

Abstract: Three- and Four-Phase Partitioning of Petroleum Hydrocarbons and Human Health Risk Calculations Technical Background Document and Recommendations

Petroleum hydrocarbons exist in the soil environment in four phases: dissolved in water; as vapor in the soil gas; adsorbed to the soil solids; and as non-aqueous phase liquid (NAPL). Phase partitioning describes the distribution of hydrocarbon mass between these phases and the concentration in each phase at equilibrium. Understanding hydrocarbon phase partitioning and the equilibrium concentrations is an integral and critical part of assessing risks to human health and the environment, and of developing effective cleanup strategies. This document

- Provides background information on hydrocarbon phase partitioning
- Introduces the “soil saturation concentration” (C_{sat}) and Raoult’s Law
- Briefly describes “forward” and “backward” risk calculations
- Describes a “hydrocarbon risk calculator”

The distribution of petroleum hydrocarbon in soil can be represented by a three-phase model (vapor phase, dissolved phase, and adsorbed phase) or a four-phase model (vapor phase, dissolved phase, adsorbed phase, and pure product phase).

This report documents that the ability of soil to hold petroleum hydrocarbon in the dissolved, vapor, and adsorbed phases is limited; this limit is defined as the “soil saturation concentration” (C_{sat}); and that at concentrations above C_{sat} , NAPL is present in the soil in addition to the dissolved, vapor, and adsorbed phases. At concentrations below C_{sat} , the distribution of petroleum hydrocarbon in soil can be represented by a three-phase model (vapor phase, dissolved phase, and adsorbed phase) while at concentrations above C_{sat} , the distribution of petroleum hydrocarbon in soil should be represented by a four-phase model (vapor phase, dissolved phase, adsorbed phase, and pure product phase). In example calculations conducted to date, NAPL is typically present in diesel-contaminated soils at the lowest ADEC Table B2 concentrations. The current ADEC cleanup levels assume the three-phase model exists at concentrations above the saturation concentration, which is technically inaccurate and overestimates the risk to human health and the environment.

The “hydrocarbon risk calculator” is an Excel spreadsheet that accomplishes the following:

- Performs hydrocarbon phase partitioning calculations
- Assesses human health risk via the soil ingestion, migration to indoor air, migration to outdoor air, migration to groundwater, and groundwater ingestion exposure routes for both residential and industrial land use patterns
- Calculates cumulative risk assuming that all pathways are complete
- Calculates cumulative risk for pathways that are complete under site-specific scenarios
- Assesses the limitations associated with offsite transport of hydrocarbon-contaminated soil
- Recommends a “site closure status” (following the SOC proposed Environmental Site Closeout concepts paper).