

Title:	Subsoil Petroleum Hydrocarbon Guidelines for Remote Forested Sites in the Green Area
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Purpose

This document provides guidance for the application of subsoil petroleum hydrocarbon guidelines at remote forested sites in the Green Area. The guidance is based on the depth at which the ecological direct contact pathway no longer applies, coupled with management limits developed specifically for these sites.

Background

Concentrations of petroleum hydrocarbons in soil in Alberta are managed in accordance with the Tier 1 and Tier 2 soil remediation guidelines (ESRD, 2014a,b). These are risk-based guidelines in that they consider various exposure pathways and receptors and provide concentrations of chemicals in soil below which no adverse effects are predicted to human health or the environment.

The *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (ESRD, 2014a) provides direction for the application of petroleum hydrocarbon remediation guidelines in surface and subsurface soil. Use of subsurface guidelines is restricted to depths >1.5 m within 5m of an oil or gas well bore and >3 m anywhere else on the site. These conditions are based on the potential for the soil to be disturbed and brought to surface. However, potential for site disturbance is greatly reduced at remote sites in the Green Area. Land use is controlled by the public lands manager and the remote location of these sites makes it less likely that construction activities will disturb the soil.

Procedure/Guideline

1. Ecological direct contact pathway exclusion

When applying the Alberta Tier 1 Soil and Groundwater Remediation Guidelines (ESRD 2014a) at remote forested sites in the Green Area, the ecological direct contact pathway may be eliminated for petroleum hydrocarbon fractions 1 to 4 below the depths shown in Table 1. These exclusion depths may be used regardless of the location of an oil or gas well bore. Fine and coarse textured soil are defined in the *Alberta Tier 1 Guidelines for Soil and Groundwater Remediation* (ESRD 2014a).

Table 1. Modified Exclusion Depth for the Ecological Direct Soil Contact Pathway for Petroleum Hydrocarbons at Remote Forested Sites in the Green Area

Soil Type	Exclusion Depth (m)
Fine-grained soil	1.5
Coarse-grained soil	3.0

2. Management limits

Pathway exclusion options for site-specific guideline development are described in the *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* (ESRD, 2014b). For sites under natural areas land use with the appropriate characteristics, it is possible that all exposure pathways may be eliminated, leaving the management limits as the site's remediation objective. For remote forested sites in the Green Area, the subsoil management limits for petroleum hydrocarbon fractions 2 and 3 shown in Table 2 may be used. Management limits for petroleum hydrocarbon fractions 1 and 4 are found in the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (ESRD 2014a).

Table 2. Modified Subsoil Management Limits for F2 and F3 at Remote Forested Sites

Soil Type	Management Limit (mg/kg)			
	F1	F2	F3	F4
Fine-grained soil	Tier 1	10,000	14,000	Tier 1
Coarse-grained soil	Tier 1	9,000	4,000	Tier 1

Tier 1: See ESRD (2014a)

When applying the management limits in Table 2, the sum of the concentrations of petroleum hydrocarbon fractions 1 to 4 must not exceed 30,000 mg/kg.

3. Definition of remote forested sites in the Green Area

Sites must meet all of the following conditions:

- the site is within the Green Area;
- the site is in a forested area and reclaimed to a forested ecosystem;
- the site is remote from existing residences and roads;
- there is no dugout on site and future construction of a dugout is unlikely; and,
- the site is stable.

In addition to the meeting the above conditions, proponents must confirm with the appropriate municipal planner and provincial land manager that there are no known plans for the future development of the site.

Further information clarifying these requirements is provided in Sections 3.1 to 3.5 below.

3.1. Green Area

The Green Area is public land that is managed primarily for timber production, although other uses are permitted. Intensive activities involving settlement or agricultural development are restricted. The Green Area boundary is set by Ministerial Order 22/99 (May 1999 as amended).

3.2. Forested Site

The exclusion depths for the ecological contact pathway in Table 1 were developed based on maximum rooting depths for tree and shrub species relevant to the forested parts of Alberta, and therefore can only be applied in forested areas that are being reclaimed to a forested ecosystem. For the purposes of this document, the part of Alberta that is considered to be primarily forested is indicated on the attached figure. Note that in other areas of Alberta, the ecological direct soil contact exposure pathway can always be excluded at 3.0 m, as explained in ESRD (2014a).

3.3. Remote location

A fundamental assumption of the guidelines developed in Tables 1 and 2 is that the subsoil profile will not be disturbed. While the land remains under public control, human disturbance can be managed appropriately by the public land manager. It is not appropriate to apply these guidelines on land where there is a reasonable expectation of the land being transferred to private ownership within the foreseeable future. Future private ownership is most likely in proximity to current private land and to public roads. These guidelines may not be applied to sites that are:

- Within 20 km of the boundary of Fort McMurray;
- Within 20 km of the boundary of the Green Area;
- Within 10 km of the boundary of any other town or settlement; or,
- Within 5 km of any Provincial road.

An example of the current distribution of land in the Green Area considered to be remote is shown in the attached figure.

3.4. Grazing Lease Dugouts

Another fundamental assumption of the guidelines developed in Tables 1 and 2 is that livestock and wildlife will not be exposed to hydrocarbons in the subsurface via the presence of a dugout. Accordingly, the guidelines in Tables 1 and 2 cannot be applied at a site where a dugout is present, or at a site where a grazing lease overlaps all or part of the site unless other factors preclude the construction of a dugout. Possible factors that could preclude the construction of a dugout include:

- site topography is not conducive to dugout construction;
- dugout construction is not permitted under the terms of the grazing lease; or,
- a readily available surface water source means that construction of a dugout is extremely unlikely.

3.5. Stable Site

As noted above, the guidelines in Tables 1 and 2 require that the subsoil profile not be disturbed. In addition to human activity, disturbance of the subsoil profile could also occur at some sites through water erosion or soil movement. For the purposes of this document, the following three conditions need to be met for a site to be considered stable.

- Absence of creeks, rivers, or other flowing water bodies. There must be no reasonable probability that any flowing water body could erode the site sufficiently to expose subsoil to which the guidelines are being applied.
- Maximum topographic slope on site. Three ranges of values are considered.
 - Maximum slope less than 6%. Site topography is considered stable.
 - Maximum slope 6% to 30%. Verification that site is stable by a professional with appropriate training is required to support the application of the guidelines presented in Tables 1 and 2.
 - Maximum slope greater than 30%. Site is considered unstable.
- The site is not located within a 100 m of an area with a higher potential for instability than the site without supporting professional verification that the site is stable.

4. Supporting Rationale

4.1. Modified exclusion depth for the ecological direct soil contact pathway

The ecological direct soil contact exposure pathway addresses the direct contact of terrestrial plants and soil invertebrates with chemicals in soil. ESRD (2014a) allows the exclusion of the ecological direct soil contact pathway from the Tier 1 guideline value for petroleum hydrocarbon fractions F1 to F4 at depths greater than 3 m (or 1.5 m within 5 m of an oil or gas well).

PTAC (2013a) completed a thorough literature review into the maximum rooting depth of tree and shrub species relevant to the forested parts of Alberta, and conducted an extensive field verification of the literature results at a wide range of forested field sites in Alberta. A review of available information on the distribution of soil invertebrates with depth was also conducted, and it was concluded that plant rooting depth, rather than the distribution of soil invertebrates would be the limiting factor in determining an exclusion depth for the ecological direct soil contact pathway.

Relevant plant species were identified by considering characteristic tree and shrub species native to forested natural regions of Alberta. Available information on rooting depth was compiled for relevant species that indicated that the maximum rooting depth for coarse-grained soils in forested parts of Alberta was 3 m, while the maximum rooting depth for fine-grained soils in forested parts of Alberta was 1.5 m.

A total of 16 sites with fine-grained soils across the foothills and boreal regions of Alberta were identified for field verification of the 1.5 m maximum rooting depth in fine-grained soil. Trenches were excavated at each of these sites adjacent to mature trees and the maximum rooting depth recorded for each. This work confirmed the maximum rooting depth of 1.5 m for trees and shrubs in fine-grained soil in the forested parts of Alberta.

At remote forested sites in the Green Area, it is unlikely that the subsoil profile will be disturbed in the foreseeable future, and it is therefore reasonable to assume that soil that is currently below the maximum rooting depth will remain there. Accordingly, at such sites, the ecological direct soil contact exposure pathway can be excluded below 1.5 m in fine-grained soils, and below 3 m in coarse-grained soils.

4.2. Management Limits

The Alberta Tier 1 guidelines (ESRD 2014a) include management limits for all four of the petroleum hydrocarbon fractions, F1, through F4. Management limits are an important part of the Alberta Framework for the Management of Contaminated Sites (see ESRD, 2014a). They are primarily based on non-toxicological considerations including contaminant mobility, safety, and others, and provide upset limits for guideline values regardless of the exclusion or modification of other exposure pathways.

The management limits for petroleum hydrocarbons included in the Alberta Tier 1 guidelines include some considerations that are less relevant in a remote forested setting. PTAC (2013b) identified four considerations that were considered relevant to such a setting (formation of mobile free-phase hydrocarbon, fire and explosion hazard, hydrophobicity, and upwards migration into the root zone). An extensive program of laboratory research was carried out to quantify these factors, and management limits were developed for petroleum hydrocarbon fractions F2 and F3 for remote forested sites in Alberta. Full details are found in PTAC (2013b).

Reference Documents

ESRD (Environment and Sustainable Resource Development), 2014a. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. May 23, 2014.

ESRD (Environment and Sustainable Resource Development), 2014b. Alberta Tier 2 Soil and Groundwater Remediation Guidelines. May 23, 2014.

PTAC (Petroleum Technology Alliance Canada), 2013a. Proposed Exclusion Depths for the Ecological Direct Contact Exposure Pathway at Remote Alberta Green Zone Sites. Report dated February 2013.

PTAC (Petroleum Technology Alliance Canada), 2013b. Proposed Management Limits for F2 and F3 Hydrocarbons at Remote Alberta Green Zone Sites. Report dated May 2013.

Original signed by

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