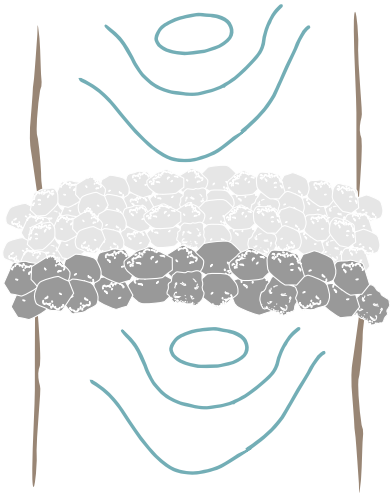

Regenerative Step Pool Storm Conveyance (SPSC)

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ALTERNATE NAMES:

coastal plain outfall; regenerative stormwater conveyance

STRUCTURE TYPE:

stormwater conveyance

Stormwater infrastructure concentrates storm runoff into pipes. When these pipes end at the top of steep slopes, the concentrated flow can cause extensive erosion, creating deep gullies (Figure 1) and contributing sediment to the receiving stream. These gullies also become drains, lowering local groundwater levels.

Regenerative Step Pool Storm Conveyances (SPSC) are used to safely convey stormwater runoff from developed areas to streams, while also improving stormwater quality, and replenishing shallow groundwater. SPSCs direct stormwater runoff through a series of pools with beds composed of a permeable, sand-based filtration media similar to that found in rain gardens and bioretention cells.

On steep slopes, rock weirs are placed in series to prevent further erosion and to create a series of shallow pools. These rock weirs are designed to behave like the rocks and logs found in naturally occurring step-pool channels. The step-pool channel morphology of steep SPSCs dissipates flow energy during storm events and filters and absorbs water through the pool beds during low flow conditions.

Application

Regenerative SPSCs are effective for channels which are first-order streams or erosion gullies/outfalls with intermittent or low flow, with both valley and channel slopes of 2-10%. While an SPSC may be designed for a site with a valley or channel slope greater than 10%, this must be done with caution, and the design should be modified to compensate for the increased hydraulic forces which will result (e.g. by reinforcing the rock weirs). An SPSC with a slope greater than 5% will generally provide fewer water quality benefits.

Figure 1. Eroded gully due to stormwater runoff (copyright Erik Michelsen, Anne Arundel County Department of Public Works).

Figure 2. Regenerative step pool conveyance directs runoff from parking lots to Broad Creek, Annapolis, MD.

General Design Guidelines

Allthough the SPSC is technically a constructed or modified channel, it should be designed to minimize alterations to the receiving stream and surrounding habitat. By constructing the SPSC in an existing first-order stream or erosion gully, stormwater runoff may continue to be discharged into the receiving stream at the same location, but with less energy. Therefore, designs should be modified on a site-by-site basis based on what is required to fit the SPSC within the existing channel, while ensuring the SPSC can safely convey the design flow. It is also important that the SPSC be connected to the receiving stream in a way that minimizes the potential for a headcut to form on the floodplain at the SPSC outlet, which could potentially undermine the SPSC.

At its most basic, the SPSC is a modified channel consisting of pools alternating with steps or cascades. Steps are constructed of large boulders and cobbles (Figure 3) and have drops of no more than 1 ft. Cascades are larger structures that can have drops up to 5 ft. The rock weirs are constructed in a shallow parabola, such that the arms of the weir form 70˚ angles with the bank. This shape will direct flows towards the center of the SPSC channel.

Pools are located between steps or cascades and should be at least 10 ft. long and more than 2 times the length of the preceding rock weir or cascade to dissipate energy. If desired for habitat purposes, root wads may be placed vertically (roots up) in pools, as long as they do not take up more than 10% of the pool volume. The overall slope of each pool should be less than 1%.

If the channel or gully in which the SPSC is constructed does not already have an outlet to the receiving stream, it is recommended that an armored-bed, constructed riffle be installed in the receiving stream to limit stream bed incision or knickpoint formation. If the receiving stream is actively eroding, a rock weir may need to be placed in the receiving stream to further dissipate the SPSC flow energy.

Construction

Material selection and sizing for the SPSC is largely dependent on the requirements that the rock weirs and channel remain structurally stable during the design flow while also creating the required weir and pool geometry. Detailed design guidance is available from the Anne Arundel County Department of Public Works. When selecting materials for the various SPSC components (rock weirs, pool beds, and vegetation), it is important to select materials which will not affect water chemistry or clog the sand filtration media.

Sand filtration media should be placed in the pools for shallow groundwater recharge using locally-sourced sand. Where water quality benefits are a project goal, a sand-woodchip filtration media mixture similar to those used in bioretention cells should be used, with an estimated 20% woodchip content by volume. Where water quality benefits are not a project goal, native soil with a comparable infiltration rate may be left in place instead, as long as the design guidelines are still met.

Construction of the SPSC should begin at the outlet and progress upstream to the inlet. If sedimentation and clogging of the SPSC beds occur due to upstream construction, the affected pools should be scraped clean of fine sediment and vegetated at the completion of the overall project.

Filter fabric should be placed beneath weir footer rocks to ensure that rock weirs will not fail by winnowing or undercutting. Filter fabric must not extend beneath the pools, or it will interfere with filtration and infiltration functions.

Mulch should be used on the side-slopes of the SPSC for scour protection if construction does not take place during a planting season. Invasive and nonnative vegetation should be removed from the site before planting.

Post-Construction Monitoring

It is recommended that post-construction monitoring be conducted for at least three years. Some monitoring activities to ensure that the SPSC functions as intended include the following:

- Monitor pool depth to ensure the pools are not aggrading or degrading;
- remove accumulated sediments or replace the bed media as necessary to maintain infiltration;
- examine the SPSC vegetation to ensure that establishment is sufficient for erosion prevention;
- regularly examine the surrounding slopes for erosion, particularly where the weirs meet the surrounding slopes;
- regularly examine the weirs for rock displacement after large flow events; and,
- regularly examine the receiving stream for aggradation or degradation caused by the SPSC structure.

Corrective action should be taken if and when problems arise. However, aggraded sediment in pools should only be removed when the infiltration into the pool beds is impeded.

Consider requesting help from local conservation or volunteer-based organizations for monitoring work that can be performed by laypeople, if resources for monitoring are unavailable or scarce.

Figure 3. Regenerative step pool conveyance weirs have a cobble apron on the upstream side, reinforced with boulders.

References

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