Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02900, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02900
EGU General Assembly 2008

Evaluation of comparative hydrological sustainability of reconstructed and natural watersheds

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Mining is an environment threatening human activity disturbing thousands of acres of landscapes for the natural resources such as oil, coal, etc. One of the remedial activities of this issue is the reclamation of the disturbed lands. In the design process of reclaimed landscapes, a major concern is the hydrological sustainability, which includes ability of storing enough soil moisture for the vegetation growth and land-atmospheric moisture fluxes. Comparative evaluation of the hydrological sustainability of the reclaimed (reconstructed) watersheds with natural watersheds is required as the goal of reconstructed watersheds is to bring them back to the level of natural watersheds in all respects. A real life example of watershed disturbance is a large scale mining in the Athabasca basin, Alberta, Canada, to gain access to the oil sands. In the process of reclamation of these disturbed lands, the overburden soil is placed back into the mined pits and reformed by curtaining with soil covers constructed with a thin layer of a peat- mineral mix overlying on a secondary (glacial till) layer on the shale formation to mimic the natural soil horizons of undisturbed watersheds.

In this study, a developed System Dynamics Watershed (SDW) model is modified and used to model the hydrological processes (soil moisture, evapotranspiration, and runoff) of a reclaimed experimental watershed located in the Athabasca mining basin. An analogous model is developed and used for modeling the hydrological processes of a natural watershed (boreal forest) located in the Southern Study Area (SSA), BOREAS, in Saskatchewan, Canada. In both the study areas, the hydrological processes are simulated reasonably well despite of high complexity induced in the soil moisture and evapotranspiration processes. Long term simulations (50 years) are carried out using the above calibrated and validated models, on both the reclaimed and natural watersheds. The daily soil moisture results are used to address the soil moisture storage capability of the watersheds, with the help of a probabilistic approach. The study shows that the reclaimed watershed provides less moisture for evapotranspiration requirements than the natural watershed. Less annual maximum soil moisture deficit is observed in the reconstructed watershed than the natural watershed for the 90% designed probability of the soil cover failure. These could be attributed to the reason that the reconstructed site is still in the process of restoration and takes a few more years to get closer to the natural watersheds in terms of the hydrological sustainability. The study also demonstrates the utility of system dynamics approach of modeling the ecosystems. Adding a vegetation growth model to the hydrological model would be more helpful for better realistic conclusions and should be useful in the design and formation of reclaimed watersheds.