LOCAL OVERLAND FLOODING – THE NSW EXPERIENCE

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Abstract

Local overland flooding describes inundation by local runoff rather than inundation created by overbank flows discharging from a watercourse, lake or dam. Depending on the nature of the local catchment and development, overland flooding can result in a flood risk, causing damage to property and risks to public safety. Local overland flooding is often characterised by a rapid rise in flood levels, particularly where the local catchment is relatively steep and small, however the flood hazard will be dependent on various factors such as depth, velocity, warning time and emergency management considerations. Those with exposure to local overland flooding are often unaware of their flood risk as it can occur in areas far from riverine floodplains. This exacerbates the sense of devastation for individuals but also creates problems for flood risk managers in identifying existing areas that are affected and implementing suitable management measures.

The NSW Floodplain Development Manual (DIPNR, 2005) recognises that flooding from all sources should be considered in flood studies in NSW however most assessments have focused on riverine flooding. The acknowledgement of overland flow as a potentially significant source of flood risk, advances in data collection and flood modelling, as well as changing requirements for land use planning, has led to an increase in studies into local overland flooding across NSW. Although it is now possible to better represent local overland flooding processes in numerical models, producing meaningful study outcomes that suit changing planning requirements, identify management solutions and can be readily conveyed to the community has proved challenging.

This paper discusses some of the local overland flooding issues encountered in NSW to facilitate a broader conversation to assist councils in their local overland flood risk management. A number of case studies are used to illustrate some of the issues faced and the significant variation in the scope and scale of problems and management techniques being used by NSW councils to achieve flood risk management outcomes.

Policy Context for Flood Risk Management in NSW

The primary objectives of the NSW Flood Prone Land Policy are to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible (DIPNR, 2005).

The NSW Government through the NSW Floodplain Management Program provides technical and financial support to councils to understand and manage their flood risk. This program traditionally focusses resources on larger scale flood problems where the damage and risk to public safety is the greatest.

Changes in 2001 which are incorporated into the Floodplain Development Manual (FDM 2005) provide councils with the opportunity to seek technical and financial support from the NSW Government for studies to better understand and manage the larger scale of local overland flooding, where there are risks to life or property, in a strategic manner. Since this time other factors have contribution to the need for local government to better understand their local overland flood risk and have influenced the approaches taken to these studies.

SEPP 2008

The NSW Department of Planning released the State Environmental Planning Policy (Exempt and Complying Development Codes), 2008 to encourage the further uptake of exempt and complying development throughout the state. This code provides for complying development to be undertaken on some land identified as being subject to flood controls. Where a property is known to have a flooding constraint council is to identify it on a planning certificate (under s149 of the Environmental Planning and Assessment Act, 1979) as a 'flood control lot'. This identification limits the ability to undertake complying development stating *"The development must not be on any part of a flood control lot unless that part of the lot has been certified, for the purposes of the issue of the relevant complying development certificate, by the council or a professional engineer who specialises in hydraulic engineering as not being any of the following: (a) a flood storage area, (b) a floodway area, (c) a flow path, (d) a high hazard area, (e) a high risk area*."

The code also sets minimum standards for development on flood control lots which include: *for areas within a flood planning area, the requirement that development must have all habitable rooms no lower than the floor levels set by the council for that lot (generally a flood planning level); use flood compatible materials in construction below the flood planning level; design the development to withstand the forces of flooding, not increase flood affectation of other properties, and to have reliable access to a safe refuge.*

Building code changes

Changes to the Building Code of Australia have meant that over time there has been a reduction in the minimum finished floor height above the final ground surface required within general building standards. This may lead to a potential increase in above floor flooding as a result of overland flow, particularly if development approval processes do not include an assessment of the local risk.

Flood Insurance Availability and Definitions

Flood insurance is becoming increasingly available within NSW and Australia. The insurance industry has a standard definition of flooding across all Australian insurance policies, which is: *"The covering of normally dry land by water that has escaped or been released from the normal confines of any lake, river, creek or other natural watercourse (whether or not altered or modified) or any reservoir, canal or dam".*

This definition was developed to specifically exclude local overland flooding, which is typically covered as a standard inclusion in home insurance policies (often as storm or water damage).

As these definitions may be different from those used by councils, insurers need to assess how the available information relates to the insurance definition of flooding. Where a council chooses to differentiate between local overland flooding and riverine flooding this may assist insurers in this assessment.

Other Changes

In addition advances in technology and the availability and accuracy of flood model input data (such as Light Detection and Ranging, LiDAR) have made local overland flood studies increasingly achievable, although not without limitations (discussed later), which need to be considered when interpreting results and considering management options.

NSW Guidance on Local Overland Flooding

The NSW Government has been supporting councils to conduct local overland flood studies for over 10 years. A review of the work done during this time has identified that there have been a variety of ways used to approach overland flood management, which have generally been driven by the scale and scope of the problem. Further, an analysis of the various approaches taken can provide valuable information for future flood risk management of local overland flooding.

Any guidance developed for this purpose would need to provide both flexibility in approach and definitions, whilst focusing on achieving effective management outcomes in areas where risk and damages are greatest.

A definition of local overland flooding

The FDM 2005 defines local overland flooding as inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Local overland flows can be generated from a variety of sources. To separate larger scale problems that need more strategic management, the FDM 2005 further categorises these into major drainage (larger scale) and local drainage (minor scale). This categorisation relates to the scale of problems occurring throughout urban areas and should not to be interpreted as the classifications of major and minor drainage systems generally designed under Australian Rainfall and Runoff over the last two decades. The principles in the FDM 2005 apply to all local overland flow associated with major drainage.

Given the significant variation in the types and scale of local overland flooding and the mechanisms that may be employed in its management, local councils apply the flexibility necessary to define major drainage in a manner that was suitable for their circumstances. FDM 2005 provided general guidance outlining that major drainage areas are typically where:

- the floodplains of original watercourses or trunk drainage systems (which may now be piped or channelised or diverted), or sloping areas where overland flows occur along alternative paths once system capacity is exceeded; and/or
- water depths are generally in excess of 0.3m (in the storm event used to derive flood planning levels). These conditions may result in danger to personal safety and damage to property; and/or
- major overland flow paths through developed areas outside of defined drainage reserves; and/or
- there is the potential to flood a number of buildings along the major flow path.

The depth of flooding of 0.3m selected for guidance to councils in defining major drainage was chosen in the FDM 2005 on the basis that the use of general building practice, where minimum floor levels, required in many circumstances to be 0.3m above finished ground level, could effectively manage this risk. However, building standards have subsequently changed to generally require finished floor levels a minimum of 0.15m above the finished ground level. Many councils now consider local overland flooding as areas flooded to a depth greater than of 0.15m in the planning flood to identify areas where additional stormwater or flood related controls may be warranted. Caution needs to be applied over the accuracy of the model results in areas identified with low flood depths.

Local drainage is defined as smaller scale problems in urban areas and is considered beyond the scope of the FDM 2005, though councils are encouraged to consider the principles in the Manual when addressing these local drainage issues.

Methodologies used for Local Overland Flood Studies

The NSW Floodplain Management Program has supported a range of studies from broad-scale to more detailed local studies to enable local councils to do either initial subjective assessments or more detailed assessment of flow paths. There are a variety of ways to investigate overland flow behaviour in a catchment.

Commonly, two methodologies are followed:

- Conducting an initial broad-scale study to assess the scale of the overland flood risk and identify hotspots. Following the broad-scale study, carrying out a detailed study/ies of the trunk drainage and hotspot areas within a catchment if required.
- Alternatively, if it is known what areas are affected by local overland flooding, or the catchment being investigated is relatively small, a detailed flood study of the catchment may be undertaken.

The methodology and modelling techniques used for local overland flood studies should take into account the objectives of the study and should be fit for purpose for the local situation. For example, a different approach may be used for the identification of properties for the purpose of meeting land-use planning requirements as compared to one that looks at mitigation options.

Broad-scale studies

Broad-scale studies can be a cost and time efficient method of assessing local overland flooding as they may satisfy planning requirements and negate the need for further study or, by identifying problem areas, reduce the size and scope for further detailed studies.

Generally broad-scale studies analyse high resolution digital elevation data using watershed/stream GIS based analytical tools in conjunction with a simple analysis of the trunk drainage system. The main output of these studies is the overland flow paths which can be used to highlight development potentially at risk of local overland flooding. However, no detailed information about flood behaviour, including depths or velocities is possible from these studies. Further studies are required to properly define flood risk. If broad-scale studies are being used to identify areas potentially at risk, the results should be ground truthed (i.e. checked to ensure that they are not being incorrectly identified as affected by overland flow purely based on this approach).

Detailed studies

Advances in data resolution and accuracy, modelling software and computer hardware have made detailed modelling of catchments increasingly viable, however they can still be costly and time intensive. Combined 1D/2D modelling is considered state of the art when it comes to flood modelling and is particularly useful in representing overland flow paths. Outputs include flood depth and velocity contours, enabling detailed information about flood risk including calculation of flood hazard and information about timing of flood events. It is important to note, however that the reliability and accuracy of flood models in areas experiencing low flows and/or depths is limited, as these models do not always appropriately take into account minor structures (such as fences, building, landscaping, etc) which can have significant impacts on flow paths and local overland flooding.

In a 1D/2D model, 1D model components can be used to define features such as the main river channel, pipe networks and hydraulic structures (such as culverts or bridges in the 2D domain which can then be connected to the 2D domain). The 2D domain can be defined by detailed elevation data such as LiDAR data, however care must be taken to ensure the LiDAR data and model data accurately represents the ground surface, and that the integrity of overland flow paths is maintained. In some circumstances manual manipulation of the ground elevations may be required to ensure the flood behaviour is appropriately represented. Additional topographic survey of bridges, culverts and any hydraulic restrictions which may impact on flood levels is also required to enable appropriate representation in the model.

Hydrology issues

Catchment inflows can either be input into the 2D model domain from a separate hydrologic model or as ‘direct rainfall’ (also known as rainfall onto the model grid).

The use of hydrologic models (such as RAFTS, WBMN or DRAINS) to supply inputs into models is a process that is well understood and has been tested and verified across a range of studies.

The direct rainfall method is a relatively new method of obtaining flows through a catchment (generally not requiring the need for a separate hydrology model) and has been less rigorously tested than the more traditional method of lumped hydrologic models. Direct rainfall uses model algorithms to choose the route of the rainfall applied to model grid cell, reducing the assumptions needed to be made by the flood modeller. Direct rainfall may not be applicable for all catchments (i.e. in high density areas, where there may be issues with response time as direct rainfall does not take into account runoff from developed areas being routed directly into the stormwater system). Model parameters such as model roughness, initial losses and continuing losses should be chosen with engineering judgement and the results compared to traditional hydrology outputs if available. If buildings are to be removed from the 2D domain either by making the cells in the building footprint inactive, or raising the building footprint, consideration should be given as to how this affects the direct rainfall quantities and flow routes.

Hydraulic model issues

Structures

The representation of structures that influence the local flood behaviour in models should take into consideration the required outputs of the flood study. Computational effort may also be a factor in deciding what method to use when representing structures such as buildings in a model. Consideration may also be given to the structure type (if known) and whether it would block and divert flood waters or whether they are structures through which floodwater can flow. Fences and other similar structures are rarely included in the model topography as obtaining that level of detail in a topographic survey, as well as their inclusion in the model, is often unrealistic. The hydraulic capacity of those structures is also often unknown. However, where structures are likely to have an impact on flood behaviour, they should be checked through ground truthing to ensure model outputs reflect likely flood behaviour (discussed later).

Models that cover a larger area and where only a general representation of overland flow paths is required may represent buildings by increasing the model roughness in the building footprint. An alternative methodology, generally used on detailed models, may be either raising the building footprint or making the model cells of the building footprint inactive to enable flow path information around buildings to be obtained. In this case, it is important to ensure the grid size of the model is appropriate to represent the overland flow path.

Stormwater network

Representation of the stormwater network may be required in detailed local overland flow studies particularly when a source of overland flow is surcharging of the pipe network. This can occur from several sources such as the results of backwater flooding in the stormwater network in particular near confluences with major drainage or low lying coastal outlets.

Previous studies conducted in NSW have compared model results with variations of stormwater network representations (Mackay et al, 2008). These have indicated that while detailed modelling provides a more realistic representation of flooding, particularly for frequent flood events, the differences in flood levels and extents between the different scenarios would not necessarily result in significantly different flood risk management outcomes or development controls being applied.

The cost of collecting stormwater data can also be problematic if this data is not already held by council. As an example, a model that included the entire pit and pipe network was estimated to be four to five times more expensive than a model that included only trunk drainage, and approximately fourteen times more expensive than a model with no drainage network.

Generally it has been found that including the entire stormwater network is not warranted for the identification of flood risk areas in the 1% AEP event (the scale of events of the most interest in flood risk management) for the cost involved. In most cases, knowledge and modelling of the trunk drainage system is adequate. If stormwater data is held by council, and there is a desire to explore management options for more frequent flooding, council could consider whether to include the pit and pipe network in the assessment. However, where the project has financial support from the NSW Government the ability to access subsidised funding for this additional work should be clarified with the Office of Environment and Heritage (OEH) before committing to it.

Flood Planning Levels and Areas

Flood planning areas (FPA) provide an important management tool for managing future flood risk. The aim is to identify those areas where flood related development controls are needed to manage the risks to people and property. The challenge for flood risk managers is to ensure that FPAs for local overland flooding are fit for purpose.

It is important to separate the area where the flood risk to be managed is primarily influenced by riverine flooding from that influenced by local overland flooding. Local overland flooding should be further separated into areas with major and local drainage issues.

The separation of areas of riverine flooding and major drainage (which may both need different flood related development controls) from local drainage (where flood related development controls are not likely to be necessary) will facilitate clearer separation of development requirements and may help with issues surrounding flood insurance and informing the community on their flood risk exposure.

Freeboard and FPA

Where a decision is made that a FPA is fit for purpose in managing risks in major local overland flood areas a freeboard needs to be considered. Freeboard is a factor to acknowledge the uncertainty and variability of the design flood estimate. It takes into account factors such as uncertainties in the estimates of flood levels, differences in water levels across the floodplain because of 'local factors' and increases in water level as a result of wave action (not determined in flood modelling). When added to the flood level of the planning flood it produces the flood planning level (FPL).

In local overland flooding the factors contributing to freeboard are not as substantial for riverine flooding and therefore a lower freeboard may be applicable. A freeboard of 0.3m has been applied in many areas and is provided as a default standard in some guidance documents (Queensland Urban Drainage Manual (QLD DEWS, 2013) for example). Studies should provide a breakdown of factors contributing to the proposed freeboard allowance to ensure transparency of the freeboard level adopted.

The FPA is usually a lateral extension of the FPL to where it intersects with the ground level, which determines the FPA extent. In local overland flood areas this may not be appropriate, particularly in flat terrain where the FPA can have significant lateral extension to areas that in practice are unlikely to flood. In such areas it may be more appropriate to divide the area into major local overland flood and local drainage areas. The categorisation of land using this approach has been trialled by a number of councils and enables councils to tailor suitable development controls to the estimated risk and as such apply relevant planning controls consistent the identified risk. Other approaches that have been adopted by councils include limiting the extent of the FPA with a horizontal buffer, however there are limitations to this approach and it should be used with caution and engineering judgement.

Mapping of Flood Study Results

Consideration should be made about how to best represent the extent of local overland flooding. This may be by mapping flood outputs extents, property lots or both, as required for planning and community consultation purposes.

In either case, flooding that is considered local drainage by council (i.e. less than 0.15m depth in a 1% AEP event) could be removed from the mapped model results to ensure that very low hazard areas do not have flood related development controls applied if these are not warranted.

Model results showing flood extents should be appropriately filtered and smoothed to provide a coherent outline. Techniques used to do this will differ on a case by case basis but will generally require:

- Smoothing of extent outline
- Removal of any isolated, small, shallow flood islands present in the flood extent that are a remnant from either the DTM resolution, mapping process or the direct rainfall modelling process.
- Engineering judgement

The FPA could then be used to determine properties to define as flood control lots (NSW Government, 2008). It may be appropriate to remove properties from the FPA where the extent only covers a small section of the property (see Table 1). Again, this approach should be used with caution and engineering judgement with consideration given to what section of the property is shown as flooded.

NSW Experience

The adopted criteria for local overland flood planning areas vary amongst local councils in NSW. These differences are a function of the variation in local issues, availability and potential variability of guidance, modelling techniques, engineering judgement, interpretation and changes to land-use planning requirements. Table 1 provides a snapshot of some of the approaches and criteria used.

Table 1 – Flood Mapping Criteria for Various NSW Councils

Different approaches used by NSW local governments for Flood Mapping Criteria
Flood planning area is considered to be the 1% AEP event plus freeboard of 0.5m. Properties within the FPA are separated into three categories – those with flood depths are less than 0.15m (not mapped), properties where flood depths are between 0.15m and 0.3m and properties where the depth is greater than 0.3m. This is to allow for flexibility in defining major and local overland flooding and setting appropriate development controls accordingly. A freeboard of 0.3m is to be applied to land within the FPA subject to major local overland flooding.
Flood planning area limited to the flood extent area (zero buffer). After freeboard of 0.3m is added the property is tagged if flood depths are greater than 0.15m in the 1% AEP event and more that 10% of the property is inundated. Isolated patches that are not part of a continuous flow path are removed. All mapping is confirmed by extensive ground truthing.
A property is tagged if it is below the 1% AEP extent plus 0.5m freeboard with greater than 0.15m property flood depth and more than 15% of property is inundated

Different approaches used by NSW local governments for Flood Mapping Criteria
1% AEP event plus 5m horizontal buffer on major Overland Flow category. Overland flow is separated into major overland flooding (greater than 0.3m flood depth) and minor overland flooding (flood depth greater than 0.15m and less than 0.3m).
Council has no minimum water depth but in ground truthing, it will include lots which have less than 0.15m flood depth if it forms a depression across the site. As most of the LGA is hilly the freeboard does not result in significant lateral extension of flood control mapping. In flatter areas the flood mapping is extended 1 or 2 properties either side of the flood study line. All new buildings within FPL zone have 0.5m freeboard. The minimum freeboard is 0.2m for catchment areas equal to or less than 2ha, varying between 0.2m to 0.5m for upstream catchment areas between 2ha to16ha.
Minimum flood depth mapped is 0.1m. Low risk is mapped as water depth 0.1m to 0.3m and has a freeboard of 0.3m. High risk areas have a freeboard of 0.5m. Medium risk areas have a freeboard between 0.3m to 0.5m evaluated on a case by case basis.

Ground Truthing and Sensitivity Testing

Ground truthing is essential in overland flow studies so that flood managers, planners and the community have confidence in the model results. Ground truthing can involve site inspections and if required survey of critical areas.

Sensitivity testing of model parameters can reveal how much impact different model parameters and associated assumptions have on the results. Testing of key parameters should be undertaken, particularly if there is little or no calibration data available, to increase confidence in the model results.

The following case study illustrates the importance of ground truthing and sensitivity testing in producing acceptable results.

Case Study 1

In November 2010 a whole of LGA draft overland flow flood study was completed and placed on public exhibition. The study identified some 4870 properties of a total of 45062 properties across the whole LGA as potential flood control lots and caused much opposition amongst residents and Councillors. Also during the public exhibition this figure was incorrectly reported in the media as 7900 houses which added to the adverse community reaction.

After detailed ground truthing, trimming of shallow flood waters and some further modelling the revised overland flood study has reduced this to 2221 properties. Figure 1 shows an example of the original and revised mapped flood control lots.

Figure 1- Example of original and revised draft flood study 100yr ARI flood control lots

Community Engagement

Defining areas subject to local overland flooding has the potential to be contentious as they can occur far from areas generally considered by the community to be flood prone and therefore the risk can be difficult to communicate to the public. Clear and early community engagement practices are necessary to achieve desirable outcomes through the engagement process, including community awareness and contribution to management measures. It is vital that the community engagement process has clear objectives and outcomes that include:

- Identify options to mitigate the risk if required and practical / feasible to do so;
- Better plan for flood risk including emergency response requirements;
- Identify and put in place appropriate development controls to reduce future risk;
- Improve community awareness & preparedness.

It has been found that community consultation for local overland flood studies should occur from the beginning of the project. Presentations to councillors and small group public exhibitions are beneficial as well as quality brochures and printed material that clearly explains the process of overland flooding and how to interpret model results. If limiting the FPA where appropriate (as discussed earlier) and ground truthing has been correctly undertaken, the public exhibition process should receive less criticism. Community consultation requirements should be clear in the study brief.

Management Options

Managing flood risk to existing properties in major local overland flood areas may involve mitigation works, where treatment is warranted, practical and feasible. This may include improving flow capacity of overland flow paths by formalising the flow path or encouraging more open style fencing to enable flow paths to work more effectively. It may also involve structural works such as detention basins, channel improvements, debris controls and/or drainage augmentation. Dependant on the risk exposure and relative costs and benefits, some of these works may be able to attract funding on a competitive basis from the NSW Floodplain Management Program, but measures to manage local drainage (i.e. the small scale of local overland flooding) are unlikely to be able to successfully compete for program funding.

Land-use planning enables the strategic management of future risk which generally involves applying development controls to new development or redevelopment in affected areas. Development controls generally aim to manage the impact of the new development on flood behaviour and flood risk to others in the community, and to manage the impact of flood risk to the new development and its occupants. It is important to ensure that where flooding is influenced by more than one mechanism (i.e. riverine and local overland flooding) that both are considered in setting appropriate development controls.

The NSW Department of Planning provides a model clause for flood planning for councils to use where relevant in their local environment plans (LEP). This clause was primarily developed for riverine flooding and can be used where fit for purpose for the application of development controls in local overland flooding areas. However, councils should consider whether an alternate or modified clause would better suit the situation or if separation between riverine and local overland flooding can effectively be undertaken in a Development Control Plan (DCP).

Conclusion

The NSW Government provides technical and financial support to councils to understand and manage their flood risk through the NSW Floodplain Management Program. This program focusses resources on larger scale flood problems where the damage and risk to public safety is the greatest. Since 2001 all sources of flooding, including local overland flow, have been considered in determining flood risks. This has enabled councils an opportunity to better understand and manage the larger scale of local overland flooding, where there are risks to life or property in a strategic manner.

This paper has discussed some of the challenges facing flood risk managers in appropriately defining, managing and communicating the flood risks associated with local overland flooding. There has been a notable variation in the way many aspects of local overland flood risk have been dealt with by councils in NSW and this paper describes some of the ways in which studies have been undertaken to meet the particular objectives of council.

Given the variation in approaches to local overland flood studies, OEH is considering the need to develop further guidance in order to provide advice on suggested approaches to deal with local overland flooding that are fit for purpose and support the outcomes required by Council. In the interim OEH staff are continuing to work with councils and practitioners by providing technical support to councils undertaking local overland flood studies.

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