Green Roof Infrastructure

Part II: The Practice of Green Roof Design

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Designing Green Roofs: A Landscape Architect's Perspective[1]

The Rise of Green Roof Design

Landscape architects exploring green roof design are finding a wide field of opportunity. Green roofs are a world apart from traditional rooftop gardens, which consist of planters perched on a complete conventional roofing system. In contrast, green roofs are an integrated roofing/waterproofing system offering enhanced environmental, aesthetic, and even economic benefits over traditional roofing alternatives. Green roof systems, originally a German technology, have evolved over the past 40 years and are now widely used in many locations in the United States.

In the past decade, green roofs have become an important new frontier in North American landscape architecture practice. Several factors have led to this phenomenon:

- **Role in Green Building Movement.** The green building and ecological design movement in general has promoted green roofs as one of the most effective multiple-benefit building practices available. This is recognized in the most widely applied green building benchmark, the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) rating system. Several points in the system can be addressed with integrated green roof design, including stormwater management, urban heat island effect, and ecosystem restoration.

- **Financial Incentives.** There are a variety of public and private grants available to help defray some of the initial extra costs associated with green roofs over conventional roofing. Watershed organizations, the EPA, and local and regional municipal governments have all supported green roofs with funding.

- **Stormwater Regulations.** Requirements for sustainable stormwater management have led to regulations and policies that encourage or even require green roofs under certain conditions.

- **Growing Familiarity.** As green roof applications have become more widespread and familiar to more people, they generally have more acceptance and appeal.

A "Green Technology"

Green roofs are increasingly used to integrate a building into its natural surroundings visually as well as ecologically. All green roofs provide ecological benefits that their conventional counterparts do not, including reduced energy use for building heating and cooling, improved air quality, reduction of urban heat island effect, and stormwater management. Because of a growing reputation as a "green technology," green roofs are often designed to maximize ecological benefits, primarily habitat creation and resource conservation. Green roofs may be designed with some or all of the following goals in mind:

- Use plants that are native or adapted to the local climate.
- Maximize diversity of plant species and structure.
- Optimize the use of rainwater for plant life.
- Retain rainwater on the roof to the extent possible; surplus rainwater can be stored and reused for irrigation and other purposes.
- Coordinate the green roof's stormwater function with elements elsewhere on the site like porous pavement, bioswales, and rain gardens.

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[1] David Yocca, ASLA, of the Illinois firm Conservation Design Forum, contributed significantly to this section.

- Create habitat for desired wildlife (primarily birds and insects).
- Select materials and design elements to evoke the character of local ecosystems.
- Establish a program for monitoring the roof's performance to contribute to the growing body of green roof research.

Often, however, a green roof design program is centered on creating a specific aesthetic or programmatic experience for the user/visitor. Such designs may feature exotic plants and materials, supplemental water use, and other departures from a strictly ecological program, while still providing many core environmental benefits.

Cost Considerations

When marketing green roofs to potential clients, cost is always an issue. It is important to distinguish between up-front costs and life cycle costs.[2] Typical costs for green roofs range from approximately $12 to $25 or more per square foot (as compared to $2 to $10 per square foot for conventional roofs), depending on the type of green roof system, building design, size, and accessibility. As explained in Part I of this report, installation and maintenance costs can be offset by reduced roof replacement expenditures, reduced stormwater detention needs, and building energy cost savings. Greater potential economic benefits can result from the integration of green roofs in a way that increases the livability of the space. For example, new residential buildings in Portland, Oregon; Chicago, Ilinois; Grand Rapids, Michigan; New York, New York; and many other cities offer access to a green rooftop terrace as an amenity to fuel sales and unit price premiums.

Maintenance Considerations

It is essential to budget and design for ongoing maintenance for a green roof. The water-impermeable roof membrane requires regular inspection, as do drainage flow paths. Green roof plants also require regular maintenance, as do all living systems. The client's budget for maintenance and concern about the possible need for repairs will influence a green roof's design.

The growing medium and plant cover of a green roof will provide a degree of protection from environmental stresses to the waterproofing membrane. A correctly installed waterproofing membrane will therefore very rarely develop a leak within the time span covered by the product warranty, with the exception of areas around flashings and penetrations. It is therefore good practice to leave a vegetation-free zone around flashings and penetrations, making access and cost of repairs comparable with conventional roofing systems. Modular green roof systems ensure access to the membrane with minimal disruption to the plantings, and are a good choice if ensuring this access is a primary concern. Leak detection systems can also expedite and simplify response to problems should they develop.

For green roof plants, proper root establishment in the first few years following installation requires regular attention, including weeding and some level of watering, depending upon time of installation. Once established, a basic drought-tolerant sedum roof requires minimal maintenance, primarily occasional weeding, and no supplemental irrigation. Maintenance requirements increase with the complexity and programs for the roof garden design.

Versatility of Green Roof Design

As green roofs gain increasing presence in the landscape, their forms illustrate the flexibility and potential complexity of green roof design. Green roofs are appropriate for new and retrofit buildings at many scales, from small sheds, garages, and homes to large warehouses and

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[2] A new web-enabled tool, the GreenSave Calculator, allows designers to compare the economics of up to three roofing systems (see www.greenroofs.org).

residential complexes. Green roofs can function simply as an alternative roofing material or can be fully integrated into the building design to maximize ecological and aesthetic benefits.

Green roofs that are designed as an integral building element can more fully articulate a design program, further boosting a building's environmental performance or creating accessible garden space to benefit building tenants. Among the most significant variables driving green roof design is the load-bearing capacity of the roof and the spatial distribution of that load-bearing capacity. In new construction, the roof's structural support may be engineered to enable a specific green roof design program. In a retrofit, the roof's load-bearing capacity is a fundamental design constraint. Still, for each weight category, alternative green roof systems and designs support multiple alternative design goals and infinite design visions.

The project profiles to follow feature a broad scope of recent ASLA and Green Roofs for Healthy Cities (GRHC) award-winning North American green roof designs. Each roof is a design team's unique response to a project's parameters and design program. Together, these projects demonstrate how green roofs improve the built environment for human habitation in abundant and critical ways, improving environmental quality, expanding available open space and access to the outdoors, creating new vantage points, integrating built and natural landscape features, and multiplying the range of human experiences that can be provided by place.

Project Profiles

The following project descriptions are adapted from the Green Roofs for Healthy Cities green roof award galleries from the years 2003–2007,[3] with the exception of the description of the Chicago City Hall, a 2002 winner of an ASLA Award of Merit, Design Category. ASLA Award-winning projects are works of landscape architecture distinguished by groundbreaking vision and exceptional execution. GRHC award winning projects recognize outstanding projects that integrate green roof design with a building, its occupants, and the surrounding community.

Project: Chicago City Hall
Chicago, Illinois

Primary Project Goals: Research and demonstrate performance of green roof technology; create visual amenity

ASLA Award Winner, 2002
Award Category: Award of Merit – Design
Landscape Architect and Ecological Consultant:
Conservation Design Forum
Green Roof Consultant: Atelier Dreiseitl
Architect: William McDonough + Partners
Owner: City of Chicago
Size: 30,000 s.f. (approx.)
Estimated cost: $13.30/sq. ft. (not including structural work)

Figure 1. Chicago City Hall. Image courtesy ASLA

Centrally located in downtown Chicago, City Hall is one of the most visible and recognized structures in the city. The primary purpose of the City Hall Green Roof Pilot Project is to provide a green roof demonstration that serves to facilitate research and educational outreach within the context of a midwestern climate. Under Mayor Richard M. Daley's direction, the City of Chicago's Department of Environment initiated this project as a pilot for an aggressive city-wide initiative to promote green roof construction.

Completed in 2001, the rooftop garden was designed to test different types of green roof systems, heating and cooling benefits, success rates of native and non-native vegetation, and reductions in rainwater runoff. The three systems integrated into the design include lightweight soils at 4, 6, and 18" in depth. These varying green roof systems are recognized respectively as extensive, semi-intensive, and intensive green roofs. Soils were fabricated using lightweight soil mixture guidelines developed in Germany over the previous 20 years.

Although the rooftop is not normally accessible to the public, it is visually accessible from 33 taller buildings in the area. The design form is intended to be read from these various vantage points. The plantings are organized in a sunburst pattern, which respects the symmetry of the historic City Hall and provides a format for arranging groups of plants over the three different roof systems. Though green roofs are typically planted with only sedums and low grasses, the

[3] Expanded descriptions of these and other award-winning green roof projects can be found on the Green Roofs for Healthy Cities website, www.greenroofs.org.

planting palette has been expanded significantly to accommodate research related to the viability of more than 100 species of plants.

The variety of plants includes native prairie and woodland grasses and forbs, hardy ornamental perennials and grasses, several species of native and ornamental shrubs, and two varieties of trees. Plants are organized by bloom color. As the season progresses from spring through fall, plants bloom across the sunburst pattern. The radiating bands of floral color are segregated by similar bands of grasses. The long bands provide opportunities for the same plant material to be applied over various depths of soil, ranges of slope, and drainage patterns.

Since City Hall's flat roof is over 100 years old, previous layers of waterproofing were left in place and a new liner water proofing system was installed. The relatively flat roof surface had gently sloping drainage lines that were left in place. Rectangular skylights (that are no longer used) had been covered and reinforced to increase weight support up to 60 pounds per square foot. The unified undulating ground surface was achieved by installing layers of lightweight insulation boards to elevate the soil layer 12"–24" above the waterproofing layer. Monitoring begun in 2002 has continued, as the rooftop serves as a living laboratory.

Project: Mashantucket Pequot Museum and Research Center
Mashantucket, Connecticut

Primary Project Goals: Visually integrate the building with its surroundings; minimize ecological impact; create attractive and usable roof space; express and interpret cultural values

GRHC Award Winner, 2006: Mashantucket Pequot Museum and Research Center
Award Category: Intensive Institutional
Landscape Architect: Office of Dan Kiley
Architect: Polshek and Partners
Owner: Mashantucket Pequot Tribal Nation
Size: 65,000 sq. ft.
Estimated cost: $25/sq. ft.

Figure 2. Mashantucket Pequot Museum and Research Center. Courtesy Green Roofs for Healthy Cities and Mashantucket Pequot Museum and Research Center.

The Mashantucket Pequot Tribal Nation's Museum and Research Center was built on the edge of the Great Cedar Swamp, a 500–acre wetland of cultural significance to the tribe. The facility was designed to express and celebrate the tribe's culture and connection to place. One of the functions of the green roof was to soften the interface of the building and the wooded edge of the surrounding natural terrain.

The 65,000-square-foot intensive green roof is accessible to the public and is used as a gathering place for museum events. The green roof terrace is also used for educational and cultural purposes. Many of the plants incorporated into the terrace gardens are culturally important. Several ethnobotany gardens have been developed to educate students about traditional uses of indigenous plants for food, medicine, and fiber. A root, herb, and berry garden is planned to supply the museum kitchen with local, seasonal foods that will reflect a traditional Native American harvest.

Approximately 12" of growing medium cover the museum's green roof. Stratified layers of substrate were used to facilitate appropriate/suitable drainage and planting objectives for the green roof. A base of gravel was overlaid with coarse/medium sands. Local topsoil saved from the construction site was redeposited to serve as the principal growing medium.

Because the green roof covers all of the museum's permanent exhibits, waterproofing was very important. The green roof membrane is reinforced hot rubberized asphalt. All of the green roof areas have a double layer of insulation with an underlying water retention mat. Excess water/stormwater is channeled through ducts into a series of retention basins at the edge of the cedar swamp and allowed to rapidly filter back into the wetland.

Maintenance for the museum's green roof is minimal. Terrace maintenance staff recycle and compost grass clippings and use environmentally appropriate fertilizers. The museum terrace has drip irrigation on bushes and timed irrigation on each layer based on growing conditions. Drought-resistant sod is used, and water resistance in the growing media is measured with a potentiometer to determine irrigation cycles.

Project: 10th @ Hoyt Apartments
Portland, Oregon

Primary Project Goals: Manage stormwater; create attractive and usable roof space

GRHC Award Winner, 2006: Koch Landscape Architecture
Award Category: Special Recognition
Landscape Architect: Koch Landscape Architecture
Architect: Ankrom Moisan Associated Architects
Owner: Trammell Crow Residential
Size: 8,500 sq. ft.
Estimated cost: $30/sq. ft.

The courtyard roof design at the 10th @ Hoyt Apartments near downtown Portland demonstrates innovative detention and display of stormwater. Driving the program were city requirements for onsite stormwater mitigation and the desire to provide attractive and engaging outdoor space to residents. The roof's design integrated water features with plant material in raised and at-grade planters. Sand-set paving captures and filters additional rainwater. Seat walls and partially covered formal seating allow for rest and enjoyment of the courtyard.

Figure 3. 10th @ Hoyt Apartments. Courtesy Green Roofs for Healthy Cities and Koch Landscape Architecture

Roofscape rainwater is channeled through three downspouts into pre-cast concrete runnel systems, two of which lead water into shallow detention basins filled with decorative stones. The third runnel fills a concrete cistern, which retains the water and then circulates it through a system of Cor-ten weir boxes penetrated by glass buttons that are lit from within. After several hours, water is slowly released into the city's system, thereby reducing the size of the stormwater interceptor from conventional sizing requirements.

The system has the capacity to hold all the roof rainwater for a 1/8" storm event and detain rainwater for approximately 30 hours, relieving the first storm flow burden into the urban stormwater interceptor system. Koch Landscape Architecture conducted extensive flow studies and calculations to determine flow volume and characteristics. As a result, the courtyard has assumed, and exceeded, the required 20 percent stormwater mitigation function for the project.

The courtyard roof design is enhanced by numerous trees, shrubs, potted plants, and ground covers rooted in 10 to 30" of growing medium. The plant life is supported by a drain mat with 6" of drain rock, a conventional irrigation system, and complemented by borders of clean ¾" black river rock. A W.R. Grace & Company “Procor 75” fluid applied waterproofing membrane covers a post-tension slab. Only simple landscape maintenance and an annual cistern cleaning are required to maintain the system.

Project: Seapointe Village Deck Restoration

Wildwood Crest, New Jersey

Primary Project Goals: Create attractive and usable roof space, retain historic design while improving technical performance

GRHC Award Winner, 2006: Jeffrey L. Bruce & Company, North Kansas City, Missouri
Award Category: Intensive Residential
Structural Engineer: Feld, Kaminetzky, & Cohen, P.C.
Associate Landscape Architect: Edgewater Design LL
Construction Manager: Gilbane Building Company
General Contractor: Merrell & Garaguso, Inc.
Owner: Seapointe Village Master Association
Size: 5.5 acres
Estimated Cost: $8.50–14.50/ sq. ft.

Figure 4. Seapointe Village Deck Restoration. Courtesy Green Roofs for Healthy Cities and Jeffrey L. Bruce & Co.

Seapointe Village is an oceanfront resort community in Wildwood Crest, New Jersey, constructed between 1986 and 1992. In addition to its three condominium towers, 5.5 acres of recreational amenities cover a parking structure. As the parking structure is located below sea level in a runoff- restricted water-quality district, its green roof helps mitigate stormwater impacts, allowing the stormwater management plans to meet local code requirements. However, leaks from this original 70,000-square-foot green roof began to damage the structure and vehicles below, even following 10 years of repair efforts. Studies revealed an accelerating rate of deterioration and potential for collapse well before the normal end of its useful life.

The primary design objective was the installation of a new waterproofing membrane for the plaza deck and parking structure, requiring the removal and reconstruction of all rooftop amenities. The reconstruction plan was to retain the original 1986 Peridian landscape design while complying with new building codes and accessibility requirements of the Americans with Disabilities Act. Designing the new green roof elevations to meet the existing thresholds of the three adjacent condominium structures was exceedingly complex.

The design greatly minimized the opportunities for construction defects by reducing slab penetrations and incorporating redundancy in most system functions, even installing a second membrane under water features and landscaped areas. This involved installing a multi-part hot-applied system ¼ to ½ inch over the concrete applied to both vertical and horizontal surfaces to prevent moisture seepage. A drainage mat and root barrier was installed over the membrane to prevent damage from decorative walkways and from plant material in planters. Irrigation lines do not penetrate the roofing membrane as they, control wires, and electrical service were installed above the topping slab in the decorative concrete pavement. The irrigation system incorporates advanced water management features, such as volumetric water sensors, to control irrigation operations.

The drainage system design used a variety of unique solutions. The growing media systems accept and store surface water for use by the landscape. The growing media on the roof deck are internally drained with percolation rates of between 6" and 15" per hour, resulting in little to no surface runoff. When the growing media reach material field capacity, the system releases excess water into the thin composite drainage boards, and using the slope of the deck, water finds its way into the roof drains. This maximizes water management by storing up to 4" of volumetric water in the growing media profile.

Local native plants were chosen for their summer color, and their ability to minimize maintenance, conserve water, and enhance biodiversity while also adapting in a harsh environment. Three growing media profiles were designed to meet the needs of this site. Being located adjacent to the New Jersey shore required considerable agronomic innovation to ensure sustainability of the landscape under airborne salt and hurricane-strength winds. Innovative application of emerging technologies included lightweight growing media, contoured structural foam, and sand-based sod technology. New soil laboratory testing protocols were designed to evaluate and understand specific agronomic performance of lightweight materials, which cannot be tested by traditional methods. Weight restrictions meant that traditional construction equipment could not be supported, so conveyers, along with motorized concrete buggies, were used to place media on the roof.

The design team has installed a variety of sensors and methods to observe the performance and functionality of the green roof. The data collected will be used to inform future projects.

Project: Millennium Park

Chicago, Illinois

Primary Project Goals: Create new, attractive, and usable open space at street level; expand cultural amenities; improve urban environmental quality

GRHC Award Winner, 2005: Terry Guen Design Associates, Inc., Chicago, Illinois
(Project Landscape Architect)
Award Category: Intensive Industrial/Commercial
Co-Submitted By: Jeffrey L. Bruce & Company
(Irrigation, Great Lawn and Turf Consultant)
Award Category: Intensive Industrial/Commercial
Owner: City of Chicago, Chicago Department of Transportation, Public Building Commission of Chicago
Operator: The City of Chicago, Richard M. Daley, Mayor; The Chicago Park District; Millennium Park Inc., John Bryan, Chair (park donors)
Project Director: Edward K. Uhlir, FAIA
Size: 24.5 acres
Estimated Cost: $480 million

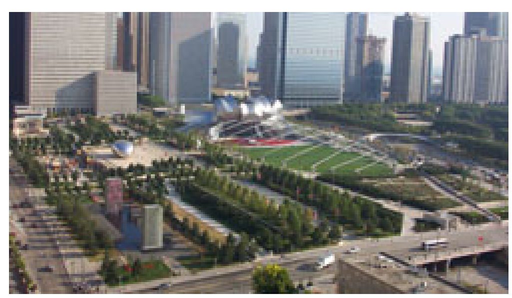


Figure 5. Millennium Park. Courtesy Green Roofs for Healthy Cities and Terry Guen Design Associates, Inc.

At 24.5 acres, Millennium Park is considered to be one of the largest intensive green roof projects in the world. The project was the result of a public-private partnership to transform an unsightly industrial area at the edge of historic Grant Park. The overall project objective was to create a free cultural venue for Chicagoans and tourists, with a focus on providing a new state-of-the-art outdoor music facility. The secondary goal was to remove (or cover) the train terminal, railway lines, and 800-space surface parking lot which occupied this prominent location in downtown Chicago.

Millennium Park holds many works of architecture, fountains, sculpture, and botanic garden spaces, as well as performance facilities, restaurants, and a skating rink. The green roof covers two new subterranean parking garages, a multi-modal transit center including a bridge over the existing railroad lines and station, and a 1,525-seat indoor performance theater. Numerous trees, shrubs, groundcovers, perennials, and annuals, along with growing media, absorb and polish storm water, clean the air, reduce the urban heat island, and provide multiple social, cultural, and economic benefits.

The centerpiece of the park is the Pritzker Pavilion and BP Pedestrian Bridge, constructed of enormous sculptural plates of curvilinear stainless steel. The 4,000-seat pavilion is home to the Grant Park Music Festival, which provides free performances throughout the summer. The pavilion is backdrop to the 7,000-seat Great Lawn: 95,000 square feet of reinforced natural turf, spanned by a grand steel trellis, which holds lighting and a state-of-the-art sound system. Designed for extreme traffic use and recovery through use of emerging turf technology, the Great Lawn includes a layered high performance drainage system.

Because the structural deck was designed to support four feet of growing medium, the park design is not limited by the pattern of the structural columns below. Growing medium for most park areas is a natural, locally available sandy loam or a blended soil based on a local sandy loam mix. The end result is varying profiles of growing media, with sand drainage throughout the project ranging from 8 inches to 4-foot depth.

The entire 24.5-acre deck was waterproofed with a hot-applied rubberized membrane system. Styrofoam fill was used to create landforms, which did not exceed the designed load capacity. Below the green roof, the subterranean parking areas provide direct pedestrian connections to the theatre and restaurants.

Project: 601 Congress Street

Seaport District, Boston, Massachusetts

Primary program goals: Achieve LEED certification; benefit building performance and environmental quality; provide visual amenity for building occupants

GRHC Award Winner, 2006: Sasaki Associates, Inc., Watertown, Massachusetts
Award Category: Intensive Industrial/Commercial
Architect: Skidmore Owings & Merrill, L.L.P
Landscape Contractor: ValleyCrest Landscape Development
Owner: Manulife Financial
Size: 11,000 sq. ft.
Estimated Cost: n/a

Figure 6. 601 Congress Street. Courtesy Green Roofs for Healthy Cities and Sasaki Associates

The intensive green roof at 601 Congress Street is on the 12th floor terrace of a 14-story office building across the harbor from Boston's Logan Airport. One of the building design goals was to achieve LEED certification. The terrace garden was created to be a sustainable design component of the project, as well as an amenity for the occupants.

It was decided for safety reasons that access to the planted area would be restricted to maintenance personnel. However, the terrace provides seating space with views of the surrounding urban landscape and harbor. A glass railing separates the paved terrace from the planted area without obscuring the visual impact of plant forms, colors, and textures, including seasonal changes in appearance.

Soil depth was limited due to structural loading limitations. Allowable depth varies from 6" at the perimeter to about 12" where low points occur in the sloped-roof drainage system. The lightweight soil mix for roof planting was specified as a custom pre-mixed blend composed of 55 percent rotary kiln expanded lightweight aggregate (expanded shale), graded sand, and treated compost derived from cranberry waste.

Drought-tolerant plant materials, including sedums and natural and ornamental grasses, were selected to cover and shade the ground plane. After the plants are established, maintenance is minimal. Annual pruning of the ornamental grasses to a 6" height in the spring, and soil nutrient replenishment once or twice a year via the drip irrigation fertilizer injector system are the only requirements.

A drainage/water storage/aeration system, manufactured by American Hydrotech, was installed over a layer of closed cell extruded polystyrene insulation. The drainage system consisted of lightweight panels of 100 percent recycled polyethylene, molded to form water-retention cups and drainage channels, and engineered to promote irrigation through capillary action and evaporation into the soil/vegetation layer.

The structural concrete roof slab was waterproofed with a hot, fluid-applied, rubberized asphalt monolithic membrane. The membrane was applied in two coats, with a layer of fabric reinforcement between layers. Hydrotech calculations indicate that approximately 70 percent of rainfall water is retained by the planting soil and drainage mat assembly. The retained water is taken up by plant root systems, reducing the need for irrigation.

Although there is no quantitative data available, it is clear that drainage, soil, and planting layers provide additional buffering of noise from planes passing overhead. Other benefits provided by the green roof include: reduction in the urban heat island effect; reduction in glare from the roof; decrease in energy costs; creation of habitat for birds, butterflies, and insect species; and improvement of air quality by reducing CO_2 levels, increasing oxygen output, and filtering and binding airborne dust and other particles.

Project: Phillips Eco-Enterprise Center (PEEC)
Minneapolis, Minnesota

Primary Project Goals: Demonstrate and research benefits to roof longevity and environmental quality; educate visitors about regional ecological identity and history

GRHC Award Winner, 2006: The Kestrel Design Group, Inc., Minneapolis, Minnesota
Award Category: Extensive Industrial/Commercial
Architect: LHB Architects
Owner: The Green Institute
Size: 4,000 sq. ft.
Estimated cost: $21.55/sq. ft.

Figure 7. Phillips Eco-Enterprise Center. Courtesy Green Roofs for Healthy Cities and The Kestrel Design Group, Inc.

The Phillips Eco-Enterprise Center (PEEC) in Minneapolis was constructed to serve as a model for comprehensive sustainable green building design. The PEEC's 4,000-square-foot extensive green roof provides the opportunity to both demonstrate and research the benefits of green roofs, including effects of the green roof on stormwater runoff, lifespan of roofing membrane, and temperature directly above the roof. The project also monitors establishment rate and survival of 18 native and 11 European green roof species in a Minnesota extensive green roof environment. The green roof's deck and seating area, constructed from recycled plastic, provide open space accessible to employees and visitors to the building. The roof was also designed to draw public attention from the adjacent elevated light rail transit line as well as provide educational opportunities.

To maximize regional identity and plant and animal biodiversity while minimizing maintenance requirements, a local native plant community, the Minnesota Bedrock Bluff Prairie, was used as a template to inform planting design. Bedrock bluff prairies are similar to many extensive green roofs in that they have shallow soil profiles and are exposed to considerable heat, drought, and wind. The same characteristics that help bedrock bluff prairie plants survive in their harsh natural environment were expected to help them thrive in the green roof environment. As the number of bedrock bluff prairies found on the Mississippi River Bluffs has greatly decreased, the PEEC green roof aims to provide an analog of this lost habitat within the Mississippi River watershed.

The PEEC planting design also called for traditional European green roof plants to be planted in swale-like depressions with 2" of growing medium, and oriented in the four cardinal directions. The roof design does not include an irrigation system. Sprinklers were used during the initial plant establishment period. Maintenance requirements include weeding and watering only during periods of extreme drought.

Accessible to the public and also visible from the adjacent elevated light rail transit line, the planting design targets both close-up viewing as well as quick glances from a distance. The orientation of the European species in the geometry of the four cardinal directions provides cues for guides leading tours of the green roof to begin their presentations, beginning with the relationship of the green roof to its context within its community. Wave-like groupings of one wildflower and one grass species in each group of native bedrock bluff prairie plants create concentrated masses of color and grasses waving in the wind, offering bold, dynamic, and ever-changing views.

Project: Ducks Unlimited National Headquarters and Oak Hammock Marsh Interpretive Centre

Winnipeg, Manitoba

Primary Project Goals: Provide rooftop habitat for native plants and wildlife and views of the surrounding landscape; mitigate the visual impact of the building

GRHC Award Winner, 2003: Number Ten Architectural Group, Project Architect
Award Category: New Intensive
Hilderman Thomas Frank, Cram & Associates, Landscape Design
Crosier Kilgourand Partners, Structural Engineers
MCW Consultants, Mechanical Engineers
AGE Engineering, Electrical Engineers
UMA Engineering, Civil Engineers
Size: 28,190 sq. ft.
Estimated Cost: n/a

Figure 8. Ducks Unlimited National Headquarters. Courtesy Green Roofs for Healthy Cities and Number Ten Architectural Group.

This building is home to the national headquarters of Ducks Unlimited, a non-profit organization dedicated to the conservation of waterfowl. Located on the edge of the Oak Hammock Marsh, an internationally designated wetland in southern Manitoba, the building was completed in 1992 and is home to the Oak Hammock Marsh Interpretive Centre. The Centre welcomes more than 200,000 visitors a year and provides education about wetlands and their preservation.

The 54,000-square-foot, two story concrete frame building is designed to blend seamlessly into its marsh and prairie surroundings through the use of two green roofs totaling 28,190 square feet. The design objectives were to reduce the visual impact from a “birds-eye” view, create maximum opportunities for observation of the marsh, and provide habitat. The green roof features include 16" of growing medium, wire mesh for rodent control, a two-ply SBS Soprema membrane system, high and low level drains, filter cloth on a granular drainage layer, and rigid insulation. A wide variety of native prairie grasses and flowers were planted including little bluestem, long headed coneflower, and western wheatgrass. Isolated sections of the green roof are home to numerous birds, such as piping plovers, as well as a few ground squirrels. The soil depth of the green roof and berming on the sides of the building eliminate the need for a chiller. Every three years, the prairie grasses are re-propagated through a controlled burn on the upper roof.

Project: Ford Dearborn Truck Assembly Plant
Dearborn, Michigan

Primary Project Goals: Benefit building performance and environmental quality, primarily through stormwater management and habitat creation; demonstrate sustainable design to visitors

GRHC Award Winner, 2004: William McDonough Partners, ARCADIS
Award Category: Extensive Industrial Commercial
Construction Manager: Walbridge Aldinger
Research Support: Michigan State University, Department of Crop & Soil Science and Department of Horticulture
U.S. Green Roof Consultant: Xero Flor America
Stormwater Consultant: Cahill Associates
Roof Membrane Installer: Christen, Detroit
Vegetation Consultant: Wildtype Native Plants
Vegetation Suppliers: Xero Flor America, LLC; Hortech, Inc.; and Walters Gardens, Inc.
Client/Owner: Ford Motor Company
Size: 454,000 sq. ft.
Cost: n/a

Figure 9. Ford Dearborn Truck Assembly Plant. Courtesy Green Roofs for Healthy Cities and William McDonough Partners, ARCADIS

At 454,000 square feet, (over 10 acres), the green roof atop Ford's truck assembly plant is one of the world's largest. The green roof is a part of a comprehensive effort to revitalize the historic Ford Rouge Center complex as a model for twenty-first century sustainable manufacturing. It is a significant component of a site-wide 600-acre stormwater management system. Other design objectives include the establishment of habitat at roof level, reduction in ambient temperatures, and protection of the roof membrane. The roof is key to Ford's visitor education program, highlighting environmentally beneficial site and building strategies.

A lightweight, easy to install Xero flor system was chosen. Lightness was a factor due to the 50-foot structural spans. Ease of installation was a necessity due to the complications of the roof size (requiring a crane and large staging areas) and the need to coordinate with remaining construction.

Researchers at Michigan State University tested a variety of plants under different soil depths and growing conditions. A mix of nine sedum varieties was specifically created to thrive in the upper Midwest climate. A growing medium of approximately 1" depth was used, consisting of 7–9 mm of porous stone, sand, and organic material with a total saturated weight of <10 pounds/square foot. This calculation includes a mineral wool fleece material that absorbs rainwater. Roots penetrate this water-retention layer.

The drainage layer is manufactured by Colbond and is a 3/4" thick nylon mesh with a geotextile fabric bonded to one side. The 100 percent recyclable nylon filaments are installed face down, creating an airspace through which drainage occurs. The rigidity of the mesh prevents its collapse and allows water to flow unimpeded. Another layer of this material, placed in an inverted position, serves as the vegetation carrier. When used as the medium/vegetation carrier, the spaces between the filaments contain planting medium. Seed and cuttings are then applied to the surface. The vegetation was pre-cultivated on the ground for over 12 weeks, after which the carrier and vegetation were cut into 3.28' x 6.56' pieces, palletized, and transported to the roof by crane.

An irrigation system was installed with the intent that it be used only while the vegetation acclimates and becomes established. The system is installed above the green roof surface. An organic liquid fertilizer was applied once during the initial year via the sprinkler system.

Waterproofing was provided by Siplast and consists of two layers, a modified bitumen product and a cap sheet made of a non-woven polyester mat, impregnated and coated with SBS-modified bitumen and a root-inhibiting agent. Xero Flor also supplied a 20-mm high-density polyethylene sheet to provide an additional root barrier above the membrane.

Current predictions anticipate a 7 percent decrease in energy use due to the green roof. Membrane life is expected to double from 25 to 50 years. It is anticipated that the green roof will also retain 447,000 gallons of water per year, amounting to 50 percent of the annual rainfall in Wayne County over the green roof area, or approximately one gallon/square foot/year. Ford identified this function as a savings due to the avoidance of a water treatment facility anticipated under new EPA regulations. Excess rainwater travels through a series of swales and wetland ponds, where it undergoes natural treatment before returning to the Rouge River.

A principal goal of the revitalization project was to attract wildlife (primarily birds and insects) back to the Ford site, which over its 90-year history had been denuded of vegetation. Dr. H.J. Liesecke of the FLL in Germany concluded that the green roof would provide 25 percent of the productive habitat of an undisturbed green site. The assembly plant's roof is also expected to improve air quality above the roof by 40 percent, in terms of dust absorption and the decomposition of hydrocarbons.

The proximity of the green roof to the Visitor Center's observation tower was a primary design consideration, and the plant's air houses, substations, and other rooftop elements were organized to present an orderly arrangement that framed the planted area. Ford has also established an apiary on the Visitor Center site adjacent to the Truck Assembly Plant. Honey produced by the bees is being collected and bottled. Honeybees have been identified gathering nectar from the sedum blossoms.

Project: The Church of Jesus Christ of Latter-Day Saints Convention Center

Salt Lake City, Utah

Primary Project Goals: Visually integrate the building with its surroundings; create outdoor public gathering space.

GRHC Award Winner, 2003: Olin Partnership, Landscape Architect
Award Category: New Combination
Owner: Church of Jesus Christ of Latter-Day Saints
Architect: Simmer Gunsel Frasca Partnership
Structural Engineers: KPFF
Theater Consultants: Auerbach + Associates
Size: 8+ acres
Cost: n/a

Figure 10. The Church of Jesus Christ of Latter-Day Saints Convention Center. Courtesy Green Roofs for Healthy Cities) and Olin Partnership

This 1.1-million-square-foot conference center, located in Salt Lake City, was completed in 2000. Design objectives were to integrate the building into the landscape of the Wasatch and Oquirrh mountain ranges, and to create a building that did not overwhelm the adjacent Mormon Temple. The roof is multi-leveled and over eight acres in size. The design includes planted terraces that step up 65 feet to roof gardens of firs, pines, and a meadow. The meadow planting involved more than a thousand volunteers who carried native plants up to the roof bucket-brigade style.

The green roof system includes a Hydrotech membrane and drainage mat, and geotextile filter fabric. The growing medium is composed of expanded aggregate and organic matter, with a depth that ranges from 2 inches to 4 feet. Coniferous trees such as Douglas fir and bristlecone pine are placed along free-standing walls anchored to the roof structure to accommodate the soil depths. The roof absorbs vast quantities of rainwater, lowering the peak rate of runoff for the site, and eliminates the extremes of air conditioning for an assembly hall of this size. The roof's vast expanse of meadows, firs, pines, and aspens creates an urban oasis and functions as a gathering point for the congregation.

Project: Life Expression Wellness Center

Sugar Loaf, Pennsylvania

Primary Project Goals: Express the building occupant's ecological ethic; visually integrate the building with its surroundings; enhance the building's aesthetics

GRHC Award Winner, 2004: Roofscapes, Inc.
Award Category: Extensive Institutional
Architect: Van Der Ryn Architects, Sausalito, California
Green Roof Installer: David Brothers Landscape Services, Worcester, Pennsylvania
Waterproofing Provider: Sarnafil, Inc., Canton, Massachusetts
Waterproofing Installer: Houck Services, Harrisburg, Pennsylvania
Owner: Ron and Joanne Gallagher
Size: 6,000 sq. ft.
Cost: n/a

Figure 11. Life Expression Wellness Center. Courtesy Green Roofs for Healthy Cities and Roofscapes, Inc.

In June 2001, a new holistic wellness center in central Pennsylvania installed a 6,000-square-foot Roofmeadow® green roof, an integral part of the center's architects' green building concept. The green roof was engineered by Roofscapes, Inc., as a 5-inch Roofmeadow® Type I: Flower Carpet system to satisfy the unusual deadload capacity and pitch of the roof as designed and the maintenance and aesthetic requirements of the architects and owner. The engineering challenges in this project were many: stabilizing vegetation on the steep slope, with deck pitches ranging from 14 to 30 degrees; detecting leaks on this sloped surface; protecting new plantings from severe mountain wind scour; and securing waterproofing at the gapped fascia.

The Wellness Center ranks among the steepest-pitched green roofs in North America. Several processes were used to achieve slope and dimensional stability for the vegetated cover. These techniques included the use of roof battens, slope restraint panels, and reinforcing mesh.

To protect the roof from wind erosion until the plants were established, the surface of the media was covered with a photo-degradable wind blanket mesh, fastened securely to the base of the green roof profile. The mesh has since disappeared into the cover vegetation.

Because the slopes make flood-testing the roof impossible, the green roof system is optimized for electric leak survey methods by using Sarnafil G-476 reinforced 80 mil single-ply PVC waterproofing membrane in a conventional configuration. The Electric Field Vector Mapping (EFVM) technique evaluates the water-tightness of waterproofing membranes without flooding and without disturbing vegetated cover systems.

The lightweight medium was engineered to absorb and retain rainfall while remaining fully drained, fulfilling the German FLL guidelines. Water drains freely by gravity due to the steeply-pitched roof. To create a curtain-like effect during rainfalls, the runoff is permitted to sheet off the roof along the length of the eaves. This was accomplished by gapping the fascia by half an inch. With the vegetation now mature, the rainfall escapes through the fascia and then drips down the tendrils of the overhanging plants. The vegetated cover reduces the rate and quantity of runoff, and also prolongs the duration of runoff, emphasizing the curtain effect.

Ninety-five percent of the plants are flowering sedum varieties from the classic German "green carpet" suite, providing a wide range of color. This drought-tolerant plant suite was selected to create a dense and uniform low groundcover. The cover was established from plugs installed on 12-inch centers, and was mature after 12 months. Weed pressure after the cover became established has been minimal. This resilience is a direct result of the xeric conditions on the roof, coupled with the dense groundcover. The roof requires minimal maintenance—typically a light spring and fall weeding.

The overall result of the green roof design has been to convert the building into a living structure that remains stable without active intervention and blends seamlessly into the surrounding landscape. It has attracted eco-conscious visitors from great distances, and is an example of a genre of green roof that can fit comfortably into suburban and rural developments.

Project: Feldman Residence
Santa Lucia Preserve, Carmel, California

Primary Project Goals: Visually integrate the building with its surroundings; create habitat; create attractive and usable open space; benefit building performance and environmental quality

GRHC Award Winner, 2007: Rana Creek
Award Category: Extensive Residential
Architect: Feldman Architecture, San Francisco, California
Landscape Architect: Blasen Landscape Architecture, Sausalito, California
Client: Dan & Sandy Feldman, Palo Alto, California
Size: 4,250 sq. ft.
Cost: $21/sq. ft.

Figure 12. Feldman Residence. Courtesy Green Roofs for Healthy Cities and Rana Creek.

This newly constructed residence was designed to integrate itself back into the land at the private Santa Lucia Preserve in Carmel, California, which integrates low-density residential development with conservation. Design goals included low water use, solar power, and habitat enhancement. Green roofs cover three small buildings built into a hillside, with the hill seamlessly continuing onto the roofs. Plant material for the roofs consists mostly of locally adapted, indigenous plants already found thriving onsite prior to building. The focus was on stabilizing all disturbed soils by planting grasses and forb mixes approved for the Santa Lucia Preserve, controlling non-native species, and simply allowing natural regeneration of the local plant assemblages.

The 6” depth of growing medium is composed primarily of sand, lava rock, and amendments that allow for both moisture retention and drainage. The growing media included inoculants for mushrooms that appear in the cool, wet winters. The roofs were installed with irrigation to support the initial establishment of the plants and for minimal summer maintenance. The waterproofing membrane is American Hydrotech MM6125 followed by a Hydroflex30 Protection Course and Root Stop WSF40. The drainage system is Floradrain FD40 underneath the growing medium layer, and ¾" to ½ " gravel with perforated pipe and surface drains at the roof’s edges.

Perennial plant species selected for the roof, such as sand sedge, Pt. Joe fescue, yarrow, and wild strawberry, are typical of the oak woodland understory and representative of the Monterey Peninsula regional flora. A host of annual wildflowers were over-seeded in the fall, and by springtime, tidy tips, lupine, poppies, and goldfields surprised the owners with a colorful spring bloom. These annuals continue to sprout and flower each spring.

The green roofs are designed to provide usable landscape, filter and store rainwater, attenuate sound, increase thermal insulation, and provide site sensitive beauty for the home. The owners benefit by reducing their energy consumption up to 30 percent during the summer months from the insulation of the green roofs. With a growing media depth of 6", the sound is reduced by approximately 43 decibels. The sounds from the humans and their activities within the buildings are also being buffered to protect the wildlife, given the sensitive nature of the habitat in the preserve.

The 33 species of native plants used on the roofs have helped the site recover from the disturbance caused by the initial building activities on the site. The ecology of the site is expected to become more complex and to resemble the natural analogs that were emulated in the design.

Expanded Project Profile: The Story behind ASLA's Green Roof[4]

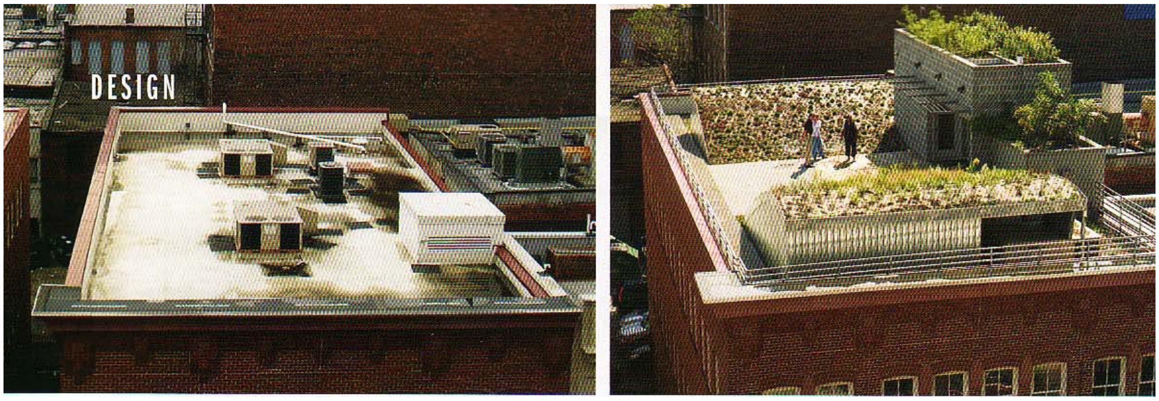


Figure 13. Before and after photos of the ASLA Headquarters building's roof. Courtesy Sam Brown

When the American Society of Landscape Architects (ASLA) decided to "green" the roof on its headquarters building, the primary goal was to showcase landscape architecture's ability to unite environmental performance with high-value, usable outdoor space, even in the least likely environments.

Green roof design was initially dominated by architects and/or roofing contractors who were interested primarily in performance. ASLA wanted to encourage the profession of landscape architecture to play a leadership role in uniting the useful aspects of green roofs with their spatial and experiential potential. The Society wanted to demonstrate the unique value that landscape architects could bring to this new medium. The program required not only that the green roof perform, but also that it communicate and inspire.

The landscape architecture firm, Michael Van Valkenburgh Associates Inc. (MVVA), selected to lead the design team, agreed with ASLA that green roofs had an unrealized potential to become useable spaces. The landscape architecture team was very excited to embark on a project that was seeking a larger role for the next generation of green roofs. The team wanted to create an inspiring and memorable landscape experience that is possible in this location only through the use of green roof technology.

A Designer's Perspective on What Makes Green Roof Design Different

The paramount technical challenge of green roof design is the need to minimize weight. Traditional roof gardens are tremendously heavy and often cost prohibitive. The breakthrough of green roof technology is a system for growing plants based on lightweight materials used sparingly. The need to remain within tight weight tolerances is one of many unique elements of green roof design.

Weight, plant height, soil depth. Some rooftops are composed of segments with varying weight-bearing capacities, which can then allow for some variation in soil depth. For the most part, however, a green roof's soil profile is minuscule—just a film of 2-4 inches. The soil can't support trees and other massive vegetation, the major spatial elements that landscape architects usually use to give shape, depth, and character to a space. In many cases, plant height will barely reach

[4] This section is based on a series of interviews with Chris Counts, ASLA, of the east coast firm Michael van Valkenburgh Associates. Counts served as project manager and associate in charge of ASLA's green roof project on its headquarters building in Washington, DC.

8–12 inches. Neither can the soil be graded to create topographical interest: the roof surface is typically evenly sloped or even level, and generally capable of supporting soil weight only if it is evenly distributed to a uniformly shallow depth.

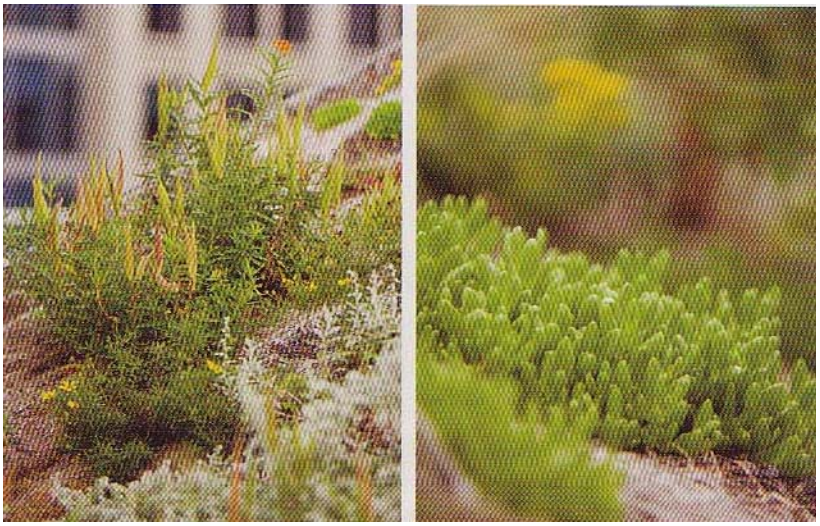


Figure 14. Typical green roof plants. Left: Asclepia tuberosa (butterfly milkweed); Right: Delosperma nubigenum (ice plant*). Courtesy Sam Brown*

Aspect, elevation, wind. On a flat roof, aspect will be more or less constant, but other taller structures nearby may shadow the roof unevenly, resulting in varying exposure to light across the roof surface, with levels of soil moisture decreasing with longer exposures to the sun. The elevation and exposure of the rooftop can make it a windy place at least some of the time. Wind can have particular significance on a rooftop, where lightweight materials are more likely to become airborne.

Machinery. Rooftops have long been the favored location for a building's mechanical systems. A green roof's design must be compatible with the operation of HVAC units, elevator exhaust shafts, pumps, and drains, while somehow not allowing these elements to dominate the space. This machinery is bulky, and OSHA requires maintaining additional clearances for all machinery that must be serviced. Intake and exhaust systems also create microclimates that may favor some plant species while hindering others.

Rooftops can be surprisingly complex environments, with structural and climatic variations that drive design in a number of ways. The type of microclimatic diversity that is created by differences in slope, aspect, soil depth, and proximity to equipment was something that we were very interested in exploring through the design of the ASLA green roof. The major topographic elements of the design, the "waves," were introduced in part to create greater variety in order to better understand its effects on plant survival and human comfort.

Design Development for the ASLA Green Roof

ASLA's green roof began as many green roof projects do: the roof needed replacing. In this case, the roof was a modest 3,300 square feet of space atop ASLA's headquarters building, a 1980s three-story structure in the city core of Washington, D.C. Because the building belonged to ASLA, it was important that the green roof design provide a powerful and memorable experience to visitors that communicated the values of the organization and the profession.

The simplest “green” design, a “big carpet,” would not offer much to visitors, even if improved with interesting planting schemes and inviting pathways. Seeking the power to engage the visitor, ASLA’s green roof design team drew as much inspiration from “roof” as it did from “green.” The focus on the concept of “roof” inspired a number of concepts that drove the design.

A green roof, like a regular roof, is *utilitarian*. The difference is that the green roof is useful in more ways. An extensive green roof system is a bioengineered machine. Like a race car, it is designed to maximize function and performance. The soil is the lightest it can be, and the plants must be able to thrive in heat and drought. The utilitarian nature of green roof components is conceptually harmonious with the modern approach to roofing in general. You don’t find anything extravagant.

All roofs have a *“behind the scenes”* quality. Rooftops have a peculiar context—they are very much in the city but also removed from the network of familiar urban locations and activities. The rooftops of the city offer both a retreat and a privileged vantage point. This intrinsic quality captures the imagination, giving visitors a rare perspective on the operations of city life. The mystery and excitement of being safely out of the city while still observing its comings and goings is something to be captured and enhanced.

The site’s context is *urban*. ASLA’s multistory brick building is one of many arranged in a tight grid. The neighborhood’s street-side sidewalks are punctuated sparely with young trees. In this city environment, all plants are magical, even those that might not impress most gardeners. Robust species that colonize harsh urban environments come across as rugged and raw. Their vitality is welcome in the city, where nature is otherwise so sparse or controlled.

One strong image guiding the design for ASLA’s roof was a romantic vision of wild nature overtaking abandoned areas in the midst of the concrete landscape. The architectural materials in the roof design would provide the transition from the polished interior and hard architecture of the building to its rooftop’s grit, mechanics, harsh environment, and rugged vegetation.

Finally, the roof needed to be *“green.”* No fertilizer, pesticide, ongoing irrigation, or other intensive maintenance would artificially sustain the roof plants. This specification further proscribed against a lush and gorgeous carpet. Plants had to be selected to survive the harsh roof environment without supplemental care. The roof would facilitate casual cohabitation by urban plants and human city-dwellers. The design would invite the forces of nature to freely occupy and enliven contrived human space.

The Design

ASLA’s green roof is a place where visitors do not need to tread lightly in order to avoid compacting soil or crushing vegetation. The rooftop’s scant 3,300 square feet provide a place for complex ecological function and human activity to overlap and coexist, a double duty made possible by a few simple design moves.

The design of ASLA’s green roof uses typical green roof materials, but layered and exaggerated to create a space that is visually engaging and multi-functional. The spatial engine of the design is an extreme vertical exaggeration of the roof insulation (Styrafoam) to create two large, sloping landforms (“waves”) that rise to a height of eight feet. These large landforms are covered with a thin soil profile to support plant life. The height of the landform on the north side of the building was calibrated to be viewable from the sidewalk below.

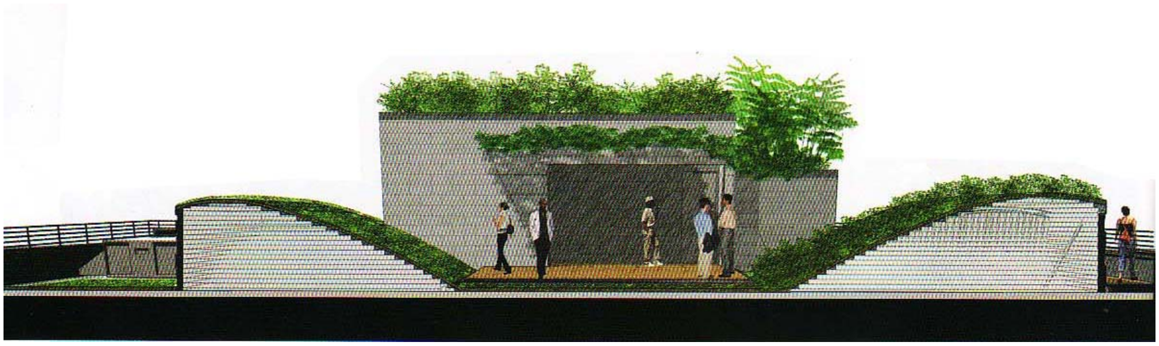
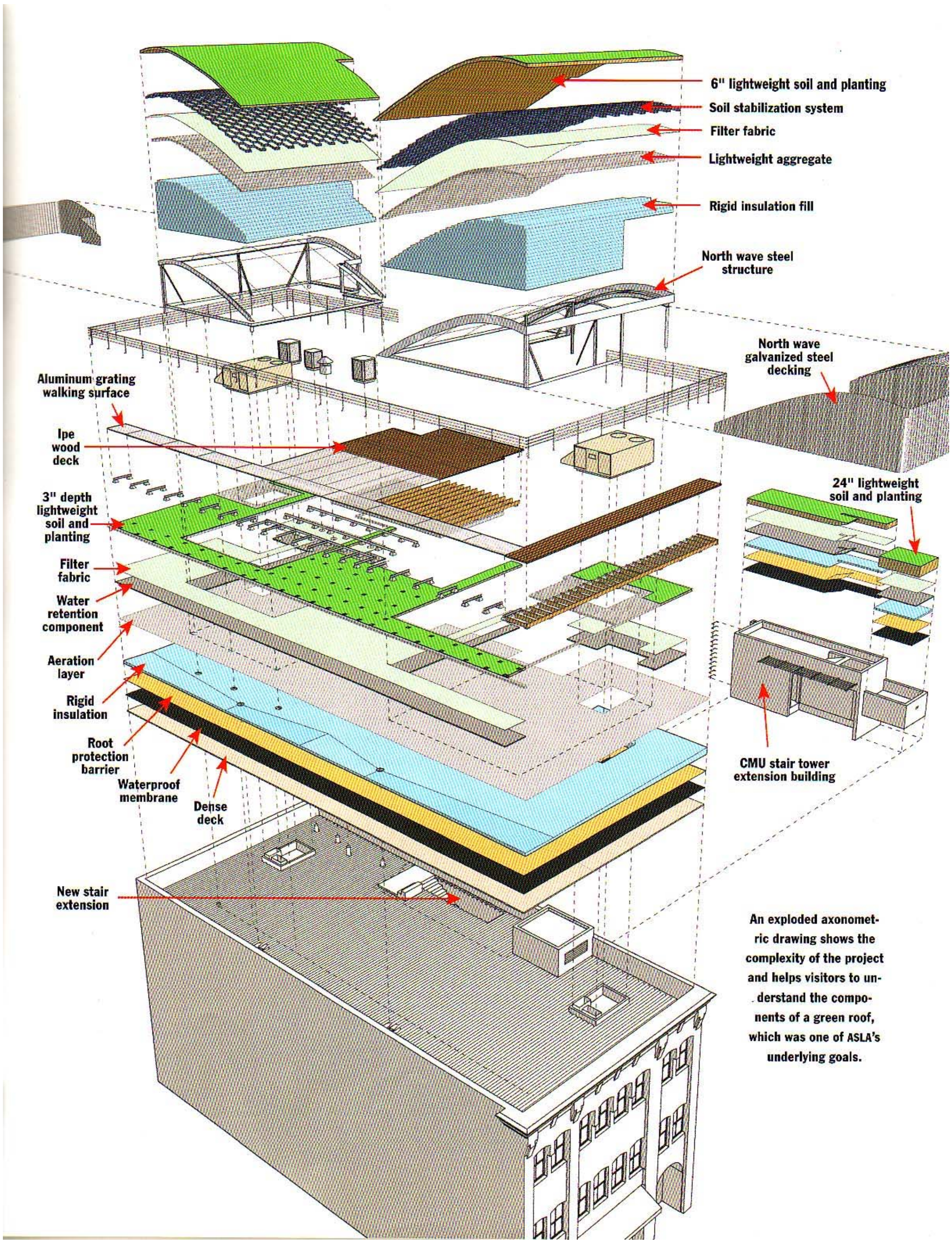


Figure 15. Elevation drawing of the ASLA Headquarters building's green roof. Courtesy MVVA

The waves immerse visitors in a green valley that creates a textured contrast with the buildings of the city. The two landforms rise from grade at a 2:1 slope, a north-facing slope and a south-facing slope converging on the entry path and together creating a green valley. The slopes assert mass and (perceived) weight, as well as creating microclimatic diversity and a gradient of growing conditions, forming a kind of demonstration garden of which plant species will survive in which locations.



An exploded axonometric drawing shows the complexity of the project and helps visitors to understand the components of a green roof, which was one of ASLA's underlying goals.

Figure 16. Exploded axonometric drawing. Courtesy MVVA

The landforms posed technical challenges. Strong winds on the small roof threatened to shear the lightweight foam from its anchors, and the shape and angle of the landforms' walls compounded this threat. Robert Sillman Associates, the structural engineer, devised an ingenious solution that used the arcing steel frames of the landforms as armature. A net of steel cables elegantly secured the two foam objects to the roof trusses below, preventing the foam from blowing off the building.

Another innovation of the ASLA green roof is the metal grating walkways over some of the green roof plantings. For the most part, sedum and green roof plants can not be walked on, suggesting a spatial trade-off between having a green roof and a place for people. The experimental system floats a super lightweight aluminum grating, low in heat conductivity, 3" over a thin green roof system of sedum. The sedum selected will grow approximately 6" in height, so that it will extend through the aluminum grating above. In the areas of high traffic, the plants that emerge through the grate will be trampled down. This will regenerate, rather than destroy, the plant and have the added benefit of recording a second order of circulation pathways along the aluminum terrace.

Figure 17. Two illustrations of grating used as a walking surface over planted sedums. Courtesy MVVA

A major challenge in the design of this and many green roofs is the obnoxiously large and noisy HVAC and utility equipment. The ASLA building's two large HVAC units were located directly in the middle of the roof. It was determined early on that the units had to be relocated. The south HVAC unit fit conveniently behind the south landform, but the north HVAC required a more innovative solution. The thin profile of the green roof media allowed for carving out the northwest corner of the north landform (where the slope peaked) to create a discrete space for the HVAC unit. In this position, the HVAC unit accommodated service and exhaust requirements while not compromising the gesture of the "wave."

Another critical issue was access. The existing roof access consisted of only a ladder and trap door. The decision was to extend the building's internal staircase vertically and create a modest structure ("pavilion") where the staircase extension terminates at the roof. The pavilion is a simple concrete masonry block structure that sits directly on the structural walls of the existing bearing wall below.

Figure 18. Computer rendering of the ASLA Headquarters building's green roof. In this picture, south is roughly 11 o'clock. Courtesy MVVA.

The extra bearing capacity of the walls of the stairwell and elevator shaft allowed for significantly deeper soil profiles on the roofs of both of these structures: 12" and 20" soil depths respectively. Elsewhere on the roof, soil depths range from 4" on the south landform, 6" on the north landform, and 3" under the grating. Together, this range of soil depths creates a kind of encyclopedia of green roof types and growing conditions. The result is a visually rich environment that displays and demonstrates the versatility of green roof technology.[5]

[5] Designed to be a demonstration project, ASLA's green roof is open to ASLA members and the public by scheduled tour through ASLA staff. ASLA's website, www.asla.org, also provides access to images collected live through a 24-hour webcam.

Reflections and Outlook

Technology and new materials now allow landscape architects to build lightweight landscapes in places that 20 years ago would have been left barren. Green roofs are both exciting new territory for landscape architects and an opportunity to demonstrate what landscape architects do best as a profession. A particular set of design constraints is clearly at play, but in the end, green roof design is still design, and the spatial and experiential challenges of place-making are not novel. The opportunity for landscape architects both to increase the environmental health of cities through green roof development and to reclaim roofscape for human enjoyment and excitement is truly extraordinary.