

How to Evaluate Urban Flooding - The Holroyd Approach

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SUMMARY: In recognition of the need to comply with the provisions of Section 149 of the NSW EP & A Summary Act - Holroyd City Council has developed a set of standards (based on relative depth of floodwaters) which when applied for a designated flood event define certain limiting conditions. If the conditions are exceeded then a flood affectation clause is included on the Section 149 Certificate.

The paper details those standards and examines, by way of proven methodology, the practical approach of how the standards are applied.

1. THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT (1979)

The NSW Environmental Planning and Assessment Act (1979) provides the framework for regulating development and protecting the environment in New South Wales. As stated in **Reference 1** it has the object of encouraging:

- c “ the proper management, development and conservation of natural and man-made resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment
- C the promotion and co-ordination of orderly and economic use and the development of land;
- C the protection, provision and co-ordination of communication and utility services;
- C the provision of land for public purposes;
- C the provision and co-ordination of community services and facilities and
- C the protection of the environment".

Within the act (under Section 149) there is provision for a Certificate which specifies various matters relating to any property, e.g. zoning, development controls, road widening

proposals, land slip, flooding, subsidence, etc. (Members of the public who own property usually are oblivious to the existence of the certificate until they decide to sell their property at which point they need a copy since the Certificate is required to be attached to contracts for the sale of property).

In respect to flooding, Councils are specifically required to advise "whether or not the Council has by resolution adopted a policy to restrict development of the land by reason of the likelihood of...flooding...". (Hence if a Council has not adopted such a policy to date, that needs to be stated on the Certificate).

A further provision of Section 149 of the Act is that "Council(s) may ... include advice on such other relevant matters affecting land of which it may be aware". Legal opinion would suggest that under this provision councils would incur no liability for providing such additional information in good faith. Legal opinion would also suggest that where Councils are aware of information regarding flooding, they should provide what information they have in the Certificate.

Legal opinion was requested by Council in March 1990 before proceeding and this stated as follows:

- " 1. Since Council is only required to state in the Section 149(2) Certificate whether or not it has adopted a policy re: flooding Council must do so and if appropriate state that it has not.
2. Section 149(5) provides that additional information may be supplied but more importantly the Section 149(6) says that Council 'shall not incur any liability in respect of any advice provided in good faith pursuant to Subsection (5)'.
3. Accordingly, use should be made of the protection afforded by Section 149(6) to Section 149(5) advice and Council should (until Council has re-evaluated likelihood of flooding in the light of its own investigations and those of the Department of Water Resources) provide what information it has in the Section 149(5) Certificate.
4. The Section 149(5) Certificate should state the problem that recent flooding has undermined previous assumptions and that Council is undertaking a study of the liability of land in the Municipality to flooding.

The Section 149(5) Certificate could then go on to describe those areas likely to be subject to flooding and those areas (adjacent or not) which Council is unable to state at this stage whether they are liable to flooding or not. Perhaps this can be done by provision of a simple map.

5. The Section 149(5) Certificate should also suggest that applicants and persons relying on the Certificate also inquire at the Department of Water Resources (where relevant).
6. On the basis that some applicants apply for a Section 149(2) Certificate only, the Section 149(2) Certificate should be endorsed to state that further information regarding flooding is provided by Council pursuant to Section 149(5)."

In accordance with its duty and moral obligations, Holroyd City Council is providing additional information on Section 149 Certificates. The designated properties are flagged on Council's computerised land information system and a special program is at present being developed to automatically print out Section 149 Certificates with the relevant flood affectation clause, including the 100 year flood level in the case of mainstream flooding. That additional information is provided on the basis of the examination of mainstream flooding or urban flood hazards (as the case may be).

Details of Council's urban flood hazard assessments are provided below.

2. HOLROYD CITY COUNCIL HAZARD ASSESSMENT

2.1 Main Creeks

Similar to many Councils, the main open creeks within Holroyd have been investigated and modelled by either the Department of Water Resources or the Water Board. These studies have established at least 100 year flood levels and usually other flood levels such as fifty year, twenty year, etc. Levels of existing land have also been provided in those studies and where insufficient, Council has carried out additional level surveys.

This data has enabled Council to establish those properties affected by 100 year storms and the following notation is added to any Section 149 Certificate requested for those properties;

"Council records suggest that the subject land may be liable to flooding, based on information from a flood study in the area. On written request, Council will supply the designated flood levels for the area which should be used with an appropriate survey plan to better interpret the flood affectation of the land".

This approach is termed "Mainstream Flooding" and some investigations and works have been implemented to reduce the level and extents of this flooding. However, the type of flooding affects a relatively small number of properties and the 100 year flood standard has been applied due to the large quantity, depth and velocity of stormwater in those creeks, compared to local stormwater systems. It is also in keeping with the standard usually applied to creek and rivers.

2.2 Local Stormwater Systems

Initially, and to be consistent, a 100 year flood protection was also applied to these systems. However, within a few months of application, this approach was abandoned for the following reasons:

- C due to the much longer length of local stormwater systems, the number of properties affected was very large;
- C even in the long term, Council could not hope to carry out works such as the purchase of properties to remove the risk, due to the massive cost;
- C it was extremely difficult to establish which properties were affected without an expensive Council-wide study and it was logically considered that such funds would be better used in carrying out works. In the case of Mainstream Flooding, such an analysis is much easier as the creeks are largely clear of obstructions such as fences, houses, etc.

As a result, a 20 year level of protection was selected for the following reasons:

- C the above problems would be overcome;
- C the 1980s storms had been reasonably well documented by Council and residents, were the largest in the memory of the local residents and caused the largest damage and social upheaval. These storms were approximately of a 20 year level magnitude;
- C in general, it was considered that if the 20 year storm could be controlled, the overland gap flow to the 100 year storm would pose a minor risk to the residents; nonetheless any analysis would still consider such a storm.

This approach is termed "Stormwater Flooding" and this paper only refers to this approach from hereon. At Holroyd, this approach generally applies to systems with flows up to approximately 24 m³/s in a 20 year storm (based on an urbanised catchment of 140ha and a corresponding 100 year flow of 32 m³/s).

Council's policy re the designated level of protection is however flexible in recognition of exceptions where a higher level of protection (to 50 or 100 year ARI) should be given. This would apply where 20 year flood protection would still leave a hazardous situation, i.e. serious over-floor flooding would still occur, involving large depth and high velocity overland stormwater flow. In general, Council aims wherever practical and economic, to provide 100 year protection to "over floor" flooding, particularly in respect to habitable areas.

Having adopted the 20 year event as the designated urban flood event Holroyd City Council set about the task of determining what flood conditions would constitute unacceptable levels of risk and/or damage in the designated event. The conditions needed to satisfy the very important objective of Council's policy of bringing to notice the fact that Council is aware of flooding occurring that is of significant concern in the community due to actual or potential loss or damage to property, or in extreme cases, life. (A side benefit of adopting a designated flood standard that equates to recent major flooding is that Holroyd Council residents are able to provide quite precise details of actual flood damages for events that are similar to the designated event).

If the conditions were exceeded then (funding permitting) the local trunk drainage system should be upgraded and potential flood affectation wording would not be required to remain on individual property Section 149 Certificates. (Conversely if the flood conditions were not exceeded then local properties would not have a flood notation on their certificates and the capacity of the trunk drainage system would not warrant any increase.)

Holroyd Council's engineering staff subsequently developed the following limiting flood depth criteria (for the designated flood event):

- (a) "inundation of enclosed floor areas of main buildings (eg dwellings, factories); or
- (b) inundation of minor improvements (eg garages, pools, storages areas, etc) and the average depth of the overland flow is generally greater than 200mm. Minor improvements is defined as minor development in Council's Draft Development Control Plan and the Floodplain Development Manual (**Reference 1**). (The 200mm depth is based on the depth at which vehicles start to float as per the Manual): or
- (c) inundation of the undeveloped part of a property (eg, rear yards) or an undeveloped property, where overland flow depth is greater than 500mm, able bodied adults would have difficulty in wading due to depth and velocity, there would be danger to life and limb, or damage potential to existing or future yard improvements (eg, fences, aviaries, pergolas, etc)". (**Reference 2**)

If Council officers are clearly aware that a property is affected by one or more of the above criteria (especially if there is written information in Council's record system), the following clause is added to any Section 149 Certificate requested:

"This property may be subject to overland stormwater flow during periods of extreme rainfall. However, Council's information is incomplete and interested persons should make their own enquiries in the local area, and/or seek the services of a suitably qualified engineer to ascertain the likely effect, if any, on the property."

3. ASSESSMENT OF 20 YEAR FLOOD CONDITIONS

Holroyd Council recognised that the above criteria would assist in identifying lengths of drainage systems that are of significant concern but that it would be more difficult to apply the test to individual properties due to incomplete information being available. It would therefore be necessary to gather together the best available (historical) information, and based on that information and also engineering judgement, identify properties for notation.

As with almost all other Councils the stormwater flooding information available to Holroyd Council is generally incomplete. Council has some knowledge of affected areas due to complaints received, observations made, or in limited cases, because of more detailed investigations by Council and the Water Board. Flood depths are not well defined or recorded, and anyway in many cases flood depths affect different properties in different ways. In some cases, it is known water has gone through houses and/or garages but in neighbouring properties, where significant flooding could be expected, little or no information may be known.

Such flooding is not as easily defined as mainstream flooding because the piped drainage network (and its associated overland flow paths) is significantly more extensive and its detailed assessment is costly, and overland flow analysis is difficult due to the complex interaction of fences and other obstructions on overland flow.

For stormwater flooding it is therefore often necessary (at least initially) to use engineering judgement to assess the extent of flooding on properties (without the benefit of detailed calculations or first hand knowledge of historical floods). In Holroyd this judgement is made against the standard of protection that Council would generally seek, that is the limiting 20 year flood conditions where stormwater flows traverse residential properties. However, it must be stressed that this judgement is not easy to apply, even though it must only be applied by very experienced engineers. Often, the decision is very difficult, in which case, a second experienced engineer is involved.

In certain neighbourhood localities where Holroyd Council was generally aware of severe historical flood problems Council has determined that detailed investigations are necessary. Once again the aim of the investigations would be to define the extent of the historical problems and to adequately define the potential 20 year event conditions (so that the need or otherwise to apply Section 149 flood notations could be resolved).

In discussions with Council's officers Bewsher Consulting, consulting engineers proposed a methodology for the neighbourhood investigations and that methodology has been successfully used in several studies. As listed below, there are seven steps in the methodology:

1. The delivery of a detailed flood questionnaire (with accompanying covering letter) to

all households in the study area

2. The commissioning of detailed ground survey through the study area and subsequent generation of survey base plans. (The survey typically includes spot levels at house and garage locations, property boundaries, road kerbs and centrelines, definition of major and minor building footprints and floor levels and the definition of boundary fence types. If not already available the survey also defines the trunk system pipe diameters and levels, pit levels, etc)
3. The careful review of historical flood information contained in the returned questionnaires, with follow-up telephone and field interviews as required.
4. Based on the compilation of flood depths throughout the study area, historical flood contours are plotted on to the survey base plans. (Ideally the contours represent the levels corresponding to the two or three best documented floods.)
5. The use of Hydraulic Grade Line (HGL) analysis to define the capacity of the pipe system.
6. The generation of a hydrological model (preferably ILSAX given its ability to define separate pipe and overland flow hydrographs) of the catchment encompassing the study area with the subsequent calculation of historical flood hydrographs and design 20 year and 100 year flood hydrographs. The historical flood hydrographs are generated from storm temporal patterns obtained from the nearest rainfall recorder station(s). The historical and design flood overland flows are compared so that the historical floods can be assigned approximate average recurrence intervals. Hence the historical flood contours are adjusted to achieve the best approximation of a 20 year flood event.
7. The 20 year flood depths through each floodprone property are then determined (by comparing the flood contours with the surveyed spot levels) and hence it is possible to determine which properties have flood depths that exceed Council's limiting depth criteria.

3.1 Case Study 1

In a study of a neighbourhood in the suburb of Greystanes (**Reference 3**) the consultant determined that nineteen of some forty properties that had experienced some form of historical flooding would be expected to experience excessive property inundation (as defined by Council's depth criteria) in a 20 year flood event including one house. Of those nineteen, twelve houses would be expected to be inundated in a 100 year flood event. (For this locality, 20, 50 and 100 year flood contours were developed following the plotting of historical flood contours for three recent and significant flood events).

As part of the study a number of flood mitigation alternatives were then examined. Each of the alternative schemes were assessed on three criteria: the number of properties still

subject to a Section 149 flood notation, the number of houses flooded in a 20 year event and the number of houses flooded in a 100 year event.

On the basis of the assessed benefits (in terms of numbers of affected properties) and estimated flood mitigation costs Council adopted a two stage scheme of which the first stage involved the purchase and demolition of the slab-on-ground dwelling on the worst flood affected property (\$200,000) and the commitment of funds for detailed design and construction of upper catchment flood retarding basins (which are now in place - \$550,000). On completion of the first stage works there would be no houses inundated in events up to and including the 100 year event and five of the original nineteen annotated properties would have the Section 149 notation removed i.e. a total of 15 properties benefit from the first stage (where two properties benefit from no house inundation and removal of the Section 149 notation).

(The worst affected property was a house that had been flooded three times in five years and the cost to provide protection by a piped drainage system (the only solution), was three times the cost to purchase the house/property, and this was additional to the cost of protecting all the other affected properties. Hence, the economic solution was purchase and demolition of this one dwelling at a cost of \$200,000.)

The second stage consists of a duplicate pipeline (which will serve to protect the balance of properties not sufficiently protected by the basins scheme). That is, upon completion of the second stage works no properties would experience significant flooding and would therefore not be burdened by Section 149 notations.

3.2 Case Study II

In a Merrylands catchment study (**Reference 4**) 29 properties experienced varying degrees of flooding in two major storms in February and August 1990. Based on returned questionnaires and follow up interviews, overland flow contours were able to be compiled for those flood events. Flood contours for 20 year and 100 year flood events were then produced. Hence it was determined that under existing conditions twelve of the properties would require flood notations, four would suffer 20 year above floor level inundation of dwellings and eight would suffer such inundation in a 100 year event.

The study examined the potential benefit of constructing two flood retarding basins on upper catchment vacant allotments owned by Council. It was found that while construction of the basins would not eliminate downstream flooding they would reduce the flood flows to such a magnitude that they would meet Council's hazard criteria. Hence, together with other (minor) works, the construction of the basins would enable the Section 149 notations to be removed from all 29 properties, and none would suffer above floor flooding in events up to and including a 100 year event.

Council subsequently approved funds for the detailed design and construction of the basins and they have been completed (at a cost of \$276,000).

4. COMMUNITY REACTION

The reaction by the community to this system, has after about three years operation, been very positive and promising, with the majority accepting the notation, after an experienced engineer has diplomatically, patiently, and clearly explained the reasons. Consequently, no political problems have arisen.

5. CONCLUSIONS

- C Guidelines have been developed by Holroyd City Council for the provision of drainage or flooding information on Section 149 (NSW EP and A Act, 1979) Certificates in the following categories:
 - "Mainstream Flooding" (large open creeks)
 - "Stormwater Flooding" (local stormwater systems)

The objective being to bring to notice where flooding occurs that is of significant concern in the community (due to potential for loss or damage to property, or in extreme cases, life). The existing property owners are not notified beforehand nor is the matter advertised.

- C Under Council's policy the notations on Section 149 Certificates would be no longer necessary where drainage or flood mitigation works are carried out to reduce urban flooding to less than the criteria given in this paper for the 20 year flood in the case of "Stormwater Flooding".
- C Removal of Notation - As far as resources permit, Council is endeavouring to investigate and carry out construction of flood mitigation and drainage works to reduce the impact of flooding and flood liability in Council's existing development areas. (A methodology used successfully in the detailed investigation of the worst affected urban neighbourhoods is presented.)
- C Each situation, in the case of "Stormwater Flooding", would need to be considered on its merits. However generally if a 20 year protection could be provided to a property, previously affected by stormwater flooding, the notation would no longer be necessary as the drainage then meets Council's standard. In cases where the drainage improvements do not totally remove the 20 year ARI affect, mainly in respect to the depth in garages or more particularly, through the undeveloped areas

of the property (but the improvements have reduced the affect), Council requires the drainage study to define the inundation depths. This more detailed information is then available (on request) to the owner or prospective purchaser as a result of the Section 149 notation.

- C Holroyd Council engineering officers certainly do not consider that this system is perfect, nor that it is easy to apply, particularly in regard to the "judgement" issue. However, it is considered to be a step in the right direction, and hopefully it will stimulate further thought and comment to provide a better system for the benefit of the community and the engineers who serve the community.

6. REFERENCES

1. NSW Government (1986) Floodplain Development Manual PWD Report No. 86101 ISBN 724030115
2. Holroyd City Engineers Report No. 90/88 Section 149 Certificates and Drainage Notation endorsed by Holroyd City Council on 17 July 1990.
3. Bewsher Consulting (1991) Upper Pendle Hill Creek (Old Prospect Road, Greystanes) Drainage Study Commissioned by Holroyd City Council. January
4. Bewsher Consulting Pty Ltd (1991) Drainage Investigation Bowden Street to Matthew Street Merrylands Commissioned by Holroyd City Council. November