HUDSON VALLEY REGION
GREEN INFRASTRUCTURE
PLANNING 2010-2011

PROJECT AREA: KINGSTON

HUDSON VALLEY REGIONAL COUNCIL

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Aerial Image NYSGIS2009

GREEN INFRASTRUCTURE CONCEPT PLANS FOR KINGSTON PLAZA

Project type: Shopping center parking lot retrofits **DECEMBER 2011**
Proposed practices: 1- Parking area reduction 2 - Tree plantings 3- Bioretention 4- Permeable paving 5- Green roof

RECOVERY.GOV

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NYWORKS

The following draft report describes a schematic landscape design proposal using green infrastructure practices for stormwater management. The illustrated plan and report are intended to give practical guidance for the owner, design professionals, contractors, and other interested parties to use in developing a final design. They are not intended to be used as final design and construction documents.

OVERVIEW

Kingston Plaza shopping center occupies a 34.7 acre site in southwest Kingston that is mostly impervious. The shopping center and the Herzog's Supply Co., Inc., the building and garden supply store at the heart of the site, are owned by Brad Jordan, who expressed support for developing a concept plan for green infrastructure. He put the project team in touch with Herzog's manager Jim Niles, who toured the property with us and discussed how different areas are used and where to focus for possible retrofits in the near term.

This plan focuses on the east end of the site, including the Hannaford supermarket parking lot— which will be due for repair and upgrade in the near future—the underutilized parking area by the ball field, and the roof of the Herzog's store. The illustrated plan of the full site highlights several other areas where green infrastructure can be implemented.

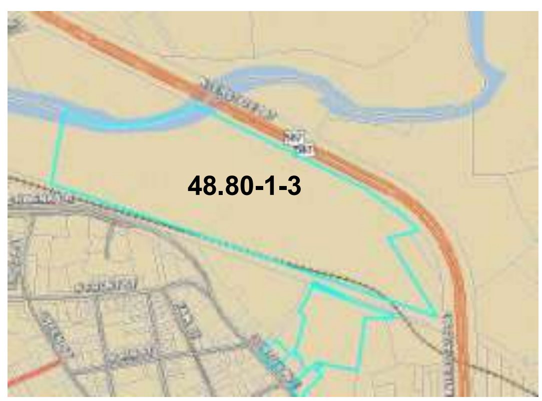
Changing the parking layout and reducing the amount of paving in the lot by the ball field would allow for the establishment of new green space for trees and bioretention, and these practices could be designed to capture and treat all of the runoff from the WQv (described on page 11). An alternative approach to the ball park lot using permeable paving is also discussed.

Five concepts are presented in the plan.

1- Parking area reduction
2- Tree plantings
3- Bioretention
4- Permeable paving
5- Green roof

LOCATION

Plaza Road, Kingston, 12401
PO Box 3228 Kingston 12402
Section, Block, Lot 48.80-1-3



Parcel Map http://gis.co.ulster.ny.us/ (accessed 6/2011)

OWNERSHIP

Herzog's Building Supply, Inc.

EXISTING CONDITIONS

SURFACE COVER/CONTRIBUTING AREA

The surface cover on the parcel is approximately as follows:
Roof 7.5 acres
Lawn and landscaped 9 acres
Paving 18 acres
Two large areas for parking are now used only for occasional parking—on the east by the ball field, and on the west for tour bus pick-up and drop off.

SOILS AND TOPOGRAPHY

The site slopes gently to towards a flood management area by the Esopus Creek. The Web Soil Survey Report of the area under consideration includes three soil types: Unadilla silt loam, Raynum silt loam, and Tioga fine sandy loam.[1] The areas were retrofits are proposed are all shown Unadilla silt loam, which is classified as a B soil, and should be well suited for infiltration practices. There are very few catch basins in the parking lot. Most of the runoff flows directly of the property into the flood control area on the north. A catch basin is located in a lawn on the south captures runoff from the adjacent parking area.

SOLAR AND WIND EXPOSURE FILTERS

The site is very open, with large areas of unshaded paving.

VEGETATION

Many of the trees planted in the parking lot are in decline. There are several large trees in front of Herzog's that would probably be preserved in a new parking lot planting and paving plan. A thorough assessment by a consulting arborist is recommended prior to developing plans.

[1] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [5/13/2011].

Figure 1 *Parking lot south of Hannaford*

Figure 2 *Herzog's entrance and large trees*

Figure 3 *Parking lot east of Hannaford*

Figure 4 *Underused lot by ball field*

Figure 5 *Potential bioretention area along rear parking and loading area.*

Figure 6 *Underused lot on west side of the site*

THE CONCEPT

The following discussion introduces the elements and explains how the parts on the illustrated masterplan relate to each other and briefly describes the practices. The detailed discussion of design issues, materials, maintenance and costs is provided in the last section.

LAYOUT AND FEATURES

The analysis of actual parking needs at Kingston Plaza would be the first step in developing any final plans for green infrastructure improvements. The parking lot area can be reduced by removing unnecessary spaces and **minimizing parking stall dimensions**, freeing up land to convert to sustainable green space designed for stormwater management and other benefits.

The plan shows a **reduced parking area** by the baseball field, which would allow for the creation of a small park or wooded area. The remaining parking could be left as is for now and a **bioretention garden** could be created on the north end of the lot to capture and treat the WQv (see page 11). Or the parking lot could be paved with any of the porous or **permeable materials** available and a planting of evergreen trees could be created instead of the bioretention area.

The plan for the Hannaford lots proposes an angle parking layout that would allow for **bioretention cells with trees** between the rows of parking. The bioretention cells would be designed to capture and infiltrate runoff from the parking lot. This layout would require a waiver of the parking code

A low profile "extensive" **green roof** is shown on the Herzog's store that would have insulation and cooling benefits in addition to reducing and filtering runoff.

Figure 7 Concept Plan *(11x17 plan is included at the end of the report)*

BIORETENTION CELLS WITH TREES

Bioretention cells with large canopy trees are shown on the plan between rows of parking. Bioretention areas capture and treat runoff on site. They are slightly depressed below the surrounding grade and allow runoff to pond temporarily, providing detention and pollutant removal benefits. Depending on the underlying soil type, water can infiltrate or exit the system through an underdrain to the storm sewer. Water above the ponding limit exits to a designed overflow point–usually a nearby catch basin inlet.

The bioretention cells would provide adequate soil volume to support healthy growth of large shade trees, maximizing stormwater benefits and reducing the urban heat island effect. Parking lot runoff could be allowed to drain into the pits through curb cuts. Areas between the trees could be planted with low maintenance shrubs and grasses, depending on other design goals. Portions of the bioretention cell surface could also be paved with permeable paving as long as the soil below the paving is designed to accommodate root growth.

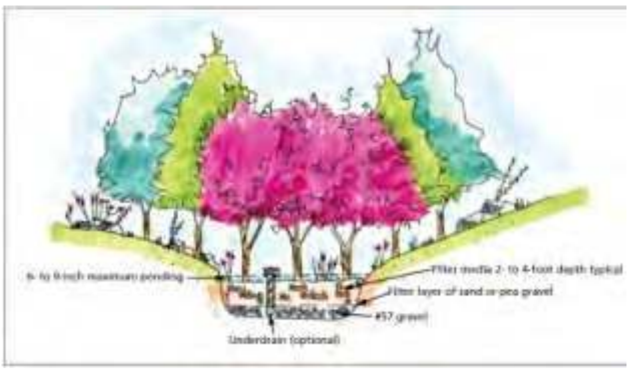


Figure 8 Bioretention are cross section
Urban Watershed Forestry Manual Pt.3, page 32.

Figure 9 Linear bioretention cell in parking lot *Johnston Memorial Hospital, Clayton, NC (Photo by Kim Hawkins, Hawkins Partners, Inc. in Green Infrastructure Digest 11/01/2010)*

3 – BIORETENTION AREA WITH GRASS FILTER STRIP

The parking area by the ball field slopes towards the area shown as a bioretention garden on the plan. If the lot were to be reduced in size as shown and the remaining paving left in place, a bioretention garden approximately 4 feet deep, prepared with appropriate well drained soils and plantings that tolerate periodic wet and dry conditions could be established on the lower end of the lot to capture and treat the runoff from it.

Figure 10 Bioretention area in parking lot *(Photo:NRCS http://www.ia.nrcs.usda.gov/features/urbanphotos.html)*

4- PERMEABLE PAVING

Permeable paving allows rain water to pass into a stone base and then infiltrate into the soil below. In the alternative plan for the ball field parking lot, various kinds of permeable paving could be used. Because the area by the ball field would have limited use, gravel-filled geocells--flexible plastic interlocking units— may be a good, economical option that would be handicapped accessible and cooler than asphalt.

Figure 11 *"Gravelpave" geocells installation*

Figure 12 *"Gravelpave" at Pentagon Memorial*

DESIGN, CONSTRUCTION, MAINTENANCE

The following section provides details about the specific design, materials, construction and maintenance considerations and the sizing calculations for each practice.

1- BIORETENTION CELLS AND TREE PLANTING

DESIGN

Layout and bioretention cell dimensions

Two similar layouts for the Hannaford lots are shown on the plan. The east lot layout shows 55° angle parking with a 15'8" aisle. This layout would require a variance[2], and it would slightly reduce the number of spaces since it would provide more generous bioretention cells at the ends of the aisles. In between each set of stalls would be an 8'6" wide bioretention cell. The rows at each end would stay as they are, with 90° spaces.

In the other parking area, on the south side of Hannaford and in front of Herzog's main entrance the layout has 60° angle parking with 16'6" aisles, and 9' wide bioretention cells. The parking row and wide aisle in front of Herzog's would remain the same. Also in front of Herzog's the large existing trees would be accommodated in a planting design. The existing raised planter and parking islands would be removed.

The bioretention cells would be slightly depressed below the level of the adjacent paving. Runoff would flow into them through curb cuts and paths across them would be provided at intervals.

There are no inlets in the east lot, which is designed with a cross slope to drain from each side toward the center and down to the north end of the site. In the south lot, in order to direct runoff towards curb cuts, "water bars" like low speed bumps would be installed.

The inflow areas would be covered with stone to prevent washing out of the mulch. Provided a well drained sandy loam soil, the runoff would infiltrate. An overflow device and underdrains would also be provided.

Soil Volume and Tree Size

Soil volume calculations should take into account a variety of specific factors including the soil type, whether the tree is growing in an open space or surrounded by paving, local climate conditions such as reflected heat and from cars, and other factors revealed in the complete site assessment. Another factor to consider is the positive effect of extended pits for multiple trees --when trees share soil, the volume of soil per tree is reduced.

The bioretention cells, at 8'-6" to 9'-0 wide and soil 3' deep would accommodate a tree with a mature canopy in the range of 35'-40' in diameter (around 1,100 square feet of crown spread) every 30-35' based on the soil volume calculation chart below.

[2] The Kingston Parking Code , Article V Section 405-34 (2)requires that "each required space, exclusive of drives and aisles, shall be not less than 18 feet long nor less than nine feet wide and shall be served by an aisle between rows of parking spaces not less than 22 feet wide. The minimum aisle space may be reduced for angle parking, but in no case shall the aisle space be less than 16 feet."

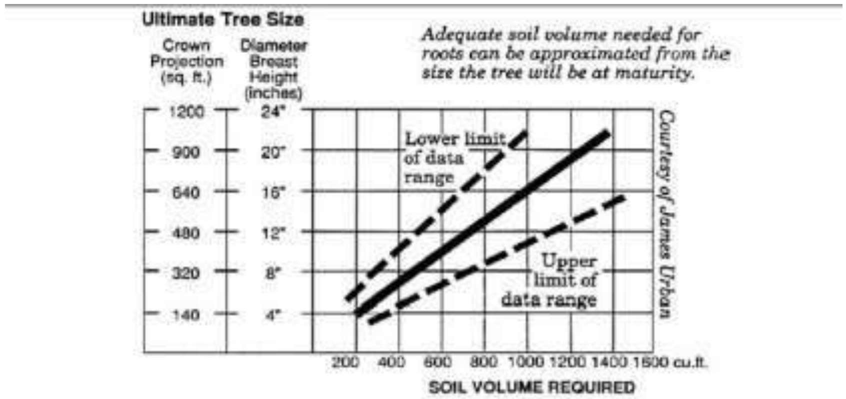


Figure 13 *The soil volume required for various size trees assumes a soil depth of 3 feet. (Source: James Urban) in Urban Watershed Forestry Manual - Part 3 page 26.)*

Bioretention Facilities with trees
Guidance from Urban Watershed Forestry Manual Part 2 (p. 36)

Bioretention and Bioinfiltration Facilities ***Continued***

Design Modifications

- ☐ Filter fabric should not be used between the filter media and the gravel jacket around the underdrain, as it creates an undesirable soil/water interface. A filter layer of sand or pea gravel may be used in lieu of filter fabric in this area to prevent the migration of fines into the gravel layer below. Ferguson (1994) provides a formula for determining the composition of this sand layer, and Prince George's County (2001) provides guidance on use of a pea gravel layer. Filter fabric may not be necessary along the sides of the excavated area unless there is concern about lateral movement of water into the adjacent soil (e.g., in applications where lateral seepage may cause upheaval of adjacent pavement).
- ☐ Use #57 (i.e., 1 ½-inch diameter) gravel instead of #2 around underdrain to provide some filtering. The underdrain may be suspended within #57 gravel to provide enhanced recharge and infiltration by increasing the stone reservoir.
- ☐ Allow for 6-9 inches of ponding during storm events.

Species Selection

Species selection is key in bioretention designs since it is more efficient than trying to change the site characteristics. Select a minimum of three hardy, native tree species that are adapted to soil and site conditions.
Other desirable species characteristics may include the following:

- ☐ Tolerant of inundation
- ☐ Tolerant of drought
- ☐ Wide spreading canopy
- ☐ Tolerant of salt

General Planting Guidance

- ☐ Have a landscape architect create a planting plan for the facility.
- ☐ Do not plant trees directly over the underdrain as a precautionary measure.
- ☐ Excavate the center only to a depth of 4 feet and backfill with filter media (infiltration rate of at least 0.5 feet per day). Use existing soil on side slopes (minimum 4:1 slopes). Use a filter medium with a lower sand ratio, or plant large trees only on side slopes to reduce potential for upheaval.
- ☐ Overplant with bare root seedlings for fast establishment and to account for mortality. Alternatively, plant larger stock when a dedicated water source is available using desired spacing intervals (35-50 feet for large and very large trees) and random spacing, or use a mix of seedlings and larger stock.
- ☐ Provide adequate soil volume for trees: in general, 2 cubic feet of useable soil for every square foot of mature canopy (Urban, 1999). Assume some shared rooting space between trees.

MATERIALS

Trees

Specific selections would be based on the site analysis, which would include climate, soil, space limitations, and visual factors. All selections should be species that are adapted to the periodic wet and dry periods that occur in bioretention gardens and that can withstand urban stress. Native and non invasive adaptive species that require no irrigation after establishment would be selected.

Other plants

Plants_with well-established root systems would be required in order to establish the garden quickly and effectively. Native shrubs, grasses, and herbaceous plants that grow in wetland and upland areas recommended by the NYSDEC can be found in Appendix H of the New York State Stormwater Management Design Manual 2010 (Design Manual).

Soil and mulch

Chemical, biological, drain, percolation, and infiltration tests should be conducted prior to the development of the final design. Site preparation would be based on soil conditions revealed in the site assessment, including drainage, pH range, compaction levels, texture and other factors. Components and proportions would be specified in the final design. Recommendations in the Design Manual for bioretention area soils and mulch are as follows:

> ***Planting Soil Bed Characteristics*** The characteristics of the soil for the bioretention facility are perhaps as important as the facility location, size, and treatment volume. The soil must be permeable enough to allow runoff to filter through the media, while having characteristics suitable to promote and sustain a robust vegetative cover crop. In addition, much of the nutrient pollutant uptake (nitrogen and phosphorus) is accomplished through adsorption and microbial activity within the soil profile. Therefore, the soils must balance soil chemistry and physical properties to support biotic communities above and below ground. The planting soil should be a sandy loam, loamy sand, loam (USDA), or a loam/sand mix (should contain a minimum 35 to 60% sand, by volume). The clay content for these soils should by less than 25% by volume. Soils should fall within the SM, or ML classifications of the Unified Soil Classification System (USCS). A permeability of at least 1.0 feet per day (0.5"/hr) is required (a conservative value of 0.5 feet per day is used for design). The soil should be free of stones, stumps, roots, or other woody material over 1" in diameter. Brush or seeds from noxious weeds. Placement of the planting soil should be in lifts of 12 to 18", loosely compacted (tamped lightly with a dozer or backhoe bucket).
>
> ***Mulch Layer***
>
> The mulch layer plays an important role in the performance of the bioretention system. The mulch layer helps maintain soil moisture and avoid surface sealing which reduces permeability. Mulch helps prevent erosion, and provides a micro-environment suitable for soil biota at the mulch/soil interface. It also serves as a pretreatment layer, trapping the finer sediments which remain suspended after the primary pretreatment. The mulch layer should be standard landscape style, single or double, shredded hardwood mulch or chips. The mulch layer should be well aged (stockpiled or stored for at least 12 months), uniform in color, and free of other materials, such as weed seeds, soil, roots, etc. The mulch should be applied to a maximum depth of three inches. Grass clippings should not be used as a mulch material (Appendix H, page 6).

Other Materials

- Stone for diaphragm and inflow path as required in final design

CONSTRUCTION STEPS

- Excavate to the depth required by the final design
- Backfill with layer of clean washed gravel
- Construct stone diaphragm and open curb if required
- Adjust grading in parking lot paving to channel runoff

- Fill to required depth with amended garden soil
- Install plantings
- Apply mulch and stones

MAINTENANCE CONSIDERATIONS

The bioretention cells would be designed for low maintenance. Weeding and watering are essential in the first year and can be minimized with the use of a weed free mulch layer. Routine maintenance would include the occasional replacement of plants, mulching, weeding and thinning to maintain the desired appearance. The gravel diaphragm would require regular maintenance to clean sediments and debris.

During the establishment period new tree plantings would be watered using water bags and spot watering with a clear understanding of the requirements of the trees to avoid over- or under-watering. Ongoing maintenance for the trees would include occasional pruning and replacements, twice yearly clean up and yearly application of mulch.

According to the Design Manual the following maintenance guidelines should be followed for tree plantings:

> During the first three years, mulching, watering and protection of young trees may be necessary and should be included in the inspection list.
>
> Inspections should be performed every three months and within one week of ice storms, within one week of high wind events that reach speeds of 20 mph until trees have reached maturity, and according to established tree inspection requirements as identified within this document.
>
> • As a minimum, the following items should be included in the regular inspection list:
>
> - Assess tree health
> - Determine survival rate; replace any dead trees.
> - Inspect tree for evidence of insect and disease damage; treat as necessary
> - Inspect tree for damages or dead limbs; prune as necessary (page 5-68).

RESOURCES

The following resources on site assessment and tree selection are recommended:

From Urban Horticulture Institute of Cornell University at http://www.hort.cornell.edu/uhi/:

Recommended Urban Trees: Site Assessment and Tree Selection for Urban Tolerance. Urban Horticulture Institute, Department of Horticulture, Cornell University, Ithaca, NY.

Visual Similarity and Biological Diversity: Street Tree Selection and Design. Bassuk, Nina,. Trowbridge, Peter. Grohs, Carol.

From the Center for Watershed Protection http://www.cwp.org/documents/cat_view/69-urban-watershed-forestry-manual-series.html

Urban Watershed Forestry Manual,Part 3:.Urban Tree Planting Guide. Cappiella, Schueler, Tomlinson, Wright. Center for Watershed Protection and USDA Forest Service, Sept 2006.

SIZING CALCULATIONS

Green Infrastructure Sizing and Design

The green infrastructure practices included in these plans are among those considered acceptable for runoff reduction in the New York State Department of Environmental Conservation Stormwater Management Design Manual 2010 (DEC Manual). The green infrastructure techniques that are included in the DEC Manual include practices that:

- reduce calculated runoff from contributing areas
- capture the required water quality volume.

The **Water Quality Volume (denoted as the WQv**) is designed to improve water quality sizing to capture and treat 90% of the average annual stormwater runoff volume. For Kingston this 90% rainfall number is 1.1 inches. The WQv is directly related to the amount of impervious cover created at a site. The following equation can be used to determine the water quality storage volume WQv (in acre-feet of storage):

WQv = (P) (Rv)(A)/12
where:
WQv = water quality volume (in acre-feet)
P = 90% Rainfall Event Number
Rv = 0.05 + 0.009(I), where I is percent impervious cover
A = site area in acres (Contributing area)
A minimum Rv of 0.2 will be applied to regulated sites.

For the most part, the plans included here focus on limiting the practices to a size that would capture the WQv in order to demonstrate clearly how the practices might fit within the particular settings and may be achieved within restricted budgets. However, in settings with sewer overflows and flooding problems, expanding the practices to capture greater volumes would be recommended.

Shown below are the calculations for the bioretention cells on the south side of the Hannaford.

Available Surface area	**24000**	**ft^2**
Total Drainage Area	**170000**	**Ft^2**
<u>1: Calculate Water Quality Volume (WQv)</u>		
WQv = (P) (Rv) (A) / 12		
P = 90% rainfall number =	**1.1**	**inches**
Rv = 0.05+0.009 (I), if Rv < 20%, use Rv = 20%	**95%**	
I = percent impervious of area draining to planter =	**100%**	
% of Total area that drains to planter	**100%**	
A = Area draining to practice =	**170000**	**Ft^2**
WQv =	**14804**	**Ft^3**
<u>2 Bioretention Details</u>		
<u>WQv*df/k(hf+df)(tf)</u>		
df = depth of soil medium =	**3**	**ft**
k = Coefficient of permeability of planting soils	**0.5**	**ft/day**
hf = Average ponding depth (max depth/2	**0.25**	**ft**
tf = filter time (days) =	**2**	**days**
3. Calculation Af = Required surface area for bioretention	**13665**	**Ft^2**

2- BIORETENTION AREA WITH GRASS FILTER STRIP BY BALL FIELD

DESIGN

The bioretention proposed for the edge of the ball field parking lot would be designed to include a grass filter strip in addition to the gravel filter, providing an additional layer of filtration, as recommended in the Design Manual. The planting options, materials construction and maintenance would be as in the previous discussion.

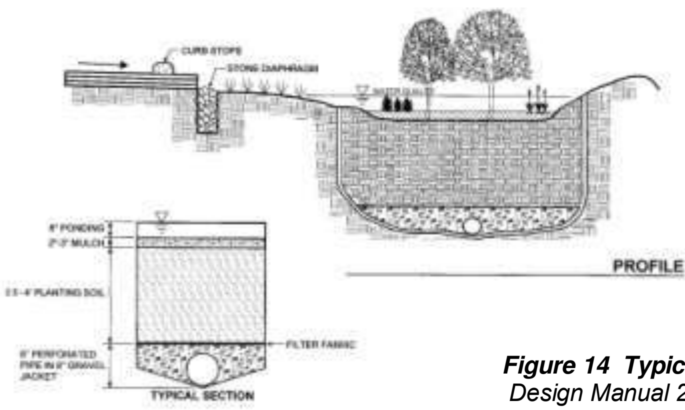


Figure 14 Typical Bioretention Garden Design.
Design Manual 2010 , page 6-49.

SIZING COMPUTATIONS FOR BIORETENTION AREA BY BALL FIELD

If the parking lot were reduced in size and new planting areas were established as shown on the plan, approximately 34,000,square feet of asphalt paving would remain. As shown in the sizing calculations below, the 2,900 square foot bioretention garden would capture and treat the WQv, for this area of paving.

Available Surface area	**2900**	**ft^2**
Total Drainage Area	**34000**	**Ft^2**
1: Calculate Water Quality Volume (WQv)		
WQv = (P) (Rv) (A) / 12		
P = 90% rainfall number =	**1.1**	**inches**
Rv = 0.05+0.009 (I), if Rv < 20%, use Rv = 20%	**95%**	
I = percent impervious of area draining to planter =	**100%**	
% of Total area that drains to planter	**100%**	
A = Area draining to practice =	**34000**	**Ft^2**
WQv =	**2961**	**Ft^3**
2 Bioretention Details		
WQv*df/k(hf+df)(tf)		
df = depth of soil medium =	**4**	**ft**
k = Coefficient of permeability of planting soils	**0.5**	**ft/day**
hf = Average ponding depth (max depth/2	**0.25**	**ft**
tf = filter time (days) =	**2**	**days**
3. Calculation Af = Required surface area for bioretention	**2787**	**Ft^2**

3- PERMEABLE PAVING ALTERNATIVE FOR BALL FIELD LOT

If the goal is just to capture and treat the WQv, a strip of permeable paving the size of the grass filter shown on the plan would be adequate for the runoff from the rest of the lot. If permeable paving were installed in the whole ball field parking lot, the larger volumes could be captured below the paving.

Tree plantings could also be planned for the center of the lot to provide shade as water quality treatment, as described previously.

The depth of the base course would depend on the expected use. Cars usually need a six- to eight-inch base course, and buses, trucks, and fire engines would require eight to 12 inches (20–30 cm) or more.

CONSTRUCTION STEPS AND MATERIALS FOR GEOCELL PAVING

The gravel base layer for pervious paving must be protected from sedimentation during construction. The construction steps would follow specification developed by a qualified professional.
For Gravelpave2 the basic construction steps are as follows:

- Excavate to required depth
- Install base course and filter fabric
- Lay out and anchor units with top of rings flush with adjacent hard surface
- Install gravel

MAINTENANCE CONSIDERATIONS

- Two excellent fact sheets on permeable and porous paving *Research Update and Design Implications* and *Maintaining Permeable Pavements* are available from the NC State University Stormwater Engineering Group at http://www.bae.ncsu.edu/stormwater/pubs.htm: [3]

Invisible Structures provides the following guidance for maintaining GravelPave2:

> Potholes will only appear if the base course has not been compacted properly before laying the rings or if the base material is allowed to mix into clay soils below (use nonwoven fabric to keep separate). Should this occur, remove a section by vacuuming the gravel from the rings, unfasten the snap fit fastener, bring the base course to the proper grade and compaction, put the Gravelpave2 square back in place, anchor, and fill to the top of the rings. Seasonally check the rings in high-traffic areas and entrance lanes for lower levels of fill and replace by sweeping gravel from other areas to bring it level again. Leaves should be raked or vacuumed and not allowed to decay. Organic matter will stimulate weed growth and reduce porosity. To attack any occasional weeds that may locate within the Gravelpave2 installation, simply spray them with a weed killer (such as Roundup™) and remove them when dead.[4]

COST

Geocells filled with gravel would be less expensive than permeable concrete interlocking pavers, and for an overflow lot would be appropriate. The cost for GravelPave2 would be in the range of $6-8 per square foot.[5]

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[3] Urban Waterways, NC State University and A&T State University Cooperative Extension.2011.

[4] Invisible Structures. Gravelpave2 Brochure: http://www.invisiblestructures.com/brochures/GPGV_brochure.pdf (accessed 11/29/2011).

[5] Manufacturer's NE regional representative Ralph Morgan. Telephone interview 11/22/2011.

SIZING COMPUTATIONS FOR PERMEABLE PAVING

If the entire 35,000 sf parking area shown on the plan were paved with to allow for truck traffic, with a base of 12", the reservoir would have a storage capacity of 14,000 cf. If the goal is just to capture the WQv, an impervious pavement could be installed that would drain to a permeable paving strip with a surface area of 7,620 sf.

Total Drainage Area	**35000**	**Ft^2**
Available Surface Area	35000	**Ft^2**
Step 1: Calculate Water Quality Volume (WQv)		
WQv = (P) (Rv) (A) / 12		
P = 90% rainfall number =	**1.1**	**inches**
Rv = 0.05+0.009 (I), if Rv < 20%, use Rv = 20%	**95%**	
I = percent impervious of area draining to practice =	**100%**	
% of Total area that drains to practice	**100%**	
A = Area draining to practice =	**35000**	Ft^2
WQv =	**3047.9**	Ft^3
Step 2: Calculate required surface area for pavement:		
Ap = WQv / *n* x dt		
where *n* = assumed porosity	**0.4**	
dt =trench depth	**1**	ft
A_P=	**7620**	Ft^2
OR		
Step 2: Calculate the available storage volume in the storage reservoir:		
Storage Volume = Ap*n*dt		
where:		
n = assumed porosity =	**0.4**	
dt = gravel bed/reservoir depth =	**1**	**Ft**
Reservoir Storage Volume =	**14000**	**Ft^2**

5- GREEN ROOF

DESIGN

At the time that the waterproof roofing membrane needs to be replaced on the Herzog store, a green roof should be considered. A simple, relatively low cost system known as an “extensive” green roof could be installed using prefabricated modules or rolls that include a light weight soil medium and short, hardy plants like sedums.

The first step for greening an existing roof is an assessment of the structure to determine the load bearing capacity. “Generally, green roofs weighing more than 17 pounds per square foot (saturated) require consultation with a structural engineer.”[6]

Stormwater treatment in green roofs occurs via evaporation, transpiration, and filtration, so the deeper the storage media and denser the plant the material the greater the benefits, and the heavier the load. Extensive green roofs systems, such as XeroFlor range from 8 to 24 pounds saturated weight per square foot. Other companies, such as Barrett have systems with minimum weights above 20 pounds per square foot. The prefabricated systems come in mats, rolls or trays.

Besides the load bearing capacity of the roof, other factors to consider in developing a final design in include stormwater management function, local wind and solar exposure, and aesthetic goals. To protect the new planting from wind erosion, erosion control matting can be used or densely vegetated mats embedded in a fibrous base can be placed on the soil, like sod.

MATERIALS

The general components of any green roof system include:

- a roof structure capable of supporting the weight of a green roof system
- a waterproofing barrier layer designed to protect the building and roof structure
- a drainage layer consisting of a porous media capable of water storage for plant uptake and storm buffering
- a geosynthetic layer to prevent fine soil media from clogging the porous media soil with appropriate characteristics to support selected green roof plants
- plants with appropriate tolerance for regional climate variation, harsh rooftop conditions and shallow rooting depths (Design Manual 5-86).

[6] Barr Engineering, 2003 in Design Manual p.5-93.

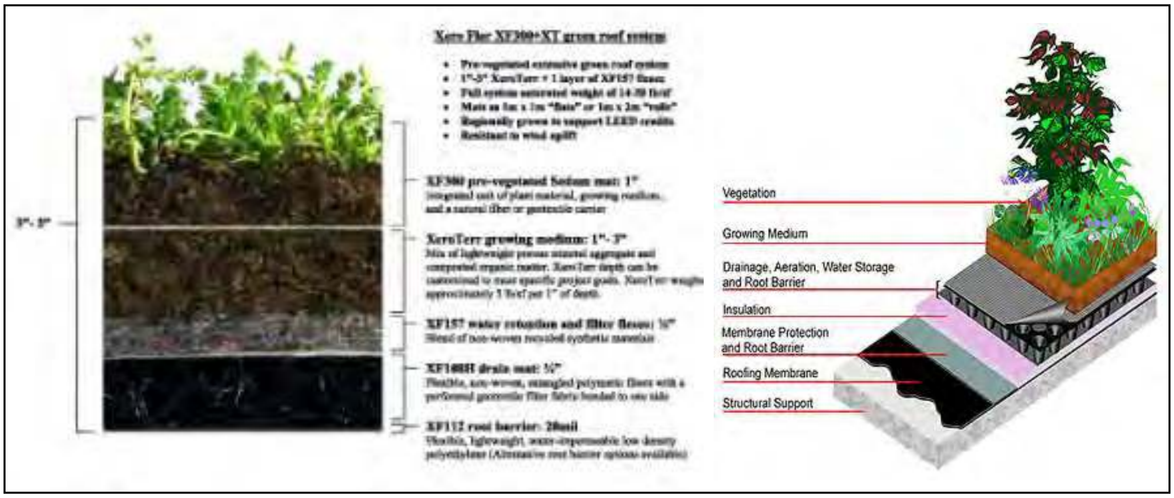

Figure 15 *Example profiles : Left: Roll out system (Xeroflora.com); Right: modular tray system*

CONSTRUCTION STEPS

For any system, the first steps would be to inspect the underlying roof components and install edging as required. The specific construction steps would be determined by the final design. The steps shown below are for a roll type system. See Appendix x for examples of specifications for several systems.

The basic installation steps for a mat or roll type green roof system would be as follows

Install:

- Root barrier
- Drain Mat
- Retention Fleece
- Growing Medium
- Vegetation Mat
- Fill in or redistribute displaced growing medium
- Water thoroughly

MAINTENANCE CONSIDERATIONS

Green roof maintenance may include watering, fertilizing and weeding and is typically greatest in the first two years as plants become established. Roof drains should be cleared when soil substrate, vegetation or debris clog the drain inlet. Maintenance largely depends on the type of green roof system installed and the type of vegetation planted. Maintenance requirements in intensive systems are generally more costly and continuous, compared to extensive systems. The use of native vegetation is recommended to reduce plant maintenance in both extensive and intensive systems. A green roof should be monitored after completion for plant establishment, leaks and other functional or structural concerns. Vegetation should be monitored for establishment and viability, particularly in the first two years. Irrigation and fertilization is typically only a consideration during the first year before plants are established. After the first year, maintenance consists of two visits per year for weeding of invasive species, and safety and membrane inspections (Magco, 2003).[7]

[7] In Design Manual pages 5-94-5-95.

SIZING COMPUTATIONS FOR GREEN ROOF

The sizing computations for an extensive green roof with a 3 inch soil layer and 2" drainage layer are given below. The storage volume would exceed the water quality volume. The final design would determine the actual runoff reduction.

Roof area	19,000	sf
WQv = (P)(Rv)(A)/12		
where:		
P = 90% rainfall number =	1.1	in
Rv = 0.05+0.009 (I) = 0.05+0.009(100) = 0.95	0.95	
I = the percentage of impervious area draining to site = 100%	100%	
A = area draining to practice =	19000	ft^2
WQv =	1654.583	ft^3
Step 2: Calculate the drainage layer and soil media storage volume:		
where:		
AGR = green roof surface area =	19,000	ft^2
DSM = depth soil media =	0.25	ft
DDL = depth drainage layer =	0.17	ft
PSM = porosity of soil media =	0.2	
PDL = porosity of drainage layer =	0.25	
VSM = AGR x DSM x PSM	950	
VDL = AGR x DDL x PDL	807.5	
DP = ponding depth = 0.5 inches = 0.04 ft	0.04	ft
Storage Volume =VSM+VDL+(DP x AGR) =	2517.5	ft^3

Mention of trade names and commercial enterprises is for information only and does not imply endorsement.

A WORD ON COSTS

Green infrastructure costs for retrofits are hard to state accurately. In new construction there is often considerably lower cost up front using and green infrastructure practices and planning versus conventional, big pipe systems. But where that "gray infrastructure" is already in place, assessing the value of adding a gi practice requires a fuller accounting. A recent report by the Center for Clean Air Policy states:

> *The value of green infrastructure actions is calculated by comparison to the cost of "hard" infrastructure alternatives, the value of avoided damages, or market preferences that enhance value (e.g. property value). Green infrastructure benefits generally can be divided into five categories of environmental protection:*
>
> *(1) Land-value,*
> *(2) Quality of life,*
> *(3) Public health,*
> *(4) Hazard mitigation, and*
> *(5) Regulatory compliance.*

The report sites, for example, New York City's 2010 Green Infrastructure Plan, "which aims to reduce the city's sewer management costs by $2.4 billion over 20 years. The plan estimates that every fully vegetated acre of green infrastructure would provide total annual benefits of $8,522 in reduced energy demand, $166 in reduced CO2 emissions, $1,044 in improved air quality, and $4,725 in increased property value. It estimates that the city can reduce CSO volumes by 2 billion gallons by 2030, using green practices at a total cost of $1.5 billion less than traditional methods .[1]

Cost Data

For installation, maintenance costs and lifespan data for the practices discussed here, the Cost Sheet developed by the Center for Neighborhood Technology (CNT) in collaboration with the *US EPA Office of Wetlands, Oceans, and Watersheds (OWOW), Assessment and Watershed Protection Division, Non-Point Source Branch,* provides useful information based on examples from various locations. It may be found at their website.
http://greenvalues.cnt.org/national/cost_detail.php

Another useful source of cost data can be found in the Center of Watershed Protection's *Urban Subwatershed Restoration Manual Series*. *Manual 3: Urban Stormwater Retrofit Practices*, pages E-1 though 14, includes a discussion of costs in terms of the amount of stormwater treated.
http://www.cwp.org/categoryblog/92-urban-subwatershed-restoration-manual-series.html

Concept Plan by Marcy Denker
Project Outreach by Victor-Pierre Melendez

[1] The Value of Green Infrastructure for Urban Climate Adaptation. Center for Clean Air Policy. Josh Foster, Ashley Lowe, Steve Winkelman. February 2011.