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Assessing the Potential of Natural Source Zone Depletion (NSZD) of Hydrocarbon as a Cold-Climate Soil Remediation Strategy

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Background/Objectives. When hydraulic methods used to remove subsurface hydrocarbon impacts from a site are exhausted, residual hydrocarbon may still be present in the subsurface. Additional remediation strategies are often pursued, but can pose safety and logistical challenges, particularly at remote sites. A remediation strategy which relies on the natural attenuation of residual hydrocarbon in the subsurface, accompanied with a thorough exposure risk analysis, may be an effective alternative to currently practiced methods.

Natural source zone depletion (NSZD) is a term reflective of all the natural degradation processes in the subsurface of an impacted soil leading to depletion of a hydrocarbon source zone (i.e. a hydrocarbon plume). Biodegradation is the dominant process in NSZD and quantification of the CO_2 generated by hydrocarbon biodegradation has been proposed as a means of estimating NSZD. Several past NSZD studies have shown great promise, but few have focused on remote, cold-climate sites, such as those in the Arctic.

Imperial has previously demonstrated the utility of above-ground, engineered bioremediation strategies at Arctic sites, but has yet to confirm that quantifiable NSZD is occurring at these sites. A demonstration of effective subsurface biodegradation occurring at a cold-climate site would serve to expand the geographic range of where NSZD could be reasonably proposed as a remediation strategy. With long-term deployments of durable NSZD monitoring technologies, many safety and logistical challenges of remediating remote sites could be lessened by reducing the amount of personnel time required in the field.

Approach/Activities. In 2015 and 2016, field campaigns were conducted at an Arctic operation in an area of known hydrocarbon contamination. Using two CO_2 efflux measurement methods, one providing a time-averaged flux and the other providing real-time flux data, the CO2 efflux of the impacted site was compared to that of a control site. The isotopic distributions of effluxed CO_2 were also analyzed to provide information on the subsurface carbon sources.

Results/Lessons Learned. Data from the 2015 field campaign was used to demonstrate that a statistically different average CO_2 efflux was noted at the impacted site compared to the control site. Additionally, isotopic analyses of the effluxed CO_2 suggested that a greater portion of “fossil-fuel” related carbon was being effluxed at the impacted site. It was estimated that NSZD is occurring at a rate of approximately 150 gallons/acre/year at the impacted site. To further refine the annual NSZD rate estimation, 2016 field activities were conducted throughout the year in an attempt to discern the seasonal variability in hydrocarbon-related CO_2 efflux at the impacted site.