Field testing of underground storage tank systems to determine probability of leakage and to identify the release source in systems complying with current California regulations

WORKPLAN

Technical Project Director, Contractor:
Dr. Thomas Young
Civil & Environmental Engineering
University of California, Davis

Technical Project Director, Subcontractor:
Dr. Randy Golding
Tracer Research Corporation

March 24, 2000

Research Objectives

The proposed research will:

1. determine the proportion of underground storage tank (UST) systems of three major design types that exhibit the potential to release stored product to the environment even though they appear to comply with all applicable regulatory standards,
2. identify the component(s) responsible for the potential leakage, either by inference (e.g., repairing a loose connection eliminates the evidence of release) or by direct observation (e.g., excavation reveals a hole in a tank or pipe),
3. estimate the environmental significance of the product release for systems with potential releases, by using the results of the Tracer testing at each test location, and
4. assess the effectiveness of existing leak detection regulations by comparing recent results from routine leak detection tests to those from testing conducted under this proposal.

Background

Previous research and anecdotal evidence has caused concern that significant releases of petroleum products can occur from underground storage tank systems in compliance with California regulations. The State Water Resources Control Board recently surveyed 1072 records from the Leaking Underground Storage Tank Information System (LUSTIS) database and collected 235 inspection records of tanks not known to have a release. Although releases are still mainly associated with non-compliant systems, these surveys indicated that newer systems had evidence of releases, especially around piping (SWRCB, 1999). The study identified 16 UST systems with double walled tanks and piping that appeared to have had a release (SWRCB, 1999). These findings are not conclusive because the leak status was determined solely by visual or olfactory evidence, no means were provided for distinguishing current from past releases, and compliance with the regulations was not explicitly determined. Despite these limitations, the findings

of this and other studies (SCVWD, 1999) suggest that environmental contamination may still be occurring even at UST systems meeting all current guidelines. The SWRCB study concluded by recommending a field-based research program (SWRCB, 1999, p. 9).

> This research should quantify the probability and environmental significance of releases from UST systems meeting the 1998 standards. The research should strive to identify the source and cause of releases, and any deficiencies in leak detection systems. It should include single-walled, double-walled, and hybrid UST systems, and should avoid bias toward known leaking systems by including a statistically valid sample of all operating UST systems.

The results of the advisory panel were influential in motivating the California legislature to pass a bill mandating the recommended field based research program (SB 989). That bill requires the SWRCB to:

> …initiate a field-based research program to quantify the probability and environmental significance of releases from underground storage tank systems meeting the 1998 upgrade requirements specified in subdivision (c) of Section 25284. The research program shall do all of the following:
> (A) Seek to identify the source and causes of releases and any deficiencies in leak detection systems.
> (B) Include single-walled, double-walled, and hybrid tank systems, and avoid bias toward known leaking underground storage tank systems by including a statistically valid sample of all operating underground storage tank systems.
> (C) Include peer review.

The present study is designed to fulfill those requirements. Testing of UST systems in this project will be performed using the Tracer Tight® method of analysis. The major advantage of this system relative to internal release detection methods such as automatic tank gauging systems or tank tightness tests is that it looks for releases in the environment around the system and therefore can identify leaks from both liquid and vapor filled components. The advantage of the method relative to external methods such as vadose or groundwater monitoring is that, by using a tracer chemical that is not in the fuel or the environment initially, it can distinguish between past and current releases. The tracer compound is added to the product stored in the tank and distributed throughout the system, a process known as inoculation. During normal operation in the 7-14 days subsequent to the inoculation the tracer escapes from any portion of the system that has a potential to leak, either as a vapor or a dissolved component. Outside the system the dissolved tracer evaporates from the liquid and the tracer vapors begin to migrate away from the location of the leak in all directions. Samples of air collected from the soil within the radius of detection of the tracer reveal the leak as a presence of the tracer chemical. Because the tracer is non-biodegradable and easy to detect at very low levels, the method is reliable and very sensitive.

Detailed Workplan

To achieve the objectives outlined above will require cooperative efforts by SWRCB, local agencies, UC Davis and Tracer Research Corporation. An overview of the flow of work is provided in Figure 1 and the tasks are described in more detail in this section.

Task 1. Facility Selection and Recruitment

Facilities will be selected using a three stage sampling strategy. In the first stage, six local agencies that maintain electronic UST system registration records will be selected to provide a geographically dispersed statewide sample. Facilities that do not have any tank systems containing gasoline will be excluded from further analysis. This exclusion is based on the fact that gasoline is the substance most commonly stored in UST systems and it is expected to pose a more significant environmental threat than other motor fuels if released. In the second stage, the records will be stratified into three groups, those that are fully double walled, those that are fully single walled and those that contain a mixture of double and single walled construction. This is intended to ensure that release probabilities are determined for all major design types allowed under current regulations. In the third stage, 13 UST systems will be randomly selected from each group in each agency's database. This approach should approximate a random sample of each type of tank system drawn from the entire state's tank population since approximately 70% of the local programs maintain such records. No systematic bias is expected within these records toward any particular leak status or construction type. It is impossible to verify this assertion presently since a statewide database of all registered tanks does not exist.

Recruitment of the selected facilities will be the responsibility of the State Water Resources Control Board (SWRCB). Recruitment efforts will be coordinated through major trade associations such as the Western States Petroleum Association (WSPA), California Independent Oil Marketers Association (CIOMA) and government organizations that own UST systems (state, county or military facilities). Meetings will be held between representatives of the contractor (Dr. Thomas Young, Dr. Randy Golding) and potential study participants to answer questions about the procedures and anticipated results. We have budgeted for no more than three such meetings. Systems will be tested (Task 2) in groups of approximately 30 facilities from each local jurisdiction with follow-up testing (Task 3) on those facilities to be completed before an additional group of systems are scheduled for initial testing.

If the SWRCB cannot arrange access at 10 of the facilities in each construction category from each jurisdiction, additional similar systems will be randomly selected from the same agency's database until 10 systems are identified that will participate. Systems will be excluded from testing if they are not in compliance with all hardware-based regulatory requirements as determined from reviews of permits, databases and on-facility inspection of system components (defined further below). Detailed records of the characteristics of the non-participating systems will be maintained to examine whether participating and non-participating systems have significantly different patterns of ownership or system design.

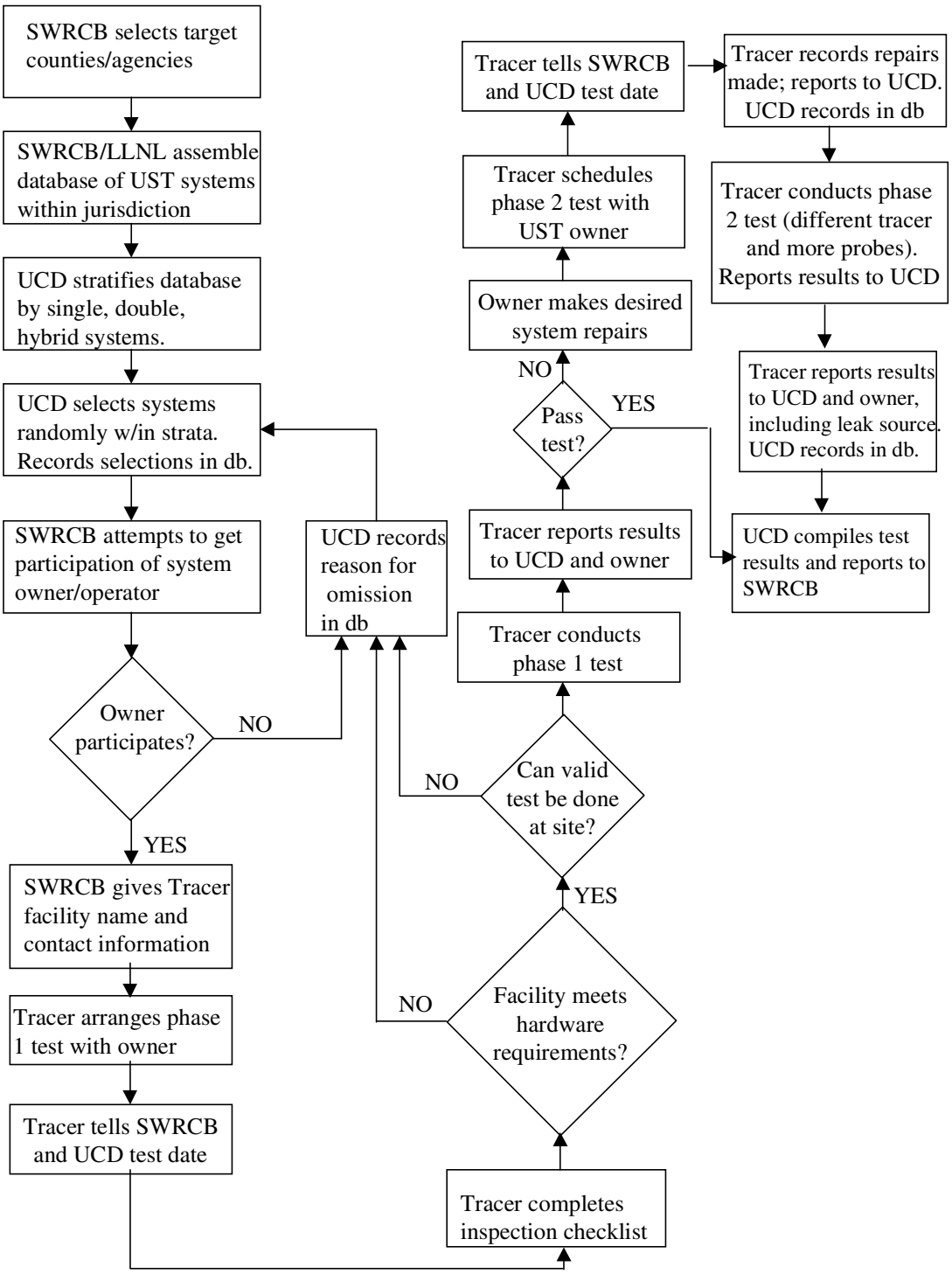


Figure 1. Summary of flow of work and division of responsibilities

Task 2. Initial Facility Testing

The first phase of the testing process is designed to determine whether UST systems in compliance with the regulations are "tight" with respect to the tracer chemical employed. The first phase consists of two facility visits. During the first visit the crew will identify major facility features, review UST regulatory compliance, install vapor probes and inoculate the tank with tracer. The first visit will begin with a review of system compliance with the regulations to verify items noted originally on the permit. For the purpose of this project, a system will be "in compliance" if it has all items on a checklist to be developed by SWRCB and the contractor. The checklist will include determination of whether the system was in compliance at the most recent annual inspection and has all of the required hardware (corrosion protection, spill containment and overfill protection device, leak detection system). The operability of this hardware will not be determined under this project, with the exception of cathodic protection tests described below. Subcontractor personnel will fill out the checklist following training by SWRCB.

Information about the facility's design such as double or single walled construction, material of construction and the type of leak detection equipment will be entered into a Microsoft Access database maintained by UC Davis. Each initial facility inspection will include careful identification and documentation of the locations of all components of the UST system. This will be accomplished using a combination of metal detectors, ground-penetrating radar, and soft excavation techniques to confirm inferred locations. The cost of digging permits will be passed through as a direct expense to the SWRCB. It is not anticipated that any facilities will require the purchase of digging permits. Since soft excavation methods will be used, the location of utilities other than the UST system itself will not be necessary. Cathodic protection systems will be tested for steel tanks and piping by measuring the potential between ground and system components. Potential measurements will be made under the on site supervision of a certified cathodic protection tester. This certification is available from NACE certified courses. TRACER has a NACE certified cathodic protection specialist on staff for consultation as needed. Information about the operation of the facility including frequency of deliveries and typical delivery amounts will be recorded. Depth to groundwater, soil type, backfill material, and any leak detection test results from the previous six months will also be noted as available from the facility owner. This information will be obtained during an interview conducted prior to the facility visit or will be available at the facility in summary form. Neither the depth to groundwater nor the type of soil outside the backfill will be experimentally determined by this study. Leak detection data will not be reviewed nor interpreted in detail. The type of leak detection used and the results of tests will be noted as summarized by the facility owner or by a representative of the local agency.

Once all relevant details about the system and facility have been recorded and the system has been shown to be in compliance with relevant system design regulations, testing will be conducted following an improved version of the certified Tracertight® test method. Procedures for conducting the certified method and associated quality control procedures are provided in Appendices 1 and 2. Modifications designed to provide additional resolution of leak location and to facilitate follow-up testing under Task 3 are:

1. ***Additional Probes.*** In the standard test, probes are placed around the perimeter of the system with the minimum requirement that all parts of the tank and piping system are within 10 feet of a probe. In this program additional probes will be installed in order to determine the nature and source of leakage during the first sampling survey. A dedicated probe will be placed in close proximity to each fixture or pipe connection on the top of the tank to determine if that fixture or pipe connection may be a source of vapor or liquid release. All items at the facility that are part of the fuel system, which are connected via threaded fittings at or below the ground surface will be subject to special scrutiny and will be probed closely enough to determine if any release is attributed to them.
2. ***Some deeper probes.*** One probe will be placed between each pair of tanks to a depth of 8 feet or to the top of the saturation zone, whichever is shallower. This probe will be used to better observe the vertical distribution of any tracers detected.
3. ***Soft installation methods.*** The standard procedures refer to probe installation using steel mandrels placed through PVC pipe that are driven into the ground with hammers. In this program all the probes will be placed in the ground by air jetting. Typically, a 1½ -inch diameter hole will be first cored through the pavement; then a probe of ½-inch PVC pipe will be pushed into the soil using high volume airflow from a compressor connected to the top of the probe. The air jet will erode and displace soil ahead of the probe enabling it to be pushed into the ground, but will not harm or disturb underground utilities. Larger holes (up to 4 inches) may be cut in the pavement as needed to confirm the location of piping trenches or to expose trench caps.

To briefly summarize the method described in greater detail in the appendix, testing will begin by inoculating the tank with a predetermined amount of tracer. Tracer will be thoroughly mixed through the system. Systems that receive more than one delivery during the week following the inoculation receive enough tracer to inoculate all of the fuel that will be received during the week. Probes will be installed near system components (within the backfill whenever possible) to provide good coverage of the facility. During the installation, each probe location will be evaluated for air permeability. If air permeability, which is required for the transport of the tracer from the leak to the sampling location, is not present at the facility or for a component of the system, then the facility or component of the system will be excluded from the study. If the UST is totally submerged in water, the facility will also be excluded from the study. The level of the local water table within the excavation area will be established by installing at least one probe to the bottom of the tank excavation zone (point 2 above). Submerged USTs cannot release tracer during the test and any existing leak could already be manifested as water ingress. Tracer Research will be responsible for repair of any damage that occurs to system components during probe installation and system inoculation.

The second facility visit will occur 7-14 days after inoculating the system with tracer. Samples will be collected from all probes and from the interstitial space of double walled systems. Collected samples will either be analyzed on-site or at a remote location

using a laboratory grade gas chromatograph (GC). The GC is calibrated using external gas standards. Samples from the facility are analyzed by direct injection and concentrations are calculated using the response factor derived from the standards. Check standards are run throughout the day as well as after the last sample is analyzed. System blanks are run after calibration, throughout the day and after the last sample is analyzed. A "non-tight" system will be declared when a positive identification of tracer has occurred. Positive identification is established when there is a reproducible detection of tracer in the soil, the horizontal and vertical tracer distribution is consistent with leakage, and hydrocarbon profiles confirm the presence of product outside the system. The subcontractor will maintain raw data from each test including chromatograms and any QA/QC results for at least 5 years beyond the end of the contract period.

Following the completion of initial facility testing, the subcontractor will submit a report within one month to the contractor and to the facility owner summarizing the results. Each report will include a CAD generated facility map showing the location of the UST system components and the locations of probes installed. The measured concentrations of tracer and hydrocarbon vapors at each probe location will be tabulated and a summary of any problems that occurred during either facility visit will be included. A sample report is included as Appendix 3.

Task 3. Follow-up facility testing

The second phase of the testing process is designed to identify, to the greatest extent possible, the source of the tracer release whenever one is detected. Identification of the source will aid in understanding modes of UST system failure and in guiding tank owners' efforts to repair leaking system components. Follow-up testing will be performed at all systems identified as having a tracer release during task 2. Initially this testing will focus on allowing the system owner to repair potential leakage sources (e.g., by tightening loose fittings or fill tubes). At the follow-up facility visit, additional probes will be added as needed to identify the potential release mechanism indicated by the initial testing. A new and additional tracer will be added to the system and then the existing and new probe locations will be sampled to determine whether the tracer signal is still detectable. The additional probes will be installed to refine the information collected previously. Along piping runs additional samples will be collected along the axis of the trench. Near tanks, vertical profiles and additional samples along the tank ridge will be collected to determine whether vapor or liquid was leaking and whether it was associated with tank connections. If the repair eliminates the tracer detection it will be presumed to have corrected the leakage source and the corrective actions taken will be documented in the database.

If the tracer signal persists after repairing suspected leakage points, the information from the follow-up test will be used to guide further repair or excavation efforts.

The subcontractor will provide the contractor with a report on the results of the follow-up testing within one month of completing the follow-up fieldwork. A copy of this report will also be sent to the facility owner.

Task 4. Interim Reporting

Within one month of receiving all initial and any follow-up testing reports on each group of 30 facilities from the subcontractor, the contractor will submit an interim report to the SWRCB. Each interim report will include a brief summary of the major results from testing of the most recent 30-facility group and will include the complete database of all facilities examined to date.

Task 5. Draft Report

A draft final report summarizing the results of all field-testing will be submitted to the SWRCB by December 31, 2001. This report will include an estimate of the frequency of test failures and the associated uncertainty for each of the three design categories targeted under this study (upgraded single walled, fully double walled, and hybrid). These category specific results will then be used to estimate the leakage rate across the entire state population of compliant tank systems using the results from the ongoing Lawrence Livermore National Laboratories tank profiling project if available. Otherwise these estimates will be scaled-up using available electronic records from the local agencies that have compiled them. The report will also highlight the most frequent sources of leakage and any available information about causes of the failures derived from the excavation and repair process conducted by tank owners. The performance of current leak detection methods will be examined by comparing results from such methods over the last six months to those from the tracer testing program.

Task 6. Peer-Review Process

The draft report will be simultaneously submitted to the SWRCB and a group of four technical peer reviewers. The peer reviewers will be given until April 1, 2002 to submit comments on the draft report.

Task 7. Final Report

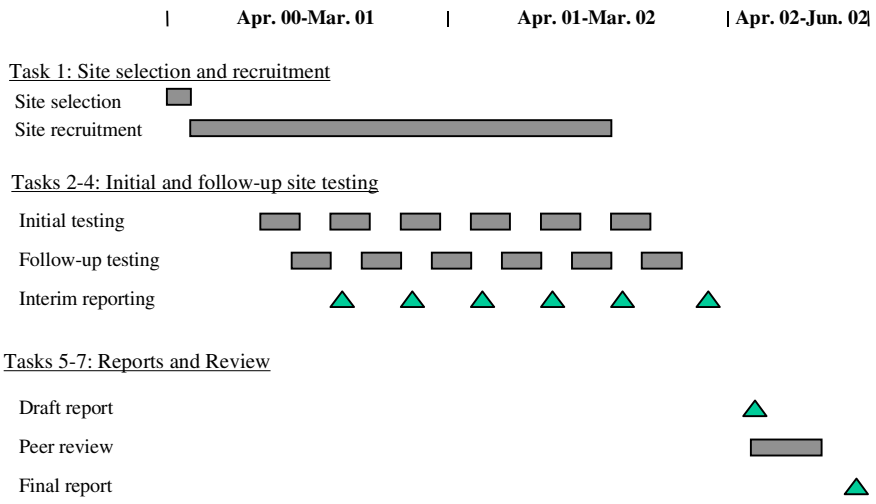
The contractor will revise the draft report after consideration of the comments of SWRCB staff, peer reviewers and other interested parties who choose to submit comments. A final report will be submitted to SWRCB by June 1, 2002.

Deliverables and Project Schedule

Figure 2 summarizes the overall schedule for the project and the associated deliverables (indicated with a triangle). By May 15, 2000, the contractor will submit the initial list of 39 facilities to be tested and this process will be completed for all local jurisdictions to be studied by June 30, 2000 subject to the availability of electronic registration records from local agencies. Initial and follow-up testing of UST systems will begin on June 1, 2000 and continue until October 1, 2001. The goal of this phase of the project will be to test 180 facilities for leakage using the TracerTight® testing method. The facilities will be scheduled in groups of 30 within a particular geographic area. Within 30 days of any initial or follow-up testing, the contractor and the facility owner will receive a report of the results of the testing. Initial test results will include the results of any applicable cathodic protection evaluation measurements. A sample report is included in Appendix 3. Initial testing of these systems will occur over a 45-day period.

Follow-up testing on any system failing the initial testing will be completed during the subsequent 45 days and will be coordinated by TRACER with the facility owner. Following testing of each group of 30 facilities the contractor will submit an interim report outlining results, problems and budget status following the deadlines listed under Task 4. The draft final report (Task 5) on the project results will be submitted by December 31, 2001. The peer review process (Task 6) will be completed by April 1, 2002 and the final report (Task 7) will be submitted by June 1, 2002.

Figure 2. Project Schedule



Staffing and Management Plan

The technical project directors at the University of California, Davis (contractor) and Tracer Research Corporation (subcontractor) designated below will manage all work performed under this contract. Following award of the contract, the subcontractor will also designate a contact for field activities who will be in charge of day-to-day field operations and test scheduling. The contractor will notify the SWRCB project manager whenever any changes in the staffing plan are required and will designate a new contact person within two weeks of the initial notification.

Technical Project Director, Contractor:
Dr. Thomas Young
Department of Civil & Environmental Engineering
University of California, Davis
One Shields Ave.
Davis, CA 95616
ph: 530-754-9399
fax: 530-752-7872
E-mail: tyoung@ucdavis.edu

Technical Project Director, Subcontractor:
Dr. Randy Golding
3755 North Business Center Drive
Tucson, Arizona 85705-2944
ph: 800-989-9929
fax: 520-293-1306
E-mail: RGolding@TracerResearch.com

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