# THE CHICAGO CITY HALL GREEN ROOF PILOT PROJECT: A CASE STUDY

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Keywords: *Chicago City Hall, pilot project, green roof, technology, urban heat island, case study*

## Abstract

Although a number of cities across Europe have benefited from green roof technology for decades, North American cities are just now beginning to learn about its possibilities. Chicago, Illinois, was one of the first North American cities to construct a green roof pilot project. This case study is a investigation into the factors that shaped the project, the design process, its sequence of events construction and results of several informal investigations of how the project has performed. Prior to its completion, little was known about green roofs in Chicago. The quarter hectare roof garden sits over 33 meters above city streets for the purposes of demonstrating extensive, simple intensive and intensive green roof systems. This case study includes examination of the project's background, goals, objectives and program, roof analyses, design concepts, bidding and implementation, results, discussion and conclusion. Plans, documents, photo records and other project facts are examined in this case study of Chicago's most recognized green roof.

## 1. Introduction

Green roofs are becoming well-known across the world as a sustainable technology that can yield multiple benefits. There are at least ten quantified benefits attributed to green roofs including: a reduced volume of storm water runoff, a delay in the peak discharge of storm water runoff, an increased lifespan of roofing membranes, energy conservation, reduction of the urban heat island, increased biodiversity, increased wildlife habitat in urban areas, reduced health care costs, mitigation of air pollution, and a reduction in noise pollution (Getter 2006). Additional benefits may include an increase in property values and green space (Doshi 2006) as well as air filtration, carbon sequestration and public education (Cantor 2008). Because of their versatile use and multiple benefits, many see green roof technology as an integral part of the sustainable site and green building movement. For example, the Leadership in Energy and Environmental Design (LEED) green building program established by the United States Green Building Council, acknowledges up to 15 of 26 points needed for certification attributed to green roofs (Kula 2005). Green roofs are becoming more popular as many cities across the world now encourage their use and in some cases require their use (Keeley 2004).

In 1998, Chicago, Illinois' Mayor Richard M. Daley traveled to Chicago's European sister cities. Mayor Daley was so impressed with the application and environmental benefits of green roofs that upon returning to Chicago he initiated a green roof pilot project to explore its possibilities (Laberge 2003). He also conceived the pilot project as a strategic venture that would enable the city to first work through multiple legal and policy issues in advance of the development community. The city was in the process of revamping a cumbersome permit process that was soon to be simplified to accommodate "green" projects.

The mayor's opportunity to develop these ideas arrived when Chicago was selected as one of five cities across the United States (U.S.) to participate in the U. S. Environmental Protection Agency's (EPA) Urban Heat Island Pilot Project. As phase one of the heat island study, Chicago first explored "cool" roof technology (H. Akbari 2001). Cool roofs are light colored roof tops that reflect solar radiation to reduce a building's energy use and the ambient air temperature above the roof top.

As a comparison to cool roofs, the mayor proceeded to investigate the feasibility of implementing green roofs on the historic Chicago City Hall building (Figure 1) as an alternative to cool roof technology (Laberge 2003).

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*Figure 1 Aerial view of the Chicago City Hall roof top's existing condition in 1999.*

## 2. Methods

This paper is organized similar to the structure recommended by Mark Francis in *A Case Study Method for Landscape Architects*. The study begins with a description of project teams. Next, the design process is explained including project goals, site analyses and program. The green roof concepts and designs are explained next followed by the bidding and construction sequence and a discussion about project maintenance. A results section discusses several informal investigations and the discussion, and concluding remarks follow.

There are two dominant sources of data for the paper. First, since the author of this paper was a project manager for the pilot project, project documents and my own observations of the events and processes that took place are used for reference. Another critical source of reference is a paper written by the Chicago Department of Environment's project engineer for this project, Kevin Laberge titled *Urban Oasis: Chicago's City Hall Green Roof.* Kevin was one of two project managers representing the client team.

## 3. The Project Teams

The City of Chicago Departments of Environment and General Services teamed together to form the pilot project's client team. As a city owned project, the feasibility study and design contract was required to be competitively bid. There were three firms that were pre-qualified by the city. Weston Solutions Inc. won the contract to lead the city through the scopes of work. Weston's other team members included Conservation Design Forum, Inc., Atelier Dreiseitl of Germany, William McDonough + Partners, Halverson and Kaye, and Katrakis and Associates.

Weston Solutions was the overall team project manager and direct contact with the client. Conservation Design Forum (CDF) led the green roof design process. CDF generated both the green roof concepts and led the construction drawing efforts. William McDonough + Partners was the project architect. As project architect, they analyzed the existing building and assisted with the development of green roof architectural details. Halverson and Kaye engineers was the project structural engineers. They analyzed the structural capacity of the existing roof decks and designed new structural support for selected locations of the roof deck. Katrakis and Associates provided an energy analysis of the building and developed an energy model to estimate the cooling effect of the roof and potential reduction of the Urban Heat Island.

## 4. Design Process

The City Hall green roof pilot project followed a design process similar to the convention described by (Dvorak 2008) where the City Hall was also used as an example. A detailed list of the sequence and events includes: a feasibility study to assess the roof deck for application of green roof systems, structure and membrane analyses, the development of project goals and objectives, conceptual design, design development, bidding, bid analysis, re-design, re-bidding, building repairs, shop drawing detailing and review, material substitution review and approval, phased waterproofing and green roof system installation, completion of plant installation and a delayed installation of the irrigation system. Because the construction of the project required to be publicly bid, the design process excluded a detailed design phase by the consultant team. This allowed for multiple green roof providers to bid on the project and prevent favored of any one provider. For this reason, the green roof concept was considered to be sufficient at the design development level. This would allow the awarded contractor to adapt the design and engineering of the green roof system to the details of their system.

### 4.1 Project Goals and Objectives

It is common practice for clients and consultants to work together to formulate project goals and objectives. For this project, the client had specific predetermined goals set by the EPA. Described in the scope of work for the Urban Heat Island Initiative study, the primary goal was to "study and quantify alternative ways of reducing the heat island effect" (Laberge 2003). The city had already looked at cool roofs as one way to reduce the urban heat island effect. Mayor Daley desired another alternative to be investigated: green roofs.

With green roofs selected as a potential method to reduce urban air temperatures, the pilot project's objective was to test the reduction of ambient air temperature above the roof. This point is stated in *The Urban Heat Island Initiative Pilot Project Final Report* published by the project team for the Chicago Department of Environment. It states that the green roof pilot project was initiated "to provide the city of Chicago a place to study the benefits of green roof systems. The City Hall rooftop garden was conceived as a demonstration project - to test the benefits of green roofs and how they affect temperature and air quality" (DOE 2008). Additional detail of project goals are stated in an awards text found on the American Society of Landscape Architects web site. In the text, a client statement remarks that the green roof pilot project "was designed to test its cooling effects and its ability to sustain a variety of plants in three different depths of growing media"(Yocca 2002). This client statement summarizes well the entire purpose and desired outcomes for the project.

### 4.2 Site Analysis

With project goals established, the team continued the design process with an analysis of the roofs' microclimate and structural capacity. As partially seen in Figure 1, the roof deck elevation is much lower than the surrounding 23 buildings. There was no formal modeling of the projected influence of wind on the roof, but it was expected that winds would be persistent and not dominate from any particular direction. The surrounding buildings were determined to have much influence on the roofs exposure to sunlight as well. The northern half of the building receives morning sun, but shade in the late afternoon. The southern half of the roof receives direct sun over eight hours per day.

The roof deck's structural analysis proved to be a slow process as the complete set of documents that were used to construct City Hall were never located. Since structural drawings were unavailable, engineers took several roof deck core samples to help investigate the structural capacity of the roof deck. It was discovered that a light-weight cinder based waterproofing was buried at various depths up to 1 meter in thickness across the main roof. The investigation uncovered drawings that showed that the roof deck was designed to support a twelfth floor of occupied space which was never built, but there was little information on what the structural capacity was. Working with the samples and visual inspections, the engineers estimated that the roof deck had a capacity sufficient to support 146,5 kg/m$^2$. This means that only extensive green roofs were applicable across the entire main deck. Intensive or semi-intensive systems could only be possible at selected locations with some structural modification to the roof deck (Laberge 2003).

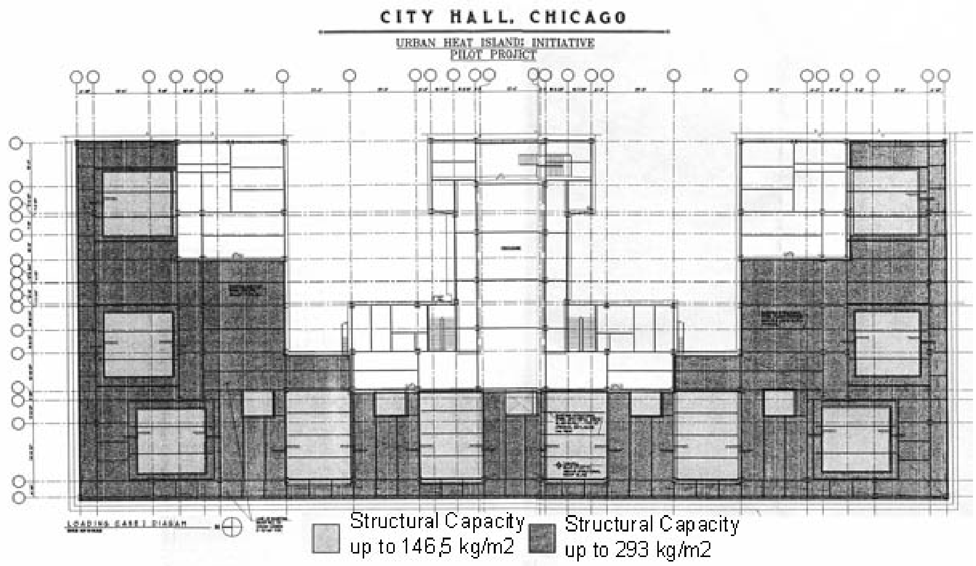


*Figure 2 Map showing structural capacity of existing roof deck and potential excavated area.*

At the time of investigation, the building was eighty eight years old with multiple layers of buried waterproofing. Initial results showed that the layers buried beneath the top membrane were fairly stable and could possibly be excavated to allow for additional dead load for the green roof systems. Through excavation of the cinder layer, the additional allowable weight of the green roof system could possible double from 146,5 kg/m$^2$ to 293 kg/m$^2$ or more. In Figure 2, the light grey area shows roof deck with a capacity of 146,5 kg/m$^2$. The dark grey area shows roof deck with a potential capacity of 146,5 kg/m$^2$ if cinder is excavated. This would allow for semi-intensive systems at any location across the main roof deck where cinder was removed.

### 4.3 Project Program

The project program was developed simultaneously with the site analysis. Typically, design consultants work with clients to develop the program, but in this case the client determined critical elements of the project program and prescribed them to the consultant team.

One of the most significant program designations was the decision to preserve the limited access to the roof. The first condition that directed this decision was the fact that barrier free access to the roof deck was not possible without major modification to the building. A stairway from the eleventh floor exits into a mechanical room before exiting onto the roof. There is no direct access through elevators. Only a service elevator connects to the roof deck, but the route to the roof access door is complex with travel over catwalks and several changes in elevation. Another factor limiting access was the lack of a tall parapet or a safety rail around the perimeter of the roof. Since the building is designated as a historic structure, in order to add a railing, much additional time and cost would have likely been needed to process such changes through a historic structure preservation review process. This means any modification to the façade including modifications to the parapet would have involved a lengthy design review process through the City and set back the schedule. Due to the expense of modifying the existing conditions, the client determined that the pilot project would not be designed for unrestricted public access, but access would be allowed only through programmed visits or pre-arranged tours.

The roof analysis and design program came together to help form a map titled “greening” versus “non-greening” areas (Figure 3). The client wanted to maximize the vegetated areas on the roof while still allowing existing building maintenance access and activities to take place without disruption. Figure 3 shows the design team’s response to these requirements including analysis of the existing structural capacity of the roof decks, slopes, drain locations, drainage patterns, roof access routes for weekly staff maintenance activities, vent and HVAC equipment locations, setback requirements from parapets, roof lines, walls and other points of access (Weston 1999). The medium grey shaded areas would be vegetated. The light grey curving path would be a maintenance path where the while areas are setbacks from the parapet and staff maintenance paths from the roof penthouse to the fan rooms.

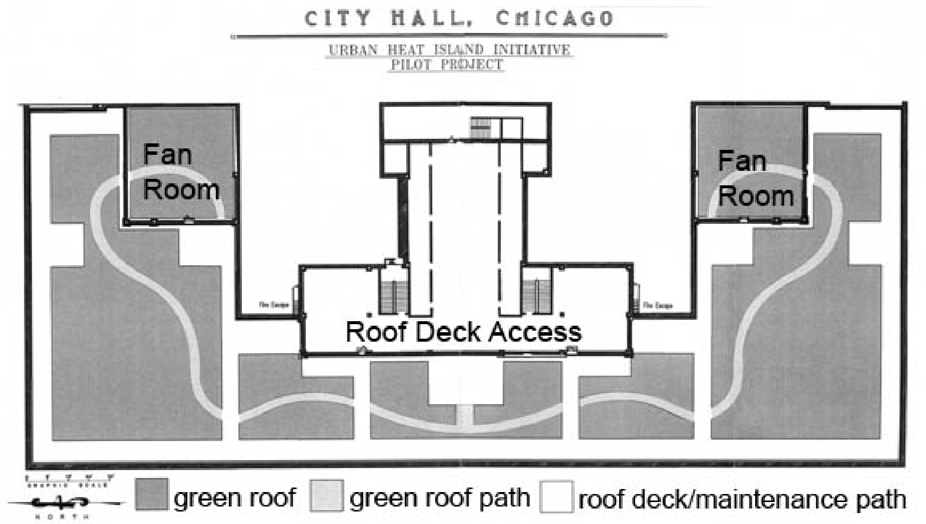


*Figure 3 Greening versus non-greening areas.*

### 4.4 Design

The original design concept emerged directly from the project goals, program and the “greening” map shown in Figure 3. The concept is a simple design that makes use of extensive, simple intensive and intensive systems. A narrow maintenance path leads through the garden for access to plants. The design favored a large proportion of garden area to semi-intensive systems because of the high priority goal to test the native plant palette. The design team assumed that at least 15 cm of growing medium is required to support native grasses and perennials. The proposed method to allow the weight of a simple intensive system across large areas was to excavate the light weight concrete cinder. The concept was further developed with a plant list and conceptual design details. The plans (Figure 4) were bid as a non-proprietary design to allow for multiple systems to bid the project. At almost $3 million U.S. dollars, the low bid was twice the estimated budget. In review of bids, it was discovered that the bidders performed multiple core samples of the light-weight concrete at locations different from the design team’s and found significant deterioration of the cinder across the roof. It turns out that the design team’s samples of the cinder were not representative of the existing condition. Firms that bid on the construction estimated that the process of removing the deteriorated cinder would be costly and likely prove to be an unstable base to support the roof membrane.

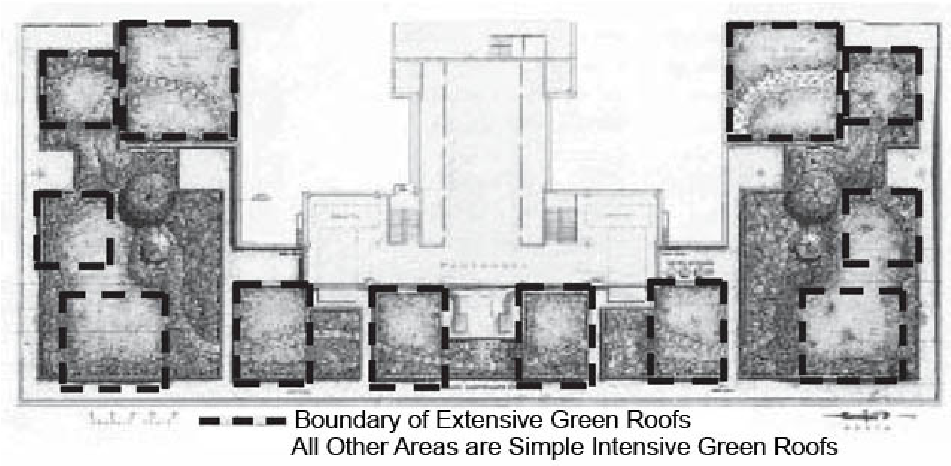


*Figure 4 Original Pilot Project Concept Bid in May of 1999.*

The city reviewed the bids together with the consultant and determined that a new design strategy was required. The new design approach involved a reversal of the initial concept. Instead of removing the cinder, it was left intact where extensive systems would now replace the simple intensive systems at the existing roof grade. In addition, the abandoned skylights were evaluated for their capacity to be structurally reinforced. After further analysis, it was determined that it would be both structurally and economically feasible to modify the raised skylight platforms to double their structural capacity from 146,5 kg/m$^2$ to 293 kg/m$^2$. A new concept was developed where the simple intensive systems would now be located on the reinforced platforms and the extensive systems would remain over the existing roof deck. This new approach allowed for changes to the overall aesthetic as well.

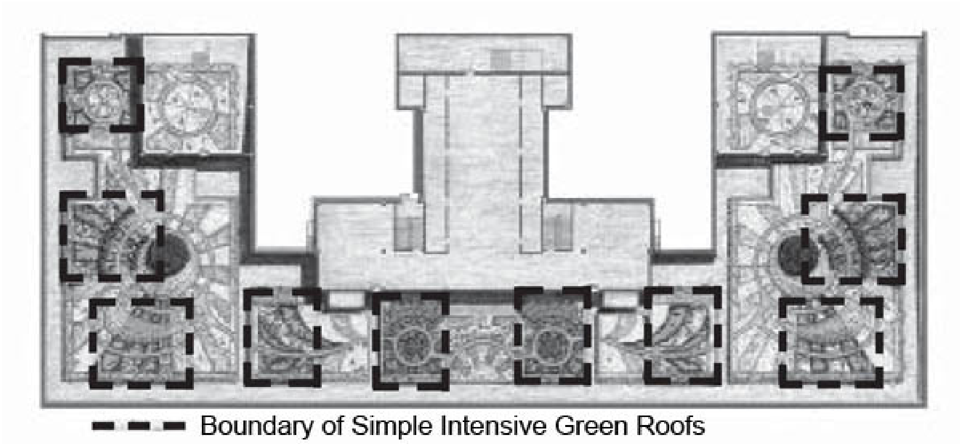


*Figure 6 Revised Pilot Project Bid in February of 2000.*

A new concept emerged where a starburst pattern would organize vegetation by alternating zones of grasses and forbs (Figure 6). Similar colored blooms (light bands) were located between bands of grasses (dark bands) as a way to organize a great diversity of plants. By locating plants with similar bloom, the city would be able to better locate specific species on the roof garden. It would also potentially provide viewers from the 33 towers looking onto the roof a show of color through the seasons. Figure 6 shows the simple intensive areas bounded by a dashed line. The two intensive areas are located at the center of the starburst with a tree and small shrubs. All other vegetated areas are extensive systems. Rolling topography was also added to the design to allow for a diversity of habitat. Since similar plants would extend across all of the green roof zones with variations in slope and sun exposure, much could be observed about plant performance under a variety of conditions. The maintenance path was modified to work with the symmetry of the historic building and provide access to more of the garden.

The new concept was immediately developed into a new set of bid documents. The new design was sent back out to public bid during February of 2000. Bennett and Brosseau Roofing was the awarded contractor to construct the roof. Bennett and Brosseau teamed with the Optigruen green roof system which was represented by Roofscapes of Philadelphia, Pennsylvania. Church Landscape was the landscape contractor at the beginning of the project. Valley Crest now shares recognition for the project because they purchased Church Landscape half way through the construction process.

## 5. Construction

Bennett and Brosseau began construction in May of 2000. After some setbacks in obtaining construction permits, construction activity began in June. The City had never processed a green roof project and several issues such as security and liability slowed the process down. Other issues emerged such as resolving some city code standards with venting stack heights. Since the garden would not be accessible to the public, extension of the vent stack heights were granted weavers (Laberge 2003).

The first day of construction unveiled another level of setbacks. The parapet wall was determined to be an unsuitable surface to adhere waterproofing. Brick was found to be deteriorated along the entire interior perimeter of the parapet wall. To keep construction on schedule for a fall planting, the contractor hired Fieldstone Building Services to rebuild the parapet in 6 meter sections alternating across the roof to minimize overlap of work space. As soon as one parapet section was rebuilt, waterproofing was adhered and was flood tested. The green roof was built up with extruded polystyrene (Figure 7) layers could only advance in segregated progress as the water tested roofing sections were compete (Laberge 2003).

Under the cramped working conditions, the contractors installed the green roof systems by the end of October for the north half of the project. The roof and parapet repairs continued through winter. By April of 2001, the southern half of the green roof was installed and planted. The central zone was redesigned to allow for removal of some heating and ventilation equipment. The green roof planting was completed in the early summer of 2001(Laberge 2003).

There were however, a few details that remained to be resolved. The irrigation lines were installed, but the irrigation system was not yet functioning. Drip irrigation was installed to ensure plant establishment and provide a resource available during periods of drought. Mayor Daley wanted the garden to remain green at all times since he would have many opportunities to show his pilot project to government officials and other community leaders. The north and south fan rooms were un-irrigated and would represent a place to test plants with only ambient rainfall.

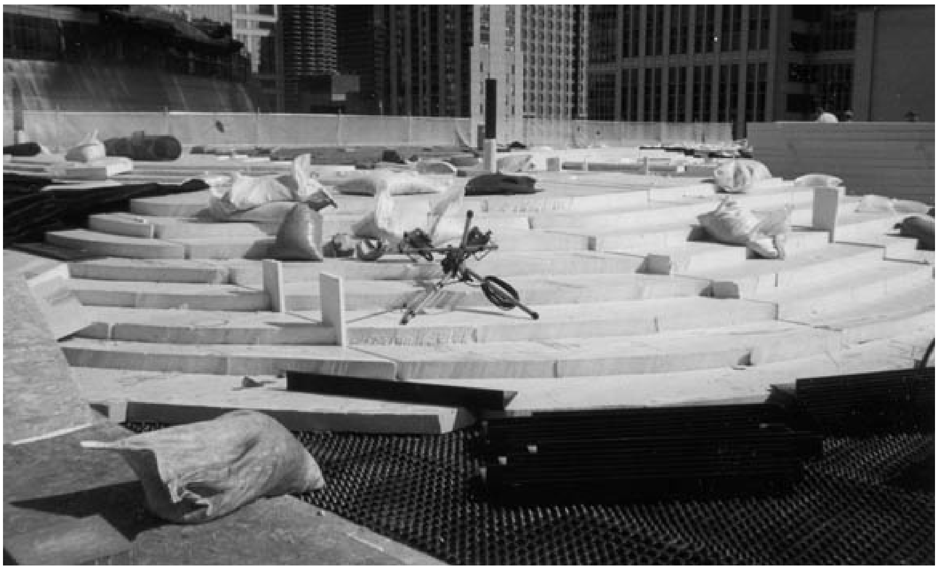

*Figure 7 Rolling topography was created with stacked layers of extruded polystyrene.*

## 6. Maintenance

This fall, the pilot project has competed its seventh growing season. Initially planted with 120 species of perennials, herbaceous flowering plants, grasses, succulents, woody shrubs and trees (Weston 1999), the garden now has over 160 species thriving (Dvorak 2008). The intended goals to establish a green roof pilot project have been achieved, but the progression and level of maintenance required to keep the project successful has changed dramatically from its installation in 2001 to 2008 (Dvorak 2008).

The landscape contractor responsible for constructing the garden was also under contract to maintain the garden for its first two growing seasons. For undisclosed reasons, the contractor was not present to maintain the site to the specified number of visits. The maintenance plan called for bi-weekly weeding during the first growing season and half as much during the second year. Since the landscape contractor maintained the site infrequently, a significant number of weeds invaded across the entire garden. The City brought in local Green Corps crews to assist with maintaining areas of the garden. At the end of the 2002 growing season, another event stressed the garden; Chicago experienced a drought. The irrigation system was in place but was not yet functioning. All of these conditions combined to create a scenario where the pilot project was in serious danger of failing. With over 33 buildings looking down onto the roof, the large areas of dead plants were visible evidence that the drought and lack of irrigation was stressing the garden. Because of the high profile nature of the project, local television stations and news papers for the first time began to question the validity of green roofs in Chicago. The city responded with action the following spring.

Early in 2003, Kevin Carroll, a Horticulturist with the City Department of Transportation, took over maintenance of the roof. Kevin's first approach was to direct his crews clean up the roof and replace barren zones with annual plants to quickly achieve cover. Species diversity during the 2003 season was down to 104 (Dvorak 2008). In addition, Kevin was successful in helping to resolve contract disputes that prevented the drip irrigation system from being completed. Over the next five years, Kevin established a maintenance plan where he annually evaluates the gardens performance and directs crews to work on eliminating certain species and or infilling with desirable species. The composition of the garden has changed dramatically in its form as the radiating bands no longer exist and the garden has the appearance of a prairie.

## 7. Results

The two principal goals established for the project state that the city wanted a place to explore ways to reduce of the Urban Heat Island Effect and explore plants appropriate to green roofs in Chicago. The achievement of these goals was investigated under two separate inquiries. To date, the city has conducted only one study of the actual cooling effects of the roof garden. On August 9, 2001, during the first full growing season, staff measured air temperatures over both the adjoining Cook County building roof and the pilot project vegetated roof. The official recorded air temperature at Chicago O'Hare airport on August 9, 2001 was 35 degrees Celsius (C). In the early afternoon, the air temperature above the dark colored bituminous county roof measured at 76.1 C. The temperatures over the pilot project ranged from 52,2-54,4 C. at paved areas and as low as 32,8 up to 48,3 degrees over vegetated areas (Laberge 2003). Though the plant material was not yet fully established, the green roof reduced ambient air temperatures up to 25,5 C.

As part of the feasibility study, Katrakis and Associates modeled potential cooling effect benefits of the green roof on Chicago. As a lone green roof, it was estimated to have no cooling effect on the City. Katrakis also made a projection about energy savings based upon hypothetical green roof data. They projected the city could save approximately $4000 U.S. dollars per year on energy based upon the energy use of the eleven story building. No formal investigation has followed up with either of these estimates (Laberge 2003).

In addition to the heat reduction investigation, an investigation of plant material was documented in a paper titled *The Chicago City Hall Green Roof: Its Evolving Form and Care*", by Dvorak and Carroll. Over 35 species of top performing plants as well as 12 plants that should be avoided on green roofs in Chicago are documented in this paper. Some of the top performing plants include species of the families: Allium, Amorpha, Baptisia, Cassia, Desmanthus, Dianthus, Eupatorium, Geranium, Heuchera, Penstemon, Petalastemon, Ratibida, and Verbena. Top performing grasses include species of the families: Andropogon, Bouteloua and Sporobolus. Sedum species perform quite well across the roof in the extensive zones but have been found to be crowded out in the simple intensive zones.

To my knowledge, the urban heat island reduction study on City Hall has not been repeated. Nor, have other publications covered the plant species composition of the garden. Some other interesting and somewhat related investigations have looked at species of birds and invertebrates. A number of scientists have visited the roof, but none have formally documented findings. One informal interview with a biologist was conducted by Kathleen Millett. (Millett 2004). Some of the documented bird species include field sparrows, junco, song sparrows, peregrine falcons, common yellowthroat warblers, wrens, chickadees, kinglets, yellowthroat and Cape May warblers, Empidonax flycatchers, woodpeckers, thrushes, robins, thrashers, starlings, a Philadelphia vireo, and even a rare olive-sided flycatcher. Some of the documented insects include grass hoppers, crickets, bees, and Argiope orb-web spiders to name a few (Millett 2004). A number of butterfly species have been spotted on the roof as well, but little documentation has been published in terms of their species, population and preferred habitat.

## 8. Discussion

The pilot project has accomplished its goals in terms of satisfying the city's and EPA's energy objectives. The pilot project performed well as a cooling effect for the roof top because in part, the vegetation maintained on the roof has thrived. Without plants, the roof top would not be shaded and the cooling effects of evapo-transpiration that takes place during photosynthesis would be lacking. The vegetation is vigorous also because the Optima green roof system is well suited to meadow like plants. Many of the herbaceous perennial forbs and grasses selected for the project grow in gravel-like prairie soils in native settings. Together, these factors with the high quality maintenance, periodic irrigation and continual exploration of new species, the roof is likely to continue performing well for as long as these conditions remain.

With the Urban Heat Island study complete, it is unlikely that any additional formal investigation will take place on the City Hall project. Today, the project functions as a green roof education site for the city. The Department of Environment and the Mayor’s office have a well prepared scripted tour of the project that many see on an annual basis.

Since its completion, the Chicago City Hall green roof pilot project has received much attention. Much of this credit is owed to Mayor Daley for initiating a bold proposition at a time in North America when green roofs were virtually unknown. Without Mayor Daley’s persistence in establishing the project and securing funding for its proper maintenance, the project would likely not have been known as a success story but as a failure. The projects’ visibility in the downtown core on the top of a historic city hall structure helps as well. For example, if Mayor Daley had preferred to locate the project at the outer limits of the city on a maintenance shed, it would have not likely received as much attention. It has also helped lead Chicago’s way towards accepting green roof technology. As a city with a long history of sleek, clean modern architecture, the pilot project helped break perception barriers of what is possible and publicly acceptable in Chicago. As a pilot project, it also helped pave the way for Chicago as a national green roof leader. The non-for-profit organization Green Roofs for Healthy Cities has surveyed the area of constructed green roofs across North America each year since 2004. Chicago has topped the list every year and to date has over 28 hectares of constructed green roofs (Cities 2005).

Though green roofs have had many success stories in Chicago, there is still much to be learned.  There are also stories emerging in Chicago of failed projects, unkempt rooftops and structurally damaged roof decks. As with all new technologies, there is a learning curve. As Chicago continues to promote green roofs, the body of knowledge needed to master green roof design will need to be greatly improved and expanded upon. This includes development of persons trained to design, construct and maintain green roofs. As a pilot project, the City Hall green roof serves these purposes as it helps promote environmental mitigation.

## 9. Conclusion

As communities across the globe continue to face increasing environmental and economic stresses, new technologies and approaches will need to be explored. Although green roof technology has been successful in many communities across Europe and Asia, North America has just begun to investigate their potential. The Chicago City Hall Green Roof Pilot Project is one example of a green solution that is helping to improve Chicago’s urban ecology and move the green roof industry forward.

## References


Cantor, S. (2008). *Green Roofs in Sustainable Landscape Design*, Norton, New York. 352.

Cities, G. R. f. H. (2005). *Final Report Green Roof Industry Survey 2004 & 2005*. Toronto, Canada.

DOE, C. D. o. E. (2008). *About the Chicago City Hall Roof Garden*. Chicago Department of Environment Web Site.

Doshi, H. (2006). *Environmental Benefits of Green Roofs On A City Scale – An Example Of City Of Toronto*. Greening Rooftops for Sustainable Communities. Green Roofs for Healthy Cities: Boston, MA. 10.

Dvorak, B., Carroll, Kevin (2008). *Chicago City Hall Green Roof: Its Evolving Form and Care*. Greening Rooftops for Sustainable Communities, Green Roofs for Healthy Cities: Baltimore, MD. 10.

Dvorak, B. M. de la fluer (2008). *Seeing Green Up*. Fabric Architecture January/February 2008: 6.

Getter, K. L. a. D. B. R. (2006). *The role of green roofs in sustainable developmen*t. Hort Science 41(5): 1276-1285.

H. Akbari, M. P., H. Taha (2001). *Cool Surfaces and shade Trees to Reduce Energy Use and Improve Air Quality in Urban Areas*. Solar Energy 70(3): 15.

Keeley, M. A. (2004). *Green Roof Incentives: Tried And True Techniques From Europe*. Greening Rooftops for Sustainable Communities. Green Roofs for Healthy Cities: Portland, OR. 10.

Kula, R. (2005). *Green Roofs And The LeedTM Green Building Rating System*. Greening Rooftops for Sustainable Communities: Washington D.C. 10.

Laberge, K. (2003). *Urban Oasis: Chicago's City Hall Green Roof. Green Roofs for Healthy Cities*. Greening Rooftops for Sustainable Communities. Chicago, Illinois: 10.

Millett, K. (2004). *Birds on a Cool Green Roof*. Chicago Wilderness Summer 2004.

Weston (1999). *Final Report Urban Heat Island Initiative Pilot Project*, Weston Solutions: 47.

Yocca, D. (2002). *Chicago City Hall Green Roof ASLA Design Award*. American Society of Landscape Architects Web Site