areas where oil was visible on the surface. Collins (1993) expanded the original study to include subsurface observations in 1990 (Figure 2) using wooden dowels pushed into the soil to visually inspect for the presence of hydrocarbons. In general, the thickness of the zone within the soil profile affected by hydrocarbon contamination was observed to thin out as a function of distance down slope of the points of release. The vertical distribution of subsurface crude oil was generally beneath the O1 and O2 horizons characterised by living moss and peat layer and contained within the A1 and C1 horizons characterised by mineral soil to a depth of between 20 to 30 cm below surface. At the upper end of the slope (3.5 m from point of release) maximum depth of oil penetration was observed to be 15 to 21 cm. At 34 m down slope the oil-affected soil horizons extended to 25 to 30 cm depth. Collins (1993) found it was difficult to ascertain whether or not the oil had moved vertically any deeper at either spill site because a zone of water saturation was encountered between 40 cm to 60 cm beneath the surface in 1990.

Contaminant transport in soils exposed to freezing

The ease with which any fluid can be transported through soil is dependent upon the properties and relative volumes of all fluids present. Introduction of contaminants of low-water solubility such as hydrocarbons into a porous medium results in a two-phase flow system, each with its own effective permeability and thermodynamic characteristics. In seasonally frozen soils such as those in the active layer at Caribou-Poker Creeks, the water to hydrocarbon ratio will control the relative permeability of the soil to each of the fluids. Increasing hydrocarbon saturation of soil for example, should decrease the permeability of the soil to water as soil pores and particle surfaces become occupied by oil. This decreases the channel widths available for the migration of water and hydrocarbons.

Laboratory studies of microstructure (White and Coutard, 1999) and field work in permafrost terrain have revealed, however, the dynamics of soils affected by freezing (cryosols) and the role of contaminants in this regard. Significant increases in hydraulic conductivity of an experimental silt took place when low concentrations of diesel fuel were introduced into the soil water (White 1999). A four-fold increase in hydraulic conductivity (2.9×10^{-4} cm s^{-1} to 9.8×10^{-4} cm s^{-1}) relative to uncontaminated material was observed where hydrocarbon

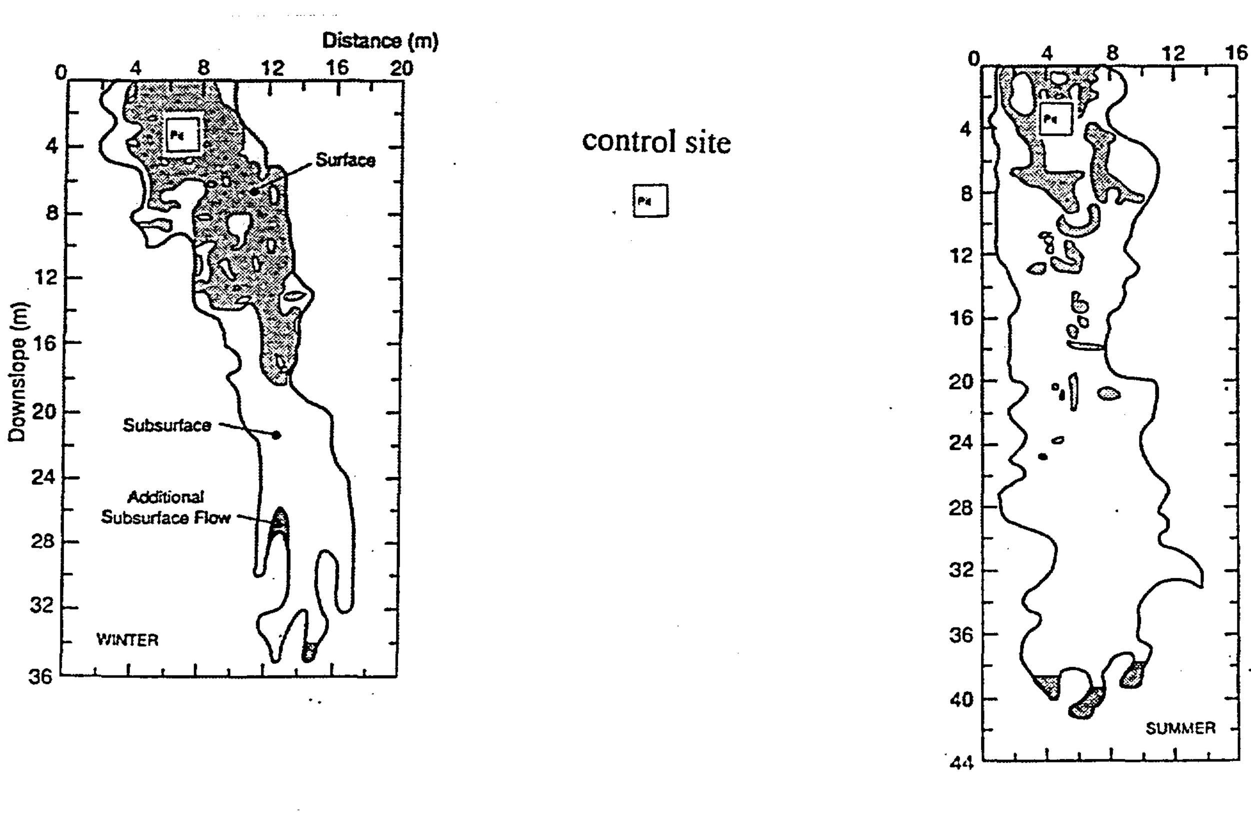

Figure 2: Winter and summer experimental spills and location of soil sampling pits. Distance between spill zones not to scale.