APPENDIX 16.11
A Zero-Discharge Program for Development on Slopes in the Village of Tarrytown, New York

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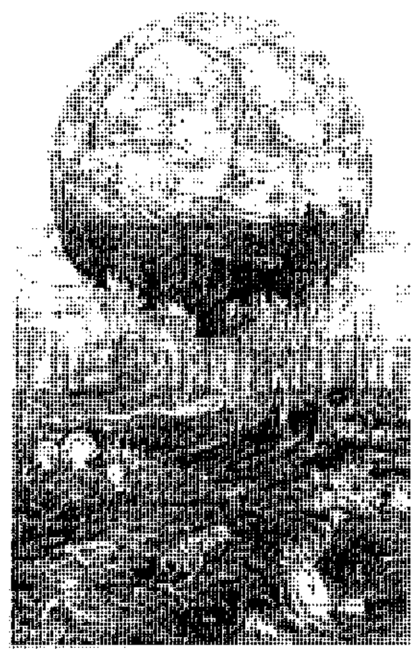

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Landscape Conservation & Enhancement For Stormwater Capture and Infiltration

Introduction

The Village of Tarrytown is situated between expansive views and direct drainage to the Hudson River toward the west, and sloping hills, a floodplain and valley to the east. While the area has been modified by roadway and rail infrastructure and development, the beauty of the surrounding forested hills is the landscape feature that adds the most value to the town's aesthetic.

Slopes move water unless their covering of soil is porous and deep enough to entrain precipitation into groundwater. The hills of Tarrytown are quite well endowed in this critical dimension of the water cycle. Chatfield and Charlton soils on the slopes around Mary Mount College come from relatively sandy glacial origins, and provide infiltration rates of between 0.6 and 6 inches per hour.[1] Water from most storms presently disappears into the ground in these environments, appearing weeks to months later in local streams and water bodies - including the Tarrytown lakes and the Hudson herself.

One serious negative result of development, however, has been to impact or nearly eliminate, in some cases, this water holding capacity of the land. This one landscape change, from pervious to impervious, can act on three critical fronts to diminish environmental quality by:

1) Reducing local biological diversity and environmental health, since runoff means that water moving off the land is no longer available to support local ecological processes around homes, on forested slopes, or along roadways;
2) Moving nutrients and pollutants from soils, lawns, and streets into receiving waters, from streams to lakes to the Hudson River, making these subject to algal blooms, lower oxygen levels, and sediment loads that destroy habitat; and,
3) Diminishing groundwater storage that can impact local wells and water supplies for households and businesses, as well as supplying lower quantities of high quality base-flow to lakes and streams.

Legends at Wilson Park is a development planned for the forested hills adjacent to Mary Mount College and is under consideration for permitting by the Village of Tarrytown. A portion of the proposed development is located in the drainage area located just to the west of Tarrytown Lakes. These reservoirs have been impacted by various construction projects and properties in the past, so utilizing the lakes to attenuate flow[2] short-circuits

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[1] Soil Survey of Putnam and Westchester Counties, New York. U.S. Dept of Agriculture. Soil Conservation Service, in Cooperation with Cornell University Agricultural Experiment Station. September 1994.
[2] DEIS for Legends at Wilson Park, Ch. 5, Pg. 2.

the potentials of natural filtration, and thus cannot attain one of the most important environmental goals of the municipality, i.e., to protect these waters from further degradation.

An even further reaching aim is to remediate historical damage, - a goal that requires a comprehensive approach to stormwater capture, natural filtration and groundwater storage both for existing structures or proposed developments in the watershed feeding into these water bodies. Associated infrastructure, impervious areas, ongoing soil erosion, and any fertilizer runoff or septic discharge into these water bodies would need to be addressed to achieve such enhanced water quality goals.

It is well known by now that the construction of most residential developments significantly modifies watershed function, ecosystem health, and environmental quality. Very frequently, these modifications are the result of an altered water budget through clearing forested land, disturbance of soil horizons, diminishing soil porosity, and the construction of impervious surfaces. The design objectives presented in this document are aimed at preserving and enhancing the present hydrologic function of the landscape for which development is proposed.

A lesser known fact is that natural approaches to water capture are often less expensive, in many instances, very much less expensive, than standard storm drains and pipe. This follows from the fact that proposed actions here are relatively simple: make use of the site topography and innovative stormwater management practices including berms, swales, depressions and terraces to capture runoff on-site. Intrinsic to this approach is stopping water on the slopes using the traditional terracing techniques, developed millennia ago on every major continent where farming has occurred in hilly and mountainous regions. Terracing, and variations on this water holding theme, can make it entirely possible, and economically viable, to build homes on this 16 acre site and protect the water quality of the Tarrytown Lakes. In the process of evaluating such approaches, a number of developers have discovered that the stormwater strategy that best protects, even enhances, the natural landscape, is also the most cost effective.

Watershed Function

Soil porosity regulates water movement through the land. That is, the amount of open space within the soil determines the rate at which water moves into the land, with highly porous (sandy) soils infiltrating and translating water into soil towards the water table at high rates. Water moves through sand at rates of inches, to tens of inches per hour. Low porosity clay soils, on the other hand, hold water tightly, transmit water at low to very low rates, and often underlie sites where wetlands develop. Other soil types and combinations fall somewhere between these extremes of rapid infiltration versus little water percolation.

The soils characteristic of the site proposed for this development are of the Charlton and Chatfield series. As indicated in the US Department of Agriculture Soil Survey for

Westchester County (see citation above), these fine sandy loam soils are capable of moving water at 0.6 – 6.0 in/hr. Presently, on this site, the great majority of water that falls to the ground during a storm event quickly infiltrates into the soil where it is stored as groundwater. This water continues to flow downward until it is slowly delivered to the lake, - pre-filtered by natural (biogeochemical) processes along the way. This infiltration, groundwater recharge and subsurface delivery is what buffers and regulates water level fluctuations for wetlands, lakes, and rivers over the course of the annual water cycle.

During the usual course of development, paved and impervious surfaces and built structures are imposed on forested lands and other natural landscapes. To move runoff generated by built structures from surrounding roadways, there must be some physical connection to the rather expensive conventional storm sewer systems that run along these same roadways. The goal of diminishing flooding with this infrastructure necessarily reduces the amount of water infiltration into soils. Groundwater recharge and natural filtration is thereby impacted in proportion to the land area covered or otherwise compromised.

The water budget of the landscapes on which development occurs is highly, negatively modified, since it is based on impervious materials and stormwater piping infrastructure, resulting in much more rapid water movement from the land into the lake during storm events. An inevitable consequence of diminished infiltration is less available groundwater during drought periods, which would help sustain plant growth on the natural landscapes of Tarrytown. The costs of building the stormwater infrastructure, and the negative environmental costs are both high.

Design Recommendations and Benefits

Chapter 5 of the Draft Environmental Impact Statement for the *Legends at Wilson Park* includes an analysis and discussion of stormwater runoff. Results from the standard method for evaluating pre- and post-construction runoff (SCS TR-55) indicate, as we would expect, that runoff will increase due to the newly developed houses and roadways. While this approach and outcome is typical, such an outcome should not be acceptable if the aim is to maintain water quality in the lakes and environmental quality in the Village of Tarrytown.

The proposed mitigation for these increased flows is to build a storm sewer network coupled with detention basins to hold the excess runoff. This proposed solution is capital and labor intensive, and may be evaluated in terms of water captured, processed, and treated per dollar spent. Clearly, this typical approach is adequate for dealing with most post-construction runoff, but does not and cannot address modifications to the water budget and ensuing ecological effects described here. The most serious inadequacy here is the dependence on conventional piping and steep sloped constructed wetland BMPs. While water can be held in such structures, they disconnect water from the surrounding soil systems, diminishing recharge, and cutting phosphorus removal by about a hundredfold[3]. And while the expanded water catchment recommended in the Tarrytown Lakes Watershed Drainage Study: Storm Water Management Plan by Dvirka and Bartilucci is an improvement, moving stormwater catchment volume up from about 650 thousand gallons to nearly 900 hundred thousand, this catchment is mainly situated near the bottom of the slopes. Positioned here, this approach minimizes infiltration and recharge, and thus by-passes what may be the largest water filtration and storage capacity offered by the on-site soils.

Storm sewer systems are built to move water along gutters and into pipes. These systems can become overwhelmed by large storm events or clogged with debris, causing system failure. Section 5.A.3 of the DEIS specifically states that "overflow discharge will be provided to the existing Village storm drainage system". Soft sediments in such runoff that settle in the lake bottom destroy fish habitat. Phosphorus associated with sediments can cause long-term eutrophication in the lakes. The existence of the pipe system itself drains water, and biological activity it would support, from the forested slopes above the lakes. It is clear, in this case, that the best stormwater catchment and conveyance system would be one that keeps water on the land. This raises the question as to how to achieve very low levels, or zero-discharge, of stormwater runoff from the site.

Ecological systems and the natural filters they sustain are distributed throughout the entire surface of the landscape, and in the vertical dimension between the soil surface and water table. To achieve the benefits of natural stormwater catchment and filtration, it is necessary to move away from concentrated, centralized water flow. This implies a number of essential steps and design recommendations to achieve *zero-discharge*, including:

- Eliminate/limit the acreage of impervious and paved surfaces required for access
  - Diminish-limit road width to an emergency vehicle optimum
  - Utilize pervious pavement and kindred technologies for traffic surfaces

- Site roads and houses on contour gradients that make sense from a stormwater management perspective
  - Locate structures on slopes < 10%

- Infiltrate runoff from paved surfaces directly into the surfaces (i.e. porous pavement) and/or immediately down-gradient from roadway and other infrastructure
  - Integrally couple roads, driveways, and homes, with porous pavement, swales, berms, basins and terraces to capture runoff

- Design overflow paths to direct water from large storm events into shallow basins in meadows and/or terraced landscapes planted with native herbaceous plants, shrubs and tree species

[3] Richardson, C.J. 1985. Mechanisms controlling phosphorus retention capacity in freshwater wetlands. Science 228: 1424-1427.

- Consider a framework of deed restrictions, conservations easements, tax incentives/penalties, mulching and soil conservation practices to maintain porosity and infiltration in and around the proposed development

Benefits to on-site stormwater capture design include:

- A focus on preserving the present water and nutrient budget of the landscape that protects regional environmental quality, forest diversity, wildlife habitat, and surface and groundwater resources, including the Tarrytown Lakes and their riparian zone of stately stands of White Pine and Sitka Spruce

- A direct connection of runoff from paved surfaces into the ground (through porous pavement) and to soil infiltration and root zone water purification systems

- A uniquely sustainable opportunity to landscape with native plant communities

- A showcase of landscaping designs that significantly increase real estate value

- The incorporation of vegetation and water capture features which protect properties including swales, terraces, and wetlands

- Storing water on-site in soils and groundwater, providing for plant survival during drought periods

- Reducing demands on drinking water for irrigation purposes

- Providing cost savings to developer over conventional stormwater infrastructure

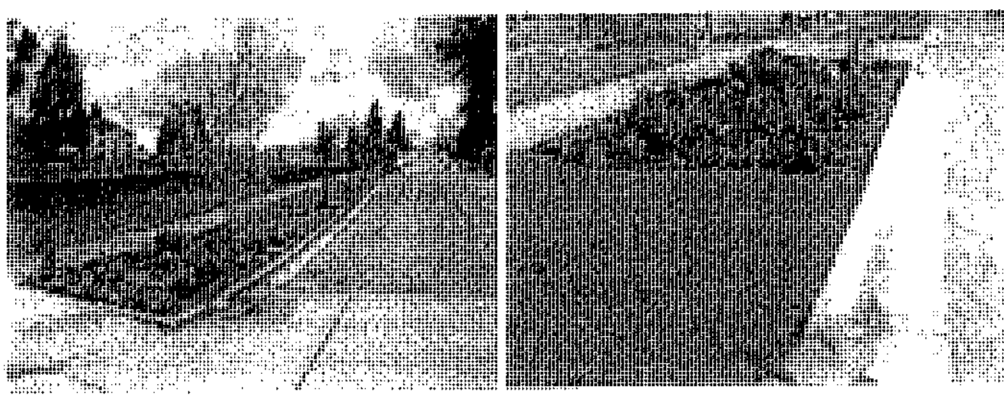
<u>Design Layout for Zero-Discharge</u>

Since steep areas accelerate runoff, soil and water conservation design must therefore aim to build in areas where slope is minimal, and to utilize construction and earth moving itself to reduce or mitigate areas which may otherwise discharge water off-site. The fundamental principals here are to build into existing contours, to minimally disturb and work to enhance existing soil horizons and structure, to minimize impervious cover, and to incorporate terracing, swales, deep soil buffers, and permeable surfaces for pedestrian and vehicle conveyance.

One basic approach from a family of design solutions that follows these general principles is laid out below. Since the precise placement of homes and infrastructure contributes greatly to runoff production, it is therefore essential that the catchment capability and permeability of soils in the areas downgradient from each structure be scaled to hold and contain a major storm event. A hundred year storm, such as hurricane

Floyd in September 1999, would be a worthwhile event to consider in regard to scaling for water capture. In this case, water holding capacity would need to contain overflow from soil-based infiltration and terraced stormwater capture systems subjected to an inch per hour of rainfall for 12 hours.

Holding such a quantity of water is probably within the capability of this landscape. The Chatfield and Charlton soils could, with infiltration rates listed in the 0.6 to 6 inches per hour, infiltrate most of the water on-site in twenty-four hours or less. Swales, terraces, and depressions designed for water holding capacity and habitat value could have substantial benefit for the water table. For most years, twelve inches of water constitutes between a quarter and a third of total rainfall. Were a major fraction of this infiltrated, stored in groundwater, and delivered as baseflow to the Tarrytown lakes and down slope water bodies, this could be a substantial contribution to the clean water budget of these aesthetic landscape features. For these reasons, the costs of capturing even larger storms, which are inevitable, but not precisely predictable, could be worthwhile and could be measured in terms the of health and productivity of the ecological systems both on the slopes and near water features downslope from the planned Legends development at Wilson Park.



Photos above: Stormwater infiltration swales with deep soil infiltration are incorporated in "SEA Streets", curbside structures designed to capture runoff from roadways and move it into groundwater, Seattle, WA. In the two years since construction, these developments have captured more than 90% of runoff.

The map shown below in Figure 1 indicates areas in color where houses would cut sharply across contour lines and/or be situated in zones of shallow bedrock. In general, the zones at distances from the grey and tan zones are areas of lesser slope and potentially greater stormwater infiltration. It is exceedingly important to note, however, that the more dispersed and covered these relatively flat areas become with houses and roadway infrastructure, the less 'natural infiltration capital' and ecologically valuable landscapes are preserved. While such open areas with less slope have been taken by many past developers as an invitation to maximize the number of units by maximizing coverage, it has been subsequently shown that this approach can lower the per unit value of the development and even profit, on a per unit basis.

Both the pink zones at the bottom of the topological map below are near areas of steep contours, and also amongst the nearest landscape on the property to the Tarrytown lakes. Such area are likely be detrimentally impacted by impervious structures, construction activities themselves, and/or heavy land use. While a careful site survey would be required here to identify the precise extent and potential impact of buffer zones in and around the pink shaded area or along the hatched red line at the bottom of the map below, the best policy is to avoid disturbing this area. As the portion of this landscape closest to the lakes, building on or disturbing these sites imposes a high probability of contributing erosion and nutrients to the lakes, especially when the increasing likelihood of catastrophic storms is factored in.

Figure 1: Site topography shows colored zones of more intense to extreme slopes. Buffer zones shaded in pink indicate areas closest to direct passage into the Tarrytown lakes. In terms of habitat orientation and site-potentials for biologically diverse plant communities, north, south, east and west facing hillsides contain different regimes of microclimate. For this reason, all such areas should be investigated in terms of their capacity to contribute to local and regional biodiversity for both native plant and bird and other animal communities.

While no specific algorithms for siting houses and infrastructure are directly considered here, landscape features considered above would be well considered in connections with principles include clustering, tree and plant community conservation, landscaping around water features, viewshed and distance from steep slopes. Such criteria (and others) may be used separately or in concert to evaluate the potential placement of houses and conservation easements within this landscape.

Whatever housing arrangements are considered, in virtually all cases, the most environmentally favorable will require minimal cut and fill, integrated with a clustering and placement strategy that minimizes impervious surface. The latter is an essential exercise, since for every 200 square feet of impervious area that is cut out from the development design, about a hundred gallons of runoff is eliminated for each inch of rainfall. This specific use of a water budget to evaluate the scale of impervious infrastructure can make substantial contributions in the short and long term, diminishing the negative environmental impact of runoff, and increasing the positive ecological contribution of providing water to plantings and to the water table.

The best single environmental measure of this proposed development is how much water it holds during and post development. This one measure provides the best instrument for maintaining the quality of the soil and natural communities in perpetuity. It also provides a tool to compare different housing lay-out schemes, and a single metric by which to systematically compare approaches to distributing and clustering houses along a roadways in terms of the conservation of open space achieved by each design, as well as critical stormwater capture goals.

This means of measuring the larger scale impact of design alternatives requires a full site analysis. Each home and area of infrastructure, however, may be designed to increase it's

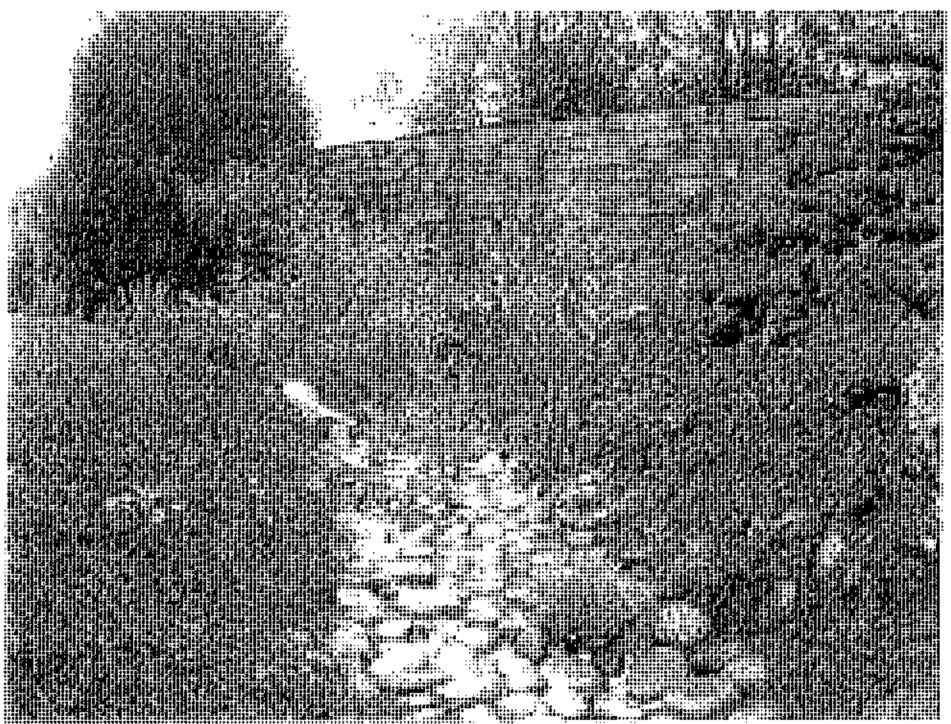


Figure2: Land areas can be designed for aesthetics and function, this image shows a bioretention "raingarden" designed to capture and infiltrate storm runoff in eastern Long Island. Kindred structures, fitted into vegetation and habitat types typical of the southern Taconiics and Hudson Valley (Thomas Muse Design)

Infiltration capacity by being coupled with swales, hollows, berms, terraces, and planting beds which act as buffers and infiltration galleries, as in Figure 2, above.

Thus a key principle to develop a plan that is workable in terms of watershed protection requires that each property needs to be evaluated in terms of on-site stormwater management practices, including minimizing/optimizing paved surfaces, incorporating porous pavement, vegetated terrace systems, swales, berms, and retention areas, subsurface storage, as well as an evaluation of how such systems would fail in the case of extremely large storms. Such designs are integrally site specific, since they are structured into the local topography and the orientation of house, transportation infrastructure, and such features as turf grass lawn area, which can discharge both runoff and fertilizer to surrounding landscapes and water bodies.

A critical consideration for any development that aims to conserve environmental and water quality, however, is how to distribute responsibility for water catchment amongst property owners. In most developments, probably including this one, land-owners could include both public and private entities. Historically, the responsibility for stormwater reverts to the entity that maintains roadway infrastructure, i.e., the municipality, county, or state. This approach has led to many problems, since critical functions, such as soil infiltration, cannot be centralized. These water catchment, processing, filtration and natural capacities require that they be distributed over the landscape, like the rainfall that they incorporate. If the natural structures that do the work of catching and purifying water cannot be functionally replaced off-site, a means of situating such structures and certifying their on-going function will be necessary for any development plan intent on conserving and enhancing the water holding capacities of the land.

Vegetated, deep soil buffers, swales, terraces and depressions can capture and store rainfall. Because of this well documented fact, structures akin to those shown in Figure 2 above and Figure 3 below need to be distributed throughout a development, and maintained to ensure water capture, storage and treatment. This requirement applies equally to both private and public lands. The greatest environmental and water quality protection, conservation and enhancement will de derived where the same performance criteria applied to both. This can be ascertained with two simple questions:

How much water does the landscape hold?
How large a storm can be captured and infiltrated by the landscape?

For both public and private property in the development, infiltration and catchment structures, together with performance criteria with measurable impacts, need to be used to ensure environmental and water quality. These water catchment and infiltration landscape facilities would need to be recognized as functional components of the hydrological system, becoming perpetuated, 'grandfathered' features of land-use to water quality in the near and long term.

Beyond a water balance or hydrological design framework, there are a number of readily available evaluation tools that can be used to evaluate potential outcomes from different land use ratios. Using runoff and soil erosion coefficients together with surface and subsurface mapping tools, the impacts of different design choices can be compared, providing rapid and low cost feedback on the impacts of specific design alternatives.

Similar evaluation tools, including a water budget and catchment capacities, need to orient and guide the construction process itself. Organic soils and mulches presently on the site must be conserved in place or by stockpiling through construction and post construction landscaping procedures. This requires that the stormwater pollution prevention plan demonstrate how runoff will be held on-site through a staged construction process and multi-barrier water catchment and erosion prevention. Long experience indicates that silt fences alone cannot succeed at this task, which requires, instead, multiple impediments to runoff coupled with multiple infiltration area options. This approach does not necessarily impose much greater cost burdens, since post-construction vegetation growth in enhanced, adding substantial value to the properties, occurs more quickly and with greater probability of success. Modular approaches to construction staging can preserve soil horizons, especially organic and mulch layers, keeping the highest concentration of nutrients intact on the ties. Strategic incorporation and adequate scaling of the terraces, swales, and retention areas of the final design into construction steps can often be used to limit both runoff and costs, thus facilitating measurable success for the stormwater pollution prevention plan.

<u>Summary</u>

Water is the prime mover of soils, fertilizers, nutrients and pollutants off the land. Because of this fundamental fact regarding all landscapes, especially slopes, sustainable development can only occur where the water holding capacities of vegetated and forested landscapes are conserved and enhanced through construction and post development processes. In terms of land-use practice, erosion is in many respects an eminently solvable problem. For some five millennia, agriculturalists, from the Alps to the Andes terraced mountainous terrain to conserve and protect their livelihood - *the land.*

For tens of millennia prior, structures as simple as windfalls – fallen trees on hillsides - have created wooden dams at angles to the slope which have worked to hold leaves and to capture organics and sediments, creating soil. In small to large streams, the woven branch dams of beaver have long worked towards the same end, - keeping water on the land. None of these structures are complicated, but, in aggregate, in multiple small steps, they work to hold and keep an immense quantity of water, charging the water table, sustaining clean lakes and streams, and creating diverse habitat mosaics which provide homes to myriads of woodland and meadow plants and animals.

Figure3: Logs pinned into this unstable road cut have created a means for capturing mulch and holding water in the Croton Watershed of New York City.

Modifications on the simple themes of terrace, berm, swale, and hollow can act together to maintain, and even enhance, the presently operative hydrologic regime on the hills surrounding Tarrytown. Such simple steps are likely to offer the only workable methods for preserving and improving water quality. The five means to conserve and enhance the site's working hydrology include:

1) Keeping the land and structures on it permeable; -PERMEABLE STRUCTURE
2) Slowing and stopping moving water;-STOP OVERLAND FLOW/PREVENT RUNOFF
3) Conserving and enhancing infiltration into soils; -SOIL INFILTRATION
4) Storing as much water as possible as groundwater;-GROUNDWATER RECHARGE
5) Maintaining and increasing base-flow from groundwater into the lakes and streams of Tarrytown; -CONSERVE GROUNDWATER FLOWPATHS

The key to achieving high quality water is building a development into the natural features and filters of the landscape. Methods require capturing water where it falls, as well as enhancing water capture where needed. The simple measure that any such development must meet is that sinks for capturing and infiltrating stormwater need to be larger than runoff sources, so much so that even precipitation during a large storm is entrained for groundwater recharge.

For the planned *Legends at Wilson Park,* a sustainable ecological and stormwater program requires arranging planned structures and infrastructure to minimize disturbance and maximally conserve natural landscape features. A number of methods that facilitate attaining such goals are standard in construction practice, e.g., minimizing or matching cut and fill on-site. Others, like minimizing or optimizing the area of impervious structure, requires matching runoff with natural or enhanced capacity nearby. This whole process requires a willingness to design with the landscape; distributing and clustered structures in modules that minimize newly constructed impervious areas while conserving aesthetic and functional landscape features. Incorporating such recommendations into the design layout for *Legends at Wilson Park* needs to ensure that soils remain in place both during and after construction, and that runoff generated from newly constructed impervious surfaces is minimized, together with potential detrimental impacts to Tarrytown Lakes.

But overall, costs may not be prohibitive, since unanticipated benefits have accompanied a number of projects that aimed to eliminate or diminish runoff. By using processes that eliminate standard stormwater pipes and storm drains, the costs of handling stormwater also diminishes. Because runoff is not delivered to the lakes in costly structures, a portion of the capital resources required for such structures can remain in the hands of the builders. An increasing number of developments show that cost effective approaches to development that incorporate on-site natural systems to capture and hold stormwater are both more beautiful, and more profitable.