The future of urban drainage

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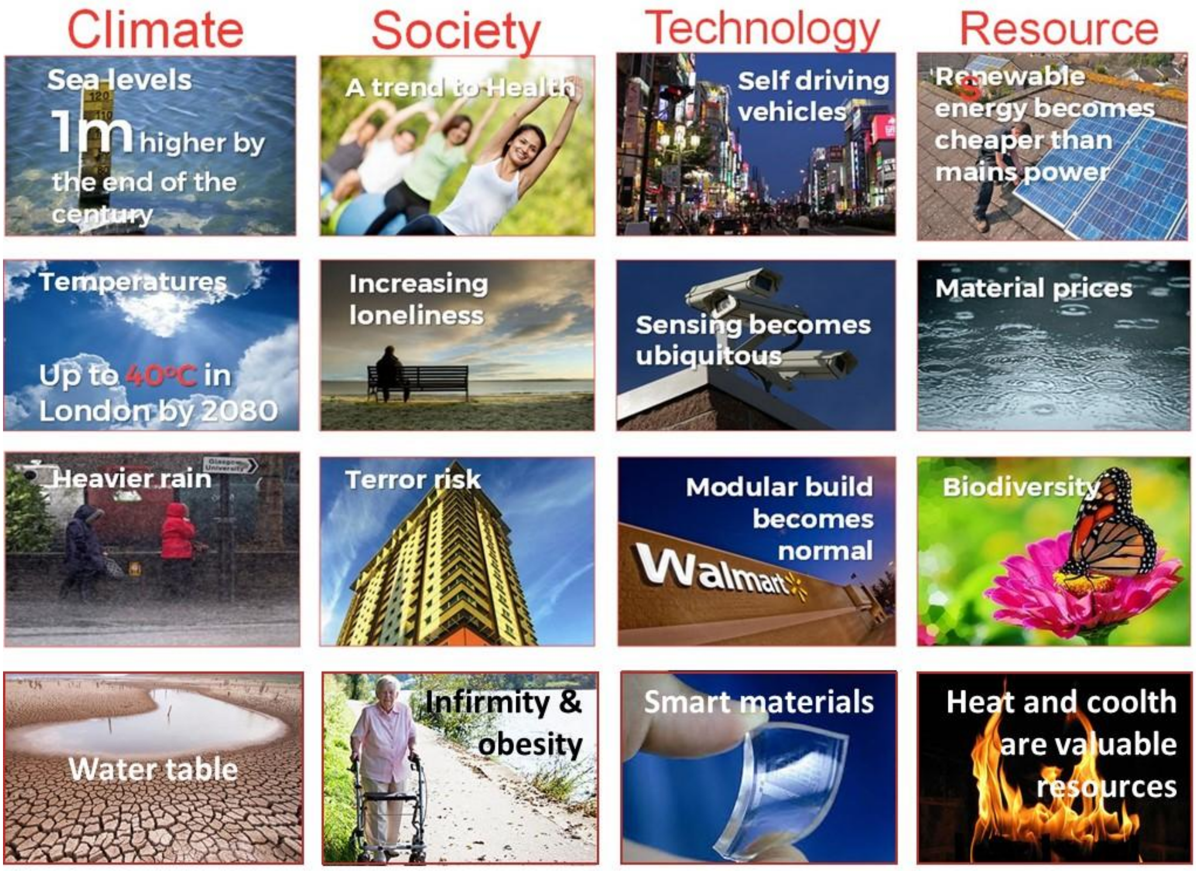
At WSP we have an initiative called Future Ready so that for all projects we consider how they will perform in the society of 40 years ahead. So what should we be designing for in urban drainage?

The new guidance on Drainage and Wastewater Management Planning encourages us to take a long term view with a particular focus on population growth. But does it look broadly enough and far enough ahead.

We are all familiar with considering population growth and increased intensity of rainfall due to climate change. Some are also considering the impact of climate change on peak river levels and sea level. But what are the other pressures.

We have identified four themes with four main topics in each theme, as shown in the diagram below. How will these impact on urban drainage?



I have picked four of these future changes and consider the impacts that they will have on urban drainage and how we will need to assess the implication measures that will be required.

Rainfall, river flow, temperature, social change.

Rainfall

Climate change has and is happening and is changing patterns of rainfall; but the pattern of change is complex and the magnitude of the change is uncertain.

The UKWIR report on rainfall for urban drainage design [1]gives some guidance on changes in the intensity of short duration rainfall – typical of the storms that cause urban flooding. There has been some challenge to the magnitude of the increases but I want to focus on the uncertainty in the change with different climate change scenarios of low, medium and high.

The table below shows percentage increase in rainfall depths for a range of storm durations for a recent project that we worked on.

Duration (hrs)	Low	Med	High	Uncertainty
		2050s		
1	+24%	+44%	+75%	±50%
3	+19%	+29%	+41%	±37%
6	+8%	+17%	+30%	±58%
		2080s		
1	+45%	+50%	+60%	±15%
3	+35%	+53%	+76%	±40%
6	+33%	+51%	+75%	±40%

The potential changes in rainfall intensity are quite frightening, particularly as the percentage change in flood volumes will probably be even greater than this. But the uncertainty in that change is also worrying at typically 40%.

How do we design for that level of uncertainty? Do we design for the best case and hope or design unaffordable solutions for the worst case? We need to build adaptable solutions that can be upgraded for future change with clear trigger points for future work. The adaptability could be by providing connections for future hard infrastructure or by rolling programmes of SuDS retrofit to balance the increase in rainfall.

Interestingly the DWMP framework recommends sensitivity testing on population growth to allow for the expected uncertainty of ±30%, but does not recommend considering the uncertainty in climate change; even though this could be greater. We will recommend considering this uncertainty as well. It will save money in the long run and perhaps in the next AMP.

River flows

River flows are important to urban drainage in more ways than one. They can increase flood risk by restricting the discharge from overflows but they also provide dilution for those discharges and the discharges from wastewater treatment works. So how will changes in river flows affect our assessment and design of urban drainage systems?

There are quoted regional figures for how river flows will change due to climate change; these are typically 20% to 40% increases. Again there is uncertainty on this with different climate change scenarios.

However these increases are for large rivers in winter conditions. In summer these same large rivers are likely to have reduced flow and less impact on flooding. Conversely small urban watercourses will respond more directly to short term rainfall and so are likely to have increased flow during summer storms – increasing flood risk.

Considering the dilution available for discharges. The low river flows in summer will provide less dilution and so potentially require a reduction in CSO discharges to maintain compliance with water quality standards. Similarly treatment works effluent may need to be of higher quality for the reduced dilution. How do we assess this?

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[1] 15/CL/10/16-2 Rainfall intensity for sewer design - Guidance for water companies

We are all familiar with Formula A as an initial approach to assessing CSO spill. But how many remember that this is only appropriate if the dilution ratio between low river flow and sewer dry weather flow is greater than 7:1. The Scottish Development method gave an amended version for dilution of 6:1. To deal with lower summer river flows we need to either amend Formula A or adopt full UPM assessments.

High temperatures

It is already the case that heatwaves kill far more people than flooding. And forecasts are that mean temperatures and extreme temperatures will continue to increase. So how does this impact on urban drainage?

There are some obvious immediate impacts. Increased river temperatures makes them more susceptible to polluting discharges from CSOs and treatment works, so discharge standards will have to increase even more on top of the increase already required for reduced dilution. The UPM water quality standards can include for a temperature adjustment, but Formula A will probably require another amendment to allow for temperature change.

On the other hand; treatment works processes will become more effective, especially for ammonia treatment so the effluent quality will improve. However the aeration process will become less efficient so energy use may increase.

There will also be second order impacts that we also need to consider.

The need to keep cool will change our use of urban spaces. Green spaces provide shade and evaporative cooling and this could become the key driver for the use of sustainable drainage rather than its benefits in reducing flood risk. The 25 Year Environment Plan recommends planting one million trees in towns and cities by 2022 with ongoing increases after that. But we would need to make sure that the vegetation stayed green in dry weather Storing runoff in tree pits is part of the solution but may not be enough for future hot dry summers. In Mediterranean and middle-eastern countries it is common to use treated effluent for irrigation of street trees and urban parks. Would we need to do the same? Does that mean that small local treatment plants are more useful than large centralised ones as the effluent can be reused locally? Do we reverse the trend to consolidated treatment works (which was largely driven by a desire to reduce the costs of manual operation) and have automated local treatment plants? How would this affect design of sewerage systems?

The increased temperatures will also lead to a greater use of air-conditioning. But air conditioning that pumps heat into the outside air just makes the problem worse. Could we instead use the flow of wastewater to carry away the heat extracted from our houses? What would be the implications for the sewerage system, the treatment process and the receiving water? In the sewerage system there would be an increased risk of septicity that could increase sewer collapses. Would that require more sewer cleansing to prevent the build-up of solids?

Customer behaviour

Social changes will also move water use from households to commercial users. People will shower more at the gym than at home and will eat out or have takeaways rather than prepare their own food. How do we allow for this in our assessment of dry weather flow?

Bag it and bin it campaigns have been going for almost 30 years and FOG reduction campaigns for more than 10 years. They have made some gains but we still have a problem. Is the current campaign on wet wipes a turning point or will there be another source of problems that we haven't thought of yet. An increasingly aged population could lead to more problems of incontinence pads. We will probably always have a future of unsatisfactory material disposed of down the drain, do we need a rethink in how we design, maintain and operate our systems? As water efficiency drives down water use but the solids content stays the same do we increase the problem. Research seems to show that the peak discharge from toilet flushing stays the same in local sewers, but there could be a point in the sewerage system where the risk is greater.

Customers are already expecting utilities to behave like customer service companies with more transparency of their performance and operations. Defra policy is that all residents should know their flood risk and the National Infrastructure Assessment has recommended that all properties should be protected against flooding to a 1:200 annual probability (1:1000 in major cities) irrespective of the cost benefit. (That is probably a bad idea; but what happens if it becomes government policy). Imaging the response to letters telling customers that their property did not meet the national standard for flood protection.

Conclusions

So bringing all of these trends together our future urban drainage systems could look very different.

We would need more sewer cleansing or automated sewer flushing to reduce blockages from the reduced flow of water and to manage odour from increased septicity.

We would have small local wastewater treatment works that recycled water to provide irrigation for gardens and street trees.

These works would either pump the sewage sludge to central treatment plants or would extract bio-energy and heat from it for local use.

The sewers would have an important role in moving heat around the community from places where it wasn't wanted to places where it could be used.

And urban drainage planners would have to stop relying standard approach and go back to first principles and do some proper thinking about adaptive long term solutions.