

# Stormwater's Role in New Urbanist Development

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With the increasing focus on the intersection of environmental sustainability and urbanism, green infrastructure is now used to manage stormwater in New Urbanist projects of all sizes. But how is sustainability quantified at different scales of development and in comparison to conventional strategies? To analyze stormwater's role in sustainable development, one must first understand the water balance and ecohydrology at both the neighborhood and local levels. When these concepts are correctly applied and quantified, proper stormwater management becomes an effective argument for density and urbanism, justifying New Urbanists' efforts to design places in balance with nature.

## Stormwater Management Concepts

### The Hydrologic Cycle: Water Balance

The concept essential to understanding the analysis of water's role in sustainable planning and design is the *hydrologic cycle*. *Hydrology* is the study of water's movement through the earth's systems, and in the *hydrologic cycle*, water falls as precipitation and is recycled in one of two ways:

- "Green water" flow returns to the atmosphere via evaporation from surface puddles and transpiration from plants and trees (evapotranspiration)
- "Blue water" flow returns to aquifers as infiltration into the ground (recharge) or runoff from the surface

Assuming that the total volume of water within the hydrologic cycle is a constant, the *water balance* quantitatively evaluates the proportions of green water flow and blue water flow. The goal of sustainable development is to match the study area's pre-development water balance condition, thus accommodating development with as little effect on nature's equilibrium as possible.<sup>1</sup>

### Ecohydrology

*Ecohydrology* is a relatively new but rapidly developing scientific field which, broadly defined, seeks to understand the interaction between the hydrologic cycle and terrestrial ecosystems<sup>2</sup>. This paper focuses more specifically on development's influence on the interaction between plant ecosystems and the water balance. In other words, how do development patterns affect open space and woodland, and what is the accompanying change in the water balance?

Figure 1 shows the various relationships between the hydrologic cycle, ecological systems, and human influences. Since the water balance defines the hydrologic cycle as a zero-sum game, changes in any one component of the cycle affect the other components, therefore evapotranspiration, recharge, and runoff are connected by solid lines. Incorporating ecohydrology, changes in natural resources (here defined as plant ecosystems such as grassed and wooded areas) directly affect evapotranspiration, represented by the solid line connection, and the replacement of ecosystems with impervious area has effects on run-

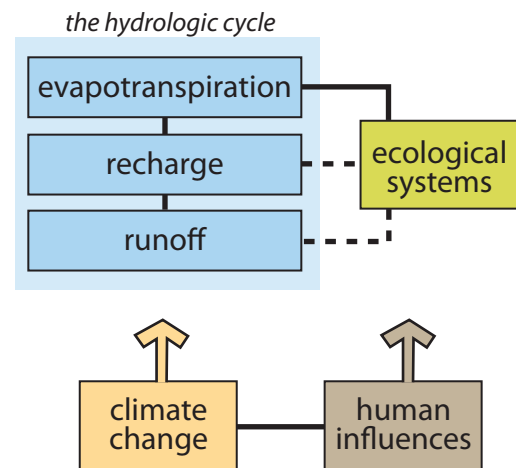


Figure 1: Development & Ecohydrology

<sup>1</sup> Water *quality* is evaluated independently from the water balance. Stormwater runoff "washes" surfaces such as roads and parking lots, taking the pollutants downstream. Oil, grease, metals, nutrients, and other contaminants are present in stormwater runoff. Management techniques are available to improve water quality by filtering the runoff flow stream to remove pollutants, and sustainable solutions encourage micro-scale naturalized processes such as biofiltration and grass swales.

<sup>2</sup> Prof. dr. A.J.H. (Han) Dolman, 2003.

off and recharge, as represented by the dashed lines. Human influences, i.e. development, have important effects on both the components of the hydrologic cycle and ecological systems. Climate change is included but not discussed in this paper.

### Human Influences

The most effective way to maintain the water balance is to avoid creating excess impervious land cover in the first place. This practice will maintain natural plant and vegetation uptake, promote water infiltration into the soil, and avoid excess runoff. Infill and redevelopment channel growth to already disturbed areas, thus maintaining natural resources elsewhere in the region and restoring disturbed sites. However, experts predict 100 million new Americans by 2037 and 34 million new housing units by 2030<sup>3</sup>. It is unrealistic to expect this growth will be accommodated by redevelopment alone. Therefore, building new communities while preserving the water balance is necessary to protect and restore water resources for future generations.

## **Evaluation of Stormwater Management at the Neighborhood Scale**

### Background and Case Study Scenarios

In order to quantify traditional neighborhood development's effects on stormwater in comparison to conventional land use patterns, a new methodology and framework for presentation of data is needed. Publications by the Environmental Protection Agency (EPA) have documented the benefits of compact development patterns at the neighborhood scale by comparing the amount of runoff generated by residential development scenarios with varying density. By developing the same number of units with higher density on less land, and conserving the remainder of the watershed, significant reductions in runoff were measured. The 2006 study by the EPA states<sup>4</sup>:

Typically, a planning department analyzes the projected stormwater runoff impacts of a developer's proposal based on the acreage, not the number of houses being built. Runoff from one house on one acre is roughly half the runoff from eight houses. However, where did the other houses, and the people who live in those houses, go? The answer is almost always that they went somewhere else in that region – very often somewhere within the same watershed. Thus, those households still have a stormwater impact. To better understand the stormwater runoff impacts from developing at low densities, the impacts associated with those houses locating elsewhere need to be taken into account. This approach has two advantages:

1. It acknowledges that the choice is not whether to grow by one house or eight but is instead where and how to accommodate the eight houses; and
2. It emphasizes minimization of total imperviousness and runoff within a region or watershed rather than from particular sites – which is more consistent with the science indicating that imperviousness within the watershed is critical.

The above argument is effective and accurate, but only a piece of the picture. New Urbanists must go a step further by adding the effects of recharge and evapotranspiration to the equation to obtain a comprehensive view of the water balance. Presenting the comprehensive water balance data can further emphasize the environmental benefits of New Urbanism. As contiguous ecologically sensitive areas are maintained, more of the green contribution to the water cycle is preserved. This preserved evapotranspiration contribution improves the efficiency of the water cycle by returning water to the atmosphere in the most direct and productive way. The added benefit is that when the quantity of green water flow is preserved the blue water flow to be mitigated by detention and/or recharge improvement efforts is greatly diminished.

A case study example may help demonstrate the recommended comprehensive methodology. Two development scenarios were used, each accommodating the same number of residential units and the same amount of commercial space, both using the same 300 acres of land as a base. The compact New Urbanist, or traditional neighborhood design (TND), scenario uses the original Mashpee Commons 60 acre core TND plan, maintaining 240 acres of the 300

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<sup>3</sup> EPA White Paper: *Where Will Everybody Live?* Arthur C. "Chris" Nelson, Virginia Tech. 2007.

<sup>4</sup> *Protecting Water Resources with Higher-Density Development*, EPA, 2006.

acre study area as untouched natural area. The conventional land use scenario accommodates the same development program but utilizes single-use low density residential development required by local zoning, dendritic local-collector-arterial street layouts, and “big box” retail development. As a result, 280 of the entire 300 acres are altered with development, requiring additional impervious area for infrastructure (see Figure 2).

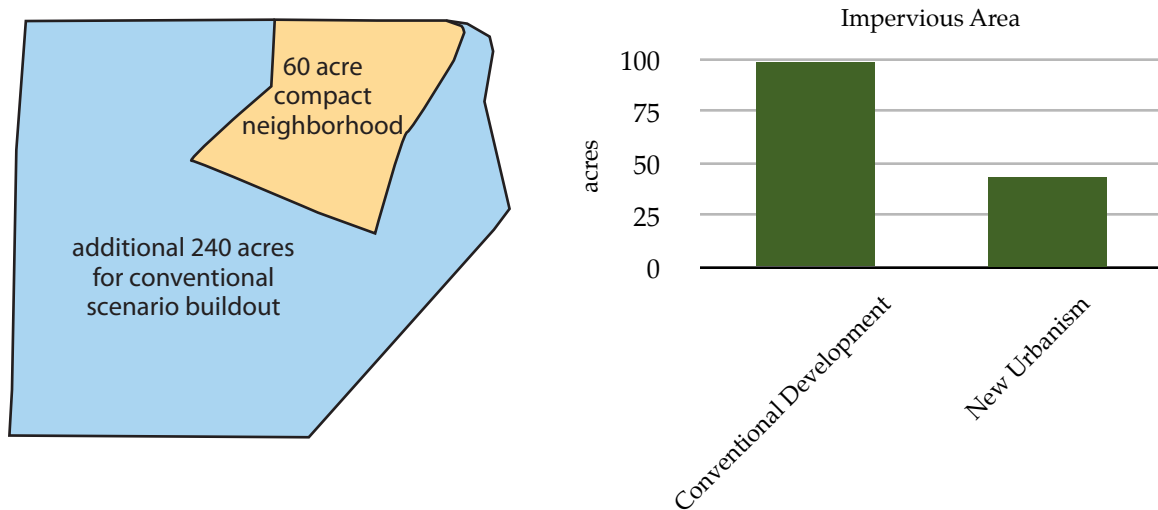


Figure 2: Neighborhood Case Study Scenarios

Reiterating the scale of development under analysis for this case study, the 60 acre TND development scenario is a complete neighborhood incorporating 300 housing units with a range of housing types along with 250,000 square feet of office, restaurant, and retail space. It is important to understand the unit of analysis is the neighborhood. Too often, site-by-site localized low impact development (LID), conservation subdivisions, or similar sustainable planning techniques are applied in locations where the transportation framework and environmental conditions support more urban, concentrated neighborhood scale development. This can be damaging to regional long-term watershed planning efforts by spreading population density within the region, adding impervious area, and not efficiently conserving contiguous natural resources. Conservation of natural resources should be considered holistically at a sufficiently large scale to ensure both:

- preservation of contiguous natural resources and wildlife habitat, i.e. wilderness and the “countryside”
- development of complete *Living Neighborhoods*<sup>5</sup>: neighborhoods of sufficient compactness, complexity, and size to support daily needs and services within walking distance of residents

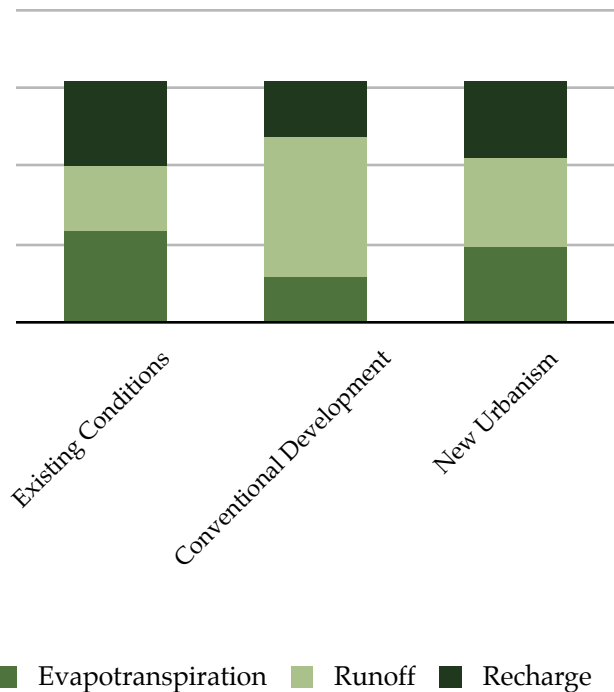
<sup>5</sup> Russell Stanton Preston. See *Living Urbanism as a Starting Point*, 2008.

## Analysis

The case study water balance looks quite different for the conventional and New Urbanist scenarios, as seen in Figure 3.<sup>6</sup> The conventional scenario's loss of natural resources and increase in impervious area leads to a significant reduction in evapotranspiration and recharge as components of the water balance. The compactness of TND preserves more natural resources and requires less total impervious area, leading to improved evapotranspiration and recharge contributions. Addition of stormwater recharge systems and incorporation of site "greening" practices to replace impervious area with planted and wooded areas would further improve evapotranspiration and recharge, bringing the water balance closer to the pre-development condition.

The case study results are telling, but as important is the methodology used and presentation of data. Presenting the annual water balance for a neighborhood within a regional framework provides the clearest picture of environmental impact by including the effects of ecohydrology. It is crucially important to accurately depict conservation of natural resources along with higher density development by comparing the TND scenario's water balance to a conventional scenario buildout, and always using existing conditions as the baseline comparison. The beneficial regional stormwater effects of concentrated development are lost if the accompanying conservation of natural resources is not included in the analysis.

Figure 3: Case Study Annual Water Balance Comparison



## Stormwater Management Techniques at the Neighborhood, Block, Street, & Building Scale

Micro-scale sustainable stormwater management "green infrastructure" solutions such as bioretention pockets, rain gardens, water quality swales, green roofs, and stormwater harvesting systems can be incorporated into conventional or New Urbanist projects, regardless of density or level of neighborhood compactness. Much like the failure of the most green big-box retail buildings to provide true sustainability when they exist within the conventional sprawl land use model, green infrastructure techniques (rain gardens, swales, pervious pavement, bioretention, etc.) incorporated into a sprawling conventional development plan provides limited benefit. When an environmentally sensitive location remote to regional transportation networks and population centers is developed with low density "sprawl" development, even the most sustainable micro-scale stormwater management measures cannot offset the macro-scale negative impacts of sprawling infrastructure.

Traditional neighborhood design is often more sensitive to misapplication of sustainable stormwater management practices. For example, swales and bioretention pockets rarely fit in the urban core without eroding the urban character of place (and necessary density), since these stormwater management solutions often require more area than conventional stormwater mitigation techniques in order to function effectively. This is not to say the urban core cannot deal with stormwater in a sustainable manner, because it certainly can. But techniques must be implemented that reinforce the urban context the place being created.<sup>7</sup> Again emphasizing the interrelated nature of the water balance, ecohydrology, and development patterns: any reduction in density at more urban levels of the transect leads to more

<sup>6</sup> Detention and recharge systems to mitigate post-development stormwater runoff rate and volume were not incorporated for this case study in order to isolate the effect of land use patterns on the water balance.

<sup>7</sup> The concept of stormwater management techniques calibrated across the transect is addressed in much more detail by Duany Plater-Zyberk's *Light Imprint New Urbanism*. Visit [dpz.com](http://dpz.com) for more information.

area required to accommodate development elsewhere, which causes a reduction in natural resource conservation, which affects the regional water balance by reducing evapotranspiration and increasing runoff.

A useful case study detailing appropriate stormwater management at the neighborhood, block, street, and building scale is a TND recently planned in Durham County, North Carolina.<sup>8</sup> Most importantly, the master plan preserves contiguous sensitive hydrologic patterns and ecological areas. In addition, the master plan strategy will incorporate stormwater management techniques such as recharge systems buried under parking, bioretention, grassed swales, pervious pavement, and rainwater harvesting, all integrated appropriately with the character of the proposed town center and residential neighborhood scales of development.

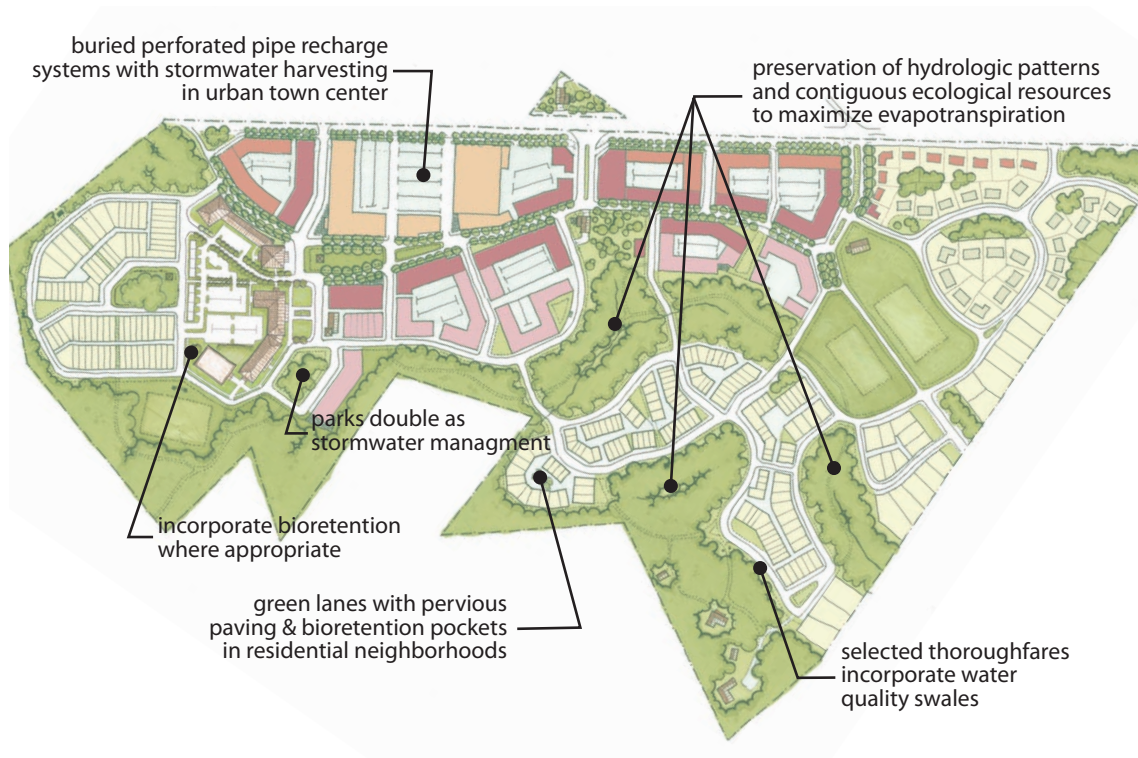


Figure 4: 751 Mixed-Use Development, Durham County, North Carolina (master plan drawing by Civitech, Inc.)

## Conclusion

New Urbanists must understand the importance of the methodology and analysis of stormwater management at the neighborhood/block/street/building scales in order to clearly communicate why TND offers benefits at these different scales. Compact and well-connected Living Neighborhoods lead to tremendous advantages in the protection and maintenance of the water balance. Block, street, and building level context-sensitive design of sustainable stormwater management techniques within the neighborhood, in combination with strategic natural resource conservation and site greening, reinforces and adds to the regional land use benefits of traditional neighborhood planning. Analysis of the regional benefits of TND and density in combination with incorporation of green infrastructure practices at the neighborhood, block, street, & building level, encompasses the integrated and comprehensive New Urbanist sustainable planning and design advantages.

<sup>8</sup> Morris Beacon Design contributed as a charrette participant and with follow-up design and analysis. The charrette was led by Civitech, Inc. for Southern Durham Development, LLC, with additional participation by Coulter Jewell Thames, Gibbs Planning Group, Opticos Design, Poole Design, and Randall Arendt.