COST BENEFIT ANALYSIS OF URBAN FLOOD PROTECTION

Allan Leahy, Principal Technical Specialist – Stormwater, MWH
Alexander Cropp, Water and Wastewater Engineer, MWH

ABSTRACT

As engineers working in the local authority environment we are often asked to make decisions on the spending of public money to provide flood protection to existing at risk urban structures. Historically, and currently, in New Zealand there has been limited quantitative information available on which to base these investment decisions. This has lead to these decisions often being based on ad hoc assessments or political pressure rather than value for money.

This paper will describe a methodology adapted from international literature to provide a quantified cost benefit approach to flood protection investment decisions. It will describe the scenario, the approach adopted and the sources of flood damage cost information used. It will further describe the limitations of available information and the work needed to provide more robustness in this area.

These issues will be discussed in the context of a real life example of application of this methodology. The impacts (benefits) of implementing this methodology on an otherwise ad hoc decision making process will be described in terms of getting the best value out of the spending of the public purse.

KEYWORDS

Cost Benefit analysis, urban stormwater, flood protection.

PRESENTER PROFILE

Allan Leahy is a Civil Engineer by training and a Stormwater Engineer by choice. He has been involved in stormwater and in particular stormwater management issues for over 25 years. He is currently Principal Technical Specialist – Stormwater for MWH NZ Ltd based in Auckland but providing support on stormwater projects nationally and around the Pacific Rim.

1 INTRODUCTION

In 2009 MWH were commissioned to prepare designs for the flood protection of an urban area subject to flooding. This commission followed a standard concept, preliminary and detailed design process for the construction of physical works. It relied on the results of modelling previously carried out by other parties.

The concept design options were considered and options costed by MWH. However, at the end of this phase questions were raised about whether the proposed flood protection works represented good value for money for the project and for ratepayers generally. MWH suggested that it would be appropriate to carry out a cost benefit analysis to confirm the value of the work to the community before committing to further expenditure on the project. The client did not have any formal methodology of determining benefits/costs for these types of works and thus MWH researched and applied a methodology found in international literature.

2 TECHNICAL PROBLEM

The area concerned is an established (30 – 40 year old) residential area built in a natural low point in the catchment. This low point drains via a single pipe with limited inlet and carrying capacity. The earlier modelling had indicated that a number of habitable and non- habitable building floor levels would flood in quite moderate events. There was however no historical record of habitable floor flooding having occurred.

Solutions considered included lowering the level of the overland flowpath, diverting water upstream and increasing the pipe and inlet capacity. The preferred solution from the concept design was to construct a new pipeline with significantly increased inlet and outlet capacities to reduce the ponding level and hence impacts. The estimated cost of this work was $1.5million. Following the derivation of the construction costs a decision was made to investigate the cost/benefit of the proposed works.

3 COST / BENEFIT RESEARCH

As the client had no formal cost/benefit analysis tool, MWH was asked to carry out some limited research on cost/benefit analysis of flood protection works and to implement the results of that research on this project.

The methodology adopted from this research was a modification of the US Army Corps of Engineers HEC-Flood Damage Analysis methodology. This methodology is ideally suited to GIS applications and can be applied to large areas. However, for this localised issue a spreadsheet adaptation was used and is described in this paper.

4 FLOOD DAMAGE ANALYSIS PROCESS

The process adopted was to:

1. Remodel the catchment and flood prone area in more detail using updated survey data (including floor level data).

   The Modelling included firstly modelling the unmodified stormwater network to determine the base case. This was subsequently extended to include the mitigation scenarios.

   The modelling also included a range of events (2, 5, 10, 20, 50 and 100 year ARI's). To ultimately enable a Damage/Frequency curve to be developed.

2. Determine depth of inundation for each habitable and non-habitable building in the flood-prone area for each event.

3. Determine the cumulative cost of damage in each event.

4. Determine the annual and cumulative 100 year flood damage cost.

5. Determine the cost/benefit of the flood protection works. Benefit to be taken as the reduction in the cost of flood damage determined from the above analysis.

5 ISSUES

Most of the work for this Flood Damage Analysis, when broken down, involves reasonably systematic and standard calculation techniques. The papers found in our research dated back to 1975, so did not necessarily rely on high levels of computation. However, a few issues were highlighted during this analysis that needed careful considerations.

1. Computational Variances

   The hydraulic computer model used in this analysis was adopted from the client's pre-existing model. As such there were a range of assumptions that were carried across, that were effectively client specific.

   Once the results of the detailed survey were incorporated into the hydraulic model, they significantly altered the flooding levels reported from the previous modelling. This issue had to be investigated and confirmed with the client's modeller prior to proceeding.

The updated/new model also yielded some significantly different results in terms of the benefits of the remedial works than indicated by the static calculations used in the design phase. Effectively, once again demonstrating the benefits of a system type analysis approach opposed to a static pipe type analysis.

Each of the above issues needed to be investigated and resolved prior to the modelled outputs being accepted for further cost analysis.

2. Damage costs

   A very key issue in the Flood Damage Analysis is the actual cost of the damage. This statement is fairly obvious, however a literature review found very little information on the costs of residential flood damage in the New Zealand context. In the end a 1992 Agricultural Engineering Institute Research report which set out the results of research carried out in the Hutt Valley on flood damage was located.

   This report provided flood damage costs for an average house and an above average house as well as non-habitable buildings. It also allowed for the varied costs of damage for different levels of inundation within the building.

   Of course these 1992 values had to be updated to 2009 values to enable comparisons with the 2009 mitigation costs. The domestic CPI was used to update the damage cost estimates to 2009 values.

3. Social Cost

   A key point to bear in mind is that the flood damage estimate used in the analysis described in this paper included for the physical cost of damage only. The social costs in terms of stress, relocation or medical costs were not factored in to the analysis. In a more comprehensive analysis these costs should be considered and included but for the purposes of this project were not.

6 RESULTS

Once the survey and remodelling were completed, the damage analysis was carried out by a relatively simple spreadsheet. This enabled damage to different buildings and different flood depths to be quantified. The damage analysis was undertaken by integrating the area under the frequency/damage curve to derive the 100 year and the annual flood damage result in terms of the cost/benefit of the previously proposed works.

These can be summarized as:

- Cost of proposed works $1,500,000.
- Benefit of proposed works $845,000.
- Benefit cost ratio of proposed works 0.57

That is in terms of physical works costs and benefits there were 57c in benefits to the project for every $1 spent on the remedial. Even considering that this analysis did not take in to account the social benefit of the works the client decided that the cost benefit did not warrant proceeding with the proposed work. Alternative options were subsequently considered. As a side note these proposed works also then increased flood flows and therefore effects downstream which also required mitigation. The benefits of not passing these flows downstream were not considered in the above analysis.

A copy of the flood depth summary is provided below.

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CALCULATIONS

Description: *Option 3: Increase the outlet pipes*

Address	Type	Reduced Level	Storm Event Effects						
			2 year	5 year	10 year	20 year	50 year	100 year	CMP 1%
			17.45	17.78	17.95	17.99	18.21	18.28	18.42
No*	House	18.92	1.47	1.14	0.97	0.93	0.71	0.64	0.50
No*	Garage	18.30	0.85	0.52	0.35	0.31	0.09	0.02	-0.12
No*	House	18.48	1.03	0.70	0.53	0.49	0.27	0.20	0.06
No*	Garage	17.96	0.51	0.18	0.01	-0.03	-0.25	-0.32	-0.46
No*	House	18.16	0.71	0.38	0.21	0.17	-0.05	-0.12	-0.26
No*	Garage	17.83	0.38	0.05	-0.12	-0.16	-0.38	-0.45	-0.59
No*	House	18.61	1.16	0.83	0.66	0.62	0.40	0.33	0.19
No*	House	19.82	2.37	2.04	1.87	1.83	1.61	1.54	1.40
No*	Garage	17.55	0.10	-0.23	-0.40	-0.44	-0.66	-0.73	-0.87
No*	House	19.69	2.24	1.91	1.74	1.70	1.48	1.41	1.27
No*	Garage	17.21	-0.24	-0.57	-0.74	-0.78	-1.00	-1.07	-1.21
No*	House	19.53	2.08	1.75	1.58	1.54	1.32	1.25	1.11
No*	Garage	17.61	0.16	-0.17	-0.34	-0.38	-0.60	-0.67	-0.81
No*	House	19.07	1.62	1.29	1.12	1.08	0.86	0.79	0.65
No*	House	19.52	2.07	1.74	1.57	1.53	1.31	1.24	1.10
No*	Garage	18.10	0.65	0.32	0.15	0.11	-0.11	-0.18	-0.32
No*	House	19.19	1.74	1.41	1.24	1.20	0.98	0.91	0.77
No*	House	19.93	2.48	2.15	1.98	1.94	1.72	1.65	1.51
No*	Garage	17.64	0.19	-0.14	-0.31	-0.35	-0.57	-0.64	-0.78
No*	House	18.92	1.47	1.14	0.97	0.93	0.71	0.64	0.50
No*	House	18.89	1.44	1.11	0.94	0.90	0.68	0.61	0.47
Total Houses effected			0	0	0	0	1	1	1
Total Garages effected			1	5	6	6	7	8	8

7 CONCLUSIONS

- Flood Damage Assessment of the costs and benefits of flood mitigation works can provide a useful tool in the justification of spending public money.

- Flood Damage Assessment requires a reasonable amount of input analysis data, but is also scalable to large or small sites, using simple spreadsheet or more complex GIS analysis.

- There is limited information published in New Zealand on the cost of flood damage to various urban structures. More work needs to be put in to improving the quality and availability of data for New Zealand Flood Damage Assessments.

- Flood Damage Assessment should include social costs as well as physical costs. These costs are harder to quantify than the physical costs but are certainly necessary in a comprehensive analysis.

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