A TIDAL BARRIER TO PROTECT CHRISTCHURCH? A CONTROVERSIAL PROPOSITION

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ABSTRACT (300 WORDS MAXIMUM)

As part of the Land Drainage Recovery Programme the Christchurch City Council undertook a pre-feasibility study of a tidal barrier across the entrance of the Avon-Heathcote Estuary. A barrier has been considered at this location for over 50 years. Its purpose for Christchurch would be two-fold: firstly to mitigate fluvial flood risk by artificially holding back the advancing tide during high flows from the Avon and Heathcote Rivers. This would allow the rivers to drain more freely into the estuary. Secondly, it would hold back exceptionally high tides to protect low lying land.

In the face of increased flood risk as a result of the earthquake sequence, and impending climate change, it was considered pertinent to consider a tidal barrier. This paper briefly explains the tidal barrier design proposition while the major focus is on the Council and community reaction to the barrier proposal.

The study concluded that a barrier is technically feasible. It would cost in the range of $300 - $350M, with operations and maintenance ranging from $2 to $7M per year. This would protect a considerable area of public and private assets.

Council requested commentary from its key stakeholders on the proposition. Strongly worded responses were forthcoming but their direction was mixed. Some stakeholders were highly opposed to a hard engineering solution and considered it represented a false security. There were widespread concerns about the perceived lack of consultation. The environmental effects were raised, but paradoxically so were the concerns that the estuary would be fundamentally changed through sea level rise. Several responses suggested a city-wide integrated approach to flood management would be more pragmatic.

The Council considered the proposal, feedback and alternatives and voted not to proceed with a full feasibility study. The paper discusses the implications for other Councils in presenting engineering options to mitigate climate change.

KEYWORDS

Tidal barrier, climate change, stakeholder engagement, estuary, feasibility study

PRESENTER PROFILE

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1 INTRODUCTION

Christchurch is a low-lying city adjacent to the coastal environment and is therefore vulnerable to tidal effects on its drainage systems. The geography also increases susceptibility to tidal flooding and the sea level rise associated with climate change.

One method of combating both challenges is the construction of the tidal barrier. In Christchurch, the logical location for this is in and around the Avon-Heathcote Estuary (Figures 1 & 2), which is the outflow from the two major urban river systems and could provide a substantial area for flood storage. Such a barrier would conceptually work in Christchurch in two ways:

1. To artificially hold back the advancing tide, which would permit the Avon and Heathcote rivers to drain more freely into the estuary, which would provide flood storage; and

2. To hold back exceptionally high tides, such as spring tides or storm surges, to protect low lying land adjacent to the estuary and river mouths. This would be of increasing importance with climate change.

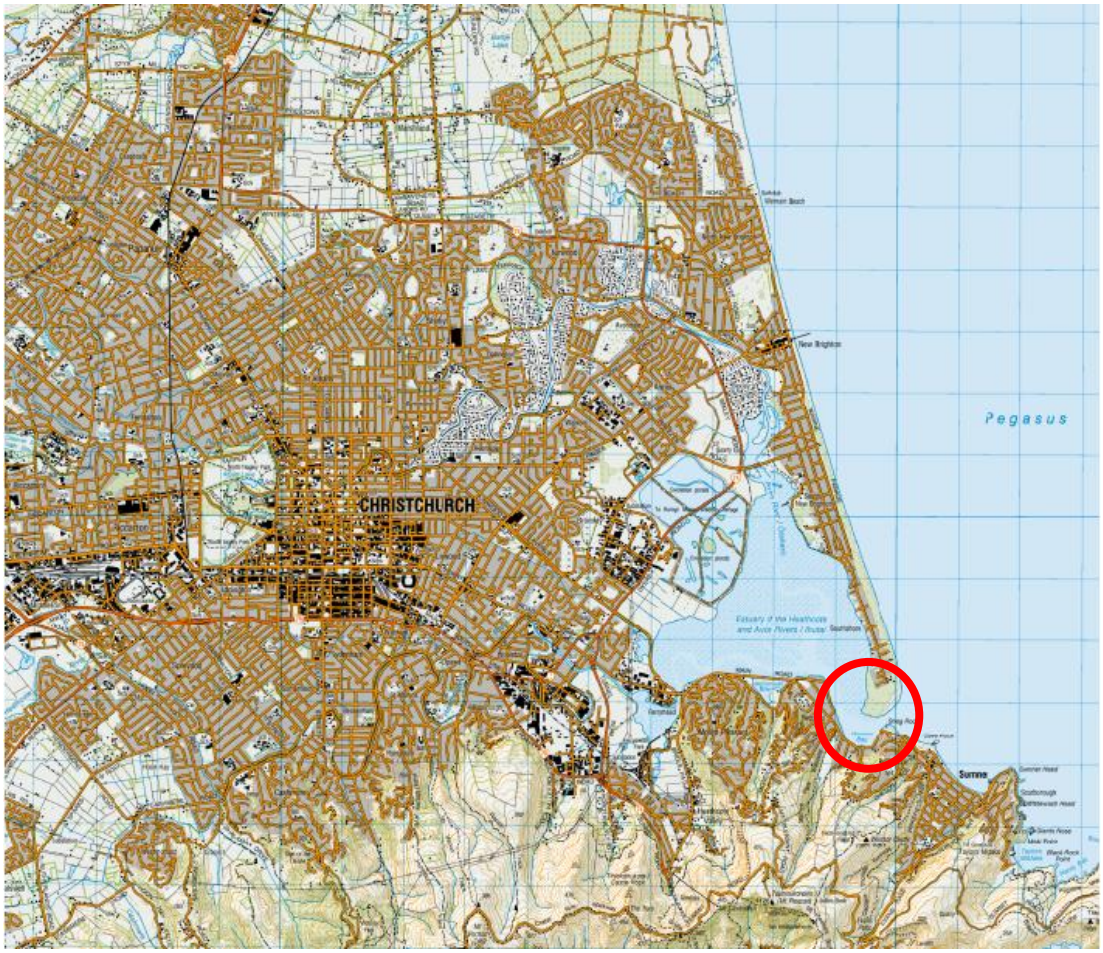

Figure 1 *Christchurch and the Avon-Heathcote Estuary, with the study area circled in red. Background map made available by Harriss (2016) at www.topomap.co.nz.*

Figure 2: Aerial photograph of the estuary mouth. Taken from GHD (2015)

Conceptually, such a barrier would have gates that could close at low tide when required, for instance when a storm is forecast. Water levels on the sea side of the barrier would rise during high tide, whilst staying low in the estuary. Once tidal levels had receded, the gates would open again and allow estuarine flows to pass. This could continue for 2-3 cycles as required for the storm to cease (Figure 3).

Figure 3: Effect of a tidal barrier at Bridge Street. Taken from GHD (2015)

1.1 PREVIOUS STUDIES

A tidal barrier across the mouth of the Avon-Heathcote Estuary is not a novel concept for Christchurch; it has been considered at this location for over 50 years. The earliest references are in a 1959 report prepared by French engineers recommending a series of hand-operated gates at Moncks Bay. Reference to this report is included a 1963 letter by

the Chief Engineer (Planning) of the Christchurch Drainage Board, which concluded that a barrier was economically favourable compared to other options (Scott, 1963). The report stated that it will be necessary in the future to build a barrier to protect metropolitan Christchurch.

This was followed by a much more extensive study by HR Wallingford (1970). This included construction of two scale models to assess the potential for a barrier. This report again concluded that a barrier was necessary to protect Christchurch from flood damage. It also discovered that long closure times could cause sedimentation that may eventually complete block the estuary mouth.

More recently, an economic analysis of flood risk by Harris (2003) identified a tidal barrier as a potential mitigation option in the face of sea level rise. This report estimated a cost of $25 million for a barrier, and highlighted the difficulty of consenting such a project under the Resource Management Act. It suggested economic benefits would be in the order of $3.9 million, therefore less than the build cost in the current day scenario, but that construction may be economic if delayed by 50 years.

Finally, the GHD (2013) River and Tidal Flood Protection project considered a tidal barrier as a potential mitigation option, while stating that international expertise would be required, as well as a detailed environmental impact assessment.

1.2 COMMISIONING

The idea was again considered in 2015 by the Horizontal Infrastructure Governance Group (HIGG), comprising Christchurch City Council (CCC), the Canterbury Earthquake Recovery Authority (CERA) and the New Zealand Transport Agency (NZTA). The HIGG was developed to formalise the management and governance arrangements outlined in the earthquake recovery's cost sharing arrangements (CERA, 2015).

The vehicle for delivery of the project was the Land Drainage Recovery Programme (LDRP). Under this programme the tidal barrier project was just one of the 106 other investigation projects to address increased flood risk across Christchurch as a result of the Canterbury Earthquake Sequence (CCC, 2015a).

A full feasibility study was initially requested, and this appeared in the Council's draft Long Term Plan (LTP) with a two million dollar allocation. This price was in recognition that the engineering investigation would have to include the complex spit morphology and geotechnical constraints, tidal, storm surge and estuarine discharge ranges, and consideration of sea level rise. There was also potential for significant community, environmental and social constraints, including requirements for navigation and allowance for the ecological significance of the estuary as a unique habitat for migratory birds. Each of these elements would require an in-depth study, and for some, fieldwork spanning multiple seasons.

This full feasibility study did not eventuate. At the initial stage it was decided to progress with a pre-feasibility study, which would focus on the engineering feasibility alone. The purpose of the pre-feasibility study was to understand whether a tidal barrier was worthy of further consideration and if the Council would be justified in conducting a full feasibility assessment. This would be a much cheaper option and would provide sufficient insight into whether a barrier could be built; not whether it should be built. The naming of this stage as pre-feasibility, and the manner of its commissioning had important implications for the report's support through the Council's democratic procedures and community consultation, as discussed below.

1.3 FEASIBILITY STUDY OUTCOMES

The study was received in final draft by CCC in July 2015. Using hydraulic modelling and analysis of the geotechnical and morphological constraints the report stated that a tidal barrier is technically feasible to construct and would function to reduce flood risk to a level comparable to alternatives. It would be within the capabilities of New Zealand contractors at a build cost in the range of $300 - $350M with operations and maintenance a further $2 - $7M per year.

The report recommended, for the purposes of feasibility, that lifting gates would be preferable. This is because they are simple, robust, and able to handle the shifting sands of the spit morphology. It also recommended that the barrier would be located at Redcliffs, rather than further towards the estuary mouth at Shag Rock.

Modelling indicated that a tidal barrier would also not remove the need for some additional defences, including stopbanks along the Avon River. The likely costs of these combined with a barrier in the present day scenario are more expensive than the one potential alternative they were costed against, being a mix of stop banking and house raising (Table 1). Other alternatives were not assessed for the purposes of this project.

Table 1: Summary of the capital costs to address earthquake exacerbated flooding and with and without a tidal barrier, in today's climate and with one metre sea level rise

Present day climate		1m sea level rise	
Stop banks / house raising solution	Tidal barrier and stopbanks	Stop banks / house raising solution	Tidal barrier and stopbanks
$211M	$430M	$571M	$545M

However, a tidal barrier could be more cost effective in the long term as sea level rise eventuates. The pre-feasibility study only considered two climate scenarios, the present day scenario and 1m sea level rise scenario. It did not determine if there is an intermediate point between these scenarios whereby a tidal barrier becomes cost effective.

In addition, the barrier would only be used on 2-3 occasions in an average year in the current climate scenario. However, as sea level rises this would gradually increase. This would give future operators the following choices:

- Increase the number of closures, until with one metre sea level rise this would adjust to require the gates to be closed on nearly every tidal cycle. This would result in more substantial environmental effects. However, in that scenario the estuary environment itself would be greatly altered so this may be tolerable;

- Increase stopbank height and horizontal length, which will increase the total project cost; or

- Acceptance of additional risk by the community over time. This may be acceptable as more building stock is replaced with finished floor levels above flood level.

The GHD report also provided visualisations of a potential barrier, with indications it could be used as a footbridge and cycleway to provide day-to-day and emergency egress

between Southshore and Redcliffs (Figure 4). These were a key resource for community consultation.

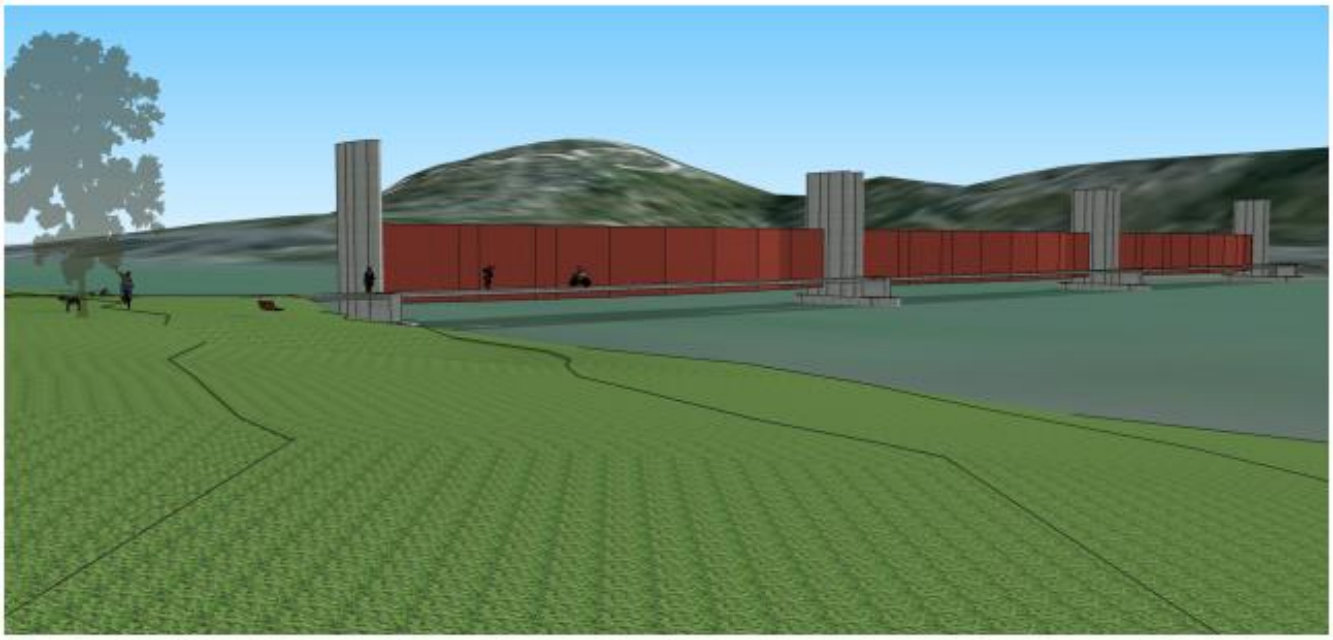

Figure 4: Visualisation of the tidal barrier. Taken from GHD (2015)

1.4 PEER REVIEW

Given the political ramifications of the report, two independent peer reviews were sought from Jacobs New Zealand Ltd and Beca Ltd, as follows.

1.4.1 PEER REVIEW OF REPORT CONTENT

The primary peer review was undertaken by Jacobs New Zealand Limited (2015), used international experience in tidal studies to review the engineering and strategic elements of the report. In general the peer review agreed that the barrier concept would work. It also highlighted that other barriers, such as that across the Thames Estuary in England, have been installed successfully in sensitive areas. It identified a number of additional items a full options appraisal should include.

Jacobs also included an example of a conceptual adaptation strategy using a barrier and stopbanks (Figure 5). This includes consideration of when a barrier might be appropriate to build and although it is not an analytical study into the options does illustrate the potential option of investim capital investment of this size over time.

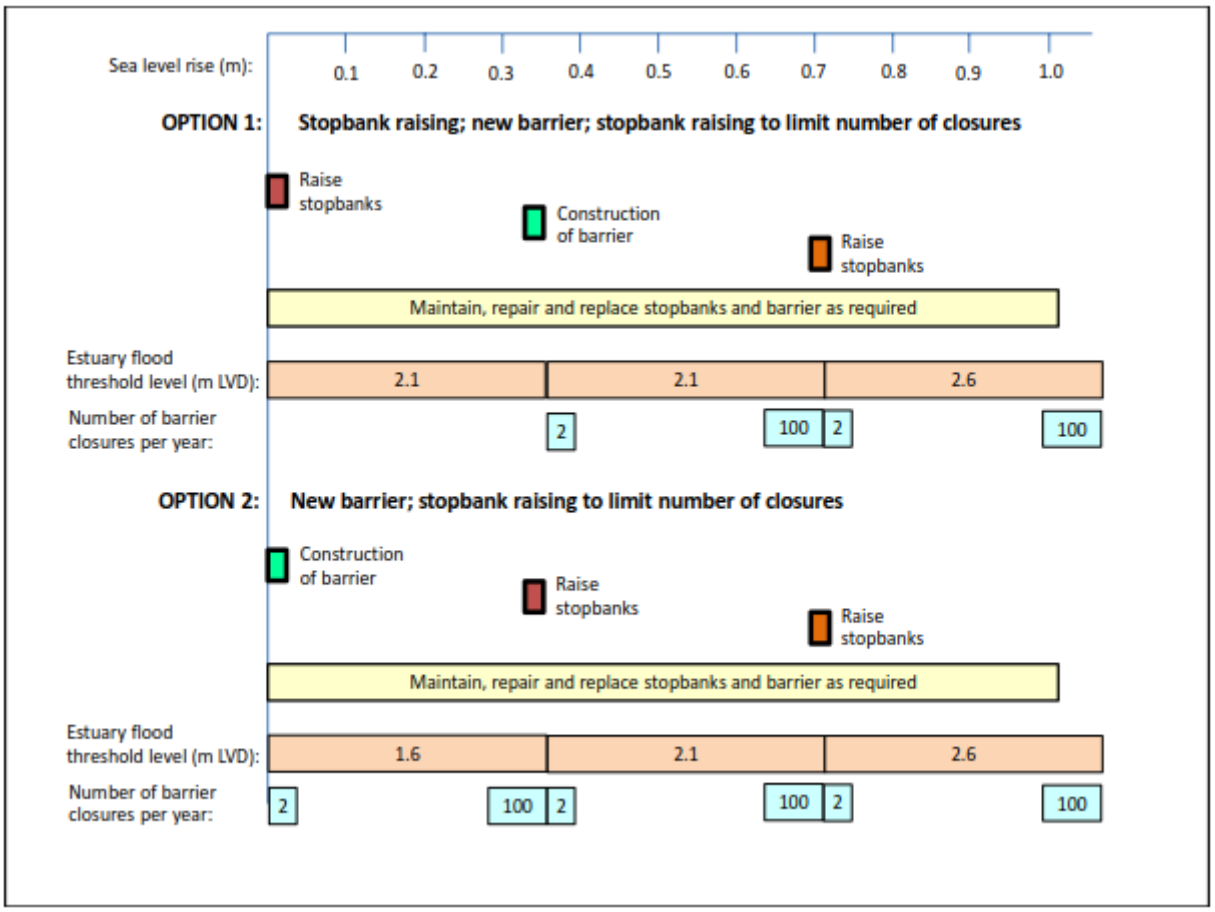

Figure 5: Adaptation strategy. Taken from Jacobs (2015)

In generally the peer review commented that although the report was correct and the proposed barrier was technically feasible, it concluded that now may not be the appropriate time to build it. It also proposed that a city-wide flood management strategy would provide greater insight into appropriate flood management options than a full feasibility study on a tidal barrier alone. This would include an assessment of all the possible engineering and non-engineering options. This could include a tidal barrier at a high level without the additional information provided by a full feasibility study.

1.4.2 PEER REVIEW OF COST ESTIMATING

A second peer review, by Beca Limited (2015), was solely on the cost elements of the work. This concluded a cost of $300-350M was likely, excluding funding risk. The review identified several other areas of cost risk, and recommended including escalation costs to cover the long construction period and an increase in contingency from 25 to 30%.

1.5 PRESENTATION TO COUNCILLORS

The final study was completed in July 2015 and tabled at the Infrastructure, Transport and Environment (ITE) Committee in August 2015. The report and minutes were made publically available online on the same day (CCC, 2015b). The ITE were concerned with the lack of public engagement around the study. Therefore, the resulting decision was that:

> *"the Council seek input from CERA, ECan, Ngai Tahu and the Avon Ihutai Estuary Trust and the Christchurch Estuary Association as partners and stakeholders on the technical report and its implications*"

Consultation had not been a core part of the study due the speed of its commissioning and its status as 'pre-feasibility'. The ITE also requested 'that the recommendations be reported back to the next Infrastructure, Transport and Environment Committee meeting', which meant a short timeframe to gather feedback on such a potentially controversial project.

1.6 CONSULTATION

Previous external communications during the preparation of the report had included workshops with ECan for early evaluation and issues identification, information sessions with Te Ngāi Tūāhuriri Rūnanga and the Avon-Heathcote Ihutai Estuary Trust, and a memorandum in July 2015 to the Hagley-Ferrymead and Burwood-Pegasus Community Boards informing them of the study. CERA was updated with copies of the draft and final report as they were received. Feedback was also received through the Long Term Plan (LTP) process.

In response to the ITE Committee's recommendations the Mayor's office prepared a letter to seek input from the nominated stakeholders. This letter stated Council staff would be in touch to arrange meetings with representatives of each organisation to discuss the study and receive feedback. This included the following organisations:

- CERA
- Environment Canterbury
- Christchurch Estuary Association
- Avon-Heathcote Ihutai Trust
- Ngāi Tahu

LDRP staff organized meetings with each party and all also responded with written responses. As a result of these meetings unsolicited feedback was also received from the following:

- Avon- Ōtākaro Network
- Southshore Residents Association
- North Canterbury branch of Forest and Bird

A meeting was also held with the Hagley/Ferrymead Community Board.

Strongly worded responses were received but their direction was mixed with proponents for, against and neutral towards progression to a full feasibility study on a tidal barrier. Some stakeholders were highly opposed a hard engineering solution and considered it represented a false security. The environmental effects were raised as a major concern, but paradoxically so were the concerns that the estuary would be fundamentally changed through sea level rise.

Several responses suggested a city-wide integrated approach to flood management would be more pragmatic. Collaborative approaches between Council and Crown were suggested, and further assessment to tease out all other potential flood mitigation

options, be they engineering or planning alternatives. The respondents wanted long-term and sustainable outcomes and it was felt that pursuing just this one option was too reactive.

Generally, there was a level of concern that earlier and more in-depth consultation did not occur.

1.7 PROJECT OUTCOME

Once key stakeholder feedback had been recieved staff once again presented to the ITE committee, this time in October 2015 (CCC, 2015c). This paper sought a recommendation from Council as to whether to proceed to a full feasibility study for the tidal barrier. Based on the consultation and the advice from the consulting engineers, the staff recommendation was not to proceed to full feasibility.

The project outcome was that the CCC Councillors voted on 29 October that a full feasibility study on a tidal barrier did not proceed, noting the feedback from a range of organisations that did not support the full feasibility study (CCC, 2015d).

Councilors did resolve that the information in the pre-feasibility report on a tidal barrier be considered as one of the engineering options for flood protection in the development of the Council's Three Waters Strategy, and that the Council continue to work closely with CERA on the options for flood plain management as part of the technical work on the future use of the Residential Red Zone. Therefore, the work involved in the pre-feasibility development will continue to be used, if not to be the basis for further investigations into the barrier.

2 DISCUSSION

The focus of this paper is not the hydraulic modelling or technical engineering involved in the pre-feasibility study. It is focussed on the process by which the study arose and how it was determined whether or not to proceed with a barrier, which provides an interesting insight for future flood risk mitigation opportunities in other areas.

Christchurch is in many ways a climate change front runner, through the land subsidence as a result of the Canterbury Earthquake Sequence that caused the city to effectively suffer many years' worth of climate change overnight. Therefore, the decision making processes in Christchurch are likely to be an indicator of those that could follow across the rest of New Zealand.

Commentary from the consultation submissions proposed a city-wide flood management strategy would provide a better option. There was the feeling that a full feasibility study would be premature, and that all options had not been considered. This show of interest in a considered, wide-ranging study was not necessarily expected and highlighted the depth of concern and understanding within the key stakeholder groups. Previous consultation may easily have led the authors to predict that at least some segments of the population would embrace a 'quick-fix' option without the expense and time of a comprehensive review of all the available options.

In general it reflected the unwillingness of the community to commit to an expensive project before the true effects of climate change are felt, or at least, very well understood.

It was also interesting that once key stakeholder engagement commenced there was a great deal of discomfort amongst respondents that consultation did not begin earlier. This was by no way a deliberate act by the project team, as the manner of commissioning and the nature of the project meant that it was felt consultation was not warranted until sufficient details of the project's potential were known. However, it demonstrates how strongly the community feels about the potential effects of climate change, and the growing desire for an increased level of discourse between local authorities and other organisations in regards to flood risk planning.

3 CONCLUSIONS

The Tidal Barrier Pre-Feasibility Study project was an interesting and engaging engineering exercise. It has been considered for many decades as a potential mitigation option for some of Christchurch's draining and flood issues. However, although it proved to be a feasible option, it is an expensive one. Although it may have been anticipated that residents may wish for an engineering response to the problem, in fact the general opinion was that wider discussion and a more strategic approach were preferred, even if this were to take a longer time. Therefore, this project has provided some thought-provoking outcomes for the wider audience in decision making around flood risk and climate change.

It still may be that a tidal barrier could be considered at some later point in the century once the effects of sea level rise are clearer. However, the community and elected members of Council have made it quite clear that this point is not now.

ACKNOWLEDGEMENTS

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