2011 Vegetative and Soil Mesofaunal Changes at Boreal Peatland Field Sites from Produced Water Spills: Implication for the Environmental Assessment and Remediation of Upstream Oil and Gas Sites

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Moderately to highly saline groundwater co-occurs with most petroleum oil and natural gas deposits. Releases of saline “produced water” potentially affect peatland-forming wetlands (bogs and fens), particularly in temperate to sub-arctic circumpolar environments. This study quantifies vegetative and soil faunal responses to salinization of western Canadian boreal peatlands, towards the development of ecological risk-based remediation guidance.

Field data on the abundance (or percent cover) of

vascular plants, bryophytes, and soil mesofauna were obtained in the summer of 2008 and 2009 from nine produced water release sites in Alberta and British Columbia. Research plots (1 m2 quadrat and peat core sample sites) were established along salinity gradients within fen (n=5), bog (n=3) and marsh (n=1) ecosystems arising from recent spills (mostly <5 years old). The diversity of vascular plants and bryophytes, measured as species richness, exhibited a significant decrease linearly in peatlands and other wetlands in relation to the log10 of salinity (measured as electrical conductivity) of either wetland soils or interstitial water. The particulars of the salt concentration – biotic response relationship were very similar for seven of nine sites (predominantly fen sites), while a statistically significant relationship between species richness and the log10 of salt levels was different for a large marsh site in central Alberta. Marshes generally exhibit higher plant diversity than peatlands: Plots at the marsh site exhibited higher plant diversity at a given salinity than the fen sites, but the slope of the best-fit line describing the species richness – salt concentration relationship was similar to that of the fen sites. The overall presence-absence data provide a clear indication of the salinity tolerance ranges of 31 dominant vascular plant and bryophytes species, including three commonly occurring species of sphagnum moss, rough bentgrass, black spruce, dwarf birch, Labrador tea, and dwarf bog cranberry. Some plants

such as fireweed, Labrador tea, dwarf birch or aquatic sedge were observed to persist at soil salinities in excess of 6 – 8 mS/cm, while some species such as Sphagnum girgenshoni or common strawberry were not observed at soil salinities in excess of 3 to 4 mS/cm.

The vast majority of observed plants and bryophytes (101 of 162 observed species) were observed in only one or a few of the 128 plots total. The salinity tolerances of these more rare species cannot be defined without use of an alternative methodology, since presence in any plot for rare species is ascribed firstly to ‘chance’ encounters and secondarily to the salt levels in the co-located soils and interstitial water.

No appreciable relationship could be discerned between soil or interstitial salt levels and the abundance or composition of soil invertebrates (mesofauna) extracted from peat cores obtained from the same plots used to assess vegetative ecology. The absence of a discernible influence of plot salinity on mesofaunal abundance or composition is hypothesized to have resulted from microenvironmental variability in near-surface environments (both laterally and horizontally) that was not adequately captured by the sampling methods, and identification of mesofaunal taxi to only the family level or higher.

Occurrence data for each plant and bryophyte species that were observed in eight or more of the 127 plots

assessed at field sites allow for estimation of frequency of occurrence statistics for each taxon along a (log10) gradient of increasing salinity. The field data for Alberta peatland environments provide evidence of salinity ranges at which various plants may persist, at least for shorter time periods of approximately a half decade or less. Among the commonly occurring peatland sphagnidae, S. magellanicum was observed to be relatively salt tolerant, while S. girgenshonii and S. fuscum are relatively salt intolerant. Black spruce (P. mariana) is poorly tolerant to salinization; therefore, at historical release sites, it can be expected that the majority of other peatland vegetation can potentially recolonize the disturbance site once P. mariana seedlings start to appear.

2011 AECOM_Saline Releases to Peatland
2011 AECOM_Ecological Effects of Salt Releases to Boreal Peatlands_Final
2013 AECOM_Saline Releases to Peatland