**Environmental Geotechnics: Learning objectives and learning outcomes**

This document gives in Table 1 the learning objectives of the course and in Tables 2 – 4 the learning outcomes for the three units with the theoretical foundations of the course[[1]](#footnote-1). The detailed learning outcomes in Tables 2 – 4 translate learning objective No 2 in Table 1 into detailed observable outcomes.

**Table 1.** Learning objectives of environmental geotechnics course.

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| **The goal is achieved if at the end of the course the students:** | |
| (1) | can locate reliable data on the effects of contaminants on human health; |
| (2) | are confident in applying principles of subsurface flow, soil-contaminant interaction and contaminant transport to problems of contamination and restoration of the subsurface; |
| (3) | are able to address the geoenvironmental aspects of landfill and clay barrier design; |
| (4) | are familiar with a wide range of remediation technologies; |
| (5) | are able to take initiatives related to modeling, i.e. related to the formulation of a simplified problem that admits solution; |
| (6) | are aware of some social or public policy dimensions of the problems of subsurface contamination and restoration. |

**Table 2.** Learning outcomes for unit: Subsurface Flow.

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| **What can I do with what I learned?** | |
| For 1-D problems (or 1-D simplifications of 2-D flow fields), and constant hydraulic gradient (in time): | |
| (1) | I can calculate hydraulic head and piezometric head; |
| (2) | I can read potentiometric maps (i.e. hydraulic head maps), i.e. I can tell the direction of groundwater flow and calculate hydraulic gradient; |
| (3) | I can apply Darcy’s law to calculate velocity, discharge, or hydraulic head; |
| (4) | I can perform calculations for advection-driven transport of contaminants (e.g. travel time). |

**Table 3.** Learning outcomes for unit: Soil-Contaminant Interaction.

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| **What can I do with what I learned?** | |
| (1) | If I want to evaluate the behavior of a contaminant in the subsurface: I can find its mass transfer characteristics (vapor pressure, Henry’s constant, solubility, soil-water partition coefficient) from reliable sources. |
| (2) | If I know or suspect the presence of a NAPL contaminant: I can estimate degree of NAPL saturation and calculate total contaminant mass. |
| (3) | With known contaminant concentration in any of the three soil phases (air, water, solids), or in a water sample, or in a soil sample, I can calculate concentration in each of the three phases and total contaminant mass in a soil sample or in the contaminated area in the field. |
| (4) | When I am asked to calculate total mass, given either NAPL saturation or contaminant concentration in one of the three soil phases, I don’t need to be reminded that the contaminant will partition to all soil phases! |

**Table 4.** Learning outcomes for unit: Contaminant Transport.

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| **What can I do with what I learned?** | |
| (1) | I can estimate the relative contribution of transport phenomena for specific combinations of pollutants, soils and characteristics of the flow and transport fields. |
| (2) | I am familiar with literature searches for values of transport parameters. |
| (3) | I can back reasonable estimates for the values of the parameters involved in a problem of contaminant transport. |
| (4) | I am aware of a variety of analytical solutions of the contaminant transport equation and I understand the limitations of each one. |
| (5) | I can select from a variety of analytical solutions of the transport equation the one that fits better the geometry of a contaminant release and the expected contribution of the transport phenomena. |

1. Definitions of terms used:

   **Learning objective**: what is to be achieved through teaching

   NOTE Typically, the learning objectives of a course/program are fewer and broader compared to learning outcomes.

   **Learning outcome**: what can be measured/observed through assessment

   NOTE Often, learning outcomes result from translating learning objectives to detailed observable outcomes. [↑](#footnote-ref-1)