Vermont Department of Environmental Conservation

Fluvial Geomorphology: a Foundation for Watershed Protection, Management and Restoration

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FLUVIAL GEOMORPHOLOGY: A FOUNDATION FOR WATERSHED PROTECTION, MANAGEMENT AND RESTORATION

Introduction:
The Vermont Agency of Natural Resources is at a significant milestone in its implementation of public policy and water resource management. Several ambitious, watershed-based initiatives of great potential consequence for the people and natural resources of Vermont are in various stages of formulation and application. These include the Watershed (Basin Planning) Initiative, Stormwater Management, TMDL Implementation, Public Education, Riparian Buffers Policy, Hazard Mapping and Geomorphic River Management and Restoration. Public policy in the area of phosphorus reduction, particularly in the Lake Champlain watershed, is shifting its emphasis toward non-point sources and erosion control as cost-effective investments to achieve phosphorus loading goals. Farm policies are beginning to embrace riparian management practices and programs, such as CREP (Conservation Reserve Enhancement Program), which can effectively protect, sustain and enhance agricultural productivity.

Successful implementation of any and all of these far-reaching initiatives is entirely dependent upon building and sustaining public support. Each program must include four components of equal strength and focus: **Protection, Management, Restoration and Education**. Equally important for achievement of cost-effective results is a science based methodology which can be applied to help prioritize and focus application of the limited resources available under any of these critical initiatives.

The purpose of this Concept Paper is to show how the principles and applied methods of **fluvial geomorphology** can be used to help provide a science based foundation to technically support the State's water resource initiatives and how public support and ultimately public policy can be influenced by measurable, incontrovertible field data that documents resource condition and quality and departure from a natural system's ultimate ecological and economic potential. **Fluvial geomorphology** is one of the essential tools and organizing principles for community-based watershed protection, management, restoration and education.

Facts:

- Fluvial geomorphology is a science which seeks to explain the physical interrelationships of flowing water and sediment in varying land forms. It is a science, the understanding and strength of which, has advanced greatly in the last decade primarily due to an extraordinary volume of rigorously measured and analyzed field data obtained from all over North America.

- The Vermont ANR has made a significant investment in staff training to become proficient in the application of the science of fluvial geomorphology.

- Partnerships between state and federal resource and infrastructure management agencies, watershed associations and individual communities are being formed and supported through shared understanding of the physical processes and geomorphic condition that is described through physical assessments.
- The Vermont ANR and its partners have made substantial progress in developing the necessary application tools including databases of field measurements of Vermont

streams supportive of resource protection, management, restoration and education decisions and policies.

- Cost-effective, multi-objective, ecological and economically supportable resource protection, management and restoration decisions are made possible by field data based physical assessments that establish system condition and potential. Field data provides the evidence upon which public support is made possible.

- The principles and applied methods of fluvial geomorphology can be used to:

  - Assess stream channel stability and understand or predict the evolution of channel adjustments that <u>must</u> take place in response to anthropogenic or other external influences. How will the stream system respond to proposed or projected land use changes, riparian corridor encroachments or channel modifications such as flood control projects?

  - Develop lake watershed management plans through sediment and nutrient budgets to develop effective strategies for nutrient reduction. What is the contribution of streambank erosion to sediment and nutrient loadings in relation of surface run-off or wastewater treatment plant discharges?

  - Assure that investments in transportation infrastructure maintain or improve channel stability and resource values and minimize maintenance costs. What are the long term effects on channel stability caused by roadway approaches to bridges or culverts that fill flood plains? Do cost-effective alternatives exist based on lower life-time maintenance costs, enhanced public safety and improved stability and resource quality?

  - Establish the basis for flood plain and riparian corridor management and protection that reduces the potential for flood losses and conflicts with human investments. A science-based methodology is made possible to determine high risk areas for development along all stream corridors; a significant expansion of and improvement over the existing National Flood Insurance Program methodology.

  - Describe the complex spatial and temporal scales of cause and effect and the implications for lake and stream impacts created by watershed land use, flood plain or channel management practices oftentimes conducted far away and in the past. How is the stream system responding today to extensive gravel mining conducted 15 years ago, or the channelization for flood control purposes performed in 1973, or the flood plain encroachments created by the construction of a railroad the entire length of the valley in 1910?

  - Predict the sensitivity of waterbodies to watershed change, channel or flood plain encroachments and how a watershed as a whole will benefit from a geomorphic based management and protection plan and restoration of channel stability. Streams of different physical type and in varying valley settings react to external influences and channel management practices differently. The science enables us to predict system response in virtually any location.

- Support the resolution of water resource problems on a watershed scale rather than continue the historic approach of reacting to the symptoms of a broader problem, site by site. Armoring 500 linear feet of unstable streambank within a mile long unstable reach invariably exacerbates the problem and represents a wasted investment.

- Illustrate to and educate the public on physical processes and the imperatives of system response to watershed and riparian corridor management decisions. Field data is a powerful tool to show physical processes and system condition in relation to potential.

- Provide the data that can support stream buffer and river corridor protection and management decisions.

Discussion:

The Vermont Agency of Natural Resources is embarking on several new watershed initiatives in response to statutory mandates, identified public need and a growing constituency for watershed protection and restoration. The Agency has become equipped and more proficient with the tools necessary to formulate, implement and sustain these initiatives effectively.

Initiatives commenced in the 70's, such as wastewater treatment, were successful because they looked at a specific problem and solved the problem of wastewater assimilation at the watershed scale. Today the problems involve the often competing demands for the use and enjoyment of waters, polluted runoff, exotic species, and the pervasive problem of stream instability. To be effective, basin planning and other initiatives must go beyond the enumeration of symptoms and use the analysis of physical, chemical, biological, and social data to explain the root problems of Vermont's troubled waters.

Watershed assessments in Vermont's 305b Report to Congress have described erosion/ sedimentation and phosphorus as the largest categories of pollution in the state. These two concerns are related, in that eroding stream bank soils may very well be one of the largest sources of sediment and phosphorus entering our watersheds. The root causes for eroding stream bank soils are the removal of riparian vegetation, hydrologic modifications, flood plain and channel encroachments and the channel management practices that have been conducted to address the symptoms of these original causes. These activities have caused stream instability at the watershed scale, wherein bank erosion at one location triggers further stream bed and bank erosion in both upstream and downstream directions.

As a result of intensive staff training in recent years, the Agency has begun to implement the principles and applied methods of fluvial geomorphology in stream alteration permits, river restoration, public hazard identification, and river education programs. Initial success with explaining complex stream problems and restoring stream reaches using a geomorphic approach presents an important opportunity for resource managers and watershed constituents. Fluvial geomorphology, a science which seeks to explain the physics of flowing water and sediment in different land forms, is an essential tool and organizing principal for community-based watershed protection and restoration. **The field data derived through physical assessments conducted on streams following a rigorous geomorphic-based methodology can be supportive of many other state water resource initiatives and programs**.

Successful initiatives that lead to meaningful actions will be important in explaining the relationship of erosion, aquatic habitats and water-based recreation with channel stability in different watershed land forms. For instance, basin plans that include an assessment of stream type and stability could then effectively explain the sensitivity of streams to land use changes, flood plain encroachments, loss of riparian vegetation and channel management activities. Once completed, these plans would address a large root cause of the erosion/sedimentation and phosphorus loading problems and present specific actions that can be prioritized on a watershed basis.

For decades now, the economic, ecological and recreational values of the majority of our Vermont rivers and streams have been substantially degraded from their true potential. The State has the opportunity now to restore and strengthen the water resource based economy of the state.

Recommended Actions:

To effectively deal with stream channel instability, arguably Vermont's greatest water resource challenge, and to support other on-going critical water resource protection and management initiatives, Vermont's water resource managers, scientists, and policy makers should take actions toward the following goals:

I). Create a multi-objective and geomorphic framework for stream management in Vermont and develop an informed partnership of resource managers and watershed constituents.

Support an approach based on applied fluvial geomorphology which focuses on improving stream stability and function as a central management goal. This approach is effective because it addresses the multiple objectives of various stakeholder groups, and can be understood and applied by such diverse individuals as town planning board members, road foremen, landowners, and local, county, state, and federal resource agencies. This strategy complements more traditional approaches to stream management by creating projects and plans that serve goals of ecosystem restoration in equal measure to human needs of flood risk mitigation, private property protection, water quality improvement and recreational opportunities. The Agency of Natural Resources has begun education, training and outreach programs as well as fostered state and federal partnerships through data collection and river stability demonstration projects.

II). Develop databases to support stream, river corridor and watershed protection, management, restoration and public education programs and to provide indices of program accomplishments and effectiveness.

In order to 1) develop and implement stream and watershed management plans, 2) prioritize stream reaches within a watershed for their relative stability, 3) design and construct geomorphically-based restoration designs, 4) monitor the effectiveness of these projects and 5) monitor the effectiveness of the program, a data collection effort is needed. **The results of this data collection effort will provide physical benchmarks with which to evaluate stream threats and impairments.** Reference data will also provide geomorphically-based design specifications to complement traditional engineering approaches to such projects as streambank stabilization, transportation infrastructure investments, flood recovery or prevention, flood plain management and stormwater controls. In addition, these databases will provide water resource managers with the necessary data to guide stream project assessments and designs throughout the state; refine conditions for stream alteration and stormwater permits; and provide a common framework for assessing the effectiveness of stream management projects in meeting their stated goals. The following four priority data collection areas will be important for completing basin plans (Goal III described below); supporting stream, flood plain and buffer management decisions and policies; hazard mapping; stream restoration designs, and program evaluation:

A). Development of a "stream geomorphic and physical habitat assessment handbook" to include standard monitoring methodologies and a "data management system" to ensure consistency, repeatability, quality assurance and control of data collection and analysis. The handbook will encourage the involvement of watershed groups and municipal officials through a tiered watershed assessment approach.

B). Development of regional relationships that correlate stream drainage area to the channel-forming (bankfull) discharge and corresponding hydraulic geometry for each hydrophysiographic province represented in Vermont using data from USGS stream gaging stations. These relationships define the standard criteria for identifying bankfull discharge and associated channel geometry (width, depth, and cross-sectional area), upon which stream assessments, morphological type, and monitoring methodologies are based for ungaged streams and stream reaches.

C. Development of a data set on the geometry of selected stable stream reaches of the range of stream types which, owing to their morphology, effectively pass flood flows and associated sediment loads and can serve as reference data for stream assessment, protection, and restoration projects.

D. Development of a data set relating stream channel and bank morphology and condition to actual erosion rates. This information will be used to predict sediment loadings, prioritize implementation of channel stabilization BMPs (Best Management Practices), and provide an evaluation tool for monitoring BMP effectiveness.

III). Develop and implement basin plans in priority sub-basins and establish a network of stream stability restoration demonstration projects throughout Vermont which will advance public understanding of fluvial processes and widespread support of protection and management programs at the state and local levels.

Basin plans should identify and prioritize concerns and problem areas and provide a schedule for attaining long-term goals for stream corridors at the sub-basin scale. Each component of a basin plan should directly or indirectly address water quality concerns arising from stream instability. Following remote sensing and targeted field geomorphology assessments (using data outlined under Goal II described above), basin plans should target stream protection, restoration, and management projects using the following set of priorities (in order from highest to lowest priority):

1. Conservation Reaches. First and foremost, we need to protect those reaches that are least disturbed, where river structure and vegetation associations are relatively intact. Remnant or refuge reaches would provide a good base to work out from, into more degraded reaches in the watershed.

2. Strategic Sites. These are highly sensitive sites, or river reaches that are sensitive to disturbance, where impacts may trigger off-site responses. We need to take a pro-active management strategy here with an emphasis on reaches where disturbances may threaten the integrity of Conservation Reaches. If we don't take action at these sites, the adjustments set in motion may lead to watershed-scale changes that would be uncontrollable without inordinate, impractical expense. The key example is the management of nick points or bed level instability. If we don't address bed level issues, we'll see significant upstream and downstream instability develop.

3. Reaches with high recovery potential. These reaches show signs or potential for self-adjustment, in a manner that fits the present-day setting and stream type. Management efforts that work with the current tendencies of the river could achieve quick and visible success. The "do-nothing" alternative may be viable at these sites but minimally invasive approaches will accelerate recovery while meeting the concerns of the landowner. For example, excluding livestock, placing tree revetments or a couple log-vanes, and re-establishing riparian vegetation on a reach that has (or nearly has) the dimension, pattern, and profile appropriate to its valley type has a high likelihood for success at minimal cost. Again, work should concentrate on reaches adjacent to or connecting Conservation Reaches.

4. Moderate to highly degraded sites. These sites may require a more invasive management strategy (consisting of changes to dimension, pattern, and/or profile). Moderately degraded sites could be defined as those with a reasonable potential to recover after reasonably-priced restoration efforts (e.g., narrowing a stream's width/depth ratio). Highly degraded sites would have little near-term (10-20 yr.) natural recovery potential and are typically high-sediment sources or accumulation zones (i.e., a river type that does not fit the valley type). Physical intervention at highly-degraded sites is often expensive with an uncertain outcome. In most cases, restoration should only go forward once upstream (and in some cases, downstream) sites have been dealt with and watershed-wide sediment and vegetation management plans have been implemented. If we pursue invasive restoration projects in isolation we are just as likely to fail as succeed.