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Flow simulation and erosion assessment in a ditch network of a drained peatland forest catchment in Eastern Finland

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One third of the land area in Finland is covered by peatlands and today 4.5 million ha of peatlands are drained for forestry purposes. In order to sustain forest productivity, ditch networks are maintained annually on an area of approximately 60 000 ha. The suspended solid (SS) load from drained peatland forest sites after ditch network maintenance causes one of the largest strains on the water system by forestry in Finland. Understanding the hydraulic processes in newly maintained ditch networks is necessary for quantifying the SS load generation and transport in the source areas.

In this study we developed a hydraulic unsteady-flow model to predict the behavior of flow in a drainage network in a boreal forested peatland site. The input to this model was in the form of a discharge hydrograph that was produced by a hydrological model (FEMMA). The simulations were performed using the algorithm of Zhu et al. (2011) for unsteady flows in a network of channels. In this iterative procedure, the Saint-Venant equations that govern the flow in each of the network channels were solved separately, and the flow depths at the junction-points were corrected using the method of characteristics. The algorithm was programmed using the numeric computing environment MATLAB by MathWorks. Based on the hydraulic conditions produced by the model, erosion risk within the network was evaluated.

The model was applied to a peatland catchment drained for forestry in Koivupuro in Eastern Finland (63°53' N, 28°40' E). In August 2011, most of the Koivupuro catchment ditch network was maintained creating simultaneously a smaller nested catchment (area 5.2 ha) which was the focus of this study. The ditch network consisted of 15 branches, altogether 1.6 km in length, and 8 junctions. The model performance was evaluated against flow depth measurements at 5 locations in the network. The simulations in the small ditches of Koivupuro with mostly very low flow rate (< 0.05 m3/s) introduced its challenges. It was found that the magnitude of flow resistance depended highly on the flow conditions and no single Manning's coefficient could be applied for the full range of flow conditions. Consequently, flow resistance was introduced as a function of discharge.

Based on the predicted flow velocity and bed shear stress evaluation, the highest erosion risk was found in the southern end of the first and second ditch, close to the outlet of the catchment. Along these reaches, the flow was relatively high and the bed slope steep. In accordance with previous studies on drained peatlands, the results suggested that only the highest peak flows have a role in SS generation in the Koivupuro ditch network.