Stormwater Management: A Keystone for Sustainable Development

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Abstract

Sustainable development is a major goal of the 21st century, and there are many ways to ensure that one generation's lifestyle and consumption habits do not comprise those of a future generation. It can be overwhelming to look at the many ways sustainable development can be achieved. In this paper, I focus on sustainable stormwater management practices, called Best Management Practices (BMPs). There are many different types of BMPs, and in this paper, I look at explore several popular options. I also look through several policies that impact sustainable water management and look to possible policy solutions for the future.

Stormwater Management: A Keystone for Sustainable Development

Sustainable development is the latest craze in urban planning. However, it has several different definitions. The textbook definition is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Harris, Roach, Page 26). The Journal of American Planning Association published an article in 2000 called "Are We Planning for Sustainable Development?" in which sustainable development is defined as "a dynamic process in which communities anticipate and accommodate the needs of current and future generations in ways that reproduce and balance local social, economic, and ecological systems, and link local action to global concerns" (Winter, Page 23). A simple Google search of the term "sustainable development" gives the definition, "economic development that is conducted without depletion of natural resources" (Google).

Despite all of these definitions, many are left wondering how they can incorporate principles of sustainable development into their communities. There is a wide variety of different ways to create both local and national sustainable development, but perhaps the best way to start is to focus on stormwater management. Stormwater is defined by the EPA as "rainwater or melted snow that runs off streets, lawns, or other sites" (EPA). Stormwater management is simply management of rainfall or snowfall to prevent flooding over impervious ground. Sustainable stormwater management applications are often referred to as Best Management Practices (BMPs). There is a wide variety of BMPs for different situations, which will be discussed further in the remainder of this paper. However, BMPs can be expensive and difficult to initially install, decreasing their popularity among understaffed local governments with small budgets. Despite the short-term complexities involved in the development of a sustainable stormwater management system, the future economic and environmental benefits will far outweigh the costs. However, those who would need to provide the up-front cost necessary for incorporating BMPs into design follow the Present-Value Principle, which is defined as "the current value for a future sum of money or stream of cash flows given a specific rate of return" (Investopedia). This means that those who provide the up-front cost value a dollar today more than a dollar in the future. Because investing in sustainable stormwater management practices such as BMPs goes against the Present-Value Principle, these sustainable stormwater management systems are difficult to implement and require cooperation from various groups to make the project feasible.

There are many benefits to utilizing BMPs for stormwater management. BMPs mimic the natural movement of water by allowing water to seep into the ground, rather than move horizontally down impervious ground cover as runoff. BMPs are often easy to incorporate into a project and do not stand out as much as traditional stormwater management techniques. Because there is a variety of different types of BMPs, project leads can work with the client to decide which would provide optimal performance and be most aesthetically pleasing for the site. With advancements in modern technology, it is even possible for a paved site, such as a parking lot, to be constructed out of impervious material, which would allow stormwater to seep through and prevent runoff. Perhaps the two greatest benefits of implementing BMPs in a design project are that they reduce the amount of pollutants entering the water collection system and that they improve water quality and the efficiency of the water treatment process (EPA).

Before a discussion on different types of BMPs, one must first have an understanding of the different types of stormwater. In undeveloped areas, soil absorbs stormwater and uses it to replenish aquifers, rivers, or streams. In addition, this stormwater will further the growth of plants and microorganisms in the given environment. In developed areas, impervious ground cover, such as parking lots, buildings, and roads, prevent the stormwater from being absorbed into the soil and, instead, cause runoff. Oftentimes, the runoff quickly flows down the side of a street until it enters the sewer system, where it mixes with sewage and then is taken to a wastewater treatment plant.

There are three main areas of concern when developing a plan for stormwater management. The first is volume. A feasible stormwater management system should decrease the amount of stormwater that enters the sewer system at any given time. The second area of concern is peak discharge. According to the EPA, the goal of peak discharge is to "reduce the maximum flow rate into the combined system by decreasing the stormwater volume and lengthening the duration of discharge" (EPA). By doing this, the chances of overflow of the sewer system are reduced. The third area of concern for stormwater management is water quality. Stormwater management aims to increase water quality by utilizing techniques such as volume reduction, filtering, and biological and chemical processes (EPA).

In developed areas, stormwater can have many negative externalities to both the economy and the surrounding environment, including habitat destruction, flooding, infrastructure damage, contaminated rivers and streams, and storm-and-sewer system overflows. BMPs help mitigate these negative consequences. BMPs treat stormwater exactly where it falls, preventing the excessive runoff and environmental damage that come from traditional stormwater management practices.

There are three main types of BMPs. The first type is called a Point BMP, which absorbs stormwater from a specific location. Point BMPs utilize a variety of different stormwater management practices, such as detention, infiltration, evaporation, and settling. Point BMPs are extremely common in the land development community with examples being found in many sites around the country. Some common types of Point BMPs include constructed wetlands, infiltration basins, bioretention cells (also called rain gardens), sand filters, rain barrels, cisterns, wet ponds, and dry ponds.

A constructed wetland is defined as "a shallow marsh system planted with emergent vegetation that are designed to treat stormwater runoff" (BMP Manual). It is one of the best BMPs to remove pollutants from stormwater, and it is extremely effective in mitigating peak runoff rates and reducing runoff of stormwater. They also provide wildlife habitats to increase biodiversity in a region, and many clients find constructed wetlands aesthetically pleasing. However, a constructed wetland requires a great deal of space and continuous rainfall to be an effective stormwater management solution.

An infiltration basin is defined by Pennsylvania Stormwater Best Management Practice Manual as "a shallow impoundment that stores and infiltrates runoff over a level, uncompacted (preferably undisturbed area) with relatively permeable soils" (BMP Manual). Infiltration basins reduce the volume of runoff through infiltration and evapotranspiration. The key to a successful infiltration basin is to ensure that the surface area provided is large enough to meet the necessary demand in the given area. Infiltration basins are a prominent stormwater management option because they come in many different shapes and sizes, making them good for projects that have different stormwater management requirements.

A rain garden is defined by the Pennsylvania Stormwater Best Management Practice Manual as "an excavated shallow surface depression planted with specifically selected native vegetation to treat and capture runoff" (BMP Manual). Rain gardens work by allowing stormwater to gather at the surface, which allows for filtration and settlement of suspended solids at the "mulch" layer with the rest of the stormwater filtering down to the plant/soil/microbe complex media, where pollutants are removed through infiltration. Rain gardens are typically used to increase water quality and decrease water quantity and are typically very successful when used in conjunction with other stormwater management techniques.

A sand filter is used to maximize the removal of pollutants from stormwater. It typically consists of both a pre-treatment component and a treatment component, and it utilizes practices such as settling, filtration, and reabsorption by the sand bed to remove pollutants from the stormwater. Sand filters are able to remove up to 80% of the Total Suspended Solids (TSS) from the stormwater, making them very efficient at removing pollutants. However, sand filters are not allowed in areas with high pollution or sedimentation loading due to fears of contaminating groundwater.

Rain barrels and cisterns are a form of Point BMP that captures stormwater runoff from impervious surfaces, such as roofs and pavement, and saves it in barrels to be used later for landscape irrigation. They reduce the amount of drinking water used for irrigation and improve water recycling. However, rain barrels and cisterns often contain sitting water when they are not in use, which can attract mosquitos. If the rain barrel is placed underground, a pumping mechanism may be necessary to move the water, which would be expensive for the client. This type of BMP is best suited for a region where rainfall is consistent. If placed in an arid climate, there will be a severe lack of rainfall, which will make the rain barrels inefficient due to high evaporation rates.

A wet pond detention basin is defined by the Pennsylvania Stormwater Best Management Practice Manual as "a stormwater basin that includes a substantial permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff shortage" (BMP Manual). It can remove up to 70% of Total Suspended Solids (TSS) found in stormwater. Wet ponds are not significant for reducing the volume of urban stormwater runoff or improving groundwater reduction. However, there are several benefits to choosing to add wet pond detention basins to a project's stormwater management plan. They are effective for pollutant removal and peak rate mitigation. Wet pond detention basins are also often considered aesthetically pleasing to clients, who like their appearance when they are on the site. In addition, wet pond detention basins can also provide wildlife habitats in a developed community. However, there is danger in using wet pond detention basins for warm-temperature stormwater, as it could discharge the warm water and disrupt the natural environment.

In addition to Point Source BMPs, there are also Area BMPs. Area BMPs differ from Point Source BMPs in that Area BMPs' treat stormwater from a wide variety of sources, while Point Source BMPs only treat stormwater from one particular source. Some common examples of Area BMPs are green roofs and porous pavement. Green roofs are very popular in urban areas where there is a lack of green space. Green roofs work by covering the roof of a building with vegetation, which absorbs stormwater and then slowly releases it into the atmosphere through evapotranspiration. Green roofs help buildings save money on air conditioning because they naturally cool the building. In addition, green roofs have a longer lifespan than traditional roofs, which is due to the vegetation protection of the roof from ultraviolet radiation. Porous pavement is defined as "[a pavement] with porosity and permeability high enough to allow water to readily pass and thus significantly influence hydrology, rooting habitat, and other positive environmental effects" (EPA Archives). It works by allowing stormwater to pass through a porous membrane at the surface of the pavement, and then pass through a retention layer, and finally seep into the surface subsoil. This is a less popular method of stormwater management due to the daunting cost of implementation, which requires current impervious surfaces to be replaced with a porous pavement.

Despite the many environmental benefits of using stormwater BMPs, policy issues remain with regard to their implementation. According to the Journal of Environmental Planning and Management, "urban space is limited and design for any type of system other than piped drainage has to be coordinated with other interests" (Stormwater Management, Page 787). A case study in Sweden noted that a major obstacle to the widespread implementation of sustainable stormwater management practices is responsibility. Stormwater BMPs are expensive and require large up-front costs and many designers, engineers, planners, and architects struggle with who should pay for these large up-front costs. A Swedish planner stated, "you cannot change our commitment [to sustainable stormwater management] because it is law-bound. The water law tells us what to do. It represents the water and sewer side. The municipality's commitment is a very different need; you need to distinguish it. They have the responsibility of the plan; they are owners of the public land" (Stormwater Management and Urban Development: Lessons from 40 Years of Innovation).

The history of water law regulating stormwater management is complex. The first law to deal with stormwater management is the Clean Water Act of 1972, which "generally prohibited the discharge of any pollutant to navigable waters from a point source unless the discharge was authorized by the National Pollution Discharge System (NPDES)" (Franzetti, Esq). However, by 1973, exemptions were granted that allowed a majority of stormwater dischargers to escape from the regulation. Through these exemptions, only those dischargers who were "identified as significant contributors to water pollution" would need to meet the additional NPDES permitting requirements (Franzetti, Esq). As time progressed, many court battles between industry leaders and environmentalists occurred over whether the permitting requirements were too lenient or too strict. The court battles continued until the federal Water Quality Act was passed in 1987.

The Water Quality Act of 1987 is the basis for modern day regulations regarding stormwater management. It was the first law to require "stormwater discharge permits from a variety of previously exempted activities" (Franzetti, Esq). Some of the previously exempted activities include discharge from industrial activity, municipal sewer systems of less than 100,000 residents, and stormwater discharge that the EPA finds to be, "a significant contributor of pollutants to navigable waters" (Franzetti, Esq.). The Water Quality Act of 1987 classified types of stormwater that would be subject to different regulations. These classes include combined sewer overflow, municipal separate stormwater systems, separate stormwater systems, and nonpoint source runoff. In addition, the Water Quality Act of 1987 separated municipal stormwater discharges from industrial stormwater discharges and set up a separate permit system for each group. As part of the different classes, the Water Quality Act of 1987 established Phase II Final Rules, which "require...small municipalities to implement stormwater management plans using best management practices (BMPs)" (Franzetti, Esq). Through these types of regulations, sustainable stormwater management has a much higher chance of widespread success.

Generally, stormwater management is thought to be regulated by the water professionals, as demonstrated in the article *Stormwater Management and Urban Development: Lessons from Forty Years of Innovation*, which states, "The water professionals are the key players in changing culture away from the use of the traditional piped system, yet they have not been particularly successful in these endeavors over the past 40 years during which chance has been promoted" (Page 788). However, water professionals are hesitant to promote sustainable stormwater management practices such as BMPs because of public liability. The duties of water professionals are highly regulated. In Western Europe, BMPs are considered a risk not taken into account by the laws that govern water distribution. If something were to go wrong with the water distribution system and BMPs were used, water professionals could face serious consequences. The article *Stormwater Management and Urban Development: Lessons from Forty Years of Innovation* proposed the following solution: "a way to increase the ability to influence stormwater issues in planning if stormwater management was accorded a legally defined status in the same way as pipes. The water division could then be responsible for any type of solution, with or without pipes, and it would be easier to influence the way in which stormwater was dealt with in the planning process" (Page 791).

Another issue in the implementation of sustainable stormwater management solutions is that there is often a large variation between what is detailed in the land development plan and what is actually constructed in the field. This can be due to a variety of reasons with some common examples being a lack of due diligence and poor knowledge of the site by the designers. If a problem arises out in the field, pipes are typically chosen to replace BMPs as a default stormwater management option. Contractors often do not like a change in routine, which also leads to pipes being chosen as the default in terms of stormwater management. This demonstrates how, even when sustainable development is a driving principle in the land planning process, it does not always lead to more sustainable results (Are We Planning for Sustainable Development?).

Studies have been conducted to determine whether having sustainability has a guiding principle in land development actually leads to more sustainable projects and solutions to common problems in the land development process. One such study, found in the article *Are We Planning for Sustainable Development?,* concluded that “whether plans integrate the sustainable development concept or not has a very limited effect on the presence of sustainability principles in those plans” (Page 27).

To increase the use of BMPs as sustainable stormwater management solutions in the land development process, several things must change. The role of sustainability in the land development process must be well-defined. Otherwise, principles of sustainability will be “superficial, lack political commitment, and cannot serve as an influential basis for policy development” (Planning for Sustainable Development). Once the role of sustainability is well-defined, a group already involved in the land development process can have control over its implementation into the final design. By providing a group with control over sustainable practices, particularly sustainable stormwater management practices, environmentally friendly development will have a better chance at success. Another way to achieve more sustainable development through sustainable stormwater management practices, such as BMPs, is to “take a balanced, holistic approach to guiding development” (Are We Planning for Sustainable Development?, Page 30). In the current atmosphere, land development “focuses narrowly on creating more livable built environments, which is the historic mainstream focus of plans” (Are We Planning for Sustainable Management?, Page 30). If these principles are followed, sustainable stormwater management practices, and eventually sustainable development, can have a better shot at becoming the norm in today’s culture.

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