzed during the pumping test conducted in extraction well EW2-1. IRA monitoring parameters are specified in the Removal Action Work Plan and IRA WDRs.
39	Table 13 presents proposed water monitoring. As discussed herein, the proposals with respect to surface and groundwater monitoring are deficient.	No response necessary.
40	Tables 14 and 15 present the rating curves for monitoring of discharge. It appears that this is what UCD and its consultants are calling "velocity." Cubic feet per second is not velocity; it is a discharge measurement.	Reference changed to discharge.
41	Figure 13 presents the locations of the wells that are being sampled. It appears that UCD does not plan to place any wells along Putah Creek to fulfill a commitment made in this revised sampling plan to evaluate the impact of UCD's wastewater discharges on Putah Creek water quality as it impacts groundwater quality along the Creek due to the Creek recharge of the aquifer. UCD needs to establish a series of sampling stations along Putah Creek to determine the full distance that its inadequately treated wastewaters are causing groundwater pollution through recharge of VOCs.	See response to DSCSOC comment #37.
42	UCD is persisting with the measurement of Eh. This parameter is not a reliable measure of any characteristic. Far more reliable information on the redox conditions of surface and groundwaters can be obtained by measuring dissolved oxygen and hydrogen sulfide.	Eh measurements will be discontinued.
43	In SOP 2-4 is presented information on measuring electrical conductivity, however no discussion of a key parameter, namely temperature impacts, is presented. I have previously commented on the deficiencies in failing to address the issue of temperature effects on electrical conductivity. UCD persists with technically invalid approaches.	Electrical conductivity meters used in the field are adjusted for the temperature of the measured solution. As a result, field measurements have been adjusted for temperature. Section 2.4 of SOP 2.0 has been modified accordingly.

44	The revised sampling plan is still deficient with respect to several key parameters. One of these is that it does not include bioaccumulation studies. DSCSOC has made it clear that bioaccumulation of potentially hazardous chemicals, including dioxins, must be measured each year in representative fish taken above, near and downstream of LEHR stormwater runoff points. This is to be an ongoing program that is to continue for at least three years, preferably five years, after the site has been stabilized following remediation. To argue that bioaccumulation samples are being taken by others is not appropriate. The bioaccumulation monitoring program has to be an ongoing program of bioaccumulation measurements for heavy metals and selected organics, including dioxins, that need to be conducted for at least 10 years.	Bioaccumulation of potentially hazardous chemicals in Putah Creek is a regional, creek-wide issue. Due to the relatively small volumes of storm water run-off from the LEHR/SCDS site that reach Putah Creek and the mobility of fish, assessing bioaccumulation from the site is not planned as part of the site investigation. Instead, storm water monitoring program will focus on the toxicity of constituents in site run-off.
45	Another significant deficiency with the proposed revised sampling program is that UCD still does not propose to address the translocation of waste materials from contaminated soils, landfills and waste disposal areas to the surface through plant uptake and release to the surface in leaves, flowers, etc. A comprehensive program devoted to assessing the translocation of hazardous and radioactive constituents must be initiated at the LEHR site to determine if public health, surface and groundwater resources and the environment are being endangered by UCD's failure to control vegetation that has developed roots into waste-contaminated areas. The translocation issue is well known; in fact, it is being used in some areas as a means for remediation of contaminated soils. For UCD/DOE to continue to ignore this and for the RPMs to allow them to continue to ignore it is a significant deficiency in LEHR site investigation.	The site biota investigation is addressed in Section 8.0 of the RI/FS Work Plan.

Table A

Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters

Analyte	EPA National Ambient Water Quality Criteria (CFR 131.36), Freshwater Aquatic Life (µg/L)	Central Valley Regional Basin Plan, 1994, Freshwater Aquatic Life (µg/L)	EPA OSWER Tier II Threshold Values for Aquatic Life, Freshwater 1996 (µg/L)	EPA Final Chronic Freshwater Value (FCV) (µg/L)	Contract Required Detection Limit (µg/L)	Instrument or Method Detection Limit (MDL or IDL) (µg/L)
1,1,1-Trichloroethane			62		0.5	0.2
1,1,2,2-Tetrachloroethane			420		0.5	0.5
1,1,2-Trichloroethane					1.0	0.3
1,1-Dichloroethane			47		0.5	0.2
1,1-Dichloroethene					0.5	0.3
1,2,4-Trichlorobenzene			110		10	0.3
1,2-Dibromo-3-chloropropane					0.5	0.7
1,2-Dibromoethane					0.5	0.3
1,2-Dichlorobenzene			14		0.5	0.3
1,2-Dichloroethane					0.5	0.3
1,2-Dichloroethene (cis)					0.5	0.3
1,2-Dichloroethene (trans)					0.5	0.2
1,2-Dichloropropane					0.5	0.3
1,3-Dichlorobenzene			71		0.5	0.3
1,3-Dichloropropene (cis)					0.5	0.3
1,3-Dichloropropene (trans)					0.5	0.3
1,4-Dichlorobenzene			15		0.5	0.3
2-Butanone					5	2.2
2,2'-oxybis(1-Chloropropane)					10	--
2,4,5-Trichlorophenol					25	1.1
2,4,6-Trichlorophenol					10	1.0
2,4-Dichlorophenol					10	1.1
2,4-Dimethylphenol					10	3.6
2,4-Dinitrophenol					25	1.5
2,4-Dinitrotoluene					10	1.0
2,6-Dinitrotoluene					10	1.2
2-Chloronaphthalene					10	1.5
2-Chlorophenol					10	0.8
2-Hexanone					5	4.5
2-Methylnaphthalene					10	1.5
2-Methylphenol					10	0.9
2-Nitroaniline					25	1.1
2-Nitrophenol					10	1.0
3,3'-Dichlorobenzidine					10	1.5
3-Nitroaniline					25	0.9
4,4'-DDT			0.013		0.02	0.01
4,6-Dinitro-2-methylphenol					25	0.7

-- Not available.

† Technical chlordane 0.1

Table A (continued)

Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters

Analyte	EPA National Ambient Water Quality Criteria (CFR 131.36), Freshwater Aquatic Life (μg/L)	Central Valley Regional Basin Plan, 1994, Freshwater Aquatic Life (μg/L)	EPA OSWER Tier II Threshold Values for Aquatic Life, Freshwater 1996 (μg/L)	EPA Final Chronic Freshwater Value (FCV) (μg/L)	Contract Required Detection Limit (μg/L)	Instrument or Method Detection Limit (MDL or IDL) (μg/L)
4-Bromophenyl phenyl ether			1.5		10	0.1
4-Chloro-3-methylphenol					10	1.2
4-Chloroaniline					10	1.3
4-Chlorophenylphenyl ether					10	1.2
4-Methyl-2-pentanone					5	3.0
3,4-Methylphenol					10	0.9
4-Nitroaniline					25	1.1
4-Nitrophenol					25	0.5
Acenaphthene				23	10	1.2
Acenaphthylene					10	1.2
Acetone					5	2.3
Aldrin					0.01	0.01
Alkalinity					10000	500
alpha-BHC					0.01	0.01
Ammonia					50	28
Anthracene					10	1.2
Antimony	30		30		5	1.7
Aroclor 1016			0.19 (total PCBs)		0.2	0.1
Aroclor 1221					0.4	0.1
Aroclor 1232					0.2	0.1
Aroclor 1242					0.2	0.1
Aroclor 1248					0.2	0.1
Aroclor 1254					0.2	0.1
Arsenic	190	10			3	3.0
Barium		100	3.9		20	0.4
Benzene			46		0.5	0.3
Benzo(a)anthracene					10	1.5
Benzo(a)pyrene			0.014		10	1.3
Benzo(b)fluoranthene					10	1.4
Benzo(g,h,i)perylene					10	1.0
Benzo(k)fluoranthene					10	1.9
Beryllium			5.1		1	0.3
beta-BHC					0.01	0.01
bis(2-Chloroethoxy)methane					10	1.2
bis(2-Chloroethyl)ether					10	5.1
bis(2-Ethylhexyl)phthalate	360		32		10	2.7
Biochemical Oxygen Demand					5000	1000

-- Not available.

† Technical chlordane 0.1

Table A (continued)

Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters

Analyte	EPA National Ambient Water Quality Criteria (CFR 131.36), Freshwater Aquatic Life (μg/L)	Central Valley Regional Basin Plan, 1994, Freshwater Aquatic Life (μg/L)	EPA OSWER Tier II Threshold Values for Aquatic Life, Freshwater 1996 (μg/L)	EPA Final Chronic Freshwater Value (FCV) (μg/L)	Contract Required Detection Limit (μg/L)	Instrument or Method Detection Limit (MDL or IDL) (μg/L)
Bromochloromethane					1	0.3
Bromodichloromethane					1	0.3
Bromoform					1	0.3
Bromomethane					1	0.7
Butylbenzyl phthalate			19		10	1.9
Cadmium	1	0.6			1	0.3
Calcium					2000	15.5
Carbazole					10	
Carbon disulfide					1	2.2
Carbon tetrachloride					1	0.3
Chlordane					0.01	0.01†
Gamma Chlordane					0.01	0.01†
Chloride					1000	7
Chlorobenzene			130		1	0.3
Chloroethane					1	0.8
Chloroform					1	0.3
Chloromethane					1	0.5
Chromium	180	210			10	0.8
Chrysene					10	1.3
Cobalt			3		10	0.7
Chemical Oxygen Demand					50000	2700
Copper	11	24			10	1.4
delta-BHC					0.01	0.01
Di-n-butyl phthalate			33		10	1.4
Di-n-octyl phthalate					10	1.9
Dibenz(a,h)anthracene					10	0.9
Dibenzofuran			20		10	1.2
Dibromochloromethane					1	0.3
Dieldrin				0.062	0.02	0.01
Diethyl phthalate			220		10	1.0
Dimethyl phthalate					10	1.2
EC					--	--
Eh					--	--
Endosulfan I			0.051		0.01	0.01
Endrin aldehyde					0.02	0.01
Endrin ketone					0.02	0.01
Ethylbenzene			[illegible]		1	0.3
Fluoranthene				6.2	10	1.5
Fluorene					10	1.3
Formaldehyde					1000	14
gamma-BHC					0.01	0.01

-- Not available.

† Technical chlordane 0.1

Table A (continued)

Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters

Analyte	EPA National Ambient Water Quality Criteria (CFR 131.36), Freshwater Aquatic Life (μg/L)	Central Valley Regional Basin Plan, 1994, Freshwater Aquatic Life (μg/L)	EPA OSWER Tier II Threshold Values for Aquatic Life, Freshwater 1996 (μg/L)	EPA Final Chronic Freshwater Value (FCV) (μg/L)	Contract Required Detection Limit (μg/L)	Instrument or Method Detection Limit (MDL or IDL) (μg/L)
Heptachlor			0.0069		0.02	0.01
Heptachlor epoxide					0.01	0.01
Hexachlorobenzene					10	2.0
Hexachlorobutadiene					10	0.4
Hexachlorocyclopentadiene					10	0.6
Hexachloroethane			12		10	1.0
Hexavalent Chromium	10	11			10	4
Indeno(1,2,3-cd)pyrene					10	2.0
Iron	1000	300			100	8.7
Isophorone					10	1.3
Lead	2.5	3.2			2	0.7
Magnesium					2000	3.4
Mercury	0.012	2.4	0.003	1.3	0.2	0.1
Methoxychlor			0.019		0.1	0.1
Methylene chloride					2	0.3
Molybdenum			240		10	0.5
N-Nitroso-di-n-propylamine					10	--
N-Nitrosodiphenylamine					10	--
Naphthalene			24		10	0.5
Nickel	160	160			20	2.3
Nitrate + Nitrite (as N)					100	7
Nitrobenzene					10	1.1
Pentachlorophenol					25	1.2
pH					--	--
Phenanthrene				6.3	10	1.4
Phenol					10	2.9
Phosphorus					1000	25
Potassium					2000	5.9
Pyrene					10	1.5
Selenium	5	5			3	1.5
Silver	0.19	4.1			10	0.7
Sodium					2000	30
Styrene					1	0.3
Sulfate					1000	41
Temperature					--	--
Tetrachloroethene			120		0.5	0.3
Thallium					10	2.7
Toluene			130		0.5	0.3
Total Dissolved Solids					20000	6300
Total Kjeldahl Nitrogen					500	3

-- Not available.

† Technical chlordane 0.1

Table A (continued)

Summary of Aquatic Limits and Detection Limits for LEHR/SCDS Storm Water and Surface Water Chemical Parameters

Analyte	EPA National Ambient Water Quality Criteria (CFR 131.36), Freshwater Aquatic Life (μg/L)	Central Valley Regional Basin Plan, 1994, Freshwater Aquatic Life (μg/L)	EPA OSWER Tier II Threshold Values for Aquatic Life, Freshwater 1996 (μg/L)	EPA Final Chronic Freshwater Value (FCV) (μg/L)	Contract Required Detection Limit (μg/L)	Instrument or Method Detection Limit (MDL or IDL) (μg/L)
Total Organic Carbon					1000	150
Toxaphene			0.011		1	0.3
Trichloroethene			350		0.5	0.3
Turbidity					100	60
Vanadium			19		10	0.5
Vinyl chloride					1	0.4
Xylenes (total)			1.8 (m-xylene)		1	0.7
Zinc	100	60.1			20	1.0

-- Not available.

† Technical chlordane 0.1

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DAVIS, CALIFORNIA

1.0 INTRODUCTION

This Revised Field Sampling Plan (Revised FSP) has been prepared as part of additional field investigations conducted by the University of California, Davis (UC Davis) at the former Laboratory for Energy-Related Health Research facility (LEHR) and South Campus Disposal Site (SCDS) located in Davis, California (Figures 1 and 2). The purpose of this Revised FSP is to document methods and rationale for current and recently completed field activities, and to provide guidance for future UC Davis field activities at the LEHR/SCDS site.

This Revised FSP incorporates revised portions of two previous site documents that are applicable to UC Davis field investigations. The two documents, the Final Draft Field Sampling Plan, RI/FS Work Plan (PNL, 1994a) and the Water Monitoring Plan (PNL, 1994b), were written to guide previous Remedial Investigation/Feasibility Study (RI/FS) field activities at the site conducted by the United States Department of Energy (US DOE). The Final Draft Field Sampling Plan, RI/FS Work Plan (PNL, 1994a) was reviewed and approved with comment by the appropriate regulatory agencies as part of the Final Draft RI/FS Work Plan. The Water Monitoring Plan (PNL, 1994b) was reviewed and approved by the appropriate regulatory agencies as a separate document.

Future responsibility for investigation and remediation of the LEHR/SCDS site has been divided between the DOE and UC Davis by investigation area (Memorandum of Agreement, June 23, 1997). This Revised FSP addresses additional work that will be conducted specifically by UC Davis at the LEHR/SCDS site. For the purposes of the additional investigations and future monitoring activities, the UC Davis portions of the LEHR/SCDS site have been divided into ten investigation areas as follows:

- The waste burial holes located south of the dog pens;
- The eastern trenches between Landfill Unit Nos. 1 and 2;
- The southern trenches along the south side of the dog pens;
- The UC Davis Landfill Unit Number 1;
- The UC Davis Landfill Unit Number 2;
- The UC Davis Landfill Unit Number 3;
- The old wastewater treatment plant;
- Groundwater;
- Surface water; and

- Storm water.

Other investigation areas on the LEHR site, consisting of the southwest trenches, the former Imhoff system, the Ra-226 system, the domestic septic tanks, and the dog pens, remain the responsibility of the DOE.

Several soil and groundwater investigations have recently been completed in these areas and were previously described in the Revised Data Gaps Work Plan (UC Davis, 1996) and a Technical Memorandum/Work Plan for Pre-Design Activities. (Dames & Moore, 1996c). The scope of these field investigations has been included in this FSP in order to document field activities conducted by UC Davis. Groundwater, surface water, and storm water monitoring is an ongoing site activity that has been conducted according to methods described in the Water Monitoring Plan (PNL, 1994b, revised 1996). Water monitoring described in this Revised FSP updates the previous monitoring program according to recent comments made by the US EPA, and incorporates recent changes in the program (i.e., new wells). The Revised FSP also incorporates the off-site neighbor's water sampling program. As appropriate, additional work plans will be developed and approved for future groundwater and soil investigations and will be incorporated into this Revised FSP by reference.

This Revised FSP, combined with the Revised Quality Assurance Project Plan (Revised QAPjP, presented separately), represents the Sampling and Analysis Plan (SAP) for additional field investigation and monitoring activities to be conducted by UC Davis at LEHR/SCDS. The Revised FSP and previous documents were developed in accordance with: the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA); and *Preparation of a U.S. EPA Region 9 Sampling and Analysis Plan for Private and State-Lead Superfund Projects* (EPA, April 1990).

1.1 PURPOSE AND OBJECTIVES

The purpose of this Revised FSP is to document the sample locations, numbers, and analytical procedures and field methods for use during additional investigations of UC Davis areas and water monitoring at the LEHR/SCDS site. Specific objectives of sampling and analysis during the additional field investigations include:

- Provide data to evaluate the composition, location, and depth of waste in UC Davis areas in order to assess the potential for the waste to impact groundwater;

- Provide data to support the Engineering Evaluation/Cost Analyses (EE/CA) process;
- Provide data for use in selecting remediation alternatives from presumptive remedies established during previous LEHR discussions;
- Provide data for eventual use in a human health and ecological sitewide risk evaluation;
- Provide information to comply with the California Environmental Quality Act (CEQA);
- Provide additional data during construction of monitoring systems to guide in the final design and selection of appropriate materials;
- Develop data to support conceptual development and design criteria for interim and final soil and groundwater remedies; and
- Provide regular groundwater, surface water, and storm water monitoring data to evaluate impacts to groundwater and surface water quality and to support future soil and groundwater remedial activities.

This Revised FSP is part of the overall quality assurance program for the LEHR/SCDS site and has been developed to be consistent with the Revised QAPjP. The QAPjP has been developed concurrently with this document. Together, the Revised FSP and the Revised QAPjP will serve as the primary documents that guide additional field investigations at the LEHR/SCDS site for UC Davis.

1.2 APPROACH AND FORMAT

To comply with CERCLA, additional field investigations conducted by UC Davis are developed using the EPA guidance document "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988). As such, to obtain sufficient quality and quantities of data, additional investigation will be performed under EPA QA/R-5 and EPA QA/G-4 quality assurance specifications.

This Revised FSP is intended to be a document for use by personnel conducting the current and future field investigations. The format of the Revised FSP was developed based on the format of the LEHR site Final Draft RI/FS FSP and on EPA Region 9 guidance document (EPA, 1990). Chapter 2, Background, summarizes the LEHR/SCDS site history, hydrogeologic characteristics, and environmental conditions in groundwater, soil, surface water, and sediment. Maps outlining each of the areas of investigation, known sources of LEHR/SCDS site constituents, and other relevant information are

discussed in Chapter 3. The rationale for sample locations, numbers of samples, and analytical parameters are presented in Chapter 4. The proposed analytical methods and methodology for sample collection are discussed in Chapters 5 and 6, respectively. The data management plan, including data receipt, data storage, data validation, and data transmittal, is presented in Chapter 7. References for this document are presented in Chapter 8. Standard Operating Procedures (SOP) that will be employed during the current and future field investigations are presented in Appendix A, and Field Documentation Forms are presented in Appendix B.

2.0 BACKGROUND

Presented below is a brief description of the LEHR/SCDS site background. A detailed discussion of the LEHR/SCDS site background and previous investigations conducted at the LEHR/SCDS site are presented in Chapters 2 and 3, respectively, of the Final Draft Field Sampling Plan, RI/FS Work Plan (PNL, 1994a).

The LEHR/SCDS site encompasses approximately 15 acres and consists of one- and two-story laboratory and office buildings, and animal-handling facilities. The LEHR/SCDS site is located in a rural area in the southeast portion of the UC Davis campus, and is bounded on the west, north and east by UC Davis research facilities. The southern boundary of the LEHR/SCDS site is the northern levee of the South Fork of Putah Creek (Putah Creek). Private land is adjacent to and surrounds UC Davis property on all sides. Most of the private land is used for agricultural purposes.

2.1 LEHR/SCDS SITE HISTORY

UC Davis conducted radiological studies on laboratory animals for the DOE beginning in the 1950s until the mid 1980s. The initial studies, conducted for the U.S. Atomic Energy Commission (AEC, now DOE), involved the irradiation of beagles at the UC Davis main campus. Eventually, irradiation experiments were discontinued at the main campus facility which was then used to house the breeding colony that supplied beagles for future studies at LEHR.

Full-scale experimental use of radioactive materials, including strontium-90 and radium-226, began at LEHR in 1960. In the initial stages of operation at LEHR, waste was handled through a central handling facility on the main campus. However, due to safety concerns, waste handling for LEHR-generated waste was transferred to the LEHR/SCDS site in the early 1960s.

Portions of the LEHR/SCDS site had previously been used as the UC Davis campus landfill. At the LEHR/SCDS site, the landfill consisted of three separate disposal units. Disposal in the oldest unit, Landfill Unit No. 1, began in the 1940s and ceased in the late 1950s to early 1960s. This area is now covered by the former Cobalt-60 field, and five isolation buildings used by UC Davis Animal Resources Services (referred to as "X" Buildings). The next oldest disposal area, Landfill Unit No. 2, received wastes from 1956 to 1967. Landfill Unit No. 2 is partially covered with the easternmost of two sets of former dog pens used for animal research at LEHR. A third landfill disposal unit located approximately

600 feet east of LEHR, Landfill Unit No. 3, was used from 1963 to 1967. The combined total acreage for the three disposal areas is estimated at approximately six acres (Dames & Moore, 1990b).

In the early 1970s, an outdoor Cobalt-60 Field was constructed at LEHR site to study the effects of chronic exposure to penetrating gamma ray irradiation on bone marrow cells of beagles. Outdoor research was terminated in 1985 and indoor irradiation was terminated in 1988; the cobalt-60 source was removed in January 1993.

In 1975, a program in basic aerosol science was initiated at LEHR to link the evaluation of airborne materials and the laboratory study of these materials utilizing cellular and animal models. The DOE (1988) reported that research activities in this program focused on the potential health effects of release to the atmosphere of combustion products from fossil fuel power plants with emphasis on coal flyash.

In 1983, construction of the Toxic Pollutant Health Research Laboratory (TPHRL) was completed at LEHR. This facility was designed for the study of highly toxic and carcinogenic agents, including both radioactive and chemical materials. Research at the TPHRL included studies of the behavior of plutonium-241 and americium-241 in beagles and monkeys; radioactive and toxic gas-particle mechanistic aerosol studies; monodisperse aerosol inhalation deposition; intratracheal applications of carcinogen-coated particles; and an organic vapor uptake utilizing beagles (DOE, 1988). Since the late 1980s, most of the buildings formerly occupied by LEHR have been used by the Institute of Toxicology and Environmental Health (ITEH), a research unit at UC Davis.

2.2 PHYSICAL SETTING

The LEHR/SCDS site is located in the southern portion of the Sacramento Valley, which extends from the Red Bluff area in the north to the Sacramento-San Joaquin Delta region in the south. The LEHR/SCDS site sits in a flat-lying or gently sloping area of former farmland. The LEHR/SCDS site and the surrounding area are located on the geomorphic unit termed "low alluvial plains and fans" (DWR, 1978), specifically the Putah Plain. This surface represents distal portions of alluvial fan deposits associated with Putah Creek. Sediments that form these alluvial fan deposits consist primarily of silts and clays with coarse-grained sediments found locally. The age of these deposits range from late Pleistocene to Recent. The thickness of the alluvial fan deposits is at least 180 feet (DWR, 1978).

2.3 GEOLOGIC CONDITIONS

The stratigraphy and hydrogeology in the vicinity of the LEHR/SCDS site were assessed previously in the Groundwater and Soils Investigation Report (Wahler Associates, 1989), the Phase II Site Characterization Report (Dames & Moore, 1993), the Field Activity Report (PNNL, 1995), the DOE Areas Characterization Report (Weiss Associates, 1997) and the Off-Site Monitoring Well Installation for the Fourth Hydrostratigraphic Unit (Dames & Moore, 1998). Beneath the LEHR/SCDS site, sediments approximately 80 feet below ground surface (bgs) are predominantly fine-grained (silt or clay). Below 80 feet bgs, coarse sand and gravel are encountered. From approximately 135 to 250 feet bgs, sediments are predominantly fine-grained (sandy clay with silt and sand lenses). At approximately 250 to 282 feet bgs, coarse sand and gravel are present. Below 282 feet bgs, silt was encountered. No investigations have been conducted at the LEHR/SCDS site to assess the thickness of the silt unit.

2.4 HYDROGEOLOGIC CONDITIONS

Groundwater is encountered beneath the LEHR/SCDS site at depths ranging from approximately 30 to 70 feet bgs. The uppermost aquifer has been divided into two units based upon stratigraphy. The first hydrostratigraphic unit (HSU) extends from the water table to approximately 80 feet bgs and consists of relatively fine-grained sediments varying from very fine-grained sandy silt or silty sand to sandy clay. The second HSU extends from approximately 80 to 135 feet bgs and consists of coarse sand and cobble gravel. Based upon review of agricultural well logs, this unit appears to be relatively extensive in this area. The base of the second HSU is defined by the underlying clay unit (the third HSU). The first and second HSUs are not separated by an identified aquitard, and are considered to be in hydraulic communication. Figure 3 presents a schematic cross-section of the HSUs at the site.

Below the second HSU, the third HSU is generally considered an aquitard that consists primarily of clay and silty clay with coarser-grained sandy intervals. The third HSU extends from the base of the second HSU to approximately 250 feet bgs and consists of predominantly sandy clay. The fourth HSU extends from approximately 250 to 282 feet bgs and consists of coarse sand and gravel. The base of the fourth HSU is defined by a sharp contact with a bluish dark gray silt. Data from slug tests support the conclusion that the fourth HSU is less permeable than the second HSU (Dames & Moore, 1998).

Groundwater in the first and second HSUs typically flows to the northeast. Regional water levels in these two HSUs decline from May to August and rise from August to May. Investigations to

assess the groundwater flow direction and the regional water level trends of HSU-4 in the LEHR site vicinity have been started with the recent completion of three monitoring wells in HSU-4.

2.5 SURFACE WATER

The South Fork of Putah Creek (Putah Creek) is the principal surface water feature of the region and the creek levee forms the southern border of the site. Putah Creek flows eastward from Lake Berryessa, located approximately 20 miles west of the site, and ultimately empties into the Yolo Bypass approximately 8 miles east of the site.

Flow in Putah Creek is regulated by releases from Monticello Dam at Lake Berryessa and from the Solano Diversion Dam. Putah Creek also receives water from the following sources:

- Runoff from adjacent agricultural land;
- Storm water from UC Davis;
- UC Davis Putah Creek Research Facility;
- UC Davis Aquatic Center Fishery;
- UC Davis Aquatic Weed Control Laboratory; and
- Treated effluent from the UC Davis Wastewater Treatment Plant (WWTP) via an outfall pipeline upstream of the site.

Flow in Putah Creek varies widely during the course of the year from high flows and flood conditions during the winter rainy season, to dry or low-flow conditions in the summer. Putah Creek is a losing stream, and during dry years, flow in many parts of the creek ceases. The bottom of the creek channel is approximately 25 feet lower in elevation relative to the site. Near the site, water is present in the creek all year long due in large part to discharge from the nearby UC Davis wastewater treatment plant outfall (approximately 1.6 million gallons per day).

2.6 STORMWATER

The LEHR/SCDS site is relatively flat with approximately 35 percent of the site unpaved and 45 percent paved, and remaining site occupied by the partially paved former dog pen areas. Because of the large unpaved areas, a large portion of site precipitation collects into puddles and infiltrates into

the subsurface. Storm water precipitation that does not infiltrate accumulates and runs off the site primarily in the five areas described below.

- The first area consists of the rooftops and paved areas surrounding the ITEH buildings located on the western portion of the site. Runoff in this area collects in a series of storm drains that direct water to a lift station. From the lift station, water is pumped into a drainage ditch that passes under Old Davis Road and drains through the levee into Putah Creek.

- The second area consists of the rooftops and parking lot located on the northwest portion of the ITEH facility. Run-off in this area drains toward Old David Road where it collects in a ditch which flows south toward the drainage ditch that passes under Old Davis Road.

- The third consists of the paved and unpaved areas on the eastern portion of the site near landfill unit #3. Water in this area drains to a shallow east-west trending ditch that empties into a large north-south trending ditch. The larger ditch collects runoff from UC Davis areas south of Interstate 80, forms the eastern border of UC Davis property, and empties into Putah Creek.

- The fourth area consists of the paved and unpaved areas near landfill unit #1 and the "X" building area. Water that collects in this area is diverted through the "X" building area into a culvert that passes through the levee and into Putah Creek.

- The fifth area consists of the paved areas within the Cobalt-60 field. Water in this area runs off into trough drains, which are then piped underground to the UC Davis sanitary sewer system.

Figure 15 presents a schematic diagram of the general drainage areas described above for the LEHR/SCDS site. Storm water sampling to date has concentrated primarily on the area that drains the western portion of the site located around the ITEH buildings. Beginning with the 1996-1997 storm season, samples were collected from the drainage outlets for the lift station, landfill unit #1, and landfill unit #3.

2.7 PREVIOUS INVESTIGATIONS

Both the DOE and UC Davis have sponsored several environmental evaluations at the LEHR/SCDS site. Two surveys, the Initial Assessment Survey (Rockwell, 1984), and the Environmental Survey Preliminary Report (DOE, 1988), presented documentation of potential environmental impacts

from past operations at the LEHR/SCDS site. The Phase I Investigation (Wahler, 1988, and 1989) was an initial investigation of environmental impacts from past LEHR/SCDS activities.

Two studies, the Solid Waste Assessment Test (SWAT) investigation (Dames & Moore, 1990b), and the Old UC Davis Landfill Additional Characterization (Dames & Moore, 1991a) addressed potential impact from the former UC Davis landfill. A Contaminant Pathway Analysis (Dames & Moore, 1990c) was conducted to assess health risk exposure from the LEHR/SCDS site area on the main UC Davis campus. Other environmental evaluations include an Evaluation of Potential Nitrate and Hexavalent Chromium Sources (Dames & Moore, 1990d), a Waste Burial Trench Investigation (Dames & Moore, 1991b), sediment and surface water sampling in the South Fork of Putah Creek (Dames & Moore, 1990e) and a CEQA Preliminary Study for Characterization Activities (Dames & Moore, 1991c). The Phase II Site Characterization (Dames & Moore, 1993) provided a summary of the previous investigations and presented results of additional soil and groundwater investigations at the LEHR/SCDS site.

The Engineering Evaluation/Cost Analysis (EE/CA) investigation (Dames & Moore, 1997) was prepared for the anticipated groundwater Interim Removal Action (IRA). The investigation evaluated alternatives for capturing, treating, and disposing of groundwater that is pumped from the second HSU at a location downgradient of site sources.

As part of the current off-site investigation being conducted downgradient of the LEHR/SCDS site, one monitoring well, an HSU-1 well, UCD2-32, was installed between December 1996 and April 1997. Three HSU-4 wells were installed during the fall of 1997. This investigation is being conducted to assess potential off-site impacts to groundwater and to assess the potential for groundwater cross-contamination due to nearby irrigation wells.

To date, a total of 43 groundwater monitoring wells, 1 extraction well, and 1 reinjection well have been installed at the LEHR/SCDS site (Figure 13). One well (UCD1-2) was abandoned in 1990 by UC Davis because it was installed through Landfill Unit No. 2 waste, and another well (UCD4-33) was abandoned after the well screen collapsed. Of the remaining 41 monitoring wells, 21 are installed in HSU-1, 16 are installed in HSU-2, and 3 are installed in HSU-4. One well (UCD1/2-27) was installed as a multi-port Westbay™ System well that allows groundwater samples to be collected from several depth-discrete intervals completed in HSU-1 and HSU-2. The extraction well (EW2-1) and injection well (IW2-1) were installed in HSU-2 as fully penetrating wells for the eventual IRA.

3.0 MAPS

This chapter explains the maps and figures that are referenced in this Revised FSP. The purpose of these figures is to illustrate:

- The location of the LEHR/SCDS site and LEHR/SCDS site boundaries;
- LEHR/SCDS site physical features and structures;
- Potential source areas for target constituents;
- Directions of groundwater, surface water, and storm water flow;
- Distribution of primary constituents of concern in groundwater;
- Known and proposed sampling and investigation locations for the UC Davis field investigations; and
- Locations of existing monitoring wells, extraction wells, and piezometers.
- Locations of off-site privately owned agricultural and domestic wells that are part of the neighbors' wells monitoring program.

A full description of the LEHR/SCDS site, a review of the history of LEHR/SCDS site operations, and a summary of previous work are presented in Chapters 2 and 3 of the Final Draft, Field Sampling Plan, RI/FS Work Plan (PNL, 1994a).

3.1 LEHR/SCDS SITE LOCATION

Figures 1, 2, and 4 present the LEHR/SCDS site location and LEHR/SCDS site structures for the LEHR/SCDS site and the surrounding area. Figure 1 shows Davis, California which is located 15 miles west of Sacramento, and 50 miles northeast of the San Francisco Bay area. Figure 2 presents the general LEHR/SCDS site vicinity. The LEHR/SCDS site is located south of the City of Davis and Interstate Route 80 and north of Putah Creek. Figure 4 presents the LEHR/SCDS site boundaries and the general locations of the UC Davis investigation areas.

3.2 INVESTIGATION LOCATIONS

The primary investigations on-going at the LEHR/SCDS site are soil, groundwater, surface water, and storm water investigations. The following sections explain the maps and figures that are associated with these investigation activities.

3.2.1 Soil Investigation

A soil investigation is currently being conducted for seven areas. Figures 5 through 12 present a detail of each individual investigation area along with the locations for soil borings, soil vapor survey points, and exploration trenches conducted as part of the Data Gaps Limited Field Investigation. The individual investigation areas include:

- Waste Burial Holes (Figure 5);
- Eastern Trenches (Figure 6);
- Southern Trenches (Figure 7);
- Landfill Unit #1 (Figure 8);
- Landfill Unit #2 (Figure 9);
- Landfill Unit #3 (Figure 10); and
- Old Wastewater Treatment Plant (Figure 12).

Additionally, Figure 11 presents a schematic drawing of disposal trenches and landfill sampling points.

3.2.2 Groundwater Investigation

In November 1990, the Phase II Site Characterization Program established quarterly monitoring of eighteen wells. The program included:

- sampling 13 of 18 monitoring wells in HSU-1 (5 wells were sometimes dry during the summer months and only used to monitor water levels);
- sampling and collecting water levels from 5 monitoring wells in HSU-2; and
- one monitoring well, UCD1-2, was destroyed.

Since then, 21 more wells have been installed. These wells include:

- 3 monitoring wells in HSU-1;
- 11 monitoring wells in HSU-2;

- 1 monitoring well (UCD1/2-27) that is a multiport Westbay™ System well and can be used to collect samples from seven discrete depths, three depths in HSU-1 and four depths in HSU-2;
- 4 monitoring wells in HSU-4 (UCD4-33 was destroyed in 1997);
- 1 extraction well (EW2-1) in the second HSU; and
- 1 injection well (IW2-1) in HSU-2.

Currently, the groundwater monitoring consists of sampling twenty-three wells and two zones from the Westbay™ system. Figure 13 presents well locations, while Figure 3 presents a schematic cross-section of the hydrostratigraphic units present at the LEHR/SCDS site.

3.2.3 Off-Site Groundwater Monitoring Wells

An off-site groundwater investigation is currently being conducted downgradient of the LEHR/SCDS site. Figure 13 presents well location for the recently installed HSU-2 and HSU-4 monitoring wells. New HSU-2 and HSU-4 wells will be included in the site monitoring program.

3.2.4 Surface Water Investigation

The surface water monitoring program at the LEHR/SCDS site also began in November 1990 and consisted of collecting quarterly samples at three locations. One of the three original points has been revised (PCD), but the other two sampling locations remain unchanged. The current surface water monitoring locations include:

- one Putah Creek location (PCU) upstream of the LEHR/SCDS site;
- one Putah Creek location (PCD) downstream of LEHR/SCDS potential source areas; and
- one UC Davis Wastewater Treatment Plant outfall location (STPO) that is located between points PCU and PCD.

These surface water monitoring locations are presented in Figure 14 and rationale for the sampling program is presented in Section 4.6.

3.2.5 Storm Water Runoff Investigation

The storm water monitoring program at the LEHR/SCDS site began in 1994. Samples were collected twice during the rainy season from 1994 through the spring of 1996 at two locations. These locations included:

- one storm drain location (SD-1) west of the western dog pens and
- one location (LS-1) at the lift station located along Old Davis Road.

Based on better understanding of past waste disposal on-site, two storm water monitoring locations were added to the monitoring during the winter of 1996-1997. These new locations included:

- one discharge pipe location (LF-1) south of the "X" building area (south of Landfill Unit No. 1); and
- one location (LF-3, labeled in the 1996 revisions of the Water Monitoring Plan as DD-1) at the discharge pipe of the main north-south trending drainage ditch at the southeast corner of the site (southeast of Landfill Unit No. 3).

Currently, the storm water program includes the sampling of monitoring points LS-1, LF-1, and LF-3. These three locations are sampled two times per rainy season: once at the beginning of the rainy season (typically October/November), and once toward the middle or end of the rainy season (typically February/March). Location SD-1 has been deleted from the monitoring program, since water from that location flows to the lift station and is sampled at LS-1. Storm water monitoring locations along with storm water flow arrows are presented in Figure 15. Storm water flow arrows were mapped by UC Davis Physical Plant personnel and will be field checked during future storm water sampling rounds. Additionally, rationale for the storm water sampling program is presented in Section 4.9.

3.2.6 Neighbors' Wells Sampling Program

The Neighbors' Wells Sampling Program has been ongoing since 1989, and currently includes 12 private domestic and irrigation wells in the vicinity of the LEHR/SCDS site. Rationale for the sampling program is discussed in Section 4.10 and Figure 16 identifies well locations.

4.0 RATIONALE AND APPROACH

This chapter presents the rationale and technical approach for the sampling and analysis activities associated with additional UC Davis field activities. UC Davis field investigations are staged so as to sequentially build on existing data to the point where the quality and quantity is sufficient to meet the objectives for the project as noted in Section 1.1. As such, subsequent data collection activities conducted by UC Davis but not described in this Revised FSP will be described in future work plans. The format of the work plans will be similar to the format of the Revised Data Gaps Work Plan (UC Davis, 1996) and will be submitted to the appropriate regulatory agencies for review and approval.

Rationale for collecting soil chemical, physical, and radiologic data from UC Davis soil investigation areas was previously presented in the Revised Data Gaps Work Plan (UC Davis, 1996), and is included in this Revised FSP as Sections 4.1 through 4.3. Investigations of groundwater chemical and physical characteristics is discussed in Sections 4.4 through 4.7. Surface water and storm water investigations and monitoring are discussed in Section 4.8 and 4.9, respectively. Sampling of neighbors' wells is presented in Section 4.10.

4.1 SOIL INVESTIGATION: UC DAVIS TRENCHES AND BURIAL HOLES

The following sections present the rationale for Data Gaps LFI at each of the UC Davis trench and waste burial hole areas. The Data Gaps LFI was conducted during the summer of 1996 and is described in this Revised FSP as a recently-completed field activity by UC Davis. The soil investigation objectives in these areas are to obtain data of adequate quantity and quality to (1) evaluate the nature of waste present in each investigation area; (2) evaluate the potential for waste in each investigation area to impact groundwater; and (3) to complete an evaluation for investigation areas to assess and select remedial actions from presumptive remedies established during the LEHR Phase III activities. These areas include the waste burial holes, the eastern trenches, and the southern trenches (Figures 5 through 7).

4.1.1 Waste Burial Holes

Forty-nine known waste burial holes are located south of the eastern dog pens and are reported to have been used to dispose of campus-generated low-level radioactive waste, organic chemicals, and laboratory wastes. Investigations conducted prior to 1996 in the waste burial holes consisted of two

reconnaissance trenching programs (Wahler, 1988; Dames & Moore, 1991b), a soil gas investigation (PNNL, 1995), and the drilling of one soil boring (PNNL, 1995). Observations from these investigations indicate that waste present in the burial holes extends as deep as 8 to 10 feet bgs. Results of these investigations include detections of tritium, semi-volatile organic compounds, and volatile organic compounds (VOC) in soil and soil gas, indicating the burial holes are a potential continuing source of impact to groundwater.

Based on these findings, containment and/or partial or complete removal are possible as remedial alternatives for the waste burial holes. As a result, the data gaps soil investigation in this area focused on collecting data to evaluate these alternatives and included a trenching and soil sampling program (Table 1 and Figure 5). Methods and details of the data gaps investigation were presented previously in the Revised Data Gaps LFI Work Plan (UC Davis, 1996).

4.1.2 Eastern Trenches

The eastern trenches are located between landfill units #1 and #2. Investigations conducted prior to 1996 in the eastern trenches have consisted of two reconnaissance trenching programs (Wahler, 1988; Dames & Moore 1991b), a soil gas investigation (PNNL, 1995), and the drilling of two soil borings (PNNL, 1995). Observations from these investigations indicate that waste is present within buried trenches, which extent to between 4 and 6 feet bgs. Waste observed in this area consists of dog pen gravel and bones, along with a variety of laboratory-type wastes that include intact vessels of chemicals. Analytical results of these investigations include detections of chromium, dieldrin, and chlordane. Soil gas results indicate that these trenches are a likely source to LEHR/SCDS site VOC groundwater impacts.

Based on these findings, containment or partial removal or treatment are possible as remedial alternatives for this area. As a result, the data gaps soil investigation in this area focused on collecting data to evaluate these alternatives and consisted of a trenching, soil boring, and soil sampling program (Table 1 and Figure 6). The methods and details of the data gaps field investigation were presented previously in the Revised Data Gaps LFI Work Plan (UC Davis, 1996).

4.1.3 Southern Trenches

The southern trenches are located south of the western dog pens. Investigations conducted prior to 1996 in the southern trench area have consisted of two reconnaissance trenching programs (Wahler, 1988; Dames & Moore, 1991b), and a soil gas investigation (PNNL, 1995). Results of these investigations show that waste is present within this area in buried trenches, which extend to between 4 and 6 feet bgs. Waste observed in this area consists primarily of dog pen gravel and bones. No detections of VOCs were reported in the soil gas samples.

Based on the limited results to date, no action, limited action, containment, removal, or treatment are all possible as remedial alternatives for this area. However, there is a general lack of data from this area and, as a result, the soil investigation in this area focused on collecting data to evaluate the composition and location of waste in the southern trenches in order to assess if there is a potential threat to groundwater and to further evaluate these remedial alternatives. The data gaps investigation consisted of a trenching, soil boring, and soil sampling program (Table 1 and Figure 7). The methods of details of the data gaps investigation were presented previously in the Revised Data Gaps Work Plan (UC Davis, 1996).

4.2 SOIL INVESTIGATION: UC DAVIS LANDFILL UNITS

An investigation was performed in the summer of 1996 as part of the Data Gap LFI in order to characterize the three UC Davis landfill units associated with the LEHR/SCDS site. The landfill units reportedly received UC Davis campus wastes from the 1940s through the early 1970s. Although the landfills reportedly received primarily municipal wastes, the potential exists that they may have received laboratory wastes related to DOE and UC Davis activities. The soil investigation objectives for these areas are to obtain data of adequate quantity and quality to (1) evaluate the nature of waste present in each investigation area; (2) evaluate the potential for waste in each investigation area to impact groundwater; and (3) to complete an evaluation for investigation areas to assess and select potential remedial actions.

4.2.1 Landfill Unit No. 1

The investigations conducted prior to 1996 in Landfill No. 1 have consisted of a soil gas investigation (PNNL, 1995), a partial geophysical program and three soil borings (PNNL, 1995).

Results of these investigations show that waste is buried in this area at depths up to five feet bgs. Waste observed in this landfill consisted of glass and rusted metal. The pesticides chlordane and dieldrin were reported in one surface sample. VOCs were reported in soil gas samples just above detection limits. Results of soil samples collected within or below the waste showed no VOCs and no radionuclides above background levels. Metals results reported in soil were all within the background concentration range. Groundwater samples collected in monitoring well UCD-11 downgradient of Landfill No. 1 show elevated concentrations of chromium.

Based on the data collected to date, no action, limited action, and containment are possible as remedial alternatives for Landfill No. 1. Additional data collection focused on collecting data to evaluate these actions, and included a geophysical investigation, a trenching and soil boring program, and a soil and soil gas sampling program (Tables 1 and 2; Figures 8 and 11). The methods and details of the investigation were presented previously in the Revised Data Gaps LFI Work Plan (UC Davis, 1996).

4.2.2 Landfill Unit No. 2

The investigations conducted prior to 1996 in Landfill No. 2 have consisted of a soil gas investigation (PNNL, 1995), a geophysical survey and three soil borings (PNNL, 1995). Results of these investigations show that waste is buried in this area at depths up to 12 feet bgs. Waste observed in this landfill consisted of metal, glass, wood, wire, and straw. Levels of VOCs reported in soil gas in the northern one-third of Landfill No. 2 were elevated, relative to levels reported in other area. Results reported from soil samples collected show that concentrations of arsenic, lead, cesium-137, and radium-226 in waste exceed background concentrations. The pesticides DDE and chlordane were also reported in waste samples. Groundwater samples collected in monitoring well UCD1-12, downgradient of Landfill No. 2 show the highest concentrations of chloroform and other VOCs reported at the LEHR/SCDS site.

Based on the data collected to date, containment or capping is the likely presumptive remedial alternative for Landfill No. 2, likely coupled with chloroform-source remediation or removal. Additional data collection focused on collecting data to further evaluate these actions, and included a trenching program, a soil boring program, and a soil and soil gas sampling program (Tables 1 and 2; Figures 9 and 11). The methods and details of the investigation were presented previously in the Revised Data Gaps Work Plan (UC Davis, 1996).

4.2.3 Landfill Unit No. 3

The investigations conducted prior to 1996 in Landfill No. 3 have consisted of a soil gas investigation and a partial geophysics program (PNNL, 1995), five soil borings, and eight exploration trenches (PNNL, 1995). Results received from these investigations have shown that waste is buried in this area at depths up to 14.5 feet bgs. Waste observed in this landfill consisted of glass, rusted metal, concrete, bricks, ceramic material, and other household and lab waste. Results reported for soil samples collected from within the waste exceed background soil concentrations for arsenic, manganese, lead, mercury, PCBs, and cesium-137. Results reported for soil samples collected below the waste exceed background soil concentrations for lead, mercury, PCBs, and cesium-137. Groundwater samples collected in-situ downgradient of Landfill No. 3 show detectable levels of chloroform.

Based on the data collected to date, containment/capping and partial or complete excavation of Landfill No. 3 are the presumptive remedial alternatives to be considered. Additional data collection focused on evaluation and supporting these presumptive actions, and included a trenching program, a soil boring program, and a soil and soil gas sampling program (Tables 1 and 2; Figures 10 and 11). The methods and details of the data gaps investigation were previously presented in the Revised Data Gaps Work Plan (UC Davis, 1996).

4.3 OLD WASTEWATER TREATMENT PLANT

Prior to the Data Gaps Limited Field Investigation, no previous assessments had been conducted to evaluate potential residual impacts from past operations in the Old Wastewater Treatment Plant (WWTP) area. As result, the data gaps LFI included work in this area to assess whether the drying bed contains treatment plant residuals and whether those residuals present a threat to groundwater. Two borings were drilled in the old WWTP drying bed area to meet these needs (Figure 12). Samples collected from the soil borings were analyzed for the parameters listed on Table 1 according to methods listed in Table 2.

4.4 ADDITIONAL HYDROGEOLOGIC INVESTIGATION

Additional hydrogeologic investigations at the LEHR/SCDS site will be conducted to evaluate groundwater impacts beneath and downgradient of the site, and to support future remediation

activities. Current groundwater field activities include the groundwater IRA (see Section 4.5), the off-site groundwater investigation (see Section 4.6), and ongoing groundwater monitoring (see Section 4.7). The objectives for the site hydrogeologic investigation are to (1) refine the current understanding of the site stratigraphy and aquifer characteristics as required to quantitatively design and evaluate groundwater remedial activities, (2) collect additional groundwater quality data in order to investigate the nature and extent of impacts and to evaluate additional remediation and discharge options, and (3) provide regular groundwater monitoring data to evaluate impacts to groundwater and support investigation and remediation activities.

Although the scope and specifics of future hydrogeologic investigations have not been established, field activities may include monitoring well installation, Hydropunch™ sampling; groundwater monitoring; and groundwater remedial activities. Locations and specifications for future well installations, Hydropunch™ sampling, or hydrogeologic monitoring will be presented in future work plans. Field activities associated with future site groundwater remediation will be presented in Removal Action Work Plans (RAWP).

4.5 GROUNDWATER INTERIM REMOVAL ACTION

The following sections present rationale for the groundwater investigation activities associated with the proposed groundwater Interim Removal Action. The groundwater IRA investigation was conducted during the fall of 1996 and included well installations and step drawdown and constant rate pumping tests. Aquifer pumping tests were conducted to estimate aquifer parameters and support design of the groundwater IRA system. Prior to performing the aquifer pumping tests, a pumping well (EW2-1) and four observation wells (UCD1-28, UCD2-29, UCD2-30, and UCD2-31) were installed. A step drawdown test was conducted to evaluate the efficiency and sustainable yield of the pumping well. Based on the results of the step drawdown test, a constant rate aquifer pumping test was conducted to estimate HSU-2 aquifer parameters and the hydraulic connection between HSU-1 and HSU-2.

4.5.1 Pumping and Observation Well Installation

To support design and implementation of the groundwater IRA, one pumping well and four monitoring wells were installed downgradient of Landfill Units #1 and #2. The objective of installing these wells is to:

- Provide pumping and water level monitoring locations during aquifer testing;
- Further assess the distribution of chemical constituents in groundwater; and
- Provide monitoring locations to assess capture zone extent during operation of the groundwater IRA.

A detailed discussion of well installation and development, and well sampling is provided in the Pre-Design Activities Technical Memorandum/Work Plan (Dames & Moore, 1996c).

Well locations were selected to accomplish the objectives listed above. The specific locations are based on our current understanding of the hydrogeology and distribution of groundwater impacts at the site (see Sections 2.3 and 2.4), coupled with preliminary groundwater flow modeling. Pumping well EW-1 was completed in HSU-2, approximately 800 feet downgradient of the suspected chloroform source area in Landfill Unit #2. It is anticipated that EW-1 will later function as an extraction well for the groundwater IRA. The location of EW-1 was selected for groundwater extraction to restrict further downgradient migration of chloroform impacts above 100 ug/L, as well as intercept other constituents in groundwater.

As shown on Figure 13, four monitoring wells were installed near EW-1. Monitoring well pair UCD1-28 and UCD2-29 were installed approximately 60 feet upgradient of EW-1 in HSU-1 and the upper zone of HSU-2, respectively. UCD1-28 and UCD2-29 will be used to assess groundwater chemistry and leakage between HSU-1 and HSU-2 near pumping well EW-1. UCD2-30 was completed in the middle zone of HSU-2, approximately 80 feet downgradient of EW-1. UCD2-30 will be used to assess drawdown and groundwater chemistry downgradient of pumping well EW-1. UCD2-31 was installed in the middle zone of HSU-2, approximately 120 feet side gradient (north) of EW-1, and will be used to assess drawdowns at a greater distance than UCD2-29 and UCD2-30 and to assess groundwater chemistry on the northern flank of the chloroform groundwater plume. Together UCD2-29, UCD2-30 and UCD2-31 are positioned to evaluate distance drawdown during the pumping test, and capture zone extent during operation of the IRA. A summary of well construction details is included in Table 3.

4.5.2 Step Drawdown Pumping Test

A step drawdown pumping test was conducted in EW-1. During the step drawdown test, the well was pumped at successively higher pumping rates and the drawdown for each rate, or step, was recorded. The result of this test provided information for estimation of well efficiency and the appropriate pumping rate for the constant rate pumping test. During the test, drawdown and recovery in the pumping well was monitored electronically using pressure transducers and data loggers. Water level readings were recorded every 10 seconds. Additional information for the transducers, data loggers, equipment, and specific pump test procedures are presented in the Pre-Design Activities Technical Memorandum/Work Plan (Dames & Moore, 1996c).

4.5.3 Constant Rate Pumping Test

A constant rate aquifer pumping test was conducted to evaluate HSU-2 aquifer parameters transmissivity (T) and storativity (s), and to assess leakage between the HSU-1 and HSU-2. The constant rate pumping test consisted of the three components listed below.

- Rest Period - The period preceding pumping used to monitor water levels to assess regional water level trends and potential effects of nearby irrigation wells.
- Pumping Period - The period in which the pumping well is operated at a constant rate, and water levels in the pumping well and nearby observation wells are monitored to assess drawdowns as a result of pumping.
- Recovery Period - The period immediately following cessation of pumping in which water levels are monitored in the pumping well and observation well to assess recovery to non-pumping levels.

During each period water levels were monitored electronically using a dataloggers and pressure transducers. Eight wells were monitored for changes in water level during the pumping test. Multi-channel data loggers were used during the aquifer test so that several observation points could be monitored simultaneously. A barometer was used to continually record on-site barometric pressure readings. Barometric pressure readings were recorded at the same time intervals as water level readings using a datalogger. Manual water level measurements were collected periodically to verify electronic measurements. A detailed description of each period is provided in the Pre-Design Activities Technical Memorandum/Work Plan (Dames & Moore, 1996c).

4.6 OFF-SITE GROUNDWATER INVESTIGATION

The following sections present rationale for the off-site well investigation. The off-site well investigation includes installing two wells downgradient of the LEHR/SCDS site during the winter of 1996/1997, and three wells during the fall of 1997. The objective of installing these wells is to:

- Provide water level data during the irrigation season;
- Provide groundwater gradient data for HSU-4;
- Assess off-site impacts to groundwater in HSU-2 and HSU-4; and
- Assess the potential for groundwater cross-contamination due to nearby irrigation wells.

A discussion of well installation, development, and sampling is provided below.

4.6.1 Well Location and Rationale

Well locations were selected to accomplish the objectives listed above. The specific locations are based on the location of nearby irrigation wells. As shown on Figure 13, two monitoring wells were installed just east of the LEHR/SCDS site. Monitoring well UCD2-32 was installed approximately fifteen feet east of the Irrigation well 22N and downgradient of irrigation well 22N. UCD2-32 will be used to assess groundwater chemistry in HSU-2 near irrigation well 22N. UCD4-33 was completed in HSU-4, approximately 30 feet east and downgradient of irrigation well 22N. The original purpose of well UCD4-33 was to assess drawdown and groundwater chemistry in HSU-4 downgradient of irrigation well 22N. However, due to a break in the well screen, the well was abandoned by pressure grouting. Hydraulic and chemical data collected from UCD4-33 prior to abandonment indicated that HSU-4 was impacted with chloroform and, as a result, three additional HSU-4 monitoring wells (UCD4-41, UCD4-42, and UCD4-43) were installed in October 1997 in off-site downgradient areas.

4.6.2 Well Installation and Development

The borehole for monitoring well UCD2-32 was advanced using hollow stem auger drilling methods to a total depth of 105 feet bgs. To evaluate lithology, continuous coring runs were

completed from ten feet prior to the anticipated screen interval to the top of HSU-2. Based on the material encountered in HSU-2. 20 feet of 20 slot, 2-inch stainless steel, wire-wrap well screen was installed in the borehole to 103 feet bgs (Table 3). The well casing extends from the top of the screen to the ground surface and consists of 2-inch Schedule 40 PVC.

The borehole for HSU-4 well UCD4-33 was advanced using air rotary/casing hammer (ARCH) methods to approximately 210 feet bgs and mud rotary drilling methods to the total depth of the borehole (310 feet bgs). Lithology was evaluated from observation of cyclone grab and continuously cored samples . The boring was advanced approximately 40 feet into HSU-4 (310 feet bgs). Based on the material encountered in HSU-4, 30 feet of 20 slot, 4-inch stainless steel, wire-wrap well screen was installed in the borehole to 290 feet bgs (Table 3). The 4-inch Schedule 80 PVC well casing extended from the top of the screen to the ground surface. Due to a break in the well casing, UCD4-33 was abandoned in May 1997.

HSU-4 wells UCD4-41 and UCD4-43 were installed using mud rotary methods. Each borehole was continuously cored and advanced to the bottom of HSU-4 (approximately 300 feet below ground surface). HSU-4 well UCD4-42 was installed inside the former Nishi irrigation well that is located 50 feet northwest of the current Nishi irrigation well 22N. Each well was screened in the upper portion of HSU-4. The three HSU-4 monitoring wells were constructed with 20 feet of 0.020-inch slotted, 4-inch diameter stainless steel wire wrap screen, and 4-inch diameter Schedule 80 PVC casing. A detailed description of the off-site well installations was presented in the August 29, 1997 work plan for off-site well installation.

Well locations and top of casing elevations were surveyed by a California licensed surveyor. Boring logs and well completion logs were prepared for each well. Following installation, each well was developed using surge, bail and pumping techniques. Periodic monitoring of extracted groundwater for temperature, pH, electrical conductivity (EC), and turbidity was conducted as development progressed.

4.6.3 Well Sampling

Initial groundwater samples were collected from each of the new wells. Each well was purged using a Grundfos RediFlo2 submersible pump. Each well was purged until temperature, pH, EC, and turbidity measurements have stabilized and at least three casing volumes were removed. Groundwater

samples were collected using disposable bailers. Groundwater samples were submitted to Lockheed Analytical Services under chain-of-custody.

4.7 GROUNDWATER MONITORING

Groundwater monitoring at the LEHR/SCDS site is conducted to evaluate the presence and distribution of contaminants in the hydrostratigraphic units beneath the site. Currently, monitoring wells installed in HSU-1 and HSU-2 are being monitored. Additional investigations will include evaluating and monitoring additional wells, including deeper HSUs beneath and downgradient at the site. Work plans to install new monitoring wells will be incorporated into this Revised FSP by reference. New wells will be incorporated into the site monitoring program by revisions to the groundwater monitoring portions of this Revised FSP.

The groundwater monitoring program presented in this FSP consists of monitoring location, analytical parameters, and a sampling and analytical schedule. This monitoring program is based on previous descriptions of site monitoring presented in the Water Monitoring Plan (1994a, revised 1996) and changes made to the monitoring program in 1995 (PNNL, 1996). This Revised FSP groundwater monitoring program includes collecting samples and water level measurements from 16 HSU-1 wells, 9 HSU-2 wells, 3 HSU-4 well, and collecting additional water level measurements for 5 first HSU wells that are sometimes dry during summer months. Sampling and analytical frequencies for several wells have been modified from previous programs using guidelines established in the 1995 Annual Water Monitoring Report (PNNL, 1996). The groundwater monitoring program is presented in Table 4 and is discussed in the following sections.

As new wells are added to the monitoring network, they will be analyzed quarterly for all analytes listed in Table 4 for one year. After one year of monitoring, the sample results will be evaluated and changes to the monitoring frequency or analyte list may be proposed.

4.7.1 Monitoring Locations

Quarterly groundwater monitoring at the site began in November 1990 under the Phase II Site Characterization. Monitoring was conducted at 18 of the 23 wells existing at that time because five HSU-1 wells (UCD1-3, UCD1-5, UCD1-6, UCD1-8, and UCD1-9) were periodically dry during summer months. The monitoring wells sampled at that time included HSU-1 wells UCD1-1, UCD1-4,

UCD1-10, UCD1-11, UCD1-12, UCD1-13, UCD1-18, UCD1-19, UCD1-20, UCD1-21, UCD1-22, UCD1-23, and UCD1-24 and HSU-2 wells UCD2-7, UCD2-14, UCD2-15, UCD2-16, and UCD2-17 (Figure 13).

As part of the RI/FS work conducted in 1995, five monitoring wells were installed. These new wells included: HSU-1 wells UCD1-25 and UCD1-34, and HSU-2 wells UCD2-26 and UCD2-35. Additionally, well UCD2-27 was installed as a multi-port Westbay™ system well that allows groundwater samples to be collected from seven depth-discrete intervals completed within HSU-1 and HSU-2. These new wells were incorporated in the Water Monitoring Plan (PNL, 1994b) modifications made in 1996.

As part of the pre-design work for the IRA in 1996, four monitoring wells and one extraction well were installed. HSU-1 monitoring well UCD1-28, HSU-2 monitoring wells UCD2-29, UCD2-30, and UCD2-31, and extraction well EW2-1 were installed. Extraction well EW2-1 was installed in HSU-2 as a fully penetrating extraction well for the eventual IRA and to collect data to estimate physical parameters and groundwater quality for the IRA system design.

As part of the off-site neighboring wells investigation, two monitoring wells were installed. Well UCD2-32 was installed in 1997 in HSU-2. Well UCD4-33 was installed in HSU-4. Due to a collapsed well screen, UCD4-33 was abandoned in May 1997.

In order to investigate potential impacts in HSU-4, three wells have been completed in that zone. A replacement for UCD4-43 was drilled off-site 400 feet east of UCD2-32. UCD4-41 was installed at the eastern edge of the site. UCD4-42 is located near UCD2-32, and was constructed inside an abandoned irrigation well to monitor HSU-4. Details on the construction of these wells is presented in Table 3.

To support the Groundwater IRA, five additional HSU-2 monitoring wells and one injection well were installed in October and November 1997. Wells UCD2-36 through UCD2-40 were located to provide information on the effectiveness of the IRA groundwater treatment system and to monitor for potential impacts from reinjected groundwater. These wells will be monitored monthly, as described in the Waste Discharge Requirements for the Groundwater IRA, and will also be included in quarterly monitoring, as described in the Revised FSP.

The current groundwater sampling plan consists of monitoring all 41 existing monitoring wells installed to date at or in the vicinity of the LEHR/SCDS site (see Table 3). The monitoring program consists of:

- Measuring water levels from all 41 wells, including HSU-1 wells UCD1-3, UCD1-5, UCD1-6, UCD1-8, UCD1-9 (which are dry during summer months of drought years);
- Monitoring 16 HSU-1 groundwater wells: UCD1-1; UCD1-4; UCD1-10; UCD1-11; UCD1-12; UCD1-13; UCD1-18; UCD1-19; UCD1-20; UCD1-21; UCD1-22; UCD1-23; UCD1-24; UCD1-25; UCD1/2-27 at Zone 3; and UCD1-34;
- Monitoring 9 HSU-2 groundwater wells: UCD2-7; UCD2-14; UCD2-15; UCD2-16; UCD2-17; UCD2-32; UCD2-35; UCD2-26; and UCD1/2-27 at Zone 5;
- Monitoring IRA wells: UCD1-28; UCD2-29; UCD2-30; UCD2-31; UCD2-36; UCD2-37; UCD2-38; UCD2-39; and UCD2-40. Upon start-up of the groundwater IRA system, these IRA wells, along with well UCD2-35, will also be monitored on a monthly schedule for at least one year as part of full-scale operation of the IRA; and
- Monitoring three HSU-4 wells: UCD4-41, UCD4-42, and UCD4-43.

4.7.2 Monitoring Parameters and Schedule

Groundwater sampling and analysis will continue on a quarterly schedule, but for certain wells sampling will be performed less frequently. Based on previous groundwater monitoring results, proposed changes to the previous parameters and schedule have been incorporated in this Revised FSP. These changes are consistent with changes made in the program in 1995 (PNNL, 1996). The sampling program presented in this Revised FSP began with the summer round of sampling in 1997.

The groundwater monitoring program is summarized in Table 4. Wells which are sampled annually will be sampled in the winter quarter (February) and wells sampled semi-annually will be sampled in the winter and summer quarters (February and August). Wells scheduled for quarterly sampling will be sampled in February, May, August, and November. Upon further evaluation of new data, this schedule of wells and parameters may be updated at a later date.

Two types of parameters are identified for measurement or collection and analysis: field parameters and laboratory parameters. Field parameters to be taken at each sampling event include pH, Eh, electrical conductivity, temperature, and turbidity. Water level measurements will be collected

monthly. During months that water sampling is conducted, water levels will be collected prior to beginning the sampling event. Laboratory parameters to be analyzed are indicated by the letters Q (quarterly), S (semi-annually), or A (annually) indicating the frequency of collection. Field QC requirements are described in Section 5.3 of this Revised FSP.

4.8 SURFACE WATER MONITORING

This section describes the site surface water monitoring program. Surface water sampling will be conducted twice per year during the rainy season at the same time as storm water monitoring (Section 4.9). Surface water samples will be collected at locations PCU, STPO, and PCD for the purpose of evaluating the extent of site constituents of concern in the South Fork of Putah Creek, and to identify potential water quality impacts from the site on Putah Creek. Surface water monitoring will be conducted during the winter months when there is the highest potential for impacts from the site from storm water discharge and high groundwater elevations.

4.8.1 Monitoring Locations

Surface water monitoring will be conducted at three locations along Putah Creek. These monitoring points include: UC Davis wastewater treatment plant outfall (designated STPO); upstream of the LEHR/SCDS site (designated PCU); downstream of all known LEHR/SCDS potential areas (designated PCD) (Figure 14). Sample location PCU serves as a monitoring point up gradient of the facility, and sample location PCD serves as a monitoring point down stream of the LEHR/SCDS site discharges. Discharge to the creek at location STPO will be monitored because a significant portion of water present in the South Fork of Putah Creek near the site is discharged from the nearby UC Davis wastewater treatment plant outfall (approximately 1.6 million gallons per day). In addition, during the fall and winter sampling events for one year, samples will be collected from PC2, a location approximately 2 miles downstream of PCD for aquatic toxicity testing. The purpose of sample location PC2 is to evaluate the potential for toxicity in Putah Creek after mixing of stormwater discharges and Putah Creek water has occurred. After one year of monitoring, the results for PC2 will be compared to PCD, and if there are no significant differences, monitoring at PC2 will be discontinued.

4.8.2 Monitoring Parameters and Schedule

The surface water analytical program is shown in Table 5. Surface water monitoring will occur twice during the rainy season in conjunction with storm water monitoring. The first rainfall sampling event will occur early in the wet season that provides enough runoff for sampling, typically in October or November. The second event will occur in the middle or late part of the rainy season, typically in February or March. Surface water sampling will focus on rainfall events to evaluate the creek when the site is most likely to discharge and impact the creek. Since storm water runoff is the only pathway for the site to impact Putah Creek, monitoring of the creek during the dry season (i.e., when there is no runoff) will be eliminated.

Two types of parameters are identified for measurement or collection and analysis: field parameters and laboratory parameters. Field parameters to be taken at each sampling event include pH, electrical conductivity, temperature, turbidity, and flow. Laboratory parameters (see Table 5) consist of chemical parameters and chronic aquatic toxicity testing. Specific methods, holding times, and detection limits for surface water samples are listed in Table 8. The purpose of analyzing for the specified chemical parameters is to evaluate the presence of site constituents of concern in Putah Creek. The purpose of aquatic toxicity testing is to assess the potential incremental increase in toxicity in Putah Creek from site runoff, using both surface and storm water samples. The chronic aquatic toxicity test will be conducted using these aquatic species: fathead minnow *(Pimephales promelas),* water flea *(Ceriodaphnia dubia),* and green algae *(Selenastrum capricornutum).*

Previously, discharge for Putah Creek in the vicinity of the site were calculated using monthly flow totals from the Solano County Water Agency (SCWA), which maintained a staff gauge at the Old Davis Road bridge. During the construction of the new bridge, the staff gauge was eliminated. The next closest staff gauge is approximately 0.8 miles upstream at the I-80 bridge over Putah Creek. The I-80 bridge staff gauge will be used in the interim until a means of recording flow in Putah Creek near the site can be re-established with the SCWA. A direct reading of the staff gauge(s) will be recorded during the surface water sampling round.

4.9 STORM WATER RUNOFF MONITORING

This section describes the site storm water monitoring program. Storm water runoff monitoring will be conducted twice annually during the rainy season at the same time as surface water sampling (Section 4.8). Storm water will be sampled at the three locations to assess potential impacts to the creek from site runoff.

4.9.1 Monitoring Locations

Storm water at the site has been divided into six zones depending on the flow path of the runoff. These six zones include: four zones where runoff is transported to the South Fork of Putah Creek; one zone where runoff is transported to the sanitary sewer system; and one zone where runoff ponds and infiltrates. The zones are shown in Figure 15 and described in more detail below.

- The first storm water zone is located at the western portion of the site around the buildings that make up the Institute of Toxicology and Environmental Health. This area is almost entirely paved and transfers storm water runoff to a lift station via catch basins. From the lift station, the storm water is pumped to a ditch along the west side of Old Davis Road, which discharges into Putah Creek just upstream of the Old Davis Road bridge.

- The second storm water zone is located at the "X" building area, just east of Landfill Unit No. 1. In this zone, water runoff flows via land contours to a drain pipe that transports the runoff beneath the levee and into Putah Creek.

- The third storm water zone is located at the southeast corner of the site at Landfill Unit No. 3. Storm water runoff in the third zone drains to a east-west trending ditch until it intersects the main north-south trending ditch on the eastern side of the site. From the main north-south trending ditch, the runoff flows beneath the levee via a spill pipe and into Putah Creek.

- The fourth storm water zone is an area within the Cobalt-60 field. The storm water in this paved area runs off into trough drains, which are then piped underground to the sanitary sewer system.

- The fifth storm water zone is located at the western portion of the site. This area contains parking areas and portions of a few buildings. The area is almost entirely paved and runoff flows to a ditch along Old Davis Road, which eventually discharges to Putah Creek.

- The sixth and last major storm water zone consists of three large areas in the central portion of the site. Storm water runoff in these areas either infiltrates relatively rapidly or forms standing water areas and infiltrates relatively slowly.

Storm water runoff monitoring will be conducted at three locations. Samples will be collected at: the lift station (LS-1) located in the southwest corner of the LEHR/SCDS site; a drain pipe located south of the "X" building area (designated LF-1); and at the north end of the spill pipe that transports runoff from the main north-south trending drainage ditch to Putah Creek (designated LF-3). LS-1 will monitor storm water runoff from the west and southwest portions of the LEHR/SCDS site. LF-1 will monitor storm water that runs off a portion of the Landfill Unit No. 1 area. LF-3 will monitor runoff from Landfill Unit No. 3 and the surrounding area. Sample location LS-1 will monitor areas of the site which are being investigated and remediated by DOE. Sample locations LF-1 and LF-3 will monitor areas under investigation and remediation by UC Davis. UC Davis will coordinate storm water sampling activities with DOE to ensure that the activities described in this plan are carried out.

4.9.2 Monitoring Parameters and Schedule

The storm water analytical program is shown in Table 6. Storm water monitoring will continue twice a year, at two separate rainfall events, and will be conducted at the same time as surface water monitoring (see Section 4.8). The first storm water runoff sampling event will occur at a precipitation event early in the rainy season that provides enough runoff for sampling, typically in October or November. The purpose of this event is to sample runoff that is representative of accumulations on the ground surface during the summer months. The second sampling event will occur in the middle or late part of the rainy season, typically in February or March. The purpose of this event is to sample storm water runoff that is representative of runoff at the LEHR/SCDS site during the height of the rainy season.

Two types of parameters are identified for measurement or collection and analysis: field parameters and laboratory parameters. Field parameters to be taken at each sampling event include pH, electrical conductivity, temperature, turbidity, and discharge. Laboratory parameters for the storm water monitoring program are presented in Table 6, and include chemical parameters and acute aquatic toxicity testing. Specific methods, holding times, and detection limits for storm water samples analyses are listed on Table 8. The purpose of chemical testing is to evaluate the presence of site constituents of concern in site runoff. The need for additional chemical testing to address removal actions or other invasive activities on the site will be addressed in future work plans. The purpose of

aquatic toxicity testing is to evaluate if site runoff is contributing an incremental increase in toxicity to Putah Creek during storm water discharge. The acute aquatic toxicity test will be conducted using fathead minnow larvae *(Pimephales promelas)*. If significant toxicity is detected, UC Davis will notify the RWQCB, the DTSC, and the US EPA within seven days of receiving the analytical results. However, if results of chronic toxicity monitoring of Putah Creek indicate that other species are more sensitive to site conditions and parameters, the FSP will be revised to include other test species (e.g., water flea *(Ceriodaphnia dubia)* or green algae *(Selenastrum capricornutum))*.

4.9.3 Toxicity Identification Evaluation

As described above, the surface water monitoring program will include analysis of chronic aquatic toxicity. The purpose of the toxicity testing is to assess potential incremental increase in toxicity in Putah Creek in the vicinity of the site. The assessment will be conducted by collecting samples from each surface water location during two separate storm events and analyzing the samples for chronic aquatic toxicity. Each sample will be analyzed by the chronic toxicity three-species test in a series of 5 dilutions: 100% original sample (no dilution); 75% original sample, 50% original sample; 25% original sample; and 10% original sample. The dilution tests will be used to qualitatively measure toxicity of the sample for each of the three species at each sample location, in accordance with Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms (EPA, 1994) and Guidance for Implementing Whole Effluent Toxicity Testing Programs (EPA, 1996).

The toxicity of each sample will be determined by calculating the effective concentration that produces a 25% effect on the test endpoint (EC_{25}) for each of the test species. The EC_{25} values will be used to calculate toxicity units (TU; $100/EC_{25}$) for each sample so that storm water and surface water samples can be compared to assess significant increases in toxicity. If significant toxicity is detected, UC Davis will notify the RWQCB, the DTSC, and the US EPA within seven days of receiving the analytical results. If, after conducting two rounds of sampling and analysis, there is an indication of a significant increase in toxicity to Putah Creek in the vicinity of the site, an additional sample will be collected from the suspect location(s). The additional sample will be used to confirm toxicity of the particular location and to determine if a Toxicity Identification Evaluation (TIE) will be started. If started, the TIE will be conducted in three phases in accordance with Methods for Aquatic Toxicity Identification Evaluations (EPA, 1991). The first phase will involve testing to identify the class of compounds that is causing toxicity. The second phase will consist of identifying individual constituents. The third phase will consist of assessing and confirming the causative agent of the toxicity. Based on the results of the TIE, recommendations may be made to evaluate and implement site-specific controls to reduce the toxicity.

4.10 NEIGHBOR WELL MONITORING PROGRAM

The offsite Neighbor Well Monitoring Program involves quarterly collection of domestic and irrigation well water samples from privately owned property adjacent to the LEHR/SCDS site. Since 1989, water samples have been collected by UC Davis and sent to private laboratories for analysis as a courtesy to neighbors, with a goal of providing beneficial but limited information regarding potential chemical and/or radiological contaminants. The program was not designed to provide comprehensive groundwater monitoring for the region in which the wells are located. The wells monitored under this program were constructed independently to a variety of dimensions, depths and designs. Therefore, data collected by the monitoring program cannot be accurately compared from well to well. The purpose has been primarily to assist the LEHR/SCDS neighbors in gaining limited information about the quality of water in their domestic and irrigation wells, and to test for the presence of specific site constituents of concern.

Since 1989, the Neighbor Well Monitoring Program has evolved in order to meet changing needs and/or address specific concerns of LEHR site neighbors. Initially, each neighbor well was sampled for a full analyte list, corresponding to that of on-site monitoring wells. In 1992, the list was reduced to those analytes that were noted to be of concern at the time. In 1994, due to concern that off-site migration of groundwater contaminants was occurring, volatile organic chemicals were added to the list for all wells. A further review of the program was conducted in 1995, and most wells that were not located downgradient and/or within a one-mile radius of the site were eliminated from the program. Radiological analytes were also eliminated at this time, since the prior years of sampling had not verified significant trends for these analytes at any neighbor well locations.

4.10.1 Monitoring Locations

Twelve wells are currently included in the neighbor well sampling program. These sampling locations are primarily downgradient (east) of the site, although five wells (three domestic and two irrigation wells) located just south of Putah Creek are also monitored. Figure 16 identifies locations of wells monitored for this program.

4.10.2 Monitoring Parameters

Currently, most wells in the neighbor well sampling program are monitored for volatile organic compounds, hexavalent chromium and nitrate as nitrogen. Table 7 provides the schedule for specific wells and analytes monitored.

4.11 AIR MONITORING

The baseline air monitoring program for the LEHR/SCDS is described in Section 7.0 of the RI/FS Work Plan and Section 6.11 of Appendix A to the RI/FS Work Plan. Baseline air monitoring is currently being conducted by the DOE. Air monitoring during specific UC Davis field activities that have the potential to cause site contaminants to become airborne will be conducted as part of Health and Safety monitoring as described in the site Health and Safety Plan.

5.0 SAMPLE ANALYSIS

The purpose of this chapter is to identify analytical methods, sample handling procedures, preservation methods, and sample holding times so that samples are delivered to the laboratory in the proper condition and are analyzed by the appropriate methods. Laboratory quality assurance and quality control procedures for the methods listed below are described in the Revised QAPjP along with analyte-specific quality control limits.

5.1 ANALYTICAL METHODS

Analytical methods for groundwater, surface water, and storm water runoff samples are presented in Tables 8 and 8a. These tables list the specific analyte and a reference for the method of analysis. The analytical methods recommended in this Revised FSP are primarily derived from SW-846 and the EPA Contract Laboratory Program. Other analytical methods with greater sensitivity will also be evaluated, as needed, to address specific requirements (i.e. risk, assessment, and eco-risk assessment).

5.2 SUMMARY OF ANALYSES

Proposed analytes, analytical methods, container types, sample handling procedures, detection limits, and holding times for soil, water, and air monitoring are presented in Tables 2 and 2a, 8 and 8a, and 9, respectively. Analytical methods listed in these tables were selected based on data requirements for the investigation of CERCLA sites, data requirements for conducting human health and ecological risk assessment, and to provide data to evaluate impacts to groundwater and surface water quality.

Information presented in Tables 2, 2a, 8, 8a, 9, and 10 will be used to request laboratory analyses for soil, water, and soil vapor samples. As samples are collected in the field, they will be handled and placed into containers as specified in these Tables. A list of the appropriate analytes for each sample will be included on a completed Sample Chain-of-Custody form (see SOP 5.0). The chain-of-custody will include the sample identification, location, date and time of sampling, number and type of containers, and a list of analyses to be performed. Sample documentation will be completed in the field, and the chain-of-custody will accompany the samples through transportation and analysis.

5.3 QUALITY ASSURANCE/QUALITY CONTROL

This chapter discusses specific applications of the Revised QAPjP to the Revised FSP. The Revised QAPjP is presented separately. Data obtained through implementation of this Revised FSP will be used in the groundwater and surface water characterization and remediation activities under the RI/FS program for the LEHR/SCDS site. Therefore, the QA/QC protocols outlined in the Revised QAPjP will be consistent with the CERCLA QA/QC protocols developed for the RI/FS program, as well as other activities anticipated during the LEHR/SCDS environmental restoration.

5.3.1 Operation of Field Equipment and Field Instruments

Field personnel will be trained in the proper use of field equipment pertaining to water sampling including generators, pumps, bailers, and proper sampling techniques for volatile samples, duplicates, etc. Field instruments require special attention with regard to documenting the proper function, standard calibration procedures, the use of NIST traceable standard solutions, and the proper corrective action when an instrument fails to perform. Specific forms have been developed for instrument calibration and are included in SOP 2.0. Calibration frequency is specified in this SOP for each parameter.

5.3.2 Quality Control Sampling

As discussed in Section 6.9, three types of quality control samples will be collected to aid in evaluating the analytical data quality. Blind duplicate samples will be collected at the rate of 10 percent, or 1 duplicate sample for every 10 samples or fraction thereof for each sample matrix. Trip blanks are prepared by the laboratory and are included in each sample shipment containing VOCs, for analysis of VOCs. Equipment decontamination blanks will be collected at a rate of 10 percent, or 1 blank for every ten samples, collected using non-dedicated or non-disposal equipment such as reusable bailers or Westbay sampling equipment. Equipment decontamination blanks will be analyzed for all applicable target analytes. In addition to the above QC samples, additional sample volume will be collected for 1 of every 20 samples in order to conduct laboratory matrix spike duplicate analyses.

5.3.3 Documentation

All field work including any water sampling activity is documented with the use of specific forms provided in the SOP for that activity. The required contents of field memorandum, equipment calibration forms, chain-of-custody forms, and sample tracking forms are all part of the QA program.

5.4 CHANGES TO SAMPLE ANALYSIS

This Revised FSP describes the analytical program for the recently-completed soil and groundwater investigation activities, and for the proposed groundwater, surface water, and storm water monitoring programs. Future soil and groundwater investigation activities will be described in additional work plans that will be reviewed and approved by the site RPMs and incorporated into this Revised FSP by reference. These work plans will include proposed soil boring and well locations, sampling frequencies, and analytical parameters.

Groundwater, surface water, and storm water monitoring activities are likely to change as new data are collected because they are ongoing site activities. Modifications to the monitoring programs will be recommended in the Annual Water Monitoring Report which compiles data collected for the previous year. If approved, changes to the monitoring program will be implemented beginning with the following summer (August) monitoring round.

6.0 FIELD METHODS AND PROCEDURES

This chapter describes the field procedures that will be used during the additional field investigations conducted by UC Davis. The field procedures themselves are described in Standard Operating Procedures (SOP) that are presented in Appendix A of this Revised FSP. Summaries of the field activities that were conducted for the soil investigation in 1996 are presented in Table 11.

General preparation and mobilization procedures for field activities are described in Section 6.1. The field procedures for geophysical investigation are presented in Section 6.2. The exploratory trench investigation is presented in Section 6.3, followed by landfill gas sampling methods in Section 6.4, and soil boring methods in Section 6.5, well installation in Section 6.6, and Hydropunch™ methods in Section 6.7. Groundwater investigation procedures are presented in Section 6.8; surface water and storm water investigation procedures are presented in Sections 6.9 and 6.10, respectively.

6.1 PREPARATION AND MOBILIZATION

The set-up procedures described below are essentially the same for geophysical, soil, Hydropunch™, groundwater, surface water, and storm water runoff field activities. Prior to beginning field activities, UC Davis will conduct set-up activities, and will gather and inspect equipment and instruments to see that they are in proper working condition. These activities will include:

- Notifying the analytical Laboratory in advance of soil or water sampling activities, of the number of samples and types of analyses, and requesting the proper number of sample containers, ice chests, and blue ice. Upon receipt, sample containers will be inspected and the laboratory will be notified of any missing or broken containers. Containers for storm water sampling will be stored at the LEHR/SCDS site until they are used during a precipitation event;

- Checking the appropriate field meters or instruments by conducting equipment inspections, battery checks, and calibrating to NIST traceable standards, when appropriate;

- Assembling field paperwork and forms as specified in the appropriate SOPs (see Appendices A and B);

- Assembling additional forms including sample Chain of Custody (COC) and pre-addressed airbills for overnight shipment; and

- Reviewing proper sampling and health and safety protocol presented in the Site Health and Safety Plan, and reviewing waste handling disposal protocol (SOP 4.0).

After the proper equipment is gathered and inspected, the field personnel will meet to review the field program, health and safety protocol, sampling procedures, monitoring points, quality control procedures, and field documentation.

6.2 GEOPHYSICAL INVESTIGATIONS

Geophysical methods may be used to identify buried debris and contrasting material types indicative of landfills, trenches, and other buried wastes. In addition to locating equipment, geophysical methods may be used to clear the anticipated locations of exploratory trenches and soil borings to avoid obstructions and damaging utilities. More than one geophysical method will be used for most areas. For each area, geophysical methods will be chosen based on the material properties of the structure or object in question. The geophysical methods which yield the most definitive information during a preliminary field evaluation in each area will be used. The geophysical techniques to be considered include:

- Ground Penetrating Radar (GPR);
- Electromagnetics (EM);
- Magnetics;
- Transient Electromagnetics (TEM);
- Seismic Refraction;
- Utility Line Location; and
- Borehole Geophysical Logging (tentative).

A description of these methods is provided in SOP 9 (Borehole Geophysical Logging) and SOP 20 (Shallow Subsurface Geophysical Methods) in Appendix A. Discussions of the anticipated geophysical methods that will be used for investigation areas will be presented in future work plans.

6.3 LANDFILL GAS SAMPLING

Landfill gas samples may be collected during drilling of soil borings in landfill areas for the potential presence of volatile constituents methane, carbon dioxide, oxygen, and nitrogen (Table 9). Landfill gas data may be used in the selection and design of remediation alternatives for each landfill unit.

The primary constituents to be measured in the landfill gas samples are VOCs, methane, carbon dioxide, nitrogen, and oxygen. Soil vapor samples will be collected into stainless-stainless canisters using a truck-mounted rig after driving steel sampling probes to the desired sampling depth and purging the probe (see SOP 21).

6.4 EXPLORATORY TRENCH INVESTIGATION

Exploratory trench investigations may be conducted throughout the LEHR/SCDS site to (1) characterize and collect samples of the contents of landfill and other buried wastes; and (2) collect soil samples from below and adjacent to the wastes.

During excavation of each trench, materials will be segregated as soil cover, native soil, and waste, and stockpiled on visqueen. Photographs of the trenches will be taken for additional documentation of trench contents. The materials in the trenches will be screened for VOCs and radiologic activity. Because of health and safety concerns, no LEHR/SCDS site personnel will enter a backhoe excavation if it is greater than 5 feet deep, or if the excavation is considered unsafe based on physical characteristics, VOC, or radiologic field monitoring readings, as described in the Health and Safety Plan Addendum. Soil samples from greater than 5 feet deep will be collected from the backhoe bucket, or from an extended drive sampler, as appropriate. Upon backfilling of each excavation, materials will be placed back in approximately the same areas and depth from which they were excavated.

The exploratory trenches will be logged according to USCS, as described in SOP 11 (Test Pit Excavation). Organic Vapor Analyzer (OVA) and radiologic activity readings will be taken continuously with field meters, as described in SOP 11, and these readings, along with other criteria will guide selection of waste and soil samples for analysis of LEHR/SCDS site constituents listed on Table 1.

Soil waste sampling is described in SOP 10 (Soil Sampling), and describes the collection of disturbed and undisturbed solid and other waste material. The criteria for selecting waste samples in the exploratory trenches include:

- Radionuclide activity or OVA readings which exceed background;
- Discoloration or stained soils;
- Odors;
- Fill or gravel material used in dry wells, seepage trenches, infiltration galleries, leach lines, etc.
- The contents of containers, or other recognizable objects; and
- Sludges, liquids or solids of tanks, distribution boxes, or leach lines.

In addition to sampling wastes, soil samples will be collected below the base of trenches and landfill units. The soil samples will be collected from areas located below waste sample locations or in discolored, stained soil to evaluate areas where material may be leaching out of waste. Soil samples will be collected as undisturbed drive samples, if possible, or from a backhoe bucket. Both disturbed and undisturbed samples must be capped and cooled immediately for analysis of volatile samples as described in SOP 10.

After logging the exploratory trench and obtaining OVA and radiologic screening measurements, the field geologist will select samples for analysis after consulting with the project geologist. Samples selected for analysis for primary parameters identified in Table 1 will be chosen based on location, depth, material type, and field screening results. Typically in each trench, at least one sample from waste material, and one sample from native soil below waste will be selected for analysis based on results from field VOC and radiologic screening. Samples collected from waste (see above criteria) will typically be composited by the lab into one sample for analysis. Additional samples may be selected for analysis to characterize soils below and adjacent to waste disposal trenches and systems. Target sample depths and locations are discussed below for each investigation area.

Whenever possible, a duplicate sample will be collected for QA/QC or archived at 4°C for additional chemical and physical analysis. The number of QA/QC samples for each trench is described in the specific sampling requirements for each area. Duplicate soil samples are collected by filling two containers with the same material or by collecting adjacent drive samples, as discussed in SOP 10. QA/QC samples will also include the collection of equipment blanks. One equipment blank will be collected during trenching activities for each investigation area. Methods for collecting equipment blanks are described in SOP 10. Each equipment blank will be analyzed for volatile organic compounds (VOCs), metals, hexavalent chromium, nitrate, gross alpha, gross beta, tritium, radium-226, strontium-90, carbon-14, and gamma emitters.

The number and locations of the exploratory trenches from the soil investigation in 1996 are summarized in Table 11. After each sample is collected, wooden stakes will be used to mark the sample locations as well as the location of any buried tanks, pipes to leach lines encountered.

6.5 SOIL BORINGS

Soil borings may be used to assess the lateral and vertical extent of LEHR/SCDS site constituents and to gather data on the soil chemical and physical properties of the LEHR/SCDS site in order to support vadose zone and saturated zone modeling efforts.

The locations of soil borings are dependent upon clearance by UC Davis Physical Plant and Underground Services Alert personnel. The boring locations from the soil investigation in 1996 are presented in Figures 5 through 11, and the total number of borings and samples are summarized in Table 11. In general, while drilling in wastes, soil samples will be collected continuously. While drilling below or adjacent to waste, samples will be collected at least every 5 feet and more frequently if necessary, based on field observations and measurements. The general procedure for conducting soil borings is given in SOP 6 (Soil Borings). The soil core will be logged according to the USCS classification system as described in SOP 7.

During the logging of the soil core, an organic vapor analyzer (OVA) and survey meter will be used to screen vapors and radionuclide activity from the core as described in SOP 7. After screening the core for OVA readings and consulting with the Project Geologist, the Field Geologist selects the samples for analysis of LEHR/SCDS site constituents listed in Table 1. Typically, in each boring, at least one sample each from the waste, one sample from native soil below or adjacent to waste, and one sample from the bottom of borehole will be selected based on results of VOC and radiologic field screening. Waste samples will typically be composited into one sample for analysis. Soil samples will be selected from discrete depths to characterize soils adjacent to and below waste disposal trenches and systems.

QA/QC samples will consist of split samples collected from adjacent rings in the core of the drive sampler, as described in SOP 6. One equipment blank will be collected for each investigation area. Procedures for collecting equipment blanks are presented in SOP 10. Preparation, handling, chain of custody, and shipment procedures are specified in SOP 5.

In addition to sampling for LEHR/SCDS site constituents and QA/QC, drive samples that are collected every 5 feet will be refrigerated at 4°C, and archived for potential additional chemical and physical analysis. After each boring is complete and the boring has been grouted, a wooden stake will be used to mark the boring location.

6.6 WELL INSTALLATION

Groundwater wells may be installed and used for monitoring, extraction, or reinjection of site groundwater. Wells will be installed in soil borings (Section 6.5) once the well screening depth has been determined based on the desired purpose of the well, data gathered from the borehole, and previously collected information from other boreholes and wells. The number, locations, and construction of wells will be presented in future work plans. General well design and construction are described in SOP 8.0.

6.7 HYDROPUNCH SAMPLING

Hydropunch™ may be used (1) to evaluate the lateral extent of groundwater impacts and (2) to optimize locations for monitoring wells for delineation of the lateral extent of groundwater impacts. Hydropunch™ sampling can provide one-time information of the approximate depth to groundwater, and limited chemical data at a sampling location.

The locations of Hydropunch™ sampling locations are dependent upon clearance by UC Davis Physical Plant and Underground Services Alert personnel. In general, Hydropunch™ samples will be collected using a truck-mounted rig after driving a cone penetrometer testing tool (CPT) to the desired sampling depth and purging the tubing (see SOP 19.0). At greater depths, hydropunch samples can be collected in conjunction with soil borings using a drilling rig (see SOP 1.2.3).

Groundwater samples will be collected directly from the sampling tubing into sample containers supplied by the laboratory. Hydropunch samples will typically be collected for a limited analyte list based on the limited volume of water available and on target constituents of the investigation. Selected samples will be filtered using a 0.45-micron filter, and preserved as required, depending on analytes, as indicated in Table 8. Sample containers will be labeled with sample identification number, date, time, requested analyses, preservation method, and sampler's initials.

6.8 GROUNDWATER MONITORING

Groundwater monitoring will consist of water level measurements, field measurements and the collection of groundwater samples. Prior to sampling activities, a groundwater level measurement will be collected from each monitoring well in order to construct groundwater elevation contour maps.

Water level measurements will be collected on the same day within as narrow a time interval as possible to minimize variations that may occur in elevations due to nearby pumping.

Groundwater sampling at the LEHR/SCDS site will be conducted by purging and sampling monitoring wells using dedicated sampling systems. The dedicated systems consist of variable-speed submersible electric pumps. The new wells installed as part of the pre-design activities for the IRA (UCD1-28, UCD2-29, UCD2-30, UCD2-31, and EW2-1) and as part of the off-site investigation (UCD2-32) will be fitted with the same electric submersible pump system. If the static water level drops below the level of a pump, that well will not be sampled. Purging and sampling procedures are described in SOP 1.0 (Appendix A). Purging of each well will continue until:

- Three to five casing volumes of water are removed from the well; and
- The field measurements of pH, electrical conductivity, temperature, turbidity, and Eh measurements of the purged water stabilize to within 10 percent of the previous reading.

Field instruments will be calibrated once prior to beginning daily sampling activities, and then every four hours (pH meter), or before each well is sampled (turbidity meter). Field measurement and calibration procedures are described in SOP 2.0. Field observations, measurements, and calibration information will be recorded on a sample summary form (see SOP 1.0).

Wells that are pumped dry prior to removing three casing volumes of water will be allowed to recover and then pumped or bailed dry a second time. Field measurements of temperature, Eh, pH, specific conductivity, and turbidity will then be collected as the well fills the second time. "Dry" wells will be confirmed by comparing field well depth measurements to well construction specifications, and documented in the field notes.

Groundwater samples will be collected directly from the sampling pumps into sample containers supplied by the laboratory. Samples will be collected at the frequency and for analytes presented in Table 4. A summary of the number of samples collected in one monitoring year is presented in Table 13. Selected analyte samples will be filtered using a 0.45-micron filter, and preserved as indicated in Table 8a. Sample containers will be labeled with site name, sample identification number, date, time, requested analyses, preservation method, and sampler's initials.

6.9 SURFACE WATER MONITORING PROCEDURES

Surface water monitoring will consist of the collection of field measurements and water samples. Monitoring will be conducted at two South Fork of Putah Creek locations (PCU and PCD) and the UC Davis wastewater treatment plant outfall (STPO) according to sampling procedures described in SOP 1.0. Samples will be collected each quarter for analytes listed in Table 5. A summary of the number of samples collected in one monitoring year is presented in Table 13. Prior to sampling at each location, three field measurements of pH, electrical conductivity, temperature, turbidity, and Eh will be recorded. Additionally, estimates of flow velocity in the South Fork of Putah Creek will be obtained by checking the nearest stream gage and obtaining the daily flow rate for the UC Davis Wastewater Treatment Plant. This information will allow an estimated flow in the South Fork of Putah Creek to be calculated each quarter. Field measurements will be conducted according to procedures described in SOP 2.0. Grab samples will be collected directly into the sample containers or by disposable containers or glass bottles and then transferred to the appropriate sample containers. Selected analytes will be filtered using a 0.45-micron filter, and preserved as indicated in Table 8a. Sample containers will be labeled with sample identification number, date, time, requested analyses, preservation method, and sampler initials.

6.10 STORM WATER SAMPLING PROCEDURES

Storm water runoff samples will be collected from three locations twice per year according to procedures described in SOP 1.0. Samples will be collected from a storm event early in the rainy season and in the middle to late in the rainy season. During each event, the storm water samples will be collected within as small a time interval as possible to maximize the comparability of the results. Samples will be collected during each event for analytes listed in Table 6. A summary of the number of samples collected in one monitoring year is presented in Table 13. A minimum of three field measurements for pH, electrical conductivity, temperature, turbidity, and Eh will be collected from each storm water runoff location. Procedures for conducting field measurements and calibrating field instruments are described in SOP 2.0.

Samples from location LS-1 will be collected out of the sump while it is receiving runoff and while the lift station pump is running. Grab samples for LS-1 will be collected directly into the proper sample containers. Samples from locations LF-1 and LF-3 will be collected out of the culvert while it is receiving runoff. Grab samples for LF-1 and LF-3 will be collected directly into the sample containers or into disposable containers and then transferred to the appropriate sample containers.

Samples for selected analytes will be collected into clean containers supplied by the laboratory and then filtered using a 0.45-micron filter, and preserved as indicated in Table 7a. Sample containers will be labeled with sample identification number, date, time, requested analyses, preservation method, and sampler's initials.

Storm water flow will be recorded at each of the three runoff locations at the time of each sampling event. Flow from LS-1 will be recorded using a gauge at the pump outfall. Because the pump cycles on and off to empty a large catch basin, pump gauge readings will be collected once before sampling and once again one-hour later to measure the flow during the storm event in gallons per hour. The flow rate will then be converted to gallons per minute. Flow at locations LF-1 and LF-3 will be measured by recording the depth of water in the discharge culverts/pipes. The slope of each pipe has been calculated by surveying the upstream and downstream end of both pipes. The flow will be interpreted from Tables 14 and 15 using the depth to water in the two pipes. Tables 14 and 15 were calculated specifically for the drainage pipes at LF-1 and LF-3 using the following Chezy-Manning equation:

$$Q = (1.49/n) * A_w * R_h^{2/3} * S^{1/2}$$

where Q = volume flow rate (ft^3/sec),
n = roughness coefficient (0.025 for a corrugated steel pipe (LF-1) and 0.015 for a cast iron pipe (LF-3)),
A_w = wetted cross-sectional area (ft^2),
R_h = hydraulic radius = A_w/P_w (ft),
P_w = wetted perimeter (ft), and
S = slope of invert pipe.

6.11 NEIGHBORS' WELL SAMPLING

Groundwater samples are collected quarterly from domestic and irrigation wells located adjacent to and downgradient of the LEHR/SCDS, in accordance with the analytical schedule in Table 7. A map of well locations is found in Figure 16. Procedures for collection of these samples are detailed in SOP 1.0 (Appendix A). Field parameters collected will include temperature, pH, and conductivity measurements. Results of sampling are sent directly to individual neighbors following data validation.

6.12 FIELD QUALITY ASSURANCE SAMPLING

Water monitoring field quality control will consist of trip blanks, equipment blanks, and "blind" duplicates. Trip blanks will be supplied by the laboratory and will accompany the sample containers to and from the laboratory. One set of trip blanks will be shipped for Volatile Organic Compound analyses each day of sampling.

When non-dedicated equipment is used, one equipment blank will be collected at a minimum frequency of ten percent for groundwater samples. As applicable, equipment blanks will be collected on-site near a monitoring point and will consist of laboratory supplied water poured over or through sampling equipment directly into the sample containers. Equipment blanks will be collected and analyzed for the same parameters as the associated samples. "Blind" duplicate samples will be collected one for every 10 groundwater samples and one per quarter for surface water samples by simultaneously filling a second, identical set of sample containers, and labeling the containers with a fictitious identification. Duplicate samples will be collected from different wells and surface water monitoring points each quarter and documented in field notes. Equipment blanks and duplicate samples will be filtered, preserved, packaged, and shipped in an identical fashion to groundwater and surface water samples.

During storm runoff monitoring, one blind duplicate sample and one trip blank will be collected for each monitoring event. The duplicate sample will be collected for the complete list of storm water runoff analytes, as presented in Table 6.

6.13 SAMPLE PACKAGING AND SHIPPING

The samples will be packaged and shipped according to procedures described in SOP 5.0. Samples will be packed in ice chests containing sealed blue ice and a completed, signed, and dated Chain of Custody (COC) form. Special care will be taken to pack sample containers to minimize breakage. Ice chests will be secured with a custody seal and will be delivered daily to a courier for overnight delivery to the analytical laboratory.

Upon receipt of the sample shipment, the laboratory will transmit a copy of the completed COC form by facsimile to UC Davis or their representative noting any missing or damaged containers. If missing or damaged containers are identified, sample water may be taken from undamaged containers from the same well, if possible. If sufficient sample water cannot be extracted from remaining bottles,

analyses for that sample may be halted and the monitoring point resampled. Samples will not be collected or shipped on Fridays to avoid potential Saturday delivery and analysis problems, unless the laboratory is notified of sample shipment arrival and can accommodate Saturday delivery.

7.0 DATA MANAGEMENT PLAN

This section presents the Data Management Plan that will be followed for this project. This plan encompasses procedures for receiving, storing, and reporting data derived from field activities and laboratory analyses. Procedures for receiving data include filing original hardcopy, sample tracking, and data entry. Data storage includes merging entered data into a computer database, verification of entered data, and backup procedures for electronic and hardcopy data. Data reporting procedures include the processes for extracting information from the database into tabular, graphic, and other informational forms.

7.1 DATA RECEIPT

Results of field measurements, laboratory chemical and radiologic analyses, and groundwater level measurements will be recorded on original forms and entered into a computer database. The results of these analyses and field investigations will be received primarily on standardized data forms, designed to fulfill the needs of both the technical and data management staffs. These data forms are illustrated in the Revised QAPjP. The completed forms will be sent to the central project file.

7.1.1 Sample Tracking

Sample tracking procedures are used to indicate whether analytical samples collected at the LEHR/SCDS site are contained, transported, and analyzed according to methods and holding times specified. The sample tracking form will be used to verify that analyses requested for each sample listed on the chain-of-custody were performed by the analytical laboratory and results have been received.

7.1.2 Data Entry

Data is entered into the database manually or by direct download of laboratory supplied electronic data. Regardless of the method of data entry, data entry quality control is maintained through several types of data checking. Data checking is carried out prior to merging the temporary input file with the master database file. This checking system involves direct comparison of hardcopy listings of the temporary input database to the hardcopy laboratory or field reports. Following correction of any inconsistencies in either the data file or the laboratory reports, the temporary input

file is merged to a proxy master file. This proxy file is used as a daily working file, and backups of it as well as the master file are maintained.

7.2 DATA STORAGE

Following data entry, the data will be stored in a computer database management system. The database will include data from previous site investigations and previous groundwater, storm water, and surface water monitoring events.

7.3 DATA VALIDATION

Data validation will be performed on analytical results received from the laboratory for groundwater, surface water, and storm water runoff. The purpose of data validation will be to identify data that does meet the quality required for CERCLA, the RI/FS program, and risk assessment, and to identify data that does not meet data quality objectives or quality assurance criteria that are set forth in the Revised QAPjP and agreed on by the laboratory. Specific procedures and descriptions are presented in the Revised QAPjP.

Data received from the laboratory will be reviewed with respect to the PARCC parameters (precision, accuracy, representativeness, comparability, and completeness). PARCC are indicators of data quality and apply to the field program and analytical results as well as to the laboratory procedures. The PARCC parameters for water monitoring at LEHR/SCDS are specified below. Analyte-specific precision and accuracy objectives are listed in the Revised QAPjP for the LEHR/SCDS site.

A USEPA Contract Laboratory Program (CLP) or CLP-equivalent data package will be provided for groundwater, surface water, and storm water runoff laboratory results. When received, a detailed validation of 10% of the analytical data will be performed, based on USEPA National Functional Guidelines. The remaining 90% of the data set will be reviewed for a limited set of validation criteria. Specific procedures for data validation are presented as part of the Revised QAPjP.

The objective of the detailed data evaluation according to USEPA National Functional Guidelines is to randomly select 10% of the data packages and then to completely regenerate the data values based on the original raw data (e.g., chromatograms, instrument values), standards, instrument calibration runs, GC/MS tuning, etc. This level of data validation technique will allow an appropriately trained person outside the project to independently validate a data package at any later date.

The remaining 90% of the data will have the same CLP or equivalent data package; however, a limited validation will be performed. Holding times, surrogate recovery, blanks, matrix spikes, matrix spike duplicates will be checked against the quality control guidelines.

7.4 DATA EVALUATION

Because groundwater, surface water, and storm water runoff data are collected on a regular basis, a consistent series of graphic and statistical methods will be used to evaluate data generated. The objectives of both graphic and statistical analyses are: 1) to evaluate the adequacy of background monitoring points; 2) to define impacted areas of the site and impacted monitoring points; 3) to develop a focused list of analytical constituents of concern; and 4) to identify any release of site constituents to the surface water or to groundwater. The following sections present information on some of the graphic and statistical methods to be used to evaluate LEHR/SCDS site data.

7.4.1 Graphical Data Presentations

At least three types of visual or graphical presentations of the groundwater, surface water, and storm water runoff data will be completed for selected analytes of concern. First, time-series graphs will present concentrations of analytes over time in order to display trends or seasonality of the data. Second, stiff diagrams or piper trilinear plots will be completed to compare the general chemical composition of different water samples. Third, contour maps of constituent concentrations throughout the site may be prepared for groundwater plume delineation. These presentations will be included in an annual summary of water monitoring at the LEHR/SCDS site.

7.4.2 Statistical Analyses

Based on supporting hydrologic and chemical information, statistical comparisons of monitoring may be completed. The objective of a statistical comparison between any specific monitoring points would be to attempt to identify site constituents and to separate the impacted monitoring points from non-impacted points upgradient or upstream of the site.

When the background monitoring points can be established, off-site influences on water quality can be evaluated quantitatively. With background and on-site monitoring points, statistical comparisons, including analysis of variance, may facilitate the distinction between constituents of

concern from the site from off-site influences. The site constituents of concern form the target analytes which are analyzed on a more frequent basis until remedial actions have been completed.

Additional statistical evaluations may be performed on a more frequent basis for a variety of reasons. These reasons include an evidence of a release of a site constituent, or trend analysis which may document statistically significant increasing concentration of a constituent found at an on-site or off-site location.

7.5 DATA TRANSMITTALS

Groundwater and surface water monitoring analytical data will be transmitted to site RPMs on a quarterly basis. Three quarterly data transmittals and one annual report will be prepared each year. The annual report will include data from the fourth quarterly sampling round, summarize results from the previous quarters, and present storm water sampling results.

After analytical data have been validated using procedures described in the Revised QAPjP, the results will be submitted to site RPMs in quarterly water monitoring data transmittals within 90 days after the conclusion of sampling. The quarterly data transmittals will present water level data, summary tables of the analytical results, a summary of field methods and a summary of QA/QC procedures as described in the Revised QAPjP.

The annual report will present more detailed analysis of the monitoring results and statistical evaluation of identified impacts. The annual report will also include information regarding hydrogeologic parameters, including groundwater gradients and flow directions, established throughout the year. It is anticipated that the annual report will be prepared after the fall quarterly sampling results have been received, and will contain storm water runoff data from the previous rainy season. The annual report will be submitted to site RPMs by April 1 of the following year.

Data collected as part of non-monitoring activities (soil borings, backhoe trenching, hydropunch) will be reported in transmittal format that includes purpose and scope of activity, summary of field activities, data validation results, analytical results in tabular form, and figures identifying sample locations. The purpose of the transmittals will be to report data in a fashion that can be later incorporated into a site remedial investigation report.

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Table 1
Soil Analytical Parameters
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Parameters Soil Samples, and Soil Sample Duplicates	Rationale
Gross Alpha Gross Beta Gamma Emitters	General radiologic parameters
Tritium Carbon-14 Radium-226 Strontium-90	Site radiologic constituents
Thorium (isotopic) - background samples only Uranium (isotopic) - background samples only	Isotope-specific radiologic analyses to establish background levels
Americium-241 - OU-2 only Plutonium-241 - OU-2 only	Possible site constituents
Volatile Organic Compounds Formaldehyde Semi-Volatile Organic Compounds Organochlorine Pesticides	Potential site organic constituents
Nitrate	Site constituent from human and animal waste
Total Organic Carbon	General organic parameter
Total Chromium Hexavalent Chromium	Possible site constituents
Antimony Arsenic Barium Beryllium Cadmium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Silver Thallium Vanadium Zinc	Metals, possible site constituents
Additional Parameters	
Total Volatile Solids Bulk Density Moisture Content Alkalinity Anions pH EC	General soil parameters
TKN Ammonia	Possible site constituents from human and animal waste

Table 2
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Organic Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRQL	HOLDING TIME
Volatile Organic Compounds	CLP SOW OLM 03.1 or equivalent	2½ inch diameter Stainless Steel Ring	4°C	Refer to Table 2a	14 days
Semivolatile Organic Compounds	CLP SOW OLM 03.1 or equivalent	2½ inch diameter Stainless Steel Ring	4°C	Refer to Table 2a	14 days to extraction, 40 days to analysis
Organochlorine Pesticides/PCBs	CLP SOW OLM 03.1 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	Refer to Table 2a	14 days to extraction, 40 days to analysis
Dioxins/Furans	EPA 8280	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	Refer to Table 2a	30 days to extraction, 45 days to analysis

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Radiologic Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT MDA		HOLDING TIME
Gross Alpha	EPA 9310	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	4	pCi/g	180 days
Gross Beta	EPA 9310	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	10	pCi/g	180 days
Tritium	EPA 906.0(M)	500 ml Glass Jar	None	6	pCi/g	180 days
Radium-226	EPA 903.1(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	1	pCi/g	180 days
Carbon-14	EPA 520/5-84-006(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	2	pCi/g	180 days
Strontium-90	EPA 905.0 (M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	1	pCi/g	180 days
Thorium - Isotopic	EPA 907.0 (M)	2 ½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	0.5	pCi/g	180 days
Uranium - Isotopic	EPA 907.0 (M)	2 ½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	0.5	pCi/g	180 days
Americium-241	EPA 907.0 (M)	2 ½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	0.1	pCi/g	180 days
Plutonium-241	EPA 907.0 (M)	2 ½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None	1.0	pCi/g	180 days

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Radiologic Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT MDA	HOLDING TIME
Gamma Spectral Analysis	EPA 901.1(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	None		180 days
Th-234				5 pCi/g	
Pb-214				1 pCi/g	
Bi-214				1 pCi/g	
Pb-210				4 pCi/g	
U-235				1 pCi/g	
U-238				5 pCi/g	
Na-22				1 pCi/g	
Ac-228				1 pCi/g	
Pb-212				1 pCi/g	
Bi-212				1 pCi/g	
Tl-208				1 pCi/g	
K-40				5 pCi/g	
Co-60				1 pCi/g	
Cs-137				1 pCi/g	

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL		HOLDING TIME
Hexavalent Chromium	EPA 7196	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5	mg/Kg	24 hours
Total Chromium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25	mg/Kg	180 days
Antimony	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5	mg/Kg	180 days
Arsenic	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25	mg/Kg	180 days
Barium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25	mg/Kg	180 days
Beryllium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25	mg/Kg	180 days
Cadmium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25	mg/Kg	180 days

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL	HOLDING TIME
Cobalt	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Copper	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Lead	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Manganese	CLP SOW ILM 04.0 or equivalent	2 ½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5 mg/Kg	180 days
Mercury	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.05 mg/Kg	28 days
Molybdenum	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5 mg/Kg	180 days

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL	HOLDING TIME
Nickel	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Selenium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Silver	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Thallium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5 mg/Kg	180 days
Vanadium	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days
Zinc	CLP SOW ILM 04.0 or equivalent	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.25 mg/Kg	180 days

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

General Chemical Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT Reporting Limit	HOLDING TIME
Alkalinity	EPA 310.1(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	1 mg/Kg	14 days
Nitrate (as Nitrogen)	EPA 300.0	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5 mg/Kg	48 hours
Total Kjeldahl Nitrogen	EPA 351.1(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	2 mg/Kg	7 days
Water Soluble Anions (Nitrate, Sulfate, Chloride)	EPA 300.0	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	0.5-2.0 mg/Kg	Varies per analyte
Formaldehyde	AOAC 931.08(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	1 mg/Kg	7 days to extraction; 30 days to analysis
Total Organic Carbon	9060 (M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	100 mg/kg	28 days
Ammonia (as N)	EPA 350.1(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	1 mg/Kg	28 days

NOTE: Some methods modified to include a 1:1 extraction of the soil. Analysis performed on resulting supernatant.

Table 2 (continued)
Sample Analyses - Soil
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

General Chemical Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT Reporting Limit	HOLDING TIME
Sulfide	EPA 9030A	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	1.0 mg/Kg	7 days
Kerosene	EPA 8015(M)	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	20 mg/Kg	14 days to extraction; 40 days to analysis
pH	ASTM 4972	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	None	Upon Receipt
EC	ASTM G-57	2½ inch diameter Stainless Steel Ring or 500 ml Glass Jar	4°C	None	Upon Receipt

Table 2a
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Volatiles	(Method CLP or equivalent)	**CAS Number**	**CRQL (μg/Kg)**[a]
1.	Chloromethane	74-87-3	10
2.	Bromomethane	74-83-9	10
3.	Vinyl Chloride	75-01-4	10
4.	Chloroethane	75-00-3	10
5.	Methylene Chloride	75-09-2	10
6.	Acetone	67-64-1	10
7.	Carbon Disulfide	75-15-0	10
8.	1,1-Dichloroethene	75-35-4	10
9.	1,1-Dichloroethane	75-34-3	10
10.	1,2-Dichloroethene (total)	540-59-10	10
11.	Chloroform	67-66-3	10
12.	1,2-Dichloroethane	107-06-2	10
13.	2-Butanone	78-93-3	10
14.	1,1,1-Trichloroethane	71-55-6	10
15.	Carbon Tetrachloride	56-23-5	10
16.	Bromodichloromethane	75-27-4	10
17.	1,2-Dichloropropane	78-87-5	10
18.	cis-1,3-Dichloropropene	10061-01-5	10
19.	Trichloroethene	79-01-6	10

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Volatiles (Method CLP or equivalent) (continued)		**CAS Number**	**CRQL (μg/Kg)**[a]
20.	Dibromochloromethane	24-48-1	10
21.	1,1,2-Trichloroethane	79-00-5	10
22.	Benzene	71-43-2	10
23.	trans-1,3-Dichloropropene	10061-02-6	10
24.	Bromoform	75-25-2	10
25.	4-Methyl-2-pentanone	108-10-1	10
26.	2-Hexanone	591-78-6	10
27.	Tetrachloroethene	127-18-4	10
28.	Toluene	108-88-3	10
29.	1,1,2,2-Tetrachloroethane	79-34-5	10
30.	Chlorobenzene	108-90-7	10
31.	Ethyl Benzene	100-41-4	10
32.	Styrene	100-42-5	10
33.	Xylenes (Total)	1330-20-7	10

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent)		**CAS Number**	**CRQL (μg/Kg)[a]**
1.	Phenol	108-95-2	330
2.	bis(2-Chloroethyl) ether	111-44-4	330
3.	2 - Chlorophenol	95-57-8	330
4.	1,3 Dichlorobenzene	541-73-1	330
5.	1,4 Dichlorobenzene	106-46-7	330
6.	1,2-Dichlorobenzene	95-50-1	330
7.	2-Methylphenol	95-48-7	330
8.	2, 2'-oxybis (1-Chloropropane)	108-60-1	330
9.	4-Methylphenol	106-44-5	333
10.	N-Nitroso-di-n-propylamine	621-64-7330	330
11.	Hexachloroethane	67-72-1	330
12.	Nitrobenzene	98-95-3	330
13.	Isophorone	78-59-1	330
14.	2-Nitrophenol	88-75-5	330
15.	2,4-Dimethylphenol	105-67-9	330
16.	bis(2-Chloroethoxy) methane	111-91-1	330
17.	2,4-Dichlorophenol	120-83-2	330

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent) (continued)		**CAS Number**	**CRQL (μg/Kg)[a]**
18.	1,2,4-Trichlorobenene	120-82-1	330
19.	Naphthalene	91-20-3	330
20.	4-Chloroaniline	106-47-8	330
21.	Hexachlorobutadiene	87-68-3	330
22.	4-chloro-3-methylphenol	59-50-7	330
23.	2- Methylnaphthalene	91-57-6	330
24.	Hexachlorocyclopentadiene	77-47-4	330
25.	2,4,6-Trichlorophenol	88-06-2	330
26.	2,4,5-Trichlorophenol	95-95-4	800
27.	2-Cloronaphthalene	91-58-7	330
28.	2-Nitroaniline	88-74-4	800
29.	Dimethylphthalate	131-11-3	330
30.	Acenaphthylene	208-96-8	330
31.	2,6-Dinitrotoluene	606-20-2	330
32.	3-Nitroaniline	99-09-2	800
33.	Acenaphthene	83-32-9	330
34.	2,4-Dinitrophenol	51-28-5	800
35.	4-Nitrophenol	100-02-7	800

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent) (continued)		**CAS Number**	**CRQL (μg/Kg)[a]**
36.	Dibenzofuran	132-64-9	330
37.	2,4-Dinitrotoluene	121-14	330
38.	Diethylphthalate	84-66-2	330
39.	4-Chlorophenyl-phenyl ether	7005-72-3	330
40.	Fluorene	86-73-7	330
41.	4-Nitroaniline	100-01-6800	800
42.	4,6-Dinitro-2-methylphenol	534-52-1	800
43.	N-nitrosodiphenylamine	86-30-6	330
44.	4-Bromophenyl-phenylether	01-55-3	330
45.	Hexachlorobenzene	118-74-1	330
46.	Pentachlorophenol	87-86-5	800
47.	Phenanthrene	85-01-8	330
48.	Anthracene	120-12-7	330
49.	Carbazole	86-74-8	330
50.	Di-n-butylphthalate	84-74-2	330
51.	Fluoranthene	206-44-0	330
52.	Pyrene	129-00-0	330
53.	Butylbenzylphthalate	85-68-7	330

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent) (continued)		**CAS Number**	**CRQL (μg/Kg)[a]**
54.	3,3'-Dichlorobenzidine	91-94-1	330
55.	Benzo(a)anthracene	56-55-3	330
56.	Chrysene	218-01-9	330
57.	bis(2-Ethylhexyl)phthalate	117-81-71	330
58.	Di-n-octylphthalate	117-84-0	330
59.	Benzo(b)fluoranthene	205-99-2	330
60.	Benzo(k)fluoranthene	207-08-9	330
61.	Benzo(a)pyrene	50-32-8	330
62.	Indeno(1,2,3-cd)pyrene	193-395	330
63.	Dibenz(a,h)anthracene	53-70-3	330
64.	Benzo(g,h,i)perylene	191-24-2	330

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Pesticides/PCBs (Method CLP or equivalent)		**CAS Number**	**CRQL (μg/Kg)[a]**
1.	alpha-BHC	319-84-6	1.7
2.	beta-BHC	319-85-7	1.7
3.	delta-BHC	319-86-8	1.7
4.	gamma-BHC (lindane)	58-89-9	1.7
5.	Heptachlor	76-44-8	1.7
6.	Aldrin	309-00-2	1.7
7.	Heptachlor epoxide	1024-57-3	1.7
8.	B-Endosulfan I	959-98-8	1.7
9.	Dieldrin	60-57-1	3.3
10.	4,4'-DDE	72-55-9	3.3
11.	Endrin	72-20-8	3.3
12.	Endosulfan II	33213-65-9	3.3
13.	4,4'-DDD	72-54-8	3.3
14.	Endosulfan sulfate	1031-07-8	3.3
15.	4,4'-DDT	50-29-3	3.3
16.	Methoxychlor	72-43-5	17.0
17.	Endrin ketone	53494-70-5	3.3
18.	Endrin aldehyde	7421-36-3	3.3
19.	alpha-Chlordane	5103-71-9	1.7
20.	gamma-Chlordane	5103-74-2	1.7
21.	Toxaphene	8001-35-2	170.0

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Pesticides/PCBs (Method CLP or equivalent) (continued)		**CAS Number**	**CRQL (μg/Kg)[a]**
22.	Arochlor-1016	12674-11-2	33.0
23.	Arochlor-1221	11104-28-2	67.0
24.	Arochlor-1232	11141-16-5	33.0
25.	Arochlor-1242	53469-21-9	33.0
26.	Arochlor-1248	12672-29-6	33.0
27.	Arochlor-1254	11097-69-1	33.0
28.	Arochlor-1260	11096-82-5	33.0

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Dioxins/Furans (EPA 8280)		**CAS Number**	**CRQL (ng/g)[a]**
1.	2,3,7,8-TCDD	1746-01-6	0.01
2.	1,2,3,7,8-PeCDD	40321-76-4	0.01
3.	1,2,3,4,7,8-HxCDD	39227-28-6	0.01
4.	1,2,3,6,7,8-HxCDD	57653-85-7	0.01
5.	1,2,3,7,8,9-HxCDD	19408-74-3	0.01
6.	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.01
7.	OCDD	3268-87-9	0.02
8.	2,3,7,8-TCDF	51207-31-9	0.01
9.	1,2,3,7,8-PeCDF	57117-41-6	0.01
10.	2,3,4,7,8-PeCDF	57117-31-4	0.01
11.	1,2,3,4,7,8-HxCDF	70648-26-9	0.01
12.	1,2,3,6,7,8-HxCDF	57117-44-9	0.01
13.	2,3,4,6,7,8-HxCDF	60851-34-5	0.01
14.	1,2,3,7,8,9-HxCDF	72918-21-9	0.01
15.	1,2,3,4,6,7,8-HpCDF	67562-39-4	0.01
16.	1,2,3,4,7,8,9-HpCDF	55673-89-7	0.01
17.	OCDF	39001-02-0	0.01
18.	Total TCDD	N/A	0.01
19.	Total PeCDD	N/A	0.01
20.	Total HxCDD	N/A	0.01

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 2a (continued)
Sample Analyses - Soil
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Dioxins/Furans (EPA 8280)		**CAS Number**	**CRQL (ng/g)[a]**
21.	Total HpCDD	N/A	0.01
22.	Total TCDF	N/A	0.01
23.	Total PeCDF	N/A	0.01
24.	Total HxCDF	N/A	0.01
25.	Total HpCDF	N/A	0.01

a Quantitation limits listed for soil/sediment are based on wet weight.

Table 3
Summary of Well Construction Details
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Well Number	Date Installed	Total Boring Depth (ft bgs)	PVC Well Diameter (inches)	Screen Interval (ft bgs)	Filter Pack (ft bgs)	Bentonite (ft bgs)	Cement (ft bgs)	Elevation Top of Well Cover (ft msl)	Elevation Ground Surface (ft msl)
UCD1-1	10/09/87	56.5	2	46.5-56.5	41-56.5	38-41	0-38	50.05	47.9
UCD1-2	Abandoned								
UCD1-3	10/23/87	51.5	2	39-49	34-51.5	(a)	0-34	50.05	48.2
UCD1-4	10/14/87	56.5	2	45-55	40-56.5	(a) 37-40	0-37	51.69	49.4
UCD1-5	10/22/87	48.5	2	38-48	33-48	(a)	0-33	48.44	48.4
UCD1-6	10/21/87	52.5	2	40-50	35-50	(a)	0-35	50.94	49.0
UCD2-7	11/05/87	90	2	80-90	75-90	(a)	0-75	51.65	49.3
UCD1-8	11/03/87	56	2	43.5-53.5	39-53.5	(a)	0-39	51.51	49.2
UCD1-9	11/04/87	51.5	2	40-50	35-50	(a)	0-35	51.38	49.0
UCD1-10	10/11/89	70	4	54-69	52-70	49-52	0-49	49.87	47.4
UCD1-11	10/17/89	66.5	4	50-65	47-66.5	44-47	0-44	50.67	47.6
UCD1-12	10/19/89	65	4	49.5-64.5	47-65	44-47	0-44	51.76	48.8
UCD1-13	10/26/89	65	4	50-65	47-65	44.5-47	0-44.5	52.19	49.2
UCD2-14	11/15/89	86	4	75-85	69-86	64-69	0-64	51.72	49.0
UCD2-15	03/28/90	120.5	4*	91-116	86-120.5	65-86	0-65	51.49	49.4
UCD2-16	04/04/90	122	4*	92-117	86-122	71-86	0-71	49.95	48.2
UCD2-17	04/10/90	143	4*	88-113	81-113	78-81	0-78	51.83	49.6
UCD1-18	10/04/90	70	4*	54-69	51-70	48-51	0-48	48.56	46.7
UCD1-19	10/01/90	74.5	4*	56.5-71.5	53.5-72.5	50.5- 53.5	0-50.5	51.33	49.3
UCD1-20	10/09/90	73.5	4*	57-72	54-73.5	51-54	0-51	49.78	48.0
UCD1-21	10/11/90	73.5	4*	57-72	54-73.5	51-54	0-51	48.77	48.7
UCD1-22	10/25/90	73	4*	57-72	54-73	51-54	0-51	49.07	49.0
UCD1-23	10/17/90	76.5	4*	56.5-71.5	53.5-73	50.5- 53.5	0-50.5	49.39	49.2
UCD1-24	10/22/90	73	4*	57-72	54-73	51-54	0-51	48.91	48.8
UCD1-25	10/06/95	75	4**	60-75	56.9-75	52-56.9	0.52	48.80	-
UCD2-26	10/06/95	102	4**	87-102	84-102	79-84	0-79	48.79	-
UCD2-27Z1	10/06/95	136	5**	53-55	51.5-57.5	49-51.5	0-49	47.79	-
UCD2-27Z2	10/06/95	136	5**	63-65	61.5-66.5	57.5-61.5	0-49	47.79	-
UCD2-27Z3	10/06/95	136	5**	73-75	71.5-76.5	66.5-71.5	0-49	47.79	-
UCD2-27Z4	10/06/95	136	5**	86-88	84.9-90	76.5-84.9	0-49	47.79	-

Table 3 (continued)
Summary of Well Construction Details
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Well Number	Date Installed	Total Boring Depth (ft bgs)	PVC Well Diameter (inches)	Screen Interval (ft bgs)	Filter Pack (ft bgs)	Bentonite (ft bgs)	Cement (ft bgs)	Elevation Top of Well Cover (ft msl)	Elevation Ground Surface (ft msl)
UCD2-27Z5	10/06/95	136	5**	96-98	94.5-100	90-94.5	0-49	47.79	-
UCD2-27Z6	10/06/95	136	5**	106-108	104.5-109.5	100-104.5	0-49	47.79	-
UCD2-27Z7	10/06/95	136	5**	116-118	114.5-119	109.5-114.5	0-49	47.79	-
UCD1-28	09/05/96	70	2*	53-68	51-70	47-51	0-47	50.34	48.1
UCD2-29	09/04/96	97	2*	80-95	76.7-97	72-76.7	0-72	50.32	48.1
UCD2-30	09/10/96	110	2*	95-110	91-110	89.5-91	0-89.5	49.83	47.6
UCD2-31	09/11/96	110	2*	94-109	91-110	87-91	0-87	49.86	47.5
UCD2-32	04/03/97	105	2*	83-103	81 -105	77-81	0-77	45.41	45.08
UCD4-33	Abandoned in May 1997 and replaced by UCD4-42								
UCD1-34	10/06/95	80	4**	61-76	57-76	50-57	0-50	55.70	-
UCD2-35	10/06/95	130	4**	107-122	103-122	98-103	0-98	55.71	-
UCD2-36	11/06/97	105	2*	82-102	79-105	73-79	0-73	48.31	-
UCD2-37	10/20/97	118.5	2*	94-114	91-118.5	85-91	0.85	49.63	-
UCD2-38	10/23/97	119	2*	95-115	89-95	83-89	0-83	57.20	-
UCD2-39	10/30/97	112	2*	87-107	84-112	80.5-84	0-81.5	49.63	47.4
UCD2-40	11/07/97	108.5	2*	86-106	83-108.5	78-83	0-78	48.98	46.5
UCD4-41	10/10/97	295	4*	257-277	255.5-280	248.5-253	0-248.5	49.37	47.0
UCD4-42	11/03/97	272	4*	248.5-268.5	245-269	240-246	0-246	47.22	47.0
UCD4-43	10/02/97	295	4*	248-268	242.5-274	233-242.5	0-237	45.06	44.52
EW2-1	09/20/96	125.65	8*	79.4- 119.4	74.4-125.65	68.4- 74.4	0-68.4	49.17	47.3
IW2-1	10/17/97	126.5	10*	84.5-119.5	80-126.5	75-80	0-75	49.39	-

Note: ft bgs – feet below ground surface.
ft msl – feet mean sea level datum.
* – stainless steel, wire wrap screen.
** – stainless steel, blank casing and wire wrap screen.
(a) Well constructed with #60 sand seal and no bentonite.

Table 4
Groundwater Monitoring Parameters and Schedule
Beginning Summer 1997[a]
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

	Analyte/Analysis																
	Radiological Analytes																
Well	Gamma[d]	Tritium[d]	C-14[d]	Sr-90[d]	Ra-226[d]	Pu-241	Am-241	Gross beta[d]	Gross alpha[d]	VOCs[b][d]	SVOCs[c]	Metals[d]	Nitrate[d]	Chromium (hexavalent)[d]	TOC, TDS	Pesticides & PCBs	Alkalinity, Cations, Anions
UCD1-18	A	A	A	*	*	*	*	A	A	A	A	A	S	S	A	A	*
UCD1-1	*	*	*	*	*	*	*	*	*	*	*	*	A	A	*	*	*
UCD1-4	Q	Q	*	Q	Q	*	*	Q	Q	Q	A	A	Q	Q	Q	Q	*
UCD1-10	A	A	*	*	*	*	*	A	A	Q	A	A	Q	Q	Q	A	*
UCD1-11	A	A	*	*	*	*	*	A	A	A	*	A	S	S	A	A	*
UCD1-12	Q	Q	Q	Q	Q	*	*	Q	Q	Q	A	A	Q	Q	Q	Q	*
UCD1-13	Q	Q	Q	Q	Q	*	*	Q	Q	Q	A	A	A	Q	Q	Q	*
UCD1-19	A	A	*	*	*	*	*	A	A	A	*	A	A	A	A	A	*
UCD1-20	S	S	S	S	S	*	*	S	S	A	A	A	A	S	A	A	*
UCD1-21	A	A	A	A	A	A	A	A	A	A	*	A	A	A	A	*	*
UCD1-22	S	S	*	S	S	S	S	S	S	*	*	*	*	*	S	*	*
UCD1-23	S	S	S	S	S	*	*	S	S	A	*	A	A	A	A	*	*
UCD1-24	A	A	A	A	A	*	*	A	A	A	*	A	A	A	A	A	*
UCD1-25	A	Q	Q	A	A	*	*	A	A	Q	A	A	Q	Q	A	A	*
UCD1-28[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD1-34	A	S	A	A	A	*	*	A	A	S	A	A	S	S	A	A	*
UCD1-27Z3	*	A	A	*	*	*	*	*	*	A	*	*	A	A	*	*	*

Table 4 (continued)
Groundwater Monitoring Parameters and Schedule
Beginning Summer 1997[a]
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

	Analyte/Analysis																
	Radiological Analytes																
Well	Gamma[d]	Tritium[d]	C-14[d]	Sr-90[d]	Ra-226[d]	Pu-241	Am-241	Gross beta[d]	Gross alpha[d]	VOCs[b][d]	SVOCs[c]	Metals[d]	Nitrate[d]	Chromium (hexavalent)[d]	TOC, TDS	Pesticides & PCBs	Alkalinity, Cations, Anions
UCD2-17	A	A	A	*	*	*	*	A	A	A	A	A	S	S	A	A	*
UCD2-7	S	S	S	S	S	*	*	S	S	A	*	A	S	S	A	A	*
UCD2-14	Q	Q	Q	Q	Q	*	*	Q	Q	Q	A	Q	Q	Q	Q	Q	*
UCD2-15	Q	Q	*	Q	Q	*	*	Q	Q	Q	A	A	Q	Q	Q	Q	*
UCD2-16	S	S	*	S	S	*	*	S	S	S	*	Q	S	Q	Q	*	*
UCD2-29[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-30[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-31[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-32	Q	Q	Q	Q	Q	*	*	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-35[e]	A	Q	Q	A	A	*	*	A	A	S	A	A	Q	Q	Q	A	*
UCD2-36[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-37[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-38[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-39[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-40[e]	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD2-26	A	Q	Q	A	A	*	*	A	A	Q	A	A	Q	Q	Q	A	*
UCD2-2775	*	A	A	*	*	*	*	*	*	A	*	*	A	A	*	*	*
UCD4-41	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD4-42	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UCD4-43	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

A = annual sampling (February); S = semi-annual sampling (February and August); Q = quarterly sampling (Feb., May, Aug., and Nov.); * = sample not analyzed for constituent

(a) At each sampling event, samples are analyzed for pH, Eh, electrical conductivity, temperature, and turbidity in the field; water levels are measured before each sampling event.

(b) Volatile organic compounds.

(c) Semivolatile organic compounds.

(d) As applicable, equipment blanks will be collected at a minimum frequency of ten percent for the same parameters as the associated samples.

(e) Well will also be sampled monthly for one year as part of the IRA monitoring; see Removal Action Work Plan and IRA Waste Discharge Requirements.

Table 5
Surface Water Monitoring Parameters and Schedule
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

	Analyte/Analysis[a]										
	Radiological Analytes										
Location	Tritium	C-14	Sr-90	Ra-226	VOCs[b]	Metals[c]	Nitrate	Chromium (hexavalent)	TDS	Pesticides & PCBs	Chronic Aquatic Toxicity[d]
PCU	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STPO	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PCD[e]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ = Collected during two storm events per year in coordination with storm water runoff sampling (see Table 6)
(a) At each sampling event, samples are analyzed for pH, Eh, electrical conductivity, temperature, and turbidity in the field and a stream gauge measurement is recorded.
(b) Volatile organic compounds.
(c) See Table 8a for specific compounds for VOC, pesticides, and PCB analyses. Metals analysis includes: antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, chromium, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.
(d) Chronic Aquatic Toxicity analysis may include measurements of alkalinity, hardness, dissolved oxygen, pH, and ammonia.
(e) In addition, a second downstream location, PC2, will be sampled for one year, for chronic aquatic toxicity.

Table 6
Storm Water Runoff Monitoring Parameters and Schedule
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

	Analyte/Analysis[a]												
	Radiological Analytes												
Location	Tritium	C-14	Sr-90	Ra-226	VOCs[c]	Metals[c]	Nitrate	Chromium (hexavalent)	TSS[e]/ TDS	Pesti-cides & PCBs[c]	TOC[e]	Acute Aquatic Toxicity[d]	Oil & Grease[e]
LS-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LF-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LF-3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ = collected during two storm events per year: a storm event early in the rainy season (typically in October or November) and a precipitation event in the middle or late part of the rainy season (typically in February or March).
(a) At each sampling event, samples are analyzed for pH, Eh, electrical conductivity, temperature, and turbidity in the field, and a stream gauge measurement is recorded.
(b) Volatile organic compounds.
(c) See Table 8a for specific compounds for VOC, pesticide, and PCB analysis. Metals analysis includes: antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, chromium, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.
(d) Acute Aquatic Toxicity Analysis may include measurements of alkalinity, hardness, dissolved oxygen, pH, and ammonia.
(e) Monitoring parameter specified by General Industrial Storm Water Permit.

Table 7
Neighbor Well Monitoring Parameters And Schedule
Revised Field Sampling Program
LEHR/SCDS Environmental Restoration

	Field Parameters		Laboratory Analytes			
Well	**Temp**	**Conduc-tivity**	**Nitrate**	**CrVI**	**VOC**	**Well location and construction data, if known**
AAIW 22A	Q	Q	S	S	Q	Northeast of LEHR
IHDW 15K3	Q	Q	S	S	Q	North/Northeast of LEHR Total depth: 130 ft.
MARIW 27C2	S	S	A	A	S	Southeast of LEHR Total depth: 305 ft. Perforation: 120-288 ft.
MDW	S	S	-	-	S	South of LEHR
MIW 28B	S	S	A	A	S	South of LEHR
NDW 15P	Q	Q	S	S	Q	North/Northeast of LEHR Total depth: 305 ft. Perforation: 130-138 ft.
NIW 22N						To be abandoned in 1998.
NJIW 22J	Q	Q	S	S	Q	Northeast of LEHR
NPIW 22P1						Abandoned in 1996.
NPIW 22P2	Q	Q	S	S	Q	East of LEHR Total depth: 456 ft. Perforation: 100-120 ft. 160-180 ft. 197-290 ft.
OHDW 14L	Q	Q	S	S	Q	Northeast of LEHR Total depth: 286 ft. Perforation: 70-286ft.
RDW	S	S	-	-	S	Southwest of LEHR
RIW 28C	S	S	-	-	S	South/west of LEHR Total depth: 340 ft. Perforation: 100-260 ft.
RUSDW 15K1	Q	Q	S	S	Q	North/Northeast of LEHR Total depth: 270 ft. Perforation: 240-260 ft.

Notes

1. A = Annual Sampling (Feb), S = Semi-annual sampling (Feb and Aug), Q = Quarterly (Feb, May, Aug, Nov).
2. Wells, analytes, and sampling frequency will be reviewed at least annually or whenever new on-site or off-site information or contamination is discovered.
3. Volatile Organic Compound analysis will consist of:
   1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,2-dichloropropane, 1,2-trichloroethane, bromodichloromethane, chloroform and methylene chloride.

Table 8
Sample Analyses-Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Field Parameters:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT	HOLDING TIME
pH	SOP 2.0[a]	NA	NA	NA	NA
EC	SOP 2.0[a]	NA	NA	NA	NA
Temperature	SOP 2.0[a]	NA	NA	NA	NA
Turbidity	SOP 2.0[a]	NA	NA	NA	NA
Eh	SOP 2.0[a]	NA	NA	NA	NA
Dissolved Oxygen	SOP 2.0[a]	NA	NA	NA	NA

a SOP 2.0 is included in Appendix A.

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Organic Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRQL	HOLDING TIME
Volatile Organic Compounds	CLP SOW OLC 02.0[b] or equivalent	3, 40 ml, G	4°C HCl, pH < 2	Refer to Table 8a	14 days
Semivolatile Organic Compounds	CLP SOW OLM 03.1 or equivalent	2 Liter, Amber G	4°C	Refer to Table 8a	7 days to extraction, 40 days to analysis
Organochlorine Pesticides	CLP SOW OLM 03.1(M)[c] or equivalent	2 Liter, Amber G	4°C	Refer to Table 8a	7 days to extraction, 40 days to analysis
Dioxins/Furans	EPA 8280	1 Liter, AG	4°C	Refer to Table 8a	45 days

[b] CRQLS reported at EPA 8260 levels.
[c] CRQLs reported at OLC 02.0 levels.

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Radiologic Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT MDA[d]	HOLDING TIME
Gross Alpha	9310	1 Liter P,G	Filter HNO3, pH < 2	2 pCi/L	180 days
Gross Beta	9310	1 Liter P,G	Filter HNO3, pH < 2	3 pCi/L	180 days
Tritium	906.0	1 Liter G	None	300 pCi/L	180 days
Carbon-14	EPA 520/5-84-006	1 Liter P,G	None	20 pCi/L	180 days
Strontium-90	905.0	2 Liter P,G	Filter HNO3, pH < 2	1 pCi/L	180 days
Radium-226	903.1	1 Liter, G	Filter HNO3, pH < 2	1 pCi/L	180 days
Americium-241	EPA 907.0 (M)	1 Liter, G	Filter HNO3, pH < 2	1 pCi/L	180 days
Plutonium-241	EPA 907.0 (M)	1 Liter, G	Filter HNO3, pH < 2	10 pCi/L	180 days

[d] Minimum Detectable Activity (MDA) may vary from sample to sample, depending on possible matrix interferences such as dissolved solids.

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Radiologic Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT MDA[d]		HOLDING TIME
Gamma Spectral Analysis	EPA 901.1	4 Liter P,G	Filter			180 days
Th-234			HNO3, pH < 2	350	pCi/L	
Pb-214				10	pCi/L	
Bi-214				10	pCi/L	
Pb-210				700	pCi/L	
U-235				25	pCi/L	
U-238				500	pCi/L	
Na-22				10	pCi/L	
Ac-228				20	pCi/L	
Pb-212				10	pCi/L	
Bi-212				70	pCi/L	
Tl-208				5	pCi/L	
K-40				100	pCi/L	
Co-60				10	pCi/L	
Cs-137				10	pCi/L	

[d] Minimum Detectable Activity (MDA) may vary from sample to sample, depending on possible matrix interferences such as dissolved solids.

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL	HOLDING TIME
Hexavalent Chromium	EPA 7196	1 Liter, P	Filter, 4°C	10 µg/L	24 hours
Total Dissolved Chromium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days
Antimony	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	5 µg/L	180 days
Arsenic	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	3 µg/L	180 days
Barium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	20 µg/L	180 days
Beryllium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	1 µg/L	180 days
Cadmium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	1 µg/L	180 days
Cobalt	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	1 µg/L	180 days
Copper	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL	HOLDING TIME
Iron	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	100 µg/L	180 days
Lead	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	3 µg/L	180 days
Manganese	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days
Mercury	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	0.2 µg/L	28 days
Molybdenum	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days
Nickel	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	20 µg/L	180 days
Selenium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	3 µg/L	180 days
Silver	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days
Thallium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH<2	10 µg/L	180 days

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Metals Analyses (continued):

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT CRDL	HOLDING TIME
Vanadium	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH < 2	10 µg/L	180 days
Zinc	CLP SOW ILC 02.0 or equivalent	1 Liter, P	Filter, 4°C HNO3, pH < 2	20 µg/L	180 days

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

General Chemical Analyses:

ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT Reporting Limit		HOLDING TIME
Alkalinity	EPA 310.1	1 Liter, P	4°C	10	mg/L	14 days
Ammonia	EPA 350.2	1 Liter, P,G	Filter, 4°C H2SO4, pH<2	0.05	mg/L	28 days
Total Kjeldahl Nitrogen	EPA 351.3	1 Liter, P,G	Filter, 4°C H2SO4, pH<2	0.5	mg/L	28 days
Sodium			Filter, 4°C HNO3, pH<2	2	mg/L	180 days
Potassium	EPA 6010	1 Liter, P	Filter, 4°C HNO3, pH<2	2	mg/L	180 days
Calcium			Filter, 4°C HNO3, pH<2	2	mg/L	180 days
Silica			Filter, 4°C HNO3, pH<2	0.1	mg/L	180 days
Magnesium			Filter, 4°C HNO3, pH<2	2	mg/L	180 days
Chloride	EPA 300.0	1 Liter, P,G	Filter, 4°C	1	mg/L	28 days
Sulfate				1	mg/L	28 days

Table 8 (Continued)
Sample Analyses - Water
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

General Chemical Analyses (continued):					
ANALYTE	METHOD	CONTAINER	SAMPLE HANDLING	DETECTION LIMIT Reporting Limit	HOLDING TIME
Phosphorus, dissolved	EPA 365.2	1 Liter, P,G	Filter, 4°C H2SO4, pH<2	1 mg/L	28 days
Nitrate (as Nitrogen)	EPA 300.0	1 Liter, P,G	Filter, 4°C	0.1 mg/L	48 hours
Total Dissolved Solids	EPA 160.1	1 Liter, P,G	Filter, 4°C	20 mg/L	7 days
Total Suspended Solids	EPA 160.2	1 Liter, P,G	4°C	10 mg/L	7 days
Hardness	EPA 130.2	1 Liter, P,G	HNO3, pH <2	10 mg/L	30 days
Total Organic Carbon	EPA 415.2	1 Liter, G	4°C H2SO4, pH<2	1 mg/L	28 days
Turbidity	EPA 180.1	500 ml, P,G	4°C	0.1 NTU	48 hours
Chemical Oxygen Demand	EPA 410	125 ml, P	4°C H2S04, pH<2	50 mg/L	28 days
Biochemical Oxygen Demand	EPA 405.1	1 Liter, P	4°C	5 mg/L	48 hours
Acute Aquatic Toxicity	EPA 600/4-90/027F	4 Liter, P	4°C	N/A	36 hours
Chronic Aquatic Toxicity	EPA 600/4-91/002	5 Gal., P	4°C	N/A	36 hours
Oil and Grease	EPA 1664 or equivalent	2 Liter, G	H2SO4	2.0 mg/L	28 days

Table 8a
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Volatiles (Method CLP or equivalent):		**CAS Number**	**CRQL (μg/L)**[e]
1.	Chloromethane	74-87-3	0.5
2.	Bromomethane	74-83-9	1.0
3.	Vinyl chloride	75-01-4	0.5
4.	Chloroethane	75-00-3	0.5
5.	Methylene chloride	75-09-2	0.5
6.	Acetone	67-64-1	5.0
7.	Carbon disulfide	75-15-0	1.0
8.	1,1-Dichloroethene	75-35-4	0.5
9.	1,1-Dichloroethane	75-34-3	0.5
10.	cis-1,2-Dichloroethene	156-59-4	0.5
11.	trans-1,2-Dichloroethene	156-60-5	0.5
12.	Chloroform	67-66-3	0.5
13.	1,2-Dichloroethane	107-06-2	0.5
14.	2-Butanone	78-93-3	1.0
15.	Bromochloromethane	74-97-5	1.0
16.	1,1,1-Trichloroethane	71-55-6	0.5
17.	Carbon Tetrachloride	56-23-5	0.5
18.	Bromodichloromethane	75-27-4	0.5
19.	1,2-Dichloropropane	78-87-5	0.5
20.	cis-1,3-Dichloropropene	10061-01-5	0.5
21.	Trichloroethene	79-01-6	0.5

[e] These reporting limits are based on low-level detection limits for EPA 8260 and are used only for projects which require meeting the lower California MCLs and the 40 CFR MCL specifications.

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Volatiles (Method CLP or equivalent):		**CAS Number**	**CRQL (μg/L)**[e]
22.	Dibromochloromethane	124-48-1	0.5
23.	1,1,2-Trichloroethane	79-00-5	1.0
24.	Benzene	71-43-2	0.5
25.	trans-1,3-Dichloropropene	10061-02-6	0.5
26.	Bromoform	75-25-2	0.5
27.	4-Methyl-2-pentanone	108-100-1	1.0
28.	2-Hexanone	591-78-6	1.0
29.	Tetrachloroethene	127-18-4	0.5
30.	1,1,2,2-Tetrachloroethane	79-34-5	0.5
31.	1,2-Dibromoethane	106-93-4	0.5
32.	Toluene	108-88-3	0.5
33.	Chlorobenzene	108-90-7	0.5
34.	Ethylbenzene	100-41-4	0.5
35.	Styrene	100-42-5	0.5
36.	Xylenes (total)	1330-20-7	1.0
37.	1,3-Dichlorobenzene	541-73-1	0.5
38.	1,4-Dichlorobenzene	106-46-7	0.5
39.	1,2-Dichlorobenzene	95-50-1	0.5
40.	1,2-Dibromo-3-chloropropane	96-12-8	0.5

[e] These reporting limits are based on low-level detection limits for EPA 8260 and are used only for projects which require meeting the lower California MCLs and the 40 CFR MCL specifications

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent)		**CAS Number**	**CRQL (μg/L)[e]**
1.	Phenol	108-95-2	10
2.	bis(2-chloroethyl)ether	111-44-4	10
3.	2-Chlorophenol	95-57-8	10
4.	1,3-Dichlorobenzene	541-73-1	10
5.	1,4-Dichlorobenzene	106-46-7	10
6.	1,2-Dichlorobenzene	95-50-1	10
7.	2-Methylphenol	95-48-7	10
8.	2,2'-oxybis (1-Chloropropane)	108-60-1	10
9.	4-Methylphenol	106-44-5	10
10.	N-Nitroso-di-n-propylamine	621-64-7	10
11.	Hexachloroethane	67-72-1	10
12.	Nitrobenzene	98-95-3	10
13.	Isophorone	78-59-1	10
14.	2-Nitrophenol	88-75-5	10
15.	2,4-Dimethylphenol	105-67-9	10
16.	bis(2-Chloroethoxy)methane	111-91-1	10
17.	2,4-Dichlorophenol	120-83-2	10
18.	1,2,4-Trichlorobenzene	120-82-1	10
19.	Naphthalene	91-20-3	10
20.	4-Chloroaniline	106-47-8	25

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent): (continued)		**CAS Number**	**CRQL (μg/L)**
21.	Hexachlorobutadiene	87-68-3	10
22.	4-Chloro-3-methylphenol	59-50-7	10
23.	2-Methylnaphthalene	91-57-6	10
24.	Hexachlorocyclopentadiene	77-47-4	10
25.	2,4,6-Trichlorophenol	88-06-2	10
26.	2,4,5-Trichlorophenol	95-95-4	25
27.	2-Chloronaphthalene	91-58-7	10
28.	2-Nitroaniline	88-74-4	25
29.	Dimethylphthalate	131-11-3	10
30.	Acenaphthylene	208-96-8	10
31.	2,6-Dinitrotoluene	606-20-2	10
32.	3-Nitroaniline	99-09-2	25
33.	Acenaphthene	83-32-9	10
34.	2,4-Dinitrophenol	51-28-5	25
35.	4-Nitrophenol	100-02-7	25
36.	Dibenzofuran	132-64-9	10
37.	2,4-Dinitrotoluene	121-14-2	10
38.	Diethylphthalate	84-66-2	10
39.	4-Chlorophenyl-phenylether	7005-72-3	10
40.	Fluorene	86-73-7	10
41.	4-Nitroaniline	100-01-6	25

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Semivolatiles (Method CLP or equivalent): (continued)		**CAS Number**	**CRQL (μg/L)**
42.	4,6-Dinitro-2-methylphenol	534-52-1	25
43.	N-nitrosodiphenylamine	86-30-6	10
44.	4-Bromophenyl-phenylether	101-55-3	10
45.	Hexachlorobenzene	118-74-1	10
46.	Pentachlorophenol	87-86-5	25
47.	Phenanthrene	85-01-8	10
48.	Anthracene	120-12-7	10
49.	Carbazole	86-74-8	10
50.	Di-n-butylphthalate	84-74-2	10
51.	Fluoranthene	206-44-0	10
52.	Pyrene	129-00-0	10
53.	Butylbenzylphthalate	85-68-7	10
54.	3,3'-Dichlorobenzidine	91-94-1	10
55.	Benzo(a)anthracene	56-55-3	10
56.	Chrysene	218-01-9	10
57.	bis(2-Ethylhexyl)phthalate	117-81-7	10
58.	Di-n-octylphthalate	117-84-0	10
59.	Benzo(b)fluoranthene	205-99-2	10
60.	Benzo(k)fluoranthene	207-08-9	10
61.	Benzo(a)pyrene	50-32-8	10
62.	Indeno(1,2,3-cd)pyrene	193-39-5	10
63.	Dibenz(a,h)anthracene	53-70-3	10
64.	Benzo(g,h,i)perylene	191-24-2	10

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Pesticides/PCBs (Method CLP or equivalent):		**CAS Number**	**CRQL (μg/L)**[f]
1.	alpha-BHC	319-84-6	0.01
2.	beta-BHC	319-85-7	0.01
3.	delta-BHC	58-89-9	0.01
4.	Gamma-BHC (Lindane)	58-89-9	0.01
5.	Heptachlor	76-44-8	0.01
6.	Aldrin	309-00-2	0.01
7.	Heptachlor epoxide	1024-57-3	0.01
8.	Endosulfan I	959-98-8	0.01
9.	Dieldrin	60-57-1	0.02
10.	4,4'-DDE	72-55-9	0.02
11.	Endrin	72-20-8	0.02
12.	Endosulfan II	33213-65-9	0.02
13.	4,4'-DDD	72-54-8	0.02
14.	Endosulfan sulfate	1031-07-8	0.02
15.	4,4'-DDT	50-29-3	0.02
16.	Methoxychlor	72-43-5	0.10
17.	Endrin ketone	53494-70-55	0.02
18.	Endrin aldehyde	7421-36-3	0.02
19.	Alpha-chlordane	5103-71-9	0.01
20.	Gamma-chlordane	5103-74-2	0.01
21.	Toxaphene	8001-35-2	1.0
22.	Aroclor-1016	12674-11-2	0.20
23.	Aroclor-1221	11104-28-2	0.40
24.	Aroclor-1232	11141-16-5	0.20
25.	Aroclor-1242	53469-21-9	0.20

[f] Modified to report CRQLs at OLC 02.0 levels.

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Pesticides/PCBs (Method CLP or equivalent) (continued):		**CAS Number**	**CRQL (μg/L)**[a]
26.	Aroclor-1248	12672-29-6	0.20
27.	Aroclor-1254	11097-69-1	0.20
28.	Aroclor-1260	11096-82-5	0.20

[a] Modified to report CRQLs at OLC 02.0 levels.

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Dioxins/Furans (EPA 8280)		**CAS Number**	**CRQL (ng/L)**
1.	2,3,7,8-TCDD	1746-01-6	0.02
2.	1,2,3,7,8-PeCDD	40321-76-4	0.02
3.	1,2,3,4,7,8-HxCDD	39227-28-6	0.04
4.	1,2,3,6,7,8-HxCDD	57653-85-7	0.04
5.	1,2,3,7,8,9-HxCDD	19408-74-3	0.04
6.	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.03
7.	OCDD	3268-87-9	0.05
8.	2,3,7,8-TCDF	51207-31-9	0.01
9.	1,2,3,7,8-PeCDF	57117-41-6	0.02
10.	2,3,4,7,8-PeCDF	57117-31-4	0.02
11.	1,2,3,4,7,8-HxCDF	70648-26-9	0.01
12.	1,2,3,6,7,8-HxCDF	57117-44-9	0.01
13.	2,3,4,6,7,8-HxCDF	60851-34-5	0.01
14.	1,2,3,7,8,9-HxCDF	72918-21-9	0.01
15.	1,2,3,4,6,7,8-HpCDF	67562-39-4	0.01
16.	1,2,3,4,7,8,9-HpCDF	55673-89-7	0.01
17.	OCDF	39001-02-0	0.03
18.	Total TCDD	N/A	0.02
19.	Total PeCDD	N/A	0.04
20.	Total HxCDD	N/A	0.04

Table 8a (continued)
Sample Analyses - Water
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL) for Organic Analyses
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Dioxins/Furans (EPA 8280)		**CAS Number**	**CRQL (ng/L)**
21.	Total HpCDD	N/A	0.03
22.	Total TCDF	N/A	0.01
23.	Total PeCDF	N/A	0.02
24.	Total HxCDF	N/A	0.01
25.	Total HpCDF	N/A	0.01

Table 9
Sample Analyses - Soil Vapor
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Soil Vapor Analyses				
Volatile Organic Compounds	TO-14	Tedlar Bag or Stainless Steel Canister	0.5 ppbv	72 hours* f
Oxygen	ASTM D3416	Tedlar Bag or Stainless Steel Canister	5%	72 hours*
Carbon Dioxide	ASTM D3416	Tedlar Bag or Stainless Steel Canister	0.1%	72 hours*
Methane	ASTM D3416	Tedlar Bag or Stainless Steel Canister	0.001%	72 hours*

* Holding time is 7 days if steel canister is utilized.

Table 10
IRA Groundwater Analytical Parameters[1]
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Parameters[2] Groundwater Samples	**Rationale**
Volatile Organic Compounds Semi-Volatile Organic Compounds Tritium Total Chromium Hexavalent Chromium Total Dissolved Solids Nitrate (as nitrogen) pH EC Turbidity	Site constituents of concern
Additional Parameters[3]	
Alkalinity Sodium Potassium Calcium Magnesium Silica Chloride Sulfate Phosphorous, Dissolved Dissolved Oxygen Chemical Oxygen Demand Barium Iron Manganese	General chemical parameter

(1) Parameters analyzed for samples collected during the pumping phase of the IRA pumping test of extraction well EW2-1.
(2) Parameters analyzed for all pumping test extraction and monitoring well samples.
(3) Parameters analyzed for extraction well samples only.

Table 11
Summary of Soil Investigation Activities
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

	Backhoe Trenches				Soil Borings				
Investigation Area	**Number of Trenches**	**Tritium Screening**	**Number of Waste Samples**	**Number of Soil Samples**	**Number of Borings**	**Number of Waste Samples**	**Number of Soil Samples**	**Number of Landfill Gas Samples**	**Surface Geophysics**
Waste Burial Holes	6	✓	9	10*	—	—	—	—	—
Eastern Trenches	4	✓	6	6	3	3	8	—	—
Southern Trenches	4	—	4	5	3	4	8	—	—
Landfill Unit #1	13	—	4	2	4	5	5	4	✓
Landfill Unit #2	13	—	6	—	3	5	7	3	—
Landfill Unit #3	10	—	6	—	2	4	4	2	—
Old Wastewater Treatment Plant	—	—	—	—	2	—	4	—	—
Totals	50	—	35 (1)	23 (1)	17	21 (1)	36 (2)	9 (1)	—

(____) = Number of duplicate samples is indicated in parentheses.
* = Two soil samples were shallow cover soil samples collected using a hand auger.

Table 12
Summary of Monitoring Points for the Water Monitoring Program
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Groundwater Monitoring Points	Surface Water Monitoring Points	Storm Water Runoff Monitoring Points
UCD1-1	PCU	LS-1
UCD1-3*	PCD	LF-1
UCD1-4	STPO	LF-3
UCD1-5*		
UCD1-6*		
UCD2-7		
UCD1-8*		
UCD1-9*		
UCD1-10		
UCD1-11		
UCD1-12		
UCD1-13		
UCD2-14		
UCD2-15		
UCD2-16		
UCD2-17		
UCD1-18		
UCD1-19		
UCD1-20		
UCD1-21		
UCD1-22		
UCD1-23		
UCD1-24		
UCD1-25		
UCD2-26		
UCD1/2-27		
UCD2-32		
UCD1-34		
UCD2-35		
UCD2-36		
UCD2-37		
UCD2-38		
UCD2-39		
UCD2-40		
UCD4-41		
UCD4-42		
UCD4-43		
Any additional wells from future groundwater investigations		

* Well sometimes dry(during drought years in summer); used only for monitoring water levels.
\+ In addition, a second downstream location, PC2, will be sampled for one year, for chronic aquatic toxicity.

Table 13
Proposed Water Monitoring Schedule for One Monitoring Year
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Monitoring Point	Samples per Event	Duplicates per Event	Event Total	Monitoring Events per Year[1]	Yearly Total Samples
Twenty-four Existing Monitoring Wells	37/23/31/23 [2]	2/2/2/2 [2]	25-39	4 (quarters — winter, spring, summer, fall)	122
Surface Water Samples	3[3]	4	4	2 (storm events))	8
Storm Water Runoff Samples	3	4	3 or 4	2 (storm events)	7

(1) Trip blanks analyzed for VOCs only. Total number of blanks depends on the number of sampling days.
(2) 37/23/31/23 - number of samples collected per quarter (winter/spring/sumer/fall).
(3) Two surface water duplicates and one storm water duplicate sample will be collected each year.
(4) In addition, a second downstream location, PC2, will be sampled for one year, for chronic aquatic toxicity.

Table 14
Flow Rates for LF-1 Storm Water Monitoring Location
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

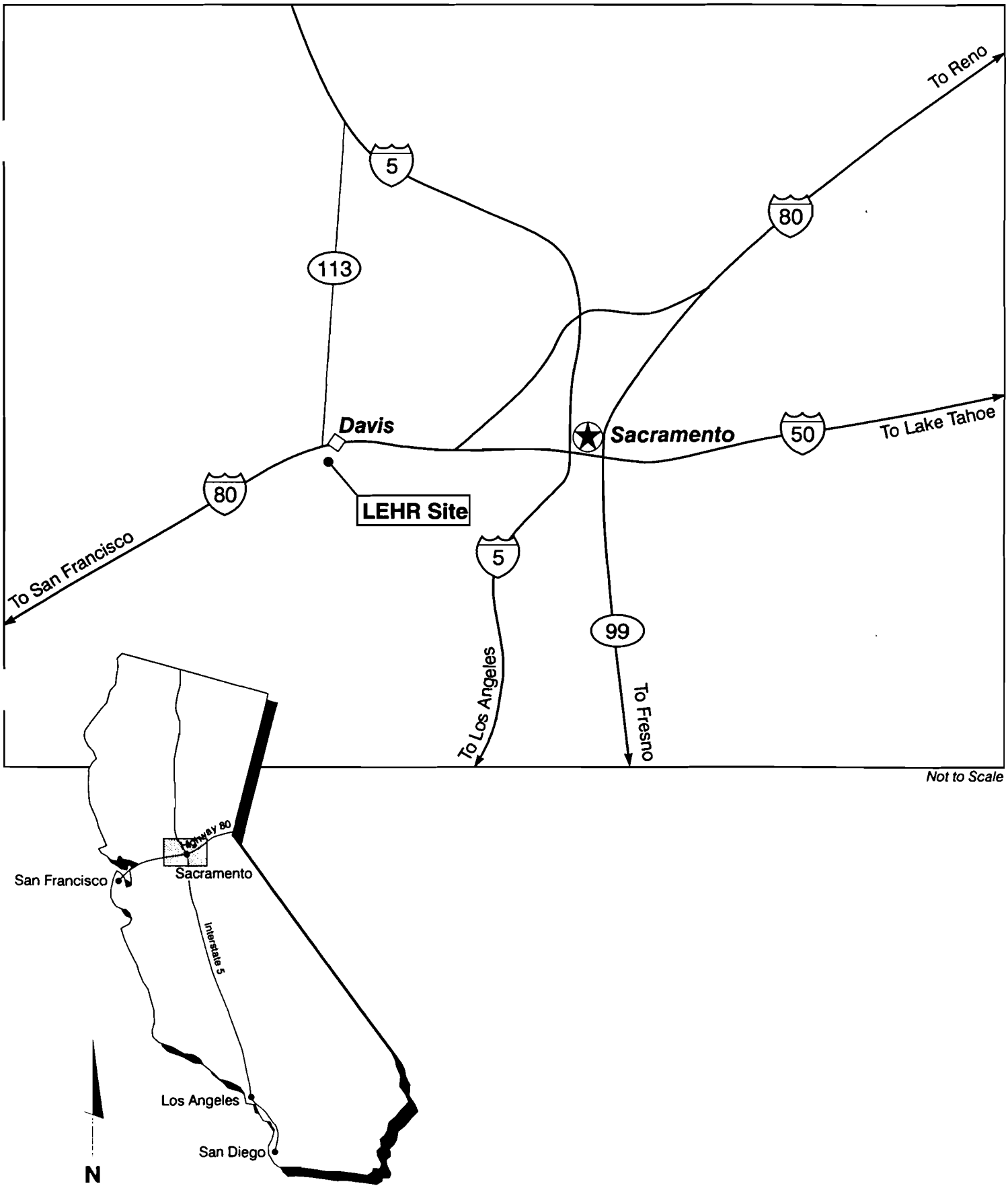
Depth (inches)	Depth (feet)	Aw (ft^2)	Pw (feet)	Rh (feet)	Q (ft^3/sec)
1	0.083	0.045	0.822	0.054	0.01
2	0.167	0.125	1.171	0.107	0.06
3	0.250	0.226	1.445	0.157	0.14
4	0.333	0.344	1.681	0.204	0.26
5	0.417	0.474	1.895	0.250	0.4
6	0.500	0.614	2.093	0.293	0.58
7	0.583	0.762	2.281	0.334	0.79
8	0.667	0.916	2.461	0.372	1.02
9	0.750	1.075	2.635	0.408	1.27
10	0.833	1.238	2.805	0.441	1.54
11	0.917	1.404	2.973	0.472	1.83
12	1.000	1.570	3.140	0.500	2.12
13	1.083	1.736	3.307	0.525	2.42
14	1.167	1.902	3.475	0.547	2.73
15	1.250	2.065	3.645	0.566	3.03
16	1.333	2.224	3.819	0.582	3.33
17	1.417	2.378	3.999	0.595	3.61
18	1.500	2.526	4.187	0.603	3.87
19	1.583	2.666	4.385	0.608	4.11
20	1.667	2.796	4.599	0.608	4.31
21	1.750	2.914	4.835	0.603	4.46
22	1.833	3.015	5.109	0.590	4.55
23	1.917	3.095	5.458	0.567	4.55
24	2.000	3.140	6.280	0.500	4.24

The drainage pipe at LF-1 is a 24" corrugated steel pipe.
N = 0.025
S = 0.00130 (surveyed data indicates that LF#1 pipe slopes slightly away from Putah Creek. A nominal slope toward the creek was therefore assumed so that a conservative flow value can be calculated).

Table 15
Flow Rates for LF-3 Storm Water Monitoring Location
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration

Depth (inches)	Depth (feet)	Aw (ft^2)	Pw (feet)	Rh (feet)	Q (ft^3/sec)
1	0.083	0.050	0.918	0.054	0.3
2	0.167	0.140	1.305	0.107	1.1
3	0.250	0.255	1.608	0.159	2.7
4	0.333	0.388	1.868	0.208	4.9
5	0.417	0.537	2.102	0.256	7.7
6	0.500	0.698	2.317	0.301	11.2
7	0.583	0.870	2.519	0.345	15.3
8	0.667	1.050	2.712	0.387	19.9
9	0.750	1.238	2.897	0.427	25.1
10	0.833	1.431	3.076	0.465	30.7
11	0.917	1.630	3.251	0.501	36.8
12	1.000	1.832	3.422	0.536	43.2
13	1.083	2.038	3.591	0.568	49.9
14	1.167	2.245	3.758	0.597	56.9
15	1.250	2.453	3.925	0.625	64.1
16	1.333	2.661	4.092	0.650	71.4
17	1.417	2.868	4.259	0.673	78.8
18	1.500	3.074	4.428	0.694	86.2
19	1.583	3.276	4.599	0.712	93.4
20	1.667	3.475	4.774	0.728	100.5
21	1.750	3.668	4.953	0.741	107.4
22	1.833	3.856	5.138	0.750	113.9
23	1.917	4.036	5.331	0.757	119.9
24	2.000	4.208	5.533	0.761	125.4
25	2.083	4.369	5.748	0.760	130.1
26	2.167	4.518	5.982	0.755	134.0
27	2.250	4.651	6.242	0.745	136.7
28	2.333	4.766	6.545	0.728	137.9
29	2.417	4.856	6.932	0.700	137.0
30	2.500	4.906	7.850	0.625	128.2

The drainage pipe at LF-3 is a 30" cast iron pipe.
N = 0.015
S = 0.130



SITE LOCATION MAP

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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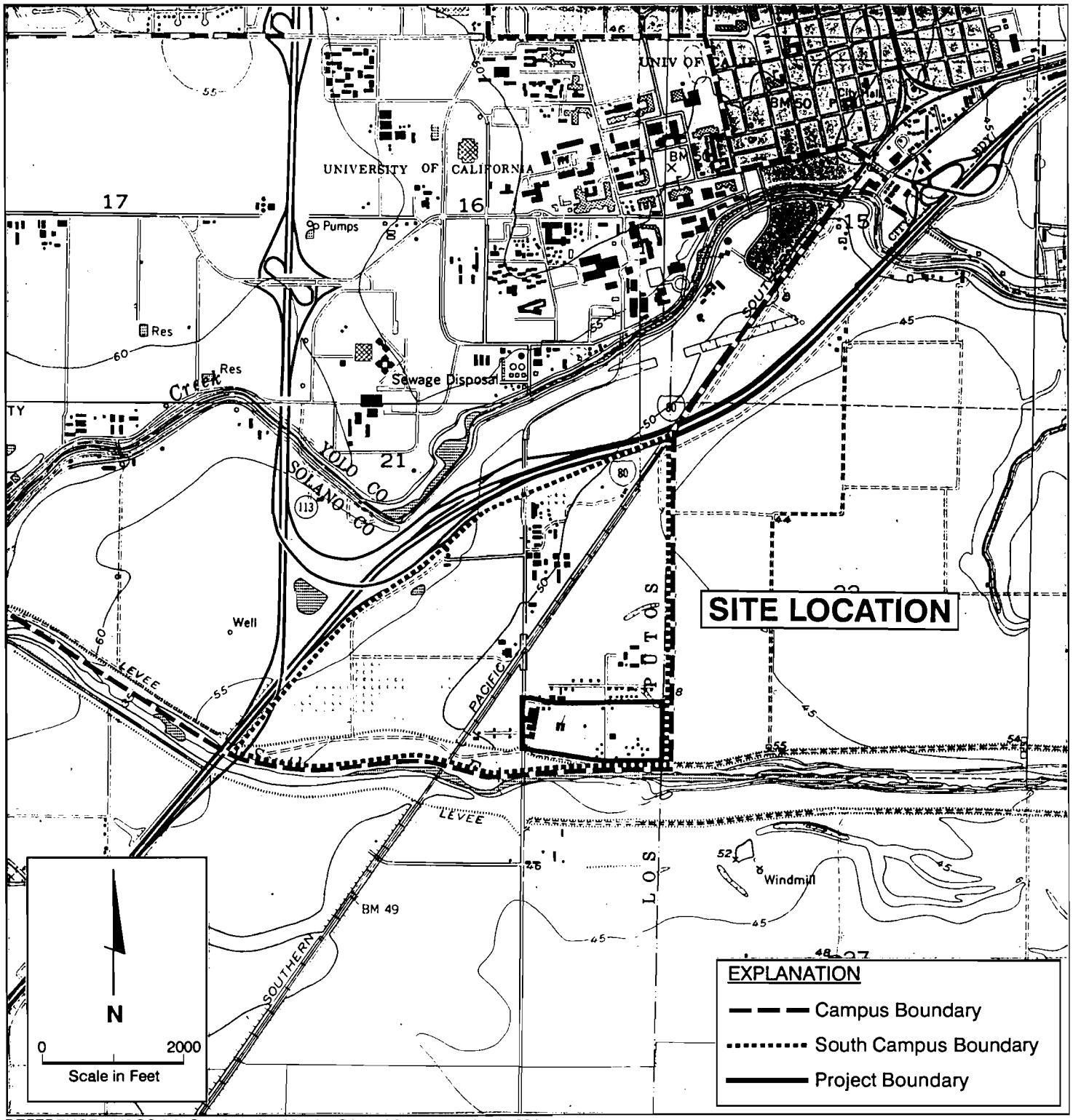
FIGURE 1



REFERENCE: USGS 7.5' Quadrangle; Merritt, CA, 1952, photorevised 1981; and Davis, CA, 1952, photorevised 1981.

SITE VICINITY MAP

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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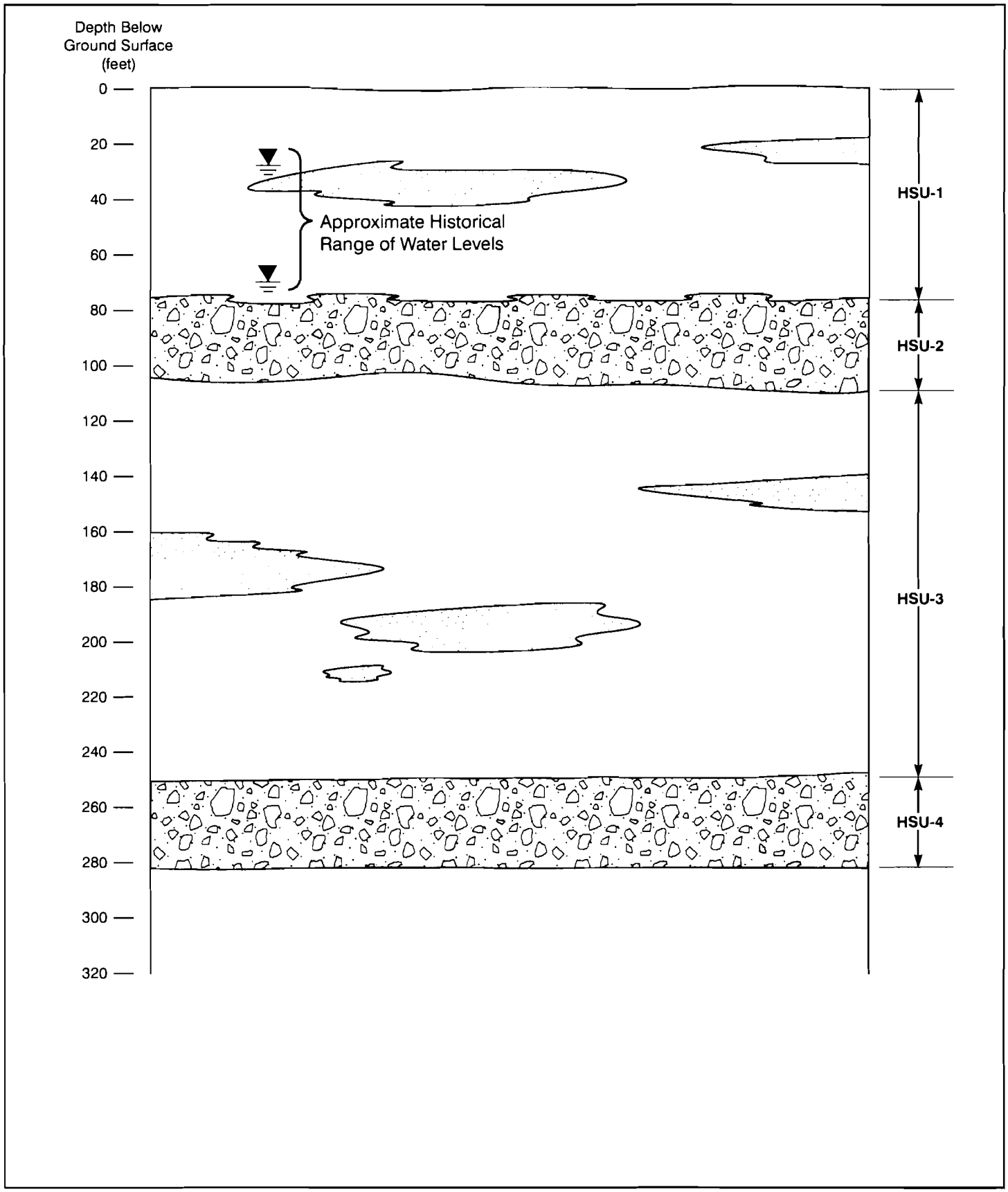
FIGURE 2



SCHEMATIC CROSS SECTION
HYDROSTRATIGRAPHIC UNITS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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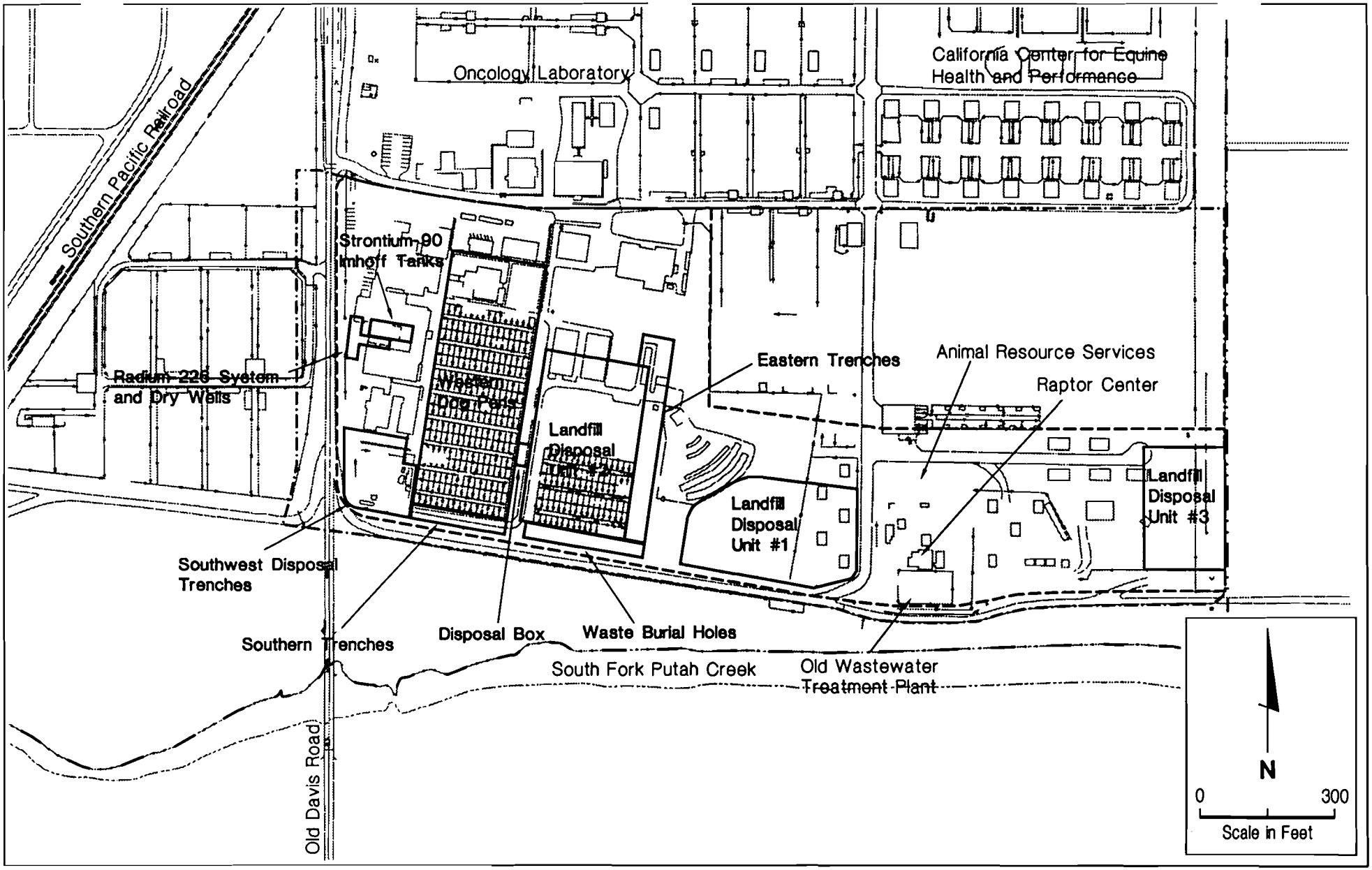
FIGURE 3



EXPLANATION

— · · — · · — Campus Boundary

- - - - - - - LEHR/SCDS Boundary

·—·—·—·— Project Boundary

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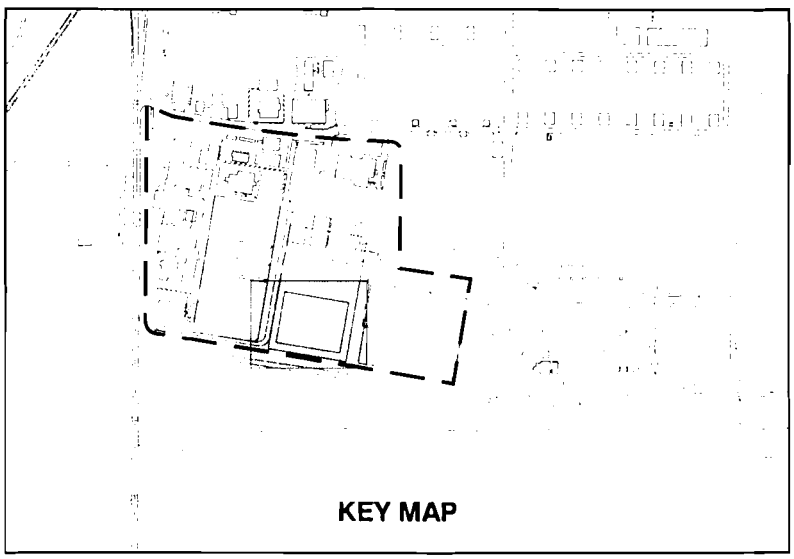
WASTE DISPOSAL AREAS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

FIGURE 4

EXPLANATION

- Trench Location
- Previous Soil Boring Location
- Waste Burial Hole Area
- GPR Anomoly Areas



WASTE BURIAL HOLES SOIL BORING AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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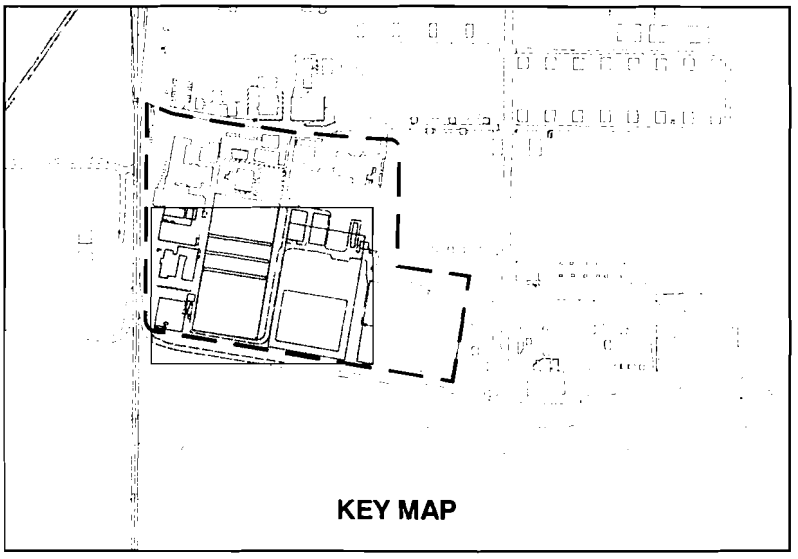
FIGURE 5

EXPLANATION

- Trench Location
- Soil Boring Location
- Previous Soil Boring Location
- Eastern Trench Area
- GPR Anomoly Areas



EASTERN TRENCHES
SOIL BORINGS AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
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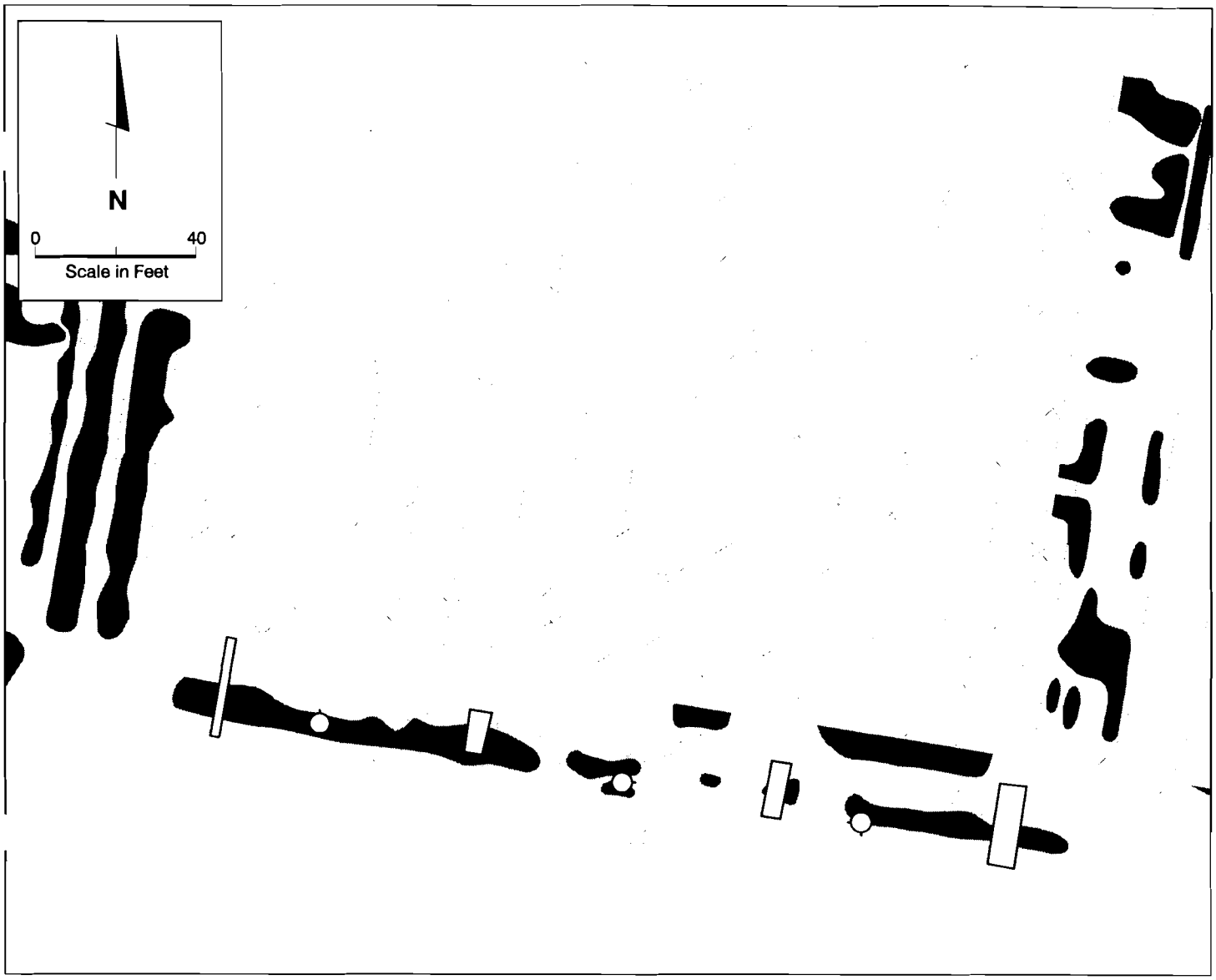
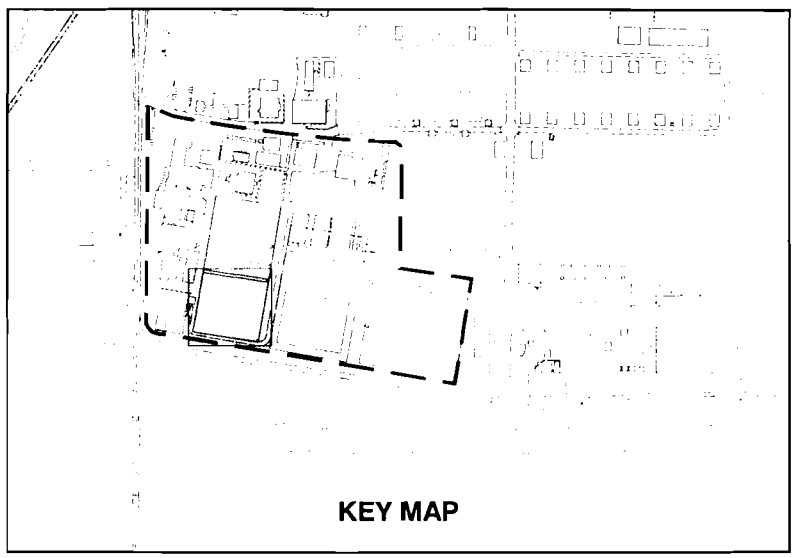
FIGURE 6



EXPLANATION

- Trench Location
- Soil Boring Location
- Southern Trench Area
- GPR Anomoly Areas



SOUTHERN TRENCHES
SOIL BORING AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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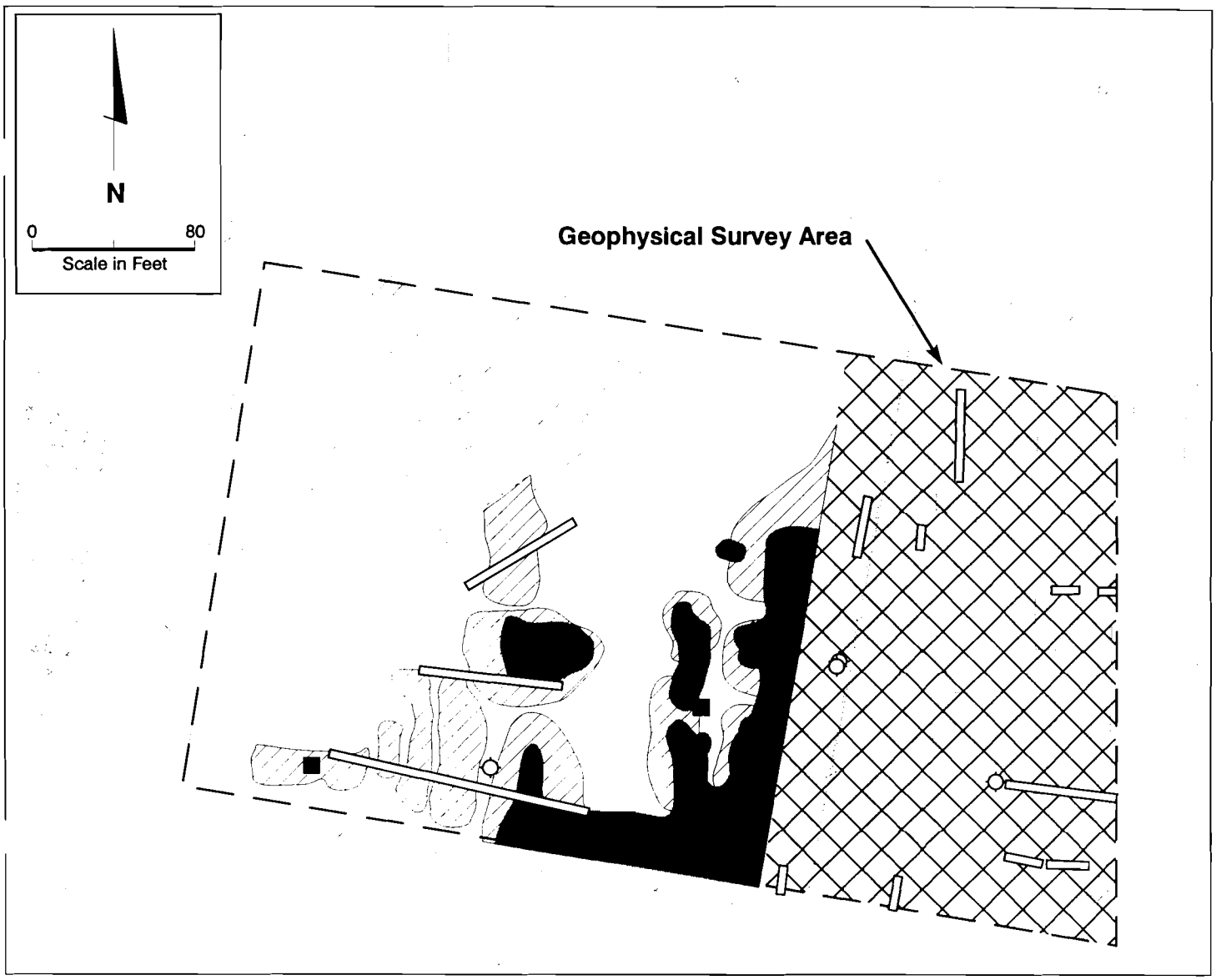
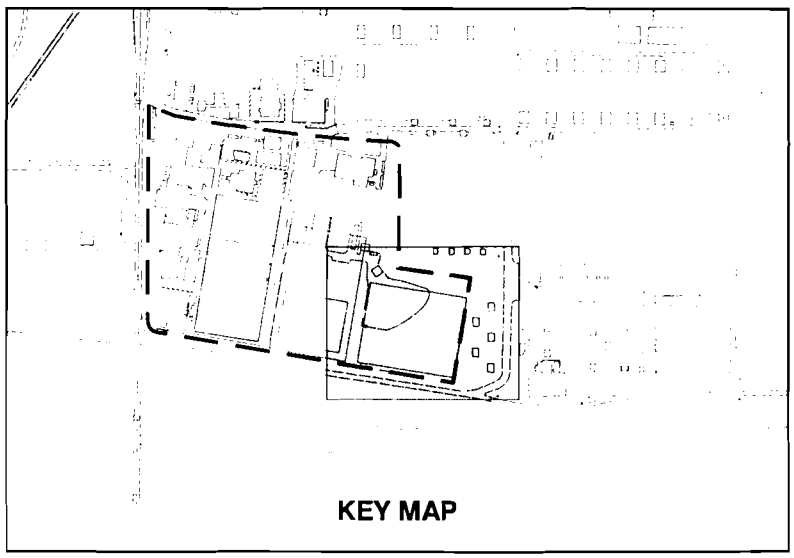
FIGURE 7



EXPLANATION

- Trench Location
- Soil Boring Location
- Previous Soil Boring Location
- Electromagnetic Anomaly
- Magnetic Anomoly
- Proposed Geophysical Survey. Remaining Soil Boring Location to be Selected Based on Geophysical Survey



LANDFILL UNIT #1
SOIL BORING AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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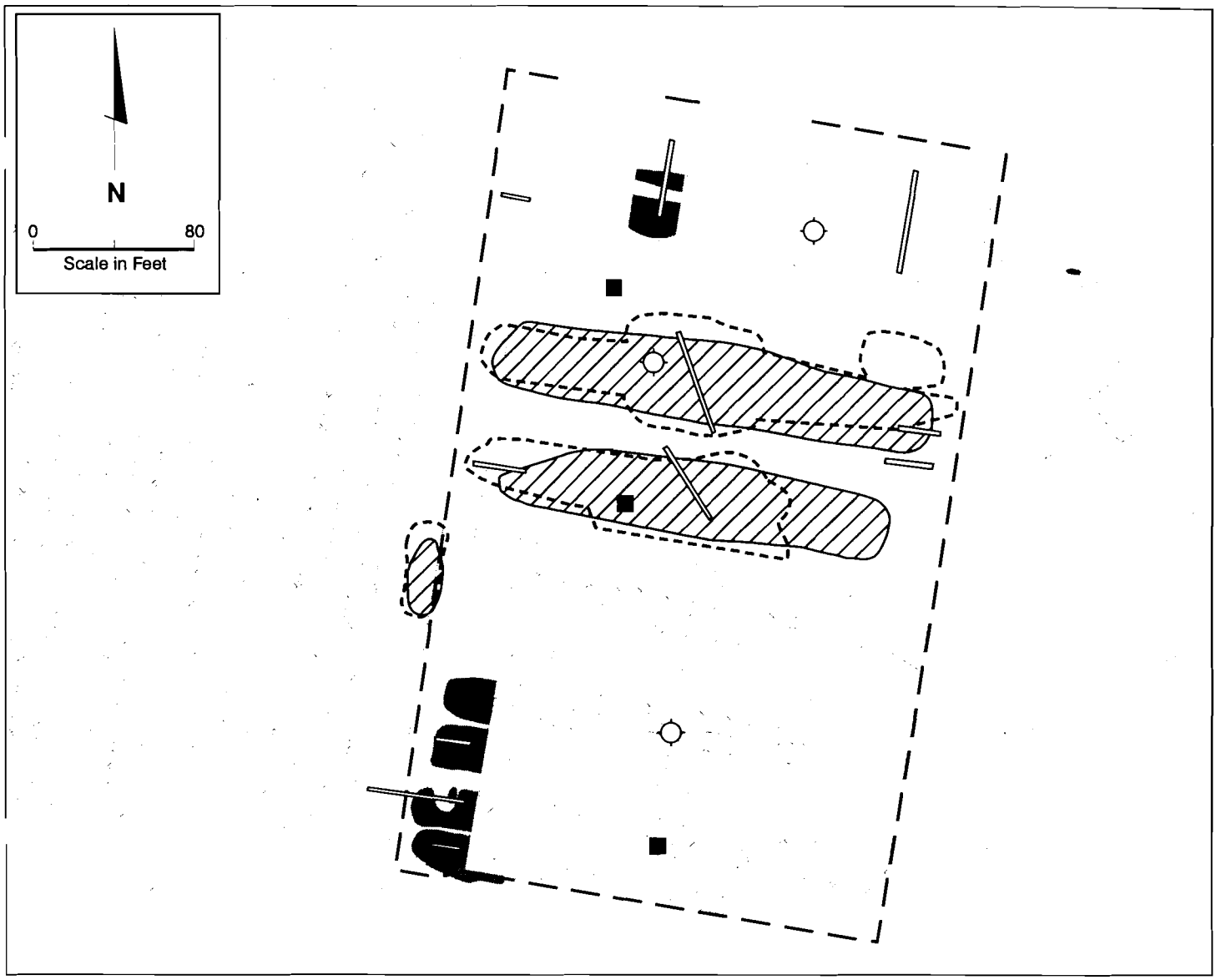
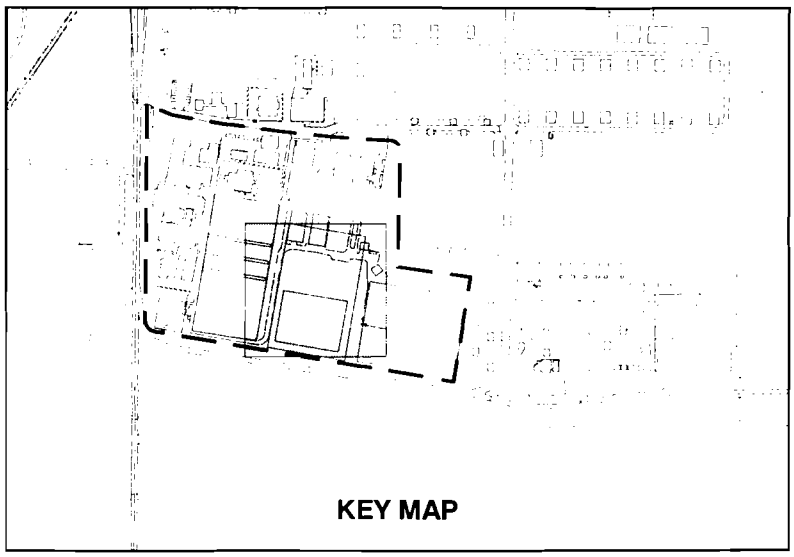
FIGURE 8



EXPLANATION

- Trench Location
- Soil Boring Location
- Previous Soil Boring Location
- Magnetic Anomoly
- Electromagnetic Anomoly
- GPR Anomoly



LANDFILL UNIT #2
SOIL BORING AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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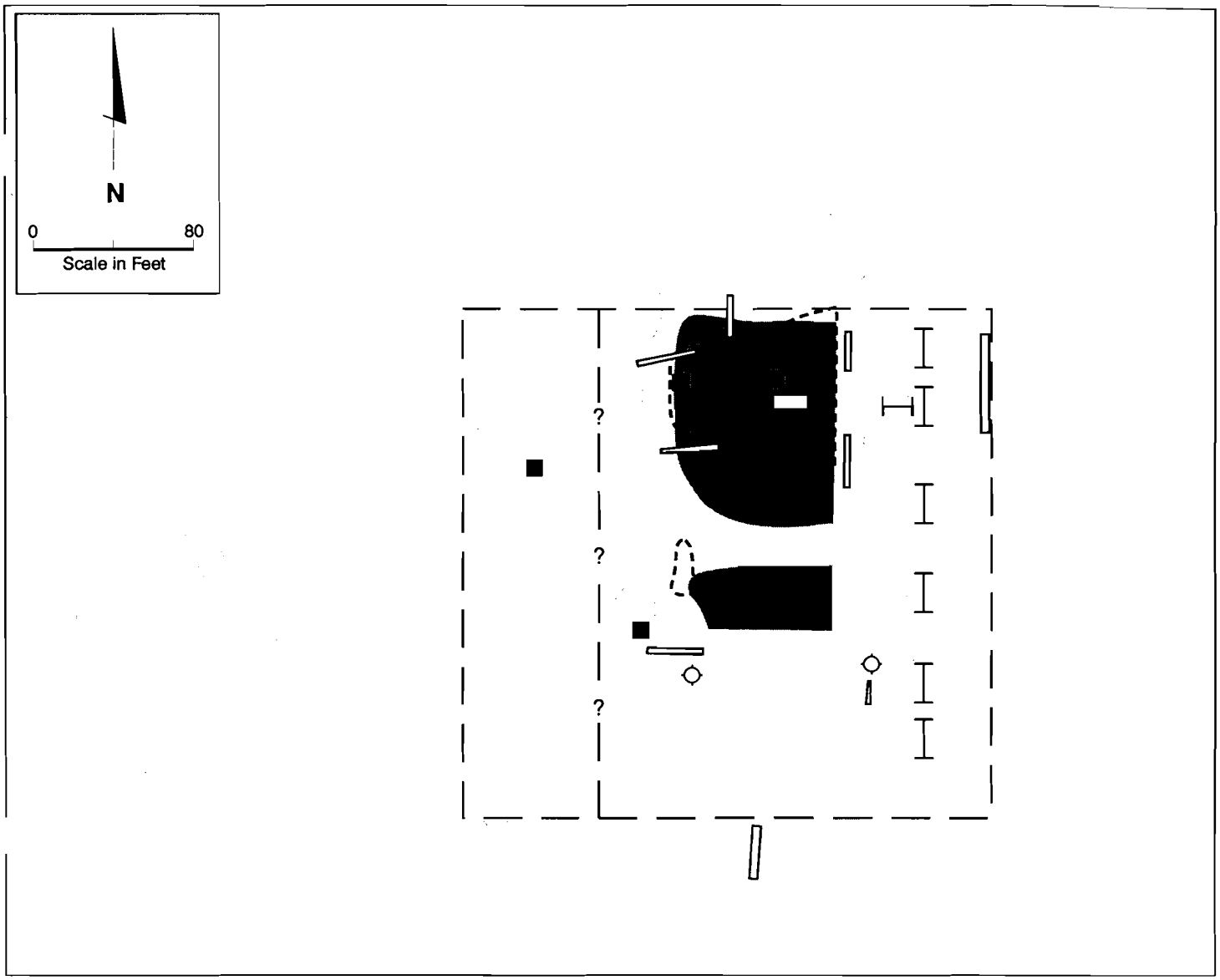
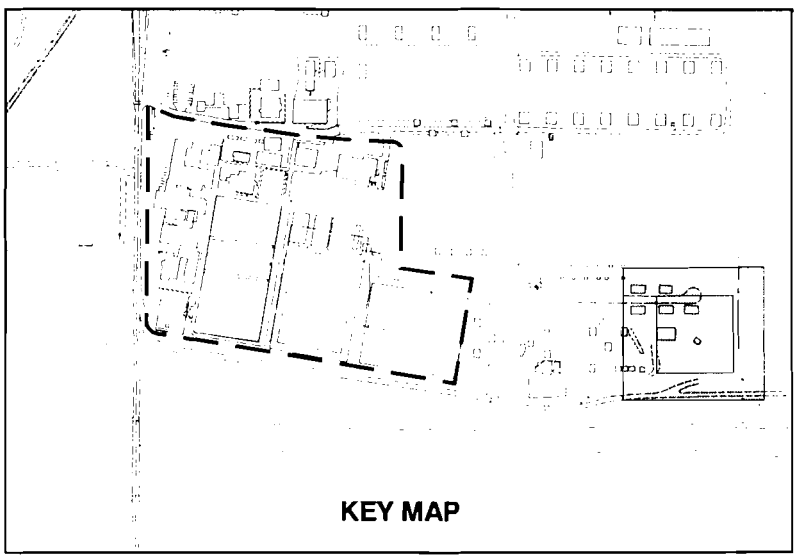
FIGURE 9



EXPLANATION

- Trench Location
- Previous Trench Location
- Soil Boring Location
- Previous Soil Boring Location
- Magnetic Anomoly
- Electromagnetic Anomoly



LANDFILL UNIT #3
SOIL BORING AND TRENCH LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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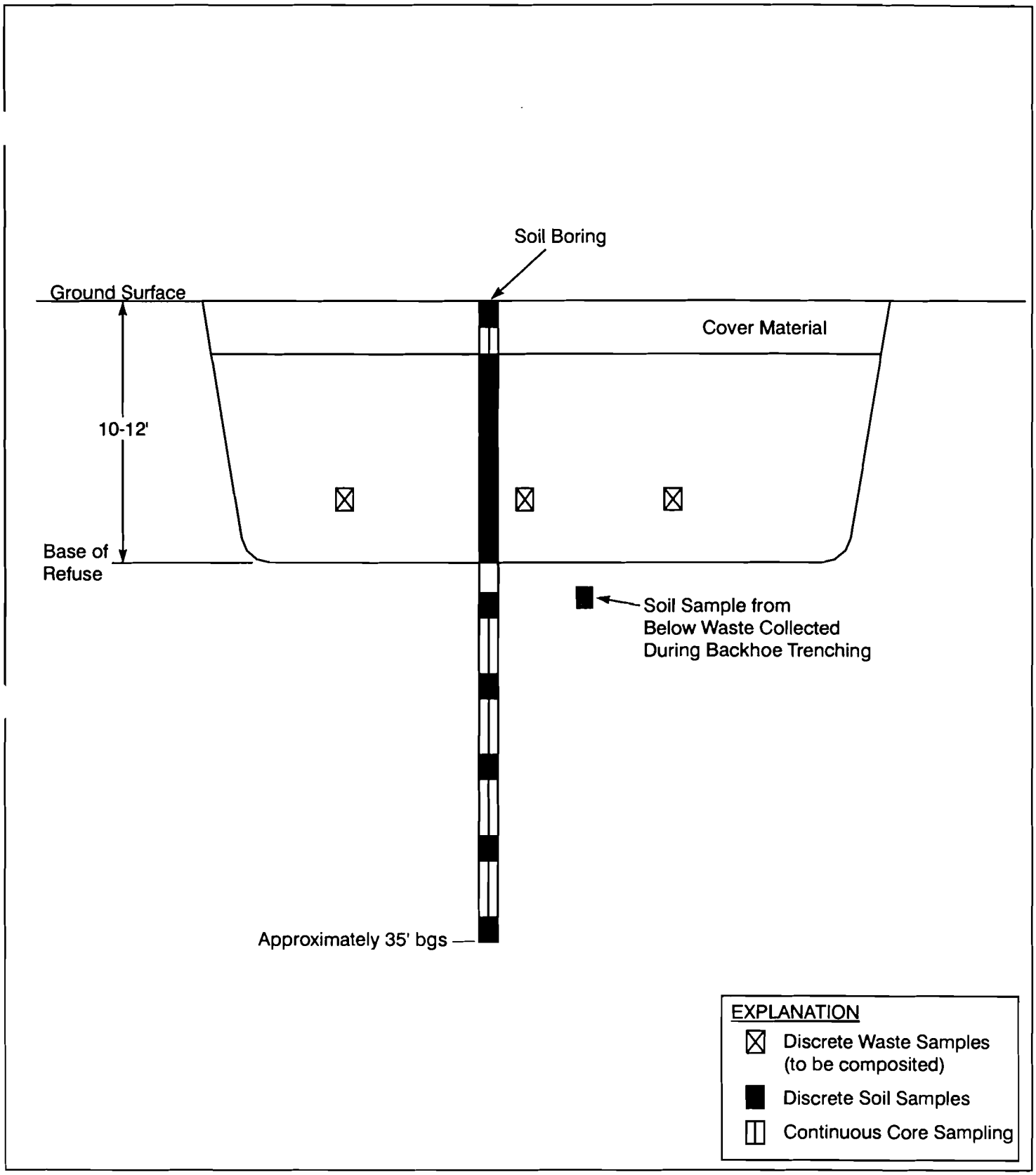
FIGURE 10



SCHEMATIC DRAWING
DISPOSAL TRENCHES AND
LANDFILL SAMPLING POINTS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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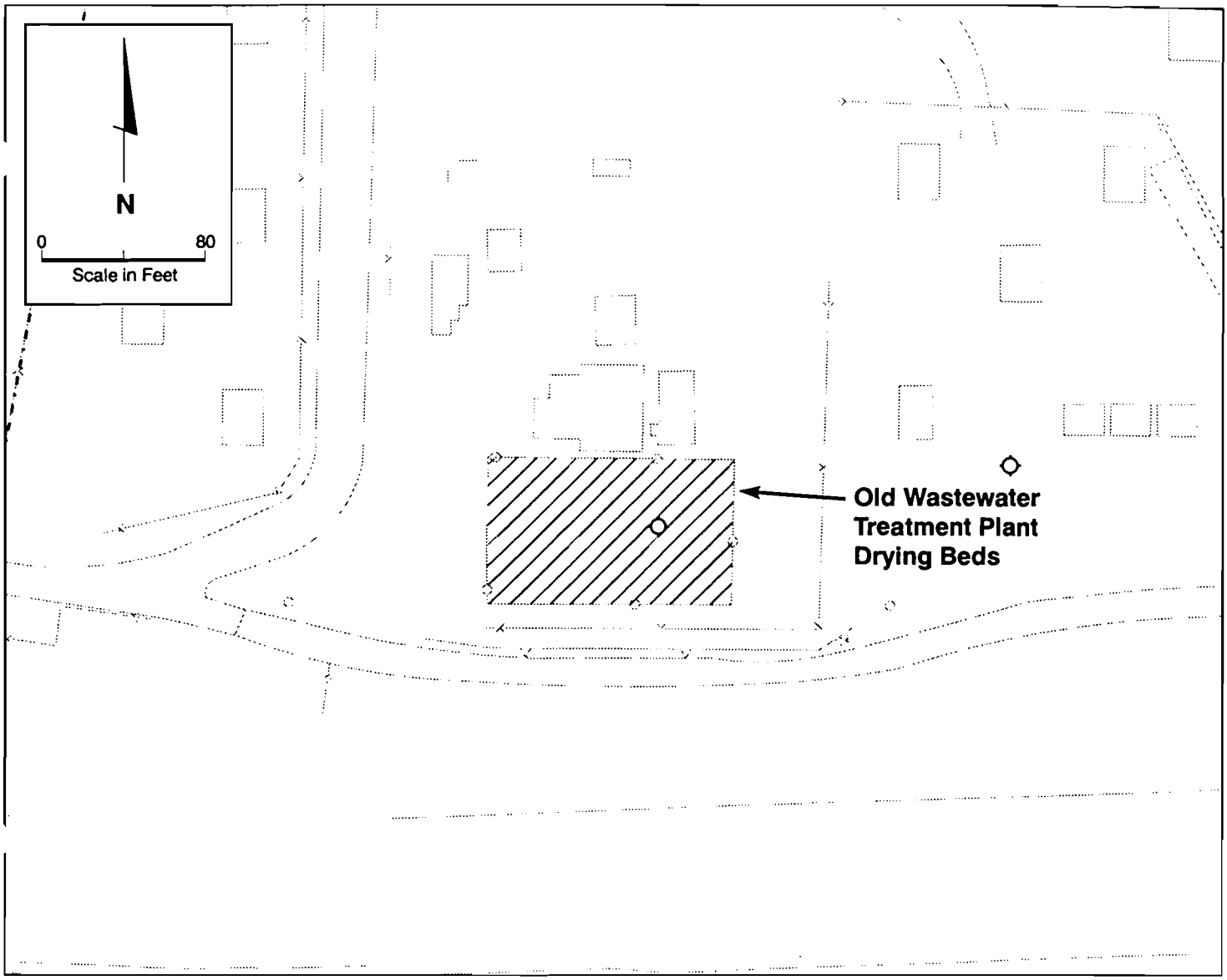
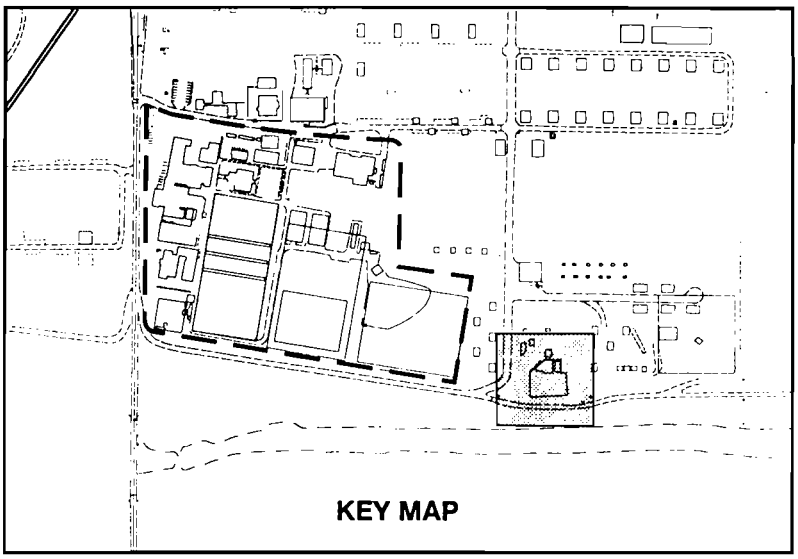
FIGURE 11



EXPLANATION

◇ **Proposed Soil Boring Location**



OLD WASTE WATER TREATMENT PLANT SOIL BORING LOCATIONS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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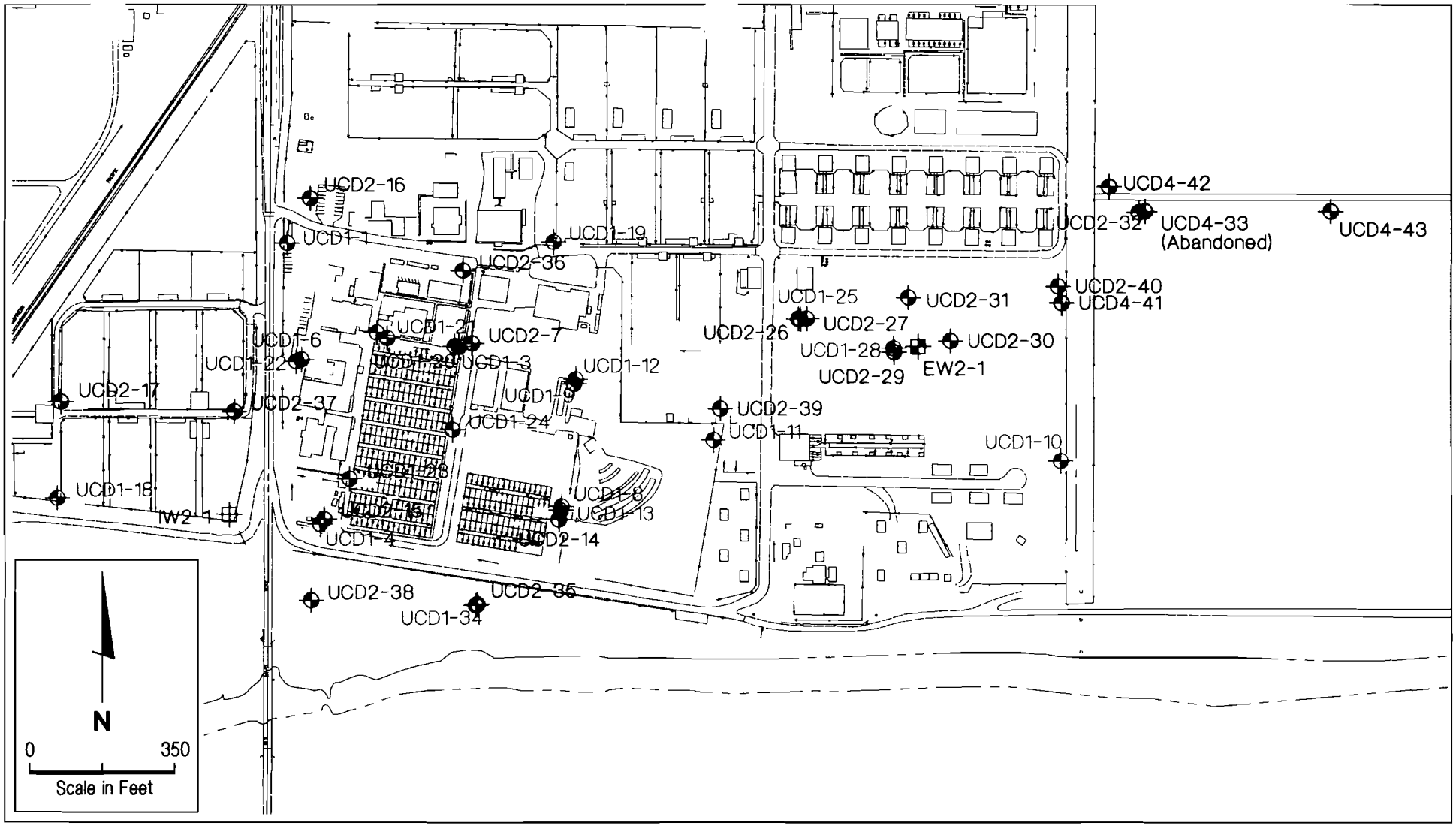
FIGURE 12



EXPLANATION

- UCD1-11 HSU-1 Monitoring Well
- UCD2-17 HSU-2 Monitoring Well
- EW2-1 HSU-2 Extraction Well
- IW2-1 HSU-2 Injection Well
- UCD4-33 HSU-4 Monitoring Well

WELL LOCATION MAP

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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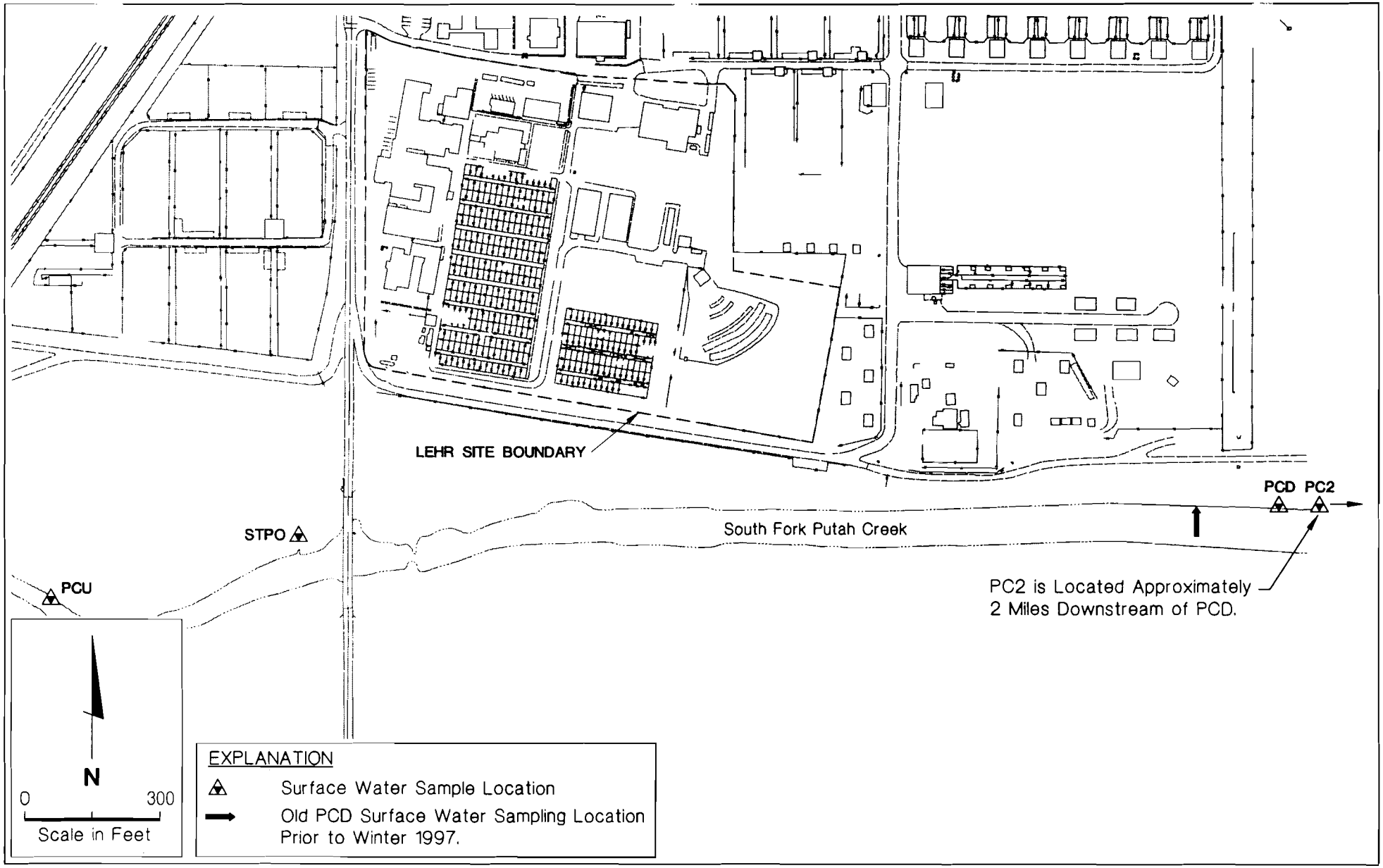
FIGURE 13



LOCATION MAP
SURFACE WATER MONITORING POINTS

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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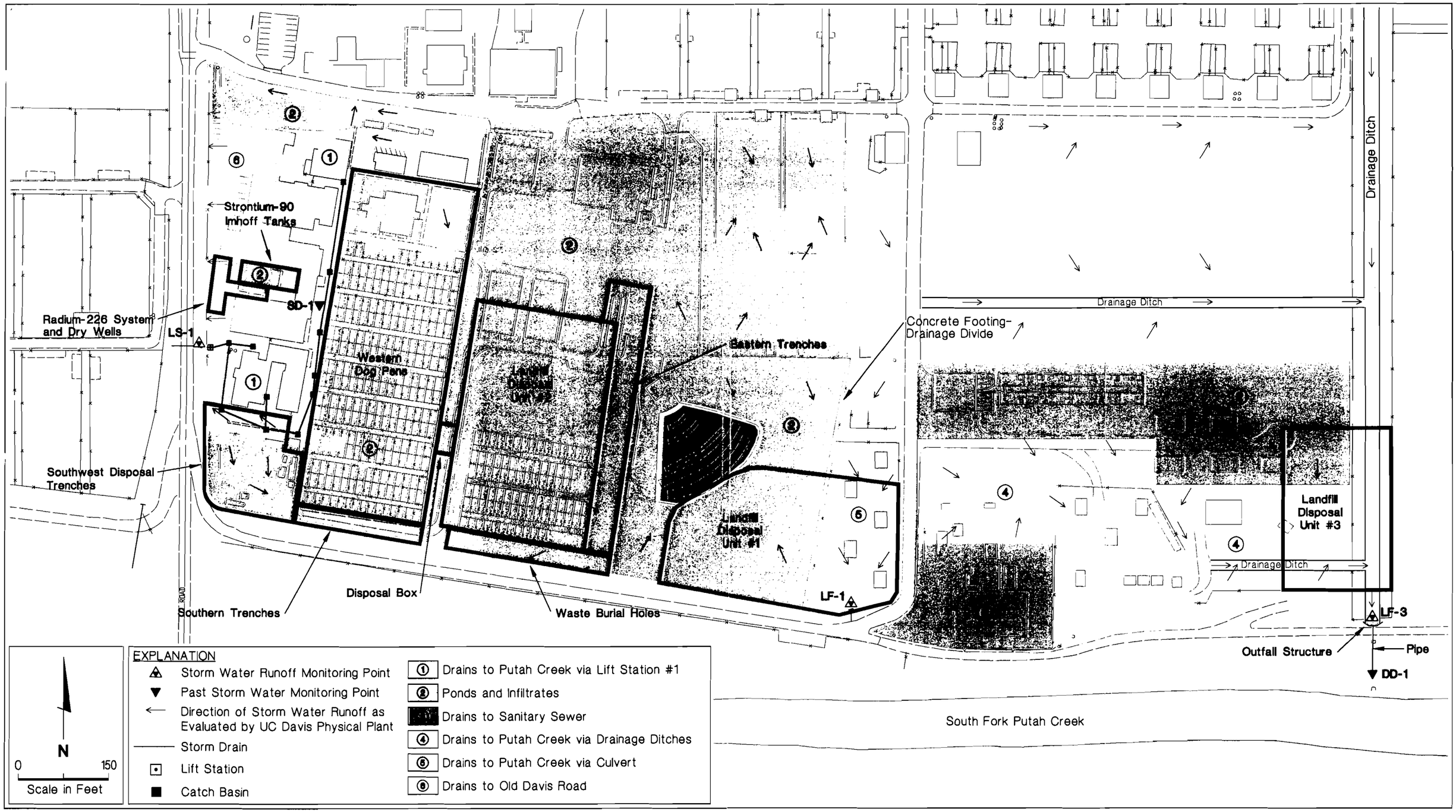
FIGURE 14



LOCATION MAP
STORM WATER RUNOFF MONITORING POINTS
Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California
FIGURE 15

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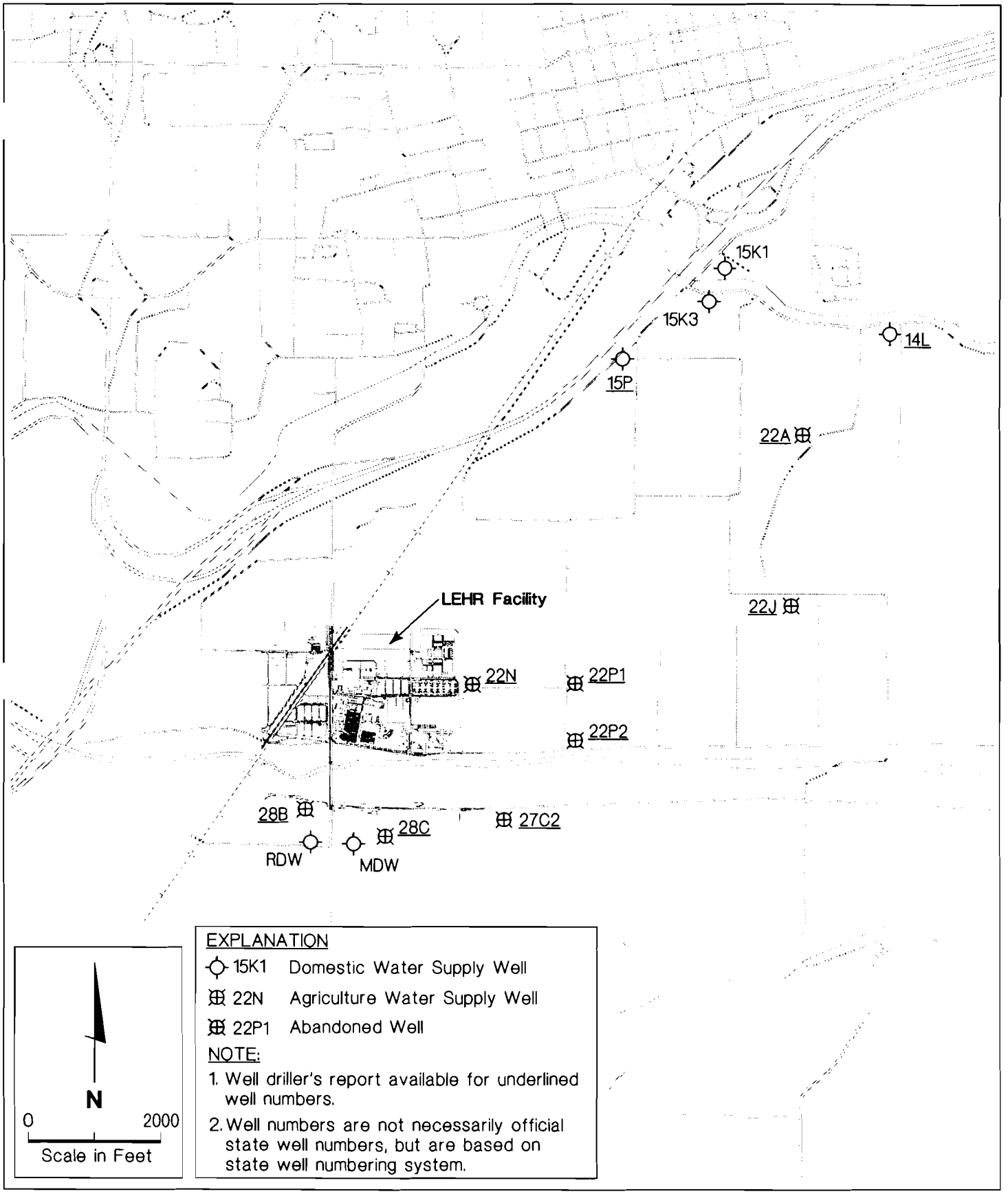

WELL LOCATIONS - NEIGHBOR WELL MONITORING PROGRAM

Revised Field Sampling Plan
LEHR/SCDS Environmental Restoration
Davis, California

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FIGURE 16

APPENDIX A
ATTACHMENT 1

STANDARD OPERATING PROCEDURES

RI/FS
LEHR ENVIRONMENTAL RESTORATION
DAVIS, CALIFORNIA

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DAVIS, CALIFORNIA

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DAVIS, CALIFORNIA

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ATTACHMENT 1

STANDARD OPERATING PROCEDURES

INTRODUCTION

This Attachment describes 32 Standard Operating Procedures (SOP) for field tasks to be completed during RI/FS-EA activities at the LEHR facility. The SOPs are intended to augment the descriptions of sampling, monitoring, and data collection in the text of the FSP. These procedures were developed as general descriptions of field methods that will be employed at various locations and phases of the field investigation. The purpose of the SOPs is to standardize and document field procedures and the collection of field data.

Each SOP describes the purpose, equipment needs, proper field documentation forms, and methodology for a general field task. Specific Health and Safety procedures and information are presented in the site-specific Health and Safety Plan. Field personnel will be familiar with the Health and Safety Plan prior to implementing field procedures. Full-size copies of field documentation forms referenced in the SOPs are included as Appendix B. Many SOPs are subdivided into more specific procedures, when necessary. Overall, the SOPs listed below provide general methods and procedures which may be changed due to variations in field conditions. Changes in procedures will be documented by issuing a Revised SOP. Significant changes made to SOPs that are not documented in a Revised SOP will be controlled and documented using SOP-31.0 (see below).

Procedures for the following field tasks are described in this Attachment:

SOP 1.0	Water Sampling
SOP 2.0	Field Measurements - Water
SOP 3.0	Equipment Decontamination
SOP 4.0	Soil Water and Waste Disposal
SOP 5.0	Sample Shipment
SOP 6.0	Soil Borings
SOP 7.0	Logging of Soil Borings
SOP 8.0	Installation, Construction, and Abandonment - Groundwater Monitoring Wells

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SOP 10.0	Soil Sampling
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SOP 17.0	Air Sampling - Radionuclides in Ambient Air
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SOP 31.0	Change in Standard Operating Procedure
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SOP 33.0	Down-Hole Radiation Monitoring

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 1.0
WATER SAMPLING

Purpose and Scope: The purpose of these procedures is to describe the general methodology for collecting representative groundwater, surface water, and storm water runoff samples for chemical analysis. The following procedures describe the techniques to be implemented for water-level measurements, well purging, sampling withdrawal, and sample collection.

Equipment:
Bailer - stainless-steel, teflon, PVC, or disposable polyethylene;
Bailer reel with twine;
A tarp or plastic sheet;
Water level indicator (100-foot length);
pH meter, conductivity meter(EC), and thermometer;
Eh meter;
Turbidity meter;
Sample containers (laboratory cleaned and provided);
Electric generator;
Electric submersible pump control box;
Oil-less compressor;
Bladder pump control box;
Ice chests; and
Blue ice.

Documentation:
Field Memorandum;
Sample Summary form;
Sample Chain of Custody; and
Instrument Calibration Log.

1.1 SET-UP

Prior to the sampling event, an appropriately trained professional will be responsible for reviewing available information and preparing the proper equipment. Preparation and set-up for water sampling will include the following:

- Review the sample locations and number of samples to be collected with Project Manager;

- Confirm analyte list with Project Manager;
- Notify the laboratory 2-3 weeks in advance of sampling of the number of samples and types of analyses. Request the proper number and type of sample containers. Upon receipt, inspect sample containers, notify laboratory of any missing or damaged containers;
- Coordinate and provide notification of sampling schedule to project managers and other affected individuals, and clear access to wells and/or surface water sampling locations; before sampling on privately owned property, obtain the owner's permission;
- Check and calibrate water level meter, pH, EC, temperature, and turbidity meters to ensure the meters are accurate and are in good working condition (see SOP 2.0);
- Assemble all required equipment and check that it is in proper working condition; and
- As part of preparation and mobilization, a field notebook or file will be compiled to be used during the sampling event. The notebook will include blank copies of the necessary documentation forms including: field memoranda, water sample tracking forms, field records of water sampling, and instrument calibration forms. The notebook may also include well specification information and sample location maps. Upon completion of the monitoring event, the notebook will be turned into the Project Manager for review and approval.

1.2 GROUNDWATER SAMPLING

Groundwater samples will be collected from monitoring wells installed as part of the LEHR Environmental Restoration Program from off-site neighbor wells, and from in-situ water encountered during drilling of soil borings. Monitoring wells, piezometers, and boreholes will be sampled after adequate purging and after field measurements have stabilized. These procedures are described below.

1.2.1 Groundwater Monitoring Wells

Groundwater samples from monitoring wells will be collected after purging so that fresh formation water is sampled. Prior to purging, the field technician will visually check the well for damage and prepare the Field Record of Water Sampling form. All non-dedicated equipment will

be decontaminated, assembled, calibrated, and tested prior to sampling. Monitoring well construction logs, along with available water level data, will be reviewed.

Field instruments will be calibrated prior to beginning daily sampling activities according to procedures outlined in SOP 2.0. Instruments will be calibrated periodically during continuous use as outlined in the QAPP. Calibration information will be recorded on the Instrument Calibration Form and noted on Field Memorandums. All field groundwater measurements will be recorded on Field Record of Water Sampling forms.

The static water level will then be measured with an electric water level indicator. Depth-to-water measurements will be recorded to the nearest 0.01 foot on the Field Record of Water Sampling form. Each well will then be purged to allow sample collection of fresh formation water. Monitoring wells will be purged at rates of two to five gallons per minute with dedicated electric submersible pumps. Purged water will be contained in 55-gallon, DOT-approved drums or similar containers, then transferred to an on-site Baker tank. If the static water level drops below the level of dedicated pumps, no sample will be collected for that well. Purging of each monitoring well will continue until the following two conditions are met:

- Three casing volumes are removed from the well or piezometer. To calculate the volume of water in the well, use the equation:

$$CV = \left(7.48 \frac{g}{ft^3} \right) \times \pi \times r^2 \times H$$

where:

CV = one casing volume of water in well (gallons)
H = height of water column (feet)
r = radius of well casing (feet)

- The field pH, specific conductivity, temperature, and turbidity measurements of the discharged water have stabilized to consecutive readings within 10% of previous readings.

Wells that are pumped or bailed dry prior to removing three casing volumes of water will be allowed to recover and then pumped or bailed dry a second time. Field measurements of

temperature, pH, specific conductivity, and turbidity will then be collected as the well fills again. Samples will be collected when measurements have stabilized.

Samples will be collected as soon as recharge has occurred or at the completion of purging. Samples will be collected for volatiles at approximately 100 ml/minute, and other parameters at rates of 500 to 1,000 ml/minute. The dedicated sample pump or a disposable bailer will be used to obtain the samples from the well. When using a bailer for sample collection, the bailer will be lowered with minimum splash to just below the water surface. Samples will be collected in the following order:

- Volatile Organic Compounds;
- Semi-Volatile Organic Compounds;
- Metals; and
- Other Parameters.

Volatile organic compounds will be collected in containers with no headspace. Sample fractions for metals and other inorganic compounds will be filtered and preserved in the field according to laboratory instruction. Sample preservative requirements are presented in Table 8 of the FSP text. Samples that require filtering will be filtered using a disposable 0.45 μm (micron) filter. If the sample is turbid, a pre-filter will be used to prevent clogging. An adequate sample volume will be pumped through the filter and into the sample containers. The filter will be disposed of and all filtering information will be recorded on the Field Record of Water Sampling form.

Labels will be affixed to each sample bottle recording sample identification number, date, time, analysis required, preservative used, and collectors initials. In addition, all information will be recorded on the Field Record of Water Sampling form and field log along with a description of the physical appearance of the sample including color, clarity, suspended solids, etc.

A Chain-of-Custody Form will accompany each sample to establish the required documentation necessary to trace sample possession. Information on this form includes project number, name, signature of collector, sample number, date and time of collection, sample type (grab or composite), number of containers, analyses required, signature of persons involved in the

chain of possession, and inclusive dates of possession. A copy of the Chain-of-Custody Form will be maintained by the sampling personnel. The Chain-of-Custody Form will be maintained as part of the project files once analyses have been completed and the signed Chain-of-Custody Form has been returned by the laboratory. Sample handling will be conducted as described in SOP 5.0.

Non-dedicated and non-disposable bailers, pumps, meters, reels, water levels meters, and teflon tubing will be decontaminated prior to first use and upon completion of sampling (see SOP 3.0- Equipment Decontamination). Disposable materials will be double-bagged and disposed as non-hazardous refuse.

1.2.2 Piezometer Sampling

Piezometers installed during investigation or remediation activities may be sampled periodically to evaluate water quality. Piezometers will be sampled according to procedures outlined above the sampling of monitoring wells. However, piezometers will not have dedicated pump systems installed so that purging will be completed using a non-dedicated pump or bailer, and samples will be collected using a disposable polyethylene bailer. Any non-dedicated and non-disposable equipment will be decontaminated upon completion of sampling (see SOP 3.0—Equipment Decontamination).

1.2.3 In-situ Groundwater Sampling

In-situ groundwater samples may be collected during drilling by the dual-tube percussion or casing hammer methods. See SOP 6.0 for a discussion of these drilling methods.

This method of sampling is essentially the same as that for monitoring wells, except that the groundwater sample is collected directly from the borehole. The water-bearing formation should be penetrated to a depth that will allow adequate production of water for purging and sampling. A water level reading should be obtained from which to calculate the purge volume. The diameter of the drill casing should be used to calculate the purge volume. Purging may be accomplished either by circulating the water from the hole and through the cyclone with compressed air, or lowering a pump or bailer into the hole. Field groundwater measurements and sample collection procedures are the same as that described above in Section 1.2.1.

1.2.4 Neighbor Well Sampling

Domestic and irrigation wells located adjacent to and downgradient of the LEHR/SCDS are sampled quarterly for specific analytes. Refer to the sampling schedule in Table 7. A map of well locations is provided in Figure 16. Communication and coordination with neighbors should occur approximately two weeks prior to the scheduled sampling. Whenever assistance is required for the sampling (some neighbors need to turn on wells and/or coordinate irrigation schedules with field workers), be sure to maintain a schedule that will allow for this. Except as noted below, sample collection and handling is essentially similar to the above groundwater sampling instructions. Keep all applicable information in the field notebook. Record sample information on the Field Record of Water Sampling form.

Field measurements for the neighbors' wells include temperature, pH, and conductivity. Field instruments will be calibrated prior to beginning daily sampling activities according to procedures outlined in SOP 2.0. Instruments will be calibrated periodically during continuous use as outlined in the QAPP. Calibration information will be recorded on the Instrument Calibration Form and noted on Field Memorandums. All field groundwater measurements will be recorded on Sample Summary forms.

If the well owner has given permission to turn on an agricultural well, look for a power switch usually on a box near the concrete standpipe. Some wells have a red/green button (red off/green on), while others have a large lever on the box as well as an on/off switch. If possible, let the pump run for at least two minutes in order to get fresh well water and not stagnant water. Be sure to obtain neighbor approval regarding the discharge location (at some times of the year or the growing season, it can be detrimental to have the water discharge onto the field or irrigation canal). Collect samples promptly after the two-minute flow to avoid unnecessary water discharge. If the sample cannot be collected directly into the sample container, lower a new disposable bailer into the well standpipe and let it fill with water. Continue filling the bailer until all sample containers are full. Fill volatile organic compound (VOC) vials first, to reduce the potential for loss of analytes.

Domestic well samples are collected as close to the well as is practical. This is usually an outdoor faucet. Let water run for one to three minutes (and/or until the pump is heard to come on).

Never take the first bit of water out of the faucet. Prevent direct contact between the tap and the mouth of the sample container. Be sure to return all hoses or other items to their place and secure the area as directed by the owner prior to leaving the sampling location.

1.3 SURFACE WATER SAMPLING — GRAB SAMPLE

Surface water samples will be collected by a grab sampling method. Prior to collecting surface water samples, the following procedures will be followed:

- Measure and record water depth at the sample location and time of measurement; and
- Collect and record three measurements of pH, conductivity, turbidity, and temperature (see SOP 2.0).

Grab samples will be collected directly into the sample containers or into disposable containers or a glass bottle and then transfered into the sample containers. Sample containers will be filled in the following order (i.e., the order of parameter volatilization sensitivity):

- Volatile organic compounds;
- Semi-volatile organic compounds;
- Metals; and
- Other parameters.

When practical, samples for volatile organic compounds will be collected directly into the sample vials to minimize potential volatilization of the sample. Sample bottles will be labeled with the required information. Complete information will also be included on the Chain-of-Custody and Field Records of Water Sampling Forms.

1.4 STORM WATER RUNOFF SAMPLING — GRAB SAMPLE

Storm water samples from storm drain or sewer systems will be collected by a grab sampling method. Prior to collecting a runoff sample, the following procedures will be followed:

- Measure and record water depth, and record condition of drain or sewer, including floating debris or distinct odors emanating from water. Flow from LS-1 will be recorded using a gauge on the lift station pump. Flow at locations LF-1 and LF-3 will be measured by recording the depth of water in the discharge culverts/pipes.

- Measure pH, conductivity, turbidity, and temperature 2 to 3 times (SOP 2.0 Field Measurements - Water).

Grab samples will be collected directly into the sample containers or by using a disposable container or disposable bailer and then transfered into the sample containers.

1.5 CLEAN-HANDS/DIRTY HANDS SAMPLING

Samples which require clean-hand/dirty-hand sampling technique will be collected using rigorous ultra-clean protocols which are summarized as follows:

- At least two persons, wearing fresh clean-room gloves at all times, are required on a sampling crew.

- One person ("dirty hands") pulls a bagged bottle from the box, and opens the outer, dirty bag, avoiding touching inside that bag.

- The other person ("clean hands") reaches in, opens the inner bag, and pulls out the sample bottle.

- This bottle is opened with a plastic shrouded wrench, and the acidified water is discarded downstream of the sampling site.

- The bottle is rinsed once with sample water, and then filled.

- Preservative (i.e., 0.5% v/v of high purity HCl for Hg and MMHG, 1.0% v/v HCl for other trace metals) may be added at this time, or within 48 hours at the clean laboratory. Samples collected for arsenic speciation must be collected into special bottles with a 2-mm hole drilled in the cap, and immediately frozen in liquid nitrogen. **Note: The hole in the cap is**

necessary to prevent bottle explosion due to inseepage of liquid nitrogen when the samples are thawed.

- The cap is replaced with the wrench, and the bottle re-bagged in the opposite order from which it was removed.

- Clean-room gloves are changed between samples and whenever something not known to be clean is touched.

- Water samples are most cleanly obtained by surface grab, using gloved hands, and facing into a flowing body of water or off the bow of a moving boat. If samples are to be taken from depth, the only non-contaminating method generally available is pumping. A peristaltic pump is used with a short (30 cm) piece of FRESHLY cleaned (heating to 70°C in 2% HCl + 5% CH_3OOH) silicone tubing in the pump. The remainder of the sampling tubing should be 6.5 mm O.D. acid-cleaned Teflon. Once cleaned, silicone tubing quickly absorbs Hg from the air, and so it should be stored in a Teflon jar until use.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 2.0
FIELD MEASUREMENTS - WATER

Purpose and Scope: These procedures describe the techniques to be implemented when field measurements of groundwater, surface water, and storm water runoff are collected. The methods described are intended to provide uniformity and continuity in operation, calibration, and maintenance of both the equipment and measuring techniques by different qualified field analysts or technicians. Measurements described below include pH, electrical conductivity (EC), turbidity, temperature, Eh, dissolved oxygen, and groundwater elevation. Procedures below were derived from manufacturer's recommendations and include methods for calibration and measurement.

Equipment:
pH Meter (one that can perform a two-point calibration) and electrode;
pH buffer solutions (pH 4.0, 7.0, 10.0) (NIST traceable);
Electrical Conductivity (EC) Meter;
EC Reference Standards (NIST traceable);
Thermometer (NIST traceable);
Eh Electrode;
Zoebell's Solution;
Turbidity Meter;
Eh Meter;
Water Level Indicator;
Distilled or deionized Water;
Spray water bottle;
Sample cup or beaker; and
Extra batteries.

Documentation:
Field Memorandum;
Field Record of Water Sampling Form; and
Instrument Calibration Form.

2.1 SET-UP

Prior to taking any field measurements, the sampling personnel will assemble all necessary equipment and check all instruments to be used to ensure they are in proper working condition. Each meter will then be calibrated. Calibration data will be recorded on an Instrument Calibration Form.

2.2 WATER LEVEL MEASUREMENT

Water level measurements will be referenced to a known elevational datum. The measuring point at the top of the casing will be permanently marked and surveyed and measurements will be consistently taken from the same marked point. Water levels will be measured prior to well evacuation with an electrical sounding device, a hydrocarbon interface measuring device, or equivalent device. A hydrocarbon interface measuring device will be used as the primary instrument when the presence of light non-aqueous phase liquids (LNAPLs) or dense non-aqueous phase liquids (DNAPLs) is suspected. Measurements will be made following manufacturer's specifications.

Water levels will be measured by lowering the probe or tape measure into the well until contact with the water surface is indicated. The electric tape will be marked at the reference measuring point and partly withdrawn. Readings will be verified by repeating the procedure until successive measurements differ by less than 0.01 foot, and then recorded. Measuring devices will be decontaminated prior to and after use in each monitoring well.

If the water level measurement indicates the well is dry, the total well depth measurement will be recorded and compared with well construction specifications. If the total depth measurement and the well specifications do not match, the dedicated pumps will be temporarily removed from the well and placed into a plastic bag. The total depth will then be remeasured to ensure that there is no interference from the pump with the water level probe.

2.3 pH MEASUREMENT

The general procedures for the operation, calibration, and maintenance of a field pH meter and its accessories are described below. Manufacturer's specifications and recommendations should be followed or referred to when the need arises.

Prior to use, the pH meter should be examined for cleanliness and checked for defects and any possible need of repair. The checks should include the battery and electrode.

- Battery check will include measurements to determine if it is functional to full scale. Batteries will be replaced or recharged if found weak.

- Electrode check will consist of checking that the electrode is properly connected to the meter. The electrode tip should be covered by a rubber sleeve or cap that protects the electrolyte from flowing out of the opening or from drying. Pull the cap off and save for storage. If bubbles are seen in the bulb area of the electrode, shake the electrode downward. This action will help eliminate bubbles that may have been generated during storage or shipment.

- The meter and electrode will be checked daily by trained personnel according to procedures provided by the equipment's manufacturer.

Procedures for calibrating the meter and for measuring the pH of a water sample are listed below:

- Turn on power;

- Allow meter to stabilize for three to five minutes. Caution: Do not leave or use meter in direct sunlight, cold wind, or rain;

- Calibrate the meter. Calibration schedule should include daily calibration, as well as periodic calibration (see QAPP) during continuous use of the meter. Instrument calibration consists of the following steps:

  — Select two buffer solutions obtained from a commercial supplier (pH 4 and 7 if acidic conditions are expected of sampling water or pH 7 and 10 if alkaline conditions are expected).

  — Measure temperature of buffers using a clean thermometer. Ensure that the thermometer is rinsed with distilled water before and after each use.

  — Rinse electrode with distilled water and replace protective cap.

  — Place pH electrode in pH 7.0 buffer solution and set the temperature knob at the mark indicating the solution temperature.

- Switch the control knob to the "pH" position. Gently swirl the solution and allow reading to stabilize. When reading is stable, enter or adjust the meter to read the appropriate value for the pH 7 buffer at that temperature (the exact procedure will vary for different meters).

- Measure the temperature of the second buffer solution and set the temperature knob at the mark indicating the solution temperature.

- Rinse the electrode with distilled water and place in the buffer solution, allowing reading to stabilize. When reading is stable, enter or adjust the meter to read the appropriate value for the second pH buffer solution After calibration to 2 buffer solutions, rinse the probe with distilled water and place it in the pH 7 buffer. If the meter reads the appropriate value for the pH 7 buffer, it is calibrated.

• Measure pH of unknown solution as follows:

  - Measure temperature of unknown sample solution.

  - Set the temperature knob at the mark indicating the solution temperatures.

  - Place probe into sample and allow meter reading to stabilize.

  - Record data on appropriate form or log.

2.4 ELECTRICAL CONDUCTIVITY

This procedure describes the operation, calibration, and maintenance of a conductivity meter for conductivity measurements and use in field sampling activity. Manufacturer's specifications and recommendations for the instrument used should be followed or referred to when needed.

Prior to using in the field, the conductivity meter should be examined for cleanliness and checked for defects and any possible need of repair. The checks should include whether the battery is operable, whether the conductivity meter is zeroed, and whether its probe is conditioned for proper functioning. Scheduled maintenance will include daily checks by trained personnel according to procedures provided by the equipment's manufacturer.

Procedures for calibrating an EC meter and taking an EC reading of an unknown solution are listed below:

- Check battery level (see above) before using the meter;
- Calibrate or standardize the instrument using a standard solution. Select a standard solution having a conductivity value near expected value of water sample. The standard solution should be of known integrity;
- Measure temperature of the standard solution and adjust temperature correction setting;
- Turn conductivity "RANGE" selector to lowest position that will accommodate the conductivity of the value standard solution on the readout meter;
- Set power switch to "ON" and immerse probe in solution, ensuring that probe is immersed to a depth to cover the electrodes. When immersing probe, dip it up and down in solution to expel any air bubbles inside and immediately outside the probe body; and
- Allow meter to equilibrate, then adjust the "CALIBRATION" knob until meter indicates known value of standard solution on conductivity scale.

To take a reading of an unknown sample solution:

- Immerse probe in sample solution, being certain that electrodes are covered, that all air has been expelled, and that probe is not in contact with the walls or bottom of the sample container;
- Measure temperature of the standard solution and adjust temperature correction setting;
- Turn "RANGE" selector counterclockwise to obtain the appropriate on-scale indication;
- Note meter indication on conductivity scale;
- Remove probe from sample solution and rinse it thoroughly in distilled water before proceeding to measure next samples or putting away the equipment; and
- Record data on log.

2.5 TEMPERATURE

This operating procedure describes the operation, calibration, and maintenance of a thermometer and its accessories for use in the field. Manufacturer's specifications and recommendations should be followed or referred to when the need arises.

Prior to measuring a sample, examine the thermometer for cleanliness, defects, and any possible need of repair. The checks should include the battery and probe.

Procedures:

- Slide switch toward display to turn the unit on;
- If the "LOW-BAT" notation is present in the display, replace battery;
- Take temperature as soon as possible after removing from well or stream and do not take reading when sample is in direct sunlight;

  Stir liquid continuously while measuring temperature;
- Record measured temperature in field log and other required information on the Field Sampling Sheets; and
- Decontaminate probe when finished.

2.6 TURBIDITY

The general procedures for the operation, calibration and maintenance of a field turbidity meter are discussed below. Manufacturers' specifications and recommendations should be followed or referred to, as necessary.

Prior to use, check that the meter is clean and that the battery is charged. If the battery is low, the low-battery light will light up. Calibrate and operate the meter as follows:

- Turn meter on by turning scale knob to "20";
- Place vial with 0.10 NTU standard solution into the measuring chamber. Place cover on chamber to eliminate outside light sources;
- after the digital reading has stabilized, adjust calibration knob to read 0.10 NTU;
- Remove calibration vial and place sample vial (with sample) in measurement chamber. If necessary, clean vial of water droplets or dirt with a clean paper towel; and
- Wait for digital read-out to stabilize and record value on Field Record of Water Sampling form.

2.7 Eh (OXIDATION-REDUCTION POTENTIAL)

The Eh probe and meter are factory calibrated and checked in the field against Zoebell's solution. Zobel Solution has a known value of 231 $\pm$25 mV at 25°C when using an ORP Electrode. The potassium ferric-ferrocyanide Zobell Solution is recommended by the United States Geological Survey (U.S.G.S.), as the standard reference solution. The check is accomplished by the following procedures:

1. Place the shorting cap on the pH input jack. Rinse the ORP electrode and a temperature sensor with deionized or distilled water and connect them to the meter. Pat dry with a laboratory tissue. Follow with a rinse of a small amount of reconstituted Zobell Solution.
2. Pour the Zobell Solution into a sample cup and immerse the ORP electrode and temperature sensor in the solution.
3. Turn on the instrument and allow the sensors to equilibrate inthe solution.
4. Set the function switch to the mV mode. Read the temperature and calcualte the correction to 25°C by adding 1.3 mV for each degree below 25°C, or by subtracting 1.3 mV for each degree above 25°C; or determine the correction by use of the table provided in the Zobell Solution instrument sheet. A corrected reading within 25 mV of the value indicated assures correct electrode function.

2.8 LUDLUM MODEL 2929 DUAL CHANNEL SCALER

See SOP 24.0 Performance checking and Operation of the Alpha Scintillation Smear Counting Instruments, or SOP 25.0 Performance Testing and Operation of the Beta Smear Counting Instrumentation.

2.9 DISSOLVED OXYGEN

For sea-level measurements using YSI 50B dissolved oxygen meter:

- Check membrane for damage; replace if necessary;
- Plug probe into meter. Place membrane in moist 100% humidity protector cap. Turn meter on and allow 15 minutes for the instrument to warm up;
- Calibrate to 100% air saturation by switching the selector knob to the "% cal" setting and adjusting to "100" on digital readout;
- Turn selector knob to "cal." Reading will start at 100%. Monitor read out; if read-out drops more than 0.3%, begin calibration again;
- Switch selector knob to to "mg/L" and insert probe into sample. Agitate until readings stabilize;
- For downhole measurements, drop probe 3 to 5 feet below water surface and raise and lower probe at approximately 1 foot per second until readings stabilize.

For measurements not at sea level, consult table in meter operation guide for adjustment of saturation values for meter calibration.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 3.0
EQUIPMENT DECONTAMINATION

Purpose and Scope: The purpose of this procedure is to describe the SOPs for equipment decontamination to minimize the potential for cross contamination between wells or sampling locations. This procedure describes the methodologies to be followed to maximize proper decontamination of drilling and sampling equipment.

Equipment:
Steam Cleaner;
Four 5-gallon buckets;
Bottle brushes;
Distilled water;
Potable water;
Non-Phosphate Cleaning Solution (Alconox®); and
4-ml plastic sheeting.

Documentation: Field Memorandum

3.1 DECONTAMINATION PROCEDURES

Decontamination procedures described in this section are applicable to any non-dedicated, non-disposable equipment. Disposable equipment will be disposed according to procedures described in SOP 4.0. All investigative-derived wastes will be stored in 55-gallon, DOT-approved drums, or Baker tank, pending characterization for disposal.

Sampling Equipment

Prior to use and after each sample is collected, all soil, groundwater and surface water sampling equipment will be washed twice in a non-phosphate (Alconox®) solution, rinsed with potable water and rinsed again with distilled water. Hard bristle bottle brushes may be used in the first two wash buckets to remove mud and debris. Samplers should be allowed to drain dry after the final distilled water rise.

Drilling and Excavating Equipment

Drilling and excavating equipment, including backhoe buckets, drill bits, casing, augers, and tools or other equipment that may have come in contact with potentially impacted soils or water, will be steam cleaned between each location. The steam cleaner will be capable of generating a working pressure of 2,000 pounds per square inch (psi), a discharge rate of 5 gallons per minute (gpm), and an operating temperature of 200°F.

An on-site area will be designated as the decontamination area. The area will be lined and bermed with two layers of 4 mil visqueen to contain rinsate from steam cleaning operations. The steam cleaning area will be designed to allow the backhoe and drilling rig and support vehicles to drive onto the visqueen. After completion of each boring, drill casing or augers, drill bits and drill rods are transported by truck to the steam cleaning area. Drill casing from the monitoring well drilling procedures will be cleaned while on the support truck. Hollow-stem augers (if used) will be placed on lumber in the decontamination area for cleaning. Rinsate collected in the decontamination area will be collected and disposed of according to the Waste Management Plan.

In addition to the drilling equipment, all monitoring-well casing, stainless steel screen, and centralizers will be steam cleaned prior to installation. Cleaned well materials will be covered with 4 mil visqueen, and transported to the well site.

Submersible Pumps

If a non-dedicated submersible pump is necessary to properly evacuate a well, it will be cleaned using a three step wash. First, the pump intake device is submersed into non-phosphate cleaning solution and run until the bucket is empty. Second, the pump is submersed into a bucket containing potable water and run until the bucket is empty. The second step can be repeated twice to sufficiently rinse the pump. The third step involves rinsing the pump with distilled water using the same method as Steps 1 and 2.

Personnel Decontamination

All personnel will follow the personnel decontamination procedures outlined in the project Health and Safety Plan.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 4.0
SOIL, WATER, AND WASTE DISPOSAL

Purpose and Scope: This SOP describes the general procedure for proper handling, storage and disposal of potentially impacted on-property and off-property soil cuttings and purge water generated during drilling and water sampling. Activities which would generate soil cuttings include: soil borings monitoring well installation; and downhole falling head permeability tests. Activities which would generate purge water and decontamination water include: water sampling; and all activities where decontamination water is generated.

Equipment: DOT-approved transport containers with covers for soil and water (e.g., 55-gallon drums, 20-yard roll-off bins, Baker Tanks, etc.); and Appropriate sample containers and sampling equipment.

Documentation: Field memorandum

4.1 CONTAINMENT

Drill cuttings and water generated during drilling may be containerizeded in DOT-approved transport containers. Purge water resulting from water sampling will also be contained. Containers will be labeled by field personnel to identify contents, date, and source location (well or boring ID). Labels will be weather-resistant vinyl, and waterproof ink markers will be used. Disposable equipment, including personnel protective equipment, will typically be double-bagged and disposed as non-hazardous waste.

4.2 DISPOSAL

Disposal of any waste from the LEHR/SCDS facility will be conducted under appropriate state and federal regulations and according to procedures described in the Waste Management Plan.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 5.0
SAMPLE SHIPMENT

Purpose and Scope: The activities described in this procedure outline general methodology to be used during the shipment of soil, water and sediment samples to the analytical laboratory. The objectives of this SOP are as follows:

- Ensure quality control in the shipping of soil, water and sediment samples;
- To develop uniformity of operation between different field personnel;
- To serve as a means that will allow traceability of error(s) during shipment; and
- To set forth procedures by which legal chain-of-custody documentation is followed.

Equipment: Cooler suitable for sample shipment and holding ice ;
Custody seals;
Shipping tape and packaging materials;
Absorbent material;
Labels;
Zippered storage bags;
"Blue" type ice;
Ludlum Model 2929 Dual Channel Scaler; and
Swipes.

Documentation: Field Memorandum
Sample Chain-of-Custody (COC) Form

5.1 PROCEDURES

Samples collected in the field will be stored during the day in the field in ice-cooled containers. Samples collected during the morning may be temporarily stored in a refrigerator (if available) until shipment in the afternoon. All samples stored in the coolers or the refrigerator will be documented on the sample tracking form. When samples are being packaged for shipment, the procedures listed below will be followed.

1. Field personnel will visually screen each sample in the cooler for loose surface contamination, and confirm that each sample is listed on the sample tracking form and the COC. If field data collected at the time of sampling indicates the potential

for radioactive material in a sample, the sample will also be screened for loose surface radioactivity.

2. Each cooler will be numbered. The number of each cooler will be noted on the sample tracking form and the COC. In addition, the freight identification number will also be noted on the sample tracking form and the COC.

3. Samples will be packed with abundant packaging material to minimize the potential for damage during shipment. Samples will be packaged with either "wet" ice or "blue-ice," as necessary to maintain appropriate temperature.

4. The completed COC will be signed and placed in a plastic zippered storage bag and taped to the inside cover of the cooler.

5. Custody seals will be placed on the cooler, then the cooler will be taped shut with clear shipping tape.

6. Samples will typically be shipped to the laboratory daily. Copies of the completed COC will be kept in the field office by the field manager.

7. Upon receiving the sample shipment, the analytical laboratory will inspect the sample containers for damage, compare the shipment to the COC, and conduct a radiologic survey.

8. The laboratory will sign and date the COC, noting the appropriate information and deficiencies, and immediately fax a copy of the COC to UC Davis or contractor representative.

9. Upon receiving the fax of the COC, the Task Manager authorize analysis of the sample shipment or provide appropriate direction to the laboratory to address the deficiencies.

10. Daily contact will be made by the sampling personnel with the laboratory Project Manager to inform them of the coming shipment.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 6.0
SOIL BORINGS

Purpose and Scope: The activities described in this procedure outline general methodology to be used in drilling penetrative soil borings. The resulting borings can be used for stratigraphic description, well construction, physical and chemical sampling, and down-hole hydrogeologic tests. This procedure describes the equipment and forms required, as well as set-up procedures to be completed for each boring. In addition, various drilling methods that may be used during remedial action, and borehole abandonment procedures are detailed.

Equipment: Drilling rig, drilling tools, and support truck with water tanks;
Steam cleaner;
Grout plant and tremmie pipe;
Portland cement, Types I through V;
Powdered bentonite; and
Plastic Sheeting;

Documentation: Field Memorandum; and
Soil Boring Log.

6.1 SET-UP PROCEDURES

All set-up and soil boring procedures will be conducted under the supervision of a Geologist, Hydrogeologist, or Engineer. UC Davis or contractor field personnel are responsible for:

- Identifying each borehole location;
- Confirming the drilling location with the project manager and UC Davis personnel;
- Review Health and Safety Plan;
- Obtaining proper clearance for potential above- and below-ground hazards; and,
- Obtaining proper permitting prior to initiating drilling.

Prior to drilling, and between each borehole location, all down-hole drilling and sampling tools will be steam cleaned. The work area will be well marked with traffic cones and barricade tape. In some cases, special arrangements may need to be arranged to penetrate surface paving

(concrete). Cuttings generated during drilling will be controlled by lining the borehole area with plastic sheeting and by storing in 55-gallon drums or bins.

Upon completion of each boring, all by-products will be properly stored and labelled (see SOP 4.0 Soil, Water, and Waste Disposal). The location will be clearly marked or staked for surveying.

6.2 DRILLING METHODS

This section provides a brief description of five drilling methods that may be used during remedial activities on the Site. The method actually used will depend on the use and anticipated depth of the boring, and the material anticipated to be encountered.

6.2.1 Dual Tube Percussion and Casing Hammer Methods

The dual tube percussion and air rotary casing hammer methods will be used in cases where boreholes penetrate unconsolidated material containing intervals of cobbles or boulders.

Where dual tube percussion methods are specified, ten-foot-long dual flush threaded casing sections fitted with O-rings will be used. The outer diameter is approximately 10 inches, the inner diameter is approximately 9 inches. Compressed air will be used to circulate drill cuttings up the inside of the inner tube. Water level measurements and drive samples can be collected from within the inner tube. A boring log based upon continuous or interval sampling and observed cuttings, will be prepared in accordance with the lithologic logging procedures outlined in SOP 7.0 Logging of Soil Borings.

Where casing hammer methods are specified, ten-foot flush threaded drive casing sections fitted with hollow drill rod will be used. The outer diameter of the drive casing is approximately 10 inches. Compressed air will be forced down the drill stem and out the drill bit to circulate drill cuttings up the annulus. Drill cuttings will be collected at least every five feet and stored in plastic bags. Water level measurements can be collected with the drill rods in place, however drive samples can be collected only after the drill bit and rod have been removed from the borehole.

Drive samples can usually only be collected at breaks in the drive casing (in this case every ten feet). A boring log based upon recovered drive samples and observed cuttings, will be prepared in accordance with the lithologic logging procedures outlined in SOP 7.0.

6.2.2 Hollow-stem Auger Method

The hollow-stem auger method will be used in cases where shallow penetrative work is to be conducted in unconsolidated sediment.

Where hollow-stem auger drilling methods are specified, hollow-stem augers, with lock bolt jointed 5-foot sections, and drill rod, plug, and bit assembly will be used. Auger diameter will be selected based upon auger availability, drilling rig capability, anticipated boring depth, sampler type, and intended boring use. A boring log based upon continuous or interval sampling and observed cuttings, will be prepared in accordance with the lithologic logging procedures outlined in SOP 7.0.

Drilling fluids will be used with hollow-stem augers only in cases where flowing sands require maintenance of a positive hydraulic gradient between the inside and outside of the augers. In those cases, potable water will be pumped directly to the inside of the augers. If the drill rod assembly within the auger should become bound by flowing sands, potable water will be pumped to the top of the drill rod assembly and the assembly will be raised and lowered through the augers until they become unbound. The source, time, and duration of use, and rate of flow of drilling water, as well as justification for water use, will be recorded on the boring log.

6.2.3 Rotary Drilling Methods

Rotary drilling methods (non-air) will be used in cases where deep penetrative work is to be conducted in unconsolidated sediments or shallow penetrative work is to be conducted in soft rock and other deposits containing boulders.

Where rotary drilling methods are specified, a drill pipe fitted with a roller, drag bit, or drive shoe will be used. The type and diameter of the bit or shoe will be specified based upon

availability, formation characteristics, drilling rig capability, anticipated boring depth, sampler type, and intended boring use (i.e., for monitoring well construction).

A boring log, based upon continuous or interval sampling and observed cuttings, will be prepared in accordance with the lithologic logging procedures outlined below in SOP 7.0.

Where appropriate, temporary surface casing may be installed to prevent migration of ground water through the borehole. Sealing of the surface casing will be specified based upon site geology and aquifer characteristics.

Potable water mixed with bentonite will be the only drilling fluid used in direct rotary applications. A portable, steel, two-stage drilling mud pit with steel gate will be used. The mud pit base will be fitted with a rubber, bentonite, or cloth gasket to prevent circulation loss at the ground surface. Make-up drilling water will be added directly to the mud pit. Settled fines will be periodically removed from the first stage of the pit. The rate of necessary drilling water make-up will be recorded on the boring log.

6.2.4 Enviro-Core® Method

The Enviro-Core® drilling and sampling method will be used for shallow penetrative work in unconsolidated sediments where no permanent groundwater well is planned and where minimal cuttings should be generated. Continuous core, discrete soil drive samples, or groundwater samples can be collected with this method.

The Enviro-Core® drilling drives two nested sampling rods with a hydraulic hammer, or vibrator, or by pushing. The small-diameter inner rods are used to obtain and retrieve the soil cores; the larger-diameter outer rods serve as temporary drive casing.

As the Enviro-Core® rods are advanced, soil is driven into a 1 5/8-inch-diameter, 3-foot-long sample barrel that is attached to the end of the inner rods. Soil samples are collected in 1 1/2-inch-diameter by 6-inch-long stainless steel sleeves inside the sample barrel as both rods are advanced. After being driven 3 feet, the inner rods are removed from the borehole with a hydraulic winch.

The stainless steel sleeves containing the soil samples are removed from the drive sampler, and can then be preserved for chemical analysis or used for lithologic identification. After adding new stainless steel sleeves, the drive sampler and inner rods are then lowered back into the borehole to the previous depth, an additional 3-foot section of Enviro-Core® rods (both inner and outer) is attached, and the process is repeated until the desired depth is reached.

The use of outer rods prevents sloughing of the formation while the inner rods are withdrawn from the hole. This ensures that the drive sampler will always be sampling soil from the desired interval, rather than potentially contaminated soil that has sloughed in from higher up in the hole. Sampling equipment will be decontaminated as described in SOP 3.0.

6.2.5 Resonant Sonic Drilling (Sonic Coring)

The resonant sonic drill head is a hydraulically activated unit that imparts high frequency sinusoidal wave vibrations into a drill string to effectuate a cutting action at the bit face. The resultant cutting action forces a circular continuous core of the formation up into the drill string. Due to the high forces developed by the resonant head and the external flush nature of the specialized drill string, excess formation material generated by the cutting face of the bit is forced into the borehole wall thus resulting in the generation of no cuttings in the drilling process. Through the development of various sizes and types of tooling, boreholes of different depths and dimensions can be drilled. The sonic method of drilling yields continuous relatively undisturbed cores; uses no air, mud, water, or other medium for penetration; drills through most types of formation; can drill at any angle from horizontal to vertical; and yields no cuttings in the drilling process.

6.3 BOREHOLE DESTRUCTION

All soil borings will be permanently sealed to prevent vertical migration of contaminants. Soil borings shall be destroyed by backfilling, from bottom to the surface, with Holeplug™, Enviroplug™, Volclay™, or a cement-bentonite grout slurry. Boreholes that extend below the water table will be backfilled by tremmie method. Grout material in boreholes that do not penetrate the water table can be poured from the surface.

- Holeplug™ and Enviroplug™ bentonite do not require mixing but are poured into the borehole dry and charged with clean water.

- Volclay™ and cement-bentonite grout (herein termed cement grout) require mixing with clean, potable water. The mix should not contain more than 5 percent bentonite.

Soil borings that penetrate two or more HSU levels will be plugged with cement grout from bottom to top.

After 24 hours, the grouted borehole shall be checked for grout settlement. That day, any settlement depression shall be filled with grout and checked 24 hours later. This process shall be repeated until firm grout remains at the ground surface.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 7.0
LOGGING OF SOIL BORINGS — USCS

Purpose and Scope: This procedure describes basic methods for logging soil borings. Logging of soil borings assures that data, information, and descriptions generated from each borehole are properly collected and documented. This procedure describes equipment and forms required, the information necessary to complete a boring log, and methods for describing drill cuttings and soil samples.

Equipment:
Hand Lens;
Dilute HCl;
Soil Knife;
Water Level Indicator;
Rock Hammer;
Measuring Tape;
Compass; and
Plastic Bags.

Documentation:
Field Memorandum; and
Soil Boring Log.

7.1 BORING LOGS

The boring log form that will be used to record information during drilling is included in Attachment 2. The procedures which will be followed in completing the boring log are outlined below.

On the first page of the log for each boring, the following information at the top of the boring log will be filled in completely and will include:

- Job Number
- Client's Name
- Job Location
- Boring Number
- Drilling Contractor
- Operator's Name
- Rig Number, if there is more than one at the site

- Name of Person Conducting the Logging
- Elevation and Reference Datum
- Complete and accurate location sketch with dimensions to landmarks. Important features such as road intersections, corners of large buildings, or other man-made structures are best used. A north arrow will be included.

Water levels will be recorded each day prior to drilling start-up and as appropriate. The casing depth must be noted for each water level reading. Drilling mud use must be noted, if appropriate. Water levels will be referenced to ground surface, unless otherwise noted. The field personnel will identify a specific static water level at the conclusion of the boring. However, any questions about the water level having reached equilibrium will be noted. When more than one boring is drilled, the elevations of the water levels will be tabulated to permit a field check of the consistency of readings from boring to boring.

The exact drilling and sampling methods used will be indicated, as well as the bit type and size, drill rod size, hammer weight and drop, types of samplers, and the rig type. Surface conditions will be noted, including vegetation or ground cover and land use, general topography (rolling, level, etc.), and physical features (hillside, river bottom, etc.). Sheet (Page) Number. The time and date of the commencement and conclusion of the boring down time, and the end and start of each shift should also be noted on the log. Each succeeding page of the field log should contain at a minimum:

- Job Number
- Client Name
- Boring Number
- Permit Number (where applicable)
- Sheet Number
- Any Water Level Measurements

Upon completion of each boring, a standard completion note will be placed at the bottom of the last page of the boring log. The note will include:

- Boring Completed at (Depth) Feet on (Date)

- Casing Used to a Depth of (Depth) Feet on (Date)
- Ground Water Level Recorded at (Depth) Feet on (Date)
- Hole Backfilled to Ground Surface on (Date)
- The casing size and depth will be recorded
- All depth numbers will be recorded in decimals.

7.2 LOGGING PROCEDURES

The left side of the boring log will be filled out accurately and completely for each soil sample and sampling attempt. The following information will be included:

- The sampler type. The abbreviations for sampler types are TW for thin-wall, P for piston, ST for Shelby Tube, and SS for standard split spoon. These abbreviations, or notations as to other sampler types, will be used in the "sampler type" column.
- The inches driven and recovered for each sample attempt.
- The depth of casing for each sample attempt.
- The sample number and depth. The sample depth is always measured to the top of the sample. A sample attempt where no sample is recovered will not be numbered, but the fact that a sampling attempt was made must be noted.
- The blow count for each 6-inch interval will be recorded opposite the appropriate interval on the depth scale.
- The sampling attempts will be marked in the "depth in feet" column.

The right side of the log will contain a detailed description of the soil strata encountered and all pertinent information regarding drilling operations and estimated soil and ground water properties.

- Soil will be classified according to the Unified Soil Classification System (USCS) (Figure SOP7.1). The textural name for the soil will be written in the "soil graph" column at the appropriate depth interval.

- Abrupt soil changes will be marked by a solid horizontal line and the appropriate depth in the "soil graph" column. Gradational soil changes will be marked by a dashed line. Diagonal lines should not be used. (Field personnel are best qualified to estimate the depth of changes. This task will not be delegated to office personnel, who have not observed the drilling operation.)

- Soil color descriptions will be consistent with the Munsell Soil Color Chart.

- Abbreviations will be used on the logs to save space for editing purposes.

Comments on the field log are extremely important. Some important aspects of the drilling operation that will be recorded follow:

- The organic content of the soil and the depth of topsoil and roots;

- Any sudden change in the speed, sound, or penetration rate of the drill rig;

- If sampling is not continuous, drill cuttings will be used to complete the log; and

- Any sample that is suspect of being disturbed, contaminated, or chemically or physically altered during the drilling process.

On jobs lasting more than a few days, field personnel will make specific arrangements for sending boring logs to the Project Manager, or someone designated by the Project Manager. Field personnel will retain one copy in the field for reference throughout the job.

MAJOR DIVISIONS			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SANO-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADEO SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRAOED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

UNIFIED SOIL CLASSIFICATION

RI/FS - EA Work Plan
LEHR Environmental Restoration
Davis, California

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 8.0
INSTALLATION, CONSTRUCTION, AND ABANDONMENT GROUNDWATER MONITORING WELLS AND PIEZOMETERS

Purpose and Scope: This operating procedure describes the procedures for the construction, installation, and development of groundwater monitoring wells. These methods assure construction of monitor wells that will: provide representative samples of groundwater for analysis; permit collection of representative water level data; and effectively isolate the separate hydrogeologic strata penetrated during drilling.

Equipment:
Drilling rig, drilling tools, and support truck with water tanks;
Steam cleaner;
Grout plant and tremmie pipe;
Portland cement, Types I through V;
Powdered bentonite;
Well casing and screen, cap and bottom plug (screen slot size based upon target geologic formation);
Stainless steel centralizers;
Bentonite pellets;
Washed, graded sand (grain size based on formation and screen slot size utilized);
Protective casing and padlock;
Concrete mix; and
Plastic sheeting.

Documentation:
Field Memorandum;
Soil Boring Log;
Well Construction Form; and
Well Development Form.

8.1 PREPARATION AND SET-UP

All necessary drilling/well permits and utility clearances shall be obtained prior to the start of drilling operations. A hydrogeologist experienced in design and construction of monitoring wells will be present to supervise the well construction. Unless otherwise arranged, well construction supplies and equipment will be supplied by the drilling subcontractor. Prior to drilling and well construction, all drilling equipment, tools, and well materials to be used in well construction will be cleaned thoroughly with a portable steam cleaning system supplied by the

drilling subcontractor. Between well installations, drilling equipment and tools will be cleaned at the designated contaminant reduction zone (see SOP 3.0-Equipment Decontamination).

8.2 MONITORING WELL DESIGN

During completion of the soil boring (SOP 6.0-Soil Boring), the geologist will prepare a boring log and keep a time log of significant events during each working day. Logs will indicate field classification of soils, sampling depths, first encountered and static groundwater levels, progress of drilling, final completion depth, and the nature and resolution of any problems encountered (see SOP 7.0-Logging of Soil Borings). Based on data gathered from the borehole, the desired purpose of the well, and previously collected information from other boreholes and monitoring wells, the geologist and project manager will determine the well specifications. These specifications will be consistent with ASTM 5095-90 and other applicable ASTM standards and include:

- Total depth of well;
- Screened interval placement;
- Screen slot-size;
- Location of centralizers;
- Filter pack size;
- Filter pack interval;
- Thickness and placement of bentonite seal ; and
- Grouting method.

Figure 8.1 presents a schematic diagram for a groundwater monitoring well. Monitoring wells installed during remedial activities will be constructed of some combination of either stainless steel or Schedule 40 PVC blank and screen. In the case of wells deeper than 150 feet, Schedule 80 PVC will be used to minimize the potential for casing blistering when grout cures. The diameter of the screen and casing will be a minimum of 4 inches less than the diameter of the borehole. Stainless steel centralizers will be placed at the top of the screen and every 40 feet along the blank casing. The bottom of each well will consist of a slip cap mounted with stainless steel screws to a flush-threaded endcap. Holes of 1/16" diameter will be drilled through both caps prior to installation to prevent water from sitting in the bottom of the well if the static water level drops below the bottom of the well. A locking cap or dedicated pump assembly will be used to secure the top of the well.

8.3 WELL INSTALLATION

Once the desired depth of the borehole has been determined, the borehole will be prepared for installation of the well casing. The well casing/screen assembly will be inserted into the borehole. The casing/screen assembly will be installed as follows:

- The well casing, including the bottom cap and screen, will be suspended in the borehole at the desired depth;

- The primary filter pack, consisting of washed, graded sand that is appropriate for the formation and slot size of the screen, will be poured from the surface or tremmied to the bottom of the annulus between the well casing and the borehole. The filter pack will extend at least 2 feet above the top of the screen. The level of filter pack in the annulus will be verified by tag-line measurement during emplacement. The volume of sand versus the annular volume will be compared to verify proper placement of the filter pack;

- When the primary filter pack is installed to the desired depth, the screened interval will be surged to settle the sand around the well screen (preliminary development). During surging, the well casing will be secured at the surface to prevent settling of the casing. Surging will continue until the filter pack stops settling. Upon completion, sand will be added to bring the filter pack up to the desired depth;

- A bentonite seal at least three feet thick will be placed immediately above the primary filter pack. The level of the top of the bentonite seal will be verified by tag-line measurement. If pellets are used, adequate time for hydration with distilled water of the pellets will be allowed before grouting the remaining annulus;

- Boring cuttings will not be used as backfill. The borehole annulus will be grouted with a cement-bentonite grout mix which will extend to within approximately 2 feet of the ground surface. The top 2 feet will be filled with a concrete mix used to make the concrete pad and secure the protective casing; and

  The grout will then be allowed to settle. If significant settlement of grout occurs, additional grout will be added to the prescribed depth of approximately 2 feet below ground surface prior to the installation of the protective casing and the concrete pad.

8.4 WELLHEAD COMPLETION

For wells completed above ground surface, steel security pipe with a hinged, lockable cover will be installed in the grout to a depth of 1 to 2 feet and equipped with a padlock. For flush-mount wells a steel protector and cover with water-tight seal will be installed in the grout. The integrity of the well will be protected with a lockable sanitary sealing well cap with an expandable O-ring which forms an air-tight seal. All locks will be keyed alike.

For wells completed above ground surface, the drilling subcontractor will construct a concrete apron (3ft × 3ft × 0.5ft) around each well. Concrete aprons will be crowned to provide positive runoff away from the well. Concrete pads may be constructed within 3 days after wells have been installed. If necessary steel guard posts 2-inches in diameter and filled with concrete will be installed around the pads. Posts will be five feet long and will have a minimum stickup of 2.5 feet above ground surface and 2.5 feet below ground surface. For flush mounts, the space around the protective casing will be filled with concrete and sloped to direct surface water away from the well.

8.5 WELL DEVELOPMENT

Well development consists of preliminary and final development. Preliminary well development will be conducted after installation for the well screen, casing, and primary filter pack, but prior to installation of seals and grout. Additional filter pack will be added, as needed, after completion of preliminary well development to bring the filter pack up to the desired depth.

Final well development will begin no earlier than 24 hours after the grout has been placed. Typically, well development will be performed using one more of these methods: surging, jetting, overpumping, or bailing. The method to be used will be selected based on specific hydrogeologic conditions at the site but will generally consist of a sequence of bailing, surging, bailing, and then pumping. Approximately ten casing volumes of water will be removed. Water exiting the well will be collected and properly disposed of as described in the Waste Management Plan. Well development will continue until the water is reasonably sand free and turbidity is reduced. As appropriate, pH, specific conductance, turbidity, and temperature will be measured to judge the

adequacy of monitoring well development. (See SOP 2.0-Field Measurement — Water). Generally, development will continue until turbidity values are less than 5 NTU.

Measurement of development parameters will be recorded on the Well Development Form which will include the time of each measurement, approximate volume of water removed prior to each measurement, and the time intervals during which development is conducted.

8.6 WELL CONSTRUCTION SUMMARY DIAGRAMS

Upon completion of well construction and development, a standard well log form (see Attachment 2) will be completed. The following information will be included:

- Job name and number;
- Job location;
- Well number;
- Permit number (where applicable);
- Land-surface elevation and datum;
- Date of installation;
- Drilling method (i.e., hollow-stem auger, air hammer, air rotary, or mud-rotary);
- Drilling contractor;
- Drilling fluids (where applicable);
- Amount of fluids lost during drilling;
- Well construction details, such as:
  - Type of well (i.e., flush-mount or stick-up);
  - Hole diameter;
  - Well casing diameter, material, and amount;
  - Final well depth;
  - Depth and type of filter pack;
  - Depth of bentonite seal; and
  - Depth and type of grout mixture.
- Well development method;
- Date of well development;
- Amount of water removed during development;

- Static depth to water;
- Pumping depth to water;
- Duration of pumping;
- Yield;
- Specific capacity; and
- Well purpose (i.e., monitoring, production, or recovery).

8.7 EXTRACTION AND RECHARGE WELL CONSTRUCTION AND INSTALLATION

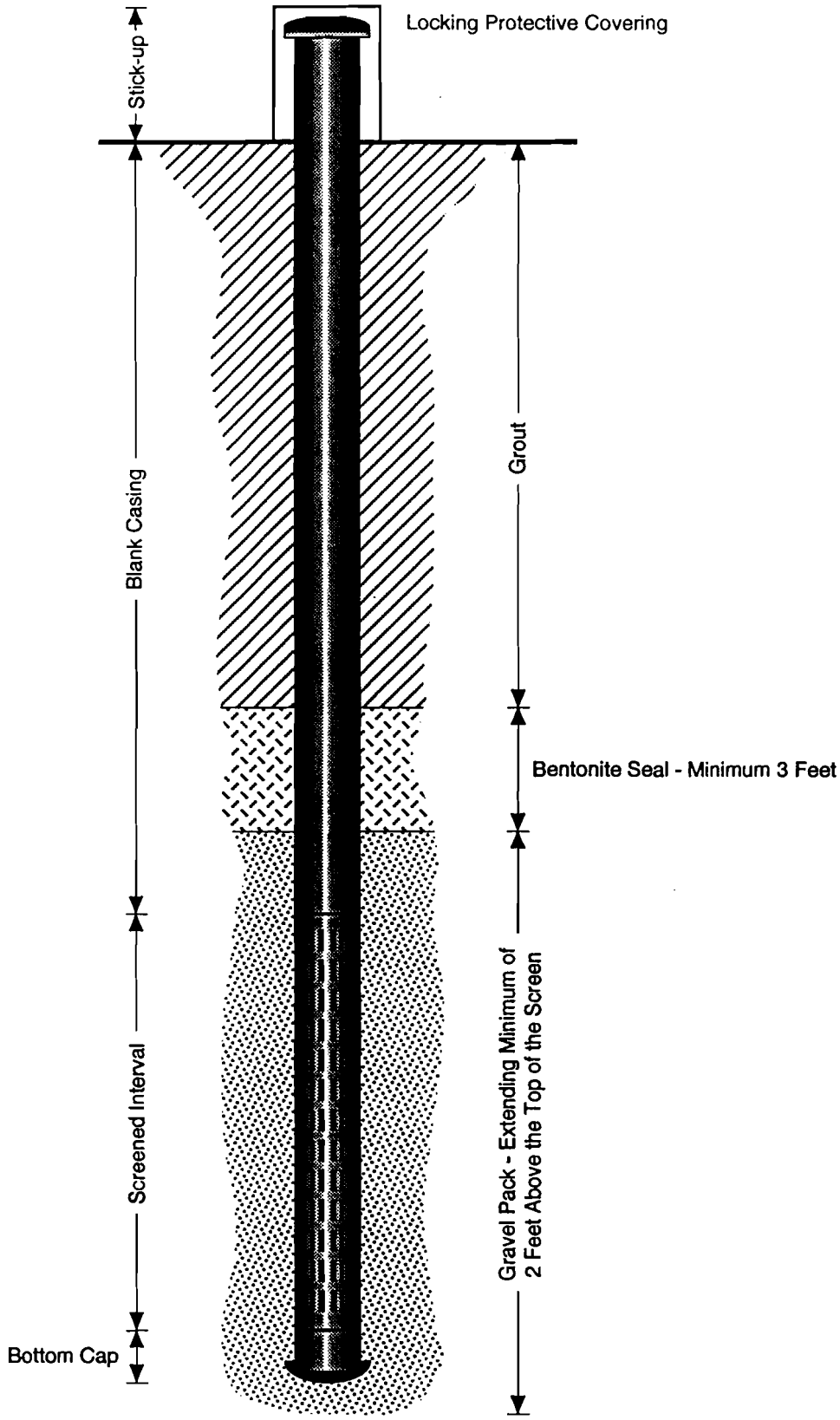
Recharge wells to be installed during remedial activities will be constructed according to the procedures outlined for Monitoring Well Installation and Construction with the following exceptions. Boreholes for recharge wells will be at least 16 inches in diameter and will be drilled by either casing hammer or tri-tube (similar to dual tube) methods. Casing will be between 8 and 10 inches in diameter. Casing material, diameter and thickness, screen slot sizes, and filter pack design will be determined based on design criteria and on material encountered during soil boring.

8.8 PIEZOMETER INSTALLATION

Piezometers installed during investigation or remedial activities will be constructed according to procedures for first-HSU wells outlined above and described for Monitoring Well Installation and Construction, with the following exceptions:

- Boreholes for piezometers may be as small as 8 inches in diameter;
- Casing will generally be 2 inches in diameter;
- Piezometer screen may be constructed of either PVC or stainless steel.

Exact specifications for each piezometer, including screen material, casing diameter, screen slot size and filter pack design, will be based on material encountered during the soil boring.



BASIC MONITORING WELL CONSTRUCTION SCHEMATIC DIAGRAM

RI/FS - EA Work Plan
LEHR Environmental Restoration
Davis, California

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 9.0
BOREHOLE GEOPHYSICAL LOGGING

Purpose and Scope: This procedure describes requirements for conducting borehole geophysical logging. The activities described in this SOP are intended to assure appropriate and standard logging methods are utilized.

Equipment:
Electrical resistance probe ("single-point" resistance);
Standard resistivity probe (both long and short normal);
Natural gamma ray scintillation detector probe;
Spontaneous potential probe (SP);
Caliper tool (three-arm);
Mechanical winch (if applicable); and
Geophysical logging unit.

Documentation:
Field Memorandum; and
Soil Boring Log.

9.1 SET-UP

Borehole geophysical logging will be performed by a qualified subcontractor. A geologist or hydrogeologist shall oversee all geophysical logging activities and perform the following steps prior to logging:

- Obtain and evaluate available logs from wells in close proximity to the test boring;
- Select appropriate probes or tools required to provide meaningful data; and
- Ensure that equipment and/or tool calibrations are performed in accordance with manufacturing user manual prior to logging.

The field procedures used for borehole geophysical surveys will be controlled by the specific type of survey equipment used to perform the survey. All geophysical survey equipment utilized at the site should be calibrated and operated in accordance with manufacturer's guidelines and specifications. Boreholes will be logged while lowering and raising the wireline probes to evaluate instrument response and data reproducibility.

9.2 METHODS

Physical properties that may be measured in soil borings on site include electrical resistance, the electrical potential of a fixed surface electrode (or spontaneous potential), natural radiation, and temperature. Typical applications include stratigraphic correlation, identification of lithology, formation thicknesses, definition of aquifer boundaries, limited water quality determination, and identification of borehole temperature gradients. The following are brief descriptions of possible methods.

9.2.1 Electrical Logging Surveys (Resistivity and Spontaneous Potential

Electrical resistivity and spontaneous potential (SP) logs are commonly recorded simultaneously. The resistivity tool measures the ability of the soil or rock, and its interstitial fluid, to resist the flow of electrical current and is expressed in units of ohm-meters. The SP log is a recording of depth versus the differences in the electrical potential in millivolts of a moveable electrode in the borehole. The electrical resistivity and spontaneous potential equipment cannot be used in a cased hole or if a conductive fluid (generally water) is not in the hole.

9.2.2 Natural Gamma Ray Logging Survey

The gamma ray log provides a profile of naturally occurring radiation emitted from geologic formations and is expressed in counts per second. The gamma ray log is most useful for lithologic identification and stratigraphic correlation. The gamma ray log may be run in boreholes which are cased or uncased, and is not affected by the presence or absence of borehole fluid.

9.2.3 Temperature Logging Survey

A temperature log provides a profile of the borehole temperature and can be used to locate significant points of fluid entry. This log may be run in both uncased and cased boreholes.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 10.0
SOIL SAMPLING

Purpose and Scope: Soil samples will be collected for identification/classification purposes, physical and chemical analysis, and to evaluate behavior of subsurface materials. This SOP describes the techniques to be implemented for a variety of methods of soil sampling, soil coring, surface soil sampling, and sample compositing. In addition, equipment and documentation requirements necessary for sampling are described.

Equipment:
Stainless steel spatulas;
Stainless steel spades;
Stainless steel hand auger buckets and hand auger accessories;
Power auger/drilling rig;
Split spoon samplers;
Continuous core samplers;
Shelby tubes;
Teflon sheets;
Plastic sheeting;
Stainless steel sampling rings;
Plastic ring caps;
Stainless steel measuring cup;
Silicon-based tape;
Stainless steel trowel;
Cleaning and decontamination equipment;
Sample labels;
Ice chest
"Blue" ice; and
Zipper storage bags.

Documentation:
Field Memorandum;
Soil Boring Log; and
Sample Chain of Custody (COC).

10.1 GENERAL PROCEDURES

Due to the wide variety of sampling conditions, types of samples, and purpose for collecting soil samples, several possible methods may be used to collect the soil sample. Specific procedures for various methods are described below. However, there are numerous procedures that will be followed for most soil sampling methods. These procedures include:

- Prepare Field Record sheets and record relevant data on Field Memorandum prior to sampling;
- Decontaminate sampling equipment as specified in SOP 3.0, if samples destined for chemical analysis are to be collected;
- Clear surface vegetation, rocks, and other material not designated for sampling from the sampling point;
- Use drilling or penetration methods (SOP 6.0-Soil Borings) if necessary to reach the desired sampling depth;
- Collect sample using appropriate sampling method described in Section 10.3;
- Lithologically log the sample and boring (SOP 7.0 - Logging of Soil Borings).
- Fill necessary sample containers;
- Affix sample container with appropriate labels, being sure to provide required information;
- Place the properly labeled sample container in an appropriate carrying container at required temperature;
- Either discard or decontaminate all items which contact the sample such as trowel, split-spoon sampler, and gloves before proceeding to the next sampling location;
- Add information pertaining to the sample to the COC, Field Memorandum, and Field Record of Soil Sampling forms; and
- Package and ship samples as described in SOP 5.0 - Sample Shipment.

10.2 SUBSURFACE SOIL SAMPLING

Several methods may be used to collect subsurface soil samples. Some of the procedures for the more common sampling methods are described below.

10.2.1 Set-up Procedures

Several drilling methods may be used to reach desired depths for soil sampling. Generally, samples are collected at regular intervals (approximately every five feet). Potential drilling methods

and general soil boring procedures are described in SOP 6.0 (Soil Borings). In addition to drilling methods, subsurface depths can be reached by a power auger, a hand bucket auger, or a backhoe.

When the desired depth has been reached, the borehole will be prepared for sampling. To prepare for sampling, the borehole should be cleaned out to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. When drilling in saturated sands and silts, the bit should be withdrawn slowly, to prevent loosening of the soil around the hole. When using dual tube or casing hammer methods, care will be taken not to drive the casing below the desired sampling depth before the sample is collected.

When the desired sampling depth has been reached and the borehole has been prepared, there are several subsurface methods that will be used to collect samples. These methods include:

- Penetration Test and Split-Barrel Sampler (split-spoon);
- Thin Wall Sampler (Dames & Moore Type U Sampler);
- Continuous Sampling System;
- Collection of Cuttings; and
- Shelby Tube Sampling.

10.2.2 Penetration Test and Split-Barrel Sampling

Penetration test and split-barrel sampling are methods used to collect representative disturbed soil samples. Samples collected by these methods will be used for description and identification, chemical analysis, and in some cases physical analysis. A split-barrel sampler consists of a section of pipe that splits into two pieces along its axis. A driving shoe and waste barrel screwed to the ends hold the split section together during driving. Aids for sample retention may also be incorporated into the split-barrel sampler. These include catchers, spring or gravity traps (in the lower end), and check valves (in the top end). The standard sampler has an outside diameter of 2 inches and an inside diameter of 1-3/8 inches.

The penetration test samplers have been used to develop an empirical relationship between driving resistance and the relative density of soil. The procedure for determining and interpreting

penetration resistance or relative density is collectively referred as the Standard Penetration Test (SPT);

- After the boring has been advanced to the desired sampling depth, and extracted drill cuttings have been suitably removed, a split-barrel sampler (outside diameter 2 inches inside diameter 1-3/8 inches) attached to drill rods is lowered to the bottom of the cleaned-out borehole;

- Once the sampler is on the bottom of the borehole, three 6-inch increments are marked on the drill rods above a convenient fixed datum;

- The sampler is driven by a 140-lb hammer free falling a distance of 30 inches onto a collar or drive head attached to the top of the rods. The sampler is driven a total of 18 inches into the undisturbed soil, and the number of blows required to advance each 6-inch increment is recorded.

- The standard penetration test should be terminated if one of the following occurs:

    - A total of 50 blows has been applied during any one of the three 6-inch increments;

    - A total of 100 blows has been applied;

    - There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

- After the total penetration of the sampler has been achieved, the sampler is retrieved to the surface and opened.

The sample is then logged and removed and the sampler is decontaminated before reassembly. If the standard split spoon samples are to be retained for future reference, they will be placed in sealable plastic bags and labeled according to standard procedures. Typically, samples are taken at each lithologic change and at intervals not greater than 5 feet (unless otherwise stipulated by the field engineer or geologist).

10.2.3 Dames & Moore Type - U Sampler

Relatively undisturbed soil samples will be obtained with a Dames & Moore Type-U or similar split-barrel (split-spoon) sampler fitted with new 2.5-inch diameter, 3-inch long stainless steel

rings. Procedures for sampling with the Dames & Moore Type-U sampler are similar to procedures described for the standard penetration test (see Section 10.2.2. Soil samples will be collected by driving the split-barrel sampler 18 inches (or until refusal) into undisturbed soil at the bottom of the borehole. The drill rig is equipped with a 140-pound hammer to drive the sampler. Hammer blows required to drive the sampler in 6-inch increments will be recorded on the Boring Log.

Upon retrieval from the borehole, the sampler will be dismantled, and the sample rings removed and placed on clean plastic. Sample rings will be separated with a clean steel knife, then logged by the on-site geologist (noting any lithologic variations between rings) using the Unified Soil Classification System (Figure SOP7.1). After logging, the exposed ends of the rings will be covered with 2-mil Teflon sheets, plastic end caps, and silicone-based tape. Sample labels will be affixed to the end caps and will contain the following information: boring number; sample locations; sample number; sample depth; date of sampling; time of sampling; sample collector's name; soil type; and name of client or facility owner. Three to six rings will be retained from each sample interval.

It is anticipated that up to 2,000 grams of soil will be necessary to complete the chemical analyses for each sample. Therefore, additional soil will be required to augment the "A" ring collected from the drive sample. The additional soil will be collected from the base of the preceding core run and placed into glass jars. If the core sample is inadequate, a second drive sample will be attempted and the additional sample collected in sample rings.

Appropriately sealed and labeled samples will be placed in ice chests cooled with "Blue Ice." Ice chests will be used to ship samples to the analytical laboratory. Samples delivered to the laboratory will remain refrigerated until analyzed.

Thin wall sampling tube methods (with a Dames & Moore - Type U Sampler) will be used where undisturbed samples of fine-grained materials are to be obtained for chemical analysis, saturated vertical hydraulic conductivity or other geotechnical analysis. Other larger diameter samples (3 to 6 inches in diameter) are helpful in sampling gravel deposits and retrieving samples of sufficient volume to perform compaction tests. If a larger diameter sampler is used, however, the size should be conspicuously noted on all penetration records.

The thin wall sampling method is conducted by attaching a sampling tube to the nose-end of the Dames & Moore Type - U sampler and pushing the tube in one continuous motion, into the material to be sampled. Once the tube is retrieved, slough material will be removed from the tube and the actual sample length will be measured. If the sample is to be retained for future reference or analysis, it will be trimmed, logged, capped, sealed, and labeled.

The bottom and top of the tube will be indicated on the tube in indelible marker. The following information will be noted on the side or top of the tube:

- Project Number and Name;
- Sampling Date and Time;
- Boring and Sample Numbers;
- Sample Depth;

10.2.4 Continuous Core Sampling System Methods

Continuous core sampling system methods may be specified where continuous soil cores are to be recovered by hollow-stem auger drilling methods. The continuous sampling system utilizes a core barrel which recovers a soil core from the interval drilled. The core barrel is recovered after each interval is drilled.

Representative samples of the soil cores can be placed in 8-ounce jars for future analysis. The entire length of the soil cores will be placed in plastic-lined core boxes should it be necessary to retain them. Care will be taken to mark intervals of core loss with styrofoam blocks. All soil cores will be logged according to procedures outlined in SOP 7.0 (Logging of Soil Borings).

10.2.5 Cuttings Collection Methods

Cuttings collection methods will be used with rotary, dual tube, and casing hammer drilling methods. Cuttings will be collected at a minimum of every five feet and at changes in lithology. Samples will be collected into plastic bags, labeled, and logged according to procedures outlined in SOP 7.0.

10.2.6 Shelby Tube Sampling

Shelby tube samples will be collected when undisturbed soil samples for physical or geotechnical analyses are required. Soil to be sampled should be have a high clay content, or contain predominantly loose silts or sands. Procedures for collecting a Shelby tube sample are listed below:

- Clean the bottom of the hole in which the Shelby tube will be inserted to the sampling elevation;
- Attach the Shelby tube sampler assembly to the lower end of the drill rods and secure set screws with allen wrenches;
- Lower the Shelby tube sampler assembly to the sampling depth at the bottom of the hole with the drilling apparatus;
- Mark off on the drill rods an interval length equivalent to the length of the Shelby tube;
- Push the Shelby tube into the ground with a continuous motion without impact or twisting. This is typically performed using the hydraulic mechanism on the drilling rig. Push the tube into the ground until the uppermost mark on the drill stem aligns with the initial location of the lower mark;
- If soils are so hard that the Shelby tube cannot be pushed, a driving hammer may be used to advance the sampler. If this is the case, record the weight, height, and number of blows in the field log;
- When the tube has been advanced to the appropriate depth, twist the tube at least two revolutions to shear off at the bottom. Raise the sample; and
- Disconnect the Shelby tube and sample from the drill rods.

If the sample is to be extracted from the Shelby tube in the lab, remove about 1/4 inch of the soil from each end of the tube, wipe the tube end (inside and out) with a clean towel, and seal the ends of the tube with paraffin wax. Place a plastic shipping cap over each end of the tube and wrap with plastic tape. If the sample is to be extracted from the Shelby tube at the site, seal the extracted sample in a glass jar and decontaminate the tube before collecting next sample.

10.3 SURFACE SOIL SAMPLING

Methods to be used for collection of surface soil samples include the scoop or trowel, hand bucket auger, and the hand drive sample method. The scoop or trowel samplers are used to collect shallow soil samples, up to 6 inches in depth.

When collecting a surface soil sample, the following steps are required:

- Clear surface vegetation, rocks, leaves, debris, and other material not designated for sampling from the sample point. Document the removal of this material;
- Decontaminate sampling equipment (see SOP 3.0);
- Collect samples;
- Lithologically log samples;
- Transfer sample into a container (with the aid of a spatula or trowel). Minimize exposure to air for any sample to be analyzed for volatile organic compounds;
- Label sample containers;
- Handle and preserve samples as outlined in the sections on sample handling and preservation;
- Discard or decontaminate all items which contact the sample such as trowel, auger, and gloves before proceeding to the next sampling location; and
- Add information pertaining to the sample to the Chain-of-Custody record, Analysis Request Form, and Field Memorandum.

In the case of the hand drive-sampler method, samples will be collected in stainless steel rings, the ends will be covered with a Teflon sheet, capped, and sealed with a silicon-based tape.

10.4 MICROBIOLOGICAL SOIL SAMPLES

Soil samples collected for microbiological analysis can be collected by surface sampling, split-barrel sampling, or thin wall sampling methods. Samples will be collected into sterile vials

provided by the laboratory or into decontaminated stainless steel rings. All equipment and rings used for microbiological samples will be decontaminated using the standard three-bucket wash and rinse, and then rinsed with isopropyl alcohol (see SOP 3.0).

10.5 BULK SOIL SAMPLING

Bulk soil samples for some physical and mineralogical tests will be collected from test pits and soil borings. Samples from test pits less than 5 feet deep will be collected from the wall of the pit with a stainless steel trowel. In test pits deeper than 5 feet, samples will be collected out of the backhoe bucket. Bulk samples from soil borings will be collected from the cuttings produced during drilling or retrieved from the sampler.

Samples of sand, silt, and clay-size material will be collected into gallon sized plastic bags or in sample sleeves. Coarse-grained gravels will be collected into 5-gallon buckets. In general, the size of the bulk sample will be at least 10 times greater than the weight of the largest clast. Samples will be labeled with the sample number, date, location, depth, and test pit or borehole.

10.6 SOIL SAMPLE COMPOSITING

Soil sample compositing is used to combine soil from two or more samples to ensure that soil submitted for analysis is representative of the entire mass of soil sampled.

Individual samples to be composited will be identified on their labels by their own sample identification and by the sample identification for the composite sample. Samples to be composited will also be clearly identified on the COC and on the Field Record of Soil Sampling by both identifications.

In the case of bulk samples, mineralogical samples, or any other soil samples to be composited for archiving or non-chemical analysis, the procedure is described below. In general, compositing consists of the following steps:

- Taking a sub-sample from each sample to be composited;
- Combining and homogenizing the sub-samples; and

- Taking a sub-sample of homogenized soil for analysis.

If samples are small, they can simply be combined as described below under "Combining Sub-samples." Often, however, mixing the samples to be combined would make an inconveniently large mass of soil, so a sub-sample must be taken from each.

Grab samples are disturbed samples obtained by shovel, hand trowel, bucket auger, or similar means. A grab sample can be sub-sampled by taking a smaller grab sample if it is reasonably homogeneous or if the grab sub-sample will contain the various types of materials in approximately the proportions present the larger sample. Otherwise, it should be homogenized and subdivided by quartering as described below.

Split-spoon and similar samples may be more easily subdivided by splitting the sample lengthwise with a spatula into halves or smaller functions. Another approach is to cut a v-shaped channel from the side of the sample and use the material from the channel. Carry out these operations on a tray covered with aluminum foil. Plastic sheeting may be used.

All sub-samples should be the same size. A measuring cup is satisfactory for determining size. The size of each sub-sample should be chosen in advance on the basis of the final sample volume and the amount of material available. Make the size of the sub-sample after quartering or splitting larger than the desired volume, then mix the sub-sample thoroughly in the measuring cup with a spatula and discard the excess.

- Combining Sub-samples. Combine the sub-samples on a tray covered with aluminum foil, or with plastic sheeting. Chop cohesive materials into pieces considerably smaller than the final sample with a trowel or spatula. Mix the composite sample until it appears homogeneous.

- Taking Composite Sample. If the composite sample is too large, subdivide it as follows: Pile the soil in a cone. Flatten the cone to a uniform thickness. Draw two lines across the pile, dividing it into quarters. Discard two opposite quarters re-mix the remaining quarters, and repeat the process until the sample is not much larger than the sample container. Fill the container and discard the excess. Label the container and complete field notes the sampling forms.

- Recordkeeping is generally the same as for other soil samples. However, be sure to identify the sample as a composite and to identify the number and locations of samples that were composited. Record any differences between procedures described in this SOP and those used in the field.

10.7 SOIL SAMPLING EQUIPMENT BLANKS

Equipment blanks will be collected during soil sampling activities to provide an additional check on possible sources of contamination related to field sampling instruments. Laboratory-supplied distilled or deionized water is passed through or over clean sampling equipment and collected directly into empty sample containers for analysis. Equipment blanks will be handled and transported in the same manner as the samples acquired that day. Equipment blanks will be analyzed according to water analytical methods. One equipment blank will be collected for each investigation activity, in each investigation area. For example, three equipment blanks would be collected in an investigation area during sampling activities that include a backhoe exploration, stage 1 soil boring, and stage 2 soil boring. Soil equipment blanks will be tested for parameters listed in Table 1 of this Revised FSP.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 11.0
TEST PIT EXCAVATION

Purpose and Scope: The activities described in this procedure outline general methodology to be used in excavating and logging test pits. The resulting test pits can be used for shallow stratigraphic description and physical and chemical sampling. This procedure describes the equipment and forms required, as well as set-up procedures to be completed for each test pit.

Equipment:
Backhoe;
Steam cleaner;
Soil hand sampling equipment;
Shovel; and
Camera.

Documentation:
Field Memorandum; and
Test Pit Excavation Log.

11.1 SET-UP PROCEDURES

All set-up procedures and test pit excavations will be conducted under the supervision of a geologist, hydrogeologist, or engineer. Field personnel are responsible for:

- Identifying each test pit location;
- Confirming the test pit location with the project manager and UC Davis personnel; and
- Obtaining proper clearance for potential above- and below-ground hazards.

Prior to test pit excavation, the backhoe bucket and sampling tools should be steam-cleaned. The work area should be well-marked with traffic cones and barricade tape. In some cases, special arrangements may need to be arranged to penetrate surface paving (concrete or asphalt). Each test pit should be backfilled following logging and photographing.

11.2 TEST PIT EXCAVATION PROCEDURES

This section provides a brief description of test pit excavation procedures. Test pit procedures described below adhere to guidelines and requirements of Title 8 CCR, Article 6, Sections 1541 and 1542.

Once the test pit location is selected and approved by the project manager, the test pit will be excavated using a backhoe. The standard backhoe bucket width is 24 inches, but a larger bucket (36-inch) may be used. The width of the excavation, regardless of the width of the backhoe bucket, will be such that movement inside the pit is not restrictive to the geologist. The initial excavation will be no greater than five feet in depth and will be cut with appropriately-sloped sides if the soil being excavated is not stable. Test pits will be greater in length than in depth in order to accommodate a relatively easy and safe entry and exit route. Specifically, entry and exit will be via a ramp at the end of the test pit opposite the backhoe.

Once the test pit is excavated as described above, the test pit walls will be scraped smooth with a shovel or other scraping device. If necessary, engineering controls, such as water spray, will be implemented to minimize generation of dust. This provides the best possible exposure for logging and photographing the exposed soil profile. Soils will be described in a similar fashion to methods outlined in SOP 7.0 for logging soil in boreholes. The exposed test pit wall(s) will then be logged by the field geologist using the standard Test Pit Logging Form and photographed.

If detailed logging is required at depths greater than five feet and entry is required to perform the logging, the test pit will be appropriately shored. Shoring will be placed as specified in Title 8 CCR, Article 6, Section 1541. No confined space entry work will be conducted.

If possible, test pits greater than five feet in depth will not be entered and observations for logging purposes will be made from the surface. In no case will a test pit greater than five feet in depth be entered without proper shoring. If soil samples from greater than five feet are required, samples will be collected from soil in the backhoe bucket taken from the desired depth. Soil sample collection methods are described in SOP 10.0. Decontamination of sampling equipment is described in SOP 3.0.

Test pits will be backfilled using the backhoe and compacted by driving the backhoe over the area after backfillind complete.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 12.0
PERMEABILITY TESTING — UNSATURATED ZONE

Purpose and Scope: Permeability testing will be performed to measure vertical permeabilities in the unsaturated zone. This SOP describes general procedures for conducting falling head tests at discrete depths in soil boreholes and describes a procedure for field measurement of the rate of infiltration of water into soils using double-ring and single-ring infiltrometers.

Equipment:
Casing hammer or hollow-stem auger drill rig;
6-inch diameter PVC casing;
5- or 15-psi pressure transducers;
Data logger;
Personal laptop computer;
Bentonite pellets or chips;
Water level indicator;
Computer disks;
Clean graded sand;
Two infiltrometer rings: 24-in. and 12 in.;
Two driving caps of heavy-gauge aluminum or steel having diameters slightly larger than that of their respective rings;
Driving equipment: 12-lb. sledge or backhoe and 2-3 foot length of wood;
Depth gauge: a hook gauge, steel tape or rule, or long nail or spike;
Shovels: one long-handled shovel and one flat-bottomed spade;
Tap water supply and appropriate containers;
Watch with seconds hand;
Carpenter's or bull's eye level;
Two thermometers for measuring soil temperatures;
Splash guards (several pieces of rubber sheet);
Rule or tape;
Tamp;
Rubber mallet;
Two graduated head tanks for measurement of liquid flow during the test. (These may either be graduated cylinders or Mariotte tubes having a minimum volume capacity of about 3,000 mL.); and
Mariotte tube support stands and tubing.

Additional Single-Ring Equipment:
80 lb. bags of powdered bentonite;
5-gallon buckets; and
Serving spoon with at least a 10-inch handle.

Documentation: Field memorandum; and

Double-ring infiltration test data sheet.

12.1 DOWN HOLE FALLING HEAD TEST

Procedures for conducting a down-hole falling head test are described below. Set-up methods are presented in 12.1.1, test procedures are presented in 12.2.2.

12.1.1 Set-Up

Prior to going into the field, all necessary equipment should be checked and tested to assure it is in good working condition. This includes:

- Checking and recharging batteries for water level indicator, computer, and data logger; and
- Running a test with the computer, data logger, and transducers to ensure that data is being recorded and that transducers are working properly.

Once in the field, soil borings will be completed to the desired depth by either casing hammer or hollow-stem auger methods (see SOP 6.0 - Soil Borings). When the desired depth is reached, the bottom of the drive casing or augers will be pulled 1 to 2 feet off the bottom and the boring will be cleaned of cuttings and caved material so that a clean, fresh, undisturbed surface is exposed. Care will be taken to ensure that either the drive casing or lead auger has not disturbed or penetrated this surface.

12.1.2 Procedures

When the borehole has been prepared, a section of 6-inch-diameter PVC blank casing will be placed on the bottom of the borehole inside the drive casing or the hollow-stem augers. Six inches to one foot of clean, graded sand will be placed inside the PVC casing to prevent scouring of the bottom when water is added. At least one foot of bentonite pellets or chips will then be added to the bottom of the borehole in the annulus outside the PVC casing. Sand will be placed inside the casing first to prevent bentonite from entering the casing from the bottom. The bentonite will be hydrated with distilled or deionized water to form a seal to prevent leakage during the test.

When the seal is sufficiently hydrated, the drive casing or lead auger will be carefully pushed into the bentonite seal. Procedures for conducting the falling head test are as follows:

- Record the borehole number in the field log;
- Measure and record the depth to the top of the sand inside the PVC casing from top of casing (TOC);
- Insert pressure transducer into the casing approximately 6 to 12 inches above the top of the sand. To prevent damage to the transducers, 5-psi transducers should be placed so that they will read no more than 10 feet of head during the test; 15-psi transducers should not read more than 30 feet of head during the test;
- Program computer and data logger to perform a "falling head" test as described below. Readings should be collected at a higher frequency at the beginning of the test, and less frequently as the test progresses. An example for a schedule of readings would be: 60 readings at 1-second intervals; 12 readings at 5-second intervals; 32 readings at 15-second intervals; 20 readings at 60-second intervals; 24 readings at 5-minute intervals; 60 readings at 10-minute intervals. The exact program and schedule will depend on the type of data logger and may be modified for the conditions encountered in the field;
- Turn on logger and check input values. Values displayed on the computer screen should be zero because no water has been placed in the casing;
- Begin "falling head" program and record the time;
- Quickly ("instantaneously") but carefully, add clean tap water to the inside of the casing, being sure not to scour the bottom. Add water until approximately 10 feet of head is read by the transducer. Check values displayed for the transducers to ensure that the equipment is functioning properly;
- Record water levels with data logger until at least 75 percent of the water column has dissipated. This time may range from less than 30 minutes to overnight, depending on site-specific conditions. Usually it is not necessary to continue measurements for more than a few hours, since longer periods indicate extremely low permeabilities;
- Decontaminate the transducer and water level indicator; and
- Download data onto a floppy disk, making sure data was recorded and transferred properly.

If time permits, additional trials for the location and depth will be run by reprogramming the datalogger and repeating the above procedures. Upon completion of the falling head tests, the borehole may be either advanced or abandoned by procedures described in SOP 6.0 (Soil Borings).

12.2 DOUBLE-RING INFILTROMETER TEST

Procedures for conducting a double-ring and single-ring infiltrometer test are described below. Preparation and set-up procedures are presented in 12.2.1 and 12.2.2. Test methods and calculations are presented in 12.2.3 and 12.2.4.

12.2.1 Preparation and Set-Up for Double-Ring Test

Prior to initial use, the test rings should be calibrated by determining the area of the small ring and the annular space between the large and small rings. Determine the area using a measuring technique that will provide an overall accuracy of 1%. The area of the annular space between the rings is equal to the internal area of the small ring minus the external area of the large ring.

12.2.1.1 Soil Preparation

The soil strata to be tested will be established from a nearby test pit or shallow soil boring. The test area should be at least four by four feet, and be nearly level. The test may be conducted in a test pit should the desired test depth be below ground surface. In such instances, excavate either with hand tools or with a backhoe to just above the desired test depth, and remove soil that was compacted and/or smeared during excavation to leave a fresh soil surface. Check this surface with the level and bring down any high areas, if necessary. Using the hand broom, sweep any loose soil from the test surface.

To install the large ring, center the driving cap on the ring and place the wood block on the cap. Drive the outer ring into the soil either with blows of a heavy sledge on the wood block or with steady pressure from the flat portion of a backhoe bucket. Drive the outer ring to a depth that will (1) prevent the test fluid from leaking to the ground surface surrounding the ring, and (2) be

deeper than the depth to which the inner ring will be driven; 6 inches is usually adequate. When using the sledge hammer, use blows of medium force to prevent fracturing of the soil surface. With the driving cap still on the ring, check the cap with the level and lightly hammer on the high side of the ring until level.

To install the small ring, center the smaller ring inside the larger ring, and, using the same technique just described, drive the ring to a depth that will prevent leakage of the test fluid; usually, 2 to 4 inches is adequate. If the surface of the soil surrounding the wall of the ring(s) is excessively disturbed, reset the rings using a technique that will minimize such a disturbance. For minor disturbances adjacent to the wall of the rings, tamp the disturbed soil until the soil is as firm as it was prior to disturbance.

12.2.1.2 Maintaining Liquid Levels

To maintain liquid levels within the inner ring and within the annular space use a graduated cylinder or a Mariotte tube. When manually controlling the flow of liquid use a depth or point gauge to visually maintain a constant head. Install the depth gauges or Mariotte tubes in such a manner that the reference head will be at least 1 inch and not greater than 6 inches. Locate the depth gauges midway between the two rings. Measure the ground temperature by inserting the temperature gauge at a depth of about 12 inches or at the mid-depth of the test zone. Measure the temperature of the water being used for the test. The water temperature should be greater than the soil temperature, to prevent dissolved gasses in the water from forming gas bubbles in test soil pore space upon infiltration.

Prior to adding water, cover the soil surface within the center ring and between the two rings with the rubber splash guards to prevent scouring of the soil when the initial liquid supply is poured into the rings. Fill both rings with liquid to the same depth. Do not record this initial volume of liquid. Remove the splash guards and start flow of fluids from the graduated cylinders or Mariotte tubes. Measure and record each addition of water to the rings. As soon as the fluid level becomes constant, determine the fluid depth in the inner ring and in the annular space to the nearest 1/6 inch using a ruler or tape measure. Record these depths. If the depths between the inner ring and annular space varies more than 1/4 inch, raise the depth gauge or Mariotte tube having the shallowest depth. Maintain the liquid level at the selected head in both the inner ring

and annular space between rings as near as possible throughout the test, to prevent flow of fluid from one ring to the other.

12.2.2 Preparation and Set-Up for Single-Ring Test

Where coarse-grained soils are encountered at the surface or at depth, the single-ring test method may be employed. This method makes use of only the large ring, therefore ring calibration consists of determining the area of the large ring. Test surface preparation is the same as that for the double-ring test. In loose gravels or cobbles with little or no fines, test surface preparation may consist only of excavating to a level test surface using the flat-bottomed spade.

Since it is not possible to drive the ring into coarse-grained material, a seal between the ring and soil is formed using bentonite powder. The seal is made by thoroughly mixing roughly equal volumes of bentonite powder and water, and applying the resulting paste with the long-handled spoon to where the outside wall of the ring meets the test surface. Approximately 5 gallons of paste should be used to adequately seal one 24 inch diameter ring onto a test surface. Care should be taken to avoid introducing the bentonite paste to the test surface within the ring. Remove such paste prior to conducting the test. Follow the same instructions for adding and controlling the liquid to the single-ring as that described for the double-ring in Section 12.2.1.2.

12.2.2.1 Maintaining Liquid Level

During the test, the geologist will determine and record the volume of liquid that is added to maintain a constant head. For average soils, the volume of liquid used will be recorded at intervals of 15 minutes for the first hour, 30 minutes for the second hour, and 60 minutes during the remainder of a period of at least 6 hours, or until after a relatively constant rate is obtained. Measurement intervals will vary, based on the permeability. For high-permeability materials readings may be more frequent then for low-permeability materials. For any test, the volume of liquid used in any one reading interval should not be less than approximately 25 mL.

To minimize evaporation, place the driving cap or some other covering over the ring during the intervals between liquid measurements.

12.2.3 Calculations

Convert the volume of liquid used during each measured time interval into an incremental infiltration velocity for both the inner ring and annular space using the following equation:

Incremental Infiltration Velocity = Vol.of fluid infil./(Area × time) = cm/sec.

Record all information on the Single Ring or Double-Ring Infiltration Test Data Sheet.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 13.0
AQUIFER TESTING

Purpose and Scope: Aquifer tests are used to assess hydraulic properties of water bearing stratigraphic intervals. Parameters such as transmissivity, storage coefficient, and leakage coefficient (if applicable) will be derived from aquifer test data for input into groundwater flow and transport models. Both aquifer pump tests and slug tests will be used in estimating aquifer parameters.

Equipment: Described below

Documentation: Described below

13.1 SLUG TESTS

This operating procedure describes methods used in performing single well aquifer or slug tests to measure aquifer hydraulic conductivity. The test involves changing the water level in a well and observing recovery to static water level. Because slug tests stress only a small part of the aquifer, longer-term pumping tests are considered more accurate in the estimation of aquifer parameters.

13.1.1 Equipment and Documentation

The following equipment and documentation will be used in conducting aquifer slug tests:

- Water level indicator;
- Decontamination equipment;
- Calculator;
- Stainless steel or solid PVC slug;
- Data logger;
- Pressure transducer (5 to 15 psi);
- Laptop Portable computer;
- Computer disks; and
- Field Memorandum.

13.1.2 Set-Up

Prior to going into the field, all necessary equipment should be checked and tested to assure it is in good working condition. This includes:

- Checking batteries for water level indicator, computer, and data logger; and

- Running a test with the computer, data logger, and transducers to assure data is being recorded and that transducers are working properly;

Once in the field, water levels in all wells to be tested will be measured and recorded. Dedicated pumps will then be removed (if necessary). Slug tests will not be performed on wells in which pumps were removed until the water level returns to the previously measured elevation.

13.1.3 Slug Test Procedures

Slug tests will be conducted only after the water level has equilibrated to static elevations. Procedures for "falling head" and "rising head" tests are as follows:

- Record the well number in the field log;

- Measure and record the depth to water from top of casing (TOC). Measure and record the depth of bottom of well from TOC, if possible;

- Insert pressure transducer into well. The transducer should be at least 1 foot above the bottom of the well, and at least six feet below the static water level. To prevent damage to the transducers, 5 psi transducers should be placed so that they read no more than 10 feet of head during the test, 15 psi transducers should not read more than 30 feet of head during the test;

- Program computer and data logger to perform a "falling head" test as described below. Readings should be collected at a higher frequency at the beginning of the test, and less frequently as the test progresses. An example for a schedule of readings would be: 60 readings at 1-second intervals; 12 readings at 5-second intervals; 32 readings at 15-second intervals; 20 readings at 60-second intervals; 12 readings at 5-minute intervals; 30 readings at 10-minute intervals. The exact program and schedule will depend on the type of data logger and may be modified for the conditions encountered in the field;

- Turn on logger and check input values. Values displayed on the computer screen indicate depth of submergence (feet of head) and should be stable and within the range expected from the previous step, if not, wait until well stabilizes. Write down initial head value on the Field Memorandum.

- Begin "falling head" program and record the time;

- "Instantaneously," but smoothly, lower a clean decontaminated slug into the well. Tie off the line to the slug when it is completely submerged below the initial static water level;

- Record water levels with data logger until at least 90 percent of the change in water level has dissipated (compare reading to initial value recorded before the test). This time may range from 1 minute to less than 1 day due to site specific conditions. Usually it is not necessary to continue measurements for more than a few hours, since longer periods indicate extremely low hydraulic conductivity;

- Reprogram the datalogger to perform a "rising head" test. Reading will be collected on a schedule similar to that other falling head test. Turn the datalogger on and check head values against initial values;

- Begin "rising head" program and record the time;

- "Instantaneously," but smoothly, remove the cylinder from the water column, being sure that the bottom of the slug is above the original static water level. Tie the slug off while it is still in the well so that the transducer cable is not disturbed by removing the slug;

- Continue collecting water level measurements until at least 90 percent of the change in water level has dissipated. End test;

- Decontaminate the slug, transducer, and water level indicator; and

- Download data onto a floppy disk, making sure data was recorded and transferred properly.

13.2 STEP DRAWDOWN TEST

Step drawdown aquifer tests may be conducted on selected wells. In a step drawdown test, the well is pumped at successively higher pumping rates and the drawdown for each rate, or step, is recorded. The results of these tests provide information to help identify well efficiency and the appropriate pumping rate for the constant discharge tests (see below). The initial discharge rate of each step drawdown test will be based upon the results of the well development (see SOP 8.0). Each step drawdown test will consist of three 1-1/2-hour steps. Where feasible, the aquifer will be allowed to fully recover before the next step is commenced.

During the step drawdown tests, drawdown and recovery in the pumping well and observation wells will be monitored by using the data logger. Additional information for the data logger, equipment, and specific pump test procedures are discussed in the Constant Rate Discharge Test section below.

13.3 CONSTANT RATE DISCHARGE PUMP TESTS

This operating procedure describes the methods involved in conducting a constant-rate discharge pumping test. The activities covered by this procedure are designed to ensure quality control in conducting pumping tests to determine aquifer parameters, and to provide quantitative data on aquifer parameters such as saturated hydraulic conductivity, specific yield, and storativity.

13.3.1 Equipment and Documentation:

The following equipment and documentation will be used in conducting constant rate discharge pump tests:

- Water level measuring tape(s);
- Flow meter;
- Steel register flow meter;
- Portable computer;
- Program diskettes;
- Data diskettes;
- Field log;
- Stopwatches;
- Calculator;
- Stainless-steel submersible pump;
- Teflon or polyethylene flexible piping;
- 4,500-watt generator;
- Stainless-steel hose clamps;
- Calibrated 5-gallon bucket;
- Flashlights, etc.; and
- Field Memorandum.

13.3.2 Set-Up

Prior to going into the field, all necessary equipment should be checked and tested to assure it is in good working condition. This includes:

- Checking batteries for water level indicators, computers, and data loggers; and

- Running a test with the computer, data logger, and transducers to assure data is being recorded and that transducers are working properly;

Once in the field, an area will be located to conduct the pumping test where the water table or potentiometric surface is relatively flat; where the aquifer is believed to be relatively homogeneous and isotropic and of constant thickness; and where there are no nearby influences on groundwater flow, such as other pumping wells, streams, lakes, or no-flow boundaries. Observation well(s) will be chosen that are within 50 to 3,000 feet of the pumping well.

Water levels in all wells to be included in the test will be measured and recorded. Dedicated pumps will then be removed (if necessary), and the well will be allowed to equilibrate for at least 72 hours prior to the pumping test. The pumping well will not be pumped for at least two days prior to conducting the pump test.

Install pressure transducer into the pumping well and observation wells several days prior to the test to obtain data on both natural and artificial regional groundwater level fluctuations and to assure all equipment is working properly. Decontamination will be conducted on all of the downhole testing equipment and will occur prior to the start of each test and upon completion of test (see SOP 3.0 Equipment Decontamination).

Install a barometer on site to continually record local barometric pressure. If there is a NOAA or Weather Service station near the site, data from the official station can be obtained as a substitute.

13.3.3 Procedures

The distance between the observation well(s) to the pumping well will be measured prior to beginning the pump test. A general pumping rate will be estimated based on results from a step drawdown test or, if no step drawdown test is performed, based on data collected from well development and from the distance of observation wells. In general, the closer observation well(s) are to the pumping well, the lower the pumping rate that will be used.

The constant rate discharge tests will be conducted for at least 24 hours. If steady-state conditions occur before 24 hours, the test will be terminated at 24 hours. If steady-state conditions are not met within 24 hours, the test will be continued until steady-state conditions occur or 72 hours have elapsed, whichever occurs first.

The pumping well and at least two observation points, if feasible, will be monitored during the constant rate test. A multi-channel data logger should be utilized during the aquifer test so that several observation points can be monitored. Drawdown in the pumping well and the nearest observation well will be measured with pressure transducers and data logger at the following intervals:

Elapsed Time	Measurement Interval
0 - 2 sec.	0.2 sec.
2 - 20 sec.	1 sec.
20 - 120 sec.	5 sec.
2 - 12 min.	30 sec.
12 - 120 min.	2 min.
120 - 1,440 min.	10 min.
1,440 - 4,320 min.	100 min.
> 4,320 min.	500 min.

The data logger will be checked every 10 minutes for the first hour of each step drawdown test and at least once every half hour thereafter.

Observation points which cannot be connected to the data logger because of distance from the equipment will be monitored with the water level meter. Observation wells will be checked every 15 minutes until drawdown is detected in the observation well. Once drawdown is detected, water levels will be measured at the following intervals:

Elapsed Time	Measurement Interval
0 - 5 min.	30 sec.
5 - 10 min.	1 min.
10 - 20 min.	2 min.
20 - 40 min.	5 min.
40 - 80 min.	10 min.
80 - 120 min.	20 min.
120 - 180 min.	30 min.
> 180 min.	60 min.

At the completion of the constant rate discharge test, recovery measurements will be made according to the same schedule as the drawdown measurements. Recovery will be measured until the residual drawdown is less than 10 percent of the total drawdown or for an equal duration as pumping.

After 48 hours, the data loggers, pressure transducers, and cables will be removed from the observation wells. Dump the data onto data diskettes using the portable computer.

Data will be recorded by the data logger as feet of water above the pressure transducer. Reduce these data to changes in potentiometric head (in feet), relative to the initial water level as measured from the top of the casing, and record this with the respective changes in time.

13.4 DISCHARGE MEASUREMENTS

Pump discharge during the aquifer testing will be measured with a totalizing flow meter. The meter will be sized so that the rate of pumping is no less than 25 percent of the meter capacity. A pressure gauge and adjusting gate valve will be installed in the discharge line ahead of the flow meter to control the pump discharge rate. The flow meter will be checked during each test by measuring and recording the time taken to fill a known volume (e.g., a 55-gallon drum) with water. If the flow meter malfunctions, the bucket and stopwatch method will be used to measure discharge during the aquifer test.

The rate of discharge during the test will be controlled to within plus or minus five percent of the designated rate. Discharge will be checked, and adjusted, every ten minutes from 30 minutes to 90 minutes of pumping, and every half hour from 90 minutes of pumping to the end of the test. Any adjustment or pertinent information will be recorded.

13.5 ABORTED TEST

Failure or shutdown of the pump for more than one percent of the elapsed pump time will constitute an aborted test. If the test is aborted, pumping will not resume until: (1) the water level in the pumped well has recovered to its static level; or (2) three successive water-level measurements spaced twenty minutes apart show no change greater than 0.01 foot; or, (3) the well has been allowed to recover for a period of time equal to or greater than the elapsed pumping time of the aborted test.

13.6 STORAGE AND DISPOSAL OF PURGED WATER

Water removed during a pump test will be stored and disposed of as outlined in SOP 4.0 (Soil, Water, and Waste Disposal) and the Waste Management Plan.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 14.0
FIELD MEASUREMENTS - SOIL

Purpose and Scope: The purpose for this procedure is to describe methods for measuring the pH of a 1:1 soil-water paste. These measurements will be used as a field estimate of soil pH.

Equipment:
pH meter;
pH buffer solutions (pH 4, 7, and 10);
Plastic cup or beaker;
Distilled or deionized water;
Graduated eye dropper;
Spray bottle; and
Field balance.

Documentation:
Field Memorandum;
Instrument Calibration Log;
Soil Boring Log; and
Test Pit Excavation Log.

14.1 SET-UP

Prior to going into the field, all equipment will be assembled and checked to ensure it is in proper working condition. Measurements of soil pH can be conducted on soil samples collected by any of the methods described in SOP 10.0 (Soil Sampling).

14.2 CALIBRATION AND MEASUREMENT

The pH meter will be checked and calibrated prior to taking any measurements according to procedures outlined in SOP 2.0 (Field Measurements - Water). Upon calibration, measurements of soil pH will be taken as follows:

- Weigh or measure 5 g of air-dry soil into a paper cup;
- With graduated dropper, add 5 ml of distilled water to the soil;

- Mix thoroughly for 5 sec, preferably with portable mechanical stirrer (a small stirrer motor, 1,550 rpm, mounted on a handle with a short, slightly bent plastic or glass rod agitator serves very well);
- Let stand for 10 min;
- Insert the electrodes into the container, and stir the soil suspension by swirling the electrodes slightly;
- Read the pH immediately on the pH meter, and record as soil pH in water, or pH_w; and
- Rinse probe and other equipment thoroughly in distilled or deionized water.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 15.0
FIELD MEASUREMENTS - AIR

Purpose and Scope: The purpose for this procedure is to describe methods for measuring the concentration of volatile organic compound vapors for compliance with the health and safety plan and to screen soil samples collected during test pit excavations, and soil borings.

Equipment:
Photoionization detector (PID);
Calibration gases;
Gas cylinder gauge;
Gas sampling bag; and
Batteries and recharger.

Documentation:
Field Memorandum;
Instrument Calibration Log;
Soil Boring Log; and
Test Pit Excavation Log.

15.1 CALIBRATION

Calibration and measurement procedures in this SOP are based on those written for a MICROTIP™ MP-100 PID. If another brand is used, consult the user's manual for calibration and measurement methods.

Prior to going into the field, the PID will be checked to assure it is in proper working condition. The check will include: an inspection for damage or missing pieces; check of batteries; check of calibration gasses to assure sufficient quantity for calibration for duration of field activities; and calibration of instrument to assure it is working properly. When in the field, the instrument will be properly maintained as indicated in the operators manual, and will be calibrated periodically as indicated in the QAPP.

The PID will be calibrated using two gases: a zero gas or clean outdoor air, and a span gas (usually 100 ppm isobutylene in air). The PID will be calibrated as follows:

- Turn instrument ON and allow it to equilibrate. Check battery;

- Switch to calibration mode (press CAL). Expose the PID to the zero gas sampling bag or to clean outdoor air. Press ENTER to zero the instrument;
- Enter the concentration of the span gas (usually 100 ppm), and connect the span gas bag to the instrument inlet. Press ENTER to set the sensitivity of the instrument; and
- Enter calibration information onto the Calibration Log form.

15.2 MEASUREMENT

Field measurements for VOC vapors will be conducted to monitor the operator breathing zone (OBZ) to ensure worker safety. Measurements of the OBZ will be conducted according to procedures in the H&S Plan.

Field measurements of VOCs will also be used as a screening tool for soil samples. Measurements of VOCs in soil samples will be conducted on continuous core samples, drive samples, drill cuttings (see SOP 6.0 - Soil Borings and SOP 10.0 - Soil Sampling), and samples collected from test pits (see SOP 11.0 - Test Pit Excavation Procedures). The soil sample will be placed into plastic zippered storage bag, the bags will be sealed and the soil broken up. After several minutes, a reading will be taken of the air inside the bag and recorded on the boring or test pit log.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 16.0
AIR SAMPLING - ROTAMETERS AND MASS FLOW

Purpose and Scope: This procedure describes the method of calibration for the individual rotameters or mass flow meters that are used at air stations for the determination of air flow rates through the sampling head and total flow through dry gas meters used in the sampling train. This procedure is applicable to the calibration of the rotameter, or mass flow meter, dry gas meter and associated sampling train configuration described in Figure 16.1. Should a different configuration of the sampling train be installed, recalibration is required and shall be documented per this procedure.

Equipment: Rotameter - A variable orifice gravity-dependent floating indicator, subject to pressure and geo-orientation variables; and
Mass Flow Meter - A flow-indicating device which is not subject to anything but specific heat of the flowing gas.

Documentation: Field Memorandum; and
Calibration Certificates

16.1 SET-UP

Prior to collecting data, the Environmental Engineer shall ensure that the measurement devices which are used at the air sampling stations are (National Institute of Standards and Testing (NIST) traceable) calibrated. The Environmental Engineer or a qualified representative shall maintain the air sampling rotameters, dry gas meters, and ensure that the calibration equipment is calibrated and functional.

16.2 CALIBRATION AND MEASUREMENT

Set up the sample head, blank filter, rotameter or mass flow meter, and vacuum system in the configuration to be used for the actual sampling. The air sampling stations are connected to the normal vacuum source or a vacuum test pump. These should be calibrated in this configuration unless a special sampling train is necessary and documented on the Calibration Certificate (CAL-AIRR).

Step 1 Inspect the entire sampling train for damaged or loose fittings which may cause air leakage. After replacing or repairing damaged parts and confirming all connections are tight, perform the vacuum leak test as follows:

- For ambient air sampling systems, remove the air particulate filter. In its place, secure plastic and duct tape across the face of the opened sampling head. This will serve as an air-tight seal during the test. Isolate the tritium sampling branch, if so equipped.

  For effluent air sampling and monitoring systems, isolate the system to be leak tested. Maintain flow through system not being tested;

- Attach the leak-test rig to the three-way valve located immediately in front of the sampling train's air pump (Figure 16.2). Confirm the water level in bottle #1 is above the black line (approximately 700 mL). Confirm the water level is below the green "zero" line of bottle #2. Fully open the metering valve and start the vacuum pump. Carefully close the metering valve until a steady vacuum of inches Hg is witnessed on the test rig manometer. Invert bottle #1. Water should not transfer from bottle #1 to bottle #2. Water transfer indicates a leak in the test rig which must be corrected before continuing. Return bottle #1 to an upright position. Switch the three-way valve to bring the sampling train on line with the test rig. When the test rig manometer again indicates 5 inches Hg and remains steady, invert bottle #1. If water does not transfer to bottle #2, activate the stopwatch. If water still has not transferred to bottle #2 after one minute, the air sampling train has passed the leak test. Should water begin transferring to bottle #2 upon inverting bottle #1, wait for the level in bottle #2 to reach the green "zero" line. Activate the stopwatch. If the level in bottle #2 passes the black line within one minute (500 cc), the sampling train has failed the leak test. Locate and repair the leak source; then repeat the test;

- If the sampler is equipped with a tritium column, isolate the air particulate sampling branch, plug the inlet to the column and perform the leak test in a manner similar to that described above. Should water begin to transfer from bottle #1, wait for it to pass the first has mark on the clear tubing between bottles. Activate the stopwatch. If the water passes the second hash mark within one minute (7 cc), the sampling train has failed the leak test. Locate and repair the leak source; then repeat the test;

- Upon conclusion of the test, complete the "Certificate of Vacuum Leak Testing" and return the system to its operating condition;

Step 2 Check the batter on the Kurz flow calibrator. Should the display not indicate the BATT OK, recharge the unit overnight prior to field use.

Step 3 Attach the mass flow meter (Kurz Model 544 or Kurz Model 1544) to the sample head using the appropriate sample head adapter and the least amount of connecting tubing necessary. Check to ensure the flow is in the correct direction (in-atmosphere, out-sample head).

Step 4 Connect the Kurz flow calibrator to the matched Kurz mass flow meter using the transducer cable (Figure 16.1, Calibration Sampling Train). Power Kurz after ensuring that cables are properly attached. Verify that the meter balances to zero on the lowest scale.

Step 5 The sampler flow rate can be adjusted with the rotameter valve or, if equipped with a mass flow meter, a flow adjustment screw. Calibrate the rotameter (flow meter) at 20 percent, 50 percent, and 80 percent full scale. Record schematic diagram of actual sampling train used, rotameter model, manufacturer and serial number, location, flow meter and rotameter readings, date, and calibrator's initials. If there is no unique identification code on the meter being calibrated, one must be assigned before the calibration is valid.

Step 6 Plot the rotameter (flow meter) flow rate versus the actual flow rate from Kurz meter on graph paper. At the desired flow rate, if the plot indicates by inspection that the rotameter requires a correction factor of more than 50 percent, deviates from previous calibrations by more than 10 percent, or is nonlinear by more than 10 percent of full scale, the unit must be replaced. In the case of the SIERRA sampler units, the mass flow meter should be adjusted as appropriate.

NOTE: The Kurz flow calibrator automatically compensates for pressure and temperature to read in SLPM (liters per minute at 20°C, 760 mm Hg). A laboratory thermometer will be used to measure the ambient condition during the test. Barometric pressure (uncompensated) will be taken within two hours of any test. If barometric measurements are not available at the site, readings from the official Sacramento area weather service will be acceptable under the conditions that:

- **The area weather system is table within the testing time frame (i.e., a storm front is not moving through the local region); and**
- **The weather service source is representative of and can be elevation compensated for the test site.**

Step 7 Calculate and record the results per steps 12 through 14.

Step 8 Calibration of the dry gas meter may be performed at the same time as calibration of the associated rotameter. A separate calibration form is required for this procedure (CAL-AIRT). To expedite replacement and to be available for emergency response, dry gas meters may be calibrated as "stand alone." Calibration will be performed monthly.

Step 9 Leak test the sampling train per step 1.

Step 10 Set and hold the flow rates for at least three minutes at each of the three levels in Step 5 recording the following data for each point:

- Schematic of sample train and location;
- Identification (model, serial number, etc.) of meter;
- Barometric pressure (mm Hg uncompensated) and time;
- Temperature;
- Calibrator reading, start/finish (slpm);
- Total cubic feet (liters) indicated on dry gas meter using the proving circles indictor; and
- Manometer inches of water (mm Hg) at meter outlet.

Step 11 Using the appropriate formulae (Section 16.7), calculate the corrected volume (STP, 25°C, 760 mm Hg) of indicated flow and the total volume through the calibrator.

Step 12 Calculate and record the correction factor and the cumulative error factor near the operating flow rate. Remove the dry gas meter from service if the correction factor is outside the 0.90 - 1.10 range.

Step 13 Post a calibration sticker including the correction factor with the calibrator's initials and next calibration date on the calibrated meter.

Step 14 The Certification of Calibration and original plot shall be maintained in the instrument file under the file heading Air Sampling Rotameter or Air Sampling Totalizer, as applicable. Instrument files shall be maintained at the project office for each sampling location.

16.3 ADMINISTRATIVE CONTROLS

Air measuring devices used at sampling stations shall be calibrated semi-annually. The correlation between the rotameter and totalizer in a given sampling train shall be checked quarterly. Sampling systems shall be leak tested on a quarterly basis.

Instruments that do not meet calibration specifications shall be repaired or replaced as soon as possible. Replacement meters upon installation or repair shall be calibrated per this procedure. An instrument will not be permanently removed from service until a replacement is available for installation.

The Kurz units should be used in clean areas only.

Perform a radiological survey on any calibrator unit used in this procedure within the plant facility building controlled areas before returning it to storage.

The Kurz units shall be calibrated on an annual cycle. This calibration shall be traceable to the National Institute of Standards and Technology.

16.4 MAINTENANCE

The Kurz flow calibrator shall be recharged following each use. The Kurz mass flow sensor shall be inspected and cleaned as necessary before each use. To clean the sensor, use a small camel's hairbrush and water, followed by an alcohol rinse. The sensor shall be dry before resuming use.

16.5 PRESSURE, VOLUME, AND ERROR COMPENSATION FORMULAE

For volume correction for temperature and pressure:

$$V_s - F_1 \times \frac{P_1}{760} \times \frac{298}{T_1}$$

(STP, 25°C and 760 mm Hg)

V_1 = volume measured at conditions P and T
T_1 = temperature of V_1 in °K
P_1 = pressure of V_1 in mm Hg

To connect to actual volumetric conditions from compensated mass flow readings:

$$Q\ act = Q\ ind \times \frac{ds}{da}$$

Where:

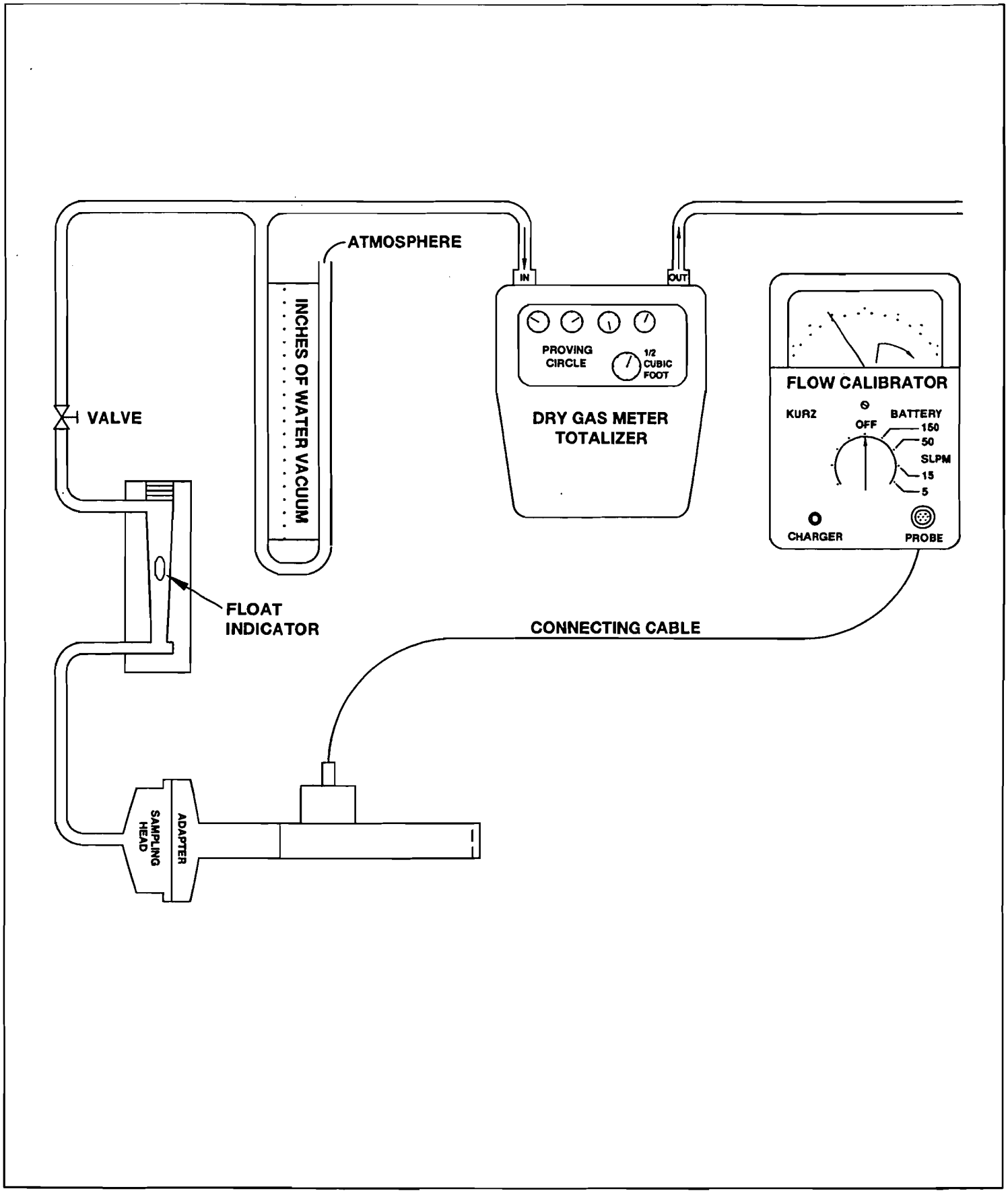
ds	=	air density at STP (25°C 760 mm Hg)
da	=	actual air density in the sample train at the calibration point
Q act	=	volumetric flow rate (lpm)
Q ind	=	indicated mass flow rate (slpm)

Cumulative error, E_v, should be less than 10 percent of total volume for air sampling instruments using the following formula:

$$E_v = \left[Es^2 + Ec^2 + En^2\right]^{\frac{1}{2}}$$

Where:

Ec	=	Percent error of the standard calibration instrument
Es	=	Intrinsic error in reading the meter scale (an acceptable estimate is the percent equivalent of one tenth the smallest scale division compared to scale reading)
Et	=	Percent error in measurement of sampling time (should be less than 1 percent)
En	=	Other errors, known or estimated in the overall system



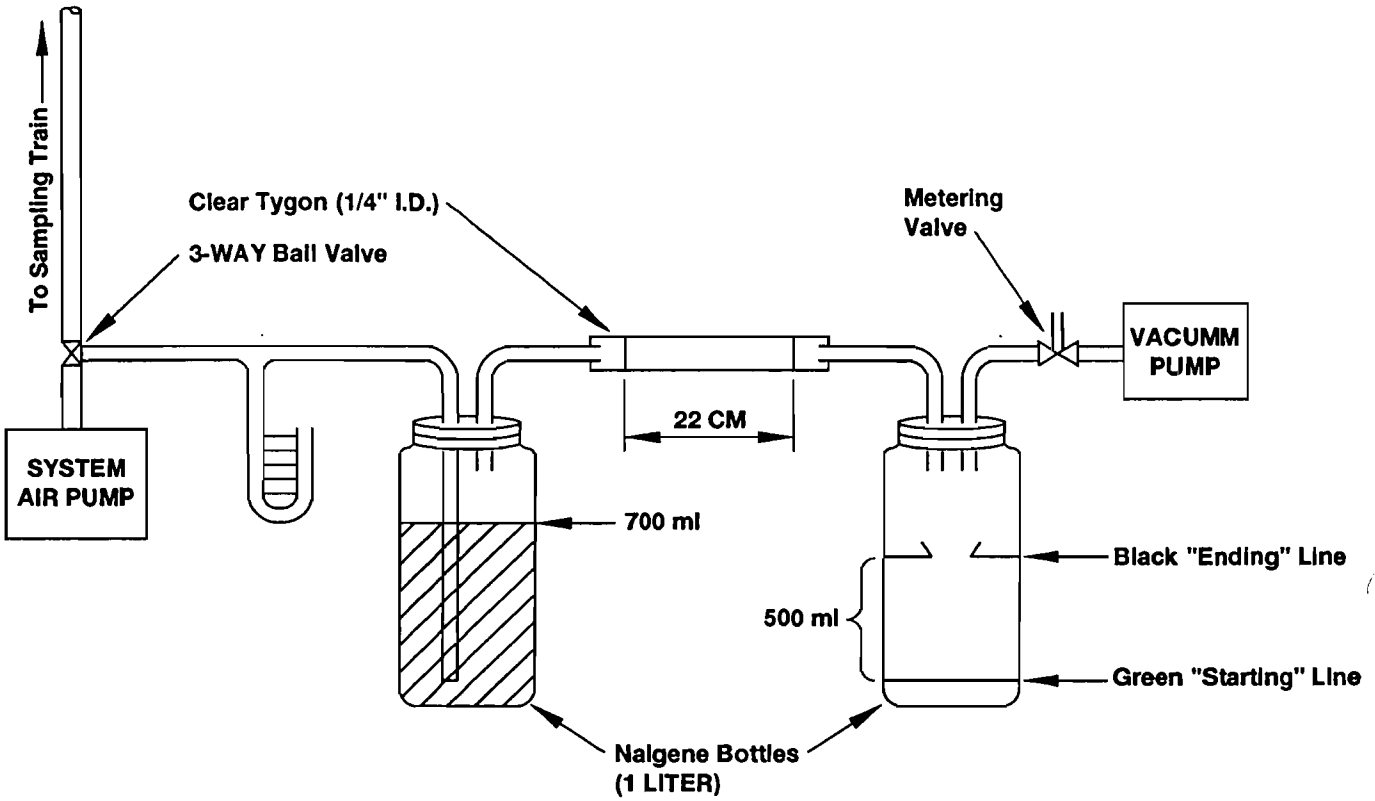
CALIBRATION SAMPLING TRAIN

RI/FS - EA Work Plan
LEHR Environmental Restoration
Davis, California

DAMES & MOORE

10805-720-044 JBS 5/18/93 CALIB

FIGURE SOP16.1



VACUUM LEAK TEST CONFIGURATION

RI/FS - EA Work Plan
LEHR Environmental Restoration
Davis, California

DAMES & MOORE

10805-720-044 JBS 5/18/93 VACUUM

FIGURE SOP16.2

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 17.0
AIR SAMPLING — RADIONUCLIDES IN AMBIENT AIR

Purpose and Scope: Collection of representative ambient air samples from various locations is necessary to determine radionuclide concentrations and monitor environmental air quality which may be affected by site operations. The data obtained from analysis of the air samples is an indicator of environmental trends and efficiency. This procedure describes the general siting requirement, configuration, and operation of air sampler systems utilized to determine the radionuclide content of ambient air. This procedure does not apply directly to stack effluent monitoring.

Equipment:
Glass fiber filters - 47 mm diameter, Gelman Sciences Type A/E;
Tweezers;
Plastic bags approximately 4.5" x 3", zippered storage type, for transport of air filters;
Permanent marker, narrow point, black preferred;
Fully calibrated air sampling system;
Watch/clock;
Desiccant column for collection of tritiated water vapor;
Charcoal cartridge for collection;
Plastic bags, zippered storage type for transport of charcoal cartridges; and
Two-way radio/walkie/talkie.

Documentation: Field Memorandum

17.1 SET-UP, ORGANIZATION AND DOCUMENTATION

Prior to calibration or collecting measurements, all sampling equipment will be checked by the field operations lead to ensure that it is in proper working condition. The Task Manager responsible for ensuring that the placement of air sampling systems is appropriate to the needs and requirements of the environmental monitoring program. The technician collecting the sample is responsible for following the procedural steps and using proper techniques and for accurately recording the appropriate data on the designated worksheet or worklog at each sampling station.

The air sampling systems obtain 110V AC electrical power from standard line service. Exercise extreme caution when working with the systems to prevent possible electrical shock. Be aware of dangers inherent with electrically energized systems.

Do not perform maintenance until the system is properly shut down.

17.2 SAMPLING AND CALIBRATION PROCEDURES

The following procedures detail the configuration, operation, and sample collection procedures for ambient air samples:

The flow rate through the desiccant columns is adjustable to compensate for seasonal changes in relative humidity. To collect an adequate sample and to prevent "breakthrough" (saturation of the desiccant), raise the flow to 500 milliliters per minute or higher during the dry winter months (less than 25 percent relative humidity), then reduce to approximately 250 mL/min during the humid (greater than 75 percent relatively humidity) summer months.

Flow rates may need adjustment weekly. When compensating for humidity levels, all ambient tritium samplers should be adjusted to approximately equal rates on the same day in order to maintain consistency.

17.2.1 General Sampling Train Configuration

Typically, air sampling systems consist of a filtration sampling head for collection of air particulates, a desiccant column for collection of water vapor (specific locations), a charcoal cartridge for collection of radioiodine (specific locations), a rotameter or mass flow meter, a dry-gas or mass-flow totalizer, an elapsed time indicator (optional), and an air pump capable of sustaining continuous flow through the system at an established rate.

In all air sampling situations, accurate air flow rate, totalizer, and calibration factors are required to determine the total volume of air sampled. The accuracy of radionuclide analysis depends directly upon the accuracy of the volume sampled.

17.2.2 Continuous Operation

The flow rate through air filters and charcoal canisters should be maintained between 30 and 60 liters per minute. The nominal target value, with compensation, is 40 standard liters per

minute. Sampling head dimensions will be selected based on manufacturer's recommendations for filter-specific linear flow rate.

17.2.3 General Sample Retrieval

Samples will be retrieved by the following steps:

- Unlock the exterior enclosure containing the sampler and open door. If sampler is not operating, determine cause and correct;

  A. Notify the Environmental Laboratory Manager or Designee immediately to report the problem. Notification will be by two-way radio if in range, or by telephone if at a remote location; and

  B. Document sampler status and actions taken to correct any problems in sampler maintenance log.

- Compare and record the flow rate on the gauge to the flow rate value (including correction factor) posted on the calibration sticker;

- Record the flow rate;

- Turn off the air pump power switch;

- Record the sample period ending date, time, to nearest minute and dry-gas meter or totalizer reading in the appropriate spaces on the Laboratory Information Management System (LIMS) Sampling Worksheet;

- Remove the sample collection medium taking care to handle it minimally (see Section 17.2.4 for instructions appropriate to the medium used);

- Install a new or regenerated collection medium;

  Note: Regenerated medium would be the desiccant used in the tritium columns. The moisture is distilled off and desiccant is then completely dried in an oven. New desiccant is put into service each quarter.

- Turn on the air pump power switch;

- Inspect the rotameter (or mass flow meter) to ensure that the flow rate is within the acceptable range. Adjust as needed to the nominal 40 standard liters per minute flow rate;

- Record the sample period starting date, time, and totalizer meter reading on the LIMS Sampling worksheet (Attachment B);

  A. Record the Hour Meter reading on the field data sheet; and

  B. Immediately calculate the time in minutes from the last visit using 10,080 minutes per week and correcting from any seasonal time changes. Compare the calculated time to the recorded time and determine the difference (calculated minus recorded). Any indicted down time must be documented.

- Visually inspect the system for possible air leakage and damaged components. Repair or replace faulty components and test the system per EM-8;

- Record results of inspection in the sampler maintenance log; and

- Close the sampler door and lock the enclosure.

17.2.4 Specific Sample Collection Media

Collect air particulates weekly on 47mm-diameter type A/E glass fiber filters as follows:

- Turn off the air sample pump per Section 17.2.3;

- Open the filter head and remove the filter. Filters should be manipulated with tweezers by grasping the outer edge. After the filter's exposure period, take care to avoid displacing adhered material, thus compromising the sample. During humid conditions, the filters are particularly delicate; be careful to avoid tearing the filter. (Extra care must be taken during severe weather conditions to prevent loss or damage to the filter due to rain, wind, etc.);

- Record sampler statistics on the LIMS Sampling Work Sheet and a plastic zippered storage bag using a permanent marker. To ease identification, place the exposed filter in the bag with the darkened side toward the clear side of the bag;

- Place a new filter in the head. Avoid contacting the filter in any manner which may result in deposition of contaminants. Confirm that the woven side of the filter is against the head (i.e., "rough" side out); and

- turn on the air pump to draw the filter against the mesh. The head may now be reassembled with little risk of damage to the filter.

  Note: Wrinkles or tears are unacceptable and must be rectified by replacing the damaged filter.

Retrieve desiccant columns weekly as follows:

- Record time collected and tritium dry-gas meter readings on the LIMS Sampling Work Sheet;
- Remove the lines connected in the service column;
- Cap the column orifices to prevent air exchange prior to analysis;
- Observe the color change. As moisture is adsorbed, the desiccant changes from deep blue (dry) to light pink (moist). Ideally, between 40% and 50% of the desiccant should be light pink;
- Adjust the flow rate as needed to maintain this level of moisture trapping;
- Substitute a dedicated column (specific to the sampling system) with fresh or regenerated desiccant for the one removed. Ensure that the lid of the "fresh" column is secure. All connections ad seals must be secure to prevent air leakage; and
- Weekly, Environmental Laboratory personnel will provide "fresh" columns for tritium sampling.

Retrieve charcoal cartridges monthly. Cartridges are located in series behind he air particulate head. Collection should occur during the routine collection nearest the calendar month end:

- Record ending date and time removed on the plastic zippered storage bag and on the cartridge itself;
- Open the cartridge holder and substitute a new cartridge in place of the exposed one. Orient according to the flow direction arrow on the side of the cartridge;
- Place the exposed cartridge in a plastic bag for transport to the laboratory; and

- Environmental laboratory Personnel will provide new charcoal cartridges.

17.3 MAINTENANCE

Maintenance of the sampling system will include initial installation, routine maintenance during operation, and identification of abnormal operation. These procedures are described below.

17.3.1 Initial Sampler Installation

The location selected for installation of ambient air samplers should be within the sector (octant) identified by using the Waite methodology given in DOE/EH-0173T, Section 5.7. The site-specific factors used in the application of the Waite method should be documented by the task manager.

Placement of samplers within the selected sector or area should follow the recommendations provided in DOE-EH-0173T to the extent practicable. Structures, roads, trees, and other anomalous areas are to be avoided. The following requirements are the minimum acceptable for new or replacement siting of ambient air samplers. Whenever possible, the ideal conditions should be met:

- Samplers should be sited at least 50 feet from the edge of dirt roads. This does not apply to low-traffic driveways;

  Generally, avoid siting locations immediately downwind of or near dusty areas, such as plowed fields, industrial yard activities, or heavily traveled unimproved roads;

- Samplers should be sited away from structures or trees such that a 90-degree cone of obstruction-free air exists above the sample, with the apex originating at the sampler head 2.0 meters from the ground. Note that ideally, a 128-degree cone is recommended (2-to-1 distance-to-height ratio) for single structures or trees, and 144 degrees for extended structures or rows of trees. Use of a Brunton pocket transit or clinometer should provide adequate accuracy to ± 1 degree;

- Clearance from obstacles should be measured when foliage is present. For each sampler, a record of the actual vertical angle and geodetic azimuth of obstructions

within the "cone" and/or closest to the "cone" should be recorded in the Maintenance Log;

- The location chosen should be assessed for security concerns including vandalism. Avoid colored sampler housings which contrast with the background or provide a silhouette suitable for a firearms target. The sampler housing should be painted to blend in with the surroundings. Proximity to public places such as recreation areas or schoolyards should be avoided to limit opportunity for vandalism. The ideal conditions include a site on State or Federal lands in an area not usually accessed by the general public, or on private property where the landowner limits access to the site;

- Line power should be from a separate 30-amp metered service with a local disconnect switch. The sampler should be connected to a weatherproof receptacle (instead of "hard wiring") so that the entire sampling unit may be replaced quickly. Power cords should be sized to exceed the expected sampler requirements to allow replicate samplers to be attached occasionally; and

  Protection devices must be installed and functional. Ground fault interrupting devices shall be installed at the receptacle, and a line voltage two-pole electronic protection device installed to protect the sampler electronics.

17.3.2 Routine Sampler Maintenance

Quarterly, an inspection of hoses, connections, and general conditions should be conducted per EM-8 to assure integrity of the system. If maintenance requiring sample train disassembly or evidence of system deterioration has occurred, the system should also be leak tested per EM-8. The inspection and any further testing should be recorded in the Maintenance Log. If sampler removal is required, turn off all power switches, including the service disconnect ***prior to*** unplugging the sampler unit for removal (see Section 17.5 for precautions).

Semi-annually during the routine calibration/leak check (see EM-8), encroaching vegetation growth and other obstructions shall be noted and recorded in the Maintenance Log. The obstruction should be measured at least annually per Step 7.2.3 and the records used to generate work order requests to control the obstructing vegetation as needed to maintain the minimum criteria.

Preventive maintenance will be conducted periodically and include:

- An inspection of the power line installation and the power cords shall be performed and documented, preferably by a qualified electrician. Replacement of deteriorated or damaged electrical cords or equipment must be performed by a qualified electrician;

- Each continuously operating air sampler vacuum pump assembly (motor and pump) shall be replaced with another unit and returned to the manufacturer for servicing. The unit shall be disassembled and inspected. At minimum, the pump carbon vanes (and motor brushes if part of the assembly) shall be replaced and the unit tested for proper operation. The unit shall be excessed if it is not repairable. The specific inspection, repairs, and parts replaced shall be recorded in the maintenance log such that any action pertaining to a specific piece of equipment is traceable.

Sampling train calibration and leak testing shall occur routinely as directed by EM-8.

17.3.3 Reporting of Abnormal Operation

Upon determining a sampler has stopped operating, or indication that a hiatus has occurred per step 6.3.9, the Environmental Scientist collecting the sample will take the following steps. Immediate reports are to be made by radio for conditions described below.

- Downtime over 10% of the week (16.8 hours) or finding an inoperative sample for categorized* ambient air sampling equipment must be reported immediately to the Environmental Lab Manager.

  Actions for downtime over 10% of the week are as follows:

  1. An Event Fact Sheet (Form WV-1098, per WV-987) and an Occurrence Report will be filed.

  2. Lab Manager will confirm with Environmental Lab Radiological group leader and main plant Shift Supervisor on facility airborne radioactivity release events (or lack thereof) for the previous week during downtime.

  3. Lab Field Group will investigate and document the cause of the sampler failure or hiatus in operation.

- Downtime under 10% of the week but greater than a standard error of ± 15 minutes (or over 10% for non-categorized equipment) must be reported to the Environmental Lab Manager upon return to the lab after routine sample collection.

Actions are as follows:

1. An Event Fact Sheet will be filed.

2. Lab Manager will confirm with Environmental Lab Radiological group leader and main plant Shift Supervisor on facility airborne radioactivity release events (or lack thereof) for the previous week during the downtime.

3. Environmental Lab Field Group will investigate and document cause.

- Downtime is under 10% of the week and less than the standard error (± 15 minutes). There will be no action.

Note:

Categorized* Samplers	Non-Categorized Samplers
AFRSPRD	AFDNKRK
AFTCORD	AFGRVAL
AFFXVRD	
AFSPRVL	
AFWEVAL	
AFBOEHN	
AFRT240	

*Categorized "Class B" under current DOE 5000.3A criteria.

If the sampler is operating, but shows abnormality (strange noises, indicator fluctuations, etc.), the unit should be replaced or repaired before it fails.

- Replace the unit as soon as possible per Section 17.3.

- Bench test the unit to determine and document problem.

- Repair and return unit to service per Section 17.3.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 18.0
ANALYTICAL WIPE SAMPLING FOR ORGANIC CHEMICALS

Purpose and Scope: The activities described in this procedure outline the general methodology to be used in collecting wipe samples from surfaces. Wipe samples are used to evaluate surfaces on which contaminated material may reside in quantities too small to sample with conventional soil sampling techniques. This procedure describes the equipment and forms required, as well as set-up procedures to be completed prior to sample collection.

Equipment: Cotton gauze swabs;
High-purity alcohol;
Sample containers and labels; and
Personal Protective Equipment (see site-specific Health & Safety Plan).

Documentation: Field Memorandum;
Field Record - Soil Samples; and
Sample Chain-of-Custody.

18.1 SET-UP PROCEDURES

All sampling procedures will be performed by UC Davis personnel or contractor's field personnel, who are responsible for:

- Reviewing Health and Safety protocol;
- Identifying each sampling location;
- Confirming sample locations and the analyte list with the Project Manager;
- Assembling all required equipment; and
- Assembling and maintaining proper field documentation as listed above.

18.2 WIPE SAMPLE COLLECTION PROCEDURE

Wipe samples will be collected from surfaces that may have come into contact with and retained potentially contaminated soil or other media. A wipe sample is collected when an insufficient volume of the potentially contaminated media exists for standard sample collection procedures. To collect a wipe sample:

- Soak a clean cotton gauze pad (typically 2 inches by 2 inches) in high-purity alcohol;

- Wearing clean rubber gloves; wipe a 100-square-centimeter area of the surface using straight back-and-forth strokes. Both sides of the gauze pad may be used;

- Place a sample pad in a clean, pre-labeled 4- or 8-ounce jar and seal; and
- Add information pertaining to the chain-of-custody form, analysis request form, field record of soil sample form, and field memorandum.

Include with the submittal of samples to the analytical laboratory some clean, unused cotton gauze pads for their analysis of "blank" samples and 40 milliliters of the alcohol if organic analyses are to be performed.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 19.0
CONE PENETROMETER TEST AND HYDROPUNCH™ SAMPLING — IN-SITU WATER

Purpose and Scope: The purpose of this procedure is to describe the general methodology for collecting Cone Penetrometer Test (CPT) data and Hydropunch™ water samples.

Equipment: CPT rig;
Hydropunch™ sampler; and
Appropriate sample bottles.

Documentation: Field Memorandum

Cone penetrometer testing (CPT) and in-situ groundwater sampling techniques (Hydropunch™) will be conducted in order to evaluate the lateral and vertical extent of impact to groundwater. An advantage to the use of the CPT and in-situ groundwater sampling techniques in combination is that stratigraphic and groundwater quality data can be obtained faster and less expensively than with well installations and generate little or no waste. The CPT and in-situ groundwater sampling should enable more accurate placement of wells for future detection monitoring and/or remediation of groundwater, if necessary.

19.1 CONE PENETROMETER TEST (CPT)

The CPT consists of a 1.5-inch diameter metal cone which is pushed into the ground at a constant rate of loading. The maximum reaction load for the CPT used is 20 tons. Instrumentation in the cone measures resistance at the tip and side friction along a sleeve just above the tip. Continuous plots of sleeve friction and tip resistance are obtained from the device and presented as tons/square foot. The ratio of sleeve friction to tip resistance is also produced on the data printout as percent. Refusal occurs when tip resistance exceeds about 400 tons/square foot.

The most common method of obtaining CPT-derived stratigraphic information is by the means of established correlations between soil type and the measured cone tip and sleeve friction resistance. The resistance to the continuous penetration encountered by the cone tip and sleeve is transmitted via electronic cable through hollow push rods and into analog and digital recorders at ground surface. The resulting data is used to develop a detailed evaluation of subsurface site

stratigraphy. In addition, site-specific correlation is typically developed through comparison with lithologic boring logs.

Decontamination of the CPT rods will be provided on the truck-mounted rig which has a self-contained rod-washing attachment which directs a hot-water jet from a steam cleaner onto the rods. The volume of waste fluids generated will be minimal and will be discharged to the ground at the CPT/Hydropunch location. Upon completion of each exploratory hole, a bentonite slurry will be pumped down the hole through a 1-inch PVC pipe placed down the hole. The surface of each hole is finished with road surface material or a non-shrinking, high-strength concrete, as appropriate.

19.2 HYDROPUNCH™ IN-SITU GROUNDWATER SAMPLING

Hydropunch™(HP) in-situ sampling is designed to provide the capability to obtain a representative formation water sample without a permanent well installation. The tool body consists of a stainless steel outer tube, an inner sample chamber, sample chamber Teflon check balls, and a drive point on the bottom, all of which can be dismantled for cleaning. The outside diameter of the tool is 1.66 inches and the length is 63.25 inches.

At each HP sample location, a solid (dummy) cone will be advanced to a few feet above the shallow sampling interval, just below the top of the saturated zone. The tool will then be replaced with the HP, and subsequently advanced to the desired shallow sample depth and a sample obtained. The HP will then be retracted out of the hole and replaced with a clean HP, and pushed to the next desired deeper depth, if warranted, and a sample obtained. This sampling technique provides depth-discrete chemical samples while minimizing the potential for cross contamination of the upper and lower sampling intervals. When collecting water samples in silty-clays, it may be necessary to leave the HP in the ground for an extended time (possibly overnight) in order to allow the sampler to fill.

At each sampling interval, once the target depth is reached with the sampling device, an upward pull opens the inlet section of the tool to allow groundwater to flow into the sample chamber. Teflon check balls in the HP seal the sample chamber when the inlet is closed, which allows the groundwater sample to be brought to ground surface. The sample will then be

transferred from the sample chamber through a Teflon tube to the appropriate sample container. Sample containers will be documented and labeled according to SOP 1 - Water Sampling, and shipped according to SOP 5 - Sample Shipment.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 20.0
SHALLOW SUBSURFACE GEOPHYSICAL SURVEY METHODS
MAGNETICS, ELECTROMAGNETICS, GROUND PENETRATING RADAR
TRANSIENT ELECTROMAGNETICS AND SEISMIC REFRACTION

Purpose and Scope: The purpose of this procedure is to describe the general methodology for shallow subsurface investigations using magnetics, electromagnetics (EM), ground penetrating radar (GPR) transient electromagnetics (TEM) and seismic refraction. The resulting data can be used to identify underground objects, buried trenches, or buried waste and evaluate regional stratography. This SOP describes the equipment and necessary documentation, and the set-up procedures to be completed for the areas to be surveyed. In addition, the general methodology for collecting magnetic, EM, TEM, GPR and Seismic Refraction data are reviewed.

Equipment:
Ground Penetrating Radar;
Electromagnetic Instrument;
Transient Electromagnetic Instrument;
Magnetometer;
Seismograph and geophones;
Data logger;
Laptop computer;
Spray paint;
Flagging; and
Nylon rope for grid

Documentation: Field Memorandum.

20.1 SET-UP PROCEDURES

Set-up and execution of the geophysical survey will be conducted under the supervision of a geologist, geophysicist, or engineer. Prior to conducting a survey, the following tasks will be completed:

- Identify and visit locations to be surveyed noting the presence of nearby buildings, structures, overhead, or buried powerlines, etc., that may interfere with data collection;

- Evaluate the geophysical methodologies best suited for the investigation objectives and the site conditions;

- Confirm survey locations and methods with project manager;
- Procure necessary equipment or subcontractors needed to collect the desired data. If warranted, test equipment to ensure it is in proper working condition; and
- Notify the proper on-site personnel of survey schedule. If necessary, mark or secure the area a day in advance to be sure there are no obstructions (e.g., parked cars) to collecting data.

Prior to collecting magnetic, EM, or GPR data, a data collection grid will be set up across the area to be surveyed. The exact grid spacing will be based on the estimated size of objects or subsurface features to be located.

20.2 GEOPHYSICAL METHODS

This section describes the background and general procedures for collecting data using magnetic, EM, GPR, TEM and seismic refraction methods. The method used will depend on the type of feature to be located, and the nature of the terrain.

20.2.1 Magnetics

Magnetometer surveys consist of measuring variations in the earths magnetic field. This may include measuring its total intensity and/or its vertical gradient. Vertical gradient measurements can be used to accurately locate buried ferrous objects such as tanks, pipes and metallic debris.

Magnetic data is collected by carrying a hand held magnetometer across the survey area. Individual readings are collected at evenly spaced points within a grid. Each magnetic measurement will be transmitted to a data logger. Magnetic measurements will be retrieved from that data logger and contoured using a personal computer. Contour maps will be used to identify areas of anomalous magnetization. These identified areas will be marked on the ground surface following identification.

20.2.2 Electromagnetics (EM)

Electromagnetic methods are used to measure earth conductivity values at specified points. The measured EM values, referred to as terrain conductivity, are obtained through electromagnetic induction as the instrument is carried 3 feet above the ground surface. The basic EM instrument consists of two coils and an electronics module. The transmitter coil is separated from the receiver coil by a specified distance. When energized, the transmitter coil induces circular eddy current which loops into the earth. The magnitude of each current loop is a function of subsurface conditions. In turn, each of these current loops generates a secondary magnetic field proportional to the value of the current flowing within the loop. A portion of this secondary magnetic field is intercepted by the receiver coil and results in an output voltage which is amplified by the instrument. The magnitude of this voltage is linearly related to the terrain (ground) conductivity. EM methods are used where shallow penetration is required to qualitatively map lateral variations only. Depth or thickness determinations cannot be made solely by this method.

EM data is collected by carrying a hand held electromagnetic instrument across the survey area. Individual terrain conductivity measurements are collected at evenly spaced points over a grid. Each terrain conductivity measurement will be digitally recorded using a data logger. The terrain conductivity data will be downloaded from the data logger to a personal computer. Contour maps of terrain conductivity will be produced using a personal computer. Areas of anomalous conductivity will be identified and marked on the ground surface.

20.2.3 TEM

The transient electromagnetic (TEM) method can provide subsurface information similar to other electrical methods; however, it provides increased depths of investigation with significantly greater resolution.

A square wave signal is transmitted into a rectangular coil placed on the ground surface. When the current in the coil is rapidly terminated, the flow of electrical current is induced at the surface of the earth; this generates a secondary current signal. The resulting secondary field is detected by a second coil and is measured over a period of time as the induced current diffuses into the earth and the secondary signal decays. This provides an indication of the change in

resistivity/conductivity with depth. The depth of penetration is dependent on the area and number of turns of the transmitting coil, the current transmitted in the coil, and the repetition rate of the transmitted current.

TEM can be used to perform vertical electric soundings (VES) or to measure subsurface variations along profiles. For vertical electric soundings, the two coils remain stationary, while signals are recorded using different repetition rates. For profiling, a variation of this method is used. Both coils are moved from station to station along a profile, and a single signal sweep is used at each location. This will provide information regarding the vertical distribution of resistivities at each station.

TEM profiling will be used to further evaluate stratigraphy in the site vicinity. Station spacing and location will be determined in the field.

20.2.4 Ground Penetrating Radar

The Ground Penetrating Radar (GPR) system most frequently used in hazardous waste site investigations is an impulse system which radiates short-duration electromagnetic pulses into the ground from an antenna near the surface. These pulses are reflected from various interfaces within the earth and are picked up by the receiver section of the antenna and returned to the control unit for processing and display. These reflections occur at different soil horizons, soil/rock interfaces, rock/air interfaces (voids), manmade objects, or at any interface which creates a contrast in complex dielectric properties. For example, digging a trench and filling it again can create a difference between the dielectric properties of the disturbed earth and those of the undisturbed material which can be sensed by the GPR.

For presentation of data, GPR signals are processed and displayed by a graphic recorder. As the antenna is moved along the surface, the graphic display results in a picture-like record showing a continuous profile along a traverse.

The depth of radar penetration is very site-specific. Depths of 10 to 30 feet can be attained. The depth is reduced if groundwater, increases in electrical conductivity, or if there are sufficiently high concentrations of fine-grained materials (silts or clays) present. For example, high

concentrations of salts or montmorillonite clay are highly attenuative of the radar pulse and penetration may not exceed three feet.

GPR data is collected by moving an antenna along the ground surface. GPR signals are processed and analog records are displayed on a strip recorder in real time. The resulting record is a continuous profile along the traverse. Records will be used to identify potential trench locations and buried debris. Suspected locations will be marked on the ground surface.

20.2.5 Seismic Refraction`

The seismic refraction method consists of measuring the travel times of compressional waves through the subsurface. Seismic wave energy is transmitted into the ground where it is refracted along interfaces of contrasting velocities (materials) back to the ground surface. By measuring the travel time of seismic waves from a source (shotpoint) to detectors at known distances on the surface, the seismic velocities and thicknesses of the respective velocity layers can be determined. This information can be used to determine thickness of fill materials, depth to groundwater, and depth to bedrock.

The seismic refraction survey will be conducted using a 12 or 24 channel signal enhancement seismograph and geophones. Source energy will be provided by striking an alloy plate with a 12 to 16 pound sledge hammer. Signal enhancement capabilities of the receiver will allow the seismic response from several hammer blows to be stacked, decreasing the effects of interference from random noise. Seismic records will be used to determine the arrival time of compressional waves at each geophone locations. Each seismic line will consist of 5 shot points: one at both end geophones, one in the center of the geophone spread, and one offset beyond each end geophone. Line lengths and geophone spacing will be determined in the field and adjusted appropriately to evaluate the refractor of interest.

Travel time curves of first compressional wave arrivals will be plotted. Slope intercept methods and generalized reciprocal methods will be used to determine the depth and velocity of each refractor.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 21.0
SOIL VAPOR SURVEY

Purpose and Scope: This procedure describes the general methods for conducting a soil vapor survey. A soil vapor survey is designed to collect shallow subsurface soil vapor samples and on-site analysis for volatile organic compounds.

Equipment: Soil vapor sample probes;
Sample collecting rig;
Mobile laboratory; and
Sample containers/syringes.

Documentation: Field Memorandum.

21.1 SET-UP

Prior to initiating a soil vapor survey, the field operations lead will meet with the project manager to review the task objectives, survey locations, and target analytes. Set-up procedures for the survey will include:

- Contacting and procuring a soil vapor sampling and analysis subcontractor for the specified time. The subcontractor will be provided with the site location, approximate number of sampling points, a range of depths at which sampling will be attempted, expected subsurface conditions, and target analytes;

- The field operations lead will conduct a site walk-through of the areas to be surveyed. Sampling locations will be identified and marked and proper utility clearance obtained through UC Davis Facilities Services and Underground Service Alert;

- If necessary, 24 hours prior to the beginning of the survey locations will be cordoned -off to prevent access problems for the soil vapor sampling rig;

- The field operations lead will notify the laboratory of the sampling schedule for analytes that are not to be analyzed on-site. The laboratory will provide the appropriate sample containers and preservatives;

- The field operations lead will review the Field Sampling Plan and Health & Safety Plan, prepare the necessary documentation, and review appropriate site information and stratigraphy; and

- Leak tests have been conducted and equipment has been calibrated.

21.2 PROCEDURES

The procedures described below for collecting and analyzing soil vapor samples are supplied from Tracer Research Corporation. Though exact procedures may vary depending on the hired subcontractor the general methods will be similar and include:

- The soil vapor investigation will be conducted by a two-person crew and over seen by a geologist. The crew will use a field van equipped with a gas chromatograph(GC) and accompanying computer equipment. Power is supplied by built-in generators;

- Prior to initiating the survey, sampling equipment will be tested and mobile laboratory instruments will be calibrated;

- Sampling is conducted by driving steel sample probes with a hydraulic press or hydraulic hammer (when gravels, buried debris or cemented material are encountered). The probes consist of 7 and 14 foot lengths of three-quarter inch diameter hollow steel pipe fitted with detachable drive tips;

- Sample probes are pushed or driven to the desired sampling depth. the above ground end of the probe is then fitted with a steel reducer and a length of polyethylene tubing leading to a vacuum source;

- Two to five liters of soil vapor are then evacuated from the system to purge the probe. If a sufficient quantity cannot be removed, the probe is pulled up a short distance until the evacuation can be completed; and

- After sufficient evacuation, a glass syringe needle is extended through a silicone rubber septa in the evacuation line and a sample is collected. Samples for volatile organic compounds are analyzed immediately with the mobile laboratory.

21.3 QUALITY ASSURANCE

Quality assurance procedures to be followed in order to minimize any potential cross-contamination of soil gas samples are as follows:

- Steel probes are used only once during the day and washed at the end of each day with high-pressure soap and hot water spray or steam-cleaned to reduce the possibility for cross-contamination. Enough probes are carried on the van to avoid the need to reuse any rods during the day;

- Probe adaptors are used to connect the sample probe to the vacuum pump. The adaptor is designed to eliminate the possibility of exposing the sample stream to any part of the adaptor. Associated tubing connecting the adaptor to the vacuum pump is replaced periodically as needed during the job to ensure cleanliness and good fit. At the end of each day, the adaptor is cleaned with soap and water and baked in the GC oven;

- Silicone tubing (connecting the adaptor to the vacuum pump) is replaced as needed to ensure proper sealing around the syringe needle. This tubing does not directly contact soil gas samples;

- Glass syringes are generally used for only one sample per day and are washed and baked at night. If they must be used twice, they are purged with carrier gas (nitrogen) and baked between probe samplings;

- Interior port septa through which soil gas samples are injected into the chromatograph are replaced on a daily basis to prevent possible gas leaks from the chromatographic column;

- Analytical instruments in the mobile laboratory are calibrated each day by analytical standards from Chem Service, Inc. Calibration checks are also run after approximately every five soil gas sampling locations;

- 2 cc sub-sampling syringes are checked for contamination prior to sampling each day by injecting nitrogen carrier gas into the gas chromatograph;

- Prior to sampling each day, system blanks are run to check the sampling apparatus (probe, adaptor, 10 cc syringe) for contamination by drawing ambient air from above ground through the system and comparing the analysis to a concurrently sampled air analysis;

- All sampling and 2 cc sub-sampling syringes are decontaminated each day and no equipment is reused before being decontaminated. Microliter size sub-sampling syringes are reused only after a nitrogen carrier gas blank is run to ensure that it is not contaminated by the previous sample; and

- Soil gas pumping is monitored by a vacuum gauge to ensure that an adequate gas flow from the vadose zone is maintained. A reliable gas sample can be obtained if

the negative pressure reading on the vacuum pump is at least 2 inches Hg less than the maximum pump capacity.

Detection limits for the compounds of interest will be a function of the injection volume as well as the detector sensitivity for individual compounds. Thus, the detection limit will vary with the sample size. Generally, the larger the injection size, the greater the sensitivity. However, peaks for compounds of interest will be kept within the linear range of the analytical equipment. If any compound has a high concentration, it will be necessary to use small injections, and in some cases to dilute the sample to keep it within linear range. This may cause decreased detection limits for other compounds in the analyses.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 22.0
SURFACE CONTAMINATION SURVEY FOR RADIOLOGICAL MATERIALS

Purpose and Scope: This procedure covers the techniques for using swipes, performing direct instrument readings and taking smears to determine removable and total radioactive surface contamination for routine evaluations, and for performing baseline surveys. This procedure is intended for use by radiation protection technicians.

Equipment:
Survey instruments equivalent to Ludlum Model 12 with 43-5 probe;
Ludlum Model 3 or 31 with 44-9 probe;
Smears;
Swipes;
Personnel Protective Equipment (see site-specific Health and Safety Plan);
Signs to post; and
Glassine envelopes.

Documentation:
Field Memorandum
Radiological Contamination Survey Form

22.1 SET-UP

Set-up for the surface contamination survey will be conducted prior to collecting field data or samples. Set-up will be conducted by the Radiation Protection Technician (RPT) after review of project requirements with the project or task manager. Set-up will consist of a review of survey data, general survey preparations, review of instrument requirements and a review of survey precautions.

22.1.1. Review of Survey Data

The RPT will be aware of the radiological conditions present or expected in the area, by reviewing the area's current and/or historical survey data, making note of:

- The type of contamination;
- The range of loose surface and fixed contamination;
- Areas of higher or lower contamination;

- Areas of higher and lower radiation;
- The wind direction and levels of, or potential for, airborne radioactivity; and
- Any other information useful in reducing radiation exposure to the RPT or other workers.

22.1.2 Survey Preparations

Preparation for the survey will consist of:

- Pre-stage equipment and material in an uncontaminated, low radiation area when practical; and
- All radiological surveys required for an area should be performed at one time to minimize personnel exposure.

22.1.3 Instrumentation Requirements

Survey instruments will have an unexpired "calibration due date" on the calibration label and satisfactorily pass a performance test and operational check as specified in the use procedure for the applicable instrument. Instruments equivalent to those specified below may be used. The UC Davis Radiation Safety Officer (RSO) or contractor's Senior Health Physicists will determine if a given instrument is equivalent.

- Ludlum Model 12 with 43-5 Probe
- Ludlum Model 3 or 31 with 44-9 Probe

Smear-counting instrumentation will have an unexpired "calibration due date" on the calibration label. In addition, performance tests will be conducted as specified in SOPs 24.0 and 25.0.

22.1.4 Survey Precautions

Latex rubber gloves will be worn (and changed when contaminated or torn) when taking smears where loose surface contamination is present or suspected.

- When changing gloves, hands should be checked for contamination.
- A pair of cotton gloves may be worn under surgeon's gloves.
- Leather gloves may be worn when surveying rough or sharp edges. Leather gloves may be worn over surgeon's gloves.

Smears and swipes taken from within a controlled area should be disposed of in the same manner as radioactive waste.

If survey results indicate contamination levels exceeding the limits for the current area posting take the following action:

- Promptly post and control the area; and
- Notify the Site Safety Officer (SSO) (see Health & Safety Plan).

Instruments used in contaminated or potentially contaminated areas should be wrapped or bagged ensuring the detectors' active area is not covered. Exercise caution when removing the covering to avoid contaminating the instruments.

22.2 SURVEY INSTRUCTIONS

22.2.1 Requirements for Routine Contamination Survey of Areas

The frequency with which routine surface contamination surveys are to be performed will be determined by the SSO, the RPT and the Work Plan. A smear survey will be performed as part

of each pre- and post-job survey required by project-specific documents, such as the contamination control portion of a Health and Safety Plan.

Direct contamination survey of the localized affected area will be performed as part of each pre- and post-job survey. The post-job surveys will be performed over the affected area.

22.2.2 Direct Measurement Technique

Surfaces or items that have the potential for fixed contamination will be surveyed for such contamination before any work, movement, or handling of materials. Fixed contamination may readily become removable during such activities and must be identified so that proper precautions may be taken. Suspected surfaces or items may be identified in a guideline or a work permit, or by user personnel.

Use a Ludlum Model 12 count-rate instrument or its equivalent, equipped with an air proportional or scintillation detector for measuring direct alpha activity.

Use a Ludlum Model 3 or 31 count-rate instrument or its equivalent, equipped with a GM pancake detector for direct measurement of beta/gamma activity.

NOTE: A HEADSET OR AUDIBLE INDICATION SHOULD BE USED FOR FASTER RESPONSE TIMES BY THE OPERATOR.

Use a shoulder strap to carry a non-belted instrument while climbing a ladder, or use a length of rope to hoist the instrument up after ascending and achieving secure footing.

Sweep the detector over the surface at a maximum rate of 2 inches per second, holding the detector within approximately 1/4 inch of the surface for alpha, and within 1/2 inch of the surface for beta/gamma surveys.

CAUTION: CARE SHOULD BE TAKEN TO AVOID CONTAMINATING THE SURVEY INSTRUMENT PROBE BY CONTACT WITH A CONTAMINATED SURFACE.

If an increase in audible or meter response is noted, slow the scanning rate to locate the source of the increased count.

Determine the area of maximum activity and hold the probe stationary for at least 15 seconds in order to take a measurement.

Record the instrument readings in counts per minute (cpm) on the Radiological Contamination Survey Form.

22.2.3 Smear Technique

CAUTION: SMEAR SURVEYS ARE PERFORMED TO QUANTIFY REMOVABLE CONTAMINATION LEVELS.

Each smear paper will be numbered and correspond to a numbered location on a diagram or sketch showing the area or item surveyed.

WARNINGS:

USE CAUTION IN SURVEYING ROUGH SURFACES TO AVOID PERSONAL INJURY OR TEARING OF THE SMEAR PAPER.

HANDLE SMEAR PAPERS CAREFULLY TO PREVENT PERSONAL CONTAMINATION OR THE SPREAD OF CONTAMINATION.

Hold a smear paper between the thumb and fingers, with the back of the smear against the fingers. Place the face of the smear paper against the surface to be smeared.

Apply moderate pressure across the smear paper to ensure that at least one-half of the face of the smear comes in contact with the surface being surveyed.

Each smear should be taken from an area of approximately 100 square centimeters (16 square inches).

Place each smear paper in a "fold-over" or glassine envelope container to prevent cross-contamination.

Smears from out of the way locations on equipment, and from other potential sources of contamination, should be obtained to ensure that a complete assessment of the area or item is made.

Smear non-uniform objects and/or surfaces such as odd shapes, interior surfaces, and small items, ensuring that these surfaces are adequately monitored and that the face of the smear paper has come in contact with a representative portion of the object.

NOTE: WET OR MOIST SMEARS SHOULD BE DRIED WITH A HEAT LAMP BEFORE COUNTING SO THAT ALPHA ACTIVITY WILL NOT BE MASKED.

Count the smears according to instructions provided in SOP's 24.0 and 25.0.

Record the measured contamination on the Radiological Contamination Survey Form. Additional preprinted pages with continuing prenumbered spaces for recording survey results will be used as needed.

To reduce or eliminate false positive results when counting alpha smears taken in areas where the limit is 20 disintegrations per minute (dpm) per 100 cm^2 (for Uncontrolled Areas), the following steps will be followed when the initial count result is greater than 20 dpm but less than or equal to 60 dpm:

- Count the smear three additional times; and
- Average the four counts and enter the average as the final result on the standard survey form.

22.2.4 Baseline Surveys

Baseline survey results will be documented on Radiological Contamination Survey Forms separate from the results recorded for routine surveys.

- The SSO will file the completed survey forms in a master survey binder kept in the Site Health and Safety office

- Survey forms will be filed by area

22.2.5 Release for Unrestricted-Use Surveys

Surveys of property to be released for unrestricted use will be performed in accordance with the following:

- Direct Surveys - Perform direct surveys for fixed-plus removable contamination in accordance with section 22.2.2 of this procedure;

- Removable Contamination Surveys - Perform smear surveys for removable contamination in accordance with section 22.2.3 of this procedure;

- Documentation - Complete a Radiological Survey Form for each item surveyed. Multiple items may be grouped on a single survey form, space permitting;

    - Provide a sketch or written description of the property, noting survey locations. Provide the survey results corresponding to each survey location, in its appropriate place on the form.

    - Survey results for removable and fixed-plus removable contamination will be recorded in dpm/100 cm^2.

22.2.6 Records

Surveys will be documented accurately and legibly in black ink. The data will be recorded in sufficient detail to ensure that the meaning and intent of the record is clear. Ditto marks and continuation lines are not acceptable for repeated data. In all cases each specific number or "< number" must be recorded independently.

Any corrections made to the recorded entries on the Radiological Contamination Survey Form will be made by drawing a single line through the incorrect entry and recording the correct entry. The originator of the recorded entry will initial and date the entry. When it is not possible for the originator of the error to make the correction, the SSO may enter a correction followed by his/her initials and the date the correction is made.

Record the results on the survey form in the space provided, matching the smear results to the location marked on the survey diagram or sketch. Smear results will be reported in dpm/100 cm^2.

The background level will be recorded on the survey form for all radiological instruments.

- Identify on the survey diagram any temporary (e.g., rope, tape) boundaries; and
- Identify on the survey diagram any step-off pads.

In addition to radiological survey data, the following information will be provided on the survey form:

- Site and site identification number (or other specific identification);
- Date and time survey initiated (if the survey is continued or completed on a shift, note this in the comments section after the date and time initiated);
- Survey description: identify the purpose of the survey (e.g., routine, post decon, etc.) and area or item surveyed;
- Type(s) of instrument(s) used, their serial number(s), the date calibrated, the date calibration is due; and

- Signature(s) of individual(s) performing the survey.

Submit the completed survey form to the SSO for review. Unacceptable survey forms will be corrected and promptly resubmitted.

Copies of completed survey forms will be posted at entrances to Radiological Areas and storage areas, as applicable.

A copy of the survey will be retained in the Site Health and Safety Office.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 23.0
PERFORMANCE TEST AND OPERATIONAL CHECKS FOR ALPHA AND BETA-GAMMA CONTAMINATION SURVEY INSTRUMENTS

Purpose and Scope: This procedure defines the method for performance testing and operational checking of the Ludlum Model 12 and Model 3 or 31 Survey Instruments, performance and operational criteria, and the documentation of test results. Equivalent instruments may be used. The UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Ludlum Model 12; and
Ludlum Model 3 or 31 survey instruments.

Documentation: Field Memorandum
Instrument Daily Source Check Log

23.1 GENERAL

23.1.1 Servicing Instruments with Expired Calibration Dates

Any instrument with an expired calibration date will be transferred to a certified calibration facility for servicing.

23.1.2 Additional Servicing of Instruments

The Radiation Protection Technician (RPT) is permitted to replace defective batteries, and mylar in the Model 12 and Model 3 or 31 survey instruments, and perform routine maintenance and repair on anything but the electronics.

The RPT may replace damaged cables as long as the same cable type and length is used. All other instrument servicing will be referred to a certified calibration facility.

23.2 INSTRUCTIONS

Ludlum Model 12 and Model 3 or 31 Instruments - All Ludlum Model 12 and Model 3 or 31 survey instruments (or their equivalents) will be operationally checked and performance tested before use, as specified in this procedure.

Visual Checks - The calibration label of each instrument to be used or tested will be visually checked to ensure the due date of calibration has not expired.

A visual inspection will be performed before using the instruments. This will include checking the cables, probes, meter faces, switches, and mylar for damage.

23.2.1 Operational Checks

The following operational checks will be conducted in the field for each instrument:

- A battery check will be conducted before each intermittent use of an instrument. Set the selector switch to the BATTERY position. The meter needle will come to rest over the meter scale area marked BAT TEST if the batteries are satisfactory;
- On the Ludlum instruments the High Voltage will be tested by placing the range selector switch to the X1000 scale and the HV test button depressed. Check the manufacturers operating instructions for the proper voltage;
- Instrument operation will be verified with a check source at the start of each job for which the instrument is used. The following method (or equivalent method) may be used to complete the operation check:
    - A known alpha source, approved for use by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists, will be used with the Model 12 alpha instruments, and a known gamma or beta source, approved for use by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists, will be used with the Model 3 or 31 beta-gamma instruments;
    - Instrument operation will be observed by holding the instrument probe against the check source;

- A positive deflection of the meter needle of ± 20% of source value corrected for efficiency indicates instrument operation;

- Non-operating instruments will be returned to a certified calibration facility for repair.

23.2.2 Performance Tests

A performance test to verify calibration of survey instruments will be performed before each day of instrument use and following the replacement of batteries, mylar or cables.

Checking of the instrument calibration label and batteries will follow the requirements outlined below. The serial number of the instrument, due date of calibration, date/time, and RPT name and employee number or social security number will be recorded on the Daily Source Check Log specified for each instrument.

Readings of the Model 12 alpha survey instrument will be obtained for a NIST traceable source and instrument range selections. Each instrument range should be checked.

- Meter readings will be recorded on the Instrument Daily Source Check Log;

- The serial number and standard calibration value of each source will be recorded on the source check logs;

- A percent error will be calculated for each scale reading by the following formula:

$$\left(\frac{Reading - NIST\ Standard\ Value}{NIST\ Standard\ Value}\right) \times 100 = \%\ E$$

Readings of the Model 3 or 31 beta-gamma survey instrument will be obtained and recorded for the NIST traceable source value.

- With the selector switch set to the 1X scale and in the "S" (slow) response mode, obtain and record a background reading taken away from the source;

- With the instrument set on the appropriate range, place the beta/gamma source on the probe;
- Allow approximately 10-15 seconds for the meter response to stabilize before taking a reading of the meter;
- Subtract the background reading from the source reading and record the result on the Instrument Daily Source Check Log;
- The serial number and standard value of each source will be recorded on the source check log; and
- A percent error will be calculated for each scale reading. by the following formula:

$$\left(\frac{Reading - NIST\ Standard\ Value}{NIST\ Standard\ Value} \right) \times 100 = \%\ E$$

Instruments with errors outside a ± 20% range for any scale tested are not within an acceptable tolerance level and will be returned to a certified calibration facility.

The Daily Source Check Logs will be checked to show whether or not instrument performance is within tolerance levels.

Instruments for which test results differ by more than ±20% will be transferred to a certified calibration facility. This finding and the action taken will be noted in the Instrumentation Log Book.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 24.0
PERFORMANCE CHECKING AND OPERATION OF THE ALPHA SCINTILLATION SMEAR COUNTING INSTRUMENTS

Purpose and Scope: This procedure provides the requirements for performance testing and operation of the Eberline Model SAC-4 and the Ludlum models 1000 and 2000 with the 43-10, and 2929 alpha scintillation smear counting instrumentation. It also covers documentation of test results. Equivalent instruments may be used, the procedures will be found in the manufacturers operating instructions. UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This procedure is intended for use by project Radiation Protection Technicians.

24.1 GENERAL

Servicing of Alpha-Scintillation Counting Instruments - The servicing of alpha-scintillation counting instruments will be referred to a certified calibration facility, the equipment vendor, or the equipment owner.

24.2 INSTRUCTIONS

24.2.1 Background Count Rate

Prior to use of alpha-scintillation counting instruments on each shift, the average background count rate will be determined and a performance test conducted.

The calibration label will be visually checked to ensure the due date of calibration has not expired.

Determine the instrument background count rate by completing the following steps:

- Open the sample drawer and carefully wipe the top of the drawer and planchet area using cotton swabs or kimwipes moistened with alcohol;
- Place a clean smear on the sample tray with tweezers. The smear must remain flat in the sample tray while closing the drawer;
- Set the control switches of the counter as follows:

(1) Power	ON
(2) Minutes	10
(3) Multiplier	×1
(4) Count Mode	TIMED

Note: Ensure the instrument power is turned on, at least 10 minutes before operation.

- Press the START/RESET button. The counting lamp will be illuminated;
- At the completion of the count time, divide the total counts by 10 to determine the average background count rate;
- If the average background count rate is less than 1 cpm, record the value on the Instrument Performance Test Log;
- Record the time of the background determination and the employee number or social security number in the space provided on the log sheet; and
- If the determination is equal or greater than 1, repeat the steps in the background guideline in section 4.1.2. If the second determination remains equal or greater than 1, the instrument may not be used.

Determine the percent error using a NIST calibrated alpha source or similar calibrated alpha source, approved for use by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists.

- Ensure the source has a current calibration label and that the source value is not less than 1,500 disintegrations per minute (dpm);
- Record the serial number of the source on the Instrument Performance Test Log;
- Record the Certified activity of the source on the log sheet;
- Open the sample drawer and carefully place the alpha source, activity side up, in the middle of the sample holder;
- Close the sample drawer;
- With the count mode set to one minute, and all other controls set as per section 4.1.2, press the START/RESET button. The counting lamp will be illuminated;

- When the counting lamp is no longer lit, record the counts per minute (cpm) on the log sheet;

- Determine the percent (%) error of the observed counts compared to the source standard value per the following:

$$\% \text{ Error} = \frac{(\text{cpm / efficiency}) - \text{Certified Activity (dpm)}}{\text{Certified Activity (dpm)}} \times 100$$

- Record the % error on the log sheet;

- The SSO will review and approve of each shift record of performance testing. These records will be available in the project files;

- If the % error does not lie within the ± 20% range on the chart, do not use the instrument and notify the SSO; and

- Remove the source from the sample holder and return it to the designated storage location.

24.2.2 Operation of the Alpha-Scintillation Counting Instrument

Normal operation of the alpha-scintillation counting instrument will be as specified.

- Verify that the electrical power to the instrument has been on for 10 minutes;

- Set the instrument controls as per section 24.2.1 of this procedure; however, one-minute counts will be obtained for routine smear counts unless a longer count time is directed by the Site Safety Officer (SSO);

- Pull the sample drawer open until fully extended and place the smear to be evaluated in the center of the sample holder, activity side up;

- Ensure the sample is a flat as possible to prevent contamination of the detector window. Carefully close the sample drawer;

- Press the START/RESET button;

- The instrument will count for the preset time. At the end of the count time, the instrument readout will display gross counts;

- Record the counts per minute and other information on the Alpha and Beta-Gamma Contamination Survey Form as required by SOP 23.0; and

- Open the sample drawer and dispose of the smear in the Radioactive Waste receptacle.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 25.0
PERFORMANCE TESTING AND OPERATION OF THE BETA SMEAR COUNTING INSTRUMENTATION

Purpose and Scope: This procedure provides instructions on performance testing, operation, use, and documentation of results when using the Eberline BC-4 or the Ludlum 2929. Equivalent instruments may be used, the procedures will be found in the manufacturers operating instructions. UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Eberline BC-4;
Ludlum 2929; and
Thin substrate NIST Certified SrY-90 beta source.

Documentation: Field Memorandum; and
Instrument Performance Test Log.

25.1 GENERAL

The BC-4 and the beta-gamma portion of the 2929 has been modified to be insensitive to alpha radiation; therefore, the results obtained will be reported in dpm/100cm^2 beta-gamma equivalent. All servicing will be referred to a certified calibration facility, the equipment vendor, or the owner.

25.2 INSTRUCTIONS

25.2.1 Conducting Background Count Rate and Performance Test

Prior to first use on each shift, the background count rate of each instrument will be determined and a performance test conducted.

The calibration label will be visually checked to ensure the due date of calibration has not expired. If calibration due date has passed, refer the instrument to a certified calibration facility, the equipment vendor, or the owner for servicing.

Inspect the instrument for any physical damage that could affect its operations. If questionable, notify Site Safety Officer (SSO).

Ensure that the instrument is connected to a power source 110 VAC/60 Hz.

Determine the instrument background count rate by completing the following steps:

- Open the sample drawer and carefully wipe the top of the drawer and planchet area using cotton swabs or kimwipes moistened with alcohol;
- Place a clean smear on the sample tray with tweezers. The smear must remain flat in the sample tray while closing the drawer;
- Set the control switches of the BC-4 or 2929 counter as follows:

(1) Power	ON
(2) Minutes	10
(3) Multiplier	x1
(4) Count Mode	TIMED

Note: Ensure the instrument power is turned on, at least 5 minutes before operation.

- Press the START/RESET button. The counting lamp will be illuminated;

- At the completion of the count time, divide the total counts by 10 to determine the background count rate, in counts per minute (cpm);
- If the background count rate is between 25 and 60 cpm, record the value on the Instrument Performance Test Log. An acceptable background is between **25** and **60 cpm**;

  Note: Background levels may vary depending on location; background levels outside the range of 25 to 60 cpm may not be an instrument problem.

- Record the time of the background determination and the employee's initials in the space in the log;
- If the determination is equal to or greater than 60 cpm, or equal to or less than 25 cpm, repeat the steps outlined above. If the second determination remains less than 25 cpm, or greater than 60 cpm, do not use the instrument and notify the Site Safety Officer (SSO).

Determine the performance test percent error using a thin substrate NIST Certified SrY-90 beta source or another source approved by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists. The source should be nominal activity 20,000 disintegrations per minute (dpm).

- Ensure that the source has a current calibration label;
- Record the source serial number on the Instrument Performance Test Log;
- Record the activity of the source in dpm according to month of use (if required), in the log;
- Open the sample drawer and carefully place the beta (or gamma) source, activity side up, in the middle of the sample holder;
- Close the sample drawer;
- With the count mode set to one minute and all other controls set as described above, press the START/RESET button. The counting lamp will be illuminated;
- When the counting lamp is no longer lit, record the cpm in the log;
- Determine the percent (%) error of the observed counts compared to the source standard value per the following:

$$\% \text{ Error} = \frac{(\text{cpm} / \text{efficiency}) - \text{Certified Activity (dpm)}}{\text{Certified Activity (dpm)}} \times 100$$

- Record the % error in the log;
- The SSO will review and approve each shift record of performance testing at the end of each week. The Performance Test Log will be available in the project files for review;
- If the % error does not lie within the $\pm$ 20% range on the chart, do not use the instrument and notify the SSO; and
- Remove the source from the sample holder and return it to the designated storage location.

25.2.2 Operation of the Beta Smear Counting Instrument

Operation of the beta smear counting instrument when counting smears will be as follows:

- Ensure the instrument power is turned on, at least 5 minutes before operation;
- Set the instrument controls as described above; however, one-minute counts will be obtained for routine smear counts unless a longer count time is directed by the SSO or Radiological Engineering;
- Pull the sample drawer open until fully extended and, using tweezers, place the smear to be evaluated in the center of the sample holder, activity side up;
- Ensure the sample is as flat as possible to prevent contamination of the detector window. Carefully close the sample drawer;
- Press the RESET/START button;
- The instrument will count for the preset time. At the end of the count time, the instrument readout will display gross counts;
- Perform the following to determine the dpm value for the smear;

$$\text{dpm} = \frac{\text{cpm - (instrument background per shift)}}{\text{count time in minutes x efficiency}}$$

this reduces to:

$$\text{dpm} = \frac{\text{CPM (net)}}{\text{efficiency}}$$

- Record the dpm smear value and other information on the Contamination Survey Form as required by SOP 23.0;
- Open the sample drawer and, using tweezers, dispose of the smear in the Radioactive Waste receptacle; and
- Repeat the above steps for all smears to be counted.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 26.0
RADON WORKING LEVEL MONITORING - GRAB SAMPLE TECHNIQUE

Purpose and Scope: This procedure covers the Kusnetz grab sample method for determining radon working levels. Equivalent instruments may be used. UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Air sampling pump;
Filters and filter holder assembly;
Alpha Counting; and
Timer.

Documentation: Field Memorandum.

26.1 GENERAL

Radon and Radon Daughters - Radon (^{222}Rn) is a gas and radon daughters (^{218}Po, ^{214}Pb and ^{214}Bi known as RaA, RaB and RaC respectively) are particulates. This method involves trapping the daughter products in a filter, allowing a short time for decay and counting. This gives a "real time" results of radon working levels. A working level is any combination of radon and radon daughters that result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy per liter of air.

26.2 INSTRUCTIONS

26.2.1 Equipment

The following equipment will be required:

Air Sampling Pump

- A pump capable of maintaining a flow rate of 2 to 25 liters per minute through the selected filter is required. The flow rate should not vary significantly during the sampling period. A calibrated air flow measurement device is also required.

Filters and Filter Holder Assembly

- Membrane type filters are recommended with a pore size not to exceed 0.8 microns and a filter holder assembly suitable for the type of filter being used. Adapters for the attachment of the filter holder to the pump are also required.

Alpha Counting System

- A detector and scaler setup, maintained, and performance tested in accordance with SOP 24.0.

Timer

- A stopwatch or timer to measure the sampling times and counting times is required.

26.2.2 Sample Collection

Install the filter in the filter holder assembly and attach to the pump

Operate the pump for exactly 5 minutes, pulling air through the filter. Record the starting time and air flow rate.

Stop the pump at the end of the 5 minute sampling period and start or reset the stopwatch.

26.2.3 Sample Counting

Carefully transfer the filter from the filter holder assembly to the detector. Orient the collection side of the filter towards the face of the detector.

Operate the counter over any 10 minute time interval between 40 minutes and 90 minutes after the sampling start time. Record the total counts for the sample and the time (in minutes after sampling) at the midpoint of the 10 minute count interval.

26.2.4 Analysis

Calculate working levels (WL) as follows:

$$WL = \frac{C}{K_t \times V \times E}$$

Where:

C = Sample cpm - Background cpm

V = Volume of Air Sampled in Liters, = flow rate (liters per minute) x time (minutes)

E = Counter Efficiency (cpm per dpm)

K_t = Kusnetz Factor - From the chart, time in minutes from stopping the pump to the midpoint of the count interval

26.2.5 Kusnetz Factor Chart

Time	K_t	Time	K_t
40	150	70	90
42	146	72	87
44	142	74	84
46	138	76	82
48	134	78	78
50	130		
52	126	80	75
54	122	82	73
56	118	84	69
58	114	86	66
		88	63
60	110		
62	106	90	60
64	102		
66	98		
68	94		

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 27.0
PERFORMANCE OF THE GAMMA RADIATION SURVEY

Purpose and Scope: This procedure defines the requirements for performing gamma radiation surveys and documenting survey results. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Gamma survey instrument; and
Watch.

Documentation: Gamma Survey Instrument Calibration Log; and
Radiation Contamination Survey Form.

27.1 GENERAL

27.1.1 Review of Survey Data

The Radiation Protection Technician (RPT) will be familiar with the radiological conditions present or expected in the area by reviewing the area's current and/or historical survey, making note of:

- The type of radiation;
- The range of loose surface and fixed contamination;
- Areas of higher or lower contamination;
- Areas of higher and lower radiation;
- The wind direction and levels of, or potential for, airborne radioactivity; and
- Any other information useful in reducing radiation exposure to the RPT or other workers.

27.1.2 Survey Preparations

Pre-stage equipment and material in a low radiation level area, when practical.

All radiological surveys required for an area should be performed concurrently to minimize the surveyor's exposure.

Use a carrying strap or lanyard to secure the instrument when climbing; or raise and lower the instrument to the appropriate elevation with a length of rope.

27.1.3 Instrumentation Requirements

Select the appropriate type instrument, using the following criteria. (The following list is a guideline for selection and is not intended as a requirement that all the instrumentation listed be available).

- Gamma survey instruments must be approved by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists. They will also determine if an instrument is equivalent.
- The appropriate gamma survey instrument will depend on the expected radiation levels that will be encountered. No one instrument will cover all of the ranges that could be found on a radium site. This will have to be determined as the project develops.
- Appropriate calibration for the types and energy range of the radiation to be measured.
- Sufficiently high range to read the highest expected exposure rate.

The RPT will verify that performance testing of the instruments has been performed daily prior to use. The RPT will record the results in a calibration log for each instrument. Performance tests for instruments will be done in accordance with the manufacturer's recommendations.

Survey instruments will have an unexpired "calibration due date" on the calibration label. A battery check will be conducted before each intermittent use of the instrument.

27.2 INSTRUCTIONS

27.2.1 Survey of Radiation Areas

Enter the area with the instrument scale selector set to measure the highest expected radiation level. Hold the instrument at waist-level and walk slowly through the area. Through the use of headset or audible response and observation of instrument readings, locate all elevated radiation levels within the area. Adjust the instrument selector downscale, as necessary, to obtain the radiation level reading(s). Record instrument readings on Gamma Radiation Survey form. The instrument reading will be an average of the meter needle fluctuations after instrument response has stabilized or the digital readout if present.

27.2.2 Survey Records

The RPT will document the survey readings accurately and legibly on a standard preprinted survey form. Use sufficient detail to ensure that the meaning and intent of the record is clear. Survey points will be denoted on work area diagrams or sketches and attached to the completed survey form.

Record the radiation survey data as follows:

- Record the radiation measurement of each survey position for each identified survey location and any areas with elevated readings;
- Unless all radiation surveys are performed at the same position (distance from the source) and that position is stated on the survey (e.g., "all radiation measurements at 36 inches from ground level"), specify the position after each measurement;
- Note distances of instrument readings taken at distances other than 30 cm on the survey form;
- Identify all posted radiological boundaries in the area surveyed; and
- Note units for all readings (either with a note at the top, or for each reading. Underline or otherwise highlight any units out of the ordinary.

In addition to the radiological information, include the following information on the survey form:

- Client identification;
- Site designation and number (or other specific identification);
- Date and time survey initiated;
- Survey description: identify the purpose of the survey (e.g., routine, post decon, etc.) and area or item surveyed;
- Type(s) of instrument(s) used, their serial number(s), the date calibrated, the date calibration is due; and
- Signature(s) of individual(s) performing the survey.

The RPT will submit completed survey forms to the Site Safety Officer (SSO) for review. Unacceptable survey forms will be corrected by the RPT and promptly resubmitted.

A copy will be retained in the Site Safety Office.

27.2.3 Control for Radiation Areas

When a radiation level exceeding 5 mrem/h is identified initiate radiation controls as follows:

1. Post and control the area in accordance with UC Davis EH&S requirements; and
2. Notify the SSO.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 28.0
USE OF THE BICRON FIDLER
(FIELD INSTRUMENT FOR THE DETECTION OF LOW ENERGY RADIATION)

Purpose and Scope: This procedure covers the general use of the Bicron FIDLER (Field Instrument for the Detection of Low Energy Radiation) to identify low-energy gamma and x-ray emitting radiation sources and to document survey findings. Equivalent instruments may be used. UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This Procedure is intended for use by project Radiation Protection Technicians.

Equipment: Bicron FIDLER (Field Instrument for the Detection of Low-Energy Radiation).

Documentation: Field Memorandum; and
Instrument Calibration Log.

28.1 GENERAL

28.1.1 The FIDLER Unit Components

The FIDLER unit consists of a Bicron Analyst meter, equipped with a scaler option, and a Bicron G-5 thin window scintillation probe connected by a signal cable. This instrument also includes a Bicron G-5 HV handle and a detector housing.

28.1.2 Low-Energy Radiation Detection

The use of the FIDLER provides a qualitative indication of the presence or absence of gamma and x-ray low-energy radiation sources. Other methods must be used for quantitative measurements of sources.

28.2 INSTRUCTIONS

28.2.1 Instrument Inspection

Prior to using the instrument, perform the following checks:

- Document that the manufacturer's calibration due date has not expired;
- Inspect the instrument for physical damage that could affect its operation;
- Document that the instrument has successfully passed a performance test within the last 24 hours by checking the field calibration log; and
- Perform a battery check and document that the needle reads in the BAT OK region.

28.2.2 Instrument Failure

If the instrument fails any of the above checks it may not be used.

28.2.3 Instrument Controls

Set the instrument controls as follows:

Response Mode	Slow
Audio	ON
Scale	x100
Mode	Channel 1

28.2.4 Background Reading

Determine a background reading in the area of use by holding the probe still and performing a one-minute scaler count. To perform the one-minute scaler count, press the count button. The red LED lamp will be illuminated, indicating that the scaler is counting. When the LED lamp goes out, the count is finished. Record the counts per minute (cpm) from the scaler display located on the instrument face. The background count should be taken at a minimum of 15 feet from the items to be surveyed and any other non-background radiation source. When doing a soil surface scan, it is recommended that the background be taken in an area where contamination is known not to exist or over a location where the background of the soil is known.

28.2.5 Probing

Hold the probe at least 12 inches from the item or surface being surveyed if the item is much larger than the probe. If the item is the same size or smaller than the probe, hold the probe on contact.

28.2.6 Scanning

Scan slowly, no faster than two inches per second, to give the instrument time to respond. Scan rates greater than two inches per second drastically reduce the probability of detection. The operator should listen closely to the audio output, as it responds faster than the instrument reading.

28.2.7 Surveying

When surveying, any response above background should be investigated by holding the instrument still for one minute to verify the above-background reading. If an above-background reading is confirmed, slow the scanning speed. Attempt to locate the source by moving the probe in different directions and by scanning in the directions yielding the highest above-background readings.

When the highest reading is located, perform a one-minute scaler count, and record the results of the count and the location the reading was taken.

28.2.8 Battery Check

Periodically during use, perform a battery check to ensure the batteries are still good.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 29.0
PERFORMANCE OF PERSONNEL CONTAMINATION MONITORING

Purpose and Scope: This procedure defines the use of instruments for personnel contamination monitoring, criteria for personnel contamination, control of contaminated personnel, and documentation of contamination occurrences. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Ludlum Model 12 or equivalent Survey Scope.
Ludlum Model 3 or 31 Count Rate Meter

Documentation: Field Memorandum.

29.1 GENERAL

29.1.1 Radiological Occurrence Response Actions

If a radiological occurrence involves a combination of conditions, response actions will be taken in the following priority:

- Critical injury or illness;
- Skin contamination;
- Noncritical injury or illness; and
- Possible inhalation of radioactive material.

29.1.2 Emergency Medical Care

Emergency medical care of critically injured or ill personnel will take precedence over radiological actions.

29.1.3 Transporting Contaminated Personnel

Care will be exercised in transporting contaminated personnel to minimize the spread of contamination in Uncontrolled Areas. A contractor-owned or leased vehicle will normally be used

for transportation. However, a personal vehicle may be used if a critical injury is involved. The transporting vehicle will be controlled until released by the Radiation Protection Technician (RPT).

29.2 INSTRUCTIONS

29.2.1 Monitoring Personnel for Contamination

Monitoring of personnel for contamination will be performed in the following situations, however, other requirements may exist in upper-tier documents (e.g., Work Plans or Site-Specific Health and Safety Plans [SSHSPs]) and should also be followed:

- Whenever leaving a Radiologically Controlled Area;
- Whenever exiting a Contaminated Area;
- During and after work where a potential exists for release of radioactive material;
- Whenever passing through a Controlled Area; and
- Following personnel decontamination.

Personnel monitoring will consist of a whole-body survey except for precautionary surveys. The whole-body survey will be conducted front and back, over the following areas or articles:

- head (pause at mouth and nose);
- neck and shoulders;
- arms (pause at each elbow);
- hands (pause at palms and back of hands);
- respirator (exterior, interior, cartridge, and straps);
- chest and abdomen;
- back, hips, and seat of pants;
- legs (pause at each knee);
- pant cuffs (pause at cuff);
- shoe-cover bottoms;
- shoe tops; and

- shoe bottoms (pause at sole and heel).

Alpha contamination monitoring will be performed as follows:

- The Ludlum Model 12 Survey Meter probe type (or equivalent) will be used. UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent.
    - The detector will be held within 1/4 inch of the body or clothing surface and moved slowly, (i.e., about 2 inches per second);
    - To the extent practical, clothing wrinkles will be smoothed prior to monitoring;
- The instrument scale selector control will be set to the range appropriate for measuring levels of contamination;
- Visual or audible instrument response will be used to determine the presence of contamination;
- Clothing will be considered contaminated if the detectable radioactivity is greater than background; and
- Skin will be considered contaminated if any level of radioactivity above background is detected.

Beta/gamma contamination monitoring will be performed as follows:

- The Ludlum Model 3 or 31 Count Rate Meter or equivalent equipped with a pancake detector will be used. Equivalent instrumentation release limits will be established by UC Davis Radiation Safety Officer or contractor's Senior Health Physicists, taking into consideration the minimum detectable activity (MDA) of the instrument;
- If the background count rate exceeds 150 counts per minute (cpm), consideration will be given to moving the monitoring station;
- The detector will be held within 1/2 inch of the body or clothing surface and moved slowly (i.e., about 2 inches per second);
- Visual or audible instrument response will be used to determine the presence of contamination;

- Clothing will be considered contaminated if 100 cpm above background are indicated; and
- Skin will be considered contaminated if any level of radioactivity is detected.

When skin contamination is detected, the contamination will be appropriately covered and contained. The RPT will escort the contaminated employee to the decontamination area. Field decontamination may be performed provided adequate decontamination equipment is available.

- For wound contamination or for contamination observed around the nose or mouth, UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will be notified immediately.

Area controls will be established for personnel contamination occurrences.

- Stop traffic through the area where contamination occurred;
- Perform contamination surveys to determine the extent of the contamination;
- Isolate the affected area by posting and barricading it;
- Identify the travel routes and other personnel that are potentially contaminated; and
- Perform area and personnel contamination monitoring as required.

Reports required for contamination occurrences will be completed, approved by the SSO, and forwarded to UC Davis Radiation Safety Officer or contractor's Health Physicists as soon as possible.

29.3 CALIBRATION

The Ludlum survey scope will be calibrated every six months, or at the manufacturer's recommendations, by the manufacturer. The instrument will also be source checked on a daily or as-needed basis to verify proper working condition.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 30.0
AIRBORNE RADIOACTIVITY MONITORING

Purpose and Scope: This procedure covers airborne radioactivity monitoring by the filtration method and includes corrections for radon daughters. Equivalent instruments to the ones listed in this procedure may be used. The UC Davis Radiation Safety Officer or contractor's Senior Health Physicists will determine if a given instrument is equivalent. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Air Sampling Pump: Such as the Eberline RAS-1 capable of maintaining a flow rate of up to 100 liters per minute or greater through the selected filter is required. The flow rate should not vary significantly during the sampling period. A calibrated air flow measurement device is also required.

Filters and Filter Holder Assembly: Membrane type filters are recommended with a pore size not to exceed 0.8 microns and a filter holder assembly suitable for the type of filter being used. Adapters for the attachment of the filter holder to the pump are also required.

Counting System: A detector and scaler setup, maintained, operated, and performance tested in accordance with Radiological Operating Procedures 30.2.1 and 30.2.2.

Documentation: Field Memorandum.

30.1 GENERAL

30.1.1 Airborne Radioactivity

Certain activities performed in the field pose the potential for airborne radiological contamination. These include the use of drilling equipment in contaminated soil, driving vehicles over contaminated ground, and decontamination. It is necessary to determine the presence and amount of airborne radiological contaminants to assess the adequacy of implemented levels of protection to the workers.

30.2 INSTRUCTIONS

30.2.1 Sample Collection

- Install the filter in the filter holder assembly and attach to the pump. Place the pump in the appropriate location as determined by indoor air flow measurements or, if outdoors, downwind of the proposed working area and as close to the breathing zone as possible; and

- Operate the pump for the time interval required, pulling air through the filter. Record the start time, the stop time, and the air flow rate on Field Memorandum.

30.2.2 Sample Counting

- The sample filter will be counted as quickly as practical for gross activity. The sample should be stored in a separate glassine or smear envelope;

- Carefully transfer the filter from the storage envelope to the detector. Orient the collection side of the filter towards the face of the detector; and

- Count the sample for 10 minutes. Record the total counts for the sample, the counting time and date, and the countrate (cpm).

- Store the sample filter for radon daughter decay, approximately 48 to 72 hours or further analysis for specific radionuclides. The sample should be stored in a separate coin, glassine or smear envelope. The envelope will be marked with enough information to identify the sample;

30.2.3 Analysis

Calculate the activity as follows for both alpha and beta activities:

$$Activity\ (A) = \frac{Sample\ cpm\ -\ Background\ cpm}{V\ *\ E\ *2.22E{+}06}$$

Where:

V = Volume of Air Sampled in Liters - flow rate (liters per minute) · sampling time (minutes) · 1000 ml/l

E = Counter Efficiency, the fraction

$$E = \frac{Source\ count\ rate\ (cpm)}{Source\ activity\ (dpm)}$$

2.22E+06 = The number of disintegrations per micro Curie.

The calculated alpha and beta activities should then be compared to the activities given in table 6-2 of the Health & Safety Plan. If either the alpha or beta activity is greater then 10% of the activities for Th-232 (alpha) and/or Sr-90 (beta) then;

The Site Safety Officer will be notified.

If only the alpha activity is above the 10% derived air concentration level then air sampling for radon working levels maybe performed in accordance with SOP 26.0.

The work area should be posted and appropriate measures taken to reduce the airborne radioactivity. (Dust control measures be put into effect and/or respirators be required if the initial activity levels are above 1 derived air concentration level.)

All personnel in the work area in question will be surveyed for radioactive contamination around the face and nasal and throat swabs collected for evaluation.

Follow-up air samples shall be collected in the work area and down wind from the work area.

At a timed interval after the initial count successive counts will be performed and the short term half life calculated.

The half life can be calculated in the following manner:

$$T_{1/2} = \frac{0.693 * T}{\ln \frac{A}{A_o}}$$

Where: $T_{1/2}$ is the half life in minutes.

T is the time between counts in minutes.

A_o is the original count rate.

A is the second count rate.

The Project Health Physicist will be informed as to the results of air sample and half life calculations, sequence of events and measures taken.

The Project Health Physicist or designee will notify the UC Davis Project Manager of results, measures taken and follow-up measures that are to be taken.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 31.0
CHANGE IN STANDARD OPERATING PROCEDURES

Purpose and Scope: The Purpose for this procedure is to allow project personnel, with appropriate approvals, to make minor changes to the SOPs based on unanticipated or unforeseen changes in the field conditions. The change may be requested by any member of the project staff and documented using the Interim Change Notice Form.

Documentation: Field Memorandum
Interim Change Notice
Record of Telephone Conversation

Interim Change Notices (ICN) will be used to identify significant changes to the SOPs where a revision of that SOP is not appropriate at that time. The interim change may be requested by any member of the project staff. The staff requesting the ICN should carefully document the series of events leading to the request for a change in SOPs. The request for change is made to the Field Manager who reviews the need for the change of procedure. The Field Manager documents the change using the ICN form and notifies the Task Manager. The Task Manager will submit the ICN to UC Davis Project Manager for review and approval. The ICNs will not be incorporated until approval from the UC Davis Project Manager has been received. Minor changes in procedures will be documented within the Field Memorandum only.

When documenting the reasons for the change, the Field Manager will include.

- The SOP affected;
- The portion of the SOP being changed;
- The series of events that lead to the need for the change;
- A description of the new procedure; and
- Specific details on when and where the new procedure will be used.

All ICNs are numbered and distributed by UC Davis or subcontractor's QA/QC personnel.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 32.0
VEGETATION SAMPLING

Purpose and Scope: Samples will be collected to characterize contaminant concentrations in vegetation compartments at the LEHR site. Terrestrial foodstuffs will be sampled to provide verification that hazardous materials traceable to the site are not present in the environment above expected background levels. The primary concern in sampling vegetation is to assure that site-generated radioactive materials and hazardous chemicals have not been introduced into the local food chain where they could be further distributed. Documented vegetation concentrations will therefore help to support subsequent ecological risk assessment calculations. This SOP describes the techniques to be implemented for vegetation sampling. In addition, equipment and documentation requirements necessary for sampling are described.

Equipment:

Maps (described above)
Calculator with random number generator
2 ten-meter ropes marked in meter units
Step ladder
Grass shears, trowel, pruner and pruner with extended handle
Wooden frame that measures one square meter
Mechanical balance with a minimum of 5 kilogram capacity
Necessary weights for mechanical balance
Measuring tape
Kneeling pad
Zippered plastic bags for sample collection
Sample labels (4" x 2" white, self-adhesive labels)
Sample Custody Seals
Waterproof pen
Stainless steel bowl and spoon
Coolers, blue ice and thermometers
Cleaning and decontamination equipment (Non-phosphate cleaning solution, four 5-gallon buckets, bottle brushes, distilled water, potable water and paper towels)
Disposable gloves

Documentation:

Field Memorandum;
Vegetation Sampling Log Book;
Sample Summary Form.

32.1 RESPONSIBILITIES AND QUALIFICATIONS

Personnel executing the protocols described in this SOP should be instructed in the use of the sampling apparatus and proper identification of species likely to be encountered. Periodic performance audits of field personnel will be conducted according to established procedures.

32.2 GENERAL PROCEDURES

Reconnaissance surveys will be performed to provide a consistent and encompassing view of area habitats and to provide qualitative observation for relative comparisons among vegetation/land use types. The principal vegetation components to be considered in the risk assessment are the native and disturbed vegetation at the site and, possibly nearby agricultural fields. Sample sites will be selected after additional site information is collected and terrestrial ecological receptors are selected.

32.3 SAMPLING PREPARATION

Field sampling will be preceded by completing and incorporating preparatory procedures. These procedures include mapping sampling locations, selecting site for quality assurance/quality control (QA/QC) samples, preparing sampling labels, acquiring and donning appropriate personal protective equipment (PPE) and reviewing and becoming knowledgeable of the necessary safety precautions.

32.3.1 Sample Locations

Prior to sample collection, a detailed map or drawing of the sampling locations will be prepared. This map will define the location in terms of area landmarks (e.g. trees, fences, walkways, etc.), so that consistent layout of the sampling grid will be established for current and future sampling. Draw map in the Vegetation Sampling Record Log Book.

32.3.2 Select Sites for Quality Assurance/Quality Control (QA/QC) Samples

In order to provide essential comparison data, it is necessary to prepare both split and duplicate samples for analysis. Sampling locations for split samples and duplicate samples will be selected from the set of sample locations. This will be accomplished through the use of a random number table or generator. The total percentage for QA/QC samples will be at least 10% of the total number of samples. If the randomly selected sample site is not collectable or has been destroyed, random sites will continue to be generated until a collectable site is identified. The duplicate and split samples will receive full analysis.

32.4 DECONTAMINATION OF EQUIPMENT

Equipment will be decontaminated before use at sampling site. Prior to use and after each sample is collected all sampling equipment will be washed twice in a non-phosphate (Alconox or equivalent) solution, rinsed with potable water and rinsed again with distilled water to prevent cross-contamination. Hard bristle bottle brushes may be used in the first two wash buckets to remove debris. Equipment should be allowed to drain dry after the final distilled water rinse.

32.5 SELECTION OF SAMPLING LAYOUT

Depending on the vegetation available at each sampling location, it is necessary to select from two sampling grid layouts; quadrant formation or transect formation. If the sampling location contains an area of mixed herbaceous and/or perennial vegetation (grasses, weeds, bushes, etc.) of approximately 10 meter square or larger, then the square quadrant formation will be applied. Although a 10 meter square area is ideal, a slightly smaller area may be adapted (eight square meters for example), when area boundaries (creek, road, etc.) do not allow the full 10 meters on each side. If, however, the location has little or no ground cover type of vegetation, but rather a row of trees, plants or bushes, then a transect formation will be applied to that location.

32.5.1 Quadrant Formation Sample Collection

(1) Go to sampling location. Indicate in log book that quadrant formation has been selected for this sample site. Determine approximately where to position the 10 meter square sample grid.

(2) Place one of the 10 meter long ropes along one side of the grid location. Mark on the prepared map to show where the rope was placed to begin the grid pattern. Draw in the complete grip formation on the map as situated. Use the random number generator (see section 32.5.3) to indicate where to place the second rope so that it is perpendicular to the first, going into the grid. This is the first coordinate of the grid location.

(3) The next number on the random number generator will designate the second coordinate to show exactly where the sample is to be taken within the plotted area. Place the square meter frame over the grid location portion, with the appropriate mark on the rope defining the bottom left corner of the frame. Mark this sample area on the map with a number (1, 2, 3 etc.) to show the order in which was selected, and write the coordinates in log book.

(4) Use the grass shears and/or pruners to cut all vegetation within the square frame dimensions. Cut the vegetation to approximately 1 cm above ground. Place the sample into the plastic bag as it is cut. Leaves collected for analysis should be clipped at the petiole and allowed to drop directly into the collecting bag. Do not allow sample to come in contact with soil after cutting. Dispose of gloves used in collecting the sample to avoid cross-contamination.

(5) When finished, weigh the amount of sample collected at that grid location, using the mechanical balance. Record in log book the grid

location and weight of sample collected. If the particular grid location has no vegetation, the weight will be zero.

(6) Continue repeating steps (3) through (5) until at least 1500 grams of sample have been collected at this location. If this location has been randomly selected as a split or duplicate sample location, a second 1500 grams will need to be collected. Duplicate samples will be kept separate from the original sample and coded as a separate sample.

(7) When the sample bag contains 1500 grams wet weight, attach the prepared label to the sample bag, and include the time sample was collected and your initials. Double bag the sample and place immediately in a cooler with sufficient dry ice to maintain the sample at 40 degrees F. Check the thermometer each time the cooler is opened. If it reads above 40 degrees, take the samples in for refrigeration or add more dry ice.

(8) Decon sampling equipment as stated in Section 32.4 after each sample is collected.

32.5.2 Transect Formation Sample Collection

(1) Indicate in log book that transect formation has been selected for sample site. Determine the approximate dimensions of the transect rectangle. For shrubs, side ratios of 1:5 or 1:10, plots of 50 or 100 square meters are sufficient. For trees, plots of 200 or more meters square, with side ratios of 1:5 or 1:10 are commonly used. Sparser vegetation will require larger sampling areas than denser vegetation. Mark the transect dimensions and situation on the map for that sampling location.

(2) When sampling trees or bushes, prepare the transect grid format so that each bush or tree has its own square. This will make sampling much more logical and allow the tree or bush to be sampled from each direction.

(3) Now use the random number generator to determine which tree or bush to sample. Samples shall be collected from all sides of the tree or bush, from the lowest branch to the highest branch that can be safely reached from the ladder with the extended pruners. Care should be taken to collect vegetation from open, unshaded areas where radionuclide deposition would not be atypical.

(4) Leaves collected for analysis should be clipped at the petiole and allowed to drop directly into the collecting bag. Do not allow sample material to fall on the ground after being cut. This can cause contamination from the soil, as well as the loss of particulate matter from the leaves, which would be significant for the analysis. Additionally, disposable gloves are to be changed between each sample.

(5) When finished, weigh the amount of sample collected at that grid location, using the mechanical balance. Record the grid location and the weight collected in the log book.

(6) Continue repeating steps (3) through (5) until at least 1500 grams wet weight of sample have been collected at this location. If this location has been randomly selected as a split or duplicate sample location (see 32.3.2), a second 1500 grams wet weight will need to be collected. Duplicate samples will be kept separate from the original sample taken at a location, and coded as a separate sample.

(7) When 1500 grams of sample have been collected, attach the prepared sample label to the sample bag, along with the time the

sample was collected and your initials. Double bag the sample and place in a cooler with sufficient dry ice to keep the sample cooled to 40 degrees F. Check the thermometer each time the cooler is opened. If it reads above 40 degrees F, take the samples in for refrigeration or add additional dry ice.

(8) Decon sampling equipment according to Section 32.4 after each sample is collected.

32.5.3 Sample Selection Using Random Numbers

Calculator with Random Number Generator: Follow directions in the instruction book for that calculator. Normally a nine-digit number is generated. Decimal points shall be disregarded. Digits may be selected from either the right side for the number, or the left (i.e. if the lot is less than 100, use the first 2 digits or the last 2 digits). When the next sample is to be selected, clear the calculator and generate a second random number.

32.6 SAMPLE HANDLING AND STORAGE

Once samples have been collected, special care must be taken to ensure integrity of sample identity and condition. The vegetation samples must be maintained at 40 degrees F, which is essential for analysis of tritium. Assure there is sufficient dry ice to maintain this temperature. Additional coolers may be necessary to allow room for both samples and blue ice.

When coolers return from the field after collection, check temperature, assure labels are complete and correct, and that field log has been completed for each sample. Complete Vegetation Sampling Log (Appendix B) to provide record of sample and analysis.

32.7 SPLIT SAMPLE PREPARATION

Carefully put contents of sample bag to be split into a stainless steel bowl. Assure that all of sample goes into bowl without spilling. Then, with a spoon, slowly stir ingredients until completely mixed. Then, with gloves physically divide the sample into equal portions and place

each half into separate sample bags. Weigh bags to verify that they are of equal weight. Adjust sample amount if needed to achieve balanced weight. Assure labels are attached to bags for correct sample identification. Split samples are to be prepared for shipment to separate laboratories for comparison analysis. Both randomly selected background and site samples should be included in the lot to be sent to the comparison laboratory.

32.8 SAMPLE PACKAGING AND SHIPPING

SOP 5.0 provides detailed instruction for packaging and shipping of samples. Assure each sample is placed in a second plastic bag, to protect the label from external moisture and assist in sample containment and integrity. Attach UCD custody seal to each bag and cover with clear tape to prevent tampering with contents prior to receipt of laboratory.

Samples will be shipped to the laboratory for analysis on the same day they were collected. If samples are held for any time before shipping, they will be stored at 40 degrees F in a designated secure area. Care must be taken to minimize handling, potential for sample contamination, or degradation of sample information on labels or documents.

All samples will be shipped by certified mail or its equivalent in order to maintain a chain of legal accountability or custody. Overnight or one day service may be necessary in order to meet holding times. Federal Express or another private carrier may be used if timing and custody requirements are met. A Custody Security Seal should be placed on the cooler and covered with clear tape after the Chain of Custody has been placed inside (see next section).

32.9 CHAIN OF CUSTODY RECORD

To establish the integrity of samples, it is necessary to demonstrate that the samples were maintain under custody from the time they were collected in the field to the time they were analyzed in the laboratory. If samples are held for any time before shipping, they shall be maintained under custody.

A sample is under custody if:

- It is in your possession
- It is in your view, after being in your possession
- It was in your possession and you locked it up, and
- It is in a designated secure area

All samples sent to the lab must be accompanied by a Chain of Custody Record. Ensure that the Chain of Custody includes all analyses required The original Chain of Custody shall be placed in a plastic bag inside the cooler with the samples and a copy shall be kept on file.

STANDARD OPERATING PROCEDURES
STANDARD OPERATING PROCEDURE 33.0
DOWN-HOLE RADIATION MONITORING

Purpose and Scope: The purpose of this procedure is to describe the method for measuring the radiation in soil surrounding a borehole. These measurements can be used to determine the presence of radioactive material above natural background, and the approximate spatial limits of the contamination. This procedure is intended for use by project Radiation Protection Technicians.

Equipment: Calibrated instrument capable of scaler and count rate modes (for example, ESP-2/HP-270 or equivalent)
Protective plastic tubing or wrap

Documentation: Field Memorandum
Survey Record

33.1 GENERAL

The Radiation Protection Technician (RPT) will be familiar with the radiological conditions expected in the borehole area by reviewing the area's historical information and results of surveys conducted on boring equipment.

Instruments used will be calibrated within six months prior to the start of down-hole radiation monitoring.

Instruments used in potentially contaminated bore holes shall be protected from contamination and surveyed for contamination after use.

On each day of use, a source check and background check will be performed and recorded in accordance with SOP 23.

A handling line will be attached to the detector probe and marked at 10 (20) centimeter intervals.

33.2 OPERATION

Prior to performing down-hole measurements, the probe and cabling will be protected from becoming contaminated (PVC pipe lining the hole will serve to protect the cable and side of the probe from being contaminated). Additionally, the probe will be protected from moisture that may accumulate in the bore hole.

With the operating instrument in the count rate mode, slowly lower the probe down the bore hole. Observe the instrument response and note any large (greater than five times background) changes in the count rate. Record the initial results.

Change the operating mode of the instrument to count rate and, starting at the bottom of the hole, perform a 30-second count and record the results.

Raise the probe 10 (20) centimeters and repeat the count and record the results.

As the probe is being raised, survey the protective covering on the cable(s) for contamination and remove and/or contain any contamination found.

Repeat the operation until the probe is out of the suspected area or out of the hole.

Survey all materials not previously surveyed that may have come in contact with or placed down the hole.

Review data and resurvey suspect readings if deemed necessary by the On-Site Manager.

APPENDIX B

FIELD DOCUMENTATION FORMS

FIELD MEMORANDUM

ACTION	INFO	
To:		File:
		X-Ref:
		Date:

From: Reply Required By:

Subject:

Reference(s):

ROUTING

114.8 (REV. 5-68)

LEHR Remedial Investigation
SAMPLE SUMMARY FORM

Sample ID:
(affix sticker from label sheet here)

Operable Unit: _____

Chain-of-Custody #: _____

Date: Time: Location ID: Depth: Other Code:

Sampling Method: Sample Matrix: Sampled By:

Water Soil Air Wipe Other: _____

Comments:

pH:_____ units Rad:_____
(include units: mr/hr or CPM)

Eh: _____ mvolts PID/OVA:_____

Temperature:_____ °C Turbidity:_____

Specific Conductivity:_____ umhos/cm2

Containers:	Preserved with:
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____
(#)_____ Type)_____	Ice/None/_____

Requested Analyses:

Soil	Water
___Volatiles	___Volatiles
___Semivolatiles	___Semivolatiles
___Pesticides	___Pesticides
___Metals	___Metals
___Hex Chrome	___Total Chromium
	___Hex Chrome
___Gross Alpha/Beta	___Gross Alpha/Beta
___Gamma Spec	___Gamma Spec
___Carbon-14	___Carbon-14
___Radium-226	___Radium-226
___Strontium-90	___Strontium-90
___Tritium	___Tritium
___Americium-241	___Americium-241
___Plutonium-241	___Plutonium-241
___Thorium (Isotopic)	_____
___Uranium (Isotopic)	_____
___Cesium-137	_____
___Chlorine-36	_____
___Cobalt-60	_____
___Sodium-22	_____
___Uranium-238	
___Alkalinity (Total)	___Ammonia
___Ammonia	___Formaldehyde
___Nitrate as N	___Nitrate as N
___Water Sol. Anions	___TKN
___Sulfide	___Sulfide
___TKN	___TKN
___EC	___TOC
___pH	___TDS
___TOC	___Turbidity
___Formaldehyde	___EC
___TPH as Diesel	___pH
___TPH as Kerosene	___Alkalinity (Total)
___Bacteriology	___Anions/Cations
___PTS	___BOD
	___COD
	___Total Sus. Solids
	___Total Oil & Grease
	___Alkalinity (Total)
	___Bacteriology

Quarterly Groundwater Monitoring
Sample Summary Form

Sample ID: *(affix sticker from label sheet here)*	Chain-of-Custody # : _____ Duplicate of Sample # : _____

Date: Time: Location ID: Depth: Other Code:

Sampling Method: Disposable Bailer Dedicated Pump Other: _____	Matrix: Water Soil Air Wipe Other:_____	Sampled By:

Purge Data for Groundwater Samples

Purging Method Prior To Sampling:

Pump Flow Rate: (T.D. - W.L.) x (D^2)(.0408) = Casing Vol.
(-) x ( )(.0408) = _____

Initial Water Level: _____ Ref. Point: _____ One Casing Volume (Gallons): _____

Time	Temp (C)	Spec. Cond.( )	pH	Turbidity (ntu)	Eh (mvolts)	Gallons Removed	Comments (Appearance of water, odor, etc.)

Containers			Preseved with:
(#)	Type)	40 ml VOAs	Ice/None/
(#)	Type)	40 ml VOAs	Ice/None/
(#)	Type)	1 Liter Amber	Ice/None/
(#)	Type)	1 Liter Amber	Ice/None/
(#)	Type)	1 Liter Amber	Ice/None/
(#)	Type)	1 Liter Amber	Ice/None/
(#)	Type)	1 Liter Amber	Ice/None/
(#)	Type)	1 Gallon Cube	Ice/None/
(#)	Type)	250 ml Glass	Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/
(#)	Type)		Ice/None/

Analysis

☐ Volatiles	☐ Ammonia, TKN, TOC, COD, Formaldehyde
☐ Semivolatiles ☐ Pesticides	☐ Anions ☐ Nitrate ☐ TDS ☐ Alkalinity
☐ Metals	
☐ Hex Chrome	NOTES:
☐ Gross Alpha/Beta ☐ Gamma Spec ☐ Radium-226 ☐ Strontium-90	
☐ Carbon-14 ☐ Tritium	
☐ American-241 ☐ Plutomium	

FIELD INSTRUMENT CALIBRATION LOG

Parameter:_____
Instrument:_____ Serial No.:_____
Manufacturer:_____ Date Placed in Service:_____
Calibration Procedure:_____

Required Calibration Frequency:_____

Date	Time	Results	Comments*	Calibrated by:

*Note: Include information on Standard Manufacturer, Lot Number, and/or Serial Number in Comments as appropriate.

Reviewed by: _____

SOIL BORING LOG

LOCATION OF BORING

JOB NUMBER | CLIENT | LOCATION

DRILLING METHOD:

BORING NUMBER

SHEET OF

SAMPLING METHOD:

DRILLING

START TIME | FINISH TIME

DATE | DATE

DATUM

ELEVATION

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	TIME	SAMPLE NUMBER / SAMPLE DEPTH	BLOWS/FT. SAMPLER	OVA AUGER	OVA SAMPLE	OVA CUTTINGS	DEPTH IN FEET	SOIL GRAPH
								0	
								1	
								2	
								3	
								4	
								5	
								6	
								7	
								8	
								9	
								0	
								1	
								2	
								3	
								4	
								5	
								6	
								7	
								6	
								9	
								0	
								1	

DRILLING CONTRACTOR

BY

CHECKED BY

DATE

45525

LEHR ENVIRONMENTAL RESTORATION RI/FS

WELL DEVELOPMENT FORM

OPERABLE UNIT Number 6

Location ID (Well Number):_____Job Number: _____

Location Description: _____

Depth of Well: _____TOC bgs One Casing Volume (CV) _____

Casing Diameter/Type: _____Screened Interval:_____ to _____

Initial Water Level: _____

Date	Time	Gallons Removed	Cumulative Gallons Removed	Water Level	Turbidity	Comments to Purge Method

Job Name _____ Well No. _____
Job Number _____ Boring No. X-Ref _____

MONITORING WELL CONSTRUCTION SUMMARY

Survey Coordinates _____ Elevation Ground Level _____
_____ Elevation Top of Casing _____

Drilling Summary

Total Depth Drilled _____
Borehole Diameter _____
Driller _____
_____
Rig _____
Bit(s) _____
_____
Drilling Fluid _____
_____
Total Depth of Well _____
Casing Stick-up Height _____
Surface Completion _____

Construction Time Log

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling				
Geophys.Logging				
Casing				
Filter Placement				
Pre-Development				
Cementing				

Well Development

	Date	Time	Date	Time
Well Development				

_____
_____
_____
Initial Water Level _____
Final Water Level _____

Well Design & Specifications

Basis: Geologic Log _____ Geophysical Log _____
Casing String(s): CC=Conductor Casing C=Casing
S=Screen ST=Sediment Trap

Depth	String(s)	Elevation
_____ – _____	_____	_____ – _____
_____ – _____	_____	_____ – _____
_____ – _____	_____	_____ – _____
_____ – _____	_____	_____ – _____
_____ – _____	_____	_____ – _____

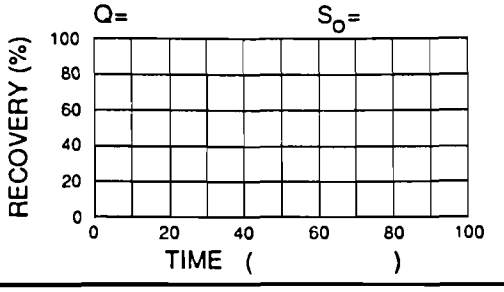
Conductor CC1 _____
Casing CC2 _____
Casing C1 _____
C2 _____
Screen S1 _____
S2 _____
Sed. Trap ST _____
Grout Seal _____
_____
Bentonite Seal _____
_____
Filter Pack _____
_____
Centralizers _____
_____

Stabalization Test Data

Time	pH	Spec. Cond.	Temp (C)	Turbidity

Recovery Data

Q= S_o=



Comments: _____
_____
_____
_____

T.D. =

Observed by: _____ Client: _____ Location: _____

DAMES & MOORE

Date Completed:
Water Level:
Orientation of Test Pit: -
Logged By: - Checked By: -
Subcontractor: -
Equipment: -
Weather: -

EXPLANATION
- ● Drive Sample
- □ Grab Sample for Chemical Analysis
- ■ Grab Sample for Physical Analysis
- — Sharp Contact
- ····· Gradational Contact

Scale in Feet
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Depth in Feet: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

USCS

DESCRIPTION

Surface Conditions -

Subsurface:

TEST PIT CROSS SECTION

Job Number

LEHR ENVIRONMENTAL RESTORATION RI/FS

DOUBLE-RING INFILTRATION TEST DATA SHEET

Job Number:_____

Operable Unit_____

Location ID:_____

Liquid Used:_____

Tested By:_____

Depth to Water Table:_____

Subject:_____

Testing by Double Ring

Constants	Area (cm^2)	Depth of Liquid (cm)
Inner Ring	_____	_____
Annular Space	_____	_____

Penetration of Rings:

Inner: _____

Outer: _____

Trial No.	Date	Time hr:m	Elapsed Time Δ/(total) (min.)	Flow Readings: Inner Ring Reading (cm)	Flow Readings: Inner Ring Flow (cm^3)	Flow Readings: Annular Space Reading (cm)	Flow Readings: Annular Space Flow (cm^3)	Liquid Temp	Incremental Infiltration Rate (cm/s): Inner	Incremental Infiltration Rate (cm/s): Annular	Soil Temp = ____ at depth of ____ Remarks
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
1											
12											

CONTAMINATION SURVEY FORM

Location: _____ Date/Time: _____ Page _____ of _____

Technician: _____ Meter Background: _____ Scaler Model/Serial: _____

Meter Model/Serial: _____ Scaler Background: _____ Calibration Due: _____

Calibration Due: _____ Survey Type: ☐ Alpha α ☐ Beta/Gamma β/γ Signature: _____

Smear Number	Item Surveyed	Location Surveyed	Direct Survey						Smear Survey					
			Gross Count Rate (cpm)		Net Count Rate (cpm)[1]		Total Activity (dpm)[2]		Gross Count Rate (cpm)		Net Count Rate (cpm)[1]		Total Activity (dpm)[2]	
			α	β/γ	α	β/γ	α	β/γ	α	β/γ	α	β/γ	α	β/γ

Note[1] Net Count Rate = Gross Count Rate - Background Count Rate.
Note[2] Total Activity = Net Count Rate ÷ Instrument Efficiency.

INSTRUMENT DAIL. SOURCE CHECK LOG

Instrument
Type: _____
Serial #: _____
Calibration Due: _____

Source
Isotope: _____
Activity (DPM): _____
ID #: _____

Acceptance Criteria ± 20%
Upper Limit (DPM: _____
Lower Limit (DPM: _____

Date	Time	Battery Check	High Voltage Check	Efficiency (cpm/dpm) Note(1)	Source Count Rate (cpm)	Background Count Rate (cpm)	Net Count Rate (cpm)(2)	Observed Activity (dpm)(3)	Acceptance (Yes/No)	RPT Initials

Note(1) Efficiency is determined during the instrument calibration.
Note(2) Net Count Rate - Source Count Rate - Background Count Rate.
Note(3) Observed Activity - Net Count Rate ÷ Efficiency.

SCALER PERFOI. ANCE CHECK LOG

Instrument
Type: _____
Serial #: _____
Calibration Due: _____

Source
Isotope: _____
Activity (DPM): _____
ID #: _____

Acceptance Criteria
Percent Error ≤ 20%

Date	Time	Efficiency (cpm/dpm) Note(1)	Source Count Rate (cpm)	Background Count Rate (cpm)	Net Count Rate (cpm)(2)	Observed Activity (dmp)(3)	$ Error (≤ 20%?)	Acceptance (Yes/No)	RPT Initials

Note(1) Efficiency is determined during the instrument calibration.
Note(2) Net Count Rate - Source Count Rate - Background Count Rate.
Note(3) Observed Activity - Net Count Rate ÷ Efficiency.

GAMMA CALIB. ION CHECK LOG

Instrument
Type: _____
Serial #: _____
Calibration Due: _____

Source
Isotope: _____
Activity (μCi): _____
ID #: _____

Acceptance Criteria
Gamma Reading Within 20% of Initial Reading After Calibration
Initial Reading (μR/hr): _____

Date	Time	Source Reading (μR/hr)	Background Reading (μR/hr)	Net Reading (μR/hr)[1]	% Difference (± 20%?)	Acceptance (Yes/No)	RPT Initials

Note[1] Net Reading = Source Reading - Background Reading.

GAMMA SURVEY FORM

Location: _____ Date/Time: _____ Page _____ of _____

Technician: _____ Meter Background: _____

Meter Model/Serial: _____ Calibration Due: _____ Signature: _____

X-X-X-X = Boundaries of Posted Areas = Gamma Radiation Levels (μR/hr)

Comments: _____

Reviewed By: _____ Date: _____

SOP/FORM/GAMMASVY.FRM

Sample Record Number (from log) _____

VEGETATION SAMPLING RECORD

1. Date:	2. Sample Identification Number
3. Performed by:	4. Location:
5. Plot Formation Type (Quadrant or Transect):	
6. If Sample is QA/QC, Identify Type (Split, Duplicate, etc.):	
7. Record of Grid Locations Sampled (Continue on back if necessary):	

Grid Coordinates	Weight Collected	Grid Coordinates	Weight Collected
a.		f.	
b.		g.	
.		h.	
c.		i.	
e.		j.	

8. Total Weight of Sample Collected	9. Time Sample Collected:

10. Map of Sample Location:
    a. Show primary trees, roads, fences, walkways, etc.
    b. Draw in sampling grid with x and y axis numbered.

11. QA Verification and Date.

VEGETATION SAMPLE TRACKING FORM

Sampling Record Number	Sample Date	Sample ID	Sampler	Analytical Lab	Date Results Retrned (attach to record)	QA	Comments

STANDARD OPERATING PROCEDURES
INTERIM CHANGE NOTICE

Date: _____

SOP Affected: _____

Revision Affected: _____ Dated: _____

Old procedure to be changed *(describe):* _____

_____

_____

Page number of old procedure: _____ of _____

Modified procedure to be implemented *(describe)* and reason for change: _____

_____

_____

List attached documentation *(i.e., telecons, field logs, field memos, etc.)*

_____

_____

Prepared by: _____ Date: _____
(Project Staff)

Approved by: _____ Date: _____
(Field Manager)

Approved by: _____ Date: _____
(Task Manager)

_____
Coordinator of Quality Assurance

Retain this until further notice ☐

This notice will be incorporated into the next revision to the controlled document referenced ☐

Other ☐

File the notice with your copy of the referenced document. The notice must be destroyed when the next revision of this plan/procedure is received.