UNH Stormwater Research –
Green Infrastructure Adaptations to Intensifying Rainfall

Jessica Zielinski
BS Sustainability Studies Program, Tagliatela College of Engineering
Dr. Jon Aktas

substances into nearby surface waters, where they degrade aquatic ecosystems. Stormwater run-off is the main pollutant to U.S. waterways today (EPA, 2014). Stormwater that flows over impermeable urban surfaces is usually collected in one of two sewer types; combined sewers or sanitary sewers. Combined sewers collect both stormwater and sewage from residential, commercial, and industrial buildings while sanitary sewers collect sewage from buildings only without collecting stormwater. Therefore, in areas that use sanitary sewers, a separate system called a stormwater sewer is required to collect rainwater run off to prevent urban flooding. In most cases, when stormwater is collected separately from sanitary waste, it is released untreated or with minimal treatment (perhaps straining to removed large debris) to nearby surface waters (Primer for Municipal Wastewater Treatment Systems, 2004).

During heavy or prolonger precipitation events, stormwater volume sometimes overwhelms combined sewers (and even sanitary sewers that allow stormwater in through leaks), causing overflows. These overflows release the untreated or minimally treated mixture of sewage and stormwater at designed system overflow points which results in contamination of nearby surface waters and/or lands. Stress to combined sewers during intense rain events can also cause sewage to back up in basements and yards. Such contamination threatens the health and safety of local and downstream life, both natural and urbanized alike (Delleur, 2003). Economic damages also often result from such overflows given the necessary closure and cleanup of recreational or fishing waters or other attractions. As an example, it is reported that approximately 27 billion gallons of sewage and stormwater overflows from combined sewers near New York Harbor and the Hudson River estuary each year as a result of about 460 separate overflow events. Given such negative outcomes, water regulatory agencies and activists are putting effort into the reduction of such overflows (Combined Sewer Overflows, 2014). Aging and overburdened sewer systems are getting no help from mother nature in some areas of the world where it is predicted that climate change will result in more frequent and more severe precipitation events. USGS models project increasing precipitation patterns for the eastern seaboard of the United States, indicating that stormwater runoff and sewer overflows could become more prevalent if water infrastructure is not improved (Climate and Land Use Change Research and Development Program, 2014).

During a rain event in August 2012, localized flooding on the UNH campus inundated one building's classrooms with stormwater, resulting in excess of $400,000 worth of property damage. Localized urban flooding, unlike large-scale flooding, is usually the result of stormwater runoff from one square mile or less of impervious surfaces that has built up and overflowed nearby sewer or stormwater systems (Types of Floods and Floodplains, 2008). Both the stormwater sewers for the campus and those connecting the campus to West Haven were insufficiently sized to handle the volume of runoff generated during the rain event, causing overflow of the system and the subsequent flooding of Kaplan Hall (Aninno, 2014 powerpoint). The rainfall that caused the August 10th 2012 flooding at UNH was documented at the Tweed New Haven Regional Airport weather station as a 2.36 in

Figure 1: UNH's hillside riprap, installed after the 2012 campus flooding event in Kaplan Hall.

Literature Review

With human populations increasingly shifting to dense urban areas, the need for reliable, efficient, and multi-purpose infrastructure is growing. Urban areas in the northeastern United States are being overwhelmed by a greater increase in intense rainfall events as compared to all other region of the U.S. (Horton et. al, 2014). From 1958 to 2012, very heavy precipitation events in New England have increased by 71%, and this trend is predicted to continue (Walsh, J., et. al., 2014). G.I. can address these urban stormwater issues and provide additional benefits such as: groundwater recharge, reduced heat island effect, water quality treatment for sediment, pollutants, and excess nutrients, increased habitat, carbon sequestration, aesthetic green-space, potential for water harvesting and reuse, as well as energy savings from roof insulation, and protecting water habitats against erosion and heat pollution. Some G.I. types perform better than others in any one of these benefits, thus choosing which G.I. type to utilize depends upon local and downstream goals. What follows is a brief description of some of the most popular types of G.I.

For developed areas, G.I. such as rain gardens, bioswales, and retention ponds can be added, as well as returning certain areas to pre-lanfottr, materials were not sourced locally or if maintenance crews drove many miles every year to maintain the site. However, unlike traditional infrastructure, GI's incorporation of plants has the ability to sequester more emissions than are produced by its construction and maintenance, resulting in a carbon-site infiltration capability due to the deeper root systems typical of many native species. If sites had sufficient infiltration capability, stormwater from nearby impervious surfaces could be routed to these areas. In particular, if infiltration and/or storage features could be placed conveniently in relation to campus buildings, the roof downspouts of these buildings could route roof runoff away from storm drains, helping to reduce the burden on campus sewer pipes. Green roofs could capture this water on roofs, however these GI features require considerable material inputs that create long pay-

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