Pooled Monitoring Initiative's Restoration Research Award Program

Project Title

Evaluation of watershed-scale impacts of stormwater management facilities on thermal loads to a Maryland Use IV stream using a high-frequency sensor network

Lead Entity

Claire Welty,
Andrew J. Miller
UMBC

Partners

Baltimore County DEPS

The Pooled Monitoring Initiative pools resources to support scientists who answer key restoration questions posed by the regulatory and practitioner communities. The research teams then provide the answers back to those who asked the questions for direct application. The goal of the program is to answer these key restoration questions that serve as a barrier to watershed restoration project implementation.

Questions? See cbtrust.org/grants/restoration-research/

Research question

How do stormwater management facilities and urban land cover impact temperature of a Maryland Use IV stream at the watershed scale?

Issue addressed

There is a gap in documenting the synergistic impacts imparted by stormwater management facilities and urban land cover discharging to streams at a continuum of spatial scales ranging from stormwater outfalls, to stream reaches, to watershed scales, at high spatial and temporal resolutions.

Project findings

Dead Run in Baltimore County, MD was used as a demonstration case study, with stream temperature data collected at a 5-minute interval every 50-100 m over 16 km for 3 years.

Spikes in stream temperature due to hot storm runoff were detected at storm discharge peaks for many storms during summer months, throughout the watershed.

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Project findings

Thermal spikes appear at multiple locations along the drainage network in the early part of a storm; the spikes are greatest at the headwater locations. The behavior at the headwaters is due in part to the headwater streams being buried in pipes, such that the baseflow at the headwater outfall is much cooler than the air and therefore exhibits a greater temperature swing as the storm pipe carrying the buried stream fills with hot runoff from street drains.

This highly variable thermal pattern becomes attenuated in the downstream direction and over time. This is owing to mixing in of many thermal sources and water transit times to the stream channel along the channel length and eventual impact of runoff coming from upstream damping out the local signal. The pattern of damping is far from uniform along the drainage network.

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Project findings

The effect of runoff (pipe or overland flow) on stream temperature depends on the size of the storm and the position in the landscape. For large storms, upstream thermal input can overwhelm lateral thermal input between a pair of sensors. For smaller storms, the opposite may be the case, when the thermal load from lateral input is greater than from upstream. In addition to storm size, this behavior is also dependent on the fractional increment of drainage area contributing flow between an upstream and a downstream sensor pair, as well as the fractional increase of impervious area contribution that imparts heat to runoff.

Storm pipes in headwater areas carrying dry-weather base flow perform an ecosystem service by keeping stream base flow cooler than ambient air temperatures until the flow exits the storm pipe. Whereas these outfall areas might therefore be considered thermal refugia, these locations are most greatly affected by contrasting hot water pulses and thermal disruption to habitat during summer storms.

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Recommendations

Our data do not indicate that stormwater BMPs have a distinctive thermal impact by comparison with surface runoff from impervious cover in the urban watershed. Large contiguous areas of paved surface draining surface runoff directly into storm drains are more likely to cause temperature pulses than stormwater BMPs characterized by warm temperatures that do not contribute as much runoff as overland flow during storms. As has been documented in the literature for years, any measures that can increase shade and green space throughout the watershed to mitigate air and land surface temperatures are likely to be effective in mitigating stream temperatures.

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Why does this study matter?

This study demonstrates watershed-scale effects of the combined impact of land cover and stormwater management facilities on stream thermal regime.

What should we do with this information?

The information could be used as documentation in land-use planning where there is a desire to promote a cooling environment for urban streams.

What will the end-user (regulator/manager and practitioner) do with this information?

The information could assist in forming policy for land management practices for newly-planned developments or retrofitting existing landscapes to promote cooler land cover regimes.

For more information:

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