A UNIFIED APPROACH FOR RIVER MORPHOLOGY, SEDIMENT TRANSPORT, AND EROSION STUDIES

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Abstract: Vectorial and variational approaches are the two basic approaches in mechanics. A systematic review of these two approaches concludes that the theory of minimum energy dissipation rate and its simplified versions of minimum stream power and minimum unit stream power can be applied to solve a wide range of problems which are difficult or impossible to be solved from vectorial approach alone. The minimization theories can be derived from thermodynamic laws and theories. They can also be derived from mathematical argument.

The unit stream power theory for sediment transport can be derived from well-established and adopted theories in fluid mechanics. Yang's unit stream power equations based on this theory are easy to apply and are generally more accurate than other equations. These unit stream power equations can be applied for the determination sediment transport in the clay, silt, sand, and gravel size range. The unit stream power theory is applicable to laminar as well as to turbulent flow conditions. The unit stream power equations can be applied to sub-critical, critical, and supercritical flows with or without the influence of wash-load.

Conjunctive use of the theory of minimum energy dissipation rate, or its simplified theories, and unit stream power equations can provide us the theoretical basis of a unified approach for river morphology, sediment transport, and erosion studies of a watershed and its river systems.

Bureau of Reclamation's Generalized Sediment Transport computer models for Alluvial River Simulation (GSTARS 2.0/2.1/3) are based on the unified approach and stream tube concept. These models can simulate and predict semi-three-dimensional erosion, transport, and deposition processes in rivers and reservoirs under quasi-steady flow conditions by solving one-dimensional equations along stream tubes. These models have been successfully applied to solve a wide range of river and reservoir sedimentation problems. The GSTAR-1D model was developed for unsteady flows with cohesive and non-cohesive sediment transport.

A review of Geographic Information System (GIS) and remote sensing technology concludes that they are useful and powerful tools to store and analyze geologic, geographic, land use, and ground cover information. These technologies can be coupled with erosion and sediment transport computer models for solving water resources, environmental, and engineering problems.

The Generalized Sediment Transport model for Alluvial Rivers and Watersheds (GSTAR-W) being developed is base on the unified approach using GSTARS2.0/2.1/3/1-D as building blocks and GIS and remote sensing as tools for the determination of total maximum daily load of sediment in a watershed and its river and reservoir systems. GSTAR-W will be a physically based, process oriented, temporal and spatially distributed model upon its completion.