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Using Ecological Systems for Alternative Stormwater Management

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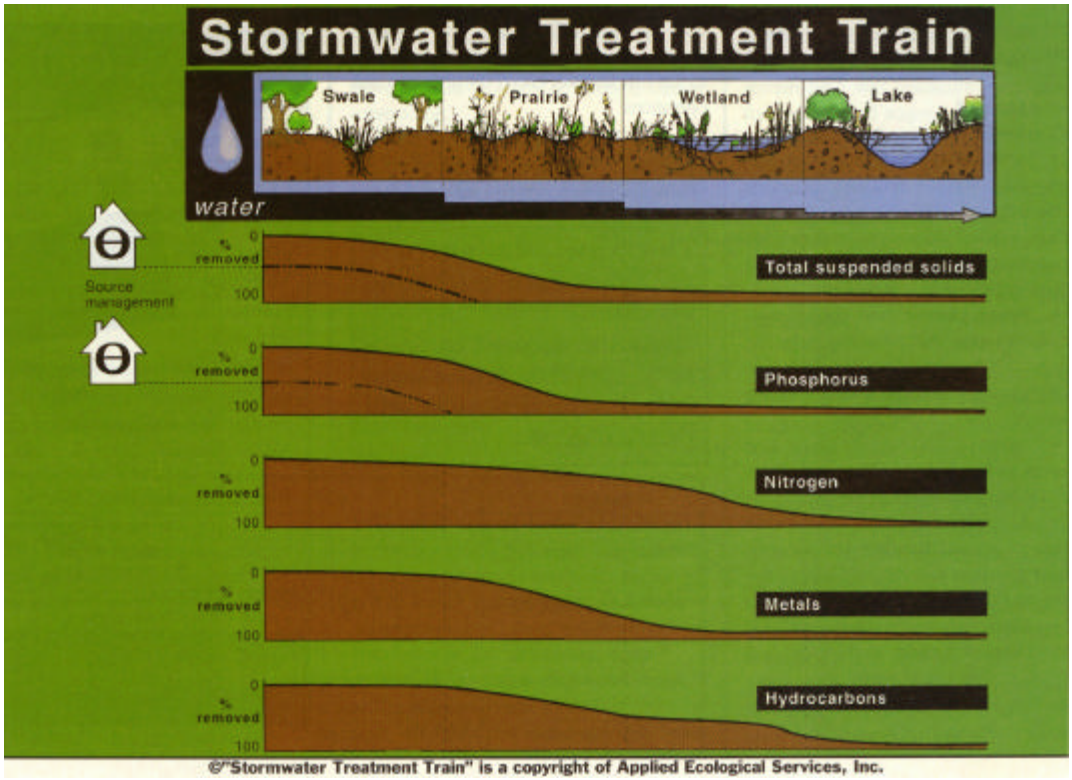
BEFORE the 1830s, when the Midwest was still considered Wilderness, the first white settlers in our region could hardly recognize the streams that now bear familiar names on the maps of our region. Original land survey records of the U.S. General Land office identified many of the streams we know today only as vegetated swales, wetlands, wet prairies and swamps.

Today, the broad, clear, meandering waterways of the past are comparatively fast-running, usually sediment-clouded streams with distinct banks and relatively frequent flood events. Lost are millions of acres of prairie, wetland and wildlife habitat, fisheries habitat and healthy ecosystems that once made the central U.S. a highly functional stormwater drainage system and an extremely productive natural area.

A review of the historic data shows that dramatic increases in discharges have occurred during low, median and high flows since settlement times. "Modern" channels have been formed either: inadvertently, through erosion caused by increased water volumes and flow rates; or intentionally, as channels were created to drain land for development and agricultural uses. In fact, current discharges may be 200 to 400 times greater than historic levels, based on data recorded from 1888 to the present on the Des Plaines River in southeastern Wisconsin and northeastern Illinois.



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Land development in both urban and agricultural areas has changed stormwater runoff patterns from diffuse overland flows to increased runoff rates and concentrated flows. Therefore, the opportunity to emulate and restore historic stormwater patterns exists through the integration of natural ecosystems in our urban and rural landscapes. Ecological solutions to stormwater management are now beginning to prove easier to maintain, less expensive, more attractive and more beneficial to wildlife than conventional stormwater management solutions.

Critical Role of Wetlands

Both historically and today, wetlands have played an important role in the maintenance of regional water balances. They also contribute significantly to the performance levels of stormwater and floodwater management strategies.

Because our river systems have changed substantially, it is important to understand the magnitude of the changes in our rivers, wetlands and their tributary upland ecosystems. By doing so we may comprehend the changes in hydrology and hydraulics these systems have undergone.

Future engineering approaches to stormwater management – even in highly urbanized environments with limited open space – can benefit greatly. This can be done by incorporating restored ecological systems (wetlands, upland prairies and forests) as important elements of creative, cost-effective solutions.

These ecological systems can improve our management of stormwater and floodwaters while simultaneously offering secondary benefits that are not typically provided by conventional approaches to stormwater management. These benefits include improved wildlife habitat, increased biodiversity, enhanced water quality and expanded open space.

Historic Functions of Hydraulic Systems

Today's rivers are clearly the most obvious indicators of changes that have occurred in their watersheds. An understanding of the hydrology of rivers can help us determine the magnitude of hydraulic change. Having this understanding, positive changes can result from incorporating wetlands, prairies and other landscape features of ecological systems as functional elements in water resource management.

Studies of the Des Plaines River and its watershed region have identified hydraulic and hydrological changes associated with the initial clearing of land for agricultural purposes and for present-day urban development. Over 90 percent of the historic native vegetation in the Des Plaines River watershed, including wetland, prairie, savanna and woodland systems, has been lost or severely degraded. The result is: increased stormwater runoff; higher suspended sediment loads; reduced stability of stream geometries; decreased stream system functions; deteriorated water quality; degraded river wildlife and fisheries habitats; and, ultimately, vanishing human opportunities that contribute to our quality of life.

The Q & A's of "Conservation Development"

What opportunities exist for developments in urban and rural areas to reestablish a percentage of the historic wetlands, prairies and forests? What benefits and costs would be associated with the pursuit of these opportunities? In addition to water quality and flood management, are there other benefits that can be factored into the cost/benefit equation?

These questions are fundamental when we're considering the integration of natural systems and conservation principles into developments that impact water resource management. Only in the past few years have answers begun to emerge from the residential and commercial "conservation development" projects that have undertaken to solve such a cost/benefit equation. And, while rock-solid scientific and financial conclusions may still be somewhat elusive, owners of these development projects are convinced the benefits of restored wetlands and prairies outweigh the costs.

In a conventional urban development, the questions are not even asked. Urban developments may cause increased stormwater runoff rates and volumes, along with increased runoff of contaminants such as sediments, fertilizers, de-icing materials, heavy metals and other chemical constituents. Conventional residential developments generally strive to maximize building density, reserving open space only on individual lots, while public open space is created only as required by ordinance for recreational parks or stormwater management purposes.

Stormwater management in a conventional development is concerned only with minimizing on-site and downstream flooding, along with some nuisance aspects of stormwater runoff. Consequently, most urban stormwater systems consist of storm sewers to convey runoff, a detention basin and an outlet structure in the basin to control stormwater release rates.

The Prairie Crossing Model

Perhaps the best model of a conservation development designed for water quality goals and environmentally sensitive stormwater management is that of Prairie Crossing, a 667-acre residential development in Grayslake, Illinois. Prior to development, the site was farmed under an annual crop rotation. Soils were modified by drainage improvements, including an extensive tile system. Native biological communities had been eliminated.

The Prairie Crossing project has taken a series of measures to reduce runoff rates, runoff volumes and pollutant loads. In addition to voluntary source controls, these measures include integrating large-scale restored landscapes into the development as a major element of the stormwater management system.

The stormwater management system consists of natural open swale conveyance systems, upland prairie biofiltration, wetlands and a lake. In combination, these increase runoff lag time, increase opportunities for pollutant removal through settling and biofiltration, and reduce the rate and volume of runoff through enhanced infiltration opportunities.

The Prairie Crossing project includes a high-density "village center" and an outer area of clustered homes. Open space has been restored to the prairie, wetland, wet prairie, and savanna communities historically found on the site. This restored landscape provides a unique living environment for the residents of Prairie Crossing. An additional 150 acres of agricultural lands are integrated into the development to maintain the rural agricultural landscapes of the area.

Stormwater Management "Treatment Train"

Open space at Prairie Crossing was planned to provide stormwater management for the project. The system, called the Stormwater Treatment Train©, was designed with sequential components that contribute to the treatment of stormwater before it leaves the site.

Stormwater from the built areas is routed overland into open conveyance swales planted with native prairie and wetland vegetation, rather than through storm sewers. The swales provide initial stormwater treatment, primarily infiltration and sedimentation. The prairies are the second component.

Prairies diffuse the flows conveyed by the swales, and the reduced stormwater velocities maximize the prairie's sedimentation, infiltration and evaporative water treatment.

Additionally, the natural adsorption and absorption of the prairie soils enables the soil to hold many contaminants. The aerobic condition of the soil promotes hydrocarbon breakdown. The prairies are able to infiltrate a substantial portion of the annual surface runoff volume due to their increased soil permeability which is created by the deep root systems of the prairie vegetation. Wetlands provide both stormwater detention and biological treatment prior to runoff entering the lake. The lake also provides stormwater detention, further solids settling, and biological treatment.

The components of this system were designed to treat stormwater runoff for water quality benefits and to reduce stormwater runoff peaks and volumes. An indication of the success of the project in reaching water quality goals is that a consortium of conservation organizations last year established a pilot program to stock threatened and endangered non-game fish species into the lake at Prairie Crossing. Fish survival this year has been excellent due to the outstanding water quality and excellent habitat established with diverse native aquatic vegetation planted along the lake shoreline.

Based on hydrologic modeling and published information on BMP effectiveness, the Prairie Crossing development can be expected to reduce surface runoff volumes by 65% and reduce solids, nutrients, and heavy metals loads by 85% to 100%. Source controls minimize the impacts of the development even further.

The result not only reduces costs to the developer, but also reduces maintenance costs for the community. There is also a substantial benefit to downstream neighbors. By treating stormwater where it falls on the land, Prairie Crossing is reducing its contribution to downstream flooding and sedimentation.

Conservation Development Gaining Momentum

Because of its commitment to healthy ecosystems, the Prairie Crossing development is unique in northeastern Illinois and probably most of the country. However, the concepts of conservation development and stormwater best management practices are rapidly gaining wider acceptance among developers and regulators.

In southeastern Wisconsin, Bielinski Development, inc. has made a strong commitment toward the concept of conservation development, and is initiating all future projects with a thorough ecological inventory of existing natural resources on potential development sites.

From that baseline, Bielinski is working with ecologists and land planners to design sites that preserve valuable resources, buffer them from the impacts of developed areas and restore healthy ecosystems. Bielinski has plans to incorporate the Stormwater Treatment Train on all of its project sites.

One Bielinski development, a 39-acre site in Germantown, Wisconsin, was chosen in a regional competition as one of three Model Conservation Development Projects of the Great Lakes region by the non-profit group, The Conservation Fund. The site is designed for 31 single family lots and nearly 60% protected open space which integrates mature woodlands, restored prairie buffers, swales and a restored wetland.

Conclusion

Wetlands and prairies can provide years of essentially free stormwater management services. However, if they are mismanaged, the cost can be considerable. To maintain higher quality wetlands,

stormwater supplied to the wetlands should be higher quality, and the delivery should be somewhat predictable. This may require pretreatment of stormwater in systems that are likely to experience extremes.

Not all wetlands are equal from the perspective of biodiversity, wildlife habitat, water cleansing, human-use, and aesthetics. Using wetlands for water quality management purposes can compromise the conservation of high quality wetlands; however, this should not discount their importance or feasibility for use in water resource management. It simply illustrates the importance for engineers to work closely with other disciplines to present accurate and adequate information to decision-makers. ***L&W***