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REGENERATIVE STORMWATER CONVEYANCE (RSC) AS AN INTEGRATED APPROACH TO SUSTAINABLE STORMWATER PLANNING ON LINEAR PROJECTS

Authors
Berg, Joe
Underwood, Keith

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Regenerative Stormwater Conveyance (RSC) as an Integrated Approach to Sustainable Stormwater Planning on Linear Projects

Joe Berg (410-554-0156, jberg@biohabitats.com) Biohabitats, Inc., The Stables, 2081 Clipper Park Road, Baltimore, MD 21211, USA
Keith Underwood, Underwood & Associates, Annapolis, Maryland, USA

Abstract

Stormwater conveyance practices are grounded in industrial design that neglects integration with system processes, economics, and aesthetics. As a result, the greater volume of runoff from impervious surfaces, coupled with smooth and hardened conveyance systems (e.g., pipes and trapezoidal concrete channels), magnifies and transfers energies to the discharge or outfall. Conventional stormwater outfalls cause erosion, conveyance structures fail, stream channels are degraded, in-stream sedimentation increases the influence of localized erosion upstream and downstream of the outfall, and an increasing spiral of degradation results. Local governments are forced to spend scare public funds on remediation measures. Alternatively, the technique of using stream restoration techniques to create a dependable open channel conveyance with pools and riffle-weir grade controls is a regenerative design since the use of these elements result in a system of physical features, chemical processes, and biological mechanisms that can have dramatic positive feedback effects on the ecology of a drainage area. This approach results in the delivery of low energy storm water discharge, potential volume loss through infiltration and seepage, increased temporary water storage, restoration of lowered groundwater, increases in vernal pool wetland area, improved water quality treatment, improvements in local micro-habitat diversity, and provides a significant aesthetic value. These projects are generally a win-win-win arrangement, as conventional construction practices and materials are more expensive, conventional conveyance provides no environmental benefits and are more difficult to permit, and people generally enjoy the aesthetics associated with a well vegetated channel form when compared to the conventional conveyance alternative.

Introduction

Regenerative Stormwater Conveyance is a large name for an open-channel approach to conveying runoff from developed surfaces. The key element in this name is the term 'regenerative', which cannot be applied to grass swales, rock channels, or other features constructed with the singular intent of discharging stormwater from a developed surface to a natural area.

In too many situations, the collection, treatment and conveyance of runoff from developed surfaces results in significant and unanticipated degradation of natural areas. This includes slope erosion at the outfall point, stream channel enlargement at the point of discharge, and other responses to loss of infiltration, increased collection and conveyance efficiencies, and increased volumes of runoff.

For a practice to be characterized as regenerative, it should create resource value. It should function as a part of a larger system. It should be self maintaining and resilient to seasonal and annual variations.

Approach

The major components of the regenerative stormwater conveyance approach include a:

- porous, carbon-rich bed material to filter runoff associated with smaller volume storms and support fungal and microbial metabolism;
- system of riffles and pools to interrupt the development of water depth and velocity along the flow path to maintain non-erosive flows; and
- native plant community that knits the site together, produces native habitat, and contributes carbon to the system.

The porous, carbon-rich bed material is most often an 80:20 blend of sand and shredded hardwood. This bed is designed to have a minimum thickness of three (3) ft, but can be thicker with greater effect. In many cases, severely eroded channel or gullies can be backfilled with this material. This allows stormwater to rapidly infiltrate into the porous media, reducing overland discharge and contributing to loss of runoff volume. In addition, as the stormwater moves through the porous media, the fungal and microbial communities associated with the 20% (by volume) shredded hardwood use nutrients in the water to support their production. This initiates grazing by secondary consumers (e.g., soil micro- and macro-invertebrates) in the porous media, increasing porosity. The establishment of a native plant community reinforces and sustains this process, as roots move through the media, supplying carbon in the form of root material, leaking exudates, and supporting microbial metabolism. Water can only move through this mea slowly, and in addition to losses of this water to the natural geology through increased contact time, each particle in the media retains a coating of water. Additional water slowly seeps through the material until it exits in a cool, clear non-erosive seepage discharge capable of supporting wetlands.

The interruption of the development of runoff water depth and velocity is critical to handling the larger volume runoff events that aren't completely converted to seepage flow in the porous media. The regenerative stormwater conveyance approach uses elements of stream restoration, riffle grade control structures and pools to safely collect and convey larger runoff events. With larger flows, the water moves over a parabolic riffle weir and into a three (3) ft deep pool. The parabolic weir shape doesn't support the development of water depth, as additional water volume results in a greater increase in stream width than depth. This limits shear stresses and transport of bed material. The pool converts the riffle flow into a non-directional turbulent flow. Water exits the pool into the next in a series of repeating series of riffle weirs and pools. The surface discharge from this conveyance system has little ability to erode material, whether discharged onto a floodplain surface or into a stream channel. Depending on the local slope, geology, soils and groundwater, the resulting hydrologic regime can be temporally and spatially complex, supporting a diverse natural community.

Establishing the edges of the flow path and some or all of pool bottom (depending on site conditions and permanence of water) with a native plant community including trees, shrubs, forbs, and floating leaved aquatics contributes functionality to the system. In addition to the replacement of carbon and increase in attachment sites for fungal/microbial production in the porous media bed, the woody root system of the trees and shrubs result in a living mortar for the system. Similarly, the fibrous roots of these plants and the forbs also contribute to structural stability, water and nutrient uptake, and a substrate for microorganisms. Above the ground, these species provide habitat for birds, small mammals, provide shade over the flow path, contribute aesthetically to the landscape, present a natural boundary for maintenance, etc.

These regenerative stormwater conveyance systems do not generally need to mimic the sinuous planform associated with many perennial streams. The horizontally sinuous perennial stream forms in response to stream energy and sediment supply. In the collection and conveyance-oriented regenerative stormwater conveyance system, the repeating riffle grade control to pool sequence limits the development of 'stream' energy. As a result, it is possible to develop a linear regenerative stormwater conveyance system that collects water along a linear feature, like a highway, with non-erosive connections to streams, wetland, and or floodplains in depressional portions of the landscape. As a result, none of the regenerative stormwater conveyance systems need to be large—we generally characterize them as zero or first order man-made stream systems. The riffle grade control structures are generally sized to provide safe-conveyance for the 100-yr storm with shear stresses insufficient to move a 25mm particle.

The use of this approach eliminates or dramatically reduces the need for detention facilities, partly as a result of the in-channel pool storage, but also due to greater roughness, increased concentration time, and water losses through infiltration and evaporation along the flow path. Furthermore, the cost of materials and construction techniques are less expensive than many common practices, including placement of drop inlets, pipes, and headwalls.

In a recent project in Maryland, we replaced approximately 3,500 lf of 15" to 30" concrete pipe and associated infrastructure with a construction cost estimate of approximately $830,000 with a regenerative stormwater conveyance network for a total cost of approximately $405,000, a savings of more than $425,000.

This was accomplished by constructing a linear regenerative stormwater conveyance system within the platted stormwater pipe ROW along the edges of the development roads. In addition to the significant short-term financial benefit, the owner anticipates higher lot purchase prices due to the aesthetics associated with the 'constructed stream' and landscaping and a significant reduction in the projected long-term O&M costs for the system. From the longer term environmental perspective, this system provides better water quality and habitat, no increase in the 100-yr storm discharge relative to the pre-development condition, and is expected to result in higher commitment to environmental stewardship among the public exposed to the project.

Imagine a road system with a ten (10) to 15-ft wide drainage channel which collects, conveys and provides water quantity and quality control treatment for road runoff to a receiving depression, wetland, floodplain and/or stream system. The collected runoff is treated along its flowpath, so the water is a resource suitable for support of groundwater, wetland and stream ecosystem function. The collection, treatment and conveyance system possesses many of the aesthetics of a natural stream channel, all of the material processing capabilities of a natural system, at a significant construction and O&M cost savings.

Summary

The use of regenerative stormwater conveyance, a created stream system for the collection, treatment and conveyance of stormwater runoff, is an innovative best management practice that can be applied to many highway projects with great benefit. The regenerative stormwater conveyance system provides significant natural resource values and ecosystem services important to society, while providing a significant cost benefit and requiring little to no long term maintenance. In addition, the system looks natural and is more attractive to drivers than current practices.

Biographical Sketches

Joe Berg is a restoration ecologist and practice leader with Biohabitats, situated in Baltimore. He graduated with a masters from University of Maryland's Horn Point Lab and has more than 25 years in the environmental consulting field. He has worked in upland forests, headwater streams and wetlands, larger streams and floodplain forests and wetlands, and estuarine habitats. His experience ranges from the assessment of resource presence and condition, mapping of resource distribution, analysis of site conditions supporting restoration, development of restoration concept plans through final construction documents, peer review of restoration plans prepared by others, construction oversight, post construction monitoring, and a variety of other related efforts. Joe is a certified Professional Wetland Scientist (Society of Wetland Scientists) and Certified Senior Ecologist (Ecological Society of America). His work passion is pushing for change in the way the engineering community uses natural resources.

Keith Underwood is a landscape architect that has specialized in understanding, protecting, and restoring bog ecosystems. He is the sole proprietor of Underwood & Associates, a Design-Build firm in Annapolis, Maryland. He has pioneered sand-seepage wetland restoration techniques and has been effective in dramatically increasing the population of Atlantic white cedar in the western shore coastal plain of Maryland.