

Detection and Sampling of Nonaqueous Phase Liquids in Monitoring Wells

FSOP 2.2.3 (March 8, 2011)

Ohio EPA Division of Environmental Response and Revitalization

1.0 Scope and Applicability

- 1.1 This procedure describes standard practices used by the Division of Environmental Response and Revitalization (DERR) for the detection, sampling and handling of nonaqueous phase liquid (NAPL), including light nonaqueous phase liquid (LNAPL) and dense nonaqueous phase liquid (DNAPL) that may be present in ground water monitoring wells at contaminated sites.
- 1.2 NAPLs are organic liquids that exist as a separate, relatively immiscible phase when in contact with water. NAPLs are divided into the general categories of LNAPL and DNAPL based on density relative to that of water:
 - 1.2.1 LNAPL floats on the water column and accumulates on the ground water surface because its density is less than that of water (< 1.0 g/cc). Petroleum products such as gasoline, diesel fuel and motor oil are typical sources of LNAPL (U.S. EPA 1995).
 - 1.2.2 DNAPL sinks through the water column and accumulates at the bottom of the well because its density is greater than that of water (> 1.0 g/cc). DNAPL sources include chlorinated solvents, coal tar, wood preservative wastes and pesticides (U.S. EPA 1991).
- 1.3 NAPL may be analyzed to determine its physical properties and chemical composition. Knowledge of physical properties such as density or viscosity is important for evaluating NAPL mobility and distribution in the subsurface and for remediation system design. Knowledge of chemical composition may be used for computing the effective solubility of NAPL components, identifying potential NAPL sources and evaluating the applicability of remedial technologies.
- 1.4 Refer to the Ohio EPA Technical Guidance Manual for Ground Water Investigations (Chapter 10) for additional guidance on collecting ground water samples from monitoring wells containing NAPL.

2.0 Definitions

Free Product: term sometimes used as a synonym for NAPL

3.0 Health and Safety Considerations

- 3.1 LNAPL typically consists of a flammable petroleum product (e.g., gasoline) that releases vapors of volatile organic compounds (VOCs) known to be toxic and/or carcinogenic (e.g., benzene).
- 3.2 DNAPL typically consists of nonflammable, volatile chlorinated solvents (e.g., perchloroethylene) that are known to be toxic and/or carcinogenic.

- 3.3 Personal protective equipment (PPE) should be chemically resistant to organic solvents.
- 3.4 If NAPL (especially LNAPL) is present in a monitoring well, vapors migrating from the well casing may contaminate the work area breathing zone with VOC concentrations and/or flammable vapors that exceed health and safety action levels (Table 1, FSOP 1.1, Initial Site Entry). Consequently, monitoring, sampling or LNAPL recovery efforts may need to be performed using respiratory protection. In addition, the work zone should be monitored using a photoionization detector (PID) for VOC concentrations and a combustible gas indicator (CGI) for lower explosive limit and percent oxygen.
- 3.5 All equipment used to monitor or sample NAPL (or ground water from wells containing NAPL) must be intrinsically safe.
- 3.6 NAPL samples that are flammable fluids cannot be shipped via air and must be delivered to the laboratory by an Ohio EPA staff member, a courier, or via ground shipment. Always assume that NAPL from an unknown source is flammable fluid for the purpose of sample shipment.

4.0 Procedure Cautions

- 4.1 Monitoring or sampling equipment that directly contacts NAPL must be resistant to organic solvents.
- 4.2 Excessive agitation of a monitoring well water column containing NAPL will distribute the NAPL throughout the filter pack and surrounding formation. This will cause subsequent NAPL recovery efforts to be more difficult and will compromise any attempt to collect a representative ground water sample from the well. Monitoring wells that contain NAPL generally should not be developed, purged using a bailer or pumped at a high flow rate relative to the well yield.
- 4.3 Measurement and sampling of NAPL layers in monitoring wells should always be performed prior to extracting ground water from the well.
- 4.4 Regardless of the measuring method used, the measured thickness of LNAPL or in a monitoring well rarely corresponds to that in the adjacent saturated formation, and typically exceeds the LNAPL-saturated formation thickness by approximately 2 to 10 times. This discrepancy can be caused by several factors, including but not limited to soil or bedrock capillary forces, the volume and rate of the NAPL release, fluctuation in ground water elevations or the presence of low-permeability layers above the water table. Therefore, a measured LNAPL thickness in a monitoring well should be qualified as an apparent thickness.
- 4.5 The measured thickness of DNAPL in a monitoring well may not correspond to that in the adjacent saturated formation depending on the placement of the well screen with respect to the DNAPL layer and the underlying impermeable layer. Therefore, a measured DNAPL thickness in a monitoring well generally should be

qualified as an apparent thickness, unless well construction records indicate that the screen intercepts the DNAPL interface and the bottom elevation of the screen closely approximates the elevation of the underlying impermeable layer.

- 4.6 If measuring NAPL thickness using a transparent bailer, the apparent NAPL thickness in the bailer may be greater than the NAPL thickness in the well casing due to positive fluid displacement by the bailer.
- 4.7 DNAPL layers should be measured and sampled using double check-valve bailers rather than single check valve bailers. The second (upper) check valve on a double-check valve bailer isolates the sample as the bailer is lifted through the well water column, thereby maintaining the integrity of a DNAPL sample.
- 4.8 Ground water elevations in monitoring wells containing LNAPL should be corrected for the depression of the LNAPL/water interface to obtain total hydraulic head. The depression is caused by the weight of the LNAPL. The correction is performed by multiplying the measured LNAPL thickness by an estimate of the LNAPL specific gravity, and then adding the result to the elevation of the LNAPL/water interface. Approximate specific gravities at 20° C (68° F) for common petroleum product sources include the following:
 - Gasoline, 0.74 g/cc
 - Jet fuel or kerosene, 0.80 g/cc
 - Diesel fuel, 0.85 g/cc
 - Motor oil, 0.90 g/cc

5.0 Personnel Qualifications

Ohio EPA personnel working at sites that fall under the scope of OSHA's hazardous waste operations and emergency response standard (29 CFR 1910.120) must meet the training requirements described in that standard.

6.0 Equipment and Supplies

- 6.1 Detecting and measuring NAPL in monitoring wells:
 - 6.1.1 Decontamination equipment and supplies (refer to FSOP 1.6. Sampling Equipment Decontamination)
 - 6.1.2 Field logbook or field log sheets and appropriate field log forms
 - 6.1.3 Combustible gas indicator (CGI), also referred to as a lower explosive limit/ oxygen LEL/O₂) meter
 - 6.1.4 Oil-absorbent pads or mats
 - 6.1.5 Oil/water interface probe or transparent bailers, single check valve (for LNAPL) and double check valve (for LNAPL or DNAPL)
 - 6.1.6 Personal protective equipment (protective gloves at a minimum)
 - 6.1.7 Photoionization detector (PID)
 - 6.1.8 Site map with monitoring or recovery well locations

- 6.1.9 Water-proof pens and markers
- 6.2 Collecting NAPL samples from monitoring wells for laboratory analysis:
 - 6.2.1 All equipment and supplies listed above in Section 6.1
 - 6.2.2 Chain-of-custody forms
 - 6.2.3 Protective eyewear and coveralls
 - 6.2.4 Sample containers and labels as specified by the laboratory
 - 6.2.5 Sample coolers
 - 6.2.6 Sampling device(s), including single-check valve bailers (for LNAPL), double-check valve bailers (for LNAPL or DNAPL), or an intrinsically safe peristaltic pump

7.0 Procedures

- 7.1 Detecting and measuring NAPL in monitoring wells:
 - 7.1.1 Always inspect purge water and development/monitoring/sampling equipment removed from any well for the presence of NAPL, which typically forms sheens, layers, or droplets of black, brown, yellow or clear immiscible fluid having a petroleum or solvent odor.
 - 7.1.2 If LNAPL is present in a monitoring well, screen the atmospheres within **(a) the breathing zone above the open well casing** and **(b) within the well casing** with a PID and CGI.
 - 7.1.2.1 If volatile organic compound (VOC) concentrations or the percentage LEL *in the breathing zone* exceed the health and safety action levels provided in Table 1 of FSOP 1.1, Initial Site Entry or site-specific action levels, close and secure the monitoring well. Work will need to be delayed until appropriate health and safety measures can be implemented.
 - 7.1.2.2 If VOC concentrations or the percentage LEL *in the well casing* exceed the health and safety action levels provided in Table 1 of FSOP 1.1 or site-specific action levels, but VOC concentrations or the percentage LEL in the breathing zone do not, work activities may continue. Continue monitoring the breathing zone continuously for VOC concentrations and percentage LEL.
 - 7.1.2.3 Use a log book or field log sheets to record health and safety monitoring data (e.g., ranges of PID and LEL measurement values).
 - 7.1.3 Measure the apparent thickness of the NAPL layer in the well (the difference between the air/LNAPL and the LNAPL/water interface depths, or the difference between the water/DNAPL and well bottom depths) using one of the following techniques:

- 7.1.3.1 Oil/water interface probe: slowly lower the probe through the fluid column to detect and measure NAPL interfaces.
- 7.1.3.2 Transparent bailer: slowly lower the bailer through the fluid column to span the NAPL layer, slowly withdraw the bailer, and measure the NAPL thickness within it. Use double check-valve bailers to retrieve DNAPL samples. Use single-check valve or double check-valve bailers to retrieve LNAPL samples. Handle bailers over oil-absorbent pads or mats to contain NAPL that may be inadvertently spilled on the ground.
- 7.1.4 Measure NAPL thickness to an accuracy of +/- 0.01 ft. If the thickness is less than 0.01 ft, describe the thickness as a "sheen."
- 7.2 Collecting NAPL samples from monitoring wells for laboratory analysis:
 - 7.2.1 Collecting samples using a bailer:
 - 7.2.1.1 To collect an LNAPL sample, slowly lower a single-check valve or double check-valve bailer through the LNAPL layer and into the underlying water column, taking care to allow as little water as possible to enter the bailer. Upon retrieval of the bailer, decant water from it by carefully opening the check valve at the bottom of the bailer. Then fill the sample containers with LNAPL by pouring from the top of the bailer. Repeat this process until all sample containers are filled or until no more LNAPL can be recovered from the well.
 - 7.2.1.2 To collect a DNAPL sample, slowly lower a double check valve bailer to the bottom of the well. Carefully retrieve the bailer, and upon retrieval, decant water from it by pouring from the top of the bailer. Then fill the sample containers with DNAPL by opening the check valve at the bottom of the bailer. Repeat this process until all sample containers are filled or until no more DNAPL can be recovered from the well.
 - 7.2.2 Collecting samples using a peristaltic pump:
 - 7.2.2.1 An intrinsically safe peristaltic pump may be used to collect LNAPL or DNAPL samples provided that the NAPL is within the suction limit of the pump (generally within the upper 20 feet of the well water column).
 - 7.2.2.2 Set the pump intake within the LNAPL or DNAPL and fill the sample containers from the pump discharge, taking care to minimize the amount of water in the sample. Repeat this process until all sample containers are filled or until no more NAPL can be recovered from the well.

- 7.2.3 Perform sampling activities over oil-absorbent pads or mats to contain NAPL that may be inadvertently spilled on the ground.
- 7.3 Decontaminate equipment in accordance with FSOP 1.6, Sampling Equipment Decontamination.
- 7.4 Properly containerize all wastes in accordance with FSOP 1.7, Investigation Derived Wastes. Pour waste NAPL and fluids containing NAPL into a DOT-approved container for flammable fluids and tightly seal the container. Segregate NAPL-contaminated disposable sampling equipment and personal protective equipment by double-bagging with heavy duty trash can liners. Contact the Site Investigation Field Unit (SIFU) for additional guidance on the containerization, transportation, and disposal of NAPL and media or disposal sampling equipment or personal protective equipment contaminated with NAPL.

8.0 Data and Records Management

Refer to FSOP 1.3, Field Documentation.

9.0 Quality Assurance and Quality Control

Not applicable

10.0 Attachments

None

11.0 References

FSOP 1.1, Initial Site Entry

FSOP 1.3, Field Documentation

FSOP 1.6, Sampling Equipment Decontamination

FSOP 1.7, Investigation Derived Wastes

Ohio EPA Division of Drinking and Ground Waters, May 2012, Technical Guidance Manual for Ground Water Investigations (Chapter 10: Ground Water Sampling)

U.S. EPA, 1995, Ground Water Issue: Light Nonaqueous Phase Liquids, EPA/540/S-95/500

U.S. EPA, 1991, Ground Water Issue: Dense Nonaqueous Phase Liquids, EPA/540/4-91-002