27th WEDC Conference Lusaka, Zambia, 2001

PEOPLE AND SYSTEMS FOR WATER, SANITATION AND HEALTH

People and puddles – is drainage important?

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WATER AND SANITATION projects have tended to focus on the provision of water supply, with sanitation aspects given a lower priority. Soft aspects such as hygiene promotion – an essential ingredient for health improvements, also lack the same status as hard engineering components. Environmental health however is not just limited to the provision of safe water and the disposal of faeces; solid waste management and drainage of rainwater are also important issues. Drainage does not have a high profile. In the last seven years there have only been two papers relating specifically to drainage and about eight others that examine a related aspect, such as pollution of watercourses or groundwater or large-scale rainwater harvesting. A DFID sponsored project is examining the issues that lie behind the implementation of urban drainage projects and to see if alternative drainage technologies are appropriate in developing countries.

This paper sets out the background to this project and discusses the problems of introducing a new technology.

Causes of flooding

Runoff occurs naturally and varies in quantity according to the frequency and intensity of rainfall, the impermeability of the land and the condition of the land when it begins to rain (e.g. saturated). Flooding can be divided into two categories:

- flooding arising outside the immediate area; and
- local flooding.

External flooding is confined to the flood plain of the watercourse. The extent of the flood plain will vary from year to year with the quantity of water coming downstream. Often a regular seasonal pattern will be apparent. Long term changes to the catchment can alter the size and the frequency of flooding. This type of flooding can be managed by:

- building conventional engineered flood defences;
- preventing the development of the flood plain, allowing the river to flood naturally;
- adapting infrastructure and livelihoods to cope with inundation (e.g. raised pit latrines); and
- Managing the catchment upstream to reduce the frequency and severity of flooding.

Local flooding is not confined to the flood plain. It will vary considerably in terms of location, duration, frequency and intensity. It is made worse by paved areas or compacted ground, reducing the capacity of the soil to absorb moisture and by actions upstream, such as inappropriate drainage provision. The division between external flooding and local flooding is not precise, as one person's local flooding will become somebody else's external flooding further downstream. External flooding will be on a greater scale than local flooding. The management of this local flooding and its impact on people is the subject of this paper.

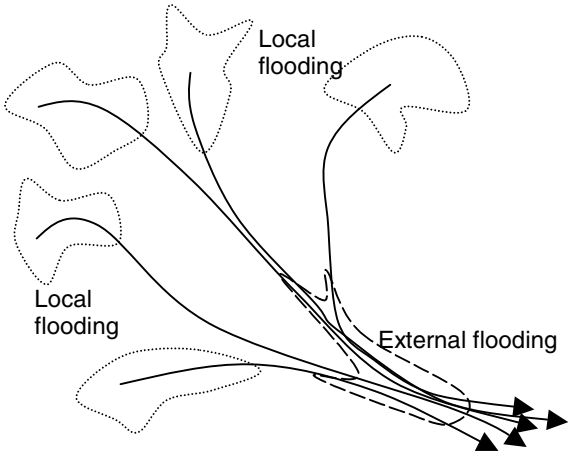

Figure 1. Flooding

The drainage of local and household rainwater is going to be more important for the control of malaria than the control of large scale flooding. Draining puddles and uneven ground may be important in depriving the mosquitoes of breeding sites near people's homes.

Drainage problems

If urban drainage has such as low profile in the Watsan community, is the management of runoff actually a problem that needs addressing? Runoff is the fraction of rainwater that flows along the surface rather than soaking into the ground. Urbanization increases amount of impervious ground and therefore increases the fraction of rainfall that becomes runoff. The problems poorly managed runoff causes include:

- small floods damaging roads and buildings, causing disruption to lives and businesses;
- pollution from overflowing latrines and sewers, causing faecal pollution and disease;
- cross contamination of water supplies;
- wet soils leading to ideal conditions for worm infections;
- providing habitats for vectors (mosquitoes and snails);

- water pollution from diffuse sources (rubbish, animal faeces, air pollutants);
- erosion of watercourses;
- siltation of watercourses;
- inconvenience (wet feet in puddles);
- safety (physical danger of being washed away); and
- landslides. [Kolsky 1998, WHO 1991]

These issues have adverse impacts on a variety of resources people use, such as:

- human (health);
- natural (water and the aquatic environment);
- financial (disruption to business, low property values);
- social (disruption to communications); and
- physical (erosion and structural damage).

The impact on the poor

The poor are more vulnerable to the problems that arise from inadequate urban drainage. They are more likely to be living in environmentally vulnerable areas (liable to flooding, landslides and pollution) and less able to cope with shocks to their livelihoods. The problems of polluted water sources and flooding of domestic properties will impact disproportionately on women.

Drainage solutions

Conventional drainage systems

The standard method of managing urban runoff is to dispose of it as quickly as possible. Roofs, roads and paved areas are designed to shed water towards gullies that are connected to pipes that collect the water and transfer it elsewhere. The pipes are designed so the water flows fast enough to carry suspended solid particles and keep the pipes clean.

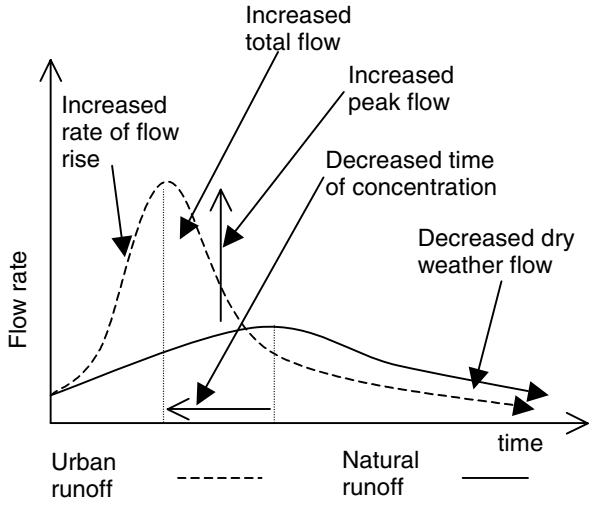

Figure 2. Impact of urbanization on a storm hydrograph

Problems with conventional drainage

The focus of conventional drainage design is to remove as much water as quickly as possible. Eventually this will have to discharge to a watercourse. The drainage system increases the flow rate and the volume of flow. This can lead to flooding and erosion problems downstream of the discharge point.

The flow rate enables the runoff to carry a sediment load causing erosion at the top of the catchment. This will eventually be deposited, leading to siltation and blockages downstream. The flood peak will arrive sooner in an urbanized catchment and have a shorter but more intense duration. This leads to a "plug" of concentrated pollutants washing downstream, causing environmental damage.

Water is also a value resource. If it is polluted and allowed to flow away, it cannot be used by people (e.g. for water supply) or the environment (e.g. replenishing wetlands). The increase in impervious surfaces reduces the infiltration to the ground and subsequently reduces the replenishment of aquifers.

Besides the technical problems, drainage systems need resources to design, build and maintain them. Conventional systems are interconnected and complex, and require a relatively high level of design expertise. Computer modelling may be able to optimize the design, but requires large amounts of detailed topographical and hydrological data. Piped systems are also prone to blockages and need to be surveyed and cleaned to maintain their effectiveness. The use of pipes may be prohibitively expensive for low-income communities.

Developing country adaptations

Adaptations can be made to conventional drainage practice to reduce some of the problems. Open channels can be used, to reduce the risk of blockages and make the inspection and the removal of debris easier. Lining the channels can reduce scouring and erosion within the channels. Open channels are easier to build and maintain than piped systems, so local men and women can be involved in the construction process. However, open channels can still become dumping areas for solid waste, and the underlying design philosophy is still the rapid disposal of water.

More sustainable approaches

For to a variety of reasons, alternative methods of managing urban runoff have been developed in the USA, Australia and Europe. These are variously termed "Best Management Practices" (BMPs), source control, or "Sustainable Urban Drainage Systems" (SUDS). These methods use a series of engineered structures and management practices to control urban runoff in a more sustainable and environmentally responsible manner [Andoh 1994]. Components include:

- the prevention of pollution and the minimisation of impermeable areas;
- the use of permeable surfaces for hard paving;
- the use of infiltration devices such as soakaways;

- the conveyance of excess runoff off the immediate site using very gently sloping unlined channels (swales); and
- the local attenuation and treatment of runoff in basins, ponds and wetlands.

The concepts behind this approach are to replicate the natural flow regime so the storm hydrograph resembles the pre-development pattern. Prevention of flow and pollution arising in the first place is favoured over its treatment and subsequent management. Local solutions (source control) are favoured over dealing with the runoff elsewhere.

Barriers

A series of research projects managed by the UK Construction Industry Research and Information Association (CIRIA) has looked at the potential for using sustainable urban drainage systems and the reasons why they are not widely used. These broke down into three main areas:

- lack of design information;
- reluctance to pioneer alternative drainage methods; and
- institutional issues.

The first issue has been addressed by a series of design manuals from CIRIA and a number of research projects where industry, the environmental regulators and research institutions are collaborating.

The second issue is the subject of dissemination activities from the regulators and CIRIA, using demonstration sites, case studies, videos, booklets and working with the professional engineering institutions to discuss SUDS at seminars and conferences. Overcoming the inherent conservatism of engineers is difficult as SUDS are site specific and do not translate well into standard designs or simple design methods. Each individual design component (basins, soakaways etc.) is well understood by engineers but the different elements need to be combined.

The third issue is proving to be less straightforward to address directly. SUDS are not sewers and so the legal and institutional framework that has been developed to manage the *quantity* of water flowing along pipes does not necessarily transfer to issues of environmental impact.

Benefits

One of the reasons for this lack of institutional fit is the variety of benefits that SUDS can provide. These include:

- better management of the quantity of runoff;
- groundwater recharge;
- wetland recharge;
- reduction in flooding;
- reduction in erosion;
- increased river baseflows;
- better management of the quality of runoff;
- reduction in pollution of surface and groundwater;
- reduction in siltation;
- better use of runoff as a resource;
- rainwater harvesting; and
- ecological use.

This range of benefits is extensive, with additional issues, such as reduction in irrigation for gardens, improved productivity of aquatic habitats and aesthetic value of water features being important to specific stakeholder groups. The multiple functions can lead to a lack of an institutional "home" for the drainage system. Drainage authorities managing an engineered system may not have the resources, skills or motivation to manage a natural resource. Is managing drainage for rainwater harvesting a drainage issue or a water resource issue?

Developing countries

Benefits

In addition to the benefits listed above, SUDS have characteristics that may make them suitable for low-income countries. The construction relies to a large part on simple earthmoving (pits for soakaways, basins for ponds, shallow ditches for swales). These can be constructed using labour-intensive methods and do not require any high levels of skill, beyond setting out.

SUDS do not depend on expensive (imported) materials such as pipes, gullies and concrete, so do not rely on extensive supply chains and foreign exchange. In some areas, SUDS may be able to be constructed solely with contributions of labour and natural materials such as stones.

The focus on preventing problems at source, rather and curing them downstream, makes SUDS design very dependent on the locality. It is best managed at this local level. This ties in with ideas of de-centralisation and subsidiarity, putting the control in the hands of the people best situated to carry out this role. This is reinforced by the principle of *polluter pays,* as failure of source controls such as soakaways will affect people in the immediate area first.

The focus on source control also puts an emphasis on controlling the drainage in the areas around people's houses. This not only has better impact on malaria control, but will support community-based approaches to implementing SUDS, as the action and results will be local.

Barriers

The same barriers to the wider use of SUDS encountered in the UK are likely to occur in developing countries. These are likely to be compounded by lack of resources for research, dissemination and promotion. The institutional barriers are likely to be reinforced by the apparent low-priority placed on drainage problems. Water supply and sanitation are important issues. They are normally tackled directly, rather than taking a wider view of the problem. Thus polluted water sources are used for drinking after expensive treatment, rather than preventing the pollution. Pit latrines in areas that experience flooding are raised, rather than addressing the control of the runoff. Solid waste in drainage channels require the drainage channels to be cleared, rather than the solid waste problem addressed first.

The lack of focus and multidisciplinary nature of the drainage systems disperse the motives for applying SUDS. One key institution in the UK has been the planning system. However the planners have little motivation or

understanding of drainage problems. This is likely to be compounded in areas where planning controls are weak. Conventional drainage systems are complicated to design [Bhattarai and Neupane, 2000], so increasing the number of stakeholders is going to further complicate the process.

There may also be technical issues that are unique to developing countries. The mosquitoes that transmit malaria breed in clean water so urban drainage may have more health implications than in industrialised nations. Drainage of clean water will have a bigger impact on malaria reduction than drainage of polluted water. However preventing pollution and building balancing ponds may create ideal habitats for their larvae and so their detention times will need to be designed so the basins dry out before the larvae have time to mature (one week or less).

The project is looking at these barriers to see if there is scope for using SUDS. The people who will be most closely involved in any implementation will be municipal engineers. The consultation will start with these stakeholders, before discussing the issue with other related groups, who may not be so aware of the technical and institutional issues, such as planners, community groups and environmental regulators.

Summary

- Urban drainage have adverse impacts on people, especially the poor, if it is not managed properly;
- Conventional drainage techniques can cause problems of flooding and pollution downstream;
- Conventional drainage as developed in industrialised countries may not always be suitable in developing countries;
- Alternative drainage systems based on natural processes may be able to prevent problems occurring, rather than relying on a cure; and
- Introducing new technologies does not just depend on getting the technology correct. It has to be:
  - Disseminated;
  - Promoted; and
  - Supported institutionally.

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This paper is an interim output from a research project funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

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