

# Green Roof Feasibility Study



Madison Central Public Library  
Madison, Wisconsin

Prepared by:  
Facilities & Sustainability Department *Staff*,  
Dept. of Public Works, Engineering Division,  
City of Madison

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## Summary

The Madison Central Public Library is located at 201 West Mifflin Street, Madison Wisconsin. The original library was designed in the early 1960's and construction was completed in 1965. After 45 years the library is being remodeled to address issues associated with deferred maintenance, accommodate new uses such as computers and other technologies, and provide additional public and staff space. As part of the Capital Budget appropriation to build the remodeled library there is a provision for city staff to complete a feasibility study for a rooftop community garden or green roof.

The renovated/remodeled library will be approximately 118,000 square feet distributed across five floors above and below grade. The new third floor will be located at the existing roof level. Approximately half of the third floor will be enclosed space accommodating meeting rooms, reading areas, staff offices as well as other miscellaneous support spaces. The other half of the existing roof level will remain as roof. This is the space addressed in the feasibility study for accommodation of the rooftop community garden or green roof.

The design team led by Meyer, Scherer, & Rockcastle Architecture & Interior Design, have completed the schematic design phase and have recently started the design development phase of the architectural design process. Currently there is no provision for an intensive green roof (i.e. rooftop community garden) in the schematic design documents nor is there any direction from the City of Madison to MS&R to include this type of roof in the design development phase or any future design phases. There is an option in the schematic design documents to include an extensive green roof.

As outlined in the following document the city staff acknowledges the benefits offered by a living roof of any type. However based on several major mitigating realities staff recommends not to pursue an intensive green roof (i.e. rooftop community garden) for the Madison Central Public Library remodel project. City staff does recommend continuing to pursue an extensive green roof as an alternative throughout the remaining design and construction bidding phases.

As an alternative to a rooftop community garden on the central public library there are possibilities for establishing a community garden in nearby Madison public parks as outlined in the body of this document and appendices V, VI, VII, and VIII.

**Report prepared by:**

**Facilities & Sustainability Department**

Jeanne Hoffman	Manager
Jim Whitney	City Architect
Bryan Cooper	Architect

**Report contributions by:**

**City of Madison Fire Department – Fire Prevention Division**

Bill Sullivan	Fire Protection Engineer
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**Comptroller’s Office**

Eric Veum	Risk Manager
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**Department of Planning and Community and Economic Development**

Mike Van Erem	Plan Review Specialist
Heidi Fischer	Real Estate Agent

**Madison Parks**

Kevin Briski	Superintendent
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**Madison Public Library**

Barb Dimick	Director
Mark Benno	Administrative Services Manager

**Office of City Attorney**

Doran Viste	Assistant City Attorney
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**Why was this feasibility study prepared?**

The enclosed feasibility study was developed by City Staff to fulfill the requirement as set forth in the City of Madison Executive 2010 and 2011 adopted Capital Budget and Capital Improvement Program. Specifically the Capital Budget allocation for the Madison Central Public Library states, “in their evaluation, development, and design of the rebuilt Central Library, City staff is directed to study and consider the feasibility of including either a rooftop intensive community garden and/or a green roof.”

### Intensive Green Roof (i.e. “rooftop community garden”)

For the purpose of this study an **intensive green roof** is a roof with enough soil depth - approximately twelve inches or more - to accommodate large plants, shrubs, small trees, or vegetable gardens. Typically an intensive green roof is designed to be accessible by the building occupants (i.e. not just maintenance staff). Of all the living roof types, an intensive green roof generally is the most expensive to construct and requires the most long term maintenance due to irrigation, feeding, soil management, etc. The specific order and composition of the materials of an intensive green roof varies depending on the design circumstances and roofing manufacturer, but generally includes the following materials listed below. See figure 1 for visual example of intensive green roof assembly.

Assembly listed from top to bottom

1. Growth media (12"+) with plants, shrubs, small trees, and/or vegetables.
2. Drainage mat with system filter
3. Moisture retention mat
4. 2<sup>nd</sup> Drainage mat – varies by manufacturer
5. Insulation
6. Root barrier
7. Roofing material (i.e. rubberized asphalt, TPO, EPDM, etc.)
8. Substrate (in the case of the central library this is an existing concrete substrate)

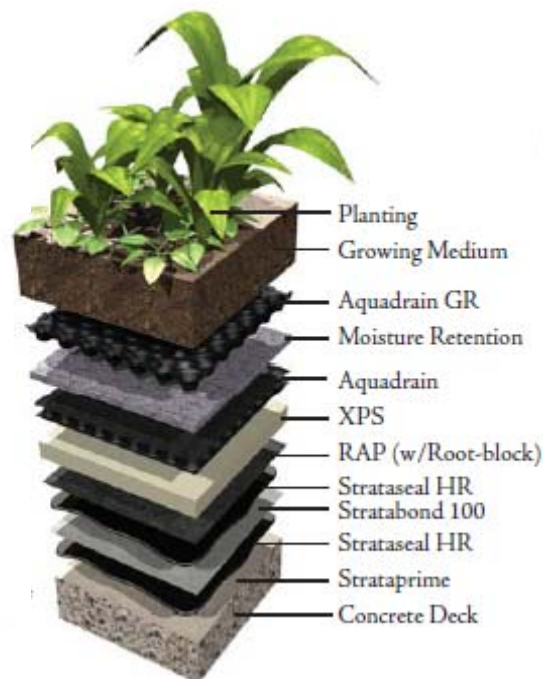


Figure 1: Intensive green roof assembly example. This particular assembly is a hot applied asphalt waterproofing system manufactured by Cetco Building Materials Group.

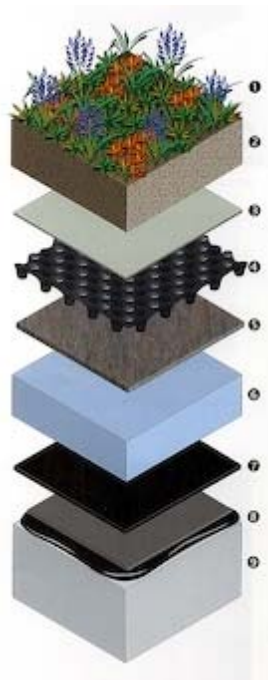


## Extensive Green Roof

For the purpose of this study an **extensive green roof** is a roof with a soil depth of 6" or less and includes shallow rooted perennials (generally sedum, moss, or other low-growing, drought-resistant, shallow-rooted plants). Typically an extensive green roof is designed to only be accessible to maintenance staff. Of all the living roof types, an extensive green roof is generally the least expensive to construct and requires the least amount of long term maintenance. Once the extensive green roof plants are established (approximately 6 months) there is little need for future irrigation and feeding; yearly weed maintenance would be required. The specific order and composition of the materials of an extensive green roof varies depending on the design circumstances and roofing manufacturer, but generally includes the following materials listed below. See figure 2 for visual example of extensive green roof assembly.

Assembly listed from top to bottom

1. Low-growing, drought-resistant, shallow-rooted plants).
2. Growth media
3. System filter
4. Moisture retention mat (optional)
5. Drainage mat.
6. Insulation .
7. Root barrier.
8. Roofing material (i.e. rubberized asphalt, TPO, EPDM, etc.)
9. Substrate (in the case of the central library this is an existing concrete substrate)



**Figure 2:** Extensive green roof assembly example. This particular assembly is a hot-applied asphalt waterproofing system manufactured by Hydrotech.

## What are the benefits of a green roof?

Green roofs offer a number of generally agreed upon benefits that can be divided into three categories: Amenity/Aesthetic, Economic, and Environmental.

### A. Amenity/Aesthetic

1. Additional space for recreational activities. As urban areas become more dense there is increased pressure on preexisting on-grade parks and gardens. Living roofs offer the urban dweller additional opportunities to have some control over their exterior environment.
2. Green roofs offer additional space to grow fruits, vegetables, and flowers are possible on a living roof (specifically an intensive green roof).
3. While not easily measured, well-maintained green roofs are typically more aesthetically pleasing than traditional non-green roofs. This generally increases the well-being of building users.

### B. Economic

1. Living roofs, if properly designed and installed, can extend roof life as the plants and planting media protect the roof membrane from the damaging effects of UV rays. In addition, the plants and planting media of a living roof mitigate the extreme temperature swings that occur daily on exposed roof membrane. UV exposure and temperature fluctuations both have a damaging effect on the chemical composition of exposed roof membrane
2. There are several ways all living roofs can reduce the energy costs of a building.
  - a. As indicated above living roofs shade the roof membrane and substrate. This shading not only protects the roof membrane it contributes to modulation of the interior building temperature by reducing solar gain.
  - b. Cooling of the building is also achieved by evaporative cooling of the plant and growing media.
  - c. Plant (specifically evergreen) material and growing media add thermal resistance and thermal mass to a roof.

### **C. Environmental**

1. Living roofs offer opportunity for biodiversity and wildlife. Extensive green roofs may be more successful than intensive green roofs in cultivating wildlife habitat as these roofs are not accessible to the public and therefore there is not additional strain placed on plants, birds, and insects.
2. Storm water runoff can be reduced by green roofs. The plant material and growing media absorb precipitation reducing run-off quantity; while some absorbed water is transpired back into the air.
3. A green roof can reduce the urban heat island affect. To be most effective – in reducing the urban heat island effect – a green roof needs to be part of a collection of urban green spaces that include neighboring green roofs and on grade vegetation.
4. Noise pollution may be decreased as sound dampening increases with media depth. Sound dampening would be more effective with an intensive green roof as the growing media depth is greater than that of an extensive green roof.
5. Plant material is capable of capturing air borne pollutants & CO<sub>2</sub>.

## A. Code

### *General*

The applicable building code used for this feasibility study is the 2006 International Building Code (i.e. the 2006 IBC). The 2006 IBC is the code the City of Madison uses for building plan review.

An intensive green roof (i.e. rooftop community garden) would be a publicly accessible roof. As such all applicable codes (refer IBC page 204, section 1004.8) would need to be followed and will be reviewed below. Many of these code requirements contain cost implications.

An extensive green roof is not a publicly accessible roof and therefore is not subject to any of the code requirements applicable to a publicly accessible space like a rooftop community garden.

### *Occupancy use type – 2006 IBC Section 303*

The occupancy type for the intensive green roof (i.e. rooftop community garden) will be classified as “Assembly Group A” in general and A-3 in particular, refer IBC page 23, section 303.1. The assembly group classifies a structure or portion of a structure used to bring together large groups of people in a relatively small area.

### *Occupant load – 2006 IBC Section 1004*

The occupant load of a building is the total number of persons that might occupy a building or a portion of the building.

For this feasibility study the rooftop community garden is assumed to be 6000 gross square feet. 6000gsf includes space for forty 4'-0" x 12'-0" vegetable garden planters/plots, space for accessible circulation, storage shed space, compost bin space, and cistern space. The rooftop community garden is assumed to be 3100 net square feet. This is derived by subtracting the space that cannot be occupied (i.e. the planter space, the cistern space, the compost bin space) from the gross square footage.

The occupant load is determined by taking the net square feet of useable area and dividing by the maximum floor area allowances per occupant per IBC page 204, table 1004.1.1. The intensive green roof (i.e. rooftop community garden) is considered an “unconcentrated assembly without fixed seats” per table 1004.1.1. The maximum floor area allowance and unconcentrated assembly without fixed seats is 15 square feet per occupant.

Dividing 3100 net square feet by 15 square feet per occupant to obtain the occupant load. In this case the occupant load is 207 occupants. When added to the rest of the third floor library occupant load (i.e. 507 occupants) as established in the schematic design documents developed by MS&R (see sheet G051 for code analysis) there is a total occupant load for the third floor of 714 occupants. Please note this calculation does not indicate the number of people that will be using the community garden, but

this is how the city calculates load for code related items. In other words even though there may be fewer people on the roof than the load requirement indicates, the city is required per code to design the occupied roof top community garden to be code compliant.

As indicated above the occupant load will affect various code criteria. Exiting path and quantity and plumbing fixture quantities are most critical to the feasibility of the intensive green roof (i.e. rooftop community garden).

*Number of Exits – 2006 IBC Section 1019. (determined by occupant load)*

Because the third floor occupant load would be 714 occupants with addition of an occupied intensive green roof (i.e. rooftop community garden) there is a code requirement to have a minimum of three exits. This means there would need to be three exits that will be “maintained until arrival at grade or the public way” (refer 2006 IBC page 223, section 1019 and table 109.1). Currently the 100% schematic design documents from MS&R includes three means of exiting from the third floor and most likely could be utilized by the intensive green roof (i.e. rooftop community garden) occupants with some modification to the current schematic design.

*Plumbing Fixture Requirement – 2006 IBC Section 2902. (determined by occupant load)*

The 100% schematic design documents include a few more toilets, lavatories, and drinking fountains than what is required by code. These additional toilets, lavatories, and drinking fountains would accommodate the additional occupant load represented by the roof top community garden and would not add cost to the project.

*Fire Sprinklers – 2006 IBC 903*

Although a minor challenge it is assumed a fire sprinkler would be required in a community garden storage shed. This could be extended from the sprinkler system required throughout the third floor and would be a minor added expense. The sprinkler requirement has cost implications. See the cost analysis in this report.

*Fire Alarm and Detection Systems – 2006 IBC 908*

Visual alarms are required per 2006 IBC 907.9.1 and audible alarms are required per 2006 IBC 907.9.2 as part of the exiting requirements. These items have cost implications. See cost analysis in this report.

*Means of Egress Illumination – 2006 IBC Section 1006*

The exit path walking surface must be illuminated and supported by emergency back-up power in case of an emergency event. This lighting has cost implications. See cost analysis in this report.

*Guards (i.e. guardrail) – 2006 IBC Section 1013*

Guards must be provided at occupied space when there is a change in elevation of 30 inches or more. Because the intensive green roof (i.e. rooftop community garden) will be located on the third floor of the library – well over 30 inches above the adjacent sidewalk elevation – a guard system will be required. The height of the guard system cannot be less than 42 inches. The required guardrails represent added cost to the project. See cost analysis in this report.

*Lighting – 2006 IBC Section 1205*

Artificial lighting requirements are set forth in 2006 IBC Section 1205.3 and provides a minimum level of lighting at 30 inches above finish floor. For the purpose of this study it will be assumed to be one light fixture at each planter bed (in order to meet the code requirement for 30 foot candles at a height of 30" above the floor level) for a total of forty non-emergency light fixtures.

**B. Security**

The Madison Public Library is the City of Madison agency with primary responsibility for security of the central library building and occupants. As such the library management would need to employ staff and security to monitor the intensive green roof (i.e. rooftop community garden) activities during regular and off hours (central library hours listed below). It should be noted the Madison Central Public Library is closed on Sunday's from May through September. This poses a problem as this is prime gardening activity time for community gardens. This would require the library to hire and pay additional staff when the library is usually closed.

**Monday - Thursday:** 9:00 - 9:00; children's room closes at 6 p.m.

**Friday:** 9:00 - 6:00

**Saturday:** 9:00 - 5:00

**open Sundays, October - April:** 1:00 - 5:00 (no telephone service)

**C. Liability/Lease Agreement**

City of Madison nor the Madison Public Library intends to sponsor or operate a rooftop community garden at the central library. Operation of a rooftop community garden at the central library would need to be operated by an entity other than the City of Madison or Madison Public Library. This entity would be required to sign a lease with the City of Madison and indemnify and hold harmless the City of Madison from any claims associated with the use of the community garden. In addition this entity would be required to be capable of acquiring insurance at levels required by the City of Madison

**D. Space Allocation and Programming***Solar Photovoltaics*

As previously mentioned the library design has entered the design development phase. One of the issues being explored during this phase is solar photovoltaic panels on the roof for the production of electricity for sale to the electric utility as well as for possible electrical use in the library. Depending on the outcome of the design of the solar photovoltaic panels there may not be roof area available to an intensive or extensive green roof.

*Future Additions*

In the future the Madison Public Library may enclose the entire third floor for additional interior use. This would preclude the use of the roof for either an intensive or extensive green roof.

*Vertical Circulation (i.e. elevators)*

The central public library project is challenged with limited vertical circulation via elevators. Only two elevators will be included in the remodeled/renovated library due to cost of adding openings in the existing floors and the elevator supply/install costs. One of the elevators will be dedicated to the public. This elevator is located in a prominent public location within in the library. It will not be acceptable for community gardeners to use the public elevator. The other elevator will be dedicated to the library staff operations. The library management and staff do not intend to add additional burden to the staff elevator to accommodate community gardener or community garden material transport. To add a third elevator to the project is an estimated \$200,000.00.

**E. Structure**

The original central library construction documents indicate the existing roof was designed to accommodate a future occupied floor. "The live load capacity for the existing 'waffle slab' concrete structure is in excess of 100 PSF." (pg. 6.D-1 MS&R Schematic Design Report). An unoccupied extensive green roof with a soil depth of 6" or less has been reviewed by the design team and confirmed it will not exceed the capacity of the existing roof structure. An intensive green roof (i.e. rooftop community garden) with a soil depth of 12"-18" that would be occupied by rooftop gardeners would also most likely not exceed the roofs structural capacity. A structural analysis to confirm the existing third floor structure's capability of supporting a rooftop community garden is beyond the scope of this study and would need to be pursued as an additional service to the base library design service contract.

**F. Cost**

In the next section an estimate is included to outline general costs for construction and long-term maintenance associated with an intensive green roof (i.e. rooftop community garden), an extensive green roof, and a traditional roof. An intensive green roof is the most expensive of the three roof types, followed by the extensive green roof, and the traditional roof. An intensive green roof (i.e. rooftop community garden) contains the highest construction costs of the three roof types due to the additional supply and install of a third elevator, soil material, planter material, compost bin material, cisterns, storage shed, plumbing, lighting, guardrails, etc. An intensive green roof (i.e. rooftop community garden) contains the highest maintenance and operational costs due to additional staff and security responsibilities, irrigation costs, and general maintenance of all the added items required to operate a rooftop community garden.

<b>MADISON CENTRAL PUBLIC LIBRARY - summary of roof construction costs</b>				
<b>Estimated Construction Cost for Intensive Green Roof (Rooftop Community Garden)</b>				
Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Intensive Green Roof (roof top community garden): base cost includes wood or precast planters	6,000	SF	\$41.25	\$247,500.00
Add third elevator to accommodate added use	1	LS	\$199,212.00	\$199,212.00
Code required guardrail	224	LF	\$250.00	\$56,000.00
Wind break	224	LF	\$250.00	\$56,000.00
Rain barrels	6	EA	\$400.00	\$2,400.00
Compost bins	3	EA	\$1,000.00	\$3,000.00
Storage/tool shed (includes cost for fire protection)	100	SF	\$218.00	\$21,800.00
Plumbing (general and irrigation)	6,000	SF	\$2.00	\$12,000.00
Electrical (includes general and emergency electrical)	6,000	SF	\$20.00	\$120,000.00
Subtotal: Construction Cost (estimate assumes no additional structural upgrades to roof)				\$717,912.00
Additional design team fees				\$57,432.96
<b>TOTAL ESTIMATED CONSTRUCTION COSTS (ROOFTOP COMMUNITY GARDEN)</b>				<b>\$775,344.96</b>
<b>Estimated Cost for Extensive Green Roof</b>				
Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Extensive Green Roof base cost	6,000	SF	\$24.00	\$144,000.00
Irrigation Plumbing	6,000	SF	\$2.00	\$12,000.00
<b>TOTAL ESTIMATED CONSTRUCTION COSTS (EXTENSIVE GREEN ROOF)</b>				<b>\$156,000.00</b>
<b>Estimated Cost for Traditional Roof</b>				
Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Total Traditional Roof	6,000	SF	\$12.00	\$72,000.00
<b>TOTAL ESTIMATED CONSTRUCTION COSTS TRADITIONAL ROOF</b>				<b>\$72,000.00</b>
<b>MCPL - summary of intensive green roof operational/maintenance costs</b>				
<b>Estimated Annual Maintenance Cost for Intensive Green Roof (Rooftop Community Garden)</b>				
Additional staff and security (required during growing season when library is closed. Assumed every Sunday May-September)	336	hours	\$100.00	\$33,600.00
Full time security during operating hours from April - October	1950	hours	\$50.00	\$97,500.00
Lamp and ballast replacement at exterior lights	1	lump sum	\$1,000.00	\$1,000.00
Repairing/removing abandoned beds	1	lump sum	\$2,000.00	\$2,000.00
Trash and plant debris clean up	1	lump sum	\$500.00	\$500.00
Guardrail repair	1	lump sum	\$3,000.00	\$3,000.00
Hose bibb maintenance	1	lump sum	\$250.00	\$250.00
Additional utility costs (water and electric)	1	lump sum	\$12,000.00	\$12,000.00
<b>TOTAL ESTIMATED ANNUAL MAINTENANCE COSTS</b>				<b>\$149,850.00</b>



**Intensive Green Roof (i.e. rooftop community garden)**

In the opinion of the City Staff it is not feasible to pursue an intensive green roof (i.e. rooftop community garden) at the Madison Central Public Library at this time for the following reasons:

01. Initial costs for construction of a rooftop community garden are significant, representing over an estimated \$700,000.00 more than a traditional roof. To include a community garden in the project at this time would result in taking construction dollars away from an efficient heating and cooling system, a well sealed and insulated building enclosure, and/or high quality interior finishes and furnishings.

02. Madison Public Library leadership and staff are not interested in including a rooftop community garden at the Madison Central Public Library. Community gardening on the roof of the library is not viewed as an activity that meshes with the library's vision or operational procedures now or in the near future. A rooftop community garden would be a significant additional operational and financial burden to the Madison Central Public Library in the form of added staffing, security, long-term maintenance, and competition for extremely limited vertical circulation (i.e. elevators). The estimated annual maintenance/operational costs for a rooftop community garden at the central library are approximately \$150,000.00 per year.

03. While there are many benefits to including community gardens on rooftops, the reality is the City of Madison is not limited in opportunities for on-grade community gardens in public parks near the downtown area. Supporting documentation for this available land is included in Appendix V, VI, VII, and VIII. Locating a community garden at grade in a public park that can be accessed seven days a week during the growing season appears to offer a number of advantages over locating on the Madison Central Public Library roof. Lower upfront construction costs, lower long-term maintenance costs, greater accessibility in terms of hours (i.e. the Central Library is closed on Sundays from May-September), as well as avoidance of a multitude of challenging issues associated with moving materials and gardeners through an occupied central library are a few of the advantages.

**Extensive Green Roof**

In the opinion of the City Staff it is feasible to pursue an extensive green roof as an alternate throughout design and bidding. It appears an extensive green roof offers the many advantages associated with green roofs without the significant challenges represented by a rooftop community garden. As previously indicated an extensive green roof does not represent a significant up charge over a traditional roof, an extensive green roof will not represent significant additional maintenance requirement for Madison Public Library Staff, and because an extensive green roof will not be accessible to the public, additional code required elements will not be necessary. A final decision to include an extensive green roof in the project would be made at the conclusion of the construction bidding phase.

Dunnett, Nigel. Planting green roofs and living walls  
Portland, OR: Timber Press, 2006.

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Country Club Hills, IL: 2006

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Portland, OR: Timber Press, 2006.