Ongoing Research

US Army Corps of Engineers®

Urban Flood Demonstration Program

Vegetation-Hydrodynamic Interactions in Flood Control Channels

Figure 1. The Upper Verde River near White Bridge, AZ

Products This research effort will produce a technical report or technical note focusing on dissemination of data and intellectual products as they relate to the practicing design engineer and one or more peer-reviewed journal papers.

Benefits Understanding flow-vegetation-soil factors and their relationship with vegetation failures (rupture and uprooting) help understand and predict vegetation washout under different flow and channel conditions. Such understanding and prediction can be valuable for the risk assessment of Corps operation.

Issue Vegetation encroachment is a serious issue in the ephemeral and flood-control channels in the Southwest U.S. region. It reduces channel conveyance capacity below design objectives and can greatly increase the risk for loss of life and property damage. Vegetation washout that may occur under high flood events can also pose threat to the safety of the flow conveyance structures and can bring massive damage under artificial damming at bridges and other conveyance structures.

Description This effort is a continuing work unit from last year wherein the foci of the research had been: 1) setting up of protocol of field data collection 2) estimation of elasticity of the major woody riparian species of the region 3) development of the predictive analytical tools for the estimation of height ratio and bending as a function of species, and better

understanding of vegetation-flow field interaction illuminating the rupture location under different flow, force and vegetation characteristics.

Elasticity of the three key woody riparian species (Cottonwood, Salt Cedar, Willows) of the Southwest US region was estimated (based on limited tree-pulling exercises in Las Vegas Wash; Rio Grande, Albuquerque; and San Louis Rey River, Los Angeles) which served as an input to the computation of height ratio under bending of the trees. The tree-pulling experiments were conducted in close cooperation with ERDC. A numerical algorithm has been developed to predict tree bending as a function of velocity. Based on the algorithm, height ratios for three different woody riparian species (Cottonwood, Salt Cedar, Willows) were quantified as a function of water velocity for the considered plant species. In addition, for better understanding of the vegetation-flow interaction, another analytical technique has also been developed for investigating vegetation bending and rupturing under emergent vegetation flow conditions. The developed theoretical approach can be used to determine the critical flow condition for which vegetation with a given maximum tensile stress is expected to fail.

The study has, to date, focused on the bending of vegetation mainly as a function of species. Bending and failure of trees are function of flow hydraulics, vegetation (species rigidity and root properties) and soil related (environmental) factors such as soil properties, soil moisture, depth to water table, and scour condition among others. In view of this, following tasks are to be undertaken this year:

Task 1. Set up a base hydraulic model for a reach in one of the three streams considered (San Louis Rey, Las Vegas Wash or Rio Grande). Get preliminary result by using iterative approach of calculating water surface elevation by applying collected information on height ratio to calculate roughness coefficient as outlined on ERDC TN-EMRRP-SR-07.

Task 2. Augment data through additional tree pulling exercise covering wide range of vegetation under different hydrologic and environmental conditions (include scours). The influence of scour will be assessed by artificially scouring the base of test trees during the bending tests and by placing scour chains in areas where we expect high flow in order to evaluate actual scour depth. This task will be done in close collaboration with ERDC.

Task 3. Perform additional analysis to elucidate the relationship of the failure mode (contributing to washout) with vegetation and hydraulic and soil properties. This will be based on the collected data in task 2 and analytical solutions. Develop predictive relationships for the vegetation bending and washout under different flow and soil conditions.

Task 4. The final objective of this task remains unchanged, which will be to incorporate the new washout prediction techniques into the methods currently applied in USACE flood reduction studies. Scaling from a single tree to a group of vegetation consisting of many species and of different sizes has been one of our main challenges. During this funding cycle, all the work completed will be compiled as an intermediate technical report and presented as a guidance document to USACE.

Sponsor

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

Points of Contact

Kumud Archarya, Desert Research Institute
Email: kumud.acharya@dri.edu
Phone: 702-862-5371

Li Chen, Desert Research Institute
Email: li.chen@dri.edu
Phone: 702- 862-5349

Cary A. Talbot, Program Manager, ERDC, Coastal and Hydraulics Laboratory
Email: Cary.A.Talbot@usace.army.mil
Phone: 601-634-2625

Partners

Craig Fischenich, ERDC, Environmental Laboratory
Email: Craig.J.Fischenich@usace.army.mil
Phone: 702-862-5371

Kyle McKay, ERDC, Environmental Laboratory
Email: Kyle.McKay@usace.army.mil
Phone: 601-415-7160