Chesapeake Bay Foundation

GREEN ROOF DEMONSTRATION PROJECT
Final Report

October 2003 – September 2008

Introduction

Modern vegetated roofs are an important technique to manage urban runoff – the largest source of pollution to urban waterways and one of the largest sources of pollution in the Chesapeake Bay. Green or vegetated roofs are beginning to gain mainstream acceptance in the United States and are very popular in Germany and other European countries. The Washington DC region is one of the more active in the US in green roof technology.

Green roofs hold and delay major rainfall flows that trigger combined sewer overflows; filter pollutants that affect storm-water releases to rivers; reduce loads on sewage treatment plants; save energy in buildings. Green roofs are especially effective in cities such as Washington, where so much surface area is taken up by rooftops and recent data shows that they achieve a significant overall reduction of nitrogen in storm-water runoff.

In 2003, the Chesapeake Bay Foundation initiated a green roof demonstration project providing incentive grants to DC building owners. The main project goal is to demonstrate the technical, policy and economic feasibility of installing green roofs on commercial buildings in Washington DC. The project began when the DC Water and Sewer Authority negotiated a settlement to a lawsuit providing the Chesapeake Bay Foundation $300,000 for the "design, installation and maintenance of demonstration green roof projects" within the combined sewer area of the Anacostia River watershed in the District. CBF set up program and a process to select qualified firms and issue grants that would partially defray the capital cost of a green roof.

The Chesapeake Bay Foundation issued grants for the installation of eight green roofs varying in size (from 3,000 to 68,000 square feet), in design, in location, in use, and including both new and existing structures. The work included technical, cost, and performance evaluations of each roof. A public outreach segment was designed to encourage more widespread replication of green roof technology throughout the metropolitan area.

Background

This green roof demonstration project was initiated with the DCWASA funds of $300.000 provided under the terms of a consent decree issued by the DC District Court

on October 10, 2003.[1] In 2004 the CBF Anacostia River office set up a small grants program and a process through which proposals were requested for commercial green roofs from private and public entities. Letters of interest were solicited from a wide range of building owners and developers. The grants were intended to partially defray the capital cost of a green roof up to approximately 20 percent. The CBF established grant application guidelines and proposals were received and evaluated by CBF assisted by an expert advisory group using a common scoring matrix. In late 2004 the CBF issued three grants to selected building owners and, in 2005, issued a second round of green roof grants to four additional qualified building owners using DCWASA funds supplemented by new funds of $50,000 received from the DC Department of Health, Watershed Protection Division. In early 2008 an eighth grant was issued with remaining funds.

Green roof designs take many forms but modern "extensive" systems were chosen for this demonstration project because of their relative simplicity, certain proven standard components and past success in controlling storm-water runoff and improving water quality.

About one third of the District of Columbia is served by a combined sewer system that, during even moderately heavy rains, becomes overloaded and discharges raw sewerage into adjacent rivers. An average of 75 overflow events each year result in 1.5 billion gallons discharged into the Anacostia River. The installation of green roofs on buildings in the combined sewer area would retain storm water during these heavy rains and consequently reduce the amount of overflow discharges. The goal of this demonstration project is to illustrate these benefits and encourage widespread applications of similar green roofs on both existing and new buildings in this watershed region.

More than half of the District's combined sewer area (about 7,000 acres) discharges into the Anacostia River. This Anacostia watershed encompasses many of the original neighborhoods of DC and includes a wide variety of commercial and residential buildings. Recent studies have estimated that about 1,500 acres of rooftops are within this target region representing at least four different types of buildings – private homes (row houses and detached houses), apartment buildings, commercial/institutional buildings, and government buildings. If green roofs are to have a significant impact on the reduction of the combined sewer system overflow problem, they will need to be installed on a large number of buildings in the target region.[2] This demonstration project could help realize major green roof coverage for Washington DC over the long term.

In Washington, the larger, steel and concrete single buildings such as apartments, commercial and government buildings with mostly flat roofs are most likely candidates for green roofs. Although precise numbers are unknown, within the CSS region, there are probably both a variety of existing buildings and planned new construction candidates for

[1] The funds for CBF's green roof demonstration project came from a court settlement that Earthjustice negotiated on behalf of Anacostia Watershed Society, Kingman Park Civic Association, Friends of the Earth, Sierra Club, and American Canoe Association

[2] For example, ten percent of the rooftops in the target region would be about 150 acres, or over six million square feet, which is equivalent to a few hundred large commercial buildings.

future green roofs. Target buildings for this demonstration project, therefore, included three major building types (apartments / commercial / government), as well as both new and existing structures. The demonstration roofs would be models which all building owners could use to guide future plans for construction or re-construction. They could also use the factual information from this demonstration including costs, construction methods, performance, and maintenance needs.

The CBF Granting Process

This project was initiated by CBF based on the very general instruction contained in the court's consent decree to install and maintain green roofs. In order to develop a workable and effective process to achieve long-term goals of promoting wide application of green roof technology in the DC metropolitan area, CBF decided to prepare a plan that would leverage the funds available and result in the construction of several green roofs by a variety of commercial and private building owners who could then be encouraged to learn from and share the experience with others with similar needs and resources.

The first step in this process was to organize an advisory panel of experts, local officials and stakeholders. This panel reviewed early plans, recommended an approach and scope and periodically reviewed progress. The CBF then established guidelines for acceptable green roof projects. To be acceptable, buildings would need to be located within the Anacostia River watershed in the District of Columbia and within the region served by the combined sewer system. Any commercial or private building could be eligible to receive a grant but the owner would be responsible for all aspects of the design, permitting, selecting contractors, construction and maintenance.

The guidelines referred to standard industry practice for extensive green roofs and asked grant applications to include preliminary designs, green roof coverage, estimates of storm-water retention, and estimates of cost. Since each grant would defray the capital cost of a green roof by about 20 percent, the building owner would be investing about 80 percent of the green roof capital cost. Each building owner would also cover all maintenance costs and, when applicable, execute a maintenance agreement with local regulatory authorities.

The Green Roof Grantees and Projects

In 2004, the Chesapeake Bay Foundation issued grants for the installation of four green roofs to the following:

- The Anacostia Economic Development Corporation for a 10,000 sq ft green roof on a new building at 1800 MLK Ave. SE. It was installed in May 2007.

- Akridge for a 12,000 sq ft green roof on a new building at 700 6th Street NW. Construction began in May 2007 and planned roof installation is late 2008.

- The JBG Companies for two green roof installations totaling 68,000 sq ft on the new Southeast Federal Center Venture at 1200 New Jersey Avenue SE and 1201 4th Street SE (The Department of Transportation headquarters). This roof was installed in September 2006.

In 2005, CBF issued a second round of grants to using remaining DCWASA funds (for the APA and DC Rec. grants) and new funds from the DC Department of Health, Watershed Protection Division (for the ASLA and JBG grants):

- The ASLA headquarters building at 636 Eye Street NW for a 3,000 sq ft green roof with a combination extensive/intensive design. This re-roofing project was completed in April 2006.

- The APA Headquarters Building at 10 G Street NE for a 3,000 sq ft green roof. This re-roofing project will be installed in 2008.

- The DC Recreation Dept. Building at 1310 Childress St. NE for a 5,000 sq ft green roof on a new recreation building. It was installed in late 2006, and the facility was opened in the spring of 2007.

- The JBG office building at 51 Louisiana Ave. NW for a 12,000 sq ft green roof on a combination of a new structure and modified existing building. The green roof installation will be in the fall of 2008.

In June 2008 CBF issued one final green roof grant, with remaining funds, to:

- A developer of low-income housing, Mi Casa Inc. will install two green roofs totaling 3,000 sqft on two separate condo buildings in the Ivy City neighborhood of NE DC. The work is currently in the design stage and the roofs will be installed in 2009.

Table 2 shows a list of the above projects with green roof coverage and storm water retention estimates for each.

The Nationals Stadium Green Roof

While not technically a part of these GRDP incentive-grants, in 2007, CBF had the opportunity to issue another grant to install and maintain a 6,000 sq ft green roof on a concession building at the new National's baseball stadium in SE DC. The grant was made possible with funding from the Summit Fund of Washington, and the roof was completed just before opening day in April 2008. This installation adds a significant public awareness aspect to green roof initiatives in Washington DC. Details about the project are available separately from CBF.

Table 2
Estimates of Green Roof Coverage and storm-water retention for seven roofs

PROJECT	Green Roof Area (sq ft)	Percent Gr Roof Coverage	Type	Annual Water Retention Est. gals	Status
ASLA Eye St NW	3,300	67%	Combined Extensive / intensive	45,000	Complete
DOT Hqtrs M St SE	68,000	42%	Extensive	1,020,000	Complete
APA G St NE	3,000	10%	Extensive w/ labyrinth	45,000	Complete
AEDC MLK Ave SE	10,500	51%	Extensive	158,000	Complete
Akridge 6th St NW	11,000	43%	Extensive	165,000	Scheduled 2008
DC Rec Childress St NE	5,400	25%	Extensive	81,000	Complete
JBG LA Ave NW	17,000	46%	Extensive	255,000	Scheduled 2008
Mi Casa Ivy City NE DC	3,000	50%	Extensive	45,000	Scheduled 2009

Total Green Roof Coverage for all projects = 121,200 sq ft
Average Green Roof Percent Coverage for all projects = 43%
Total estimated annual storm-water retention = 1,814,000 gals

Illustrating Technical and Economic Feasibility

These CBF green roof projects demonstrate technical and economic feasibility by showing how each system is successfully designed and installed and by providing an accounting for the costs of each system. The green roof industry has matured to the extent that architects and engineers can specify components and refer to standards when preparing building designs. Therefore, each of the green roofs listed above have had a set of design specifications and drawings prepared by the building architects and engineers. Those designs that need to meet storm-water requirements of the District of Columbia have been submitted to the appropriate agencies and have received approvals. In addition, the systems have been inspected when completed and each owner has executed a maintenance agreement with the DC Department of the Environment.

The most important aspect of good technical performance of these green roofs is whether they will remain sound and effective over time without extensive maintenance required. The CBF and its commercial building partners periodically review the status of each roof and report their experience.

Whether these green roofs are economically feasible also depends on performance over time. CBF has collected data on capital costs of each project, based on initial design estimates as well as actual costs for those roofs completed. Each grant proposal included an estimate of the green roof capital cost (that is: the added cost of all green roof components above that which would be required for any standard roof). In general this would include the cost of plants, growing media, drainage system, filters and root barriers, but not the basic waterproofing components. This estimate formed the basis of calculating the 20% incentive grant amount requested.

The following shows the range of cost estimates based on data collected so far.

- Per sq ft cost for small re-roofing projects (under 5,000 sq ft) ------ $25-30
- Per sq ft cost for moderate new roof projects (up to 10,000 sq ft) -- $20-25
- Per sq ft cost for large new projects (15,000 – 70,000 sq ft) --------- $10-15

Another indicator of economic feasibility for these green roof projects is the extent to which commercial building owners and developers are willing to invest their own money. Since the grant procedure followed here only supplied 20% of actual green roof costs, the owner had to make a financial decision to invest 80% based on his estimate of the expected return on that investment. The one obvious return for new buildings in DC is that storm-water regulations require some kind of treatment system and the green roof is a substitute for such systems as sand filters. There may be a number of other cost savings as well (such as energy savings) that an owner could expect. There may also be intangible benefits to owners such as tenant esthetic preferences, but these data are not yet available.

Thus this project has show that certain commercial businesses will make these investments an incentive grant of about 20% is offered.

Green Roof Performance Indicators

Green roof technology improves storm water management by reducing total quantities of rooftop runoff and peak flow rates during high-intensity rains. The water quantity retention performance of green roofs has been measured and documented for a range of conditions and design parameters. In contrast to water quantity data, however, water quality measurements from green roof systems are much less available. As green roofs become standard acceptable technologies for managing storm-water, their water quality performance will need more verification. With the green roof projects funded under the CBF grant program, each grantee has been asked to estimate the storm water retention expected from the proposed green roof. CBF has also reviewed the existing research on performance and has supported a monitoring project with one of its grantees.

Extensive, sedum-vegetated green roofs with 3" to 4" of growing medium have been shown to reduce storm-water runoff by 50-100% during most rains resulting in an average of about 50% -75% total water retention from rainfall over a typical year. Thus, more than half of the annual rainfall usually stays on the roof until it is evaporated back into the air. Over an average year of typical Washington DC rainfall, such a green roof would retain about 15 gallons of storm-water per square foot of coverage.

In very heavy rains green roofs will not retain all of the water but will delay runoff and reduce peak flow rates. The effectiveness of green roofs as storm-water retention systems depends on the system design, depth of substrate and climate. All green roofs have a limited retention capacity that can be described by a "threshold storm" (defined by volume, rate and duration). In designing green roofs it is important to define the size and type of storms it will address.

The reduction in flow rates from storms that green roofs provide can serve to reduce overflows of combined sewer systems and reduce storm-water runoff in general. The data on water quantity control performance are available from several sources. One source is the Center for Green Roof Research at Penn State, which has collected recent data from their test roofs that can be applied to local US east coast conditions such as Washington DC. Another source is a Federal Technology Alert published by the US Department of Energy, which contains data on rainwater runoff and retention capacity for different green roof soil depths. It concludes that a green roof with 3-4 inches of soil can retain about one inch of rainfall and that a typical green roof will absorb, filter, retain and store up to 75% of the annual precipitation under conditions prevalent in most areas of the United States.

In other research work, the City of Portland Bureau of Environmental Services found that a typical green roof captures and evaporates between 10 and 100 percent of the rainfall depending on both the roof design and the characteristics of the rain event. The nature of the growing media such as size and texture of soil particles as well as the soil depth have

a large influence on water retention capacity. Because most extensive roofs have growing media specifically engineered to be lightweight and thin, their design has great influence on retention capacity. Some additional data collected by the firm "Roofscapes, Inc." show that about three inches of growing media will reduce average annual rainfall by more than 50 percent. These data also have been confirmed by a recent study, "Evaluation of an Extensive Green Roof" by a Toronto, Canada agency with monitoring work conducted by York University.

Using a combination of the above and CBF's own monitoring data for guidance, the following table provides estimated water retention capacity for a typical extensive green roof under the conditions prevalent in the Washington DC area. These numbers can be used for making first estimates of performance but each roof design will have its own performance measures that should be determined through the application of test data for specific systems.

Table 3
Storm-water retention capability of typical extensive green roof in Washington DC

	Gals per sq ft of green roof	Gals per acre of green roofs
Green roof water retention max for single rain event	0.6	25,000
Green roof water retention total for average year of rain	15	630,000

Some US researchers have collected data measuring water quality from green roof experiments. Measurements reported recently are from experiments by the City of Portland, Oregon; by North Carolina State University; and by Pennsylvania State University. Water quality data were also collected in the monitoring work in Toronto by York University where it was shown that water quality loads could be reduced for almost all variables, primarily due to decreased flow volumes. In addition, some longer-term studies have been done in Germany and provide data to help design green roofs that will remove certain pollutants.

Green Roof Monitoring Experiment

As part of its green roof demonstration work, CBF cooperated with one of its grantees to conduct a limited water quantity and quality monitoring experiment during 2007 on the 3,000 sq ft green roof installed in May of 2006 at the headquarters of the American Society of Landscape Architects (ASLA) on 636 Eye Street NW, Washington DC. The experiment was conducted by Dr. Charles Glass of Howard University. Water quality and quantity were measured for 5 rain events in the fall of 2006 and the spring of 2007. Temperature, pH, total suspended solids, total dissolved solids, dissolved oxygen, chemical oxygen demand, and nutrients were measured on rain water and runoff

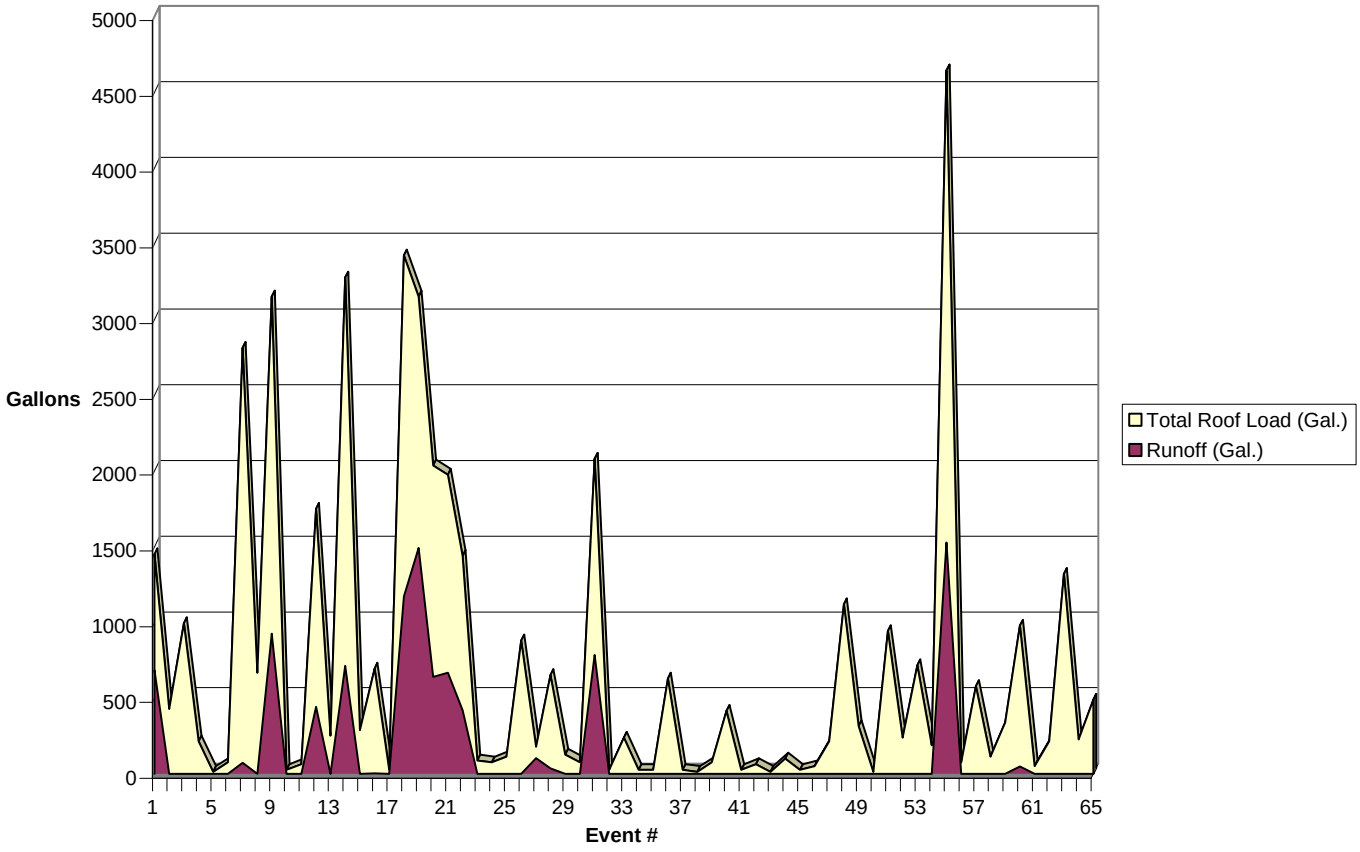
collected from the green roof. Heavy metals were measured for two rain events to check for their presence.

The ASLA green roof retained approximately 75% of the total rainfall volume that fell on it over the ten month period that data were collected. The COD, phosphate, total phosphorus, total suspended solids, and total dissolved solids all increased by significant amounts over the concentration originally present in rain water; however the concentrations were below the E.P.A.'s promulgated freshwater chronic concentration standards. Nitrogen concentrations measured in the ASLA green roof runoff were similar to the values measured in the rainwater indicating that, when combined with the measured volume reduction, a significant overall reduction of nitrogen in stormwater runoff from a green roof can be expected.

The monitoring was designed to provide initial performance indicators for a typical green roof operating in Washington DC with a focus on water quality because very few previous studies produced such data. The data collected must be examined with care given the limited scope and the low number of samples. However, a few general observations are instructive and can be used as a basis for a more comprehensive evaluation of green roofs and how they could reduce city-wide pollution problems from storm-water runoff.

Water Quantity Measurements

Green roofs are highly effective at storm-water volume reduction. To produce runoff from green roofs, storms generally have to be larger than 1 inch in a 24-hour period, and often must come in quick succession. The ASLA green roof retained approximately three quarters of the total rainfall volume that fell on it over the ten month period that data were collected for this monitoring effort. The following graph shows both rainfall and green roof runoff amounts measured during this experiment.



Water Quality Measurements

Production of certain nutrients (esp. phosphorus) can be expected from a young green roof; however the concentrations of nutrients should generally fall below the E.P.A.'s promulgated freshwater chronic concentration standards and concentrations currently found in runoff from local streets and possibly normal roofs. Nitrogen concentrations measured in the ASLA green roof runoff were similar to the values measured in the rainwater indicating that, when combined with the measured volume reduction, a significant overall reduction of nitrogen in stormwater runoff from a green roof can be expected.

Heavy metals can also be produced by green roofs however they too should largely fall below the allowable limits and below street concentrations.

Monitoring Experiment Conclusions

This experiment should be viewed as providing useful initial data for beginning to evaluate green roof performance in the Washington D.C. metropolitan area. The ASLA green roof seems to perform well with water retention and evapotranspiration and reducing the nitrogen load in runoff. In time, as the green roof continues to mature, there will probably be lower concentrations of phosphorus in the water that does pass through the roof.

The results obtained here are also consistent with other recent research on green roof performance at the Center for Green Roof Research at Penn State University, with research by Dr. Bill Hunt and others at the Water Resources Research Institute, N. C. State University and studies conducted by Dr. Manfred Kohler and Dr. Marco Schmidt at the Technical University of Berlin. These studies indicate that, with the appropriate choice of substrate, mature green roofs can be designed to reduce total pollutant discharges.

In Conclusion, Green roofs have significant potential for reducing certain most harmful storm-water carried pollutants in major metropolitan areas such as Washington DC. However, more comprehensive and extensive monitoring studies are needed to evaluate specific performance measures of specific designs and develop accurate predictive tools. A paper describing this experiment and the results was presented by Dr. Glass at the annual Green Roofs for Healthy Cities conference in Baltimore in May 2008, and the data are also documented on the ASLA website.

Encouraging More Green Roofs in Washington DC

The project efforts described in this report will only result in significant reductions in pollutants entering the Anacostia River if a next step focuses on the ultimate goal of expanding green roof coverage in Washington DC on a very large scale. Such large scale replication will take time and financial investments but is achievable given enough political will and commercial awareness of economic benefits. The CBF demonstration project has developed a workable and effective granting process and shown that incentive grants can get results. It has also demonstrated the technical and economic feasibility of commercial green roofs in this city. As more of the roofs are completed, there will be additional opportunities to learn about specific green roof designs and their uses.

This work has also provided useful data to illustrate performance and estimate long-term benefits of large-scale green roof coverage projections. It is now important to establish a more permanent institutional system with adequate financing to provide either incentives or requirements for widespread adoption of commercial green roofs and, at the same time, establish technical requirements and standards to ensure that future green roofs will be built and perform as predicted.

Appendix A

Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Built]

U.S. Department of Transportation Headquarters Building(s)
Southeast Federal Center
September 2008

Building: New construction twin office buildings completed in 2007. Offices for DOT top management and that of the several major federal agencies within DOT. Building is privately owned and leased to the federal government. Occupants moved in June 2007.

Building Owner: JBG / Federal Center, LLC

Address: 1200 New Jersey Avenue, SE

Green Roof Coverage:
68,000 sq ft on both lower roof sections and top of penthouses on two separate, adjacent buildings with pavers for walkways around perimeter and access through doorways in utility penthouse.

CBF Grant Amount:
$100,000

Total Green Roof Cost:
$720,000 -- Actual as-built cost from contractor data

Installation Date: October 2006

Green Roof System: Extensive green roof system design. Components were supplied by *American Permaquik* and include a root barrier, filter fabric and moisture retention mat (design specs similar to *American Hydrotech Garden Roof System).* The lightweight growing medium, about 3 inches deep, meets ASTM standards and is similar to *American Hydrotech Lite Top Soil.* Sedum plugs are planted at two per square foot. The roofer was *Gordon Contractors,* and the green roof installer was *Davey Trees.*

Storm-water Retention:
This roof is estimated to retain approximately 1,020,000 gallons of storm water over a one-year period of typical rainfall in the Washington DC region. This calculated amount was part of the application to the District of Columbia for a building storm-water management permit and reflects an average 56% retention factor for the green roof.

Access: Limited access to roof for small, escorted groups by appointment. Contact JBG, DOT or CBF for further information.

Appendix B

Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Built]

D.C. Department of Parks and Recreation – Trinidad Recreation Center
September 2008

Building: New construction completed in 2007; Center includes gym, other youth activity rooms, game rooms, meeting rooms and fitness center.

Building Owner: District of Columbia, Department of Parks and Recreation

Address: 1310 Childress Street, NE

Total Green Roof Coverage:
5,400 sq ft on lower roof section with pavers for walkways around perimeter and access through a fixed roof ladder and hatch.

CBF Grant Amount: $20,000

Total Green Roof Cost (initial estimate):
$120,000.

Installation Date: December 2006

Green Roof System: Extensive green roof system design using a modular roof top garden system as manufactured by *Green Tech Inc.* The modules are 4ft by 4ft plastic trays with built-in drainage channels. The planting medium fills the trays to about 8 inch depth. The plants are sedums.

Storm-water Retention:
This roof is estimated to retain approximately 81,000 gallons of storm water over a one-year period of typical rainfall in the Washington DC region.

Access: Limited access to roof for small groups by appointment. Contact DC Parks and Rec. or CBF for further information.

Appendix C

Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Built]

American Society of Landscape Architects Headquarters Building

September 2008

Building: Substantial rooftop renovation and re-roofing of existing ASLA office building completed in spring 2006.

Building Owner: American Society of Landscape Architects (ASLA)

Address: 636 Eye Street NW

Total Green Roof Coverage:
3,300 sq ft on two elevated "waves" on either side of a patio plus a surrounding extensive system covered by a grating walkway. Access is through a new stairwell with planting on top.

CBF Grant Amount: $20,000

Total Green Roof Cost:
The cost was estimated by ASLA at $350,000 for a unique system incorporating special educational, architectural, esthetic and experimental components.

Installation Date: April 2006

Green Roof System: Combination intensive / extensive green roof system design. One of the elevated "waves" is planted with sedums and the other with deeper soil is planted with hardy perennials and grasses. A low extensive system with sedums is covered by an aluminum grating walkway. The planting over the stairwell includes some trees and about 21 inches of soil. Components and services were supplied by *American Hydrotech, Inc.; Emory Knoll Farms; Chapel Valley Landscape Co.; Green Roof Products / St Louis Metal Works; and Ohio Gratings.*

Storm-water Retention:
Based on initial estimates, this roof would retain approximately 45,000 gallons of storm water over a one-year period of typical rainfall in the Washington DC region. ASLA has installed monitoring instruments on the roof and has collected runoff data over the year 2006-2007. CBF has cooperated with ASLA and Howard University to monitor and report on water quality data and a report on the results is available on ASLA web site or from CBF.

Access: Tours and presentations on the roof are available by prior appointment. Contact ASLA (www.asla.org) for further information.

Appendix D
Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Built]

Anacostia Gateway Building
September 2008

Building: New construction office building with ground retail space, completed in 2007; Three floors with about 68,000 RSF total building area.

Building Owner: Anacostia Gateway LLC [Anacostia Economic Development Corporation (AEDC) and DRI Partners, Inc.] – Tenants are DC Housing Authority.

Address: 1800 Martin Luther King Jr. Avenue, SE, Washington DC

Total Green Roof Coverage:
10,500 sq ft of green roof covering about 51% of total rooftop

CBF Grant Amount: $50,000

Total Green Roof Cost: $250,000.

Green Roof Installation Date: May 2007

Green Roof System: Extensive green roof system design. "Hydrotech Garden Roof" Assembly; Concrete surface conditioner; Monolithic Membrane 612EV-FR and flashings, protection/separation course; root barrier protection; "Styroform" brand insulation; protection/water retention mat; drainage/water retention component; filter fabric; and 4" lightweight engineered soil/growing medium.

Incorporates a roof terrace with access through a penthouse. The plants are sedums (sedum kamtschaticum).

Storm-water Retention:
This roof is estimated to retain approximately 158,000 gallons of storm water over a one-year period of typical rainfall in the Washington DC region.

Access: Limited access to roof by appointment. Contact AEDC or CBF for further information.

Appendix E
Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Built]

APA Headquarters Building
September 2008

Building: This office building is owned by the American Psychological Association and is the national headquarters of the World Resources Institute. It is located near Union Station in Washington DC and is undergoing a re-roofing incorporating a green roof and a meditation labyrinth with access for tenants, guests and the public.

Building Owner: The American Psychological Association

Address: 10 G Street NE

Total Green Roof Coverage: 3,000 sq ft

CBF Grant Amount: $20,000

Total Green Roof Cost: $50,000 [est]

Installation Date: Completed September 2008

Green Roof System: Green grid system – The standard GreenGrid® are light weight planting modules measuring 2ft by 4ft by 4in. Each module arrived on site with mature plants and ready to be installed. The modules are grown in a nursery for 30-60 days and transported in nursery racks or on pallets. The modules were carried on a freight elevator to the roof eliminating the need to use an external crane. After installation the modules may be moved if necessary to accommodate future maintenance, additions or other changes. This system is well-adapted to convert almost any standard roof to a green roof.

Storm-water Retention: Approximately 45,000 gallons of water will be retained on this roof during a typical year of average rainfalls.

Access: Public tours and outreach in partnership with the World Resources Institute, a building tenant.

Appendix F
Chesapeake Bay Foundation
GREEN ROOF PROJECT DATA SHEET
[As Designed]

51 Louisiana Ave. Office Building
September 2008

Building: An existing office building, near the US Capitol, is undergoing expansion and re-development with the addition of an adjacent 320,000 sq ft building and a green roof.

Building Owner: The JBG Companies

Address: 51 Louisiana Avenue NW

Total Green Roof Coverage: 17,000 sq ft

CBF Grant Amount: $21,000

Total Green Roof Cost: $276,000 (est)

Installation Date: Expected in late 2008

Green Roof System: Extensive green roof system with drainage layer, about four inches of growing media and sedum plantings.

Storm-water Retention: Approximately 255,000 gallons of water will be retained on this roof during a typical year of average rainfalls.

Access: Public access and outreach activities planned

Appendix G

GREEN ROOF PROJECT DATA SHEET

[As Designed]

700 6th Street NW Office Building
September 2008

Building: A new 300,000 sq ft, 12 story office building is under construction in downtown DC near the Gallery Place Metro and will be completed in 2009.

Building Owner: Akridge

Address: 700 6th Street NW

Total Green Roof Coverage: 11,000 sq ft

CBF Grant Amount: $50,000

Total Green Roof Cost: $220,000 (est)

Installation Date: Expected in late 2008

Green Roof System: Extensive green roof system with drainage layer, about four inches of growing media and sedum plantings.

Storm-water Retention: Approximately 165,000 gallons of water will be retained on this roof during a typical year of average rainfalls.

Access: Public access and outreach activities planned

Appendix H

GREEN ROOF PROJECT DATA SHEET

[As Designed]

Ivy City Condo Buildings

September 2008

Building: A DC developer of low income housing will renovate and improve two condo buildings in the Ivy City neighborhood. This affordable condo development will incorporate units designed for seniors and extended families. Mi Casa will install green roofs on each building.

Building Owner: Mi Casa Inc.

Address: 1302 Gallaudet NE and 1917 Capitol Ave. NE

Total Green Roof Coverage: 3,000 sq ft

CBF Grant Amount: $12,000

Total Green Roof Cost: $60,000 (est)

Installation Date: Expected in 2009

Green Roof System: Extensive green roof system with drainage layer, about four inches of growing media and sedum plantings.

Storm-water Retention: Approximately 45,000 gallons of water will be retained on this roof during a typical year of average rainfalls.

Access: Public access and outreach activities planned