New Jersey
Department of Environmental Protection

Site Remediation and
Waste Management Program

Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance

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TABLE OF CONTENTS

APPENDICES

EVALUATION OF EXTRACTABLE PETROLEUM HYDROCARBONS IN SOIL TECHNICAL GUIDANCE

1.0 INTENDED USE OF GUIDANCE

This technical guidance is designed to help the person(s) responsible for conducting the remediation to comply with the New Jersey Department of Environmental Protection requirements, the Technical Requirements for Site Remediation (Technical Rules), N.J.A.C. 7:26E. This guidance will be used by many different people involved in the remediation of a contaminated site; such as Licensed Site Remediation Professionals, Non-LSRP environmental consultants and other environmental professionals. Therefore, the generic term "investigator" will be used to refer to any person that uses this guidance to remediate a contaminated site on behalf of a remediating party, including the remediating party itself.

The procedures for a person to vary from the technical requirements in regulation are outlined in the Technical Rules at N.J.A.C. 7:26E-1.7. Likewise, the procedures for a person to vary from technical guidance are outlined in the Site Remediation Reform Act, N.J.S.A. 58:10C-14c(4). In both instances, the investigator must appropriately document and adequately support with data or other information.

This guidance supersedes previous DEP guidance issued on this topic. Technical guidance may be used immediately upon issuance. However, the Department recognizes the challenge of using newly issued technical guidance when a remediation affected by the guidance may have already been conducted or is currently in progress. To provide for the reasonable implementation of new technical guidance, the Department will allow a 6-month "phase-in" period between the date the technical guidance is issued (or the revision date) and the time it is effective for all sites.

This guidance was prepared with stakeholder input. The following people were on the committee that prepared this document:

David Barskey, Co-Chair, Department (retired)
John Ruhl, Co-Chair, Department
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John Donohue, Fuel Merchants Association of New Jersey
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2.0 PURPOSE

This technical guidance replaces the previous *Protocol For Addressing Extractable Petroleum Hydrocarbons* (EPH Protocol, Version 3.0, 9 August 2010). **The main differences between the August 2010 EPH Protocol and this technical guidance are:**

- the addition of six EPH-applicable petroleum products to Table 2-1 of N.J.A.C. 7:26E-2.1(d);
- the addition of an equation to calculate AOC-specific EPH alternative product limit concentrations;
- the 8,000 mg/kg EPH default product limit typically associated with Category 1 EPH is now designated to some Category 2 petroleum products;
- the establishment of an EPH ceiling limit concentration; and
- inclusion of compliance averaging options for the ingestion-dermal exposure pathway per the *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria* (https://www.nj.gov/dep/srp/guidance/#attainment_comp) for EPH Category 1 residential and non-residential soil remediation criteria.

This technical guidance provides direction on how to evaluate the EPH soil sample data from the site investigation, remedial investigation, and remedial action phases at sites with petroleum storage and discharge areas of concern (AOCs) pursuant to the Department's Technical Requirements for Site Remediation (Technical Rules, N.J.A.C. 7:26E) and the Department's guidance library. It is most useful when the horizontal and vertical delineation of the discharge is complete in both the saturated and unsaturated soil pursuant to N.J.A.C. 7:26E-4.2(a) so that the distribution of EPH in soil is well understood. This may include the remedial action verification sampling.

As listed in Table 2-1 at N.J.A.C. 7:26E-2.1(d), this technical guidance addresses petroleum products that include No. 2 heating oil, diesel fuel, No. 4 heating oil, No. 6 heating oil, hydraulic oil, cutting oil, crude oil, lubricating oil, waste oil, unknown petroleum hydrocarbons, waste vehicular crankcase oil, mineral oil, dielectric fluid, dielectric mineral oil, transformer oil, or manufactured gas plant (MGP) sites. For petroleum products and mixtures not listed in Table 2-1 at N.J.A.C. 7:26E-2.1(d), consult with the Department contact(s) for EPH listed at http://www.nj.gov/dep/srp/srra/srra_contacts.htm.

This technical guidance does not apply to discharges from the more volatile petroleum products (e.g., gasolines, kerosene, jet fuels, or light petroleum distillates), which must be investigated pursuant to the Technical Rules. Also note that for those situations where multiple petroleum hydrocarbon mixtures are involved, the evaluation must address all the types known to be present. Where the petroleum product type is unknown, sampling and analytical parameters for waste oil must be applied.

In accordance with N.J.A.C. 7:26E-2.1(a)6, the analytical method "*Analysis of Extractable Petroleum Hydrocarbon Compounds (EPH) in Aqueous and Soil/Sediment/Sludge Matrices*" (NJDEP EPH Method 10/08, Revision 3 August 2010) shall be used when investigating petroleum storage and discharge areas. https://nj.gov/dep/srp/guidance/srra/eph_method.pdf The results of this analytical method are reported as extractable petroleum hydrocarbons (EPH).

3.0 INTRODUCTION

This technical guidance applies to all petroleum storage facilities and petroleum discharge AOCs for EPH analysis of soil required pursuant to N.J.A.C. 7:26E-2.1(d). The focus of this guidance is on the evaluation of EPH data for its compliance with the EPH soil remediation criteria which are not included in the Department's Remediation Standards (N.J.A.C. 7:26D), and on EPH product limits which are not included in other technical guidance. The EPH soil remediation criteria and EPH default product limits are summarized in APPENDIX 1.

The Department is mandated by the Brownfield and Contaminated Site Remediation Act (N.J.S.A. 58:10B-12) to employ a health-based approach when developing remediation standards. The EPH residential and non-residential soil remediation criteria are based on an exposure scenario for protection from noncarcinogenic health effects at a hazard index of 1 and are based solely on effects via the ingestion-dermal exposure pathway. This technical guidance provides a health-based approach to accomplish the remediation of EPH for the petroleum products identified in Table 2-1 of N.J.A.C. 7:26E-2.1(d) that require analysis for EPH. Likewise, remediation shall also comply with Technical Requirements for Site Remediation (N.J.A.C. 7:26E), including, but not limited to, the requirements to treat or remove free product and residual product to the extent practicable (N.J.A.C. 7:26E-5.1(e)).

This technical guidance provides direction for:

- **Evaluating the EPH soil sample data** from the investigation of petroleum storage and discharge areas (Category 1, Category 2, or mixture).
- **Applying the EPH soil remediation criteria (SRC)**

  A discussion of the derivation of the human health-based residential and non-residential SRC which are based on the ingestion-dermal exposure pathway is found in Appendix 3.3. Some components of this guidance can be used to address EPH contamination at sites regulated under the Heating Oil Tank System Remediation (HOTSR) Rule (N.J.A.C. 7:26F). However, compliance with the HOTSR Rule is not included in this EPH technical guidance. Refer to the HOTSR Rule and its associated technical guidance.
- **Evaluating the soil sample data for the additional analyses** required pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d).
- **Evaluating potential ecological concerns** pursuant to N.J.A.C. 7:26E-1.16 when the ecological screening criterion of 1,700 mg/kg EPH is exceeded.
- **Applying the EPH default product limits** (or an AOC-specific EPH alternative product limit or the ceiling limit).

The basis for the Department's two default product limits for EPH in soil is detailed in Sanders (2009) in **Appendix 3.1**. An EPH product limit of 8,000 mg/kg has been established for Category 1 EPH. Additionally, the EPH product limit of 8,000 mg/kg is also applied to the Category 2 EPH products: crude oil (source of No. 2 heating oil); LNAPL at MGP sites, which

contain compounds comparable to Category 1 fuels; cutting oils, which are diverse in compositions; and unknown petroleum hydrocarbons. An EPH product limit of 17,000 mg/kg has been established for all other Category 2 EPH petroleum products. The EPH default product limits are based on an assessment of the residual saturation concentrations for various petroleum products and in various soil types included in a paper by Brost and DeVaull (2000). The residual saturation data for medium sand (a representative soil texture for most soil in New Jersey) was selected for establishing default limits for EPH product based on residual saturation. If the applicable default product limit is exceeded, the investigator can use the EPH Alternative Product Limit Calculator to calculate an AOC-specific EPH alternative product limit. In part, the calculator is based on the relationships between soil texture, product viscosity, and product density. EPH product determined to be immobile by this method can have an alternative product limit greater than the EPH default product limit concentration, but may not exceed the 30,000 mg/kg product "ceiling limit". The Department established the ceiling limit with the consensus of the stakeholder EPH Technical Guidance Committee (Appendix 3.2).

Exceedances of the EPH product limits, whether they are the default limits or AOC-specific EPH alternative product limits, require treatment or removal pursuant to N.J.A.C. 7:26E-5.1(e). Containment (i.e., engineering control) of EPH product can only be considered where treatment or removal of EPH product is not practicable pursuant to N.J.A.C. 7:26E-5.1(e).

This technical guidance presumes compliance with all other Departmental rules and guidance that apply to the remediation of contaminated sites in general and to remediation of petroleum hydrocarbons contamination in all media. This includes, but is not limited to the following:

- *Technical Guidance for Investigation of Underground Storage Tank Systems*
- *Ecological Evaluation Technical Guidance*
- *Light Non-aqueous Phase Liquid (LNAPL) Initial Recovery and Interim Remedial Measures Technical Guidance*
- *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria*
- *Ground Water Technical Guidance: Site Investigation Remedial Investigation Remedial Action Performance Monitoring*
- *Technical Guidance for Site Investigation of Soil, Remedial Investigation of Soil, and Remedial Action Verification Sampling for Soil*
- *In Situ Remediation: Design Considerations and Performance Monitoring Technical Guidance Document*

The technical guidances listed above can be found at: https://www.nj.gov/dep/srp/guidance/.

4.0 OVERVIEW OF PROCEDURE:

4.1 Determine Correct EPH Category

In order to apply this guidance, the investigator must determine the appropriate EPH category or categories requiring evaluation at each petroleum storage and discharge area pursuant to N.J.A.C. 7:26E-2.1(d), based on the current and historical petroleum products stored or used at each AOC being investigated.

4.1.1 **Category 1 Defined:**

Category 1 consists of only No. 2 heating oil and diesel fuel.

4.1.2 **Category 2 Defined:**

Category 2 consists of No. 4 heating oil, No. 6 heating oil, hydraulic oil, cutting oil, lubricating oil, crude oil, waste oil, unknown petroleum hydrocarbons, waste vehicular crankcase oil, mineral oil, dielectric fluid, dielectric mineral oil, transformer oil, or EPH-type discharges associated with manufactured gas plant (MGP) sites.

4.1.3 **Mixtures:**

Where both Category 1 and Category 2 petroleum products may have been discharged at an AOC, unknown petroleum products may have been discharged, waste oil comprised of Category 1 and Category 2 petroleum products, or complex mixtures such as crude oil or manufactured gas plant (MGP) materials are of concern, evaluate EPH using both the Category 1 and the Category 2 sections of this technical guidance. Complex EPH product mixtures such as crude oil or MGP materials often contain compounds that display characteristics common to both Category 1 and Category 2 products; and therefore, need to be evaluated using the guidance for both. For these situations, the investigator should use the on-line EPH Soil Remediation Criteria (SRC) Calculator and Category 1 EPH product limit, as summarized below.

4.2 Determine Human Health-Based Remediation Goal

Evaluate the EPH sample concentrations against the applicable EPH Soil Remediation Criteria (SRC) and the applicable EPH product limit. **If the Department has established an EPH soil remediation standard in N.J.A.C. 7:26D, then the soil remediation standard (SRS) supersedes the SRC in this technical guidance.**

For Category 1, if all EPH soil concentrations are ≤1,000 mg/kg, then remediation is complete and an unrestricted use Remedial Action Outcome (RAO) can be issued for EPH in soil. For EPH soil concentrations >1,000 mg/kg for Category 1 EPH at sites with residential land use, the EPH SRC of 5,100 mg/kg applies. For Category 1 EPH at sites with non-residential land use, the EPH SRC of 54,000 mg/kg is superseded by the EPH default product limit of 8,000 mg/kg, or if calculated the lower of an AOC-specific alternative product limit or 30,000 mg/kg EPH ceiling limit.

Because the composition of Category 2 EPH varies by petroleum product, the Department applies the approach used for Category 1, but the health-based criterion is determined on a sample-specific basis. For Category 2 EPH, calculate sample-specific EPH SRC using the Department provided on-line EPH SRC Calculator found at: https://www.nj.gov/dep/srp/guidance/srra/evaluation_eph_soil_cat2_health_based_calculator.xlsm. For residential use, calculate the applicable residential SRC for each sample from the AOC. For non-residential use, calculate both the residential and non-residential EPH SRC for each sample from the AOC to determine the sample concentrations to be included in the institutional control and to establish those areas requiring an engineering control for the EPH remedial action.

The Technical Rules require the horizontal and vertical delineation of free product and residual product pursuant to N.J.A.C. 7:26E-4.2(a)4, and the treatment or removal of free product and residual product to the extent practicable pursuant to N.J.A.C. 7:26E-5.1(e). The Department previously selected EPH default product limits of 8,000 mg/kg for Category 1 EPH and 17,000 mg/kg for Category 2 EPH (see Appendix 3.1). With this technical guidance, the default product limit of 17,000 mg/kg for Category 2 EPH is no longer universally assigned. Instead, either 8,000 mg/kg or 17,000 mg/kg EPH is the applicable EPH default product limit based on the specific petroleum product (see Appendix 1). If the default product limit is exceeded, this guidance provides an option for determining an AOC-specific EPH alternative product limit as described in Appendix 2. Collection of soil samples for grain size distribution analysis is required if the investigator seeks to develop an AOC-specific alternative product limit.

4.2.1 Exceedance of the EPH Default Product Limits

Pursuant to N.J.A.C. 7:26E-5.1(e) the person responsible for conducting the remediation shall treat or remove free product and residual product to the extent practicable. Consequently, when the concentration of EPH exceeds the default product limits, an AOC specific alternative product limit, or the EPH ceiling limit, compliance averaging is not an acceptable alternative for remediation of EPH product. Where EPH product exceeds the applicable EPH default product limit and an EPH alternative product limit is calculated, EPH product shall be remediated to the lower of the EPH alternative product limit or the ceiling limit.

A Remedial Action Permit for soil that includes both institutional controls and engineering controls is required for a site where the EPH concentration exceeds the default product limits, an AOC specific alternative product limit or the EPH ceiling limit, as applicable, and it is impracticable to remove or treat the EPH product.

For situations where there is evidence of EPH free product (e.g., LNAPL on ground water) and EPH soil concentrations are less than the EPH product limits, additional investigation or remedial action of soil may be needed to address a source of EPH product that may not have been previously identified.

4.2.2 **Technical Impracticability – large or complex non-residential sites**

The Department recognizes that compliance with the EPH product limit may be impracticable for meeting the requirement at N.J.A.C. 7:26E-5.1(e) to treat or remove free product and residual product at large or complex non-residential sites. For purposes of this technical guidance, large sites would consist of refineries and petroleum storage facilities that extend over multiple acres with multiple AOCs. An example of a complex site is a MGP site. Typically, these large and complex sites also involve:

- Impacts to ground water or surface water;
- a potential for vapor intrusion or ecological risk;
- off-site migration of EPH product; or
- an active facility with continuing operations.

For these types of sites, the investigator is advised to seek consultation with the Department before proceeding with a determination of impracticability or making a final decision on a remedial action. The typical variation for these types of sites may involve long-term remedial actions that may delay full compliance with the requirement to treat or remove free product and residual product, or it may involve remedial actions that include some form of containment and active remedial actions for soil and other media. All variances from the Technical Rules shall be documented in the applicable remedial phase report pursuant to N.J.A.C. 7:26E-1.7. All deviations from this technical guidance shall be documented in the applicable remedial phase report pursuant to N.J.A.C. 7:26E-1.5(b) and Administrative Requirements for the Remediation of Contaminated Sites (ARRCS) Rules pursuant to N.J.A.C 7:26C-1.2(a)3.

There are circumstances where it may be technically impracticable to completely remediate free product and residual product to the applicable EPH product limit in soil. Common impediments are physical obstacles that inhibit or preclude accessibility to the product. It is contingent upon the investigator to evaluate both removal and treatment options before acceding it is technically impracticable to remediate free product and residual product, and to include a description of the evaluations used to conclude technical impracticability in the applicable remedial phase report. Consider using the Department's *In Situ Remediation: Design Considerations and Performance Monitoring Technical Guidance Document* (https://www.nj.gov/dep/srp/guidance/#in_situ) for evaluating possible removal and treatment options. The report must also include a detailed description of the means used to contain the free product and residual product.

Pursuant to N.J.A.C. 7:26E-5.3, any remediation initiated on or after May 7, 2010, where either new construction or a change in use creates a residence, a school, or a child care center, the person responsible for conducting the remediation shall submit a remedial action workplan pursuant to N.J.A.C. 7:26E-5.5 and obtain the Department's written approval before implementing a remedial action at any area of concern when treatment or removal of free product or residual product is not practicable.

4.3 Address Additional Analytical Requirements

Address all additional analysis requirements listed in Table 2-1 ("Analytical Requirements for Petroleum Storage and Discharge Areas") at N.J.A.C. 7:26E-2.1(d). For Category 1 petroleum products, samples are required to be analyzed for 2-methylnaphthalene and naphthalene when the EPH soil concentrations at the AOC exceed 1,000 mg/kg, and additional remediation is not to be conducted. For Category 2 petroleum products, analytical requirements listed in Table 2-1 at N.J.A.C. 7:26E-2.1(d) apply for the selection of the additional analyses.

Where both Category 1 and Category 2 petroleum products are being investigated at an area of concern (AOC), conduct the applicable additional analyses pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d) for each petroleum product. For those situations where the petroleum product type is unknown, or for Category 2 petroleum products that have been used and are not virgin products, sampling and analytical parameters for waste oil/unknown petroleum hydrocarbons apply as listed in Table 2-1 at N.J.A.C. 7:26E-2.1(d).

A sufficient sample volume should be collected from each sample location for both initial EPH analysis and the additional analyses specified in Table 2-1 at N.J.A.C. 7:26E-2.1(d). The investigator should also collect sufficient soil volume for performance of Synthetic Precipitation Leaching Procedure (SPLP) analysis to evaluate the potential of an impact to groundwater (IGW) if the results of the additional parameters are detected above the default IGW soil screening levels. The investigator shall comply with the soil sample handling and holding time restrictions for EPH analysis stipulated by the analytical method, the additional analyses specified in Table 2-1 at N.J.A.C. 7:26E-2.1(d), and SPLP available at: (https://www.nj.gov/dep/srp/guidance/rs/).

4.4 Assess Ecological Risk

For all EPH concentrations exceeding 1,700 mg/kg, the investigator also needs to determine whether a remedial action is necessary for EPH to address ecological risk pursuant to N.J.A.C. 7:26E-1.16 and -4.8 and the Department's *Ecological Evaluation Technical Guidance* (https://www.nj.gov/dep/srp/guidance/#eco_eval). Note that an ecological evaluation is not required at areas of concern that consist of an underground storage tank storing heating oil for on-site consumption in a one to four family residential building (Brownfield and Contaminated Site Remediation Act at N.J.S.A. 58:10B-12a).

5.0 EPH EVALUATION STEPS

Step by step guidance for the completion of the tasks just described is provided below. A tabular summary of the technical guidance is provided as **Appendix 1**. All steps in the EPH evaluation must be followed and all site conditions documented in the applicable remedial phase report. The licensed site remediation professional is reminded that pursuant to the requirements of the Administrative Requirements for the Remediation of Contaminated Sites (N.J.A.C. 7:26C-1.2), departures from this technical guidance require written rationale to be provided if the LSRP determines the guidance is inappropriate or unnecessary to meet the remediation requirements of all applicable New Jersey statutes and New Jersey rules.

5.1 CATEGORY 1 - Discharges of only No. 2 heating oil or diesel fuel: Residential Land Use

The steps below presume a residential land use is the endpoint of the remedial action at the area of concern (AOC). Complete all steps below with appropriate documentation in the applicable remedial phase report. Reference to sample contaminant concentrations includes site investigation, remedial investigation, and remedial action confirmation samples.

When all EPH sample concentrations are ≤1,000 mg/kg at the AOC, then remediation is complete and an unrestricted use RAO for EPH can be issued.

For all EPH sample concentrations >1,000 mg/kg, complete each of the Steps below to determine whether remediation of EPH or other contaminants is necessary.

Step 1. Evaluate EPH against RSRC and product limits/ceiling limit
Evaluate all EPH sample concentrations against the 5,100 mg/kg residential soil remediation criterion (RSRC) and the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit as described in Appendix 2), **then go to Step 2**.

A. For all EPH sample concentrations ≤5,100 mg/kg, remediation is complete for the EPH RSRC and the EPH default product limit of 8,000 mg/kg. **Go to Step 2.**

B. For all EPH sample concentrations greater than the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit as described in Appendix 2), either:

i. Excavate or treat EPH product-contaminated soil and collect remedial action confirmation samples, then **return to Step 1**; or

ii. Contain all soil with EPH concentrations greater than the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit) may be considered when treatment or removal is not practicable pursuant to N.J.A.C. 7:26E-5.1(e).

This will require implementation of institutional and engineering controls. Include appropriate documentation in the remedial action workplan (RAW) and remedial action report (RAR) to support why treatment or removal is not practicable and how containment will be implemented and monitored. This may result in Department review of the RAW or RAR, so possible containment of EPH product should be discussed with the Department prior to implementation. A RAW shall be submitted for Department written approval pursuant to N.J.A.C. 7:26E-5.3(d) for any AOC when new construction of, or a change in use to, a residence, a school, or child care center will occur. If contaminants other than EPH will be subject to an institutional and engineering control, determine whether that engineering control is also feasible as the engineering control to contain EPH product. **Go to Step 1.C.**

C. For all EPH sample concentrations >5,100 mg/kg and <8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit as described in Appendix 2), either:

i. Excavate or treat contaminated soil and collect remedial action confirmation samples, then **return to Step 1**, or

ii. Perform compliance averaging using the Department's *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria* (http://www.nj.gov/dep/srp/guidance/srra/attainment_compliance.pdf)

a. If compliance requirements are satisfied, then remediation is complete for the EPH soil remediation criterion and the EPH product limit. **Go to Step 2**.

b. If compliance requirements are not satisfied, then **repeat Step 1.C.i, or**

iii. Consider implementation of institutional and engineering controls, if feasible after completion of the remaining steps in this technical guidance. Establishing an institutional and engineering control will restrict the future use of the property. **Go to Step 2**.

Step 2. Analyze samples > 1,000 mg/kg EPH for contingency analyses

For all EPH sample concentrations >1,000 mg/kg, collect samples, if not already collected, for additional analyses of both 2-methylnaphthalene and naphthalene pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d). Determine the number of samples requiring additional analysis using the table below, then **go to Step 3**.

No. of Samples with EPH >1,000 mg/kg	No. of Samples for Additional Analyses
1-4	1
5-8	2
9-12	3
13 or more	1 additional sample for each additional set of 1 to 4 samples

Note: Pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d) ("Analytical Requirements for Petroleum Storage and Discharge Areas"), additional sample analysis shall be conducted on those samples with the highest EPH concentration(s). The investigator shall be aware of the soil sample handling and holding time restrictions for EPH and all additional analyses when evaluating the initial EPH sample concentrations and should ensure sufficient sample volume is collected for both EPH and additional analyses.

Step 3. Evaluate the sample concentrations of the contingency analyses

A. If all sample concentrations do not exceed the impact to ground water (IGW) soil screening level of 8 mg/kg for 2-methylnaphthalene and do not exceed the residential direct contact soil remediation standard of 6 mg/kg for naphthalene, then remediation is complete for 2-methylnaphthalene and naphthalene. **Go to Step 4.**

B. If any sample concentration is >8 mg/kg for 2-methylnaphthalene or >6 mg/kg for naphthalene, then

i. Excavate or treat soil and collect remedial action confirmation samples, **then return to Step 3**, or

ii. For all samples where the concentration of 2-methylnaphthalene is >8 mg/kg or for all samples where the concentration of naphthalene is >6 mg/kg, using available guidance complete the remedial investigation or remedial action, as applicable, for these exceedances of the soil remediation standards (SRS). **Go to Step 4.**

Note: The following option for 2-methylnaphthalene concentrations greater than the IGW soil screening level departs from the protocol found in technical guidance *Development Of Site-Specific Impact To Ground Water Soil Remediation Standards Using The Synthetic Precipitation Leaching Procedure* (http://www.nj.gov/dep/srp/guidance/rs/splp_guidance.pdf). This option is applicable only if one or two of the contingency samples analyzed for 2-

methylnaphthalene is >8 mg/kg, and is not applicable where three or more contingency samples analyzed for 2-methylnaphthalene is >8 mg/kg.

Consider conducting SPLP analysis on the one or two samples. Compare the sample leachate concentrations to the 600 ug/L leachate concentration for 2-methylnaphthalene.

a. If all sample leachate concentrations are ≤600 ug/L, remediation is complete for 2-methylnaphthalene. **Go to Step 4**.

b. If one or both sample leachate concentrations is >600 ug/L, remediation for 2-methylnaphthalene is not complete. **Return to Step 3.B.**

Step 4. Evaluate EPH for ecological concern

Note: An ecological evaluation is not required at areas of concern that consist of an underground storage tank storing heating oil for on-site consumption in a one to four family residential building (Brownfield and Contaminated Site Remediation Act at N.J.S.A. 58:10B-12a). **Otherwise, go to Step 4.A.**

A. If all EPH sample concentrations are less than or equal to the ecological soil screening level of 1,700 mg/kg, then the remediation is complete relative to addressing ecological risk for EPH. For all EPH sample concentrations greater than the ecological soil screening level of 1,700 mg/kg, **go to Step 4.B**.

B. For all EPH sample concentrations >1,700 mg/kg, where EPH is present in or may migrate to an environmentally sensitive natural resource (ESNR), complete an ecological evaluation pursuant to N.J.A.C. 7:26E-1.16 and 4.8 and the Department's *Ecological Evaluation Technical Guidance* (http://www.nj.gov/dep/srp/guidance/srra/ecological_evaluation.pdf). In lieu of an ecological evaluation for a terrestrial soil ESNR, excavate or treat soil until EPH is less than or equal to 1,700 mg/kg.

i. If a remedial action for EPH to address ecological risk is not necessary pursuant to N.J.A.C. 7:26E-4.8 and the Department's *Ecological Evaluation Technical Guidance*, then the remediation to address ecological risk for EPH is complete.

ii. If a remedial action to address ecological risk is required pursuant to N.J.A.C. 7:26E-4.8 and the Department's *Ecological Evaluation Technical Guidance*, then perform a remedial action for EPH to the site-specific ecological risk-based remediation goal for the applicable media in an ESNR. However, EPH cannot exceed 4,000 mg/kg in an ESNR for terrestrial soil (see Section 6.4.5 in the *Ecological Evaluation Technical Guidance*).

5.2 CATEGORY 1 - Discharges of only Number 2 (No. 2) heating oil or diesel fuel: Non-Residential Land Use

The steps below presume a non-residential land use is the endpoint of the remedial action at the area of concern (AOC). **If an unrestricted use is desired, use the Category 1 – residential land use section of this technical guidance.** Complete all steps below with appropriate documentation in the applicable remedial phase report. Reference to sample contaminant concentrations includes site investigation, remedial investigation, and remedial action confirmation samples.

When all EPH sample concentrations are ≤1,000 mg/kg at the AOC, then remediation is complete and an unrestricted use RAO for EPH can be issued.

For all EPH sample concentrations >1,000 mg/kg, complete each of the Steps below to determine whether remediation of EPH or other contaminants is necessary.

Step 1. Evaluate EPH against NRSRC and product limits/ceiling limit

Evaluate all EPH sample concentrations against the 54,000 mg/kg non-residential soil remediation criterion (NRSRC) and the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit as described in Appendix 2).

A. If all EPH sample concentrations are less than or equal to the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit), then remediation is complete for the EPH NRSRC and the EPH product limit. However, all EPH sample concentrations greater than the 5,100 mg/kg residential soil remediation criterion (RSRC) shall be included in an institutional control for the AOC. In addition, an engineering control may be needed to prevent migration from the AOC to other media or prevent on-site exposure to surface soil above the applicable SRC. **Go to Step 2.**

B. Evaluate all EPH sample concentrations greater than the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit), as follows:

i. Excavate or treat EPH product-contaminated soil and collect remedial action confirmation samples and **return to Step 1.A.**

ii. Containment of a horizontally and vertically delineated volume of soil with EPH concentrations greater than the EPH default product limit of 8,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit) may be considered when treatment or removal is not practicable pursuant to N.J.A.C. 7:26E-5.1(e). This will require implementation of institutional and engineering controls. Include appropriate documentation in the remedial action workplan (RAW) and

remedial action report (RAR) to support why treatment or removal is not practicable and how containment will be implemented and monitored. This may result in Department review of the RAW or RAR, so possible containment of EPH product should be discussed with the Department prior to implementation. A RAW shall be submitted for Department written approval pursuant to N.J.A.C. 7:26E-5.3(d) for any AOC when new construction of, or a change in use to, a residence, a school, or child care center will occur. If contaminants other than EPH will be subject to an institutional and engineering control, determine whether that engineering control is also feasible as the engineering control to contain EPH product. Finally, all EPH sample concentrations greater than the 5,100 mg/kg residential soil remediation criterion (RSRC) and less than the EPH product limit shall be included in the institutional control. **Go to Step 2.**

Step 2. Analyze samples > 1,000 mg/kg EPH for contingency analyses

For all EPH sample concentrations >1,000 mg/kg, collect samples, if not already collected, for additional analysis of both 2-methylnaphthalene and naphthalene pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d). Determine the number of samples requiring additional analysis using the table below, then **go to Step 3**.

No. of Samples with EPH >1,000 mg/kg	No. of Samples for Additional Analyses
1-4	1
5-8	2
9-12	3
13 or more	1 additional sample for each additional set of 1 to 4 samples

Note: Pursuant to Table 2-1 at N.J.A.C. 7:26E-2.1(d) ("Analytical Requirements for Petroleum Storage and Discharge Areas"), additional sample analysis shall be conducted on those samples with the highest EPH concentration(s). The investigator shall be aware of the soil sample handling and holding time restrictions for EPH and all additional analyses when evaluating the initial EPH sample concentrations and should ensure sufficient sample volume is collected for both EPH and additional analyses.

Step 3. Evaluate the sample concentrations of the contingency analyses

A. If all sample concentrations do not exceed the impact to ground water (IGW) soil screening level of 8 mg/kg for 2-methylnaphthalene and do not exceed the non-residential direct contact soil remediation standard of 17 mg/kg for

naphthalene, then remediation is complete for 2-methylnaphthalene and naphthalene. **Go to Step 4.**

B. If any sample concentration is >8 mg/kg for 2-methylnaphthalene or >17 mg/kg for naphthalene, then

i. Excavate or treat soil and collect remedial action confirmation samples, **then return to Step 3**, or

ii. For all samples where the concentration of 2-methylnaphthalene is >8 mg/kg or for all samples where the concentration of naphthalene is >17 mg/kg, using available guidance complete the remedial investigation or remedial action, as applicable, for these exceedances of the soil remediation standards (SRS). **Go to Step 4.**

Note: The following option for 2-methylnaphthalene concentrations greater than the IGW soil screening level departs from the protocol found in technical guidance *Development Of Site-Specific Impact To Ground Water Soil Remediation Standards Using The Synthetic Precipitation Leaching Procedure* (http://www.nj.gov/dep/srp/guidance/rs/splp_guidance.pdf). This option is applicable only if one or two of the contingency samples analyzed for 2-methylnaphthalene is >8 mg/kg, and is not applicable where three or more contingency samples analyzed for 2-methylnaphthalene is >8 mg/kg.

Consider conducting SPLP analysis on the one or two samples. Compare the sample leachate concentrations to the 600 ug/L leachate concentration for 2-methylnaphthalene.

a. If all sample leachate concentrations are ≤600 ug/L, remediation is complete for 2-methylnaphthalene. **Go to Step 4**.

b. If one or both sample leachate concentrations is >600 ug/L, remediation for 2-methylnaphthalene is not complete. **Return to Step 3.B.**

Step 4. Evaluate EPH for ecological concern

Note: An ecological evaluation is not required at areas of concern that consist of an underground storage tank storing heating oil for on-site consumption in a one to four family residential building (Brownfield and Contaminated Site Remediation Act at N.J.S.A. 58:10B-12a). **Otherwise, go to Step 4.A.**

A. If all EPH sample concentrations are less than or equal to the ecological soil screening level of 1,700 mg/kg, then the remediation is complete to address ecological risk for EPH. For all EPH sample concentrations greater than the ecological soil screening level of 1,700 mg/kg**, go to Step 4.B.**

B. For all EPH sample concentrations >1,700 mg/kg, where EPH is present in or may migrate to an environmentally sensitive natural resource (ESNR), complete an ecological evaluation pursuant to N.J.A.C. 7:26E-1.16 and 4.8 and the Department's *Ecological Evaluation Technical Guidance* (http://www.nj.gov/dep/srp/guidance/srra/ecological_evaluation.pdf). In lieu of an ecological evaluation for a terrestrial soil ESNR, excavate or treat soil until EPH is less than or equal to 1,700 mg/kg.

i. If a remedial action for EPH to address ecological risk is not necessary pursuant to N.J.A.C. 7:26E-4.8 and the Department's *Ecological Evaluation Technical Guidance*, then the remediation to address ecological risk for EPH is complete.

ii. If a remedial action to address ecological risk is required pursuant to N.J.A.C. 7:26E-4.8 and the Department's *Ecological Evaluation Technical Guidance*, then perform a remedial action for EPH to the site-specific ecological risk-based remediation goal for the applicable media in an ESNR. However, EPH cannot exceed 4,000 mg/kg in an ESNR for terrestrial soil (see Section 6.4.5 in the *Ecological Evaluation Technical Guidance*).

5.3 CATEGORY 2 – Discharges of petroleum products other than No. 2 heating oil or diesel fuel: Both Residential and Non-Residential Land Uses

CATEGORY 2 petroleum products include: Numbers 4 and 6 heating oil, hydraulic oil, cutting oil, lubricating oil, crude oil, waste oil, unknown petroleum hydrocarbons, waste vehicular crankcase oil, mineral oil, dielectric fluid, dielectric mineral oil, or waste mineral oil, or EPH-type discharges associated with manufactured gas plant (MGP) sites.

The steps below address unrestricted use, limited restricted use, and restricted use remedial actions. Limited restricted use will require an institutional control (i.e., deed notice), but usually not an engineering control. Restricted use will require both an institutional control and an engineering control. Because a sample-specific soil remediation criterion (SRC) for EPH is generated for each sample, none of the compliance averaging options described in the Department's *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria* can be used for Category 2 EPH. Determine the applicable EPH default product limit of either 8,000 mg/kg or 17,000 mg/kg based on the specific petroleum product or products stored or discharged. Complete all steps below with appropriate documentation in the applicable remedial phase report. Reference to sample contaminant concentrations includes site investigation, remedial investigation, and remedial action confirmation samples.

Step 1. Determine sample-specific EPH soil remediation criterion

For each sample, determine the sample-specific soil remediation criterion (SRC) for EPH.

A. Determine whether each sample is to be analyzed for EPH using the non-fractionation or fractionation option in the NJDEP EPH Method (N.J.A.C. 7:26E-2.1(a)6).

i. If there is reason to believe that the EPH concentration in a sample is ≤2,300 mg/kg, then the non-fractionation option of the NJDEP EPH Method may be used. **It is important to ensure sufficient sample volume is collected in case the sample requires fractionation when the non-fractionated EPH concentration is >2,300 mg/kg.**

ii. If there is reason to believe that the EPH concentration in a sample is >2,300 mg/kg, or if the non-fractionated EPH concentration for a sample is >2,300 mg/kg, then analyze the sample using the fractionation option of the NJDEP EPH Method.

B. For each EPH sample concentration, determine whether the sample-specific health-based soil remediation criterion (SRC) shall be calculated using the Department's on-line EPH SRC Calculator.

i. For each non-fractionated or fractionated EPH sample with a concentration ≤2,300 mg/kg, **go to Step 5**.

ii. For each fractionated EPH sample with a concentration >2,300 mg/kg, use the Department's on-line EPH SRC Calculator to calculate the sample-specific EPH SRC for both the residential and non-residential exposure pathways. **Go to Step 2**.

Step 2. Evaluate fractionated EPH against SRC and product limits/ceiling limit

Evaluate each fractionated EPH sample concentration >2,300 mg/kg against the sample-specific EPH SRC for the applicable residential or non-residential land use and the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit as described in Appendix 2).

A. For all EPH sample concentrations less than or equal to the calculated residential soil remediation criteria (RSRC) and are less than or equal to the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg, **go to Step 5.**

B. For all samples where the EPH sample concentrations are greater than the calculated RSRC and are less than or equal to the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg, **complete Steps 4 and 5**.

C. For all samples where the EPH sample concentrations are greater than the calculated RSRC and are also greater than the applicable EPH default product

limit of 8,000 mg/kg or 17,000 mg/kg (or AOC-specific EPH alternative product limit or ceiling limit), **complete Steps 3, 4, and 5**.

D. For all samples where the EPH sample concentrations are less than or equal to the calculated RSRC and are greater than the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg (or AOC-specific EPH alternative product Limit or ceiling limit), **complete Steps 3 and 5**.

Step 3. EPH concentration greater than the applicable default product limit

For all samples with EPH concentrations greater than the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit):

A. Excavate or treat EPH product-contaminated soil and collect remedial action confirmation samples, **then return to Step 2.**

B. Containment of a horizontally and vertically delineated volume of soil with EPH concentrations greater than the applicable EPH default product limit of 8,000 mg/kg or 17,000 mg/kg (or the lower of the AOC-specific EPH alternative product limit or ceiling limit) may be considered when treatment or removal is not practicable pursuant to N.J.A.C. 7:26E-5.1(e). This will require implementation of institutional and engineering controls. Include appropriate documentation in the remedial action workplan (RAW) and remedial action report (RAR) to support why treatment or removal is not practicable and how containment will be implemented and monitored. This may result in Department review of the RAW or RAR, so possible containment of EPH product should be discussed with the Department prior to implementation. A RAW shall be submitted for Department written approval pursuant to N.J.A.C. 7:26E-5.3(d) for any AOC when new construction of, or a change in use to, a residence, a school, or child care center will occur. If contaminants other than EPH will be subject to an institutional and engineering control, determine whether that engineering control is also feasible as the engineering control to contain EPH product.

Step 4. EPH concentration greater than its calculated SRC

For each sample with an EPH concentration greater than its calculated SRC:

A. Excavate or treat soil and collect remedial action confirmation samples based on the calculated sample-specific SRC for the applicable residential or non-residential AOC land use and selected unrestricted, limited restricted, or restricted use remedial action, **then return to Step 2.**

B. Implement either institutional or institutional and engineering controls as follows:

i. For residential AOC land use, for all EPH sample concentrations greater than their calculated RSRC, implement an institutional control and appropriate engineering control.

ii. For non-residential AOC land use:

a. For all EPH sample concentrations greater than their calculated RSRC, but less than or equal to their calculated non-residential SRC (NRSRC), implement an institutional control.

b. For all EPH sample concentrations greater than their calculated NRSRC, implement institutional and engineering controls.

Step 5. Determine additional analytical requirements

A. Perform all additional analyses that apply based upon the petroleum product(s) discharged, as listed in Table 2-1 at N.J.A.C. 7:26E-2.1(d).

B. Evaluate the additional analytical sample concentrations as follows:

i. For all sample concentrations that do not exceed the applicable soil remediation standards (N.J.A.C. 7:26D) and the default IGW soil screening levels (or AOC-specific IGW soil remediation standards), **go to Step 6**.

ii For all sample concentrations that exceed the applicable soil remediation standards (N.J.A.C. 7:26D) or the default IGW soil screening levels (or AOC-specific IGW soil remediation standards), complete the remedial investigation or remedial action, as applicable. **Go to Step 6.**

Step 6. Evaluate EPH for ecological concern

Note: An ecological evaluation is not required at areas of concern that consist of an underground storage tank storing heating oil for on-site consumption in a one to four family residential building (Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-12a). **Otherwise, go to Step 6.A.**

A. If all EPH sample concentrations are less than the ecological soil screening level of 1,700 mg/kg, then the remediation is complete to address ecological risk for EPH. For all EPH sample concentrations greater than the ecological soil screening level of 1,700 mg/kg, **go to Step 6.B.**

B. For all EPH sample concentrations >1,700 mg/kg, where EPH is present in or may migrate to an environmentally sensitive natural resource (ESNR), complete an ecological evaluation pursuant to N.J.A.C. 7:26E-1.16 and 4.8 and the Department's *Ecological Evaluation Technical Guidance* (http://www.nj.gov/dep/srp/guidance/srra/ecological_evaluation.pdf). In lieu

of an ecological evaluation for a terrestrial soil ESNR, excavate or treat soil until EPH is less than or equal to 1,700 mg/kg.

i. If a remedial action for EPH to address ecological risk is not necessary pursuant to N.J.A.C. 7:26E-4.8 and the Department's *Ecological Evaluation Technical Guidance*, then the remediation to address ecological risk for EPH is complete.

ii. If a remedial action to address ecological risk is required pursuant to N.J.A.C. 7:26E-4.8 and the Department's Ecological Evaluation Technical Guidance, then perform a remedial action for EPH to the site-specific ecological risk-based remediation goal for the applicable media in an ESNR. However, EPH cannot exceed 4,000 mg/kg in an ESNR for terrestrial soil (see Section 6.4.5 in the Ecological Evaluation Technical Guidance).

6.0 GLOSSARY

Area of concern (AOC) – defined in the Technical Requirements For Site Remediation, N.J.A.C. 7:26E-1.8.

Category 1 EPH – consists of discharges of only Number 2 (No. 2) fuel oil and/or diesel fuel.

Category 2 EPH – consists of discharges of petroleum hydrocarbon mixtures other than No. 2 fuel oil and/or diesel fuel (i.e., Number 4 fuel oil, Number 6 fuel oil, hydraulic oils, cutting oils, crude oil, lubricating oil, waste oil, waste vehicular crankcase oil, and waste mineral oil.

Environmentally sensitive natural resource – an area defined at N.J.A.C. 7:1E-1.8(a), or an area or resource that is protected or managed pursuant to the Pinelands Protection Act, N.J.S.A. 13:18A-1 et seq., and the Pinelands Comprehensive Management Plan, N.J.A.C. 7:50.

EPH alternative product limit concentration in soil – for a specified petroleum product for an AOC, it is the lower concentration of either the median of the calculated EPH product limit concentrations for an inputted set of grain size samples or the EPH ceiling limit.

EPH ceiling limit – the maximum concentration of EPH allowed to remain in soil on a sample-specific basis which is 30,000 mg/kg as established in this guidance.

EPH default product limits – the 8,000 mg EPH/kg soil and 17,000 mg EPH/kg soil generic concentrations established as upper limits in the NJDEP's "Default EPH Product Limits for No. 2 Fuel Oil, Diesel, and Heavier TPH Products" (Sanders 2009 in Appendix 3.1) to prevent the occurrence of mobile free product.

Extractable Petroleum Hydrocarbons (EPH) – For the purposes of this technical guidance, the results in milligrams of EPH per kilogram of soil or sediment as determined and reported using the NJDEP analytical method "*Analysis of Extractable Petroleum Hydrocarbon Compounds (EPH) in Aqueous and Soil/Sediment/Sludge Matrices*" (NJDEP EPH Method 10/08, Revision 3 August 2010) https://nj.gov/dep/srp/guidance/srra/eph_method.pdf.

Free product – defined in the Technical Requirements For Site Remediation, N.J.A.C. 7:26E-1.8.

Heating oil tank system – defined in the Heating Oil Tank System Remediation Rules, N.J.A.C. 7:26F-1.5.

Petroleum product – For the purposes of this technical guidance, the petroleum products listed in TABLE 2-1 Analytical Requirements For Petroleum Storage And Discharge Areas of N.J.A.C. 7:26E-2.1(d) that require analysis for EPH in Soil/Sediment.

Residual product – defined in the Technical Requirements For Site Remediation, N.J.A.C. 7:26E-1.8.

Technical impracticability – a condition where remediation of soil is not feasible from an engineering perspective because of the extent or type of physical impediment(s) that limit the ability to complete soil remediation to the applicable standards or criteria. Cost is only considered as subordinate to that of ensuring protection of public health, safety and the environment.

7.0 ACRONYMS

AOC	area of concern
CSM	conceptual site model
EPH	extractable petroleum hydrocarbons
ESNR	environmentally sensitive natural resource
HOTS	heating oil tank system
IGW	impact to ground water
LNAPL	light non-aqueous phase liquid
LSRP	licensed site remediation professional
mg/kg	milligrams per kilogram
MGP	manufactured gas plant
MLE	multiple lines of evidence
NAPL	non-aqueous phase liquid
NJDEP	New Jersey Dept. of Environmental Protection
NRSRC	non-residential soil remediation criterion
RAO	remedial action outcome
RAR	remedial action report
RAW	remedial action workplan
RSRC	residential soil remediation criterion
SPLP	synthetic precipitation leaching procedure
SRC	soil remediation criteria
SRP	Site Remediation Program
SRS	soil remediation standards
TPH	total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
UST	underground storage tank

8.0 REFERENCES

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APPENDIX 1

Summary Table of EPH Soil Remediation Criteria, Thresholds for Additional Analyses and Evaluations, and EPH Product Limits

EPH Category	**Category 1**		**Category 2**	
AOC Use	**Residential *1**	**Non-residential *1**	**Residential *1**	**Non-residential *1**
EPH Soil Remediation Criteria	5,100 mg/kg	54,000 mg/kg	Sample-specific calculation	Sample-specific calculation
EPH Threshold Concentration for Additional Analyses	>1,000 mg/kg	>1,000 mg/kg	Pursuant to N.J.A.C. 7:26E-2.1, Table 2-1	Pursuant to N.J.A.C. 7:26E-2.1, Table 2-1
Additional Analyses (if required)	2-methylnaphthalene and naphthalene	2-methylnaphthalene and naphthalene	Pursuant to N.J.A.C. 7:26E-2.1, Table 2-1	Pursuant to N.J.A.C. 7:26E-2.1, Table 2-1
EPH Default Product Limit	8,000 mg/kg	8,000 mg/kg	17,000 mg/kg (except for MGP, crude oil, cutting oil, and unknown petroleum products which are 8,000 mg/kg; waste oil is parent product dependent)	17,000 mg/kg (except for MGP, crude oil, cutting oil, and unknown petroleum products which are 8,000 mg/kg; waste oil is parent product dependent)
AOC-specific EPH Alternative Product Limit Concentration for Soil	Lower of: AOC-specific median of Calculated EPH Product Limit Concentration for grain size samples -OR- 30,000 mg/kg ceiling limit	Lower of: AOC-specific median of Calculated EPH Product Limit Concentration for grain size samples -OR- 30,000 mg/kg ceiling limit	Lower of: AOC-specific median of Calculated EPH Product Limit Concentration for grain size samples -OR- 30,000 mg/kg ceiling limit	Lower of: AOC-specific median of Calculated EPH Product Limit Concentration for grain size samples -OR- 30,000 mg/kg ceiling limit
EPH Threshold Concentration for Ecological Evaluation*2	>1,700 mg/kg	>1,700 mg/kg	>1,700 mg/kg	>1,700 mg/kg

*1: For tank systems subject to the Heating Oil Tank System Remediation (HOTSR) Rule (N.J.A.C. 7:26F), refer to the HOTSR Rule for specific requirements.

*2: An ecological evaluation is not required at areas of concern that consist of an underground storage tank storing heating oil for on-site consumption in a one to four family residential building (Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-12a).

APPENDIX 2

EPH Alternative Product Limit Calculation Procedures

2.1 Obtaining Appropriate Grain Size Distribution Data

2.2 Documentation and Information to be Submitted for Calculation of an AOC-specific EPH Alternative Product Limit in Soil

2.3 Derivation of Equation for Calculating an EPH Alternative Product Limit in Soil

2.4 Variables Table and Table of Petroleum Product Viscosity and Density

APPENDIX 2

EPH Alternative Product Limit Calculation Procedures

When to use the EPH Alternative Product Limit Calculator

The Department's selection of and basis for the two EPH default product limits in soil is provided in Appendix 3.1. To summarize, the Department relied on residual concentration calculations published by Brost and DeVaull in 2000. For Category 1 EPH, the Department selected 8,000 mg/kg based on the value listed by Brost and DeVaull for medium sand. For Category 2 EPH, the Department selected 17,000 mg/kg based on the "residual saturation for fuel oils heavier than diesel" assuming all soils are composed of "medium sand". The Department also judged "that the value of 17,000 mg/kg used for heavier fuel oil is also adequately protective for lubricating oils" for a generic New Jersey soil composed of medium sand.

It is recognized that not all soils in New Jersey have textures solely consisting of medium sand. Consequently, the EPH Technical Guidance Committee developed an equation that provides the investigator via a spreadsheet calculator, a method to determine an AOC-specific EPH alternative product limit concentration based on the AOC-specific soil texture and the stored or discharged petroleum product(s).

The derivation of the equation for calculating an EPH alternative product limit in soil is provided in Appendix 2.3. The equation includes several variables which are defined and described in Appendix 2.4. For consistency and protectiveness, the Department has fixed several variables utilizing conservative assumptions for nearly all the variables. The investigator needs only to identify the discharged petroleum product(s) and obtain the "effective diameter" (D_{10}) value from grain size distribution analyses from soil as the same lithology (i.e., same depth interval) as the EPH product zone. Calculating an AOC-specific, EPH alternative product limit concentration is most useful when the soil texture is finer than medium sand as reflected by the D_{10} value. Based on the conceptual site model (CSM) and multiple lines of evidence (MLE), the investigator determines whether the EPH default product limit or the EPH alternative product limit concentration becomes the EPH product limit for the AOC. The decision to calculate an EPH alternative product limit concentration in lieu of using the EPH default product limit resides with the investigator.

Variables used in the equation are defined in Appendix 2.4 including a table of petroleum product-specific density and dynamic viscosity values assigned to the petroleum products for which the EPH Alternative Product Limit Calculator can be used.

The technical guidance addressing the number and locations of soil samples needed to determine the D_{10} value is provided in Appendix 2.1. Refer to Appendix 2.2 for the documentation and information to be included in the applicable remedial phase document when an AOC-specific EPH alternative product limit has been calculated and applied to EPH remediation in soil.

The following steps outline the process to complete the calculation of an AOC-specific EPH alternative product limit:

Step 1. For each AOC, complete horizontal and vertical delineation of EPH in soil to the applicable EPH default product limit concentration for the petroleum product that was stored or discharged. Delineation of EPH must be completed in both the saturated and unsaturated zones without regard to the property boundary pursuant to N.J.A.C. 7:26E-4.2(a)4.

Step 2. Soil samples for grain size analysis may be collected at any time. If the investigator suspects that the petroleum product discharge may exceed the EPH default product limit when conducting remediation, it may be prudent to collect soil samples for grain size analysis early in the investigation. It should be noted that soil samples for grain size analysis should be free of EPH so that the laboratory sieves and hydrometers are not adversely impacted. It is important to discuss this aspect with the laboratory to avoid sample rejection.

Step 3. The soil samples should be sent under proper chain-of-custody procedures to the laboratory. If it is not certain whether there is an exceedance of the EPH default product limit, the grain size samples may be placed on "laboratory hold" until the EPH analyses are completed. The determination of grain size is a physical test, without any holding time restrictions on soil samples.

Step 4. The soil samples for grain size analysis can be analyzed using an appropriate analytical method that accurately characterizes the soil grain sizes including clay, silt, sands and gravel mass fraction. The laboratory report will provide the weight fractions for specific sieve and hydrometer particle sizes. The ultimate goal is to identify the effective diameter D_{10} which represents the equivalent particle size in millimeters where 10% by dry weight passes (i.e., is finer). It is suggested the investigator request the laboratory calculate the D_{10} to decrease the quantity of manual data entry into the EPH Alternative Product Limit Calculator. Alternately, because the laboratory reports the mass fraction of the grain sizes, the EPH Alternative Product Limit Calculator can determine the D_{10} value for each soil sample.

Step 5. After receiving the laboratory report, access the Department's on-line EPH Alternative Product Limit Calculator and follow the instructions to calculate an EPH Alternative Product Limit Concentration for Soil for the AOC.

Step 6. The Calculator automatically determines the "EPH Alternative Product Limit Concentration for Soil in this AOC" by determining the median of the calculated EPH product limit concentrations for the grain size samples that were inputted and comparing the median against the 30,000 mg/kg EPH Ceiling Limit concentration. The more stringent (lesser concentration) between the median value and the ceiling limit is the "EPH Alternative Product Limit Concentration for Soil in this AOC".

If the AOC has more than one lithologic zone with EPH concentrations that exceed the EPH default product limit (i.e., when the petroleum product discharge has migrated to other distinct soil textures) calculate an AOC-specific alternative product limit for each additional product zone. An AOC-specific alternative product limit must be calculated for each distinct soil matrix where an EPH concentration exceeds an EPH default product limit (see Appendix 2.1). If more than one petroleum product is being investigated or was discharged at the AOC, calculate an EPH alternative product limit concentration for soil for each petroleum product.

Appendix 2.1

Obtaining Appropriate Grain Size Distribution Data

The following describes the process for collection of an appropriate number and characteristics of soil samples for grain size distribution analysis for calculation of an AOC-specific EPH alternative product limit concentration. The grain size distribution data generated via sieve and hydrometer analyses are used to derive the effective diameter "D_{10}" input parameter for use in the Department's EPH Alternative Product Limit Concentration Calculator. The calculator employs grain size distribution analyses. A web-link to several test methods is included in Section 8.0 **REFERENCES**.

Selection of appropriate soil samples for grain size distribution analysis should be based on the conceptual site model, characterization of the limits of EPH concentrations in the soils and include consideration of soil lithology for each distinct stratigraphic horizon containing petroleum product in exceedance of the applicable default product limit within the AOC. The guidance was developed with the perspective that the soil to be evaluated for developing an EPH alternative product limit was deposited naturally, and that the horizontal variation in texture across short "AOC-sized" distances is expected to be minimal. Where historic fill material is documented, the investigator must determine if the historic fill material is suitable for calculation of an EPH alternative product limit concentration. Soil samples from historic fill material may not be amenable to the sieve and hydrometer analyses because of inherent contamination; consultation with the laboratory is recommended. Also, non-uniform historic fill material (e.g., construction debris, non-hazardous solid waste, etc.) may not be amenable to developing an EPH alternative product limit. For these situations, use the EPH default product limits. The procedures for collecting soil samples, whether naturally deposited or from suitable historic fill material, are described below.

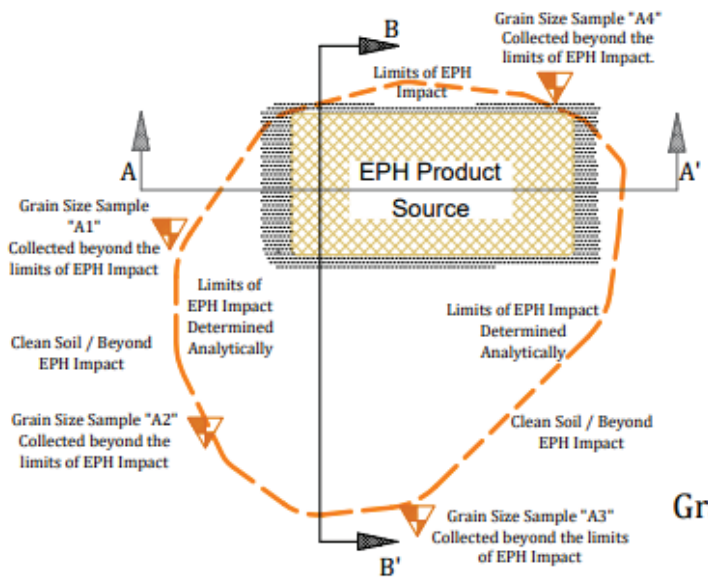
It is recommended that the investigator first delineate the horizontal and vertical extent of the EPH product mass to the applicable EPH product limit concentration pursuant to N.J.A.C. 7:26E-4.2(a)4. However, it may be possible to collect soil samples for grain size distribution analysis concurrent with EPH product delineation. Whichever option is chosen, grain size soil samples should be collected as close as practicable to the EPH product mass to be most representative of the soil lithology retaining EPH concentrations in exceedance of the default product limit. The investigator is cautioned that analytical laboratories may reject samples for grain size analyses which contain EPH. Therefore, the investigator should contact the prospective laboratory to determine the constraints under which the laboratory will analyze petroleum-contaminated samples for grain size distribution.

The Department's Office of Quality Assurance does not offer certification for grain size/particle size analyses.

Collect grain-size soil samples free of EPH from locations that are side-gradient to the mass of soil with EPH exceeding the default product limit. Figure 2.1-1 presents potential grain size sampling locations based on one contiguous lithology across the entire AOC. If petroleum product impacts two or more lithologies in an AOC, the investigator should collect an additional set of three soil samples for each distinct lithology. In general, follow the criteria below for the collection of appropriate soil samples.

- The grain size samples should be biased toward soil sample locations that are physically similar to the lithology of the EPH zone.
- Collect additional grain size soil samples where the EPH product concentrations exceed the default product limit is larger than one-quarter acre (10,890 square feet) based on the delineation of the site.
- If there are multiple AOCs in close proximity (e.g. within one-quarter acre) with exceedences of the EPH default product limit in the same lithologic soil horizon, it may be appropriate to collect grain size distribution soil samples whose results can be applied to more than one AOC.
- If two soil lithologies are encountered and the delineation indicates they are both subject to impact in exceedence of the default product limit, collect a minimum of three grain size samples from each lithology type.
- The investigator should report all the calculated EPH alternative product limit concentrations.
- Utilize the "**EPH Alternative Product Limit Concentration for Soil in this AOC**" from the Calculator spreadsheet.

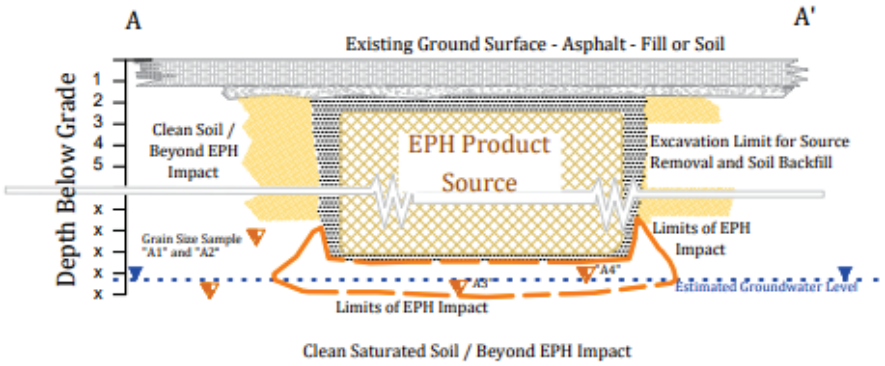
Figure 2.1-1 -Grain Size Sample Locations - 1 Soil Horizon
Obtaining Appropriate Textural Analysis Distribution Data



EPH Grain Size Sample Notes:

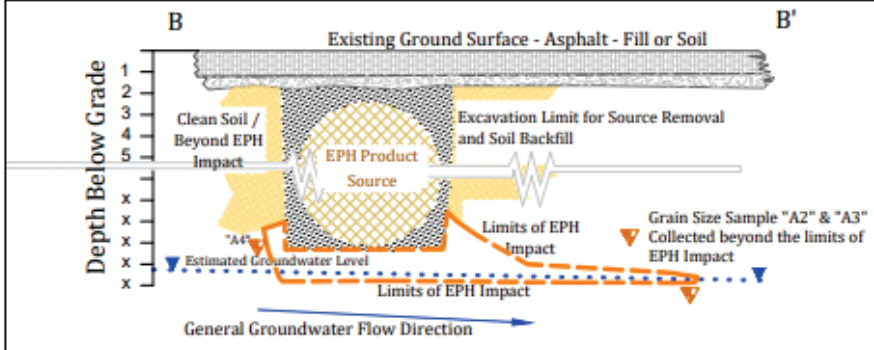
1. Only one (1) petroleum product was discharged at the AOC above the default EPH Product Limit Concentration.
2. The horizontal and vertical extent of EPH above the residential soil criteria has been delineated via analytical testing.
3. The figure presents possible EPH sample locations. The final sample locations must be selected by the site professional.
4. Collection of a minimum of three Textural Samples for each AOC with exceedances of the default EPH Product Limit Concentration.
5. Textural Soil samples should be collected from the soil horizon representative of the NAPL zone, but beyond the limits of the EPH impact.
6. The Investigator should present the textural sample locations on a site plan and cross sections similar to this figure.

Grain Size Sampling Plan (Plan View)
One Soil Horizon
Not to Scale



Note: If horizonal extent of separate phase product zone preferentially extends in specific direction(s), the Investogator should bias textural soil samples in the same direction.

Profile View A to A'
Grain Size Sampling
Not to Scale



LEGEND

- Typical Soil Textural Sample Location. Site Investigator must select the most appropriate location for each AOC and each petroleum product.
- Typical limits of EPH concentrations in soil above the residential soil criteria.
- Typical groundwater elevation demonstrates the Investigator may select to collect textural samples above or below the water level.
- Typical drawing section line, demonstrating the depths of the textural samples should not be directly associated with the original release depth below grade.

Profile View B to B'
Grain Size Sampling
Not to Scale

Appendix 2.2

Documentation and Information to be Submitted for Calculation of an AOC-specific EPH Alternative Product Limit in Soil

The person responsible for conducting the remediation shall submit the required information, documentation, and discussion pursuant to N.J.A.C. 7:26E-4.9 "Remedial investigation report", N.J.A.C. 7:26E-5.5 "Remedial action workplan requirements", and N.J.A.C. 7:26E-5.7 "Remedial action report requirements" for the applicable remedial phase under which an AOC-specific EPH alternative product limit for soil is calculated. The data presentation should conform with N.J.A.C. 7:26E-1.6 "General reporting requirements" and include the following information for each AOC where an EPH alternative product limit has been calculated:

- the petroleum product source material (if known) and applicable EPH default product limit;
- a description of the source and cause of the discharge (if known);
- the EPH concentrations that exceed the EPH default product limit including the soil sample field identification numbers and depth intervals;
- the EPH concentrations that horizontally and vertically delineate the product zone including the soil sample field identification numbers and depth intervals;
- the vertical and horizontal soil lithologic profiles across the EPH product source area including the soil physical descriptions;
- the stratigraphic log for each EPH soil sample that exceeds the EPH default product limit and that horizontally and vertically delineates the product zone;
- the EPH alternative product limit concentration calculated for each AOC which exceeded the EPH default product limit;
- all printouts from the EPH Alternative Product Limit Calculator;
- the complete laboratory data deliverables supplied by the laboratory for all analytical methods used in the grain size distribution analysis(es); and
- if the effective diameter D_{10} is calculated by the laboratory, include the laboratory's method used to calculate D_{10}.

Appendix 2.3

Derivation of Equation for Calculating an Alternative EPH Product Limit in Soil

Introduction

The purpose of this appendix is to define an equation and its terms for use in calculating an EPH alternative product limit concentration "C". As discussed in Appendix 3.1, the Department's EPH default product limits are based on residual saturation concentrations for petroleum products in medium sand (Brost and DeVaull 2000). Where an EPH alternative product limit may be appropriate based on the AOC-specific soil grain size and petroleum product properties, the equation derived in this appendix may be used.

Definition of Immobile NAPL Conditions

The calculation of NAPL concentration in soils at which the NAPL is considered immobile requires baseline assumptions of mobility and site characteristics. This derivation utilizes the following parameters to define the site characteristics which identify the limit of NAPL mobility.

i	– Vertical Groundwater Gradient – dimensionless	1.0 feet/foot
q	- Darcy Flux value – feet/year	0.01 feet/year
S_r	- Residual petroleum hydrocarbon saturation – percent	2%
ρ_s	- Grain density of the soil - grams/cm^3	2.54 gm/cm^3
Temp	– Standard temperature of the NAPL in the soil	15-degrees C

For all the terms presented below, please see Appendix 2.4 for their definitions, purpose, and values as used in the following equations.

Mass Concentration of NAPL in Soil

An EPH alternative product limit concentration can be calculated by defining the mass concentration of non-aqueous phase liquid (NAPL) in a dry soil[1] as given by Equation 1 (Eq. 1) below:

$$C = \frac{M_o}{M_s} = \frac{\text{Mass of NAPL}}{\text{Mass of Dry Soil}} \qquad \text{(Eq. 1)}$$

Consider a soil with the following properties: porosity ϕ, grain density ρ_s, and ratio of NAPL volume per total volume of soil sample θ_o, and oil density ρ_o. The NAPL ratio θ_o cannot be greater than and is usually less than total porosity (ϕ), because the content

[1] It is a standard practice to report the concentration of chemicals in soil on a dry sample basis.

of material filling the pore space between soil grains can never exceed the total pore space by definition. Substituting these terms into Eq. 1, one has the following:

The mass of dry soil is:

$$M_s = (1 - \phi) * \rho_s \qquad \text{(Eq. 2)}$$

The mass of oil is:

$$M_o = \theta_o * \rho_o \qquad \text{(Eq. 3)}$$

Therefore, substituting the terms for the mass of NAPL and the mass of dry soil we can determine the mass concentration of NAPL in dry soil is:

$$C = \frac{M_o}{M_s} = \frac{\theta_o * \rho_o}{(1-\phi) * \rho_s} \qquad \text{(Eq. 4)}$$

Example:

An example calculation is provided to illustrate an equation result for No. 2 heating oil. Consider a soil with porosity ϕ = 0.41 and the grain density ρ_s = 2,540 kg/m^3. Furthermore, assume that the soil has an oil content of 10% (i.e., θ_o = 0.10) and the petroleum product density is ρ_o = 820 kg/m^3 (0.82 g/cm^3). Substituting these values into Eq. 4, one obtains the mass concentration of NAPL in this dry soil of:

$$C = \frac{M_o}{M_s} = \frac{\Theta_o * \rho_o}{(1 - \phi) * \rho_s} = \frac{0.10 * 820}{(1 - 0.41) * 2540} = \frac{82}{1499} \cong 0.055 \ \frac{\text{kg of NAPL}}{\text{kg of dry soil}}$$

$$C = 55.0 \ \frac{\text{gm NAPL}}{\text{kg dry soil}} \cong 55{,}000 \ \frac{\text{mg NAPL}}{\text{kg dry soil}}$$

NAPL Mobility

Eq. 4 calculates the mass concentration of NAPL in a dry soil without consideration of NAPL mobility, which is a function of petroleum product type and additional soil characteristics beyond porosity. To calculate a site-specific EPH alternative product limit, NAPL mobility in soil must be considered. The flow or movement of NAPL, such as a petroleum product, through a porous medium (i.e., soil) can be characterized using the same soil properties and equations that apply to ground water. (Fetter 1994, p. 95).

By definition, the residual saturation of NAPL is the value at which NAPL in soil becomes discontinuous (Bear 1988) and will not migrate due to gravity and therefore is immobile (Brost and DeVaull 2000). The mobility of NAPL in a porous medium can be assessed using Darcy's law:

$$q = K * i \qquad \text{(Eq. 5)}$$

Where q is the Darcy flux (flow rate) and i is the hydraulic gradient (Fetter 1994, Section 4.4). The term K is the hydraulic conductivity given by:

$$K = \frac{\rho g}{\mu} k k_r \qquad \text{(Eq. 6)}$$

Where g is gravity acceleration, ρ and μ are the density and dynamic viscosity of the fluid, respectively, k is the intrinsic permeability of the medium, and k_r is the relative permeability, which depends on the saturation of the medium by the fluid (Boufadel et al. 1998). The values of ρ, μ, and k could be obtained by measurement, whereas k_r would need to be estimated based on a migration velocity within the soil below which the NAPL is considered to be immobile. For example, if the NAPL is migrating at 0.01 foot/year, it is reasonable to consider NAPL immobile for purposes of this guidance.

For a hydraulic gradient of 1.0 (a large hydraulic gradient such as water running downward along a vertical wall), and a Darcy mass flux [q value of 0.01 foot/year], then one may compute K from Eq. 6. The value for q cannot be set at zero, so it has been set by the committee at 0.01 foot/year as defining NAPL as immobile (see Table 2.4-1 of Appendix 2.4). Then, with ρ, μ, and k measured, one can find the value of k_r from Eq. 6. After finding k_r, one would be able to find the NAPL saturation θ, as discussed below.

The relation between k_r and θ can be obtained using the van Genuchten-Mualem model (Mualem 1976, van Genuchten 1980). One solves for the effective saturation S_e, which represents the relative fraction of saturation available for NAPL flow (Boufadel, et al. 1998). Hence,

$$S_e^{(1/2)} \left[1-\left(1-S_e^{n/(n-1)}\right)^{(n-1)/(n)}\right]^2 = k_r \qquad \text{(Eq. 7)}$$

Where "n" (the van Genuchten uniformity coefficient) can be obtained by capillary-retention (or capillary-saturation) experiment using water as a surrogate for NAPL (Boufadel et al. 1998). One then finds S_e, and subsequently, the NAPL saturation ratio S:

$$S = (1-S_r)S_e + S_r \qquad \text{(Eq. 8)}$$

Where S_r (residual saturation of NAPL) could be estimated (along with n) from a capillary-retention experiment with water, but the EPH Technical Guidance Committee has set default values of S_r = 0.02 and n = 4 (see Appendix 2.4 for basis). The amount of NAPL or petroleum hydrocarbon content (volume basis) in the sample is then:

$$\theta_o = S \cdot \phi \qquad \text{(Eq. 9)}$$

As n is set equal to 4 one can use Eq. 7 to find S_e from a given value of k_r. Then, the NAPL saturation ratio S can be found from Eq. 8. Figure 2.3-1 shows a plot of S_e as function of k_r for n = 4. Also shown is the best fit equation using a power law:

$S_e = 1.135 * k_r^{0.31}$ (correlation coefficient R^2=0.9998) (Eq. 10)

Given k_r, it is much easier to use Eq. 10 to obtain S_e than to use the fundamental equation, Eq. 7. The large R^2 associated with Eq. 10 suggests that the difference in S_e obtained from the two equations is negligible.

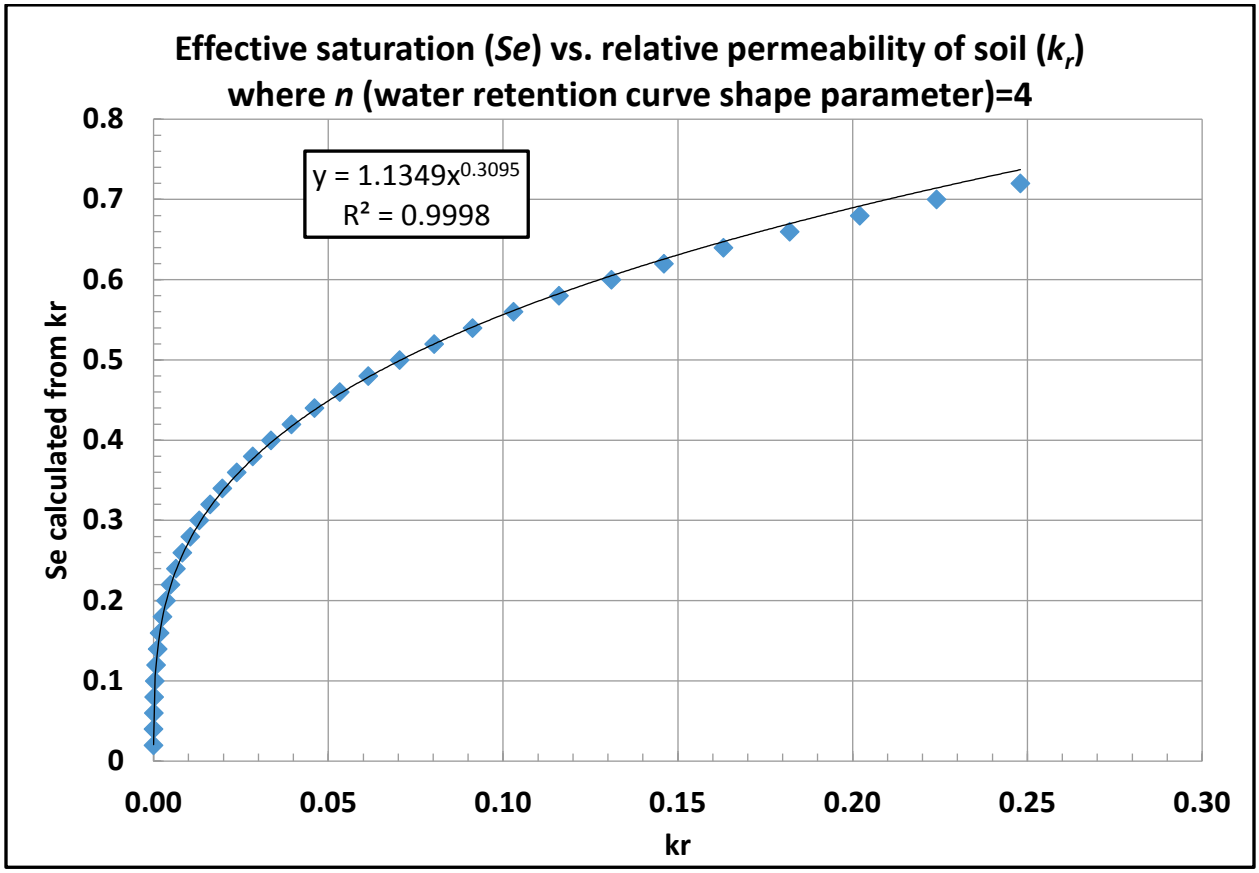


Figure 2.3-1: Variation of effective saturation of water as function of the saturation ratio for n = 4.

Example:

To find the (residual concentration of NAPL or "immobile" NAPL concentration as used at end of the example) – consider a soil with a petroleum product such as #2 heating oil with a dynamic viscosity (μ) of 0.020 poise (i.e., approximately 20 times the dynamic viscosity of water) and a density (ρ_o) of 820 kg/m^3 in a sandy soil with a grain density (ρ_s) of 2,540 kg/m^3, intrinsic permeability (k) =10^{-11} m^2, porosity (ϕ) = 0.41, van Genuchten uniformity coefficient (n) = 4; residual petroleum hydrocarbon ratio (S_r) = 0.02 (i.e., 2% of the porosity, Appendix 2.4). Setting the Darcy Flux value (q) equal to 0.01 foot/year under a hydraulic gradient of 1.0, thus, Hydraulic conductivity (K) = 0.076 m/year, which is equal to $9.67x10^{-11}$ m/s. From Eq. 5, one obtains the relative permeability (k_r) for the specific NAPL material:

$$k_{r=}\frac{\mu K}{\rho g k} = (0.020 * 9.67x10^{-11}) \; / \; (820 * 9.81 * \; 1x10^{-11}) \; = 2.4x10^{-5} \text{ (unitless)}$$

Using the value of k_r in Eq. 10, one obtains $S_e \cong 0.042$, and Eq. 8 gives:

$$S = (1 - S_R)S_e + S_r = 0.98 * \ 0.042 + 0.02 \ \cong \ 0.06 \quad \text{(unitless)}$$

Thus, the NAPL saturation ratio (S) that satisfies the criterion of 0.01 foot/1 year for q is 6% of the pore space while the residual saturation (S_r) is 2%. The volumetric content of NAPL is obtained by multiplying the NAPL saturation ratio by the porosity, which gives:

$$\theta_o = S * \ \phi = 0.06 * 0.41 = 0.025 \ (unitless)$$

Using this value in Eq. 4, along with the given values above, the maximum NAPL concentration that can be considered immobile for a sandy soil and NAPL (No. 2 heating oil or diesel petroleum product) of the 55,000 mg/kg calculated in the Eq. 4 example calculation on page 2:

$$\text{C} = \frac{M_o}{M_s} = \frac{\Theta_o \ \rho_o}{(1-\phi) \ \rho_s} = \frac{0.025 * 820}{(1-0.41)*2540} = \frac{20.5}{1499} \cong 0.013 \ \frac{kg \ of \ NAPL}{kg \ of \ dry \ soil}$$

$$\text{C} = \ 13.67 \ \frac{g \ of \ NAPL}{kg \ or \ dry \ soil} \ \cong \ 13{,}670 \ \frac{mg \ of \ NAPL}{kg \ of \ dry \ soil}$$

Therefore, the calculated "immobile" mass concentration of NAPL is approximately 13,670 mg/kg of dry sandy soil for a number 2 heating oil release in a sandy soil with an intrinsic permeability of $1x10^{-11}$ m^2.

Permeability

The Eq. 4 example just calculated for the mass concentration of NAPL in soil does not consider site-specific soil permeability. To calculate a site-specific residual saturation NAPL concentration, one needs to modify Eq. 6 to input site-specific soil permeability for k to replace the default value of 10^{-11} m^2.

Using the Kozeny-Carmen equation (Clark 1996), an estimate of the intrinsic permeability, k, can be obtained based on the sample porosity ϕ and D_{10} value obtained from a grain size distribution analysis. The D_{10} value, also referred to as d_{10}, is the particle size (millimeters) where 10% of the mass of a soil sample is finer than that sieve size (USDA-SCS 1987), or alternatively, the sieve size that retains 90% of the mass of the dry sample. The selection of the value of D_{10} is slightly arbitrary following convention. The D_{10} is also used in the permeability estimation using the Hazen formula (Cedergren 1967), which is used in geotechnical engineering. Recent studies, summarized in Bobo et al. (2012), suggest using different formulas or diameters based on the grain size may provide similar estimates of intrinsic permeability. For example, the US Bureau of Reclamation uses the D_{20} and/or the uniformity coefficient (equal to D_{60}/D_{10}) (Vukovic and Soro 1992, Bobo et al. 2012). For calculating an EPH alternative product limit, the Department has selected to use the Kozeny-Carmen equation. The Kozeny-Carmen equation is valid when D_{10} grain size diameters are less than 3 mm (Bobo et al. 2012).

The Kozeny-Carmen equation (Clark 1996) is given as:

$$k = \ \tau_f \ \frac{1}{F} \ \frac{\phi^3}{36 \ (1-\phi)^2} \ D_{10}^2 \qquad \text{(Eq. 11)}$$

Where τ_f is the tortuosity to flow, commonly taken as 0.5, and *F* is a shape factor that varies from 2.0 for circular pores to 3.0 for flat pores. As a reasonable and protective value, F can be taken equal to 2.5, thus Eq. 11 becomes:

$$k = \frac{\emptyset^3}{180*(1-\emptyset)^2} D_{10}^2 \qquad \text{(Eq. 12)}$$

An illustration of computation of the intrinsic permeability is shown in Figure 2.3-2 for the porosity of ϕ = 0.41 for D_{10} varying from 0.02 mm to 1.0 mm. Sand has a D_{10} typically larger than 0.2 mm.

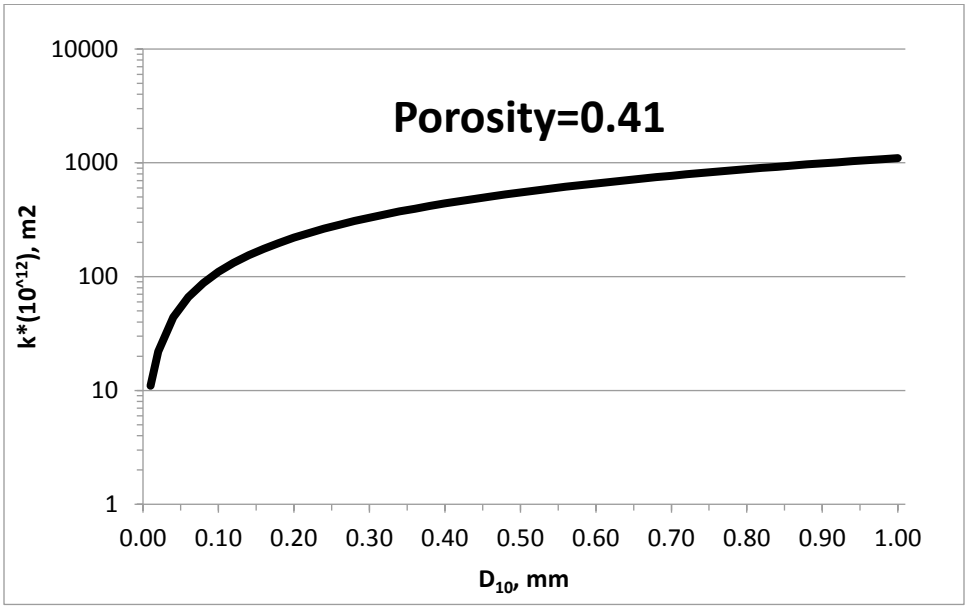


Figure 2.3-2: The intrinsic permeability, *k*, as function of the D_{10}. Note that one needs to divide the ordinate (i.e., "y" axis) by 10^{12} to obtain the value in m^2. For example, the value 1,000 on the "y" axis represents an intrinsic permeability of 10^{-9} m^2.

Example –Effects of Permeability

Using the estimated permeability based on the D_{10} characteristics of the soil and concentration of oil in Eq. 4, the maximum NAPL concentration that can be considered for a site-specific soil and a No. 2 heating oil NAPL may be estimated as follows.

If D_{10} = 0.50 mm, the Kozeny-Carmen yields the following

$$k = \frac{\emptyset^3}{180*(1-\emptyset)^2} D_{10}^2 = \frac{0.41^3}{180*(1-0.41)^2} (0.50)^2 = 0.00275 \text{ mm}^2 = 2.75\text{x}10^{-10} \text{ m}^2$$

Substituting site specific permeability estimate into Eq. 6 yields

$$k_r = \frac{\mu K}{\rho g k} = \frac{(0.020 * 9.67x10^{-11})}{(820 * 9.81 * 2.75x10^{-10})} \cong 8.6x10^{-7} \text{ (unitless)}$$

Using the site-specific value of k_r , one calculates the effective petroleum saturation (S_e) as follows from Eq. 10:

$S_e = 1.135 * k_r^{0.31} = 1.135 * (8.6x10^{-7})^{0.31} \cong 0.015$

Using Eq. 8 to calculate the NAPL saturation ratio,

$$S = (1 - S_r)S_e + S_r = 0.98 * 0.015 + 0.02 \cong 0.035 \quad \text{(unitless)}$$

The volumetric content of NAPL is obtained by multiplying the NAPL saturation ratio by the porosity, which gives:

$$\theta = S * \phi = 0.035 * 0.41 \cong 0.014 \text{ (unitless)}$$

Combining the site-specific residual petroleum hydrocarbon content (θ_r) and the physical characteristics of a No. 2 heating oil into the modified Eq. 6 yields the following.

$$C = \frac{M_o}{M_s} = \frac{\Theta_o \ \rho_o}{(1-\phi) \ \rho_s} = \frac{0.0143*820}{(1-0.41)*2540} = \frac{11.767}{1499} \cong 0.00785 \ \frac{kg \ of \ NAPL}{kg \ of \ dry \ soil}$$

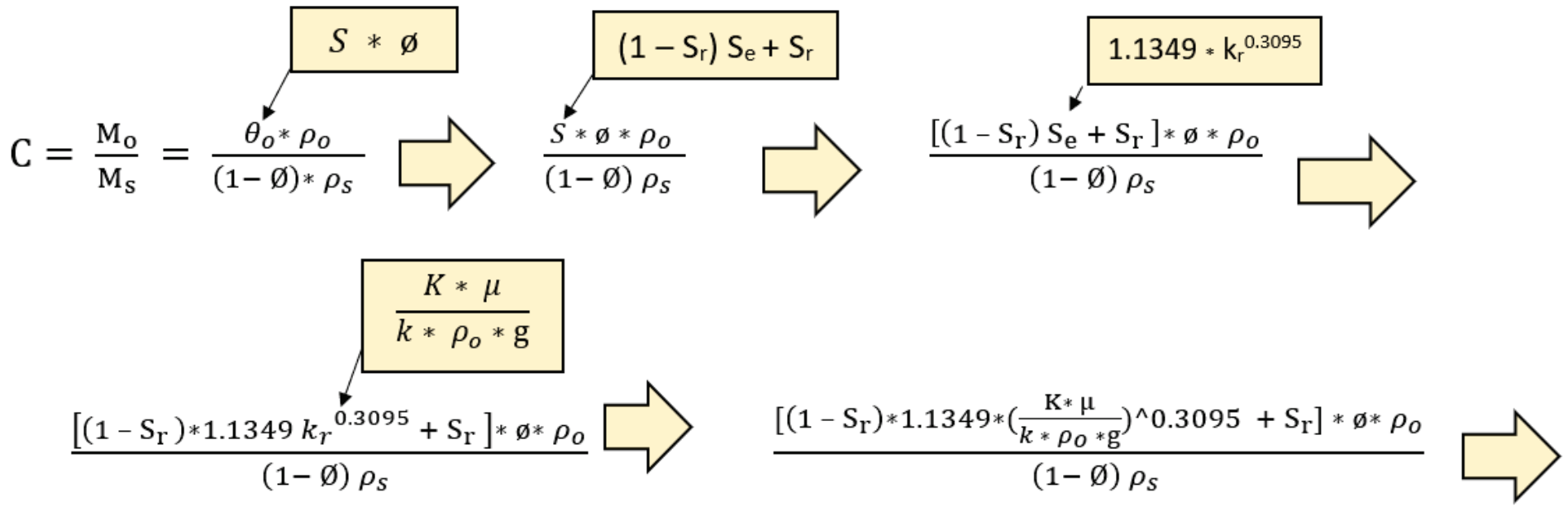
$$C = 7.85 \ \frac{g \ of \ NAPL}{kg \ or \ dry \ soil} \cong 7{,}850 \ \frac{mg \ of \ NAPL}{kg \ of \ dry \ soil}$$

The calculated "immobile" mass concentration of NAPL is approximately 7,850 mg/kg in soil with a D_{10} of 0.5 mm for a No. 2 heating oil discharge.

Thus, data for three variables are needed to determine an AOC-specific EPH product limit concentration in soil (i.e., C in Eq. 1). They are: (1) the density and (2) dynamic viscosity of the petroleum product, and (3) the D_{10} value derived from the grain size distribution analysis of the soil.

A comprehensive diagram of the preceding equation components used to calculate an EPH alternative product limit in soil is presented in Figure 2.3-3.

Figure 2.3-3: **Diagrammed Equation used to Calculate an EPH Alternative Product Limit in Soil**



Input the parameter default values and convert the units to mg/kg. The remaining parameters are specific to the type of petroleum product and the site's soil-specific properties.

$$C = \frac{[(1 - 0.02)1.1349 * (\frac{10^{-9} * \mu}{k * \rho_0 * 9.81})\text{^}0.3095 + 0.02] * 0.41 * \rho_o}{(1 - 0.41)\, 2.54} * 10^6 \frac{mg}{kg}$$

Appendix 2.4

Variables Table and Table of Petroleum Product Viscosity and Density

Table 2.4-1

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
C	Mass concentration of NAPL in dry soil	mg/kg	No	N/A	Calculation	Calculated value (Eq. 1, Eq. 4, and Diagrammed Equation in Figure 2.3-3 of Appendix 2.3).
M_o	Mass content of non-aqueous phase liquid	mg	No	N/A	Calculation	Calculated value (Eq. 3 in Appendix 2.3).
M_s	Mass of dry soil	kg	No	N/A	Calculation	Calculated value (Eq. 2 in Appendix 2.3).
Ø	Porosity: Total volume not occupied by soil grains; includes volume filled with air, water, and petroleum hydrocarbon liquid phases	Unitless	0.41	Default value (NJDEP 2008)	N/A	Cannot change from NJDEP default value.

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
ρ_s	Grain density: Mass per unit volume of the soil grains	g/cm^3	2.54	N/A	Calculation	Calculated from dry soil bulk density and porosity, $\rho_s = \rho_b / (1- Ø)$. Using default values for porosity and bulk density (NJDEP 2008), grain density equals 2.54 g/cm^3. [ρ_s = (1.5 g/cm^3) / (1 - 0.41) = 2.54 g/cm^3].
θ_o	Petroleum hydrocarbon content (volume basis): Ratio of petroleum hydrocarbon volume per soil sample volume.	Unitless	No	N/A	Calculation	Calculated value (Eq. 9 in Appendix 2.3). $\theta_o \leq Ø$. $\theta_o > \Theta_r$. Unique for a given soil and petroleum product.
ρ_o	Petroleum hydrocarbon density: Mass of petroleum hydrocarbon per unit volume of petroleum hydrocarbon liquid phase	g/cm^3	Specific to each petroleum product type	Environment Canada	N/A	See Table 2.4-2 below of petroleum product density and viscosity for the default values used in the EPH Alternative Product Limit Concentration Calculator. Most protective values were selected.
ρ_b	Bulk density: Mass per unit volume of entire undisturbed soil sample	g/cm^3	1.5	Default value (NJDEP 2008)	N/A	Cannot change from DEP default value.

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
q	Darcy flux value: velocity below which liquid (water or petroleum hydrocarbon liquid) is considered immobile. Defined for the purposes of this calculation.	m/s	10^{-10}	Default value (NJDEP 2014)	N/A	Default value of 10^{-10} m/s equates to approximately 0.01 foot per year which is defined as immobile for this guidance (1ft./100yrs) from IGW SESOIL FAQ (NJDEP 2014). (Eq. 5 in Appendix 2.3).
K (eq. 6)	Hydraulic conductivity value: The hydraulic conductivity value that will produce the Darcy flux value. Defined for the purposes of this calculation.	m/s	10^{-10}	N/A	N/A	For i=1 and q=10^{-10} m/sec, this is a constant. Equates to approximately 0.01 foot/year (Eq. 5 and Eq. 6 in Appendix 2.3).
i	Hydraulic gradient of NAPL: Slope of the advective pathway, defined as the decrease in pressure (head) of the liquid body over the distance of travel.	unitless	1	N/A	N/A	Set to 1, as this is a conservative approach (i.e., will make the petroleum hydrocarbon flow faster). Conservative because "i" should be <1, as the petroleum is moving in a relatively flat plane.
g	Gravitational acceleration: Rate at which a falling object accelerates toward earth in the absence of interfering forces such as wind resistance.	m/s^2	9.81	(de Marsily 1986)	N/A	This is the acceleration due to gravity at sea level at approximately New Jersey latitude.

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
μ	Dynamic viscosity of fluid (i.e., petroleum hydrocarbon): Resistance to shearing flows, where adjacent layers of the same liquid move parallel to each other with different speeds	poise (kg/(m·s))	Specific to each Petroleum Product type	Environment Canada	N/A	See Table 2.4-2 below of petroleum product density and viscosity for the default values used in the EPH Alternative Product Limit Concentration Calculator. Most protective values selected.
k	Intrinsic permeability: Permeability which is characteristic of the soil structure only (and not of the fluid).	m^2	No	N/A	Calculation	Calculated value (Eq. 6 and Eq. 12 in Appendix 2.3) from porosity and D_{10} using Kozeny-Carmen equation (Eq. 11 in Appendix 2.3).
k_r	Relative permeability to petroleum hydrocarbon. It is the ratio of the effective permeability to the intrinsic permeability.	Unitless	No	N/A	Calculation	Calculated value from Eq. 7 in Appendix 2.3.
S_e	Effective petroleum hydrocarbon saturation ratio: Ratio of volume occupied by mobile oil to the maximum possible volume of mobile oil.	Unitless	No	N/A	Calculation	Calculated value from Eq. 10 in Appendix 2.3. Calculated using best fit equation for n=4.

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
n	van Genuchten Uniformity Coefficient related to pore size distribution and reflects a "shape parameter" n = 1 / (1 - m) m is also a van Genuchten Uniformity Coefficient related to pore size distribution. An empirical constant affecting the shape of the retention curve. m = (1 - 1/n)	Unitless	4	(van Genuchten (1980); (van Genuchten et al. 1991)	N/A	Set by committee at 4 as a reasonable choice for a well-sorted soil. Note that unitless parameters m and n are related to one another (m=0.75 when n = 4). Default value cannot be changed.
S	NAPL saturation ratio	Unitless	No	N/A	Calculation	Calculated from Eq. 8 in Appendix 2.3.
S_r	Residual petroleum hydrocarbon ratio: Ratio of volume of petroleum hydrocarbon liquid to porosity.	Unitless	2%	(Brost & DeVaull 2000)	N/A	Set at 2% by committee based on Table 3 (Brost & DeVaull 2000) which identifies S_r of 0.02 as a screening value for fine to medium sand at 95% statistical tolerance limit.
θ_r	Residual petroleum hydrocarbon content (volume basis): Ratio of residual petroleum hydrocarbon volume per soil sample volume.	Unitless	0.082	N/A	Calculation	Default value calculated from S_r and porosity = 0.41 $\theta_r = S_r * Ø$

Variable	Definition/Purpose	Units	Default Value	Literature Source for Default Value	Measurement or Calculation	Notes
D_{10}	Known as "effective diameter" in geotechnical engineering. Sieve diameter that passes 10% of the mass of the dry sample.	mm	No	N/A	Measurement	Must be laboratory-determined by grain size distribution sieve analysis with hydrometer (field description insufficient).

Table of Petroleum Product Dynamic Viscosity and Density used in the EPH Alternative Product Limit Calculator

Table 2.4-2

Petroleum Product [TABLE 2-1 of N.J.A.C. 7:26E-2.1(d)]	Density (g/cm^3)	Dynamic Viscosity (poise)	Petroleum Product Values used in EPH Alternative Product Limit Calculator	Information Source
No. 2 Heating Oil	0.8245 @ 15°C	0.02 @ 15°C	Diesel Fuel	Environment Canada
Diesel Fuel	0.8245 @ 15°C	0.02 @ 15°C	Diesel Fuel	Environment Canada
No. 4 Heating Oil	0.9250 @ 20°C	0.23 @ 20°C	No. 4 Heating Oil	Environment Canada
No. 6 Heating Oil	0.9879 @ 15°C	403.4 @ 15°C	No. 6 Heating Oil	Environment Canada
Hydraulic Oil	0.8727 @ 15°C	1.02 @ 15°C	ATF III (mineral)	Environment Canada
Cutting Oil	0.8245 @ 15°C	0.02 @ 15°C	Diesel Fuel	Environment Canada
Lubricating Oil	0.8498@ 15°C	1.4217 @ 15°C	Lubricating Oil Electrical	Environment Canada
Unknown Petroleum Hydrocarbons	0.8245 @ 15°C	0.02 @ 15°C	Diesel Fuel	Environment Canada
Waste Vehicular Crankcase Oil	0.8848 @ 15°C	1.75 @ 15°C	Lubricating oil (Engine, Gasoline)	Environment Canada
Mineral Oil	0.8673 @ 15°C	0.19 @ 15°C	Electrical Insulating Oil - used	Environment Canada
Dielectric Fluid, Dielectric Mineral Oil, Transformer Oil	0.8673 @ 15°C	0.19 @ 15°C	Electrical Insulating Oil - used	Environment Canada

Notes:

- Values used were from sources with paired Density and Dynamic Viscosity values
- Contact the Department for Crude Oil and Manufactured Gas Plant (MGP) sites
- If the petroleum product has been used (e.g. a Waste Oil), select the appropriate parent petroleum product

APPENDIX 3

Established EPH Product Limits, Standards, Screening Levels, Basis and Policy

3.1 EPH Default Product Limits, Basis

3.2 EPH Product Ceiling Limit, Basis

3.3 EPH Category 1: Health Based Soil Remediation Criteria, Derivation

3.4 EPH Screening Level, Ecological

3.5 Application of pre-September 2010 Petroleum Hydrocarbon Data

Appendix 3.1

EPH Default Product Limits, Basis

Default EPH Product Limits for No. 2 Fuel Oil, Diesel, and Heavier TPH Products

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Health-based soil remediation standards for No. 2 fuel oil, diesel fuel, other fuel oils, and lubricating oils may be very high under certain conditions (e.g., non-residential pathways). For this reason, it is necessary to develop maximum allowed concentrations for total petroleum hydrocarbons in soil to protect against other undesired effects of these contaminants when present at high levels. The presence of non-aqueous phase liquid (NAPL) when the soil saturation limit (Csat) is exceeded is one parameter that has been used as an upper limit on individual contaminant concentrations in soil (USEPA, 1996; New Jersey Soil Remediation Standards: New Jersey Administrative Code 7:26D, accessed 2009). However, for petroleum products, this concentration has been calculated to be quite low, and far below health-based screening levels. For example, a Csat concentration of 18 mg/kg has been estimated for diesel, compared to the NJDEP residential health-based concentration of 5,300 mg/kg (Brost and DeVaull, 2000). Thus, the Csat concentration is not a useful parameter to use as an upper limit concentration for petroleum hydrocarbon products. A more practical parameter, the residual saturation point, has been defined as the concentration below which NAPL becomes discontinuous and is immobilized by capillary forces within the soil (Mercer and Cohen, 1990). This is analogous to the field capacity parameter for soil moisture. Above this concentration, NAPL may become mobile and be subject to downward drainage due to the effects of gravity. The fraction of the NAPL above the residual saturation point has been termed "free product," or "flowable product," and is generally not allowed by the NJDEP to remain in soil after remedial action is taken. The residual saturation concentration is therefore suitable as an upper limit for petroleum product concentrations in soil when the health-based soil remediation standard is very high. This parameter has also been utilized by Washington State [Washington Administrative Code 173-340-747, accessed 2009], Ohio [Ohio Administrative Code C 3745-300-09, accessed 2009] and Alaska (Alaska Statement of Cooperation Working Group, 2006).

The American Petroleum Institute recently reviewed available measurements of residual saturation points of various petroleum fuels as a function of soil type (Brost and DeVaull, 2000). This review includes the work of Cohen and Mercer (1990), Fussell et al. (1981), Hoag and Marley (1986), API (1980), and others. The residual saturation point is dependent on contaminant properties (especially viscosity) and upon soil properties (particularly soil texture). Low viscosity fuels, such as gasoline, have lower residual saturation points, while higher viscosity fuels, such as No. 2 heating oil, have higher values. Residual fuels, such as No. 6 fuel oil,

are high viscosity products and may have residual saturation points many times higher than gasoline. Finer soil textures (such as silt) exhibit higher residual saturation points than coarser textures (such as sand).

The compiled data from Brost and DeVaull indicate that residual saturation concentrations for "middle distillates" (i.e., No. 2 fuel oil and diesel) ranged from 2,300-23,000 mg/kg as soil texture ranged from coarse gravel to silt (data from Fussell et al.). API (1980) reports a value for residual saturation diesel in "soil" as 34,000 (moisture content unknown). Sand was selected by the NJDEP as a reasonably conservative soil texture for determination of a default upper limit concentration for No. 2 fuel oil and diesel based on the residual saturation point. The results of Fussell et al. indicate that the residual saturation point for "medium sand" ranged from of 8,000-13,000 mg/kg. The soil moisture in these measurements was approximately 0.04 (v/v), which is in between median values for the wilt point (~0.02) and the field capacity (~0.06) for subsurface sand (Carsel et al., 1988). Since infiltrating petroleum would likely displace some of the soil moisture being held at field capacity, this soil moisture content was felt to be appropriate. As is discussed in Brost and DeVaull, the residual saturation concentrations from the study of Fussell et al. tend to be lower than those from other studies. This is illustrated by comparing the range of residual saturation points of gasoline in medium sand by Fussell et al. (3,000-6,000 mg/kg), with a range of 20,000-44,000 mg/kg reported for medium sand under similar moisture contents (Hoag and Marley, 1986). Thus, the residual saturation points of Fussell et al. appear to be conservative relative to other studies. Based on this assessment, Brost and DeVaull recommend a residual saturation concentration of 8,000 mg/kg for medium sand soil and middle distillates (i.e., diesel and No. 2 fuel oil). The NJDEP concurs that this value appears reasonable as a generic concentration to use as an upper limit for these fuel types in order to prevent the occurrence of mobile free product.

Using a similar analysis for "fuel oils" (i.e., fuel oils heavier than diesel and No. 2 fuel oil), the compiled data from Brost and DeVaull indicate that residual saturation concentrations for heavier fuel oil ranged from 5,000-51,000 mg/kg as soil texture ranged from coarse gravel to silt (data from Fussell et al.). API (1980) reports a value for residual saturation fuel oil and lubricating oil in "soil" as 53,000 (moisture content unknown). Again, looking at the results for medium sand from Fussell et al., where soil moistures were judged to be appropriate, the residual saturation point was estimated to be in the range of 17,000 to 30,000 mg/kg, and the recommended value for residual saturation for fuel oils heavier than diesel is 17,000 mg/kg. The NJDEP concurs with this assessment.

Data for lubricating oils other than mineral oil, as reported in Brost and DeVaull, is scarce. Furthermore, many of the reported results either do not include soil moisture contents or were inappropriately run on dry soil. For this reason, Brost and DeVaull do not recommend a residual saturation concentration for lubricating oils. However, review of the Brost and DeVaull report yields residual saturation values for mineral oil in glacial till and alluvium with water contents of 0.02 and 0.03, respectively. The reported residual saturation values are 11,000-19,000 mg/kg for glacial till and 61,000 mg/kg for alluvium. Both of these materials may vary widely in soil texture, but glacial till is more likely to be similar to sandy soils than alluvial material. Given that the residual saturation value selected for heavier fuel oils lies within the range reported for mineral oil in glacial till, it is judged by the NJDEP that the value of 17,000 mg/kg used for heavier fuel oil is also adequately protective for lubricating oils.

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Appendix 3.2

EPH Product Ceiling Limit, Basis

Various petroleum products released into fine grained soil materials may become immobile at relatively high EPH concentrations. The EPH Alternative Product Limit Calculator has the potential to generate AOC-specific alternative product limit concentrations that are in the percent range concentrations in soil (10,000 mg/kg or 1% by mass, and greater). In order to be protective, an EPH product ceiling limit (ceiling limit) based on the professional judgement of the Department and the consensus agreement of the stakeholder EPH Technical Guidance Committee has been established. The selected ceiling limit is 30,000 mg/kg or 3% hydrocarbons by mass of soil which is applicable to both EPH Category 1 petroleum products and EPH Category 2 petroleum products.

Appendix 3.3

EPH Category 1: Human Health-Based Soil Remediation Criteria, Derivation

The 5,100 mg EPH/kg residential soil remediation criterion and 54,000 mg EPH/kg non-residential soil remediation criterion are based on an exposure scenario for protection from noncarcinogenic health effects at a hazard index of 1 and only apply to discharges of No. 2 heating oil and diesel fuel. These values are based solely on effects via the ingestion-dermal exposure pathway. Potential inhalation exposure pathway concerns are addressed by evaluating naphthalene, and potential impact to ground water exposure pathway concerns are addressed by evaluating 2-methylnaphthalene.

A field study (EPH-TPH Field Study) was conducted between July and August 2007 at various sites located throughout New Jersey. The purpose of the field study was to determine a typical chemical composition of No. 2 heating oil. Based on this average composition, the health-based criteria were developed.

The Site Remediation Program (SRP) decided to take the conceptual approach of Massachusetts and the Total Petroleum Hydrocarbon Working Group which evaluated No. 2 fuel oil and/or diesel fuel oil as a mixture of individual components, each with an assigned toxicity factor. The method used for the field study analyzed the samples as aliphatic and aromatic fractions, each with five equivalent carbon ranges. Representative toxicity factors were assigned to each of these analytical fractions. An average health-based criterion was then derived using standard USEPA residential and nonresidential exposure scenarios and factors, by calculating a weighted average based on the composition and the assigned toxicity values, such that the hazard index does not exceed one (1). The originally calculated residential value was 4,800 mg/kg. This value has been further assessed as part of the Department's initiative to update the Remediation Standards Rule in 2010 which affirmed 5,100 mg/kg as protective.

The EPH-TPH Field Study conducted between July and August 2007entailed collection of soil samples from14 different residential sites undergoing underground storage tank (UST) removal. The sites were located throughout New Jersey to ensure geographic and geologic diversity. At each site one sample was collected near the underground storage tank in an area with free or residual product and one sample from the perimeter of the excavation. The perimeter sample was generally collected some distance away from the UST at a location with indications of contamination (odors and sheen) but no free product. All samples were analyzed using both USEPA Method 418.1(TPH data) and the "Analysis of Extractable Petroleum Hydrocarbon Compounds (EPH) in Aqueous and Soil/Sediment/Sludge Matrices" ("NJDEP EPH Method"; EPH data).

Objectives of the EPH-TPH Field Study included empirically generating No. 2 heating oil composition information; determining the ability of the NJDEP EPH Method to analyze actual soil samples contaminated with No. 2 heating oil; determining whether the two methods (EPH and 418.1) yielded comparable results; and determining whether there is a compositional difference

between samples collected close to the point of discharge and those collected farther from the point of discharge.

To determine the comparability of Method 418.1 and NJDEP EPH Method, the SRP statistically evaluated the data pairs for all of the soil samples using linear regression. Based on this analysis, the SRP has concluded that the EPH and TPH data are comparable at a ratio of roughly 1:1 (regression coefficient (R^2) of 0.8473). Therefore, Method 418.1 results can be directly applied to the findings that were derived using EPH data. Alternatively, findings based on Method 418.1 results can be extended to situations where EPH analyses are employed.

Appendix 3.4

EPH Screening Level, Ecological

At the time that petroleum storage and discharge areas were evaluated for TPH, the 1,700 mg TPH/kg ecological screening level was established following a literature search and a review of the pertinent documents. There are clear adverse effects on soil organisms above this TPH concentration. Below 1,700 mg/kg TPH, adverse effects to ecological receptors are possible but not likely and further ecological evaluation in most cases is not warranted.

Based on the Department's field study results of 2007 that compared TPH and EPH, the Department concluded these methods produce equivalent results. Therefore, the EPH concentrations reported using the NJDEP EPH Method will be considered equivalent to the TPH values in the historical literature. If data from contaminated site soil sample analysis are above 1,700 mg/kg EPH and a sensitive ecological receptor is potentially impacted, the soils shall be either remediated to 1,700 mg/kg EPH or a site-specific, risk-based ecological remediation goal shall be determined from more rigorous biological testing. Additional basis for the 1,700 mg/kg screening level is presented in section 6.4.5 Extractable Petroleum Hydrocarbons of the Department's *Ecological Evaluation Technical Guidance*.

Appendix 3.5

Application of pre-September 2010 Petroleum Hydrocarbon Data to Active Investigations

Investigations that commenced prior to September 1, 2010 may require the Investigator to consider laboratory results for soil samples analyzed for Total Petroleum Hydrocarbons using analytical methods in use prior to the adoption of NJDEP EPH Method Revision 3. The historical TPH methods include USEPA Method 418.1, USEPA SW846 Methods 8015B and 8015B/C, NJDEP OQA-QAM-025 and OQA-QAM-025 rev. 7, and NJDEP EPH Method Revision 2.

For Category 1 EPH; the existing TPH data can be used. However, since the contingency analyses for naphthalene and 2-methylnapthalene had not been required, 25% of the samples with EPH or TPH results greater than 1,000 mg/kg, will need to be resampled and analyzed for the presence of these contaminants. The samples collected for the contingency analytes shall be biased to locations and elevations presenting the highest TPH or EPH concentrations. Remediation is still required in areas where historical TPH sample results exceeded 10,000 mg/kg.

For Category 2 EPH, the Department will allow the person responsible for conducting the remediation to reanalyze 25 percent of the samples, biased to worst-case, where petroleum hydrocarbons were detected between 2,300 mg/kg and 10,000 mg/kg. This will determine whether any of the areas where petroleum hydrocarbons were historically detected exceed the sample-specific EPH health-based criterion. It is not possible to have an exceedance of a health-based concentration of 2,300 mg/kg or lower. Therefore, any historical TPH concentration of 2,300 mg/kg or lower should also be below the sample-specific health-based criterion.

If the resampling of the worst-case historical results does not indicate contamination in exceedance of the calculated health-based criteria, no additional resampling of historical areas will be required. The entity in charge of remediation oversight (e.g., Department, LSRP, Sub-surface Evaluator) will determine on a case-by-case basis what additional sampling is required if the resampling of the worst-case historical results indicates contamination in exceedance of health-based criteria.

Remediation is still required in areas where historical TPH sample results exceeded 10,000 mg/kg. The person responsible for conducting the remediation has the option of resampling the locations of TPH exceedances, analyzing the samples using the NJDEP EPH Method and calculator, and delineating to below sample-specific health-based criterion or the Investigator may choose to remediate where the TPH samples exceed 10,000 mg/kg.