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It never Drains when it Pours

B Carter[1], D Watts[1], S Joyce[2*]
[1]Morphum Environmental Ltd, Auckland NZ
[2]Morphum Environmental Ltd, Melbourne, Victoria

Abstract:

Climate change will bring about more frequent and severe flooding in urbanised areas. In low lying areas sea level change is already having an impact on the performance of piped stormwater systems and sedimentation of waterways and harbours is choking outlets. Existing piped stormwater systems were generally designed for events less than 10 year ARI. In addition inlet capacity is limited due to lack of design or blockage. Aging piped systems suffer root ingress and defects limit their performance. The outcome is that piped stormwater systems are frequently surcharging even during events they were originally designed for and this situation is likely to become significantly worse due to increasing imperviousness, climate change rainfall, sea level rise, aging infrastructure and limited funding. Much greater attention is needed to manage overland flow on roads, through private property and via waterways to cater for severe storms. This paper sets out to provide an overview of the above issues and impacts and propose practical ways to better manage overland flow and minimize reliance on piped systems by a combination of sound geospatial knowledge of the system, well integrated design, land use management and optimisation.

Examples of practical solutions will include:

- Obtaining and utilizing geospatial information to understand stormwater systems and issues.
- Establishing prioritized programmes to undertake assessment of flood risks and management of assets.
- Identifying, avoiding and mitigating overland flow issues when planning and carrying out land development.

Keywords:

climate change, flooding, stormwater, geospatial information, overland flow.

1. Introduction

On a world scale we are seeing almost daily reports of devastation as a result of severe weather events. The most dominant images include flooding, landslip, erosion and the profound impacts these events have on the affected communities, property and the environment. The accompanying reporting typically refers to the need to invest in the repair and upgrade of stormwater systems. At an anecdotal level there is a growing sense of the reality of climate change and an anxiety that the impacts from extreme events are not about to slow down any time soon. This paper sets out to provide an overview of the issues and impacts associated with existing stormwater systems and puts forward practical ways to better manage overland flow and minimize reliance on piped systems in urban environments by a combination of sound geospatial knowledge of the system, well integrated design, land use management and optimisation.

2. Impacts of Climate Change and Development

The realities of climate change and urban development are being experienced on a global scale and are being reported by government and research agencies in many countries including Australia and New Zealand. [1], [2].The experience and projections reported by agencies point towards:

- Increasing rain intensities in normally wet areas both for short duration and long duration storms.
- Increasing runoff associated with land-use changes such as urbanization and deforestation.
- Increasing impacts of sea level rise in low lying coastal areas.
- Increasing erosion of land and streams and deposition of sediments in harbours and major waterways.

3. Typical State of Stormwater Systems

Urban areas within Australia and New Zealand generally have well established piped stormwater systems. Typical characteristics of these systems and their performance include:

- Ageing stormwater pipes generally designed to have capacity to convey runoff from less than a 5 year average recurrence interval (ARI) storm.
- Capacity of inlets to stormwater systems generally less than the capacity of the pipe system they connect to.
- Less than optimal maintenance of existing stormwater systems further reducing capacity during major storm events.
- A history of flood plain and/or overland flow path flooding causing inundation to low lying properties.
- Sedimentation in receiving environments affecting the capacity of the stormwater piped system particularly in the vicinity of discharge points.

4. Common Response to Flood Events

When major flood events occur in urban areas common responses include:

- Increased spend on damage repair to restore and improve stormwater infrastructure.
- Increased spend on infrastructure planning and network modelling to understand and make provision for stormwater systems improvements.
- Realisation that the costs associated with repairing and maintaining existing systems are significant and that future improvements are often unaffordable.
- Investment generally being confined to greenfield development while the problems in existing urban areas remain unresolved.

5. Approaches to improve Affordability and Resilience

Although effort will inevitably be needed to repair stormwater systems affected by flood damage consideration should also be given to ways to improve the resilience of the system and to take a realistic assessment of affordability for the communities affected and benefit/cost of alternative approaches particularly in light of anticipated and impending impacts of climate change. Such considerations should include:

1. Obtain and manage good quality data to enable in-depth geospatial planning to be undertaken.
2. Recognise the inherent limitations of piped systems in the management of stormwater.
3. Identify and manage overland flowpaths through design and minor improvement works on roads and private property.
4. Policy initiatives including long term managed retreat from flood affected areas particularly in low lying property beside streams, rivers and coastal areas.
5. Integrated design taking into account environmental values, treatment and conveyance of stormwater and the potential for multiple benefits for the community

including provision of public open space and pedestrian/cycle ways.

6. Better information and education for the public and stakeholders around stormwater and flood risk management.

The following sections will expand on each of the above approaches.

5.1. Data Capture and GIS Analysis

Technology developments in recent years have enabled cost effective means of capturing and presenting geospatial data. For stormwater management in an urban context there is great value to be gained in procuring digital terrain data, building footprints and asset data.

Digital terrain data is most efficiently obtained through a LiDAR survey.

A building footprints layer can be established cost effectively by digitizing aerial photos.

A well specified, managed and prioritised CCTV programme will provide multiple benefits including:

- Asset data such as size, depth, location and connectivity.
- Asset condition data including pipe defects, root intrusions, sedimentation, intrusion from laterals and other services.

GIS tools and processes can be applied to the above data to create:

- A digital elevation model
- Rapid flood hazard mapping
- Network connectivity model
- Overland flow paths

With these data sets it is feasible and cost effective to undertake further analysis and mapping to inform flood risk management and asset management including:

- Where flood plains and/or overland flow paths intersect with building footprints.
- Nominal full capacity of piped systems.
- Defining depression areas and affected buildings.
- Contributing catchment to any part of the piped network and/or overland flow paths.
- Pipe criticality analysis.
- Prioritised programme for further investigation of pipe repairs, renewals and upgrades.
- Prioritised programme for further investigation of flood risk associated with flood plains, overland flow paths and depression areas.

Traditionally detailed flood modelling has been undertaken in many areas prior to having all of the above building blocks in place. The value and benefit of undertaking detailed flood modelling on a wide scale in advance of the above programmes and analysis should be carefully considered. While detailed flood modelling provides a robust basis for considering detailed options in a targeted area the data capture and analysis indicated above can go a long way towards building a well- founded cost effective understanding of the stormwater system and impacts of potential flood events.

5.2. Limitations of Piped Systems

Frequently the response to a major flood event is to call for more funding to provide more conveyance capacity in the existing piped network. Existing piped systems have often been designed to take the runoff from storms ranging from 2 to 10 year ARI. Storms resulting in major flood events normally have ARI's well in excess of 10 years. We generally have piped stormwater systems purposely designed not to convey the full flows from major storm events and we therefore expect that surface flooding will occur in such events.

Added to this the inlets to the piped network frequently have capacities less than the pipe capacity. Blockage of inlet grates further limits their capacity and is more likely to occur during a major storm event when debris, vegetation and litter is transported to the inlet.

Moving down to the point of discharge to waterways there is a common and growing problem. Sedimentation within harbours and major waterways is limiting discharge capacity, resulting in surcharging of the piped system and more frequent overland flows. In coastal areas sea level rise will exacerbate such issues leading to more extensive inundation in such localities.

Focusing stormwater management on the provision of pipe capacity will rarely result in managing flood risk. Safe storage of flood waters and conveyance through effective flow paths and waterways needs to have far greater attention in the management of flood risk.

5.3. Managing Overland Flow Paths

Mapping the approximate location of overland flow paths through GIS techniques provides a very useful basis for the management of associated flood risk.

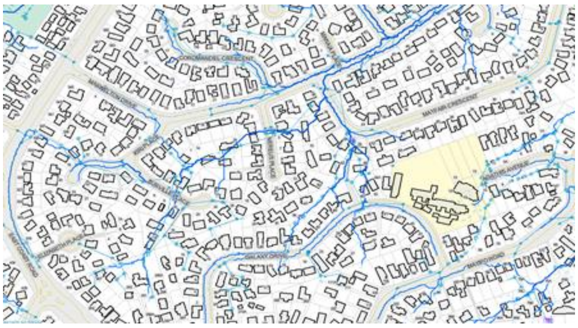

Figure 1: Overland flow paths

In local areas with small free draining catchments of less than 4 ha it is common for up to 80% of flooding of habitable floors during major storms to be attributable to overland flow. [3]. Where flow paths leave the road reserve at sag points or via driveways there is often a problem with flooding of adjoining downstream properties. Desktop studies of GIS data sets can show where flow paths leave the road and intersect with building footprints. Based on such analysis priority can be given to on-site inspection to determine flood risk and potential mitigation works.

Mitigation can often be as simple as minor ground reshaping and landscaping, relocation of obstructions such as small sheds and construction of planter boxes to divert flows from entering buildings.

Figure 2: Overland flow management

Planners and consenting officers can also use mapped flow paths to control new development and ensure that flood risk to new and existing properties is appropriately managed. The prevalence of infill and slab on ground construction in many cities is leading to an increase in flood risk that can only be managed by having a good understanding of the location of overland flow paths. Furthermore the poor design and construction of vehicle crossings and driveways for houses below road level is a common problem leading to flooding of habitable floors.

Figure 3: Poor vehicle crossing design

For larger subdivision development the location of overland flow within road and public reserve corridors should form a fundamental part of overall design of lot layout in order to manage and minimize flood risk for habitable buildings.

5.4. Flood Management Policy

Policies on flood management can be informed by running scenarios on potential climate change effects including increased rainfall and sea level rise. In low lying areas it may not be feasible from either an engineering or economic perspective to protect existing properties from flood inundation. In such cases managed long term retreat and land use change may be the only viable option. The alternative may be to face the potentially more devastating impacts of loss of property and life by continuing to occupy such land during combined storm and tidal events. The recent devastating erosion along the New South Wales Coast serves as a reminder of the reality of such risks.

Figure 4: Coastal erosion

5.5. Integrated Multiple Benefit Design

Management of flood flows can often be a driver for large scale projects. Opportunities to gain multiple benefits from such projects should be carefully considered including the potential for creating public open space, walkways, cycleways, day-lighting buried streams, providing stormwater storage and treatment, improving amenity and habitat. Many very successful projects have taken this approach and effectively utilized multiple funding sources from contributing asset owners. The resulting assets can have a very positive sustainable outcome for the community and the environment.

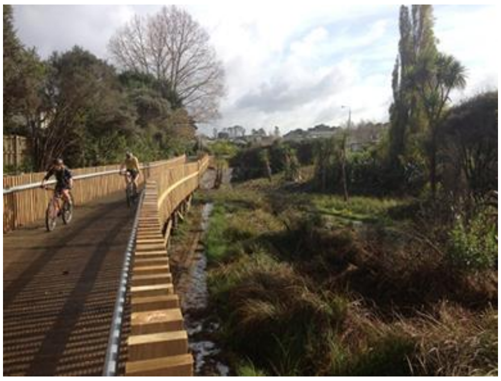

Figure 5: Alexandra Stream project

5.6. Information and Education

Last but not least, effective information sharing and education for the public and stakeholders is an essential tool in managing expectations and providing understanding related to climate change effects and flood risk.

This is an area often overlooked and under-resourced. Well designed GIS viewers can provide a wealth of knowledge relating to rainfall records, flood risk, and overland flow paths both at a broad scale and at a local level. Accompanying FAQs and graphics can provide straightforward explanations of the common issues, risks and means of managing risk. This can be particularly useful for homeowners and those developing existing or new buildings. Simple guidance of what to do and what not to do in managing overland flow at a house lot scale will in many cases go a long way towards managing the impacts of high intensity storms.

6. Conclusions

As local authorities face the increasing impacts of climate change, severe storm events and limited resources to maintain and improve stormwater systems there is a need to review and consider alternative approaches to stormwater management. Investment in geospatial data and its management can provide a cost effective basis for understanding the issues and limitations related to flood plains, ponding areas, the overland flow system and the piped network. From this understanding GIS tools and techniques can be used to:

- Provide thematic mapping of areas potentially at risk of flooding and parts of the piped network under capacity and/or in poor condition.
- Establish prioritized programmes to target flood risk assessments and potential mitigation works for properties likely to be affected by flood plains, ponding areas and overland flow.
- Establish prioritized programmes to assess and carry out repairs, renewals and improvements to optimize piped systems.
- Provide mapping and information to assist local authorities, property owners and developers in making well informed decisions related to flood hazards including potential climate change impacts.

The net result of this approach is a cost effective and sustainable means of identifying and managing flood risk at a property and catchment scale without over-investment in piped infrastructure.

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