Phased Remedial Approach Following the BATNEEC Principle to Address Off-Site Migration Risks

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Background/Objectives. At an active industrial plant in Belgium, a multi-level remedial strategy has been developed to address a complex cocktail of contaminants (chloroethenes, chloroethanes, chloromethanes, chlorobenzenes, chlorophenols, chlorotoluenes and nickel) present in soil and groundwater. High-resolution investigation efforts identified multiple on-site source areas associated with historical production activities. Remediation is required to mitigate off-site migration and address potential human health risks towards downgradient receptors. The remedial strategy consisted of installing a hydraulic containment barrier at the downgradient Site border to mitigate to the extent possible off-site contaminant migration, and a phased approach to remediate the major sources of pollution, within the limits of the BATNEEC (Best Available Technique Not Entailing Excessive Costs) principle as defined in European Union directives. Pilot tests have been performed at the source areas to evaluate the feasibility of implementing a soil vapor extraction (SVE) system in the vadose zone, and enhanced reductive dechlorination (ERD) in the saturated zone. Concurrently, a Monitoring Natural Attenuation (MNA) program was implemented to further characterize the natural attenuation processes occurring in the on- and off-site plumes.

Approach/Activities. Given the historical nature of the contamination, remedial objectives were defined following a risk-based approach. The Biochlor model was used to define the concentrations to be reached in soil and groundwater at the source areas in order to achieve regulatory threshold values at the site border. The remedial approach consists of installing a multi-phase extraction (MPE) system in the backfill and upper silty layers, and a recirculation system to enhance the biodegradation of the chlorinated solvents in the deeper and more permeable sandy layer. This approach was defined based on the results of a field pilot test performed at the site to evaluate the best injection technique and carbon substrate. The design of the full-scale remediation approach followed the BATNEEC principles, the potential synergy with the existing P&T system, and the contaminant mass flux contribution of the different contaminated layers.

Results/Lessons Learned. The original remediation strategy consisted of addressing the unsaturated zone with a SVE system and the saturated zone by enhanced bioremediation. Given the local hydrogeological conditions, carbon substrate injections in the shallow layers could not be implemented successfully. Given that extracted groundwater can be treated via the existing P&T installation, it has been decided to address the unsaturated zone and the upper saturated zone by a MPE system. During the pilot test, enhanced bioremediation was tested in the deep sandy layer via direct push points and via a Push-Pull test. Further, a Step-Drawn test and injection tests were performed to evaluate the possibility of amending the carbon source via a recirculation system. The results of these tests indicated that a network of recirculation wells was the best technique to amend the sandy layer with a carbon source to stimulate reductive dechlorination.