GreenRoofs for Stormwater Control

By Joanne Gerson

1. Runoff/ Stormwater Background.

When rain falls on undisturbed land there is rarely any surface runoff. About 30% of the rainwater reaches shallow aquifers where it nourishes plants, another 30% percolates into the deeper aquifers, and approximately 40% is almost immediately returned into the atmosphere through evaporation and transpiration. In contrast to this, in metropolitan areas with 75% or more impervious surface coverage, a staggering 75% of the rainwater becomes surface runoff. [i]

Stormwater runoff creates high peak flow which in large rain events causes flash floods. Even small stream floods can be very costly. Damage can be spread out over a large area. In July, 2001, a significant amount of rain fell in a short period of time, resulting in major flooding along some of the small streams in Hamilton County. In the northeast corner of Hamilton County, Polk Run Creek overflowed its banks. The usually narrow quiet creek quickly became a raging river flowing over roads and bridges. The damage left behind cost the affected communities over $3.1 million dollars. On one bridge, a car with 4 teenagers was quickly swept into the rushing water. Tragically one of the passengers lost her life when she was caught in the wild water. (Appendix A)

Years ago there was a horse boarding stable located next to Polk Run Creek where it joined the Little Miami River. I boarded my horse there for several years in the early 1980's. There were no flooding events until the development up-stream began. But as development increased the flooding increased and the owner of the stable was forced to sell the property.

In Colerain Township, flooding became a problem in an established housing development. The township ended up buying and demolishing 13 homes at the cost of $1.3 million.

2. Tie to Stormwater.

Due to increased demand on resources and increased stormwater run-off, many communities are looking for innovative ways to design low impact

buildings in order to preserve the environment and to reduce cost related to flooding.
"Roofs cover a significant portion of the urban landscape and generate large volumes of stormwater runoff. By the same token, they provide an excellent opportunity to control runoff if they are covered with plants. Europeans have been using vegetative roof covers for more than 25 years to control runoff, improve air quality, and save energy."[ii]

3. Greenroof Definition.

A greenroof or ecoroof "is a green space created by adding layers of growing medium and plants on top of a traditional roofing system. This should not be confused with the traditional roof garden, where planting is done in freestanding containers and planters, located on an accessible roof terrace or deck." [iii]

4. Greenroof Cross-Section.

"The number of layers and the layer placement vary from system to system and greenroof type, but at the very least all greenroofs include a single to multi-ply waterproofing layer, drainage, growing media and the plants, covering the entire roof deck surface." [iv] (Appendix D)

There are two types of greenroofs, intensive and extensive. The intensive greenroof has at least one foot of soil dept to enable use of larger plant material including trees and shrubs whereas the extensive greenroof may have as little as 1 inch to 5 inches of soil dept, adding less weight to the roof structure. [v]
Depending on the type of greenroofing system a greenroof is capable of retaining 25 to 75% of stormwater from the roof. "A study in Berlin, Germany showed that greenroofs can absorb 75% of the precipitation that falls on them, which translates into an immediate discharge reduction to 25% of normal levels." [vi]

5. Stormwater Benefits.

When the soil on the roof becomes fully saturated excess water is filtered slowly through the soil to a drainage outlet. The soil layer traps sediments, leaves and other particles, treating the stormwater before it reaches the outlet. The greatest cost benefit is provided by the first inch of soil and

vegetation cover. However, 2.5 to 3-inch soil cover is recommended to support and maintain a diverse and healthy plant community. [vii]

"The quantity of rainfall retained or detained by a green roof can vary, but for small rainfall events little or no runoff will occur and the majority of the precipitation will return to the atmosphere through evapotranspiration. For storms of greater intensity and duration a vegetated roof can significantly delay and reduce the runoff peak flow that otherwise occurs using conventional roof design. This helps to reduce the risk of flash flooding and the frequency of combined sewage overflow.

As with natural soil/plant systems, green rooftops reduce runoff problems by a variety of means including: the storage of water in the substrate, absorbing water in the root zone, capturing and holding precipitation in the plant foliage where it is returned to the atmosphere through transpiration and evaporation, and slowing the velocity of direct runoff as it infiltrates through layers of vegetated cover." [viii]

In addition, greenroofs absorb and filter heavy metals and pollutants from rainwater[ix] and cool the excess water that drains from the greenroof. Greenroofs can be designed for exceptional stormwater retention capability. A storm-water retention study for the City of Portland, Oregon found that if half of the buildings in the downtown area had green roofs, (219 acres), an estimated 66 million gallons of water would be retained annually. This would eliminate combined sewage overflows by 17 million gallons." [x]

6. Cost Benefits.

Green roofs save money.

The savings are seen in the reduced load on storm sewer systems. Money is also saved by reducing the land area needed for detention and retention areas. This is especially important in densely populated areas with high real estate values.

Greenroofs double the life span of conventional roofs. [xi] "Vegetated cover reduces wear and tear caused by temperature-related expansion and contraction and protects the roof from ultraviolet (UV) radiation and cold winds that break down traditional roofing materials."[xii] Green roofs conserve energy by keeping roofs cool in the summer and insulated in the

winter. The insulation effects reduce the cost to air condition the building in the summer and heat it in the winter.

Greenroofs absorb CO2 and help lower the urban heat island effect and ozone levels with living, breathing plants through the natural process of photosynthesis and evapotranspiration. [xiii] "The urban heat island is a dome of higher air temperatures above a city. The heat island is a major contribution to ozone production and affects local and regional weather."[xiv]

"Chicago began constructing its City Hall rooftop garden in April 2000 after 1.5 years of planning. In total, 20,000 herbaceous plants consisting of 156 varieties, 112 shrubs, and 37 vines were planted in a special blend of compost, mulch, and lightweight absorbent materials, occupying 20,000 sq ft of the 38,000 sq ft roof. Rainwater is collected from 2,500 sq ft of penthouse space and stored in holding tanks for periods without rain.… The total available cooling effect from evapotranspiration by City Hall rooftop garden is 730% of what is needed to eliminate the cooling load of the City Hall roof. The surplus cooling effect available for the surrounding microclimate can reduce cooling costs in buildings downwind of City Hall. Further, if green roofs were installed on all Chicago roofs – approximately 30% of the city's land is covered by building roofs - the avoided peak energy demand would be 720 megawatts. Reduced load on the storm sewer system would be 70%."[xv]

Some additional advantages include;

- Acoustic insulation and reduce noise by as much as 50 dB [xvi]
- Fire resistance barrier with high water content plants called sedums and saturated growing medium
- Habitat for birds and butterflies
- Aesthetically pleasing
- Provide safe accessible green space for public housing
- Potential for food garden
- Recreation space at work
- Achieve points towards LEED certification

7. **Considerations.**

   Roof requirements, total costs, maintenance and fire prevention are important factors to consider before adding a green roof to a building.

- Roof Requirements. A structural engineer will need to determine the load-bearing capacity of the roof. A mechanical engineer may be needed to evaluate the heating and cooling implications and proposed rooftop mechanical equipment and drainage needs. [xvii]
  "Using light-weight media and geo-synthetic fibers and membranes, contemporary green roofs can be readily engineered to conform to the load requirements of most roofs. Beautiful vegetated roof covers weighing only 15 pounds per square foot have been installed. This weight is comparable to the weight of gravel ballast placed on many conventional roofs… Green roofs vary greatly in weight, depending on their depth and the materials employed. The important measurement is **'wet' weight,** including fully-saturated fabrics and plants."[xviii]
- Costs. An *Extensive* roof may be as low as $9/sq.ft for 3" of growing media and sedum. But more commonly the range is between $14 - $25/sq.ft. including the roofing membranes. An *Intensive* roof may run $40 or more. "The Ford Motor Company River Rouge Plant greenroof in Dearborn, MI, for example, came in around $4/sq.ft., an extensive greenroof that is almost 500,000 sq. ft. in size." [xix]
  "A recent cost analysis was posted on the USGBC Web site and reports that the average green cost premium for LEED certified projects were only 1.84 percent above an average non-LEED building. This report also confirmed that these minimal increases result in lifecycle savings of 20 % of total construction costs — more than 10 times the initial investment."[xx]
- Maintenance. "It is recommended to do a semi-annual maintenance review, at which time you can look for invasive weeds, disease, stray tree seedlings, etc….Extensive greenroofs would benefit from occasional watering during extreme periods of duress ….. Drip irrigation is ideal for large projects plus it is inexpensive and delivers the right amount of water to the best area – the base of the plants.….. Intensive greenroofs can accommodate a large variety of plants, shrubs, and trees, their watering requirements are higher than succulents and herbs. Treat any intensive greenroof like any garden or landscape at ground level, but take into account that high winds can be very drying. Usually large intensive roofs have an irrigation system installed…. You can install a traditional active irrigation system or a solar powered system. Pair this with a recycled rainwater collection system, harvested in cisterns at roof deck or at ground level, and

you've got the ideal self-sustainable answer to supplemental water and how to power it."[xxi]

- Fire Prevention. "There is evidence from European manufacturers suggesting that green roofs can help slow the spread of fire to and from the building through the roof, particularly where the growing medium is saturated." [xxii] "In Germany, green roofs actually have a **better fire rating** than conventional roofs because the mineral media layers cannot burn. The extensive use of *Sedums* (a type of succulent), and gravel borders and breaks also protect against fire."[xxiii] "However, the plants themselves, if dry, can present a fire hazard. Similar to preventing grass fires at grade, the integration of "fire breaks" at regular intervals across the roof, at the roof perimeter, and around all roof penetrations is recommended. These breaks would be made of a non-combustible material such as gravel or concrete pavers, 60 cm (24") wide, and located every 40 cm (130 feet) in all directions. Other options would be the use of "fire retardant plants", such as sedums, or a sprinkler irrigation system connected to the fire alarm." [xxiv]

8. Changes are needed in zoning codes.

In order for changes to occur, higher zoning codes standards must be set in place. Historically, few developers care to spend extra money to design a "green" building that will preserve the environment and in the long term save the occupant money. Planners in communities around the world have begun to realize the importance of strict code guidelines. German municipalities led the way when they changed their codes in the early 1980's. Cities in the U.S. and in other countries are now following their example.

Good stormwater zoning codes are necessary to incentivize builders to add greenroofs. These stormwater codes can be divided into 4 categories; Zero Discharge, Infiltration Rates, Floor Area Ratio (FAR) Bonus and Tax Incremental Financing (TIF) assistance.

- Zero Discharge means that stormwater runoff from the built property must mimic the predevelopment natural hydrologic conditions so that man-made water collections systems are not needed. All stormwater runoff from impervious surfaces must be contained on the property and recharged into the ground. Examples are found in Lacey, WA, (Appendix F) and Newport-News, VA, (Appendix G) zoning codes.

Another example is from the City of Tumwater, WA, ordinance No. 02000-010.`

- Infiltration Rates is taking the concept of zero discharge but to a lesser degree. The Wisconsin Department of Natural Resources recommend in the Runoff Management Rules, NR 151, that jurisdictions incorporate a performance standard that requires a portion of the runoff volume to be infiltrated. Also see Appendix H, Minneapolis Rice Creek WD ordinance.
- Floor Area Ratio (FAR) Bonus refers to a formula that allows builders to increase their floor area ratio in exchange either a greenroof or porous pavement. The square footage permitted for the exchange depends on the particular zoning code. Examples are found in Portland, OR, Minneapolis, MN, and Chicago, IL zoning codes.
- Incentives can work one of two ways. In some communities a Stormwater Value Tax is assessed on the property. If the builder designs systems to reduce stormwater run off, the tax is reduced in relationship to the reduction of runoff. Zoning code examples are found in Minneapolis, MN, Rice Creek Watershed District, and Newport- News, VA. Portland is developing a Clean River Incentive program that will provide financial incentives for green roofs based on the reduced stormwater according to www.greenroofs.org/index.php?page=policyfinsupp.

Several jurisdictions give Incentives for meeting LEED™ certification requirements. The US Green Building Council developed the Leadership in Energy and Environmental (LEED™) voluntary program. A system of points is given for constructing sustainable buildings that support interior and exterior quality environments. A greenroof can obtain up to three credits for energy efficiency and natural views. Chicago (see Appendix E) and Seattle, WA provide such incentives relative the number of points achieved in the LEED™ program. Seattle requires that all new municipal buildings be LEED ™ certified. Chicago will cut the time in half to get a building permit if a greenroof is to be installed.

Many of these codes refer specifically to the benefits of Greenroofs. The Portland, Oregon Stormwater Management Manual requires that all construction with at least 500 square feet of impervious surface must implement stormwater pollution reduction and flow control measures. Greenroofs are one of the acceptable measures. (Appendix H) Chicago developed an Energy Conservation Ordinance to combat the urban heat island effect. The ordinance states that all new and refurbished roofs must

have greenroofs or reflective roofing installed. Minneapolis set up a stormwater utility fee with a generous credit system that allows up to 100% credit for installation of greenroofs, bioswales and porous pavers. Newport-News gives credit for post-development reduction in stormwater peak runoff rate and for green areas (Appendix G Section 37_1-15).

9. Next Step.

There are a number of simple changes that can be made in your zoning code to address some of the stormwater runoff problems. Study your existing code and look for ways to improve it. You will find many simple changes that can be done in a few meetings.

Other changes, including Zero discharge, FAR bonuses and Incentive's will take more study. There is some funding available to help you.
At the website www.greenroofs.org/index.php?page=policyfinsupp I found two programs, the Green Municipal Enabling Fund (GMEF) and the Clean Water Act, Section 319 Grants. Also, the Cincinnati Public Library has a grants division that is an excellent resource for funding.

Educate your community. Develop public awareness of the importance of stormwater runoff issues and gain support for this important project. (There are numerous helpful websites listed in Appendix B.) We all want a cleaner, healthier and safer environment. Changing your zoning code will have long lasting effects by creating a better environment for now and the future. Your community will save money through energy savings, improved water quality and reduced or eliminated flooding.
You can make a difference, but only if you start now.
If not now, when! (Hillel in 30 B.C.)

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