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Alameda County
Environmental Health

Hanson
HEIDELBERGCEMENT Group
Hanson Aggregates West Region
12667 Alcosta Blvd., Suite 400
San Ramon, CA 94583

August 28, 2012

Mr. Jerry Wickham
Alameda County Health Care Services
Environmental Health Services
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Subject: Work Plan to Assess Non-Aqueous Phase Liquid at the Mission Valley Rock and Asphalt Plant Located at 7999 Athenour Way in Sunol, California Alameda County Case No. RO0000207 and GeoTracker Global ID T0600102092

Dear Mr. Wickham:

The attached Work Plan to assess non-aqueous phase liquid (NAPL) recently observed in well MW-11D was prepared by ARCADIS U.S., Inc. (ARCADIS) on behalf of Lehigh Hanson West Region ("Hanson") for the asphalt plant area of the Hanson Aggregates Mission Valley Rock Facility, located at 7999 Athenour Way, Sunol, California ("the Site"). The work plan was prepared in response to the Alameda County Environmental Heath Services (ACEH) letter to Hanson dated June 21, 2012 and presents a scope of work to assess the presence of the NAPL.

I declare, under penalty of perjury, that the information and/or recommendations contained in the attached report are true and correct to the best of my knowledge.

If you have any questions or comments concerning this report, please call me at (925) 244-6584 or Ron Goloubow of ARCADIS at (510) 596-9550.

Sincerely,

Lee W. Cover
Environmental Manager
Lehigh Hanson West Region

Attachment

ARCADIS-U.S., Inc.
2000 Powell Street
7th Floor
Emeryville, CA 94608
Tel 510.652.4500
Fax 510.652.4906
www.arcadis-us.com

ENVIRONMENT

Mr. Jerry Wickham
Alameda County Environmental Heath Services
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

sent via email only

Subject:
Work Plan to Assess Non-Aqueous Phase Liquid at the Mission Valley Rock and Asphalt Plant Located at 7999 Athenour Way in Sunol, California
Alameda County Case No. RO0000207 and GeoTracker Global ID T0600102092

Date:
August 28, 2012

Contact:
Ron Goloubow

Phone:
510.652.4500 ext 550

Email:
Ron.Goloubow@arcadis-us.com

Our ref:
EM009480.0015

Dear Mr. Wickham:

In response to the Alameda County Environmental Heath Services (ACEH) letter to Lehigh Hanson (Hanson) dated June 21, 2012 (ACEH letter), ARCADIS U.S. Inc. (ARCADIS) has prepared this Work Plan on behalf of Hanson for the Mission Valley Rock and Asphalt plant located at 7999 Athenour Way, Sunol, California (the Site; Figure 1). The ACEH requested that the following four issues be investigated:

- Sources of the light non-aqueous phase liquid (LNAPL) recently observed in well MW-11D (other than the former diesel fuel underground storage tanks [USTs] to the north of the well).
- The possibility of a significant thickness of LNAPL in the gravel layer intersecting the screen interval for well MW-11D.
- The integrity of well MW-11D and its ability to prevent LNAPL from entering from shallow intervals above the screened interval.
- LNAPL thickness and a baildown test in well MW-11D.

The scope of this Work Plan includes data collection, data analyses, and reporting activities for assessing these issues arising as a result of the LNAPL measured at well MW-11D in May 2012. Thus the objectives of the scope of work provided in this Work Plan are to assess the following:

- The potential sources of the LNAPL
- The vertical extent of the LNAPL

- The mobility of the LNAPL

Historically, LNAPL has been observed at the Site during the groundwater monitoring events in groundwater monitoring wells MW-2, MW-3, MW-9D, and MW-11D (ARCADIS 2011; ARCADIS 2012). LNAPL thicknesses in those wells have ranged up to approximately 4 feet (well MW-2 in January 1999). However, data collected through 2010 have indicated that LNAPL thicknesses have decreased significantly over time, and an appreciable measurable amount of LNAPL had not been measured in any wells at the Site between 2002 and 2010 (ARCADIS 2011). The following table summarizes the occurrences of LNAPL in the four wells mentioned.

Well	Occurrence/measured thickness	Number of occurrences
MW-2	4.00 feet	1
	Less than 1 foot	13
	Not Detected	6 (including the last five measurements before well abandonment)
MW-3	Sheen	2
	Not Detected	35
MW-9D	Sheen	2
	Not Detected	16
MW-11D	0.61 foot	1
	Sheen	3
	"Observed"	2
	Not Detected	12

As part of the regulatory case closure process, a water level elevation survey was conducted at the Site in May 2012 (ARCADIS 2012) in response to comments provided by ACEH in an April 9, 2012 letter. During that water level elevation survey, approximately 0.61 foot of LNAPL was measured in well MW-11D. In addition, during two previous water level measurement events on December 24, 2010 and September 27, 2010, a "petroleum hydrocarbon-like liquid," was observed on the water level probe; however, LNAPL thickness was not measured using an interface probe (ARCADIS 2011). As a result of the measurement of the LNAPL at well MW-11D, the ACEH requested additional investigation (the ACEH letter of June 21, 2012) and the following scope of work is intended to provide the data necessary to respond to the ACEH letter.

Scope of Work

Further characterization of LNAPL in the vicinity of well MW-11D is proposed to evaluate the vertical extent of LNAPL in this area and to characterize surrounding lithology and potential sources for the observed LNAPL. Results of this characterization will be utilized to assess various aspects of the LNAPL.

Specifically, the scope of work will consist of the following tasks.

Task 1 – Assessment of Physical and Chemical Properties and Transmissivity of LNAPL in Well MW-11D

The scope of this task includes the collection and analysis of samples of the LNAPL and groundwater samples from well MW-11D, and baildown testing. The groundwater samples will be analyzed for physical parameters as described below.

LNAPL and Groundwater Sampling

Samples of the LNAPL and groundwater will be collected during the baildown testing to be conducted at well MW-11D (described below). The LNAPL and groundwater samples will be submitted to PTS Laboratories Inc. (PTS), located in Santa Fe Springs, California, and analyzed for the "NAPL and Water Fluid Properties Package" that includes:

- dynamic viscosity and fluid density
- surface tension for each fluid
- interfacial tension (three phase pairs: oil/water, oil/air, and water/air)

In addition, the LNAPL sample will be analyzed using PTS's proprietary OILPRINT™ qualitative chromatography test to identify the type and potential source of the LNAPL and the degree of weathering.

LNAPL and groundwater samples will be collected in laboratory-supplied containers. The sample containers will be labeled with the sample identification, the time and date of collection, the analysis requested, and the initials of the sampler. The samples will be stored in ice-chilled coolers and submitted to the laboratory via overnight shipment or hand delivery (courier) under strict chain-of-custody protocols.

Baildown Testing of LNAPL Transmissivity in Well MW-11D

LNAPL transmissivity will be measured by conducting baildown testing of the LNAPL at well MW-11D. Baildown testing consists of LNAPL removal and monitoring of LNAPL recovery in the test well over time immediately following removal, similar to a traditional aquifer slug test. The rate of LNAPL flow into the well during the recovery period of a baildown test is a function of LNAPL saturation, permeability of the surrounding formation to LNAPL, LNAPL physical properties, and the magnitude of the initial hydraulic gradient toward the well developed during LNAPL removal. Please note that the collection and analysis of the LNAPL samples that were presented above will be part of baildown testing procedures.

LNAPL baildown testing will be conducted in accordance with the attached ARCADIS Standard Operation Procedure for LNAPL Baildown Testing (Attachment 1). Given the relatively small (less than 1 foot) apparent thickness of product in well MW-11D, LNAPL will be evacuated from the well manually using a wide-mouth bailer. If greater than 80% recovery (approximately 0.5 foot of LNAPL) is achieved the same day as the test, another baildown test will be conducted the following day, to ensure repeatability of results, and to assess the aquifer response versus LNAPL that could be draining out from the sand pack that is present around the screened interval of well MW-11D.

If the LNAPL recovery is less than 80% during the same day as the test, a hydraulic recovery test consisting of extracting a minimum of 10 casing volumes at a rate of approximately 8 gallons per minute or at the maximum well yield will be performed the following day to assess if LNAPL recovery can be enhanced by pumping the well. An electric powered submersible pump will be used to extract the groundwater.

Observations concerning the LNAPL thickness, quantity of LNAPL removed, and color of the LNAPL withdrawn will be recorded during the baildown and hydraulic recovery testing process. The baildown test data (e.g., water level and LNAPL thickness recovery over time) will be analyzed using American Petroleum Institute's (API's) baildown test evaluation spreadsheet to obtain estimates of LNAPL transmissivity. The API spreadsheet makes the necessary correction for LNAPL density and calculates transmissivity using guidelines developed by both the Huntley (2000) and Lundy and Zimmerman (1996) methods for adapting groundwater slug test analysis methods to LNAPL baildown testing. Prior to importing data into the spreadsheet, each dataset will be carefully examined to determine the appropriate method for analysis.

The extracted product and other investigation-derived waste generated during the field activities, including soil cuttings, decontamination or rinse water, and personal protective equipment, will be stored temporarily at the Site in labeled, Department of Transportation-approved 55 gallon drums or similar, until waste disposal is arranged.

Task 2 – CPT/ LIF Investigation to Characterize Extent of LNAPL

The scope of this task includes the drilling of one soil boring near existing well MW-11D using a Cone Penetrometer Test (CPT) drilling rig equipped with a Laser-Induced Fluorescence (LIF) tool. Prior to initiating field activities at the Site, ARCADIS will perform the following tasks:

- Obtain permits (and pay fees) required for the proposed CPT/LIF boring from the Alameda County Public Works Agency, Water Resources Section.

- Meet with Hanson representatives to locate and mark underground infrastructure and/or utilities prior to clearing the proposed CPT/LIF boring location. A private subsurface utility location subcontractor will be retained to clear the proposed soil boring location for subsurface obstructions. The boring location will be also cleared to a minimum of 5 feet below ground surface (bgs) using either an air knife or hand auger.

- The CPT/LIF boring location will be modified, as necessary, to avoid existing structures, underground infrastructure, and/or utilities.

- Submit a sample of the LNAPL and/or the laboratory results to the CPT/LIF contractor to confirm that the LIF methodology/detector is capable of detecting the LNAPL at the Site.

A LIF system will be utilized to screen for petroleum hydrocarbons in subsurface soils to assist in delineation of LNAPL in the vicinity of well MW-11D. Petroleum hydrocarbons contain compounds that fluoresce when excited by ultraviolet light (light at a specific wavelength generated from a laser). The LIF system uses a pulsed laser mounted internally within a probe that is pushed into the ground with a truck-mounted CPT rig. The laser causes certain aromatic petroleum hydrocarbons to fluoresce, the intensity of which is measured with an optical detector that is also located internal to the CPT probe. Soils impacted with petroleum hydrocarbons will exhibit fluorescence intensity that is proportional to the contaminant concentration, thus allowing the presence of LNAPL to be inferred. This drilling technology allows

for the “real-time” collection of lithologic data as well as indicators for hydrocarbon-affected sediments.

CPT is performed simultaneously with the LIF system, and provides physical/electrical measurements of parameters from which lithology is inferred via an automated interpretation program. The CPT cone measures cone tip resistance and sleeve friction from which the corresponding lithologic profile (e.g., clay, sand, and silt) is interpreted.

One CPT/LIF soil boring is proposed to be located immediately adjacent to well MW-11D (Figure 2). The boring will be advanced to a depth of approximately 30 feet below the water table or to refusal. After withdrawal of the direct-push tools, the boring will be backfilled with a bentonite grout, and a surface patch applied as warranted. The CPT and LIF data collected from this boring will be used to assess the thickness of LNAPL in the gravel layer intersecting the screen interval for well MW-11D.

Task 3 – Data Evaluation and Report Preparation

Following the completion of field activities, field data collected as part of this scope of work as well as historical site data will be evaluated to assess:

- LNAPL type/composition and potential sources of the LNAPL
- The vertical extent of LNAPL near well MW-11D as indicated by LIF data
- Other relevant aspects of the LNAPL based on the data collected

Following the data analysis, the results will be included in a report under a separate cover and submitted to ACEH. The report will include:

- Results from the LNAPL characterization and baildown tests
- Results from CPT/LIF activities, including figures depicting maximum LIF detector responses
- Assessment of potential LNAPL sources based on current and historical facility operations

- Multiple line of evidence evaluation of integrity of well MW-11D and its ability to prevent LNAPL from entering from shallower intervals above the well screen
- Recommendations

Schedule

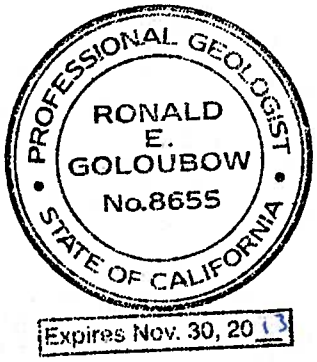
- Task 1 – LNAPL Characterization and Baildown Test (2 days): October 2012
- Task 2 – CPT/LIF Investigation (1 day): October 2012
- Task 3 – Data Evaluation and Report Preparation (2 - 4 weeks including laboratory analyses): November - December 2012

Closing

If you have questions regarding this letter or the project in general, please call me at 510.652.4500.

Sincerely,
ARCADIS U.S., Inc.

Ron Goloubow, P.G.
Principal Geologist



Copies:
Mr. Lee Cover, Hanson
Brooks Loeffler (sent via email to: brooksnsue@yahoo.com)
Jennifer Nyman, ARCADIS
Fred Stanin, ARCADIS

Attachments:
Figure 1. Site Location Map

Figure 2. Site Plan Showing Proposed CPT/LIF Locations

Attachment 1. ARCADIS' Standard Operating Procedure for LNAPL Baildown Test, Rev. # 2, January 14, 2010

References

ARCADIS. 2011. Fourth Quarter 2010 Air Injection System and Groundwater Monitoring Report. March 18.

ARCADIS. 2012. Response to Alameda County Environmental Health Public Comments for Fuel Leak Case No. RO0000207 and GeoTracker Global ID T0600102092, Mission Valley Rock and Asphalt, 7999 Athenour Way, Sunol, CA 94586. June 1.

Huntley, D. 2000. Analytic Determination of Hydrocarbon Transmissivity from Baildown Tests. Ground Water, 38(1), 46-54.

Lundy, D.A., and L.M. Zimmerman. 1996. Assessing the Recoverability of LNAPL Plumes for Recovery System Conceptual Design. Proceedings of the 10th annual National Outdoor Action Conference and Exposition, National Ground Water Association, Las Vegas, NV. May 13-15, 1996.

CITY: DIV/GROUP: DB: LD: PIC: PM: TM: TR:
Project (Project #)
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Feet

GRAPHIC SCALE

HANSON AGGREGATES, 7999 ATHENOUR WAY,
SUNOL, CALIFORNIA

SITE LOCATION MAP

ARCADIS

FIGURE
1

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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EXPLANATION:

MW-9S	Groundwater monitoring well (single completion; well cluster)
MW-7S/7D	Groundwater monitoring well (dual nested)
MW-2S/2M/2D	Groundwater monitoring well (triple nested)
MW-2	Abandoned groundwater monitoring well
TB-6	Grab groundwater sample location
SB-4	Temporary soil boring location
B-2	Sonic boring / grab groundwater
MIP-3	MIP boring / grab groundwater
OXY-1S	Air injection well (approximate location)
SG-1	Soil gas monitoring probe (approximate location)
LIF-1	Proposed CPT/LIF boring location

AST = Aboveground storage tank
UST = Underground storage tank
MIP = Membrane Interface Probe
CPT = Cone Penetrometer
LIF = Laser induced Fluorescence

N

0 30 FEET
APPROXIMATE SCALE

HANSON AGGREGATES, SUNOL, CALIFORNIA

SITE PLAN SHOWING PROPOSED CPT/LIF LOCATION

ARCADIS

FIGURE
2

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Standard Operating Procedure for LNAPL Baildown Test

Rev. # 2

Rev. Date: January 14, 2010

Approval Signatures

Prepared by: _____ Date: January 14, 2010
Jonathon J. Smith

Reviewed by: _____ Date: January 14, 2010
Brad W. Koons, P.E.

I. Scope and Application

The objective of this Standard Operating Procedure (SOP) is to establish uniform procedures for conducting rising-head light non-aqueous-phase liquid (LNAPL) baildown tests to evaluate LNAPL conductivity (K_n) in the subsurface at a specific well location. The data generated from the LNAPL baildown test can be used, along with other site data, to evaluate LNAPL mobility and recoverability at a site. This SOP describes the equipment, field procedures, materials and documentation procedures necessary to determine LNAPL conductivity. The details within this SOP should be used in conjunction with project work plans.

This SOP applies to task orders and projects associated with ARCADIS. This SOP may be modified, as required, depending on site-specific conditions, equipment limitations or limitations imposed by the procedure. The ultimate procedure employed will be documented in the appropriate project work plans or reports. If changes to the testing procedures are required due to unanticipated field conditions, the changes will be discussed with the project manager as soon as practicable and documented in the project report.

II. Personnel Qualifications

Only qualified ARCADIS-related personnel will conduct LNAPL baildown tests. ARCADIS field sampling personnel will have sufficient “hands-on” experience necessary to successfully complete the LNAPL baildown test field work. Training requirements for conducting LNAPL baildown tests include reviewing this SOP and other applicable SOPs and/or guidance documents, instrument calibration training, and health and safety training.

ARCADIS field sampling personnel will have completed current company-required health and safety training (e.g., 40-hour Hazardous Waste Operations training, site-specific training, first aid and cardiopulmonary resuscitation (CPR) training), as needed.

III. Equipment List

Equipment and materials used for conducting the LNAPL baildown tests may include, but are not limited to, the following:

- appropriate personal protective equipment (PPE), as specified in the site Health and Safety Plan (HASP)
- equipment decontamination supplies
- photoionization detector (PID) (see ARCADIS SOP: Photoionization Detector Air Monitoring and Field Screening)
- plastic sheeting
- oil absorbent pads
- stopwatch
- polypropylene rope
- clean disposable bailers
- oil-specific skimmer pump
- vacuum truck
- plastic bucket with lid
- plastic beakers or graduated cylinders (appropriately sized for anticipated NAPL/water recovery volume)
- Calculator
- appropriate field logs/forms
- oil-water interface probe (see ARCADIS SOP: Water Level Measurement)
- data logger and transducer
- white masking tape

- measuring tape with gradation in hundredths of a foot
- indelible ink pen
- monitoring well keys
- bolt cutters
- monitoring well locks
- field log book or PDA or field (computer) notebook

IV. Cautions and Procedure Considerations

Wells containing LNAPL for baildown testing should be selected based on project-specific objectives and a review of historical site data. It is good practice to select several baildown test wells to bracket the range of observed historical apparent LNAPL thickness measurements and LNAPL mobility/recoverability conditions across a given area. As a rule of thumb, apparent LNAPL thicknesses in wells used for baildown tests should be greater than or equal to the borehole diameter (Lundy and Parcher, 2007). Additional guidelines for selecting appropriate wells for LNAPL baildown testing include:

- Select wells located near the interior and exterior portions of the LNAPL plume(s)
- Select wells located in a variety of geologic materials, as feasible
- Consider the position of wells relative to groundwater and LNAPL flow direction
- Consider the potential of wells to exhibit different equilibrated apparent LNAPL thicknesses
- Select wells which contain different types of LNAPL, if present

In addition, understanding the areas affected by recent remediation efforts should be considered because these areas may not be representative of static subsurface conditions. Also, ARCADIS field sampling personnel must be aware of historical fluid levels as they compare to the conditions at the time of testing (i.e., the smear zone).

If higher LNAPL recovery rates are expected, larger diameter wells (4- to 6-inch-diameter casings) are generally preferred. The increased area of the wellbore

seepage face for larger diameter wells will provide information that is applicable to a larger, more representative volume of aquifer material. However, if the expected recovery rate is low, smaller diameter wells are often preferred because the volume of the borehole is smaller relative to the formation recovery capacity. Further discussion on accounting for the well filter pack is presented in *A Protocol for Performing Field Tasks and Follow-up Analytical Evaluation for LNAPL Transmissivity using Well Baildown Procedures* (Beckett and Lyverse, 2002).

ARCADIS project personnel must confirm that the test wells have been properly developed. This cannot be overemphasized, as incomplete well development results in underestimates of LNAPL transmissivity (T_n) and LNAPL conductivity (K_n). See the ARCADIS SOP titled *Monitoring Well Development* for additional details.

ARCADIS field sampling personnel must verify that the air/LNAPL and LNAPL/groundwater interfaces occur within the screen interval. At a minimum, the piezometric head elevation in the well should occur below the top of the screen.

ARCADIS field sampling personnel will choose the most appropriate technique to evacuate the LNAPL from the well. These techniques include:

- **Manual bailer** — A 1¾-inch-diameter bailer will be used for 2-inch-diameter wells. For 4-inch-diameter wells, a 3-inch-diameter bailer will be used for LNAPL recovery. ARCADIS highly recommends using product recovery cups, which attach to the bottom of the bailer and maximize the surface area for LNAPL recovery (For example, the Superbailer™, manufactured by EON Products, Inc. has this feature built-in). This will allow for more complete LNAPL removal and more accurate recovery measurements.

- **Pumping** — LNAPL removal can be accomplished by using an oil-specific skimmer pump that operates at a pumping rate which exceeds the LNAPL recharge capacity. For shallow wells (< 25 feet below ground surface), a peristaltic pump may also be a useful, effective and appropriate mode of LNAPL removal.

- **Vacuum Truck** — If large LNAPL volumes are to be removed or extremely rapid recovery rates are anticipated, LNAPL removal can be accomplished using a vacuum truck. The vacuum extraction line is to be outfitted with a small-diameter stinger attachment that will be extended down the well and an in-line site glass to observe extracted fluid color for determination of whether LNAPL or groundwater is being extracted. Begin pumping at the LNAPL/air interface and slowly move the stinger tube downward to extract LNAPL. When groundwater recovery is observed indicating that the LNAPL has been evacuated withdraw the stinger tube and begin fluid level measurements.

Follow the sequential steps below for each baildown test well. Data collection is generally manual using an interface probe, although a data logger can also be used as long as it can sense either the fluid interfaces or the head change only with respect to LNAPL. Before performing an LNAPL baildown test, allow monitoring well water and LNAPL levels to equilibrate with atmospheric pressure. Gauge fluid levels periodically for 5 to 10 minutes to monitor changes in head. Monitoring wells without vents (flush mounts) may require more time to equilibrate with atmospheric pressure following well cap removal.

ARCADIS recommends taking LNAPL measurements initially in one-minute intervals and then adjusting the frequency of measurements thereafter, based on site-specific conditions. The rate of LNAPL recovery will usually slow over time unless the zone of interest is highly conductive. Once the rate of recovery is slow enough, a new baildown test can be initiated at another location, returning to take periodic measurements at the initial test well. Continue this process as long as it is viable based on soil characteristics, field logistics, well locations and data collection needs. Real-time examination of the data curves is the best indicator of data sufficiency. A plot of the change in LNAPL thickness over time may exhibit up to three theoretical segments:

1) initial steep segment that could reflect filter pack drainage

2) main production segment where the formation LNAPL gradient to the wells controls recovery

3) third segment where the diminishing formation LNAPL gradient produces a flatter recovery curve

Repeatedly introducing the oil-water interface indicator may alter the fluid-level measurements. Avoid splashing the probe into the water table or lowering the probe too far beyond the LNAPL-water interface depth. To avoid introducing surface soil or other material into the monitoring well, stage downhole equipment on a clean and dry working surface.

Two field personnel are recommended to adequately perform this test, one person to collect the data and one person to record the data.

V. Health and Safety Considerations

Overall, the Loss Prevention System™ (LPS) tools and the site-specific HASP will be used to guide the performance of LNAPL baildown tests in a safe manner without incident. A Job Safety Analysis (JSA) will be prepared for LNAPL baildown tests. The

following specific health and safety issues must be considered when conducting LNAPL baildown tests:

- Monitoring for volatile organic compounds (VOCs) in the monitoring well head space must be conducted with a PID and recorded in the field logbook prior to initiating the LNAPL baildown test. PID readings will be compared to action levels established in the site HASP for appropriate action.

- Appropriate PPE must be worn to avoid contact with LNAPL during the baildown test.

- LNAPL removed from the test well must be managed with caution to avoid igniting the LNAPL material. LNAPL characteristics must be reviewed in the JSA, which will be prepared and reviewed by the project team prior to implementing the baildown test.

- LNAPL generated during the baildown test must be properly managed in accordance with facility and applicable regulatory requirements.

- Well covers must be carefully removed to avoid potential contact with insects or animals nesting in the well casings.

VI. Procedure

Specific procedures for conducting LNAPL baildown tests are presented below:

1. Identify site, well number, date and time on the LNAPL Baildown Test Log and field logbook or PDA, along with other appropriate LNAPL baildown testing information. An example LNAPL Baildown Test Log is provided in Attachment 1 to this SOP.

2. Place clean plastic sheeting and several oil absorbent pads on the ground next to the well.

3. Unlock and open the monitoring well cover while standing upwind from the well.

4. Measure the concentration of detectible organics present in the worker breathing zone immediately after opening the well using a PID. If the PID reading(s) exceed the thresholds provided in the HASP, take appropriate actions per the HASP. After monitoring the worker breathing zone, proceed to

monitor the well head space with the PID and record the PID reading in the field logbook.

5. Prepare a test log to record LNAPL recovery data. Initially, data should be collected very frequently. As time progresses and the LNAPL recovery rate slows, less frequent measurements will be required. In most cases, initial measurement increments of 1 minute are sufficient, with subsequent measurements farther apart as appropriate, based on observed rate of recovery during the first few readings. If LNAPL recovery rates are high, data should be collected more frequently. For lower LNAPL recovery rates, time intervals between measurements can be increased.

6. It is important to monitor rapid LNAPL recovery at a higher frequency, again as indicated by the observed recovery data.

7. Secure one end of the rope to the bailer and the other end to the well casing using a bowline knot.

8. Before beginning the baildown testing, measure and record static fluid levels using the oil/ water interface probe (i.e., depth to LNAPL and depth to groundwater) and document the well construction details. Using the conversion chart at the bottom of the test log, the measured LNAPL thickness and the well diameter, calculate and record the initial LNAPL volume in the well. Gauge fluid levels periodically for 5 to 10 minutes to monitor changes in head. Do not begin the test until the well has equilibrated. Ideally, one person will be responsible for lowering the bailer into the well and recording time intervals in the log, and another person will be responsible for lowering the water-level probe into the well and measuring and communicating water-level depths to the person recording information in the log.

9. To begin baildown testing, slowly lower the bailer or equivalent into the well until it is just below the LNAPL-water interface.

10. Set stopwatch. Wait to start the stopwatch until immediately after LNAPL removal is finished.

11. Evacuate LNAPL from the well by gently bailing, pumping, or vacuum recovery as described in Section IV above while minimizing water production. One of the assumptions employed in the analysis of the baildown test data is that the LNAPL is removed from the well instantaneously. Thus, it is important to avoid spending excessive amounts of time (more than 5 minutes) removing LNAPL from the well.

12. Record the time at which LNAPL removal is complete (or removed to the maximum practical extent) as the test start time. Begin measuring the elapsed time, starting with this point. Monitor depth to LNAPL and depth to water at the appropriate intervals, as discussed above (5). Measure fluid levels to the nearest hundredth of a foot with the oil-water interface probe and record, along with the corresponding time reading in minutes and seconds.

13. Transfer the LNAPL and groundwater evacuated from the well into an appropriately sized beaker or graduated cylinder. Record the volumes of LNAPL and groundwater on the Baildown Test Log (Attachment 1). If an LNAPL/water emulsion was formed during fluid recovery, allow time for LNAPL/water separation and make note of the observed emulsification.

14. Two to eight hours of data collection is usually sufficient. However, faster LNAPL recovery need not be monitored for extended periods, and slow recovering wells may benefit from follow-up readings the next day.

15. Place all LNAPL and groundwater collected during the test into an appropriate container for proper waste management.

16. Decontaminate the oil-water level indicator with a non-phosphate detergent and water scrub, a tap water rinse, a reagent grade methanol rinse, a second tap water rinse, a second methanol rinse, a third tap water rinse, and a triple rinse with distilled water (see SOP titled *Field Equipment Decontamination*).

17. Secure the monitoring well prior to leaving by replacing the well cap and/or cover and locking it.

VII. Waste Management

Rinse water, PPE and other waste materials generated during equipment decontamination must be placed in appropriate containers and labeled. Containerized waste will be disposed of in a manner consistent with appropriate waste management procedures for investigation-derived waste.

VIII. Data Recording and Management

ARCADIS field sampling personnel will record data using the LNAPL Baildown Test Log (Attachment 1). All information relevant to the test data beyond the items identified in the Baildown Test Log will be recorded using the field logbook, PDA or field computer. Field equipment decontamination activities and waste management activities will be recorded in the field logbook. Records generated as a result of

implementing this SOP will be controlled and maintained in the project record files in accordance with client-specific requirements.

IX. Quality Assurance/Quality Control

ARCADIS project personnel will review the data set collected during the LNAPL baildown test in the field to determine whether or not the data are reasonable given site-specific conditions. For example, if the data indicates that LNAPL recovery is very rapid in a very low-permeability soil type, this may indicate that there are problems with the data set. If the data are questionable, the field equipment must be checked to confirm it is working properly and the test will be repeated, if possible. Depending on data quality objectives, a duplicate LNAPL baildown test may be conducted as a quality control check 48 hours after the initial test, assuming water levels and apparent LNAPL thicknesses have returned to static conditions.

Any issues that may affect the data must be recorded in the field log book so that analysts can consider those issues when processing the data.

X. References

Beckett, G.D. and Lyverse, M.A. 2002. *A Protocol for Performing Field Tasks and Follow-up Analytical Evaluation for LNAPL Transmissivity using Well Baildown Procedures, August 2002.*

Lundy, D. and Parcher, M. 2007. *Assessment of LNAPL Volume, Mobility and Recoverability for Recovery Systems: Design and Risk-Based Corrective Action. National Ground Water Association Short Course, November 2007.*

ARCADIS SOPs Referenced Herein:

Field Equipment Decontamination, Revision No.1, April, 2009.

Monitoring Well Development, Revision No.2, March, 2008.

Photoionization Detector Air Monitoring and Field Screening, Revision No. 0, July, 2003.

Water Level Measurement, Revision No. 1, March, 2004.

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Attachment 1: LNAPL BAILDOWN TEST LOG

LNAPL Baildown Test Standard Operating Procedure

Site Name		Test Well ID	
Date and Time In		Date and Time Out	
Personnel		Weather	

Well Construction Details

Top of Casing Elevation (ft amsl)		Screen Slot Size (in)	
Total Well Depth (ft)		Filter Pack Type	
Depth to Top of Screen (ft)		Depth to Bottom of Screen (ft)	
Well Casing Diameter (in)		Borehole Diameter (in)	

Initial Test Conditions

Static Depth to LNAPL (ft)		Test Date	
Static Depth to Water (ft)		Start Time	
LNAPL Thickness (ft)		Initial LNAPL Volume in Well (gal)	

LNAPL Removal Information

LNAPL Removal Method/Equipment		Time LNAPL Removal Begins	
Volume of LNAPL Removed (gal)		Time LNAPL Removal is Completed	
Volume of Groundwater Removed (gal)			

Baildown Test Data

Elapsed Time (min)	Depth to LNAPL (ft)	Depth to Water (ft)	Observations

(Modified after Beckett and Lyverse, 2002)

Well Casing Volumes	1-¼" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65
(Gal./Ft.)	1-½" = 0.09	2-½" = 0.26	3-½" = 0.50	6" = 1.47