Water – **too much** and **too little**…. 

Climate change?

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Water – too much and too little....

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and to the

School of the Built Environment.

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EDINBURGH and DUBAI.
Water – too much and too little – 21st Century challenges for the building services engineer.

John Swaffield FRSE
President CIBSE 2008-09

and

Professor Emeritus, School of the Built Environment,
Heriot Watt University, Edinburgh.

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Water – too much and too little....

Climate change will present a series of challenges to the Building Services Engineer in dealing with both the provision and disposal of water – too much and too little at the same time.
Images of Climate Change

CURRENT COMPLEXITIES

Warm water flowing north

Cold water returning south

1928

2004

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Images of Climate Change

Outback drought

Forest fires, Sydney

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Water – too much and too little….  

Climate change will result in reduced summertime precipitation as well as wetter winters. 

In addition the severity of rainfall events will tend to increase placing extra loading on installed infrastructure. 

Dealing with these challenges will require an understanding of the unsteady nature of the loading imposed on systems.
Climate change water issues include rainfall frequency and severity, droughts, agriculture, water supply and hydroelectric generation.
Water is the ‘new’ carbon.
At least a fourfold variation from North West to South East is apparent from this historic data across the UK.
Predictions for the future consequences of climate change indicate that systems will have to be capable of withstanding winters up to 30% wetter.

This effect will be accompanied by increased event severity.

Summers may be 50% drier.
Predictions of UK climate change during the coming 80 years.
Water – too much and too little….

These changes will have effects upon the water resource available to support housing and other construction aspirations across the UK.
Water – **too much** and **too little**....

Water resource predictions in 2001 already highlighted concerns as to the water availability in the proposed Thames Gateway development.

![Map showing water availability](image)

*Figure 1: Current indicative availability – summer surface water*

- **No additional water available**
- **Additional water available**
- **Unsustainable or unacceptable abstraction regime**

*Source: Environment’s Agency’s Water Resources for the Future, March 2001*

*Proposed location of major housing developments east of London.*
Water – **too much and too little**....

More recent predictions confirm the need for water conservation to become an integral part of construction strategy.

1. Anglian Water
2. Bournemouth and West Hampshire Water
3. Bristol Water
4. Cambridge Water
5. Essex and Suffolk Water
6. Folkestone and Dover Water
7. Mid Kent Water
8. Northumbrian Water
9. Portsmouth Water
10. Severn Trent Water
11. South East Water
12. South Staffordshire Water
13. South West Water
14. Southern Water
15. Sutton and East Surrey Water
16. Tendring Hundred Water
17. Thames Water
18. Three Valleys Water
19. United Utilities
20. Wessex Water
21. Yorkshire Water
22. Anglian Water (formerly Hartlepool Water)


The Environment Agency has developed a methodology for identifying and classifying relative levels of water stress in water company areas in England. The Government has used this map to designate areas of serious water stress for the purpose of accelerating water metering.
Recent floods and droughts have confirmed these predictions across the UK.

Pluvial street flooding, Glasgow.

Weir wood reservoir near Gatwick at 32% full in September 2005 illustrates SE UK problem.

Howden Reservoir, Peak District.
Water — too much and too little....

Fire Fighting, Oregon

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Three main challenges arise for the building service engineer, namely –

1. Water conservation to limit the effect of droughts and to allow housing and construction expansion,

2. Development of sustainable drainage options to deal with the higher precipitation expected,

3. Recognition of the impact of heavier system usage due to climate change and urbanisation on drainage operation and the possibility of cross contamination.
1. Water conservation to limit the effect of droughts and to allow housing and construction expansion.
Current under provision of acceptable water supply and sanitation across the developed and developing world.

Sanitation, distribution of unserved population

- Asia, 80%
- Latin America and Caribbean, 5%
- Europe, 2%
- Africa, 13%

Water Supply, distribution of unserved population

- Asia, 65%
- Latin America and Caribbean, 6%
- Europe, 2%
- Africa, 27%

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Water supply and sanitation challenges.

**Sanitation distribution of unserved population**

- Latin America and Caribbean, 5%
- Europe, 2%
- Africa, 13%
- Asia, 80%

**Water Supply, distribution of unserved population**

- Latin America and Caribbean, 6%
- Europe, 2%
- Africa, 27%
- Asia, 65%

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Effect of Climate Change on sanitation and water access in the developing world.

The UN estimates that a third of the world's population live in areas with water shortages and 1.1 billion people lack access to safe drinking water. 2.6 billion people are without adequate water for sanitation.

Climate change will account for about 20 percent of the increase in global water scarcity.
Could climate change herald mass migration?

Combination of upstream de-forestation aggravating immediate run-off of heavy rainfall and rising sea levels will lead to major problems in delta areas such as Bangladesh.

Greenpeace estimates that 75 million Bangladeshi and 45 million Indians will become "climate migrants" by the end of the century.
International assessment of water consumption shows considerable agreement.
Water – **too much and too little**....

Current Public Water Supply Usage, England and Wales, Meagalitres per day and %.

- **Household use, 7,756, 52%**
- **Non-household use, 3,500, 23%**
- **Company leakage, 2,545, 17%**
- **Customer leakage, 873, 6%**
- **Other, 319, 2%**

Source: based on Ofwat 2007 data
International per capita water consumption, litres/person/day, 2006

National water usage data

Water consumption (litres per capita per day)

- Belgium
- Germany
- Holland
- Denmark
- UK
- Eire
- Finland
- France
- Poland
- Austria
- Luxembourg
- Sweden
- Greece
- Spain
- Italy
- Switzerland
- Norway
- Australia
- Japan
- USA
- Canada

Nation states

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The Defra publication ‘Future Water, The Government’s water strategy for England’ 2008 aims to introduce water consumption that will reduce water usage to 130 or possibly 120 litres per capita per day by 2030.

The document recognises that its people who use water not housing stock and in future housing will be assessed at the design stage to ensure that the local water resource will be sufficient to meet the projected usage by occupants.

A set of target categories have been established…
Water – **too much and too little....**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Credits</th>
<th>Mandatory Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water consumption (l/person/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 120 l/p/day</td>
<td>1</td>
<td>Levels 1 and 2</td>
</tr>
<tr>
<td>≤ 110 l/p/day</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>≤ 105 l/p/day</td>
<td>3</td>
<td>Levels 3 and 4</td>
</tr>
<tr>
<td>≤ 90 l/p/day</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>≤ 80 l/p/day</td>
<td>5</td>
<td>Levels 5 and 6</td>
</tr>
<tr>
<td>Default Cases</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Water usage calculations will be undertaken at the design stage to identify any proposed construction within one of the categories above.
Water – **too much and too little....**

<table>
<thead>
<tr>
<th>Installation type</th>
<th>Unit of measure</th>
<th>Capacity/flow rate</th>
<th>Use Factor</th>
<th>Proportion in dwelling max=1</th>
<th>No of uses/perso n/day</th>
<th>Litres water used/person/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC (fixed flush)</td>
<td>ush</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td>4.80</td>
</tr>
<tr>
<td>WC (dual flush)</td>
<td>Full ush</td>
<td></td>
<td>0.33</td>
<td></td>
<td></td>
<td>4.80</td>
</tr>
<tr>
<td></td>
<td>Part ush</td>
<td></td>
<td>0.67</td>
<td></td>
<td></td>
<td>4.80</td>
</tr>
<tr>
<td>Bidet*</td>
<td>Litre per use</td>
<td>2.64</td>
<td>1.00</td>
<td></td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>Wash hand basin taps</td>
<td>Litres/minute</td>
<td></td>
<td>0.67</td>
<td></td>
<td></td>
<td>7.90</td>
</tr>
<tr>
<td>Shower</td>
<td>Litres/minute</td>
<td></td>
<td>5.00</td>
<td></td>
<td></td>
<td>0.60</td>
</tr>
<tr>
<td>Bath</td>
<td>Capacity to overflow</td>
<td></td>
<td>0.40</td>
<td></td>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td>Kitchen sink taps</td>
<td>Litres/minute</td>
<td></td>
<td>0.67</td>
<td></td>
<td></td>
<td>7.90</td>
</tr>
<tr>
<td>Washing machine</td>
<td>Typical Practice</td>
<td></td>
<td>49</td>
<td></td>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>Actual Litres/use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td>Typical Practice</td>
<td></td>
<td>13</td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Actual Litres/use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water softener*</td>
<td>Litres per use</td>
<td>12.5</td>
<td>1.00</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Table 1 Calculation of internal potable water consumption using BRE Water Calculator**

* where no bidet or water softener is specified the proportion should be entered as zero.
Water usage prediction may also incorporate savings resulting from grey water reuse or rainwater harvesting.

### Table 2 Calculation of total potable water needed from the mains, for internal use, taking into account any grey- or rainwater recycling

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Potable Water Used:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collection of grey water for WC flushing:</td>
<td>Bath, shower and hand-washing basin usage [1] (l/person/day)</td>
<td>Percentage of used water (normally bath, shower and taps) to be recycled [2] (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey water reused [3] (l/person/day)</td>
</tr>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>Collection of rainwater for internal use:</td>
<td>Collection Area [5] (m²)</td>
<td>Rainfall [6] (average m/year)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainfall Collected per person [7] (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainwater collected [8] (l/person/day)</td>
</tr>
<tr>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
</tr>
<tr>
<td>Total Water required from the mains:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Final Water Consumption (l/person/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(f - g - h)</td>
</tr>
</tbody>
</table>

\[
\text{Total potable water used (l/person/day)} = (f - g - h)
\]

\[
\text{Grey water reused (l/person/day)} = a \times b
\]

\[
\text{Rainwater collected (l/person/day)} = \frac{c \times d \times e \times 1000}{365}
\]
Water – too much and too little....

Water usage may be drastically reduced by a combination of conservation measures, as illustrated in the projected ‘Water House’

The combination of water efficient appliances and reuse systems allows a Level 5, 80 litres / capita / day to be achieved.

<table>
<thead>
<tr>
<th>Appliance/fitting</th>
<th>Standard new built house (150 l/p/d)</th>
<th>Contribution to daily use</th>
<th>House meeting Code for Sustainable Homes level 5 (80 l/p/d)</th>
<th>Contribution to daily use</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC</td>
<td>6 litre single flush</td>
<td>28.8</td>
<td>40.6 litre dual flush (5.33x 8.36)</td>
<td>14.69</td>
</tr>
<tr>
<td>Washbasin taps</td>
<td>4 l/min</td>
<td>14.11</td>
<td>6 l/min</td>
<td>15.87</td>
</tr>
<tr>
<td>Shower</td>
<td>10 l/min</td>
<td>30</td>
<td>7.75 l/min</td>
<td>23.25</td>
</tr>
<tr>
<td>Bath</td>
<td>180 litre</td>
<td>28.8</td>
<td>120 litre</td>
<td>19.2</td>
</tr>
<tr>
<td>Sink taps</td>
<td>8 l/min</td>
<td>28.22</td>
<td>7 l/min</td>
<td>18.52</td>
</tr>
<tr>
<td>Washing machine</td>
<td>49 litre</td>
<td>16.66</td>
<td>40 litre</td>
<td>13.6</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>13 litre</td>
<td>3.9</td>
<td>10 litre</td>
<td>3</td>
</tr>
<tr>
<td>Water re-use system</td>
<td>...</td>
<td>0</td>
<td>-100m² roof, 0.6m annual rainfall, 0.6 efficient, 3 persons.</td>
<td>-28.29</td>
</tr>
</tbody>
</table>

Box: Future Water House

New housing will need to be more efficient in the way water is used. A house with the following fittings shows how level 5 of the Code for Sustainable Homes could be achieved. The water use in this house is around 80 litres per person per day (l/p/d), compared to around 150 l/p/d in a standard new house built today.

Source: BRE Source: Code for Sustainable Homes

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An appliance design led approach to water conservation.

Reduction in w.c. flush volume from 1900 to 2007 - illustrating the potential for water saving based on appliance design rather than user opinion.

Australian proposals for the use of non circular section building drains may allow further reductions in flush volume without reduction in transport efficiency.

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Water – too much and too little....

2. Development of sustainable drainage options to deal with the higher precipitation expected.
A number of solutions are available including

1. Use of SUDS principles within the building boundary, including storage to delay loading the sewer infrastructure,

2. Introducing an increased use of siphonic roof rainwater systems, possibly in combination with storage installations,

3. Green roofs as a means of attenuation and delaying the peak system loading.
Impact of rainwater harvesting on inflow hydrographs and routing.

Overflow to underground receiving network depends upon rainfall profile, tank capacity and use of harvested water. Profiles unchanged.

CONVENTIONAL DOWNPIPE

SIPHONIC DOWNPIPE

GROUND SURFACE RUN-OFF

DISCHARGE TO SURFACE WATER DRAIN

Overflow to underground receiving network depends upon rainfall profile, tank capacity and use of harvested water. Profiles unchanged.

CONVENTIONAL DOWNPIPE SIPHONIC DOWNPIPE GROUND SURFACE RUN-OFF
Sustainable Urban Drainage is simply a means of applying the unsteady continuity of flow equation to the boundaries of a building or group of buildings so that the peak loading on the drainage network is attenuated as the unsteady rainfall on the local catchment, including roofs or paved areas as well as porous media, is diverted into temporary storage areas or absorbed temporarily by the surrounding surfaces. This has the effect of reducing the peak load on the sewer and reducing the probability of downstream surcharge.
Local ponds absorb rainfall and reduce peak discharge flows. Local safety issues are however a design consideration.
Reed Beds, HWU
Research Park, Edinburgh
Swale to Drain installation, HWU Research Park, Edinburgh

Swale installation, HWU Research Park, Edinburgh

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Siphonic Rainwater Drainage Systems – What are they?

- Pipes flow full (>95%).
- Max pressure = the height of the building.
- Flow velocities are much higher.
- Smaller pipe diameters are required.
- Fewer downpipes are required.
- Less interior space is consumed by pipework.
- Less need for groundworks.
Siphonic roof rainwater system installation at the National Archives of Scotland

Siphonic gutter outlets

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International Green Roofs

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