Rainwater Harvesting Theory & Practice
Richard Hammond 05 October 2011

Rainwater Harvesting Principles
• environmental benefits of water conservation in buildings
• review of LEED BD&C 2009 water use reduction criteria
• opportunities for rainwater utilization indoors & outdoors
• system design considerations

Rainwater Harvesting Case Studies
• Sisters of St. Joseph’s Residence
• UWO Lassonde Pavilion
• Stoney Creek Community Centre
<table>
<thead>
<tr>
<th>Richard Hammond</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.E.S.</td>
</tr>
<tr>
<td>B. Arch</td>
</tr>
<tr>
<td>OAA</td>
</tr>
<tr>
<td>MRAIC</td>
</tr>
<tr>
<td>LEED® AP (BD+C)</td>
</tr>
<tr>
<td>GGP</td>
</tr>
</tbody>
</table>

- 1978 Engineering & Visual Art at UWO
- 1979 - 1981 Environmental Studies at UWaterloo
- 1982 - 1984 Architecture at UWaterloo
- 2008 – 2011 Sustainable Technology at ASU (online)
- 2011 Environment & Resource Studies at UWaterloo
Environmental Benefits of Water Conservation in Buildings

Canadians’ Excessive Water Use
• Environment Canada estimates that water consumption in Canada has increased by 13% over the past decade
• Canadians use 343 liters of water per day per person - among the highest rates of OECD countries (NRCAN, 2009)

Municipal Water Consumes Energy
• municipally treated water requires a significant amount of energy to deliver, including construction & maintenance of water service infrastructure
• recent US study showed embedded energy of 1149 kWh per acre-foot of municipal water, excluding wastewater treatment (NRDC, 2004)
Environmental Benefits of Water Conservation in Buildings

Misplaced Priorities?

- Current price of water in London for residential customers is $1.50/m3 (0.15 cents/liter)
- Current price of regular gasoline is 110-125 cents/liter
- Which one can you live without for a day?
Environmental Benefits of Water Conservation in Buildings

Focus of Conservation Efforts
- reduce potable water use for irrigation (esp. lawns)
- reduce potable water use for toilet flushing
- both of these are addressed by harvesting rainwater
• administered by Canada Green Building Council (CaGBC) see www.cagbc.ca
• original standard developed in 1998 by USGBC
• 2004 Canadian Standard v1.0 based on U.S. v2.0
• 2009 Canadian Standard has 100 points
• organized into five categories:
  • 26 credits: sustainable sites
  • 10 credits: water efficiency
  • 35 credits: energy & atmosphere
  • 14 credits: materials & resources
  • 15 credits: indoor environment
  • 6 credits: innovation & process
  • 4 credits: regional priorities
LEED® Canada 2009 Design & Construction Standard

WE Prerequisite #1 Water Use Reduction
• minimum fixture performance standards

WE Credit #1 Water Efficient Landscaping
• reduce outdoor water use by 50% (2 points)
• eliminate outdoor water use (4 points)

WE Credit #2 Innovative Wastewater Technologies
• reduce wastewater use by 50% (2 points)

WE Credit #3 Indoor Water Use Reduction
• reduce water use by 30-40% (2–4 points)
LEED® Canada 2009 Design & Construction Standard

**WE Prerequisite #1 Water Use Reduction**

- minimum fixture performance requirements

<table>
<thead>
<tr>
<th>fixture type</th>
<th>commercial</th>
<th>residential</th>
<th>2006 OBC</th>
<th>available</th>
</tr>
</thead>
<tbody>
<tr>
<td>toilets</td>
<td>6.0 LPF</td>
<td>6.0 LPF</td>
<td>6.0 LPF</td>
<td>3.0 LPF</td>
</tr>
<tr>
<td>urinals</td>
<td>3.8 LPF</td>
<td>3.8 LPF</td>
<td></td>
<td>1.9 LPF</td>
</tr>
<tr>
<td>wr faucets</td>
<td>1.9 LPM</td>
<td>8.3 LPM</td>
<td></td>
<td>1.9 LPM</td>
</tr>
<tr>
<td>other faucets</td>
<td>8.3 LPM</td>
<td>8.3 LPM</td>
<td></td>
<td>5.7 LPM</td>
</tr>
<tr>
<td>showerheads</td>
<td>9.5 LPM</td>
<td>9.5 LPM</td>
<td></td>
<td>4.7 LPM</td>
</tr>
</tbody>
</table>
**WE Credit #1 Water Efficient Landscaping**

- monthly water reduction for 600m² landscaped area

<table>
<thead>
<tr>
<th>plant</th>
<th>area</th>
<th>species</th>
<th>density</th>
<th>micro</th>
<th>K_1</th>
<th>E_TO</th>
<th>IE</th>
<th>TWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>shrubs</td>
<td>120</td>
<td>0.5</td>
<td>1.0</td>
<td>1.3</td>
<td>0.65</td>
<td>138.2</td>
<td>0.625</td>
<td>17247</td>
</tr>
<tr>
<td>lawn</td>
<td>480</td>
<td>0.7</td>
<td>1.0</td>
<td>1.2</td>
<td>0.84</td>
<td>138.2</td>
<td>0.625</td>
<td>89156</td>
</tr>
</tbody>
</table>

**BASELINE (JULY) with conventional planting and sprinklers**

**DESIGN CASE (JULY) with drought-tolerant planting and drip irrigation**

<table>
<thead>
<tr>
<th>plant</th>
<th>area</th>
<th>species</th>
<th>density</th>
<th>micro</th>
<th>K_1</th>
<th>E_TO</th>
<th>IE</th>
<th>TWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>shrubs</td>
<td>120</td>
<td>0.2</td>
<td>1.0</td>
<td>1.3</td>
<td>0.26</td>
<td>138.2</td>
<td>0.9</td>
<td>4791</td>
</tr>
<tr>
<td>g.cover</td>
<td>390</td>
<td>0.2</td>
<td>1.1</td>
<td>1.4</td>
<td>0.31</td>
<td>138.2</td>
<td>0.9</td>
<td>18565</td>
</tr>
<tr>
<td>lawn</td>
<td>90</td>
<td>0.7</td>
<td>1.0</td>
<td>1.2</td>
<td>0.84</td>
<td>138.2</td>
<td>0.625</td>
<td>16717</td>
</tr>
</tbody>
</table>

**WATER USE REDUCTION 62%**

Total Water Applied = Area x Landscape Coefficient (K_L) x Local Evapotranspiration (E_T) x Irrigation Efficiency

Landscape Coefficient (K_L) = species factor x density factor x microclimate factor

Note there is no Innovation Credit available for exemplary performance.
## LEED® Canada 2009 Design & Construction Standard

### WE Credit #2 Innovative Wastewater Technologies

- Calculation of daily sewage for 3000m² office building

<table>
<thead>
<tr>
<th>Fixtures</th>
<th>Quantity</th>
<th>Uses/Occ/Day</th>
<th>Flow Rate</th>
<th>Total (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong> (214 occupants: 107f/107m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilets</td>
<td>7f</td>
<td>3</td>
<td>6.0</td>
<td>1926</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>6.0</td>
<td>642</td>
</tr>
<tr>
<td>Urinals</td>
<td>3m</td>
<td>2</td>
<td>3.8</td>
<td>813</td>
</tr>
<tr>
<td><strong>Design Case</strong> (dual flush toilets / waterless urinals)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilets</td>
<td>7f</td>
<td>3</td>
<td>4.2</td>
<td>1348</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>4.2</td>
<td>449</td>
</tr>
<tr>
<td>Urinals</td>
<td>3m</td>
<td>2</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Wastewater Reduction</strong></td>
<td></td>
<td></td>
<td></td>
<td>53%</td>
</tr>
</tbody>
</table>

Note that lavatories are not used for calculation of wastewater volume.
## LEED® Canada 2009 Design & Construction Standard
### WE Credit #3 Water Use Reduction
- calculation of daily water use for 3000m² office building

<table>
<thead>
<tr>
<th>fixtures</th>
<th>quantity</th>
<th>uses/occ/day</th>
<th>flow rate</th>
<th>total (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASELINE (214 occupants: 107f/107m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>toilets</td>
<td>7f</td>
<td>3</td>
<td>6.0</td>
<td>1926</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>6.0</td>
<td>642</td>
</tr>
<tr>
<td>urinals</td>
<td>3m</td>
<td>2</td>
<td>3.8</td>
<td>813</td>
</tr>
<tr>
<td>lavs</td>
<td>4f+4m</td>
<td>3@15s</td>
<td>1.9</td>
<td>305</td>
</tr>
<tr>
<td>DESIGN CASE (dual flush toilets / low-flow urinals)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>toilets</td>
<td>7f</td>
<td>3</td>
<td>4.2</td>
<td>1348</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>4.2</td>
<td>449</td>
</tr>
<tr>
<td>urinals</td>
<td>3m</td>
<td>2</td>
<td>1.9</td>
<td>407</td>
</tr>
<tr>
<td>lavs</td>
<td>4f+4m</td>
<td>3@15s</td>
<td>1.9</td>
<td>305</td>
</tr>
<tr>
<td>WATER USE REDUCTION</td>
<td></td>
<td></td>
<td></td>
<td>32%</td>
</tr>
</tbody>
</table>
**LEED® Canada 2009 Design & Construction Standard**

- daily savings from rainwater cistern for 3000m² office building

<table>
<thead>
<tr>
<th>fixtures</th>
<th>quantity</th>
<th>uses/occ/day</th>
<th>flow rate</th>
<th>total (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASELINE (214 occupants: 107f/107m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>toilets</td>
<td>7f</td>
<td>3</td>
<td>6.0</td>
<td>1926</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>6.0</td>
<td>642</td>
</tr>
<tr>
<td>urinals</td>
<td>3m</td>
<td>2</td>
<td>3.8</td>
<td>813</td>
</tr>
<tr>
<td>lavatories</td>
<td>4f+4m</td>
<td>3@15s</td>
<td>1.9</td>
<td>305</td>
</tr>
</tbody>
</table>

**DESIGN CASE (dual flush toilets / low-flow urinals / fed by rainwater)**

<table>
<thead>
<tr>
<th>fixtures</th>
<th>quantity</th>
<th>uses/occ/day</th>
<th>flow rate</th>
<th>total (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>toilets</td>
<td>7f</td>
<td>3</td>
<td>4.2</td>
<td>1348 (rain)</td>
</tr>
<tr>
<td></td>
<td>2m</td>
<td>1</td>
<td>4.2</td>
<td>449 (rain)</td>
</tr>
<tr>
<td>urinals</td>
<td>3m</td>
<td>2</td>
<td>1.9</td>
<td>407 (rain)</td>
</tr>
<tr>
<td>lavatories</td>
<td>4f+4m</td>
<td>3@15s</td>
<td>1.9</td>
<td>305</td>
</tr>
</tbody>
</table>

**WASTEWATER REDUCTION (excludes lavatories)**

100%

**WATER USE REDUCTION**

92%
LEED® Canada 2009 Design & Construction Standard

WE Credits #2 & #3 Water Use & Wastewater Reduction

- sizing of cistern for 3000m² office building
- minimum capacity from previous slide is 2204 liters/day
- need to account for seasonal variation in rainfall

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>TOTAL of collectable roof areas (square metres)</td>
</tr>
<tr>
<td>7</td>
<td>Rainfall per year in your area (mm). Use rainfall chart on about 2, a figure between 60 and 170.</td>
</tr>
<tr>
<td>8</td>
<td>Collectable rainwater per annum (in litres - discounted by 20% to account for water loss (YIELD))</td>
</tr>
<tr>
<td>10</td>
<td>Amount of water you require every day</td>
</tr>
<tr>
<td>11</td>
<td>Amount of water you require every year (DEMAND)</td>
</tr>
<tr>
<td>12</td>
<td>How many days drought protection do you need? Enter a number in the box to the right, typically 31.</td>
</tr>
<tr>
<td>13</td>
<td>Capacity of water storage in litres required for drought protection</td>
</tr>
<tr>
<td></td>
<td>The lesser of YIELD (10) or DEMAND (12) per annum</td>
</tr>
<tr>
<td></td>
<td>Therefore, volume of rainwater storage required</td>
</tr>
</tbody>
</table>

www.rainwaterharvesting.co.uk/calculator.php

- allowing for 7 days of drought conditions, size of tank is 11,000 liters (11 m³)
- allowing for 21 days of drought conditions, size of tank is 33,000 liters (33 m³)
### 2006 OBC Part B Requirements for Non-potable Systems

#### 7.7.1 Connection
- 7.7.1.1.(1)
  a non-potable water system shall not be connected to a potable water system

#### 7.7.2 Identification
- 7.7.2.1. (1)
  non-potable water piping shall be identified by markings that are permanent, distinct, and easily recognized

#### 7.7.3 Location
- 7.7.3.1.(1)
  where non-potable piping cannot be located
- 7.7.3.2.(1)
  where non-potable supplied fixtures cannot discharge
Case Studies

Sisters of St. Joseph's Residence

Project Description

- 4 storey 130,000 sf residential care facility
- 74 residential suites & 26 bed nursing care wing
- LEED Gold certified, 2007
- Innovation credit for exemplary water use reduction
Case Studies

Sisters of St. Joseph's Residence
RW Harvesting System Details

GREYWATER SYSTEM SCHEMATIC

PUMPS & CONTROLLER

30000 LITER CISTERN
Case Studies

Sisters of St. Joseph’s Residence

Operating Experience

• original pump system had issues with 4 m of lift (from dissolved air)

• replaced with submersible pumps, system has worked well since

• some discoloration of water but no concerns from users

• system available for local education/demonstration
Case Studies

**UWO Lassonde Pavilion**

**Project Description**

- 4 storey, 45,000sf teaching/research facility
- Cistern serves toilets, exterior irrigation & interior planter
- LEED Gold certified, 2009
- All building systems exposed for student teaching/research
Case Studies

UWO Lassonde Pavilion

RW Harvesting System Details

GREYWATER SYSTEM SCHEMATIC

10000 LITER CISTERN

25% GREEN ROOF AREA
**Case Studies**

**UWO Lassonde Pavilion**

**Operating Experience**

- BAS shows cistern operated off backup supply most of July 2011
- UWO reports significant maintenance costs for filters
- System is connected to green roof: silt causing water to appear cloudy
- OH&S is testing to see if any health concerns
Case Studies

Stoney Creek Community Centre YMCA & Library

Project Description

• 80,000 sf assembly building

• Swimming pool, fitness, meeting, library facilities

• LEED Gold certified, 2011
Case Studies
Stoney Creek Community Centre YMCA & Library
RW Harvesting System Details
Case Studies

Stoney Creek Community Centre YMCA & Library

Operating Experience

- system has performed well since opening
- no comments from users or maintenance personnel
- very low water use compared to similar YMCA facilities
Case Studies

Carter House, Bermuda

Project Description

- constructed ca. 1640

- unique roof design traps & collects rain

- all buildings in Bermuda now required to have rainwater collection
Case Studies

Carter House, Bermuda

RW Harvesting System Details

• all systems regulated by Public Health Regulation (1951) which sets out requirements for roof/tank coatings & maintenance

• cistern systems used for drinking water, wells for toilet flushing (due to high salinity of groundwater)

• no water quality issues when systems are properly maintained (Rowe, 2011, Peters, 2008, Levesque, 2008)
Thank you.