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# **Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons**

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# Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons

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# 1. Executive Summary

Livestock may be exposed to accidental releases of petroleum hydrocarbons at or near exploration and production sites and, in these cases, there may be a need to estimate potential risks to these receptors. A framework was developed to 1) determine when livestock should be included in a risk evaluation and 2) estimate risks of petroleum hydrocarbon exposure to livestock. A conceptual site model (CSM) was developed to assess whether complete and significant exposure pathways for livestock exist at a site.

To estimate potential risks in this screening-level risk assessment, toxicity reference values (TRVs) and drinking water and soil risk-based screening levels (RBSLs) for petroleum hydrocarbons, including: crude oil; benzene, toluene, ethylbenzene, and xylene (BTEX); and polycyclic aromatic hydrocarbons (PAHs) were developed for livestock. TRVs and RBSLs were developed for the protection of a variety of livestock including dairy cattle, beef cattle, calves, sheep, goats, camels, and horses.

TRVs for petroleum hydrocarbons were based on available toxicity values from studies conducted on livestock, if available, or on small mammals extrapolated to be protective of livestock evaluated in this report. RBSLs were calculated for the two complete and significant exposure pathways identified in the CSM, drinking water ingestion and incidental soil ingestion. Drinking water and soil RBSLs were calculated based on the TRVs and the selected exposure assumptions for the livestock.

The TRVs and RBSLs developed for this framework were comparable to human health RBSLs as shown in the following table:

| Livestock    | Toxicity Reference Values (TRVs; mg/kg-bw/day) |         |         |              |        |         |         |
|--------------|------------------------------------------------|---------|---------|--------------|--------|---------|---------|
|              | Crude Oil                                      | Benzene | Toluene | Ethylbenzene | Xylene | LMW PAH | HMW PAH |
| Dairy Cattle | 211                                            | 5.70    | 35.6    | 4.65         | 28.5   | 0.798   | 0.160   |
| Beef Cattle  | 211                                            | 5.95    | 37.1    | 4.86         | 29.8   | 0.833   | 0.167   |
| Calves       | 211                                            | 10.3    | 64.5    | 8.43         | 51.7   | 1.45    | 0.289   |
| Sheep        | 211                                            | 10.0    | 62.5    | 8.17         | 50.1   | 1.40    | 0.280   |
| Goats        | 211                                            | 11.8    | 73.6    | 9.62         | 58.9   | 1.65    | 0.330   |
| Camels       | 211                                            | 5.55    | 34.6    | 4.53         | 27.8   | 0.777   | 0.155   |
| Horses       | 211                                            | 5.67    | 35.4    | 4.63         | 28.4   | 0.794   | 0.159   |

| Livestock    | Drinking Water Risk-Based Screening Levels (RBSLs; mg/L) |         |         |              |        |         |         |
|--------------|----------------------------------------------------------|---------|---------|--------------|--------|---------|---------|
|              | Crude Oil                                                | Benzene | Toluene | Ethylbenzene | Xylene | LMW PAH | HMW PAH |
| Dairy Cattle | 1,199                                                    | 32.4    | 202     | 26.4         | 162    | 4.53    | 0.907   |
| Beef Cattle  | 1,114                                                    | 31.4    | 196     | 25.6         | 157    | 4.40    | 0.880   |
| Calves       | 293                                                      | 14.3    | 89.5    | 11.7         | 71.7   | 2.01    | 0.402   |
| Sheep        | 855                                                      | 40.5    | 253     | 33.1         | 203    | 5.68    | 1.14    |
| Goats        | 622                                                      | 34.8    | 217     | 28.4         | 174    | 4.87    | 0.974   |
| Camels       | 7,673                                                    | 202     | 1,259   | 165          | 1,009  | 28.3    | 5.65    |
| Horses       | 2,763                                                    | 74.3    | 464     | 60.6         | 371    | 10.4    | 2.08    |

| Livestock    | Soil Risk-Based Screening Levels (RBSLs; mg/kg) |         |         |              |        |         |         |
|--------------|-------------------------------------------------|---------|---------|--------------|--------|---------|---------|
|              | Crude Oil                                       | Benzene | Toluene | Ethylbenzene | Xylene | LMW PAH | HMW PAH |
| Dairy Cattle | 47,151                                          | 1,273   | 7,946   | 1,039        | 6,367  | 178     | 35.7    |
| Beef Cattle  | 44,894                                          | 1,266   | 7,901   | 1,033        | 6,331  | 177     | 35.5    |
| Calves       | 44,894                                          | 2,198   | 13,715  | 1,794        | 10,990 | 308     | 61.5    |
| Sheep        | 20,095                                          | 953     | 5,949   | 778          | 4,767  | 133     | 26.7    |
| Goats        | 17,583                                          | 982     | 6,129   | 802          | 4,911  | 138     | 27.5    |
| Camels       | 69,522                                          | 1,829   | 11,412  | 1,492        | 9,144  | 256     | 51.2    |
| Horses       | 28,133                                          | 756     | 4,719   | 617          | 3,782  | 106     | 21.2    |

mg/kg-bw/day = milligrams per kilogram body weight per day.

mg/L = milligrams per liter.

mg/kg = milligrams per kilogram.

LMW PAH = low molecular weight polycyclic aromatic hydrocarbon.

HMW PAH = high molecular weight polycyclic aromatic hydrocarbon.

## 2. Introduction

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Consumption of petroleum hydrocarbons by livestock has been found to lead to a range of health problems, including neurotoxicity (Coppock *et al.* 1995; Khan *et al.* 1995), fetal toxicity (Coppock *et al.* 1995), damage to the gastrointestinal tract (Coppock *et al.* 1996), respiratory system, kidney, and liver (Meadows and Waltner-Toews 1979; Edwards 1985a; Coppock *et al.* 1995; Coppock *et al.* 1996; Stober 1962). Petroleum ingestion has also been linked to anorexia (Edwards and Zinn 1979), lethargy (Meadows and Waltner-Toews 1979; Edwards 1985b), and fatal poisoning in cattle (Edwards and Zinn 1979; Meadows and Waltner-Toews 1979; Edwards and Gregory 1991).

The purpose of this study was to develop toxicity values and screening guidelines for evaluating risks to livestock from exposure to petroleum hydrocarbons. This report addresses how to: (1) determine whether livestock should be included in a risk evaluation, and (2) estimate risks of petroleum hydrocarbon exposures to livestock.

In this report, the approach used to develop toxicity values and screening guidelines for livestock from petroleum hydrocarbon exposures was divided into two steps:

- The first step included evaluation of the potential for exposure through the development of a conceptual site model (CSM).
- The second step included development of Toxicity Reference Values (TRVs) and Risk-Based Screening Levels (RBSLs) for the protection of livestock.

This report focused on whole crude oil and its toxicologically important constituents (i.e. benzene, toluene, ethylbenzene, and xylene [BTEX] and polycyclic aromatic hydrocarbons [PAHs]). Metals can also be present in petroleum products, but they are generally not found at high enough concentrations to provide a significant health risk (Magaw et al., 1999) and therefore metals are not addressed in this report.

The approach presented herein is consistent with a screening-level risk assessment and used a conservative approach to determine potential risks to receptors by comparing exposure levels of petroleum hydrocarbons from a site to petroleum hydrocarbon threshold levels protective of livestock. Although threshold values for the protection of livestock have been developed by some agencies (e.g., Canadian Council of Ministers of the Environment [CCME] and Alberta Environment), these values are either region-specific or cover limited constituents of petroleum hydrocarbons. In this study, a more generalized approach was used to develop conservative threshold values such as TRVs (i.e., toxicity values) and RBSLs (i.e., guidelines) for petroleum hydrocarbons that can be used to characterize risks to livestock across a variety of conditions.



## 3. Conceptual Site Model

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A conceptual site model (CSM) identifies complete and potentially complete exposure pathways and receptors to be considered in a risk assessment. If no complete significant pathway(s) exist for exposure of livestock to petroleum hydrocarbons, a screening-level risk evaluation for livestock is not necessary. By definition, if there is little to no significant exposure to a potentially toxic compound, there is little to no likelihood of significant unacceptable risk to the receptor from that compound. A CSM was developed as presented in Figure 1 to assess the potential for exposures to livestock and the need for a risk evaluation. Components of a CSM generally include receptor evaluation and exposure pathway evaluation, which are described below.

### 3.1 Receptor Evaluation

Livestock that are potentially vulnerable to toxic effects of petroleum hydrocarbons include animals that could ingest significant quantities of soil, water, and/or food in oil-contaminated areas. Access to the contaminated areas is key; cattle, sheep, goats, and horses that forage in pasture areas are more likely to be potential receptors, while species that are raised in more confined and controlled conditions, such as chickens or pigs, would have less chance of exposure to petroleum hydrocarbons. Outside of the United States, other types of livestock animals may also be exposed to petroleum compounds, such as camels, llamas, oxen, etc. It was assumed that exposures to these receptors would be similar to those of typical livestock in the United States based on similarities in body weights and feeding habits.

### 3.2 Pathway Evaluation

The pathways by which livestock could be exposed to petroleum hydrocarbons are incidental soil ingestion, water ingestion, and direct ingestion, inhalation, dermal absorption, and plant ingestion. Based on available information, the primary exposure pathways considered significant in the exposure model as shown in the CSM (Figure 1) included incidental soil ingestion, water ingestion, and direct petroleum product ingestion. Inhalation, dermal absorption, and plant ingestion were considered minor pathways for petroleum hydrocarbons (CCME 2000). The exposure pathways listed above are described in more detail below.

#### 3.2.1 Soil Ingestion

Soil can comprise a substantial proportion of the livestock diet. Livestock may consume soil inadvertently during grazing (Zach and Mayoh 1984; CCME 2000) or may intentionally ingest salty-tasting soil (Coppock *et al.* 1995). According to the CCME (2000), cattle are exposed to petroleum hydrocarbons primarily through consumption of contaminated soils, particularly during grazing. The authors state that the majority of petroleum hydrocarbon exposure in cattle is due to ingestion of surface soils.

#### 3.2.2 Water Ingestion

Chronic exposure through drinking water can be a significant exposure pathway for livestock (CCME 2000). The amount of water ingested by cattle varies according to age, physiological status (growth, fattening, pregnancy, lactation), diet composition, breed, size, and, for all animals, temperature (Agriculture and Agri-Food Canada 2001; National Research Council [NRC] 1988).

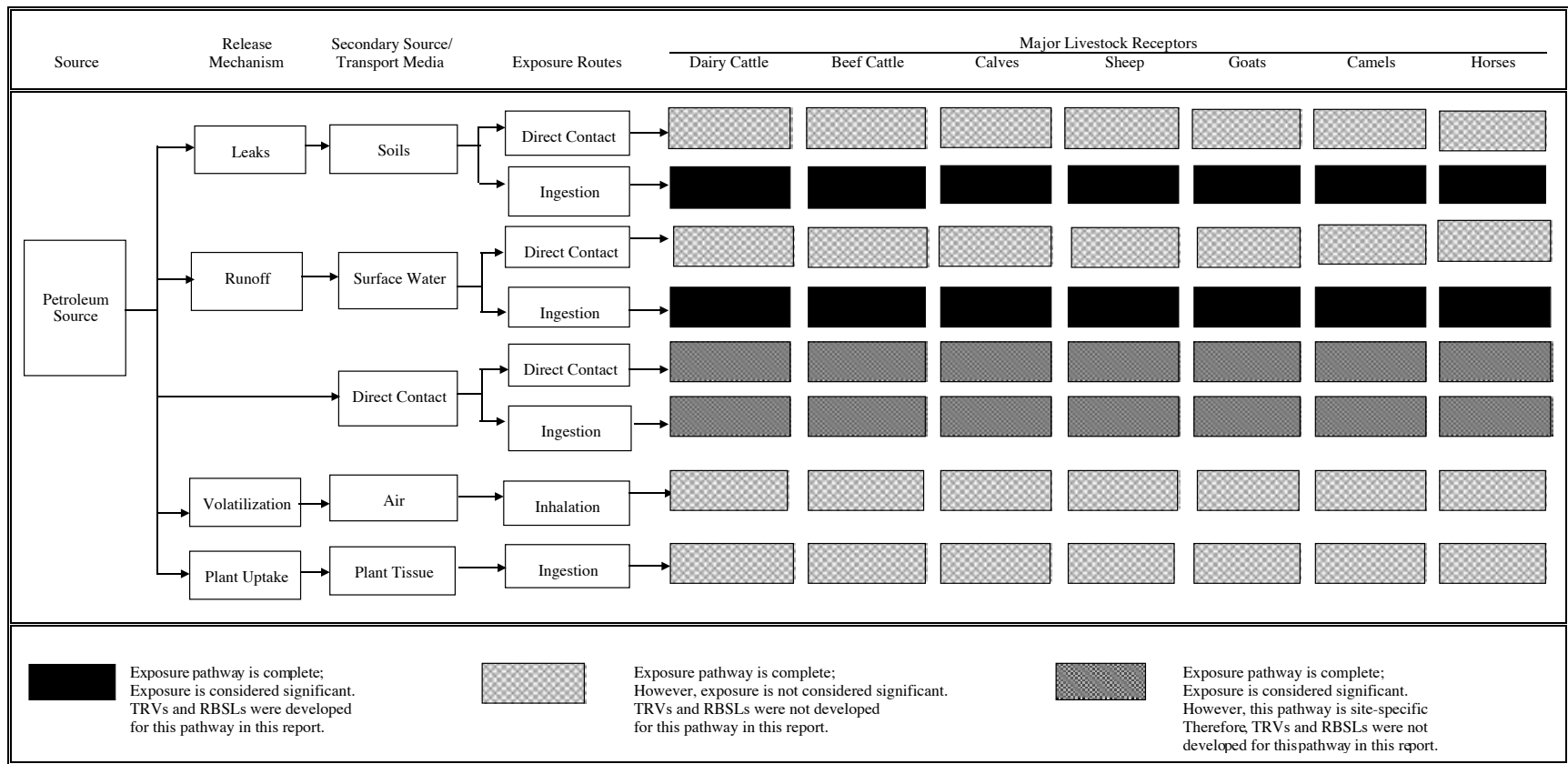


Figure 1. Conceptual Site Model for Livestock Exposed to Petroleum Hydrocarbons

### 3.2.3 Direct Ingestion

Cattle may directly ingest crude oil and other petroleum compounds from pools of oil formed by leaking pipelines or storage tanks (Edwards and Zinn 1979; Coppock *et al.* 1995; CCME 2000) due to curiosity (particularly in young calves; Edwards 1985b), or to add salt to their diet (Edwards 1985b, Coppock *et al.* 1995). Reported cases include steers consuming petroleum distillate, drinking from a slush pit, and drinking petroleum from puddles near a tank battery (Edwards and Zinn 1979). Oil and natural gas industry guidance (API 1997) and many regulatory agencies (e.g., the Railroad Commission of Texas 1993) stress the importance of removing free-oil accumulations on the ground that animals could potentially ingest.

### 3.2.4 Dermal Absorption

Dermal absorption of petroleum hydrocarbons in livestock is considered a minor exposure pathway because of their thick coats (CCME 2000). While methods are available to assess dermal exposure to humans, data necessary to estimate dermal exposure are generally not available for livestock or wildlife (EPA 1993). Additionally, dermal exposure has been shown to be negligible for most terrestrial mammals (EPA 2000).

### 3.2.5 Inhalation

According to CCME (2000), inhalation of petroleum hydrocarbons is also a minor exposure pathway for livestock. Inhalation of petroleum hydrocarbons was assumed to be negligible for two reasons: (1) due to the assumed presence of vegetation on grazing lands, exposure of contaminated surface soils to winds and resulting aerial suspension of contaminated dust particulates would be minimized, and (2) most volatile organic compounds (VOCs)—the contaminants most likely to present a risk through inhalation—get rapidly diluted and dispersed in ambient air, making significant exposure to VOCs through inhalation unlikely. In situations where inhalation exposure is believed to be more significant, evaluation of this pathway should be considered.

### 3.2.6 Plant Ingestion

Exposure to petroleum hydrocarbons through ingestion of plants is considered a minor pathway (CCME 2000). The authors explain that although the ingestion rates of plants are high for livestock, plants are considered a minor contributor to this proportion, due to the limited phytoaccumulation (i.e., a process by which plants accumulate contaminants into roots and above ground shoots or leaves) potential of petroleum hydrocarbons (CCME 2000; Alberta Environment 2001a).

## 3.3 Summary of the CSM for Livestock

If the CSM can identify any complete and significant exposure pathway(s) for livestock receptors at a site, then the next step would be to conduct a screening-level risk assessment. However, another factor to consider in determining whether there is need to assess livestock risks is the size of the contaminated area or release relative to the size of the grazing area. This is referred to as a site use factor (explained further in the following section). A small affected area (e.g. less than one acre) is unlikely to result in significant risks to herds of livestock and may not warrant a screening-level risk assessment (Texas Natural Resource Conservation Commission [TNRCC] 2000 and Pennsylvania Department of Environmental Protection [PADEP] 1998). Cumulative risks can be estimated for livestock receptors exposed to petroleum hydrocarbons via multiple exposure pathways (for example, via soil ingestion and water ingestion at a site).