Green Roofs

Daniel Apt, RBF Consulting

ASCE LID Conference 2010

LID 201 Workshop

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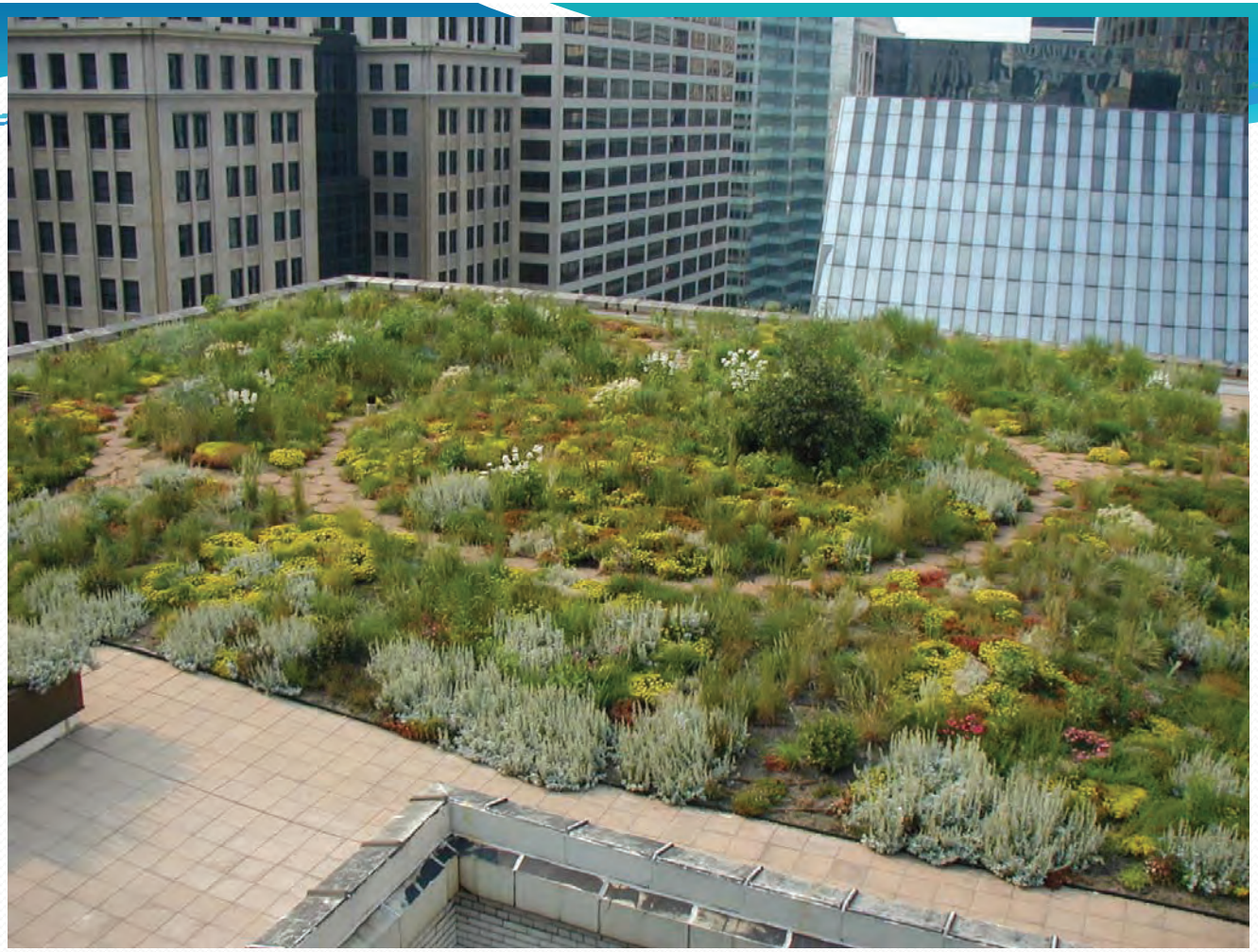

Chicago City Hall Green Roof. ***Photo courtesy of Roofscapes, Inc.***

Green roofs are multi-beneficial structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing detaining and evapotranspirating rainfall.

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Residential High Rise

Solaire Residential Tower, New York. ***Photo courtesy of NASA Earth Observatory***

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Commercial High Rise

Lincoln Mercury Headquarters, Irvine, CA. ***Photo courtesy of Roofscapes, Inc.***

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Commercial Building

MEC Building, Toronto. *Photo courtesy of Treehugger.com*

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Single Family Residential

Photo courtesy of Urban Agriculture Online

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Utility/Parks Buildings

Park Building, Coraville, Iowa. ***Photo courtesy of NRCS***

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Building Entrance

Photo courtesy of Urban Agriculture Online

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Innovative Design

Sinagapore Office Building
Photo courtesy of Earth First.com

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California Academy of Sciences

Photo courtesy of Earth First.com

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Extensive Green Roof

- Passive
- Shallow soil system
- Vegetation
  - Grasses & Succulents
- Non-recreational

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Intensive Green Roof

- Active
- Deep Soil System
- Vegetation
  - Trees & Shrubs
- Recreational

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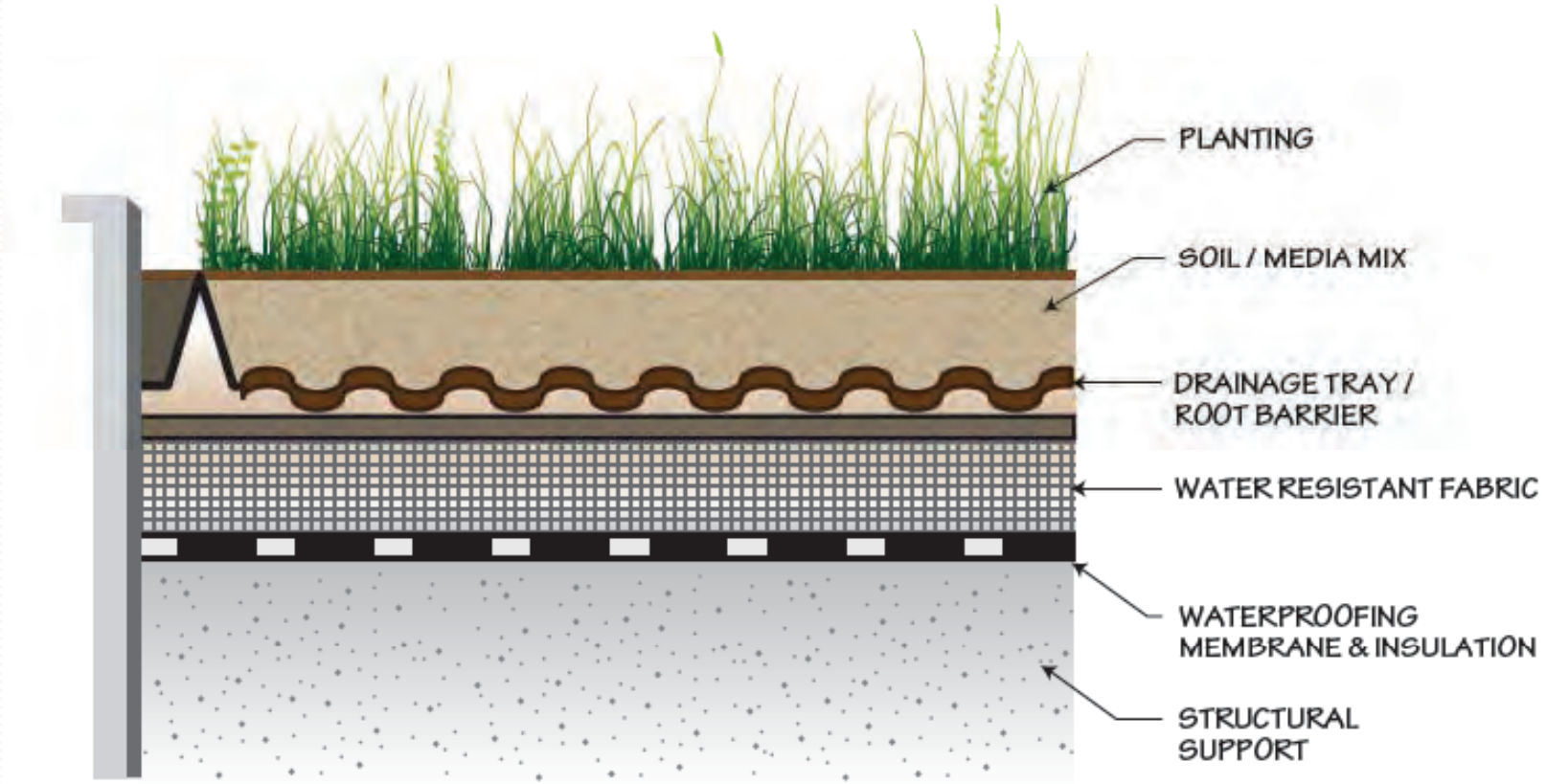
Green Roof Design



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Design Considerations

- **Structural Roof Support**
  - **Additional weight of green roof: saturated weight**
  - **10-50 pounds per square foot (extensive)**
  - **80-120 pounds per square foot (intensive)**

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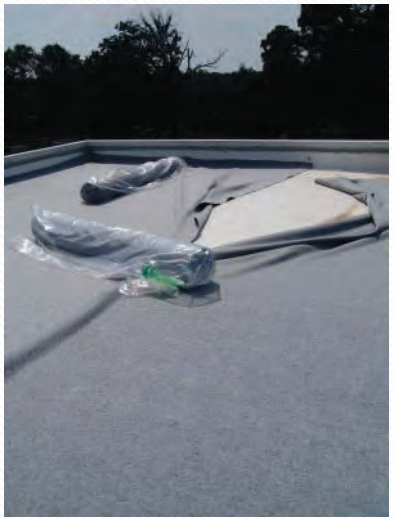
Design Considerations

- **Waterproof Membrane**
  - **Can be various materials including:**
    - **Modified asphalts (bitumens)**
    - **Synthetic rubber (EPDM)**
    - **Reinforced PVC**

- **Water Resistant Fabric**
  - **Provides extra layer of protection**
  - **Synthetic**
  - **15-30 oz per square yd.**



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Design Considerations

- **Root Barrier**
  - **Made of dense materials that inhibit root penetration**
  - **Need for a root barrier depends the waterproof membrane used**

- **Drainage Layer**
  - **Applied over the entire roof area to carry away excess water**
  - **Plastic sheets**
  - **Thin layer of gravel**

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Design Considerations

- **Engineered Growing Medium/Soil Substrate**
  - **Minimum of 2.5 inches thick (extensive)**
  - **3-6 inches thick (extensive)**
  - **8-24 inches thick (intensive)**
  - **Well drained**
  - **Typical mix of 25% topsoil, 25% compost, 50% sand but dependant on:**
    - **Type of plants**
    - **Depth of soil**
    - **Allowable weight**
    - **Climate**
    - **Irrigation needs**

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Design Considerations

- **Plantings**
  - **Extensive**
    - **Shallow root system**
    - **Good regenerative qualities**
    - **Resistance to direct sunlight, drought, frost, and wind**
    - **Minimum of 90% vegetation coverage is recommended**
    - **Native plants are recommended**
  - **Intensive**
    - **Allows for greater variety**
    - **Grasses, perennials, shrubs, trees**
    - **More maintenance**
    - **Irrigation**

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Native Plant Pallet (Northern CA)

Trees	
Cercis occidentalis	Western Redbud
Chamaecyparis lawsoniana	Port Orford Cedar
Cornus nuttallii	Pacific Dogwood
Lyonothamnus floribundus	Catalina Ironwood
Platanus racemosa	California Sycamore
Sequoia sempervirens	Coast Redwood
Shrubs	
Arctostaphylos (many)	Manzanita
Baccharis pilularis	Dwarf Coyote Bush
Ceanothus (several)	Wild Lilac
Galvezia speciosa	Island Bush Snapdragon
Lavatera assurgentiflora	Tree Mallow
Myrica californica	Pacific Wax Myrtle
Prunus i. ilicifolia	Hollyleaf Cherry
Ground covers, Perennials	
Achillea millefolium	Common Yarrow
Artemisia californica	California Sagebrush
Heuchera (several)	Coral Bells
Lilium (several)	Lilies
Muhlenbergia rigens	Deer Grass
Penstemon heterophyllus	Beard Tongue
Sisyrinchium bellum	Blue-eyed Grass

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Native Plant Pallet Southern (CA)

Grasses & Grass-like Plants	
Achnatherum hymenoides	Indian Rice Grass
Nassella pulchra	Purple Needlegrass
Groundcovers & Perennials	
Castilleja foliolosa	Wooly Indian Paintbrush
Lotus scoparius	Deerweed
Shrubs & Shrubby Groundcovers	
Artemisia tridentata	Great Basin Sage Brush
Ceanothus 'Joyce Coulter'	Joyce Coulter Mountain Lilac
Eriogonum fasciculatum polifolium	Interior California Buckwheat
Haplopappus linearifolius	Narrowleaf Goldenbush
Sphaeralcea ambigua	Apricot Mallow
Annuals	
Antirrhinum multiflorum	Multiflowered Snapdragon
Eschscholzia californica	California Poppy
Lupinus succulentus	Arroyo Lupine
Phacelia campanularia	California Blue Bells
Lasthenia californica	Dwarf Goldfields
Trifolium gracilentum	Pin Point Clover

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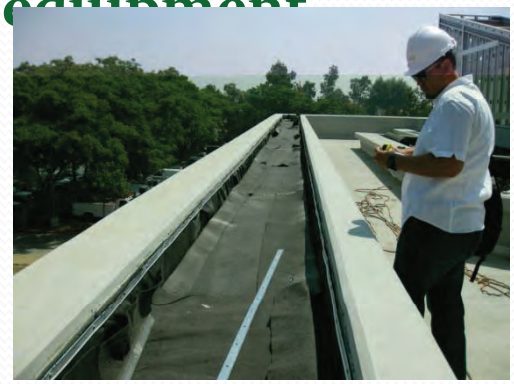
Construction Concerns

- **Waterproof membrane**
  - **Protect from construction punctures**
  - **Inspect for leaks before other installed**
- **Water resistant fabric**
  - **Ensure proper installation and even layout**
- **Drainage Layer**
  - **Immediate inspection of drainage flows prior to soil**
- **Soil**
  - **Even distribution**
  - **No compaction**



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Operations & Maintenance

- **Initial Establishment**
  - **Irrigation**
  - **Fertilization**
  - **Weeding**
- **Slow release fertilizer twice per year to prevent acidification of thin soil layer**
- **Maintain 90% vegetation cover**
  - **Weeding**
  - **Remove dead vegetation**

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Operations & Maintenance

- Inspect for standing water
  - Removal of sediment that impedes dewatering
- Inspect roof for leaks annually
  - Repair any damage to the waterproofing membrane, root barrier or drainage layer
- Irrigation
  - Vegetation
  - Climate
- General Maintenance
  - Intensive
  - Extensive

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Costs

- **Extensive: $15 to $25 per square foot**
- **Intensive: $25 to $40 & up per square foot**
- **Long-term benefits and the energy savings outweigh the original investment**
- **Cost Breakdown**
  - Root Barrier/Waterproof Membrane $10-15 per sq ft
  - Drainage Layer/Soil $5-10 per sq ft
  - Plants $1-3 per sq ft
  - Installation and labor $3-8 per sq ft
  - Maintenance $1-2 per sq ft
  - Irrigation system $2-4 per sq ft

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Performance

- **Water Quality**
  - **Metals 90-95%**
  - **Nitrate 75-80%**
  - **Phosphate 65-70%**
  - **Soil filtration**
  - **Biological uptake**
- **Water Quantity**
  - **60-75% of annual rainfall retention**
    - **Evapotranspiration**
    - **Soil retention**
    - **Biological uptake**

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Other Environmental Benefits

- **Energy Savings**
  - **Reduction of cooling costs 50-70%**
  - **Reduction of heat loss up to 25%**
- **Reduction in the Heat Island Effect**
  - **Reduction of dark surfaces**
  - **Plants cool through dew and evaporation cycles**
- **Improved Air Quality**
  - **1 square meter of green roof can remove 0.2 kg or airborne particulates per year**
  - **Carbon dioxide reduction**

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Other Environmental Benefits

- **Creation of habitat**
  - **"Stepping Stone" habitat connecting natural isolated habitats to each other**
  - **Endangered or threatened species**
- **Minimize waste by increasing roof lifespan**
  - **Elimination of exposure to the sun's ultraviolet radiation**
  - **Last up to twice as long as a conventional roof**
- **Sound reduction**
  - **A green roof with a 12 cm substrate can reduce sound by up to 40 decibels**

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Other Benefits

- **Aesthetics/Quality of Life**
- **Recreational Opportunities**
- **Increased Property Values**
- **Improve Employee Productivity**
- **Food Production**

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Leadership in Energy & Environmental Design (LEED)

- **SS Credit 5.1 Protect or Restore Habitat**
- **SS Credit 5.2 Maximize Open Space**
- **SS Credit 6.1 Stormwater Design: Quantity Control**
- **SS Credit 6.1 Stormwater Design: Quality Control**
- **SS Credit 7.2 Heat Island Effect: Roof**
- **WE Credit 1.1 Water Efficient Landscaping: Reduce by 50%**
- **WE Credit 1.2 Water Efficient Landscaping: No potable Water Use or No Irrigation**
- **EA Credit 1 Optimize Energy Performance**
- **ID Credit 1-1.4 Innovation in Design**

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Issues with Green Roofs

- Water leakage and drainage backups
  - Need to select appropriate waterproof membrane system
- Pesticide leakage
  - Do not use pesticides
- Unwelcome wildlife
  - Raccoons, squirrels, rats etc.
- Vegetation die off
  - Select vegetation appropriate for climate and exposure
  - Irrigation if necessary
- Irrigation requirements
  - Select plants appropriate for conditions
  - Some irrigation may be needed
  - Do not over irrigate

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Green Roofs: Lessons Learned

- **Benefits of Green Roofs must be presented early in the design process**
- **Green Roofs should be presented as cost effective over the lifecycle costs**
- **Identify the benefits (other or environmental) that target what the owner/developer values**
- **Specific to climate**
- **Installation by experienced contractor**

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Questions?

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