Welcome to the Webcast

• To Complete the Webcast Survey – After the webinar, we will have a short multiple choice survey to get feedback on your experience. Please take a few minutes to fill the survey out so we can identify areas for improvement.
• Continuing Education Credits – We are offering CEUs for our watershed and stormwater management webinar series. A total of 1.0 CEU can be earned for attending five webcasts. Only the registered attendee is eligible to earn the CEU. The registered attendee must watch the entire webinar. Email webcast@cwp.org if you are interested in earning CEUs and did not indicate this during the registration process. Two PDUs are also available for certified professionals (CPESC, CPSWQ) for this webinar.

• Resources – After the webinar, we will email a resources sheet, speaker contact information, and the presentation.

To Adjust How the Slides Appear on Your Screen – Just above the slide show on the left hand side is an icon that looks like a screen with a magnifying glass. Click on the arrow next to the icon, and scroll down to “Zoom” and click on “Auto Fit.”

To Answer a Poll Question – Polling questions will appear throughout the webinar. To answer a poll question, click on the radio button to the left of your answer and click submit. Do not type your answer in the chat box.

To Ask a Question – The lower left-hand corner of the screen contains a chat box. Click on the “Public” tab and type your question in the box and click on the arrow to submit it. We will try to answer as many questions as possible during the webinar.

Webcast Outline

• Rainwater Basics & Components (Sarah)
• Designing for Stormwater Management (Sarah)
• Case Studies from North Carolina (Mitch)
• Rainwater Harvesting in the Northwest (Pete)
• Rainwater Harvesting Down Under (Guenter)

Sarah Lawson
Rainwater Management Solutions
Rainwater Harvesting Lexicon

Alternative water supplies are named by the source, not the use……

Rainwater ≠ Graywater

Rainwater ≠ Reclaimed Water

Rainwater can be used for potable or non-potable uses.

Water Usage

<table>
<thead>
<tr>
<th>User Type</th>
<th>% Non-Potable</th>
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</thead>
<tbody>
<tr>
<td>Residential</td>
<td>50 – 78 %</td>
</tr>
<tr>
<td>Office</td>
<td>86 %</td>
</tr>
<tr>
<td>Hotel</td>
<td>43 %</td>
</tr>
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</table>

What makes a rainwater system different from a detention system?

• Roof materials can have a significant effect on water quality.

Filters

• Water quality in the tank and of the receiving waters should be protected.

• Prevent debris and from entering the tank.
Inlets to Tank

Storage Tanks

- Storage tanks vs. infiltration chambers
- Aboveground vs. belowground

Pumps

- Consider an elevated uptake point
- Work with the plumbing designer to size the pump.

Stormwater Benefits:

- Making a difference beyond saving water
- Reduction in Volume of runoff
- Reduction in pollutant loads (through volume reduction)
- Reduction in frequency and magnitude of Combined Sewer Overflow (CSO) bypass events

Rainwater Harvesting Specification & Spreadsheet

- Detailed Specification
- Cistern Design Spreadsheet
- Runoff Reduction Credit

Sizing a system

Three approaches:

- **NOT RECOMMENDED**
  - Approach 1: Event modeling – not good for water supply
  - Approach 2: Monthly budget – tends to overestimate supply and underestimate runoff

- **RECOMMENDED**
  - Approach 3: Continuous simulation

www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html
Continuous simulation -- recommended

Water is added to the tank from precipitation (Pt)
Water is taken from the tank for daily use (Dt)
If more water is added to the tank than it can hold, water overflows from the tank (Ot)
Final water level in the tank is:

\[ T_t = T_{t-1} - D_t + P_t - O_t \]

Example – Continuous simulation

Quantifying Stormwater Credit
Cistern Design Spreadsheet Tool

Runoff Reduction credit (%) = 
\[
\left( \text{Runoff from 1" of rain or less} \right) - \left( \text{first flush} \right) - \left( \text{overflow} \right)
\]
\[
\text{Runoff from 1" of rain or less}
\]

473,000 - 85,000 - 54,000
473,000 = 71%

- If reuse on-site is very high, overflow will be very low and the credit will be very high. If reuse is very low, overflow will be high and the credit will be very low.
- Model cistern performance with daily rainfall data continuation simulation model over a long period of time (many years). Summarize and average results over time to quantify credit.

Principles for Stormwater Treatment Credit

1. Dedicated Year-round drawdown for credit
2. Utilization of rainwater as a resource.
3. Only rooftop areas are to be harvested (no at grade level surfaces) and closed conveyance should be used once water reaches ground surface
4. Pollutant load reduction from site is realized only through reduction of runoff volume leaving the site.
5. Reduction in peak flows is realized due to reduced volume of runoff.

Adapted from Foraste, 2009

Using one tank to do it all

1. Constant orifice drawdown
4. Overflow & freeboard volume
2. Channel/flood protection volume

Figure adapted from Alex Foraste, 2009
Questions?

Using Rainwater Harvesting as a Stormwater BMP: Case Studies from NC

Mitch Woodward
Area Spec. Agent
Watersheds / Water Quality
NC Cooperative Extension
Raleigh, NC

Kathy M. DeBusk, E.I.T.
Graduate Research Assistant
Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC

Meet the NC Stormwater Team

- **Campus** -
  - Teaching
  - Research
- **County** -
  Extension/Outreach:
  - Demonstration
  - Installation
  - Maintenance
  - One Goal - Accelerate the Adoption of Solutions!!!

NCSU Water Harvesting Study Sites

Phase I and Phase II Research Studies

Research Phase I

- Raleigh
- Kinston
- Holden Beach
- New Bern

Toilet Flushing

Problems:
- Poor Utilization of the Water
- Cistern never drawn down lower than 80% capacity
- Overflowed Often
OBJECTIVE:
DOES AUTOMATION OR INTENDED USE OF THE WATER AFFECT THE FREQUENCY OF USE?

Result: Automation Improved Utilization!

Biggest Lesson Learned:

*In theory, theory and practice are the same, but not in practice……..*

Rainwater Harvesting for Stormwater Mitigation in NC

- Stormwater treatment credit for rainwater harvesting systems is possible in NC
- Must prove consistent, dedicated, reliable use
- NCDENR - DWQ

NC Stormwater Treatment Credit

- To receive credit, rooftop runoff must be captured and meet **one** of the following criteria:
  1. Be used on site
  2. Be treated and released
  3. Be infiltrated
• In addition, **one** of the following criteria must also be met for the design volume:
  1. Drawn down (used) within 5 days
  2. Have an overflow of no more than 14% of annual average historic rainfall
  3. Drawn down within 5 days and discharged to a properly designed BMP
• Dedicated water use system must be automated
• DWQ may require a meter to document usage
Current Status: It Works!

- Mitigation Program is in its Infancy
- Statewide, Systems Receiving Credit:
  - 2 in Cary, 1 Jacksonville, 1 Durham, 1 Asheville
- Impediments to Adoption:
  - Engineers out of their comfort zone.... inexperienced w/ technology
  - Cost / treated gallon
  - Plumbing code......complex automated systems......irrigation usually not a year-around

Lessons Learned

1. Keep System Simple - Gravity is a wonderful thing...
2. Convenience is King – Locate near point of use and automate
3. Keep Costs Low – Simple basic systems (In conflict with Convenience / Automation Requirement?)
4. Design System for Ease of Maintenance
5. Perform Maintenance Regularly
6. Did I Mention Perform Maintenance Regularly???
Questions?

Water Harvesting in the Northwest
Pierce County Central Maintenance Facility
Roof Water Harvesting System for Toilet Flushing, Irrigation, Process Water
- 15,000 Gallon Sub-Grade Vault (Toilet water supply)
- 700,000 Gallon Open, Lined Pond (Irrigation / Process Water)

Water Harvesting in the Northwest
City of Tacoma Police Fleet Warehouse
Roof Water Harvesting System for Toilet Flushing
(2) 8,000 Gallon Tanks
Annual Potable Water Use Reduction: 36%
(Approx 146,000 Gallons / year)

Water Harvesting in the Northwest
Mason County PUD No. 3 Operations Center
Roof Water Harvesting System for Toilet Flushing and Irrigation
- (2) 20,000 Gallon Sub-Grade Tanks
- Started with 1.5 M Gallons/Year for Standard Development
- Ended with 0.09 M Gallons/Year Using R/W Harvesting
- Projected Annual Potable Water Savings: $1,600
Projected Well Water Use Volumes ("Standard Project")

Annual Demand = 5,500,000 gal/yr

Gallons Roofs = 12,000,000 gal/yr
Gallons Tarmac = 6,000,000 gal/yr

Water Harvesting in the Northwest
The Resource of Rainwater

Average Rainfall
Forks = 122 inches
Seattle = 37 inches
Othello = 3 inches
Shelton = 65 inches

Water Demand Compared to Resource

Lessons Learned

1. Confirm local/state design & water rights requirements
2. Keep design simple to reduce maintenance time
3. Integrate multiple systems to improve payback
4. Water rates increase faster than inflation, so paybacks shorter
5. Have a backup plan for dry weather
Questions?

Rainwater Harvesting Down Under
Guenter Hauber-Davidson
Managing Director, Water Conservation Group

guenterhd@watergroup.com.au

Topics covered
• Status update: Where we’re at after the drought
• Rainwater harvesting as part of an integrated urban water supply
• Design guidelines – the difference between stormwater drainage and capture
• Innovative solutions at half the price
• Case studies

Background
• Immense public pressure
• need to diversify supplies
• significant scope
• capture water where it rains and where people live – rather than where the dams are (but no rain)

Setting the Scene
• Australia was in the midst of the worst drought on record
• Dam levels were/are at all time lows for most major centres
• In response, severe water restrictions were everywhere
• lamenting “driest continent” yet Australia is not dry!
• high affinity with rainwater tanks – urban population responds
• commercial rainwater harvesting

Typical coastal rain distribution
Stormwater harvesting schemes in Sydney

Source: www.water4life.nsw.gov.au

Large stormwater harvesting schemes in planning and under consideration in SA

Source: SA Government, Urban Stormwater Harvesting

Fit for purpose reuse matrix

Cost Effective Design
How to overcome the design challenge
• build a tank not a dam
• intercept only what’s needed
• make it part of an integrated urban water supply
• find a high non potable demand
• choose the right combination: Collection area, intercept, tank location, size, demand, reticulation
• look for clever design solutions
• value engineer – cut the right corners, for example:

<table>
<thead>
<tr>
<th>Location</th>
<th>Annual Rainfall (mm or inch)</th>
<th>Cost of Water and Sewerage per A$/kL or US$</th>
<th>Value/1,000m2 or ft2 roof area</th>
<th>Comment</th>
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<td>$3.15</td>
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<tr>
<td>Sydney - West</td>
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<td></td>
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<td>Melbourne - City</td>
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Economic Value of Rainwater Harvesting

Value Engineering – no 1st flush

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<th>Min</th>
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<td>0.04</td>
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<td>6.7</td>
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<td>6.5-8.5</td>
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<tr>
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<td>uS/cm</td>
<td>10</td>
<td>3</td>
<td>63</td>
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<td>109</td>
<td>250</td>
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<tr>
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<td>Hardness</td>
<td>mg/L CaCO2</td>
<td>7</td>
<td>3</td>
<td>17</td>
<td>58</td>
<td>33</td>
<td>200</td>
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<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>0.07</td>
<td>3</td>
<td>1.8</td>
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<td>13</td>
<td>5</td>
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<td>Lead</td>
<td>mg/L</td>
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<td>TKN</td>
<td>mg/L</td>
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<tr>
<td>Nitrate</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
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<td>TKN + NH4</td>
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<td>3</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0.2</td>
</tr>
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<td>0.64</td>
<td></td>
</tr>
</tbody>
</table>
Sizing Tools
RainHarD & StormHarD – rainwater and stormwater harvesting design model

- daily time steps
- Input variables: Local rainfall, collection area, runoff coefficient, initial loss, demand curves, tank size
- Output: Daily trend line, water saved, utilisation
- up to 20 year time series run
- Sensitivity analysis module for cost optimisation

Executed Rainwater Harvesting Schemes

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Water Use</th>
<th>Calibrated Event</th>
<th>Annual Water Saving</th>
<th>Tankage</th>
<th>potable water saved</th>
<th>wastewater saved</th>
<th>Payback yrs</th>
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</thead>
<tbody>
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<td>2550 mm</td>
<td>1200 mm</td>
<td>100</td>
<td>500</td>
<td>2550 mm</td>
<td>500 mm</td>
<td>10</td>
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<tr>
<td>Hospital Vehicle</td>
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<td>1200 mm</td>
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<td>500</td>
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<td>1200 mm</td>
<td>100</td>
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<td>500</td>
<td>-100 mm</td>
<td>500 mm</td>
<td>10</td>
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</tbody>
</table>

Design Guidelines

- avoid large volumes – 50 to 80mm (2-3”) max to fill an empty tank
- annual savings about 10-12 times tank volume
- you save about 2/3 of the runoff
- you save more with a greater demand
- limit the intercept rate
- good engineering
- monitor

A Rainwater tank – not a dam!

Design Philosophies – where rain and stormwater harvesting are different

Traditional Hydraulic Design:
- maximum flow for safety/flood protection; avoid structural damage, disruption, erosion, health & well being
- based on “accepted” level of recurrence (1 in 20, 50 or 100 years, 5 min in 20 years)

Rain or Stormwater Harvesting Design:
- economically optimised scheme to supplement urban water supplies
- what is the minimum extraction or diversion rate needed to collect most water whilst optimising harvested water quality

-
There is a better way - we checked it

- 6 min rainfall data – fed into RainHarD
- continuous demand
- initial losses neglected
- ratio of capture area, tank volumes and demand based on a well designed commercial system:
  - 40-80mm (1.5 – 3”) to fill an empty tank
  - assessed harvest flow rates equivalent to 20-3 mm (0.8-0.1”)/hr rain intensity

The Results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Available Storage Capacity kL</th>
<th>Harvest Rate mm/hr</th>
<th>Demand kL/yr</th>
<th>Assessed Water Savings kL/yr</th>
<th>Max Savings of unrestricted harvest rate kL/yr</th>
<th>% of Max Savings</th>
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<tr>
<td>80 / 3 / 600</td>
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<td>3</td>
<td>600</td>
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<td>742</td>
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<td>40 / 8 / 600</td>
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<td>800</td>
<td>632</td>
<td>632</td>
<td>100%</td>
</tr>
</tbody>
</table>

Results

- few events have intensities >10mm (0.4")/hr
- for large events extraction rates of <3mm (1.1")/hr would have yielded same savings
- only 1 event showed significantly less capture at restricted rates - but negligible in annual balance

Intercept Design Conclusions

- drainage pipes are sized for a 1 in 10 year event
- downpipes for 5min in 20 yrs
- does not apply to rain and stormwater intercept design
- no justification for rates equivalent to 30-40mm (1.2-1.6")/hr
- diversion rates as low as 1-3 mm (0.4-0.12")/hr, or 0.3-0.8 L/s per 1,000m² or 0.4-1.1 gpm/ft² yield close to maximum savings

Recommendation

Use an extraction/diversion rate of 5mm (0.2")/hr, or 1.4L/s per 1,000m² (2gpm/ft²) effective runoff area
What this enables: Peak Flow Diversion
Benefits/Why?

For large schemes
• Collection main e.g. 150mm(6") instead of 650mm(24")
• Easier to deal with residual overflows
• Enables solutions that otherwise would not have been possible

Try doing this with a 20” main!

The associated collection area:
2 Football fields!
21,000m²
5 acres

Benefits/Why?
For large schemes
• Smaller collection mains, e.g. 150mm instead of 650mm
• Easier to deal with residual overflows
• Systems “without overflows”

Attention to detail
Expansion!
How we worked the tank harder – and saved 1.5 times more

Benefits/Why?
For large schemes
- Smaller collection mains, e.g., 150mm instead of 650mm
- Easier to deal with residual overflows
- Systems “without overflows”
- Smaller extraction rates = smaller pumps & pipes
- Better water quality

Potable water consumption before & after rainwater harvesting

Before RWH
60-120 m³/day
16,000-32,000gal/d

After RWH
60-80 m³/day
16,000-21,000gal/d

Another example of “An empty tank is a good tank”

Large stormwater harvesting schemes

Excellent water quality
Re-cap

- tanks sized for 40-60mm (~2 inches) of rain to fill an empty tank
- tanks as part of an integrated urban water supply system
- annual water savings 10-15 times tank volume
- flow rates equivalent to a rainfall intensity of 5mm/hr (2/10 of an inch/hr) ok for hydraulic design
- paybacks of 6-10 years for hard working commercial systems
- modelling, good hydraulic design & attention to detail

Conclusion:

Appropriately sized hard working commercial rain or stormwater harvesting systems capturing the water where it falls and where the demand is, can provide an economically attractive sustainable solution to diversify our water supplies to combat the effects of stormwater runoff, climate change and increased population pressure.

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Questions?

Resources

- Resources Sheet will be emailed to you:
  Helpful links, speaker contacts & bios
- CWP Videos:
  http://www.youtube.com/user/CenterforWatershed

Upcoming Webcasts

  October 5, 2011, 12:00 – 2:00 PM EST
- Stream Restoration
  November 16, 2011, 12:00 – 2:00 PM EST

Register at:
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Post Webcast Information

- To Complete the Webcast Survey – We will be providing you with a short multiple choice survey to get feedback on your experience. Please take a few minutes to fill the survey out so we can identify areas for improvement.
- Continuing Education Credits – We are offering CEUs for our watershed and stormwater management webcast series. A total of 1.0 CEU can be earned for attending five webcasts. Only the registered attendee is eligible to earn the CEU. The registered attendee must watch the entire webcast. Email webcast@cwp.org if you are interested in earning CEUs and did not indicate this during the registration process. Two PDUs are also available for certified professionals (CPESC, CPSWQ) for this webcast.
- Participation Certificate – Participation certificates are also available. If you have multiple attendees, please save the certificate to your computer. You can type the attendees name in the name field and then print the certificate.
Webcast Archive

- We will make every effort to post the archive as quickly as possible. The archive should be available on the first Monday following the webcast, pending any edits.
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- Membership through August 2012

For more information visit www.awsp.org

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