Green Infrastructure and NPDES Permits: One Step at a Time

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ABSTRACT

The use of green infrastructure to control stormwater runoff is becoming more widespread in many communities. The incorporation of requirements to implement green infrastructure as part of NPDES permits to control combined sewer overflows (CSOs) and stormwater discharges is becoming more common-place, but is likely to actually be required nationally in some form under EPA's new Stormwater Rule (expected in 2012). This paper describes the benefits of green infrastructure, examines challenges, and provides examples of how incorporation into permits is beginning to take shape.

KEYWORDS: Green infrastructure, stormwater, NPDES.

INTRODUCTION

Green infrastructure is defined as approaches and technologies that allow for the infiltration, evapotranspiration, capture and reuse of stormwater to maintain or restore natural hydrologies. They can range from small scale designed systems to the maintenance of urban forests and stream buffers. Green infrastructure practices, such as green roofs, street side bio-retention, vegetated rain gardens, and permeable pavement, are recognized by many as an effective and sustainable approach to managing stormwater. In addition to controlling stormwater runoff, the benefits of green infrastructure implementation are many and include better air quality, enhanced carbon cycling, improved urban heat balance, and energy conservation. Aesthetic benefits also accrue from the "green" in green infrastructure, and there is evidence of economic benefits associated with green infrastructure as well. However, the wide-spread and voluntary incorporation of these practices is currently not commonplace. In fact, there is much uncertainty about it use and costs. The purpose of this paper is to provide an overview of benefits, examine a range of challenges to widespread implementation, and describe recent developments that forecast the use of green infrastructure in NPDES permits as a way to reduce stormwater runoff and comply with total maximum daily load (TMDL) requirements.

BENEFITS OF GREEN INFRASTRUCTURE

On a larger scale within less densely developed urban settings, green infrastructure can include forested or otherwise vegetated open spaces that provide valuable, but often under-appreciated "ecosystem services," such as cleaner water for streams and rivers, cleaner air, cooler local temperatures, carbon capture, wildlife habitat, and recreational opportunities among others. As urban development increases, this green infrastructure is rapidly being squeezed out, the ecosystem services previously provided by nature for free are lost, and our built or gray infrastructure is forced to pick up the slack where it can. Protection and restoration of large scale green infrastructure is critical for effective stormwater management.

On a smaller scale, green infrastructure is often used as a collective term for stormwater management retrofit practices that can be integrated into a dense urban landscape to mimic and recreate natural hydrologic processes on a local level. This is the definition that is often implied when referring to green infrastructure as a stormwater management technique. Green infrastructure practices include engineered structures like green roofs, bio-retention, vegetated swales, permeable pavement, rain barrels and cisterns, as well as natural practices like planting trees and native landscaping. The before and after vision presented in Figure 1 shows how a variety of green infrastructure practices can be retrofitted into an urban neighborhood. Green infrastructure practices represent decentralized alternatives to the traditional approach of capture, conveyance, and distant downstream discharge. While stormwater management is the primary function of green infrastructure in this localized form, it is important to note that it also provides many of those same ecosystem services that larger scale green infrastructure provides.

In pilot studies and demonstration projects across the U.S., green infrastructure has repeatedly shown considerable potential to reduce runoff volumes, peak flow rates, and pollutant loads. The multiple functions and other ecosystem benefits from green infrastructure practices make them even more appealing. One of the most widely cited demonstration projects is the Street Edge Alternative (SEA) pilot project in northwest Seattle, WA (Horner, 2002). In 2001, Seattle Public Utilities and other partners removed the existing curb and gutter drainage system from a one-block study area to reduce the impervious cover, and installed bio-retention cells to manage runoff from the remaining streetscape. Monitoring demonstrated that the project reduced runoff by 98% during the wettest time of the year. These results were sufficiently compelling that Seattle is now moving forward with similar projects for entire neighborhoods. In other cities, monitoring results from green infrastructure projects have been similarly remarkable, with 90% reductions consistently noted. Other studies have shown that green infrastructure practices are capable of retaining or removing between 30 and 95 percent of stormwater pollutants depending on the pollutant and the practice. Large scale modeling exercises have also shown that green infrastructure can be a highly effective stormwater management tool. One such example is the Green Build-out Model for Washington, DC, which LimnoTech developed in conjunction with

EPA and the Casey Trees Foundation (LimnoTech, 2009). The Green Build-out Model was used to examine the practical potential for green infrastructure retrofit placement across the city and to

Figure 1. Vision of integrated green infrastructure in developed Washington, DC neighborhood.

calculate the runoff and discharge reductions that might be achieved with implementation. Using a detailed geographic information system (GIS) analysis and a set of design and siting guidelines, this study identified tens of thousands of locations that would be suitable for green infrastructure retrofits. Modeling predicted that annual city-wide runoff reductions greater than 25% could be achieved and that annual runoff reductions in certain sewersheds could reach 80% with aggressive implementation of green infrastructure practices. The model also showed that combined sewer overflow (CSO) discharge volumes could be reduced by as much as 43% in an average year with this same level of implementation. The key finding of the study was that, even in the densest urban areas, there can be substantial opportunities to incorporate green infrastructure retrofits.

Green infrastructure is also highly touted as a stormwater management technique because of the multiple functions and multiple benefits that it provides. The benefits of gray infrastructure approaches for the most part are limited to water quality management and flood control. Green infrastructure provides these benefits as well as increased groundwater recharge, reduced air temperatures, improved air quality, reduced energy demand, enhanced aesthetics, and higher property values among others. A study of the Seattle SEA project showed that houses in the green infrastructure pilot area sold for three and a half to five percent more than otherwise comparable houses nearby (Ward, 2008). When one begins to monetize the ecosystem services that green infrastructure provides, the cost-benefit analysis typically tips in favor of the green approach over the gray. Take the effect on building energy demand for example. A study of Chicago's City Hall green roof demonstrated that the roof temperature in August was over 50 degrees Fahrenheit lower than a nearby black tar roof, which translates to an annual 10 to 15 percent decrease in heating and cooling costs (roughly $3,600). Keeping the roof membrane cool also serves to extend the life of the roof. This is all above and beyond the stormwater management benefits provided by green roofs (City of Chicago, 2003).

As green infrastructure is becoming better understood, the benefits are becoming increasingly obvious, but many communities are not yet convinced of these benefits. The reasons for this are discussed in the following sections.

CHALLENEGES ASSOCIATED WITH WIDE-SPREAD IMPLEMENTATION

There are quite a few challenges to moving ahead with wide-spread implementation of green infrastructure in communities with the jurisdiction to require such changes. The main challenges will be described in this section along with observations on these challenges.

Institutional Resistance to Change
Communities that have made the most progress implementing green infrastructure, such as Portland, OR and Seattle, WA, have embraced change. Unfortunately, many other communities are reluctant to deviate from the use of approaches and techniques that have been implemented for years. Some have made progress, and many aspire to be green, but change is not easy. As John F. Kennedy said, *"There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things."* Leadership and passion are key ingredients needed to overcome institutional resistance to change.

Agency Mission
Municipal government can be complex. Most communities have many agencies that play a large role in stormwater management, have jurisdiction over related aspects of stormwater management, or manage public land. Public works departments are often the key agency within city governments as they are responsible for municipal drainage programs. Transportation departments are also very important because they oversee the reconstruction and paving of streets, sidewalks and alleys. Education departments play a role in that they manage key pieces of public property with large rooftops and large parking lots that lend themselves to green infrastructure. Similarly, recreation departments also manage key pieces of open land that can, in many instances, be modified with green infrastructure. Lastly, sewer authorities may have a role, particularly where there are combined sewer systems that convey both sanitary sewage and stormwater runoff in the same pipe system. It often takes a substantial amount of coordination and effort to overcome inter-agency competition and “turf battles” to obtain cooperation between key agencies. Again, strong leadership is very valuable in assuring agencies work together for a common cause.

Building Codes and Road Design Standards
Building codes are rules that specify acceptable levels of safety for structures and adjacent non-structural facilities like sidewalks and parking lots and are often approved as law. Road design standards are generally established by state agencies, with some specificity added by county or municipal transportation agencies. Building codes, design manuals and road design standards promote uniformity in design procedures. They typically address design considerations that are important to green infrastructure, such as grade, drainage, and materials. Green design concepts; however, often run counter to existing codes and standards. Communities that are progressive in this area have assured that their codes are amenable to green infrastructure practices. For example, the City of Seattle’s Stormwater Code contained in Seattle Municipal Code (SMC) 22.800-22.808 requires projects to implement green stormwater infrastructure (GSI) to the maximum extent feasible (MEF). Chapter 4.3 presents the general requirements for all infiltration facilities, including setbacks and site restrictions, and subsurface evaluation requirements. Chapter 4.4 outlines the design guidelines and criteria for use of green stormwater

infrastructure best management practices (BMPs). Information includes engineering limitations, sizing requirements, and submittal requirements for the implementation of green stormwater infrastructure as a part of stormwater code compliance. Overcoming this challenge will require communities to adopt design standards that enable architects and engineers to move ahead with green solutions.

Economics

The economics of green infrastructure are not well understood. One reason for this is that is difficult to generalize about the cost of green infrastructure because many individual applications are governed by site-specific conditions (i.e., the size and load handling capacity of a rooftop, the local cost of permeable pavement, etc.). Another reason is that green infrastructure practices have not been in use for very long. As a consequence, performance, maintenance requirements, and costs are changing. The answer to this challenge is time. Much is being learned about costs and performance from those communities that are on the forefront. Over time an increasing number of pilot demonstration projects and case studies are being documented that include lessons learned about implementation and economics. The construction and landscape industries are gearing up to meet the challenge with innovative materials and new technical approaches. Cost are going down, and this trajectory will increase as practices become more standardized to meet specific codes and ordinances.

Implementation Time

Implementing green infrastructure on a broad meaningful scale will take a great deal of time – probably on the order of several decades. In suburban areas with new development, one can expect that green infrastructure will accompany new development as it spreads across previously undeveloped areas. In urban areas, where the rate of redevelopment is slower, retrofitting of green infrastructure becomes more important. One answer to this challenge is to look at this as an exercise in replacing current infrastructure with new green infrastructure products as the life expectancy and serviceability the old products ends. For example, roofs need replacement every 15 to 30 years, concrete walkways every 20 to 25 years, and asphalt driveways once in ten years on average. Implementation is likely to take on momentum when costs are viewed as competitive and municipal codes, design standards, and ordinances are written to encourage the use of green infrastructure.

Large Numbers of Facilities

The area covered by individual green infrastructure practices such as a short piece of sidewalk, a driveway, or a single rooftop is relatively small. Consequently, the number of green infrastructure practices implemented will need to be very, very large in order to make a difference. LimnoTech's previously referenced study of the potential for green infrastructure to make a difference in Washington, DC illustrates this point. The number of facilities required across the city to accomplish a 25 percent reduction in runoff included:

- 22,000 roof leader connections to rain barrels
- 55,000 roof leader connections to rain gardens
- 8,500 sidewalk bio-retention planters in business and commercial areas
- 22,000 curb bump-out bio-retention planters in residential areas
- 34,000 green roofs (20 percent of the rooftops in DC) covering 100 million square feet
- 42 million square feet of permeable pavement spread across thousands of driveways and parking lots

Looking at the number of traditional gray facilities in existence enables these large numbers to be put into context. In Washington, DC there are approximately 10,000 fire hydrants and 25,000 catch basins. Regardless, this number of green infrastructure facilities will require a substantial amount of planning, design, and maintenance and municipal agencies will need new programs in place for their implementation and management on public land. Similarly, homeowners will need education and incentive to construct and maintain new green facilities on private property. Ramping up to meaningful levels of green infrastructure will require time and, in many instances, patience.

Attainment of Water Quality Standards

The idea that green infrastructure on its own is going to lead to attainment of water quality standards in impaired water bodies in urban and suburban areas is inappropriate. EPA is; however, promoting the use of green infrastructure to manage stormwater to *help* reduce pollutant loads and maintain the natural hydrology of a watershed. As EPA states in its fact sheet *Incorporating Green Infrastructure Concepts into Total Maximum Daily Loads* (EPA, 2008), incorporating green infrastructure "into TMDLs can point the way toward implementation actions that can reduce stormwater runoff loads and erosive effects, and help meet pollutant loadings identified in the TMDL."

The implementation of a meaningful amount of green infrastructure is going to take decades, and even then its ability to bring urban waters into attainment will be limited. A number of factors are at work.

- Green infrastructure does a good job of reducing stormwater flow on an annual basis, but its ability to reduce pollutant loads is less well understood.
- Some pollutants will track well with the reduction in stormwater overflow volume. Others will not. For example, the ability of green infrastructure to reduce peak flow rates and lessen streambank erosion will certainly help to reduce sediment loads. This may be very important for waterways where impairment is caused by sediment. However, bacteria TMDLs in many waters call for up to 95 percent removal of bacteria through municipal separate storm sewer system (MS4) programs. Green infrastructure in its own is unlikely to come close to meeting targets that are this aggressive. As noted earlier in

the Washington, DC example, it will take a substantial amount of green infrastructure to reduce stormwater volume by 25 percent.

- Another consideration is that large storms are not well controlled by green infrastructure and pollutants are often washed into nearby waterways when they occur.

Looking ahead, green infrastructure can do many things but it will not solve urban water quality problems on its own. Continued investment in gray infrastructure will be needed until a balance of how much gray and how much green is found.

GREEN INFRASTRUCTURE AND NPDES PERMITS

EPA has expressed enthusiastic support for green infrastructure over the past five years. Many states are equally enthusiastic. Historically, stormwater permits (MS4 permits) were written to address the reduction of pollutants in stormwater to the maximum extent practicable (MEP). Increasingly, EPA and some states are emphasizing reduction in runoff volume in stormwater permits with the control of hydrology as the main objective under this approach. In urban areas this approach is being realized through implementation of green infrastructure practices that effectively reduce imperviousness and facilitate infiltration. For new development, a "do no harm" approach is used wherein post development hydrology is expected to match pre-development hydrology. For re-development, green infrastructure is used to reduce the existing imperviousness on site.

In March 2007, the Assistant Administrator of EPA, issued a memorandum promoting the use of green infrastructure entitled *Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and Other Water Programs* (EPA, 2007a). The memorandum stated that "green infrastructure can be both a cost effective and an environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions." Although a number of states and municipalities had already been using green infrastructure, this memorandum provided the incentive and backing of EPA to incorporate its use on a wider scale.

In April 2007, EPA and four other signatory organizations signed a Green Infrastructure Statement of Intent to *"promote the benefits of using green infrastructure in protecting drinking water supplies and public health, mitigating overflows from combined and separate sewers and reducing stormwater pollution, and to encourage the use of green infrastructure by cities and wastewater treatment plants as a prominent component of their Combined and Separate Sewer Overflow (CSO & SSO) and municipal stormwater (MS4) programs*"(EPA et al., 2007)

EPA continued to provide clarity on the use of green infrastructure in August 2007 when the Directors of the Water Permits Division and the Water Enforcement Division issued a memorandum entitled Use of Green Infrastructure in NPDES Permits and Enforcement Actions (EPA, 2007b). This memorandum stated that *"in developing permit requirements, permitting authorities may structure their permits, as well as guidance or criteria for stormwater plans and CSO long-term control plans, to encourage permittees to utilize green infrastructure approaches, where appropriate, in lieu of or in addition to more traditional controls. EPA will also consider the feasibility of the use of green infrastructure as a water pollution control technology in its enforcement activities."*

Despite the fact that a number of permittees across the country had begun using more innovative green infrastructure technologies to address stormwater and were already implementing their second and third round of MS4 permits, EPA continued to identify urban stormwater as a primary source of water quality and aquatic habitat degradation in urban stream systems. As shown in Figure 2, EPA has stated that runoff from urban/suburban areas (MS4s) is the only major source that is not reducing nitrogen, phosphorus, and sediment pollution in the Chesapeake Bay Watershed (EPA, 2010a).

EPA asked the National Research Council (NRC) to conduct a review of its stormwater program in 2006. NRC released the report *Urban Stormwater Management in the United States* in 2008 (NRC, 2008). This report examined issues with the current program and recommended a number of actions to improve the stormwater program. This included two recommendations particularly important to green infrastructure: 1) reducing impervious surfaces, and 2) retrofitting urban areas with green infrastructure. As a result of this report, EPA proposed a rulemaking in 2009 to strengthen its stormwater program to more comprehensively reduce stormwater discharges from new development and redevelopment.

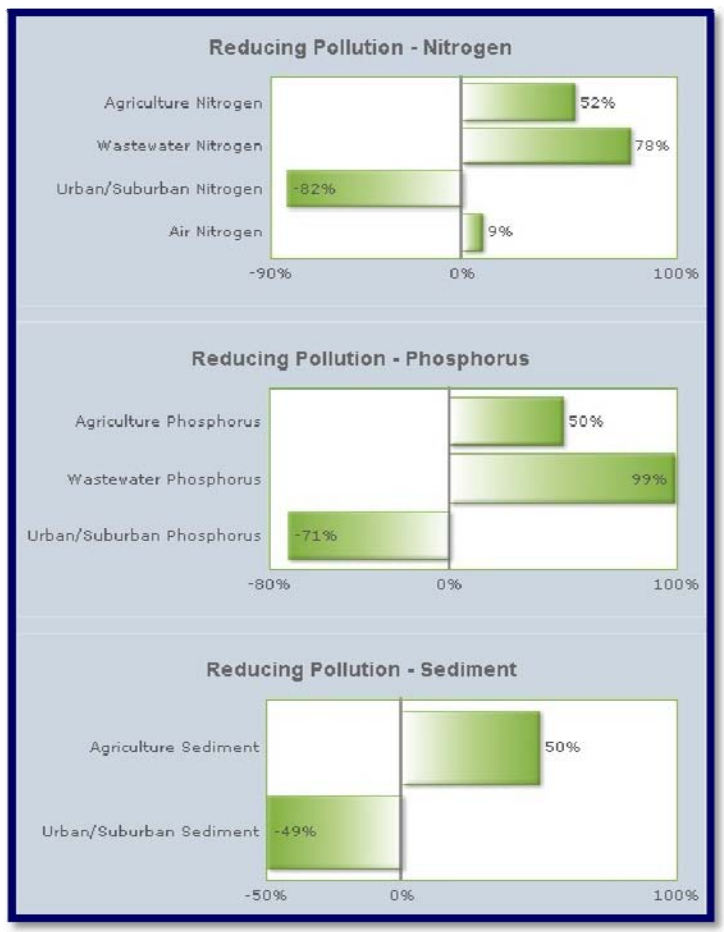

Figure 2 – Pollutant removal achievements by source from 1985 – 2009 in the Chesapeake Bay Watershed

While the final rule is not expected until 2012, EPA has continued its approach to strengthen the stormwater program with the publication of the MS4 Permit Improvement Guide

(EPA, 2010b). The purpose of the Guide is to strengthen MS4 permits stressing, in part, that "permits should contain a performance standard for post-construction that is based on the objective of maintaining stable hydrology to protect water quality of receiving waters".

While EPA is evaluating new federal requirements for the use of green infrastructure, a number of states and municipalities across the country have been very proactive in encouraging and implementing green infrastructure. In fact, several states are incorporating requirement to address flow and maintaining natural hydrologic conditions into regulations and MS4 permits. Some examples include:

Maryland – The state requires Phase I MS4's to retrofit 10% of impervious area that currently does not have stormwater controls in place. It is anticipated that the percentage of area requiring retrofits will double in the next permit cycle. Maryland has also recently adopted new stormwater regulations for development and redevelopment that require, in part, the use of green infrastructure to the maximum extent practicable.

Washington, DC – The draft Phase I MS4 permit requires on-site retention of 1.2 inches of rainfall (90% capture) for new development and retrofits or design to achieve retention of the predevelopment runoff volume of stormwater from a 24-hour storm for the 1, 2, 10, and 100 year storm events. The on-site retention requirement is 1.7 inches of rainfall for federal facilities. The permit promotes green infrastructure for retrofits and establishes specific minimum performance measures for increased enforceability.

Tennessee – The small MS4 general permit requires runoff reduction with the use of green infrastructure. Site design standards are to provide for infiltration, evapotranspiration, or reuse of the first inch of every rainfall event preceded by 72 hours of no measurable precipitation. The first inch of rainfall must be 100% managed with no discharge to surface waters. An alternative standard for this runoff reduction requirement is the removal of 80% of total suspended solids (TSS) from the discharge.

Massachusetts – The draft small MS4 general permit requires 100% capture of volume of water runoff from a one inch storm event. Stormwater management must be designed to remove 80% of the average annual post-construction load of TSS. The permit also includes requirements to inventory impervious areas connected to the MS4 and MS4-owned property and infrastructure that may have the potential to be retrofitted with BMPs to reduce the frequency, volume, and peak intensity of stormwater discharges to and from its MS4.

New Jersey – The New Jersey Stormwater Management Rules require that projects that disturb at least 1 acre of land or create at least 0.25 acres of new or additional impervious surface must either:

- *Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual preconstruction groundwater recharge volume for the site;* or
- *Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the two year storm is infiltrated.*

(New Jersey Stormwater Management Rules, N.J.A.C. 7:8)

North Carolina – The permit *To Construct, Operate and Maintain Impervious Areas and BMPs Associated with Residential Development Disturbing Less Than 1 Acre* provides the option that stormwater can be managed through the installation of rain cisterns or rain barrels that collect the first 1.5 inches of rain with any overflow directed to a vegetated area in a diffuse flow.

Permittees can construct all uncovered driveways, uncovered parking areas, uncovered walkways, and uncovered patios out of permeable pavement or other pervious materials. Permittees can also direct rooftop runoff from the first 1.5 inches of rain to an appropriately sized and designed rain garden.

West Virginia – The draft small general MS4 permit includes watershed protection elements that address hydrologic cycle functions, as well as a performance standard for new projects and redevelopment. Specifically, the permit includes language that any policy and/or planning documents must include, in part, a description of how the MS4 will m*inimize the amount of impervious surfaces (roads, parking lots, roofs, etc.)* within each watershed, preserve, protect, create and restore ecologically sensitive areas that provide water quality benefits and serve critical watershed functions, implement stormwater management practices that prevent or reduce thermal impacts to streams (vegetated buffers along waterways, disconnecting discharges to surface waters from impervious surfaces), and avoid or prevent hydromodification of streams and other water bodies caused by development, including roads, highways, and bridges.

The permittee must also implement and enforce site design standards for all new projects and redevelopment that require, in combination or alone, management measures that keep and manage on site the first inch of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation.

California – The Los Angeles Regional Water Quality Control Board included new development and redevelopment performance criteria in the draft MS4 permit for Ventura County that states that "[p]ermittees shall require that all new development and redevelopment projects… control pollutants, pollutant loads, and runoff volume emanating from impervious surfaces through percolation, infiltration, storage, or evapotranspiration, by reducing the percentage of Effective Impervious Area to less than 5 percent of total project area."

Additionally, green infrastructure is being required in other California permits. For instance, the San Francisco, MS4 permit requires the evaluation of pilot projects for green streets. The San Diego County MS4 permit requires green infrastructure to be used to the maximum extent practicable for certain retail gas outlets and heavy industry, with development projects that pose a potential threat to water quality, and for all other new and redevelopment where feasible.

SUMMARY

The use of green infrastructure as a means of controlling stormwater runoff is clearly on the rise. With growing enthusiasm at EPA and with some state permitting authorities, more specific requirements in NPDES MS4 permits to maintain pre-development hydrology and to reduce effective impervious area with retrofits can be expected. Additionally, as a growing number of TMDLs are developed, pollutant loading reduction requirements will be tied to MS4 permits and green infrastructure in order to meet pollutant loadings identified by TMDLs. Communities that are not yet required to implement green infrastructure or are not currently implementing it proactively should be aware of these trends and plan accordingly.

The pace of implementation of green infrastructure is accelerating, but there are many serious obstacles and challenges to implementation. The greening of American cities and suburbs will take a substantial amount of time. The tipping point will come when costs are viewed as competitive and municipal codes, design standards, and ordinances are written to encourage the use of green infrastructure. The enthusiasm and encouragement is already there.

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