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An evaluation of the hydrological functioning of a constructed wetland in the Athabasca oil sands region, Canada – six years after commission

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Bitumen extraction via open-pit surface mining has resulted in large scale alteration of Boreal forest and wetlands in the Athabasca oil sands region (AOSR) of Alberta, Canada. As part of the operating license, companies must reclaim disturbed landscapes into functioning ecosystems such as forests, wetlands and lakes that existed in the landscape prior to mining. While reclamation of forest ecosystems has received considerable attention, only recently have companies constructed integrated upland-lowland systems with the objective of forming sustainable peat-forming wetlands. The challenge is to design and construct sustainable ecosystems that are resilient to inherent climate variability while limiting salinization from the underlying mine waste material upon which reclamation occurs. To date, two upland-wetland systems have been constructed in the AOSR, and research has focused on the immediate hydrological, biogeochemical and soil physical changes following construction. Only recently has sufficient data been collected to evaluate possible trajectories. In this study, we present six years of findings from the Sandhill Fen Watershed (SFW), a 52-ha upland-wetland system built on soft tailings designed with a pump and underdrain system to provide freshwater if needed, support drainage, and limit salinization from underlying waste. Since the SFW was commissioned in 2012, the system has undergone considerable changes as a result of water management and natural hydrological and ecological processes. SFW was initially wet and heavily managed in its first few years, yet since 2014 no water has been added artificially to the system and despite a drier than normal climate, an extensive saturated lowland has developed that requires occasional drainage as no natural outflow occurs. Mixed boreal species have established in the upland, whereas Carex and Typha dominant the wetland. In terms of hydrological fluxes, the system is predominantly vertical with evapotranspiration varying little between uplands and lowlands and being most responsive to inter-annual climate at present. Runoff from upland hummocks to wetlands has occasionally been observed during snowmelt and preliminary evidence suggests some lateral redistribution. Geochemical changes have been considerable, with an increased salinity year-over-year and changing ionic composition, with certain areas of SFW having electrical conductivity in excess of 4000 [U+F06D]S/cm. Net ecosystem exchange indicates that the lowland rapidly became a carbon sink after three years, yet has returned to a source in recent years as a result of changes in vegetation. While there have been considerable changes during the first six years, it is uncertain as to the continued rate of change of salinity and its impact on plant health and biogeochemical processes. Furthermore, as SFW is integrated into the larger landscape with time, changes in hydrology will occur. It is critical to continue long-term research at these experimental ecosystems for future guidance in wetland design, as current landscape disturbance exceeds 800 km2 with the potential to increase up to 4800 km2 in the future.