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Modeling and Managing Hydromodification Effects: Summary of Available Tools and Decision-Making Approach

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EXECUTIVE SUMMARY

Hydromodification management has traditionally focused on addressing excessive erosion or deposition in channels and the resulting geomorphic changes. The evolution of stormwater management beyond a focus on water chemistry is an important step forward in holistic efforts to protect the physical, chemical, and biological integrity of water courses. However, current approaches to hydromodification have been limited to managing runoff at the site of new or re-development. Although this approach is beneficial, there is a need for hydromodification management to evolve to a watershed-based approach focused on restoration and protection of watershed processes. Accomplishing this requires developing and organizing new tools and approaches that support integrative assessment and management. This document summarizes suites of modeling tools that can be used to help characterize and predict the complex and multifaceted effects of hydromodification. We also present an approach for developing management prescriptions that account for the specific needs and constraints of individual stream reaches in the context of the watershed in which they exist.

Modeling tools can be organized into four basic categories in increasing level of complexity: descriptive tools, statistical models, mechanistic models with deterministic outputs, and probabilistic models. Descriptive tools are the easiest to apply, but typically provide only general or coarse resolution output. Statistical and mechanistic models are more precise, yet require more data input for their use. Finally, probabilistic models are relatively new for stream analysis, but have the advantage of providing an explicit account of model uncertainty. In most cases, multiple modeling tools will be necessary to fully assess potential hydromodification effects; however, the precise combination of tools applied will vary based on needs, quality of streams being managed, and available resources.

We have developed several new tools, which are also described in this document. These include:

- Revised *regional hydrologic curves* for estimating discharge in ungauged basins.
- Analytical *regime diagrams* that allow prediction of changes in channel dimensions based on changes in water or sediment discharge.
- A regional update to the *channel evolution model* that illustrates expected trajectories of channel response to hydromodification.
- Several statistical *channel enlargement models* based on regression using local data.
- An *artificial neural network model* for predicting change in channel cross-sectional area based on a suite of watershed variables.
- An updated version of the *GeoTools spreadsheet package* for assessing geomorphic response.

These tools, in combination with existing tools, have the potential to advance hydromodification management by:

- Providing a physical basis for making predictions of stream response to watershed development.

- Assessing alternative future states of streams under different management scenarios.
- Avoiding one-size-fits-all solutions through:
  - Improved prediction of relative magnitude of potential channel change and proximity to response thresholds; and
  - Tailoring mitigation strategies to streams with different levels of susceptibility.

Statistical models developed in this study indicate that the magnitude of channel enlargement and overall risk of channel instability are highly dependent on the ratio of post-to pre-urban sedimenttransport capacity over cumulative duration simulations of 25 years. This ratio is often termed the *erosion potential (Ep)* or *load ratio (Lr)* and is a better predictor of long-term channel response than stream discharge. In addition, hydraulic variables (such as *Ep*, shear stress, or stream power) provide a "common currency" for managing erosion and associated effects that can be applied across many streams in a region. *Overall, the enlargement models point to the importance of balancing the postdevelopment sediment transport to the pre-development setting over an entire range of flows rather than a single flow in order to reduce the risk of adverse channel responses to hydromodification*.

As with modeling, management strategies should also address the complexity of processes that affect stream response to hydromodification through application of a broad suite of management strategies beyond traditional site-based flow control. The foundation of any hydromodification management approach should be a watershed-scale analysis of existing and proposed future land uses and stream conditions that identifies the relative risks, opportunities, and constraints of various portions of the watershed. Site-based control measures should be determined in the context of this analysis. Clear objectives should be established to guide management actions. These objectives should articulate desired and reasonable physical and biological conditions for various reaches or portions of the watershed. Management strategies should be customized based on consideration of current and expected future channel and watershed conditions including constraints that may limit the ability to apply certain approaches (e.g., existing development and channelization). A one-size-fits-all approach should be avoided.

An effective management program will likely include combinations of on-site measures (e.g., low-impact development techniques), in-stream measures (e.g., stream habitat restoration), and off-site measures. Off-site measures may include compensatory mitigation measures at upstream locations that are designed to help restore and manage flow and sediment yield in the watershed. To address existing, legacy and anticipated future effects, management approaches will need to focus on controlling erosion, deposition, and planform change as well as restoring watershed processes that ensure movement of water and sediment in ways that help maintain the dynamic equilibrium of stream channels. Such process-based management actions include:

- Protecting and restoring coarse sediment-supply areas.
- Maintaining and sediment transport capacity through critical stream reaches.
- Protecting and restoring floodplain connections and infiltration areas adjacent to channels.

Modeling and management programs should be connected to robust monitoring that can provide data to calibrate, test, and refine models and improve management approaches and the empirical basis upon which they are constructed.

Full Text

http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/753_HydromodModelingMgmt.pdf