



Ministry of
Environment and
Climate Change Strategy

PROTOCOL 16 ***FOR CONTAMINATED SITES***

Determining the Presence and Mobility of
Nonaqueous Phase Liquids and Odorous Substances

Version 2.0

Prepared pursuant to Section 64 of the
Environmental Management Act

Approved:

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Director of Waste Management

October 31, 2017
Date

Effective date: November 1, 2017

1.0 Definitions

The following words, acronyms and expressions used in this protocol are defined in the [Procedure 8, “Definitions and Acronyms for Contaminated Sites”](#):

Act	LNAPL
aquatic habitat	mobile DNAPL
dense nonaqueous phase liquid	mobile LNAPL
Director	NAPL
DNAPL	nonaqueous phase liquid
fractured bedrock	soil
free phase liquid	soil surface
high water mark	Regulation
light nonaqueous phase liquid	theoretical solubility limit

2.0 Introduction

Schedule 3.1 – Part 2 and Schedule 3.1 - Part 3 of the Contaminated Sites Regulation (the Regulation) contain environmental quality standards for nonaqueous phase liquids and odorous substances. For all land uses, the Schedules list those standards as “not present” and in footnotes 15 and 16 of Schedule 3.1 Part 2 and footnotes 10 and 12 of Schedule 3.1 Part 3 further explain that soil must be remediated so that these substances are not present in quantities in excess of those acceptable to a Director.

This protocol provides the Director’s requirements in the context of these footnotes and the standard “not present”. In addition, it describes the circumstances when two types of nonaqueous phase liquids (NAPLs), dense nonaqueous phase liquids (DNAPLs) and light nonaqueous phase liquids (LNAPLs) are considered mobile. Contaminant mobility is a key factor used in site risk classification in the contaminated sites regime.

Scientific background information on methods and assumptions for determining the presence of mobile LNAPL is contained in Golder Associates Ltd.’s 2008 report [“Guidance on assessment of light nonaqueous phase liquid mobility for site classification purposes in British Columbia”](#).

3.0 Nonaqueous phase liquids (NAPLs) presence and mobility

For any of the eight land uses (wildlands natural, wildlands reverted, agricultural, urban park, residential low density, residential high density, commercial and industrial) provided in the Regulation, under section 11(1) of the Regulation a site is contaminated if NAPL is present at the site. The site would be considered remediated under section 17(1) of the Regulation if the NAPL is removed so that NAPL is considered not present.

The following subsections indicate when the Director considers light nonaqueous phase liquid (LNAPL) and dense nonaqueous phase liquid (DNAPL) present and not present.

3.1 Presence of LNAPL and DNAPL

3.1.1 When LNAPL is present

LNAPL is considered present when either of the following occurs at a site:

- a) free phase liquid is found in soil or on the soil surface; or
- b) free phase liquid is found in monitoring wells at a thickness greater than 2 mm.

3.1.2 When DNAPL is present

DNAPL is considered present when any of the following occur at a site:

- a) free phase liquid is found in soil or on the soil surface;
- b) free phase liquid is found in monitoring wells at a thickness greater than 2 mm; or
- c) individual DNAPL substances are detected in water at concentrations exceeding 1% of their theoretical solubility limit.

3.2 Mobility of LNAPL and DNAPL

Mobile LNAPLs and DNAPLs represent a contaminant source with potential to cause contaminant spreading, undetermined future risks as well as increased complexity, cost, and effort in site remediation. Mobility is therefore a factor which is considered in classifying the risks a site poses to human health and the environment.

Nonaqueous phase liquids are considered mobile when they are present at a site and the following conditions occur.

3.2.1 When LNAPL is mobile

Under this protocol, LNAPL is defined as mobile when any of following conditions occurs:

- a) LNAPL is present over an area greater than 10 m² on the land surface;
- b) LNAPL is present in fractured bedrock;
- c) LNAPL is measured in the subsurface over an area greater than 50 m² and at least one of the following apply:
 - Seasonal water table fluctuations exceed 1 m (unless monitoring data is available to determine maximum LNAPL thickness at both high water and low water levels);
 - Hydraulic gradients exceed 0.01 m/m for soil compositions listed in Table 1;

- Preferential pathways intersect zones containing LNAPL with a thickness exceeding 0.3 m;
 - LNAPL thicknesses exceed values indicated in Table 1;
- d) quarterly groundwater monitoring events indicate increasing thickness of LNAPL in monitoring wells; and
- e) quarterly groundwater monitoring events indicate advancement of LNAPL across a monitoring well network.

Table 1. LNAPL thickness considered mobile as a function of soil composition^{1,2}

Soil Type	Characteristic Fraction	Percent Fines (silt and clay)	LNAPL Thickness (m)
Coarse sand or gravel	> 20% Coarse sand	< 3	0.03
Coarse sand or gravel	> 20% Coarse sand	3-10	0.05
Medium sand	Medium sand	< 10	0.1
Fine sand	Fine sand	< 10	0.2
Silty sand	Sand	> 10	0.3

Notes:

1. Soil compositions are based on the Unified Soil Classification System.
2. Soil compositions falling outside listed soil types must be assigned the soil type that most closely approximates the permeability characteristics of the soil. In the event of uncertainty, a coarser grained soil type must be assigned.

3.2.2 When DNAPL is mobile

DNAPL is considered mobile when any of the following conditions occur at a site:

- a) DNAPL is present in fractured bedrock;
- b) DNAPL is present over an area greater than 10 m² on the land surface;
- c) quarterly groundwater monitoring events indicate advancement of DNAPL across a monitoring well network;
- d) free phase liquid is found in monitoring wells at a thickness greater than 2 mm; and
- e) individual DNAPL substances are detected in water at concentrations exceeding 10% of their theoretical solubility limit.

3.2.3 Mobility exemption with evidence of NAPL stability

After NAPL at a site has been determined to be mobile under the criteria specified in Section 3.2, if any of the following conditions is met, the NAPL present at a site would be considered not mobile:

- a) Quarterly groundwater monitoring events for one year with at least one of them in low water table season provides evidence that the NAPL conditions at a site have not changed over time.
- b) Historical monitoring data with at least two years of groundwater monitoring results for a site has provided evidence that the NAPL plume is stable.

4.0 Odorous substances presence

Schedule 3.1 Parts 2 and 3 of the Regulation provide “not present” standards for odorous substances for all eight land uses specified in section 12(3).

Under section 11(1) of the Regulation a site is contaminated with respect to odorous substances if a substance is present at the site whose concentrations exceed any of environmental quality standards in Schedule 3.3 for the applicable land use. As well, the site would be considered remediated under section 17(1) of the Regulation with respect to odorous substances if the substances exceeding the generic numerical vapour standards in Schedule 3.3 for the applicable land use are remediated to concentrations less than those standards or if the exposure is managed to meet risk-based standards.

For more information, please direct inquiries to site@gov.bc.ca.

Revision history

Approved Date	Effective Date	Document Version	Notes
May 31, 2010	June 1, 2010	1.0	
August, 2017	November 1, 2017	2.0	Updated for CSR Stage 10 amendment