

Integrated, Fluvial Process-Based Performance Standards Used in Vermont to Promote Restoration and Avoid New Channelization and Loss of Natural Floodplain Function

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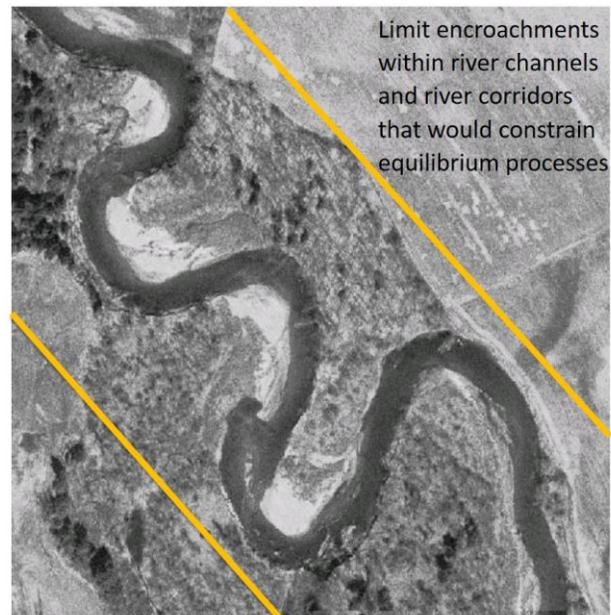
Vermont has adopted river and floodplain regulations that have begun to reverse decades, if not centuries, of river and floodplain alterations, promoting both passive and active restoration. The state is using fluvial process-based performance standards¹ recognizing: 1) that natural floodplain function depends on sound river management to ensure stable vertical connectivity of the river and its floodplain, and 2) that geomorphically stable and ecologically functioning rivers depend on the attainment and maintenance of natural hydrology/hydraulics and the erosion and deposition processes that occur in unconstrained, functioning river meander belts and riparian buffer systems (i.e., protected floodplains and river corridors).

Vermont Fluvial Process-Based Regulatory Standards

Stream Alterations: To avoid adverse effects to public safety and significant damage to fish, wildlife, and riparian owners, the Vermont Agency of Natural Resources applies the following performance standards in reviewing activities that alter the course, current, or cross-section of a perennial stream (other than those practices that address existing threats to public safety):

- *Equilibrium Standard* - An activity shall not change the physical integrity of the stream in a manner that causes it to depart from, further depart from, or impede the attainment of the channel width, depth, meander pattern, and slope associated with the stream processes and the equilibrium conditions of a given reach of stream, resulting in no unnatural aggrading (raising) or degrading (lowering) of the channel bed elevation along the longitudinal stream bed profile.
- *Connectivity Standard*- An activity shall not alter local channel hydraulics, natural streambank stability, or floodplain connectivity in a manner such that changes in the erosion or deposition of instream materials results in: a) localized, abrupt changes to the horizontal alignment of streambanks or vertical profile of the stream bed; or b) a physical obstruction or velocity barrier to the movement of aquatic organisms. A person shall not establish, construct, or maintain a berm in a flood hazard area or river corridor unless authorized temporarily as an emergency protective measure.

River Corridor and Floodplain Encroachment: To avoid adverse impacts to public safety from flood and fluvial



¹ The Vermont Stream Alteration Rule, the Vermont Flood Hazard Area and River Corridor Rule, and the Vermont Water Quality Standards

erosion hazards, the Vermont Agency of Natural Resources applies the following performance standard in reviewing land uses under state jurisdiction:

- *River Corridor Standard:* A proposed development shall provide for a meander belt and riparian buffer that ensure no increase in fluvial erosion hazards by causing the river reach to depart from or further depart from the channel width, depth, meander pattern, and slope associated with natural stream processes and equilibrium conditions. Proposed development shall not be approved in a river corridor, if, as a result of the development, there is an immediate need or anticipated future need for stream channelization that would increase flood elevations and velocities or alter the sediment regime triggering channel adjustments and erosion in adjacent and downstream locations (For example, channelization such as streambank armoring that is needed to protect a new encroachment from lateral channel adjustments within the river corridor would result in a departure/further departure from equilibrium and thereby exacerbate fluvial erosion hazards).

With approximately 75% of Vermont rivers and streams moderately to severely incised and disconnected from their floodplains at the 2-year return frequency flood, and the consequent loss of floodplain function at reach and watershed scales, state-wide river corridor mapping, planning, and protection have become critical components of the state's floodplain restoration program.

Water Quality and Aquatic Habitat Impacts: Vermont's Water Quality Standards (2016) also incorporate fluvial process-based performance standards for protecting the designated use of aquatic habitat. New criteria based on stream geomorphology will support an evaluation of the cumulative impacts of instream and floodplain activities on stream equilibrium and connectivity when implementing anti-degradation policy during CWA Section 401 reviews.

Vermont's Base-Level Aquatic Habitat Management Objectives: Waters shall be managed to achieve and maintain high quality aquatic habitat. The *physical habitat structure, stream processes, and flow characteristics* (see definitions below) of rivers and streams and (the) physical character and water level of lakes and ponds, necessary to fully support all life-cycle functions of aquatic biota and wildlife, shall be maintained and protected.

"Flow characteristics" means the depth, volume, velocity, and variation of streamflow that, in part, determine stream processes, physical habitat structure, and aquatic habitat quality in channels and floodplains as governed by factors associated with valley setting, geology, and climate.

"Stream processes" means the hydrologic, bed-load sediment and large woody debris regimes of a stream reach and is a term used to describe stream channel hydraulics, or the erosion, deposition, sorting, and distribution of instream materials by the power of flowing water. Stream processes work toward an equilibrium condition, are governed by flow characteristics, stream morphology, channel roughness, and floodplain connectivity and, in part, determine physical habitat structure and aquatic habitat quality.

"Physical habitat structure" means the diverse combination and complexity of instream forms created within substrate and woody debris on and within the bed and banks of the channel by stream processes and flow characteristics. Physical habitat structure, in part, determines aquatic habitat quality at the stream reach and stream network scales by providing for all life cycle functions, which include the full set of forms necessary for the provision of and access to cover, overwintering, and temperature refuge and the substrates necessary for feeding and reproduction of aquatic biota and wildlife.

Managing for Performance Over Static Conditions

Fluvial process-based standards are used in regulating both development and restoration projects because they reference natural forms and function and promote the use of larger spatial and temporal scales to evaluate impacts. This contrasts with river regulatory standards that reference fixed or static river conditions or focus only on small spatial and/or temporal scales. The Stream Functions Pyramid developed by Harman, et. al. (on the following page) may be used to explain how human communities next to Vermont streams become flood resilient when actions are taken to protect and restore the natural hydrology, hydraulic, AND geomorphology functions in their watersheds.

VERMONT COMMUNITIES

FUNCTION: Flood resilient village centers and infrastructure.

PARAMETERS: Decreasing flood & fluvial erosion damage and recovery costs; protected natural Infrastructure (e.g., wetlands, river corridors and floodplains functioning at 2yr flood stage)

An alternate top-layer (4/5b) to the Stream Functions Pyramid (next page)

For example, Vermont will cautiously use the base-flood elevations that establish floodways and special flood hazard areas on FEMA FIRMs, recognizing the limitation of maps made during the 1970s and 80s at the height of channel alteration and incision. After 30-40 years of channel evolution (i.e., with dramatic vertical changes in bed elevation), we can predict that base-flood elevations are going to be different. We now understand that channel evolution is a desirable geomorphic process from a large-scale flood hazard reduction standpoint. While developments should be regulated to avoid unnatural increases in flood heights and velocities, restoration along the continuum of channel evolution toward natural fluvial processes and equilibrium conditions should be encouraged even if flood heights and velocities are increased at a given location (with due consideration to existing public safety concerns).

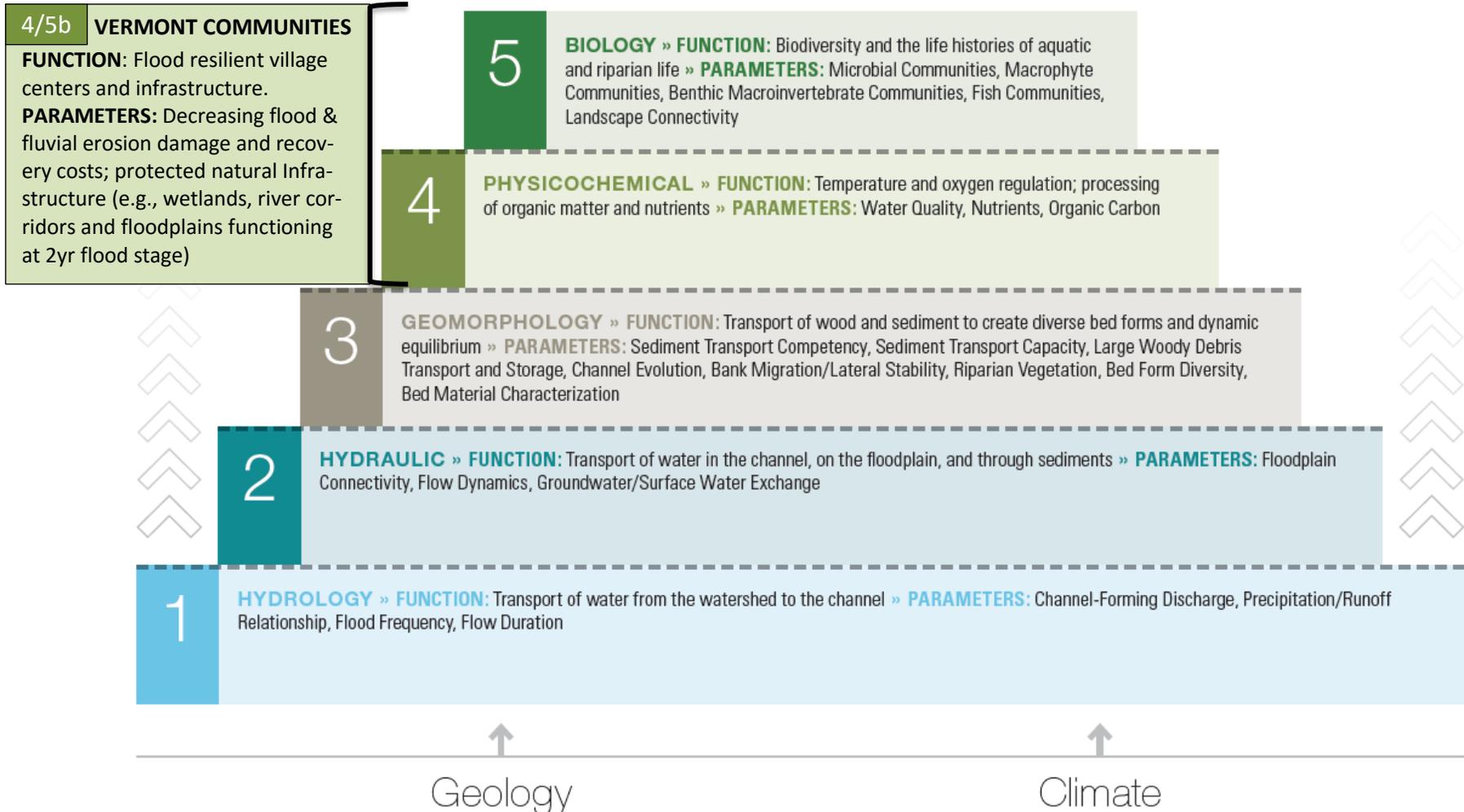
LIDAR and other modern remote sensing data may soon provide real-time modelling of different flood stages as may be affected by channel and landscape changes over larger time scales. But, in the meantime, Vermont has begun using delineations of stream and river meander belts (that correlate well with minimal floodplain widths necessary to achieve channel stability) as a primary means to protect and restore a critical quantity of natural floodplain function for the future.

Interagency recognition of Vermont's fluvial process standards is critical to their success. FEMA Region 1 has recently approved Vermont codes and standards for the replacement of damaged bridges and culverts after a declared disaster under the Public Assistance (PA) Program. The Stafford Act dictates that the PA Program only reimburses communities for the replacement of stream crossing structures in-kind. The result of this federal policy has been that the same structure size and type, that just failed during the flood, is being replaced back into the stream, ensuring taxpayers the opportunity to replace it yet again during the next disaster.

To change this paradigm, Vermont took advantage of another PA reimbursement eligibility requirement that the replacement structure adhere to applicable local standards and permit requirements. Vermont stream alteration general and individual permits now include design requirements for new or replacement bridges and culverts with the specificity required by the PA Program, but that also ensure compliance with the Vermont's equilibrium and connectivity performance standards (above). FEMA's notification to Vermont that its codes and standards are now PA eligible, will allow Vermont communities to replace under-sized stream crossings with larger, more flood resilient crossings, that adhere to the GP design requirements, without having to apply and compete for FEMA hazard mitigation funds. This state-federal partnership is a case study of how climate-informed, fluvial process data and methods may contribute to the restoration of natural floodplain function.

Stream Functions Pyramid

A Guide for Assessing & Restoring Stream Functions » FUNCTIONS & PARAMETERS



Citation - Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006 (Addition made with authors permission by Mike Kline, Vermont Rivers Program Manager)

