Rediversion of Kaituna River into Maketu Estuary
Hydraulic Modelling and Costing

Report prepared for Environment Bay of Plenty
by

Philip Wallace

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1 Introduction

At present, most of the Kaituna River flows through the Te Tumu Cut (made in 1956). In 1996 a floodgate culvert structure was installed to allow a small amount of flow back through Fords Cut into the Maketu Estuary. (Figure 1).

In 2001 and 2002, a number of options for rediverting more Kaituna River flow through the Maketu Estuary were identified. Hydraulic modelling of the options enabled the effects of each of the options on flood and drainage levels, and the effectiveness of each in diverting water to the Estuary, to be compared. (Ref)

More recently, the Maketu Estuary Focus Group has selected several of these options, and identified two more, that it wishes to be further assessed. This report summarises the hydraulic effects of the latest set of options, and also presents indicative costings for each. The results should be regarded as for comparative purposes only. Once the list of options is narrowed further, more detailed analysis of the options will be required.

Figure 1 Current Layout, Kaituna River Mouth and Maketu Estuary

2 Rediversion Options

The Maketu Estuary Focus Group has requested that the following options be assessed:

- Option H – block off Te Tumu Cut, remove culverts and causeway between river and estuary at Fords Cut, plus open Papahikahawai channel between river and estuary, and remove block in old river channel upstream of Fords Cut
- Option I - status quo and double the number of culverts between Fords Cut and estuary

- Option J – status quo, with culverts at Fords Cut lowered to be submerged at mid tide (invert level at -1.6 m RL[1])
- Option K - remove culverts and causeway between river and estuary at Fords Cut, but with the opening between Fords Cut and the estuary defined by two large culverts (as a bridge)
- Option L - remove culverts and causeway between river and estuary at Fords Cut, but with the opening between Fords Cut and the estuary defined by two large culverts that are floodgated to prevent backflow into the river
- Lower stopbank between Te Tumu cut and Fords Cut to average flow levels, leave Te Tumu cut open, open Papahikahawai Channel (Don Paterson option, referred to as "Option P" in this report).
- Control gates at both Te Tumu cut and at Fords Cut – control gates at Te Tumu opened in flood events (Red Barker option, referred to as "Option R" in this report).

These options have each been compared to the existing case.

Each of the options is illustrated and explained in more detail in Appendix 1.

3 Previous Modelling

The hydraulic modelling of 2001-02 used an existing model of the Kaituna River, the canals and drains on the lower floodplain and the Maketu Estuary. The model was first developed in 1999-2000 by Environment Bay of Plenty. The model used MIKE 11 software, a program developed by the Danish Hydraulic Institute (DHI) that has been used in New Zealand for river and floodplain hydraulic analysis for a number of years.

Data used in the model included river cross-sections surveyed in 1997 and estuary bathymetry obtained in 1996.

MIKE 11 uses 1-dimensional flow equations and allows a network of connected channels to be modelled, the flow within each is assumed to be one-dimensional. This assumption is perfectly reasonable in the river and canals. However, cross-sections in the estuary, derived from the bathymetry, are up to 1km wide which stretches the assumption of one-dimensional flow to near or beyond reasonable limits.

The model was calibrated to floods of July 1998 and May 1999. File notes also suggest that data gathered by the University of Waikato in 1996 were used to help calibrate the model in the estuary area. However, the river portion of the model has not been calibrated to low and normal flows.

4 Current Modelling

Since the 2001-02 analysis, modelling techniques have advanced. For example, the software programme MIKE FLOOD has been developed by DHI to allow combined 1-D and 2-D flow. MIKE FLOOD incorporates MIKE 21 (i.e. 2-D flow equations) and MIKE 11 (1-D flow equations), allowing them to be dynamically linked during a simulation. This program is better suited to estuarine modelling than MIKE 11 alone. It still however allows the use of MIKE 11 in well-defined flow channels such as the Kaituna River. (DHI, 2004)

Thus a MIKE FLOOD model of the river and estuary has been built. This model uses the original MIKE 11 model of the river and floodplain (simplified slightly in areas not relevant

[1] Reduced Level, relative to Moturiki Datum (which is approximately mean sea level)

to this Maketu Estuary study), but replaces the estuary channel of the original model with a MIKE 21 model of the estuary. The bathymetry assumed in the MIKE 21 component is based on a composite of bathymetry surveys in 1996 and 2006.

However much of an improvement the software is, it still relies on adequate input data to produce reliable results. Unfortunately, areas of the estuary bathymetry are still uncertain, in particular through the mouth (which also has moved noticeably since 1996). No effort has yet been made to refine the MIKE FLOOD model calibration for this reason.

Furthermore, each simulation with the MIKE FLOOD model takes up to ten times as long to complete as the equivalent simulation with the MIKE 11 model. Therefore final runs in this current analysis were made with MIKE 11. However, some runs with MIKEFLOOD were also done for comparison, as outlined in Appendix 2.

5 Hydraulic Analysis

Each of the rediversion options has been assessed to estimate its effect on three key parameters: the volume of flow into the estuary and the drainage of the Plains (both under normal conditions) and design flood levels.

5.1 Volume of Inflow to the Estuary

The principal aim of the rediversion is to increase the inflow to the Estuary from the river. To assess the effectiveness of each option in doing this, a mean river flow ($40m^3/s$ at Te Matai) has been simulated in conjunction with several cycles of neap and spring tides (with current mean sea levels), and the average inflow per tidal cycle has been derived from the results. These are summarised in Table 1, ranked in terms of the effectiveness of restoring flow to the estuary.

Option	Net Inflow (m^3)
Option H	2886921
Option R	2855535
Option L	383118
Option J	199459
Option I	196973
Option P	160109
Existing	104893
Option K	57604

Table 1 Average Net Inflow per Tidal Cycle, Typical River Flow (Over two neap tide cycles, one intermediate cycle and two spring tide cycles).

(Note the net inflow figures will differ if a different start point in the tidal cycle is assumed, but the relativity of options will be the same.)

The value given for Option P includes the flow across the river bank to the “Brains” land, which then has to flow across that low-lying land before it reaches the estuary. Some attenuation of this flow will occur, so the net flow reaching the estuary proper will be slightly less.

Inflow hydrographs for each option, compared to the existing situation, are plotted in Figures 2-8.

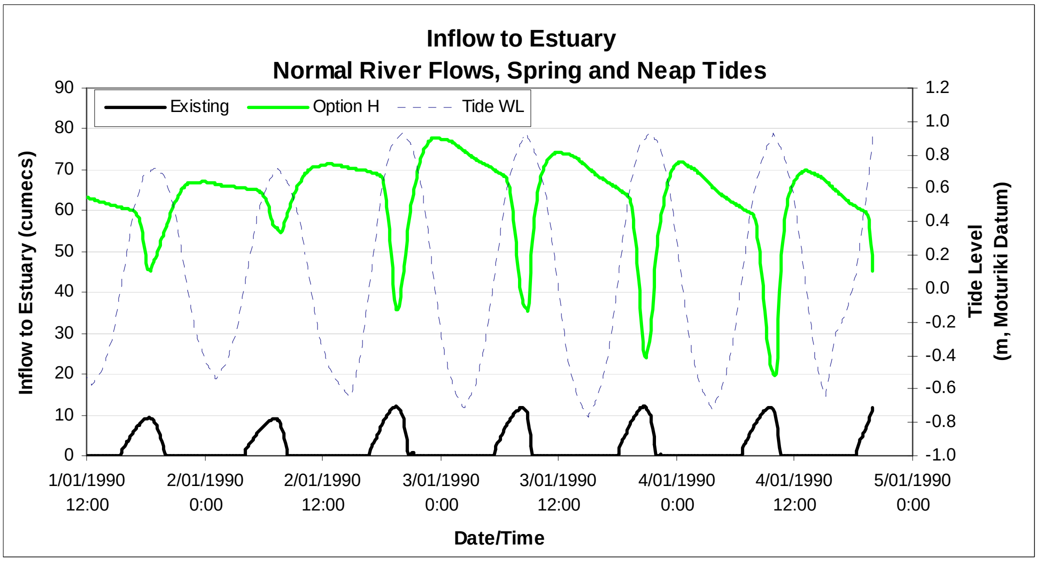

Figure 2 Estuary Inflows, Existing Situation and Option H

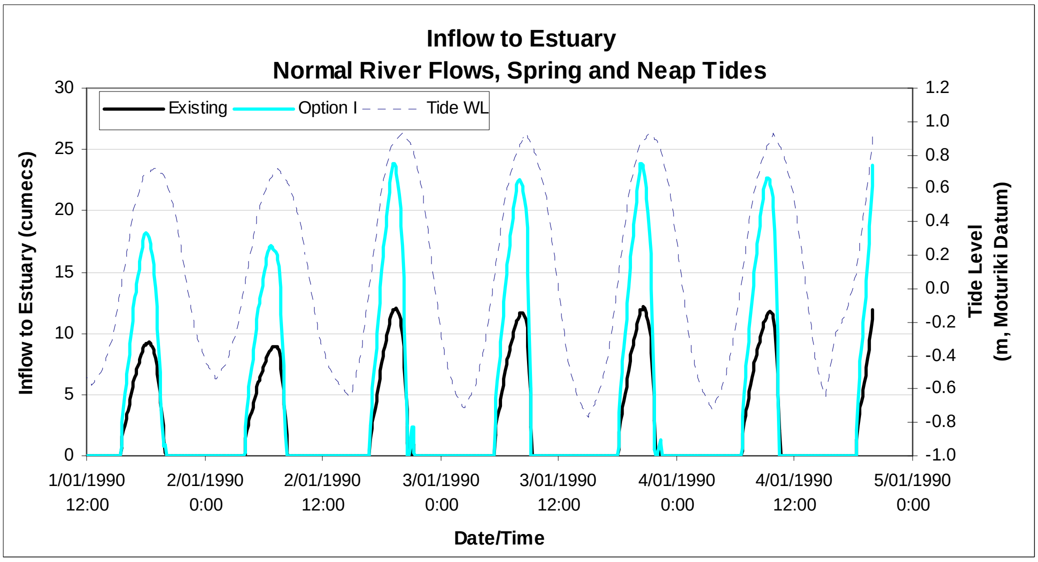

Figure 3 Estuary Inflows, Existing Situation and Option I

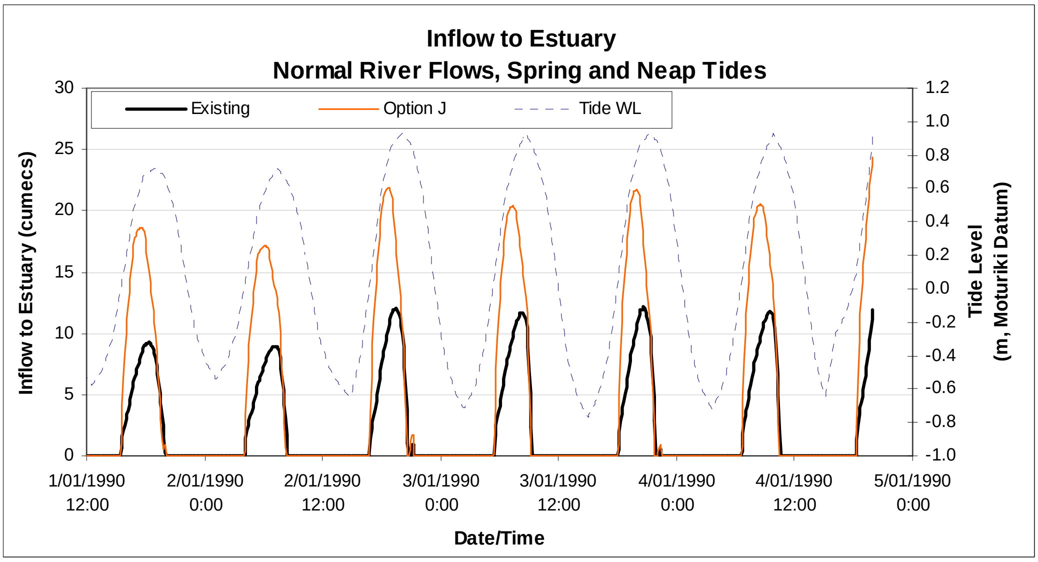

Figure 4 Estuary Inflows, Existing Situation and Option J

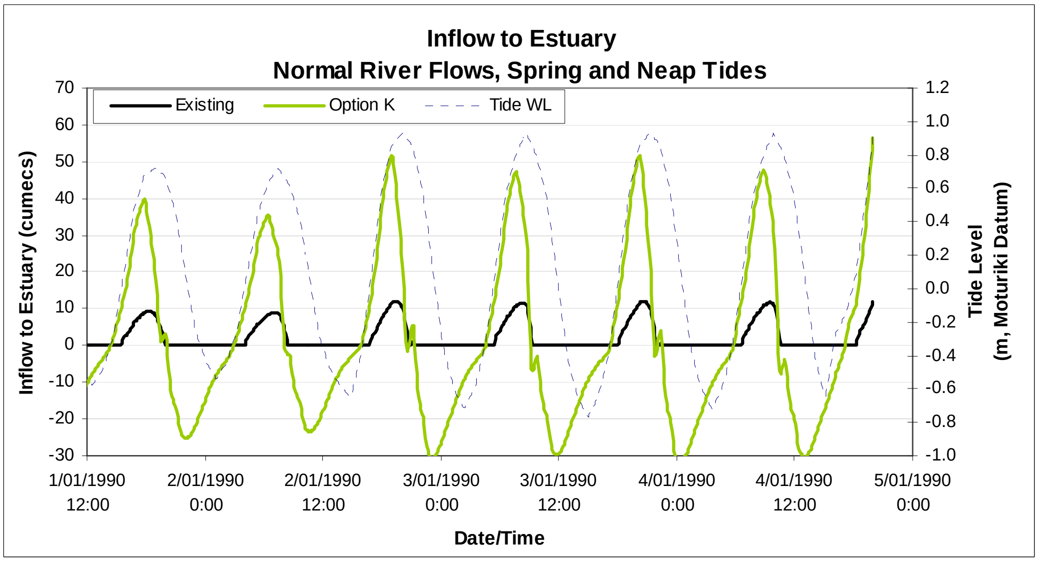

Figure 5 Estuary Inflows, Existing Situation and Option K

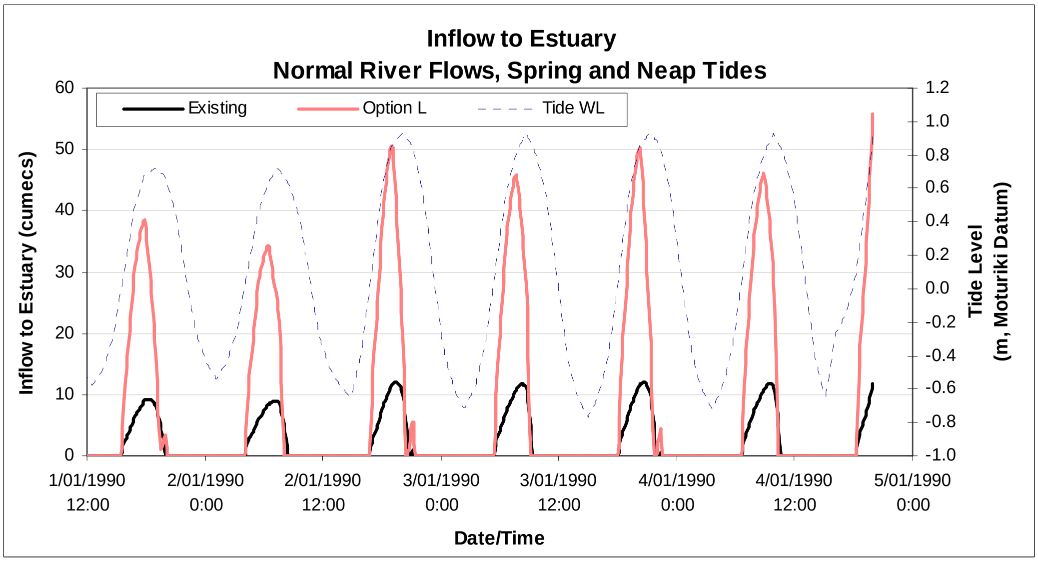

Figure 6 Estuary Inflows, Existing Situation and Option L

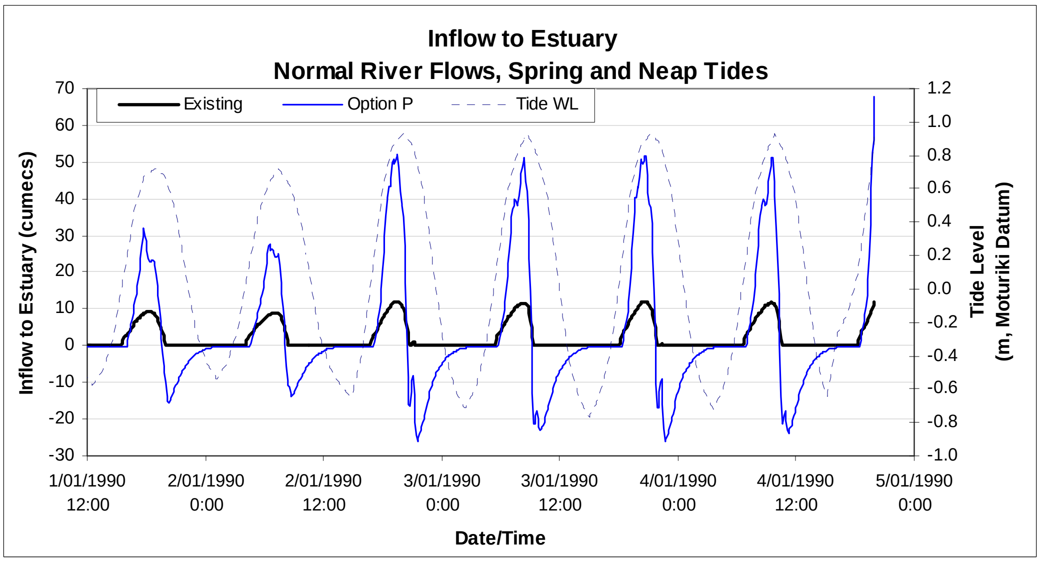

Figure 7 Estuary Inflows, Existing Situation and Option P

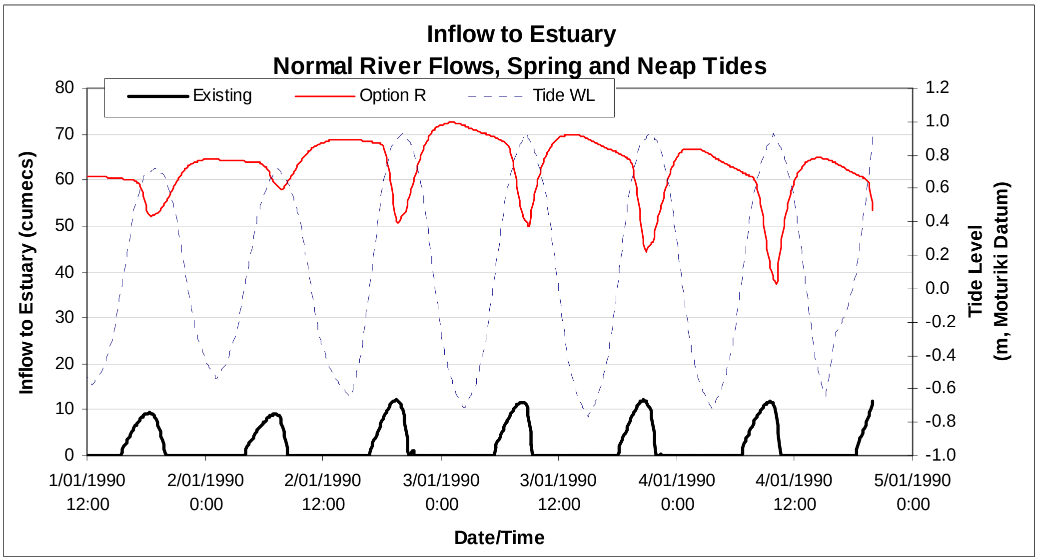

Figure 8 Estuary Inflows, Existing Situation and Option R

5.2 Design Flood

The Kaituna Catchment Control Scheme is designed to provide protection against a 1% AEP[2] flood. Such an event may result from a 1% AEP river flood or from a 1% AEP sea level. In practice, the sea level is likely to be elevated during times of river flood, due to low barometric pressure for instance. For design purposes, Environment Bay of Plenty determines 1% AEP flood levels at any location from the highest level at that location of two scenarios:

1% AEP river flood plus 20% AEP sea level
1% AEP sea level plus 20% AEP river flood.

<u>Climate Change</u>

Climate change over the next century is likely to increase sea levels. A range of estimates exists but current “most likely” estimates are a 5 to 32 cm rise (mid range estimate 20 cm) from 1990 to 2050 and a 9 to 88 cm rise (mid range estimate 43 cm) from 1990 to 2100 (IPCC, 2001).

A second, but less quantified adverse effect of global warming is that the frequency and magnitude of high intensity rainfalls are expected to increase. With climate change, *“Increases in high-intensity events are likely at many locations* [in the world]*”* (IPCC, 2001) – i.e. return periods of given size events are expected to decrease. Uncertainty surrounding the changes is high, but current estimates are that the frequency of floods of a particular size will increase between zero and four-fold by the year 2070 AD (NZ Climate Change Office, 2003a,b).

Environment Bay of Plenty has assumed a rise of 0.49 m to 2100AD (an earlier IPCC estimate of the rise. At this stage however, design levels for the Kaituna do not include the effects of an increase in the 1% AEP flood.

[2] By definition, a 1% Annual Exceedence Probability (AEP) flood has a 1% probability of occurring in any one year. This is also known as a 1 in 100 year flood or simply as a 100 year flood. Likewise a 20% AEP flood has a 20% probability of occurring in any one year, and is also known as a 5 year flood.

In this current investigation, the 1% AEP scenarios with and without sea level rise have been modelled. Figures 9 and 10 show design flood levels in the Kaituna River with sea level rise, while Figure 11 shows design levels without sea level rise. For clarity, not all options have been shown. (Option J gives results similar to those of the existing situation; Option R results are similar to Option I; and Option K results are similar to Option L.) Figure 13 shows the location of river distances referred to along the x-axis of Figures 9-11.

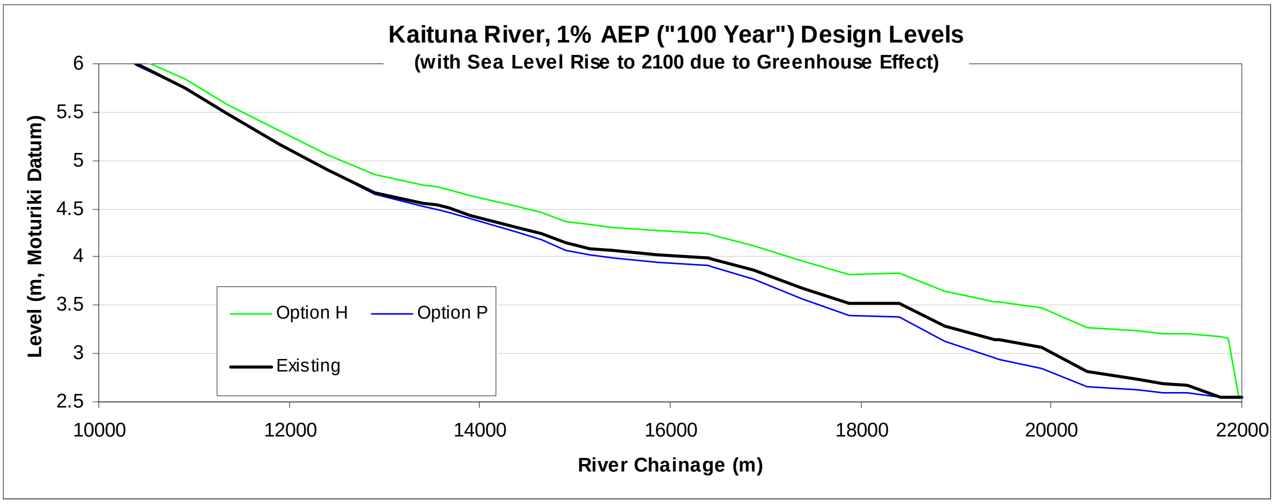

Figure 9 1% AEP Design Levels (with Sea Level Rise), Kaituna River

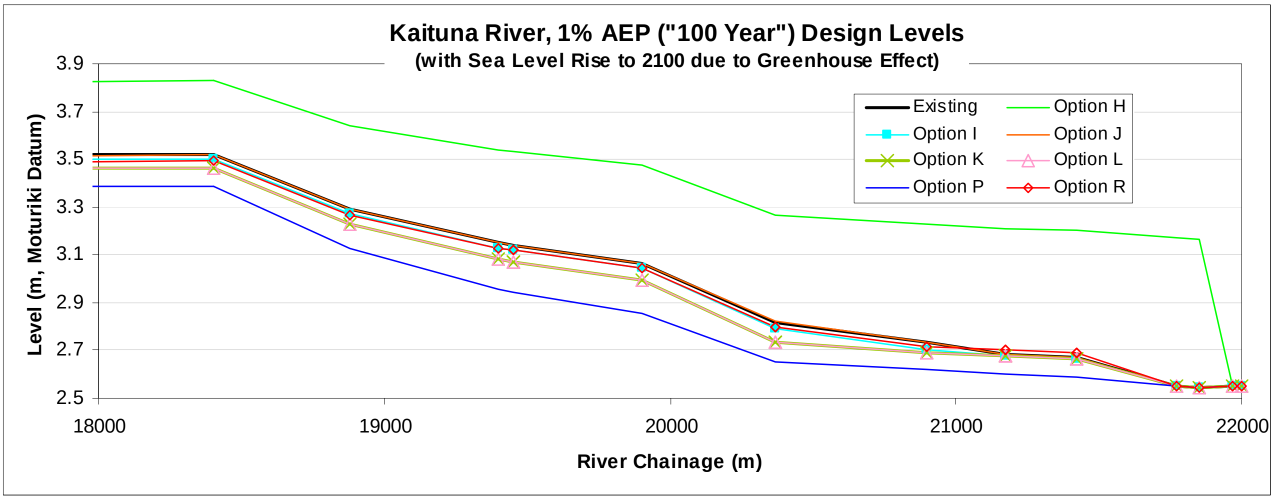

Figure 10 1% AEP Design Levels (with Sea Level Rise), Kaituna River (Lower Reaches)

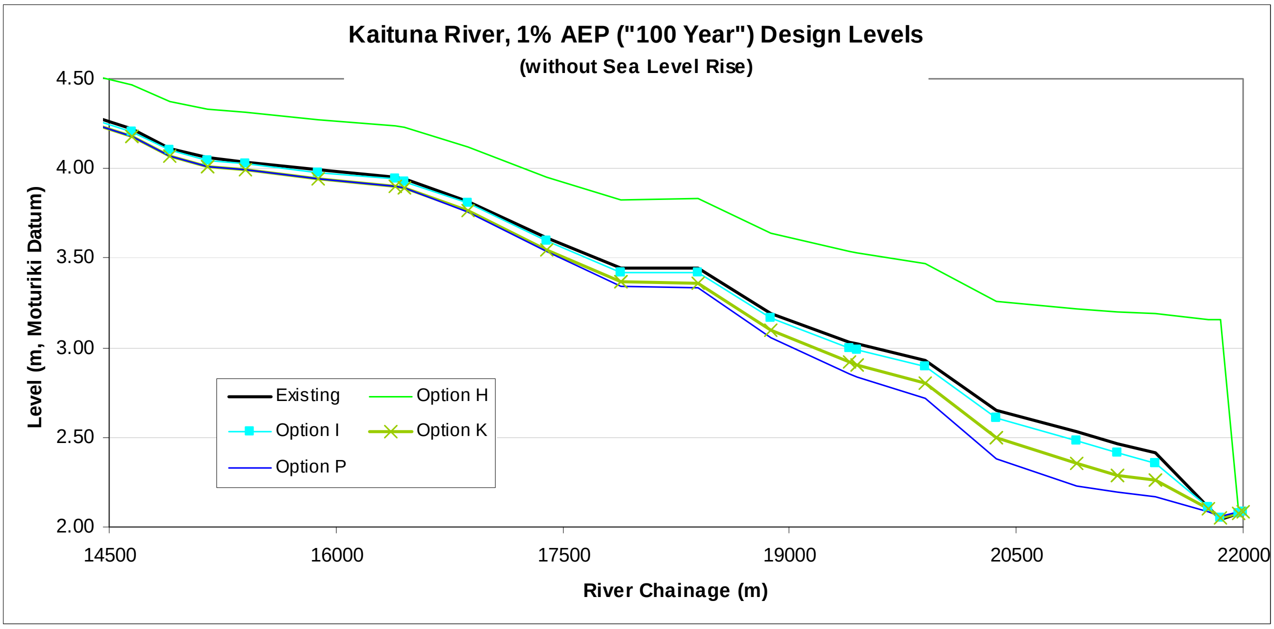

Figure 11 1% AEP Design Levels (without Sea Level Rise), Kaituna River

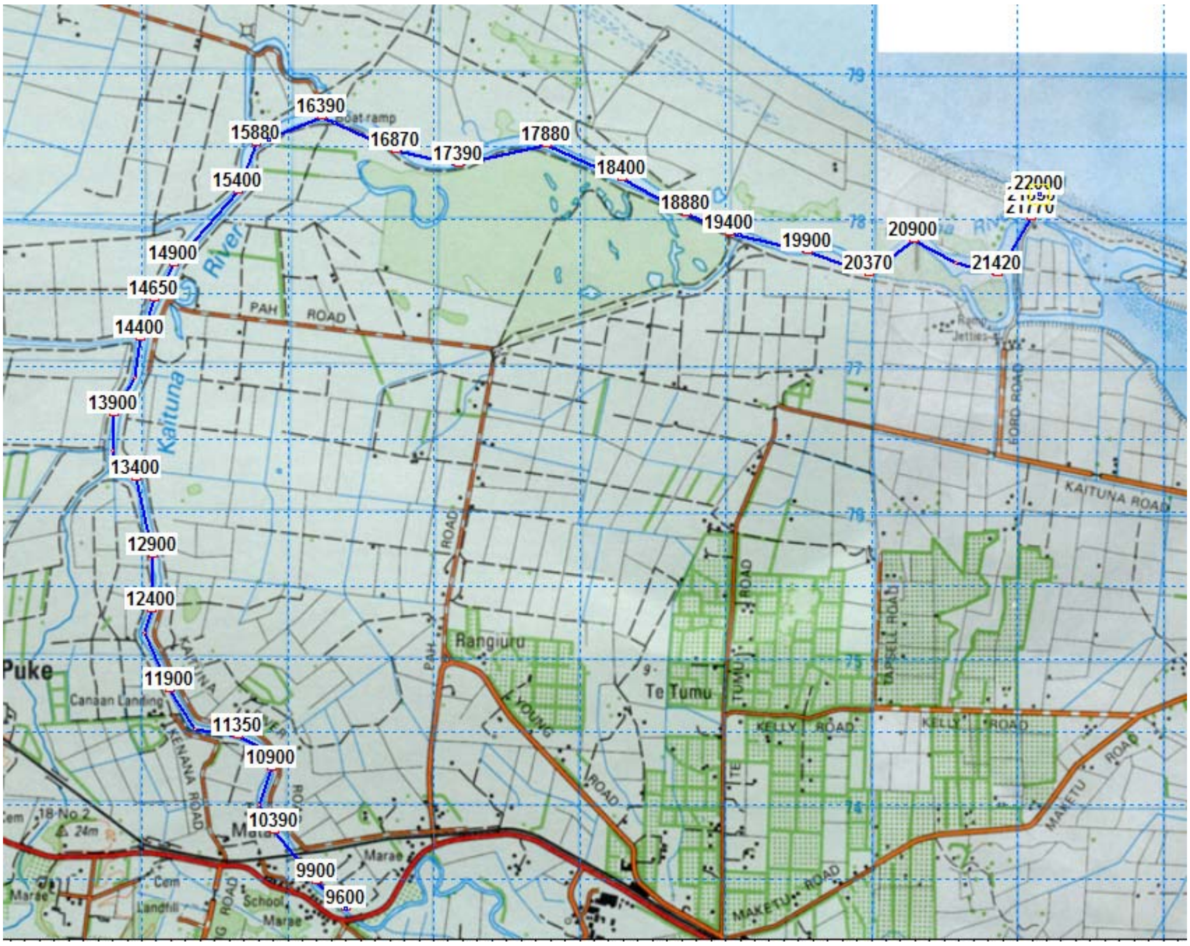

Figure 12 Kaituna River Chainage

Table 2 presents design levels, with sea level rise, for each option at selected locations on the Kaituna River.

Option	21940m (downstream of Fords Cut)	19450m (Diagonal Drain outlet)	16390m Bells Rd Drain Outlet)
Option P	2.59	2.95	3.91
Option K	2.66	3.07	3.95
Option L	2.66	3.07	3.95
Option I	2.66	3.12	3.98
Option R	2.69	3.12	3.97
Existing	2.67	3.14	3.99
Option J	2.67	3.14	3.99
Option H	3.20	3.53	4.24

Table 2 Peak Design Levels (1% AEP, with sea level rise) at Selected Locations on Kaituna River

Option H does raise levels in a 1% AEP river flood and normal tide scenario. In higher tide scenarios, the difference is less marked. The 1% AEP design levels in the estuary are controlled by the 1% AEP tide scenario, and Option H has no significant impact on those levels. Even in the 1% AEP river flow plus 5% AEP tide scenario, the difference is negligible. Thus Maketu township, for instance, is not affected by the options.

5.3 Drainage

As river levels rise, drainage of the Plains becomes more difficult. To assess the impact of the rediversion options on drainage, the minimum river levels under normal flow and several cycles of neap and spring tide (i.e. the scenario modelled above) have been extracted from the results. (In practice, lowest levels occur during spring tides, at low tide.)

Results are as shown in Figure 13. Again, for clarity not all options are presented: levels for Options I, J, L and P are all as per the existing situation. Low tide levels for each option at selected locations are presented in Table 3.

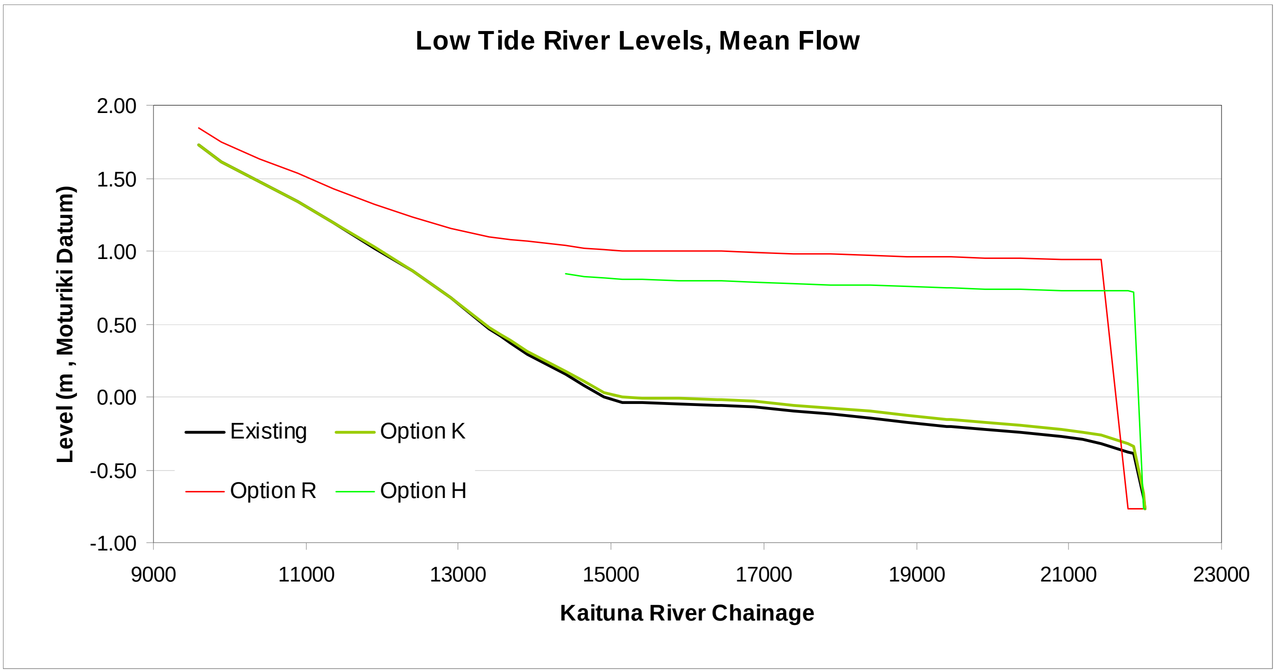

Figure 13 Low Tide River Levels, Mean Flow, Kaituna River

Option	21940m (downstream of Fords Cut)	19450m (Diagonal Drain outlet)	16390m Bells Rd Drain Outlet)
Existing	-0.32	-0.20	-0.06
Option I	-0.32	-0.20	-0.06
Option J	-0.32	-0.20	-0.06
Option L	-0.32	-0.20	-0.06
Option P	-0.32	-0.20	-0.05
Option K	-0.27	-0.16	-0.02
Option H	0.72	0.75	0.80
Option R	0.94	0.96	1.00

Table 3 Low Tide River Levels at Selected Locations on the Kaituna River

In the case of Options H and R, it is possible that the mouth will scour to adjust to the additional flow being sent through, leading to lower levels. However, sensitivity tests with the mouth area being more than doubled show only a minor drop of a few centimetres in the vicinity of the mouth and no change in river levels.

6 Option Costs

Option costs, in terms of June 2007 dollars, are summarised in Table 4. These are preliminary only, and may need refining in any detailed analysis of selected options. It is particularly worth noting that for options L and R, involving control gates, the very infrequent demand for such works within New Zealand could result in tender prices being quite different from the estimates.

Options H and R impact on the drainage of the Kaituna plains, and would require additional pumping . The additional requirements for each of Option H and R have been confirmed to be more or less the same as estimated in the 2002 investigation for Option

H. The costs of the additional pumping requirements have therefore been taken from the 2002 figures, updated to the current price index.

Option H also raises design flood levels significantly and the cost of raising stopbanks to provide an equivalent standard of protection to the status quo has been estimated. As in the 2002, any required top-ups of less than 50mm are ignored. Raising of less than 150-200mm would probably not be carried out immediately either, but has been costed as that additional allowance would be included at a later date when the bank eventually needed raising due to, for example, bank settlement or loss of channel capacity.

Design bank levels for Options K, L and P are lower than for the existing situation (other than a very minor increase along the Fords Cut), so there would be a potential saving in future stopbank works. In its Kaituna Asset Management Plan, Environment Bay of Plenty assumes that every 20 years, 20% of the length of the stopbanks will need to be topped up, as the stopbanks settle below design levels. The cost of the savings is spread over the next 100 years and discounted (a discount rate of 6% is assumed). Any benefit from saved damages due to a higher standard of flood protection before top-ups is ignored.

Furthermore, Option P removes the stopbanks between Fords Cut and the Te Tumu mouth. The amount allowed in the Asset Management Plan for the next top-up of these banks has been deducted from Option P costs also.

(Stopbank costs have been based on the "without" sea level rise case, as the allowance for sea level rise would not need to be built in at the moment.)

Further details and assumptions are provided in Appendices 3-5.

Option	Net Cost
Option H	$7,892,000
Option I	$567,000
Option J	$490,000
Option K	$234,000
Option L	$805,000
Option P	$390,000
Option R	$6,627,000

Table 4 Summary of Net Cost of Options (June 2007$)

7 Other Considerations

General comments about some of the options and the issues that will need to be considered if an option is pursued further are offered below.

Option H

- Prior to a permanent river mouth cut being made at Te Tumu, the river periodically broke out through the spit. The possibility that this may happen again, or that the river breaks out back through the current Te Tumu cut location, should be considered. Additional erosion protection may be needed if this is to be prevented. (This has not been included in the costings.)

- As the Papahikawai Channel develops after the reintroduction of flow through it, material may scour from it and deposit in the estuary or in the estuary mouth.

- As noted, flood levels will increase and drainage will be affected in areas in the Plains. The above analysis assumed that the current design standards of flood protection and drainage would be maintained. The alternative is that these standards are lowered, which would impact upon the current landuse of the Plains.

- Access to the river mouth on the right bank would be prevented.

- The salinity would increase in the river, potentially impacting upon river ecology and farm productivity. (This would also be an issue for options K and R).

Option L

- A substantial power supply will be needed to work the gates.

- The hydraulic analysis here assumes that the gates will open and close as if they were gravity gates. That is, they will generally open and close with the tide. In practice, some more complex rules for the operation of the gates under various flow and tide scenarios may be desirable.

Option P

- As with Option H, additional erosion protection may be needed to protect against erosion of the spit or the river returning to the Te Tumu Cut. if this is to be prevented.
-
- Also as with Option H, material may deposit in the estuary or mouth as the Papahikahawai Channel develops over time.

- Again, as with Option H, access to the river mouth on the right bank would be prevented.

- The management of the Brains land, which will revert to being underwater for at least during high tides, will need to be considered.

Option R

- As with Option H, the impact on the drainage of the Plains will need to be addressed.

- Substantial gates at the river mouth will be needed to allow flood flows to pass. Not only would these require a substantial power supply, the scale of such a structure has not been seen in New Zealand in a coastal setting. Overseas, river mouth gates are more commonly associated with highly developed areas of population. Although there are similar, if smaller, gates upstream at Okere Falls, they are not in a coastal environment. A coastal environment is more dynamic and the structure would need to be protected against erosion, even if it were sited a little upstream of the mouth. The outlet channel from the structure would also need to be maintained, perhaps by regular gate openings, to ensure it is effective when required.

- Rules for the operation of both sets of gates under various flow and tide scenarios will be required.

8 Conclusions

The hydraulic modelling undertaken has been based on a number of assumptions. For example, the dimensions of the estuary and river mouths have been assumed in the absence of complete data, and it is also assumed that those dimensions are fixed during flood events. Furthermore, there are limited estuary calibration data, particularly during flood events, while the river model is calibrated to historical flood events but not to normal or low flow conditions. The physical dimensions of the structures and channels for each option have also not been optimised to maximise effectiveness and minimise costs and impacts.

Nonetheless, modelling results do give a clear indication of the relative effectiveness and impacts of each rediversion option. Options H and R, which redivert all normal flows through the estuary, are predicted to allow nearly thirty times as much net inflow to the estuary as is the case now, under the normal flow conditions assumed. Options L, J, I and P would also significantly increase net inflow to the estuary. Option K would lead to greater inflows but amount of outflow from the estuary to the river means that the predicted net inflow is actually less than is the case now.

Options H and R however significantly impact upon the drainage of the Kaituna Plains area. Additional pumping would be required if the landuse of the Plains was to be maintained. Option H also would significantly raise flood levels. There are major cost implications of each of these effects.

On the other hand, results for Option P, and to a lesser extent Options K and L, show a slight reduction in design flood levels along the Kaituna River. None of the Options assessed would affect the current level of flood protection to the Maketu township.

Options K, I and J would be the simplest options to implement, and of these Option K is the cheapest. The economics of Option P are improved by no longer needing Kaituna River stopbanks downstream of Fords Cut and by a reduction in flood levels in other areas, but the land ownership and management of the areas then subject to daily inundation would need addressing. Option R presents significant practical and cost issues.

More detailed analysis of the effectiveness, hydraulic impacts, costs and economic impacts will be required if any of the options are selected for further consideration. As well as inflow volumes, flood level changes and drainage impacts, other parameters may need to be considered. A range of other flow scenarios should also be assessed.

An update of the river hydraulic model is programmed by Environment Bay of Plenty for 2007/08, which will include a resurvey of the river cross-sections. Together with LIDAR data for the Maketu area that will be available later in 2007, that update will allow refinements to the combined 1-D/2-D flow model. With a programme of calibration data collection (over a range of flows from low flow to floods), the predicted impacts and effectiveness can be refined, and the dimensions of preferred options optimised.

References

Environment Bay of Plenty (2000); Comparison of Modelling and Tidal Gauging 10 May 1996. Memorandum to John McIntosh from Matthew Surman, 17 May 2000. File Reference 5600 05

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DHI Software (2005); MIKE 21 Flow Model - Hydrodynamic Module User Guide.

Nigel Goodhue (pers. comm.)

Philip Wallace (2002); Estimate of Cost of Closing Te Tumu Mouth and Rediverting Full Kaituna Flow Through Maketu Estuary. Report prepared for Environment Bay of Plenty, October 2002.

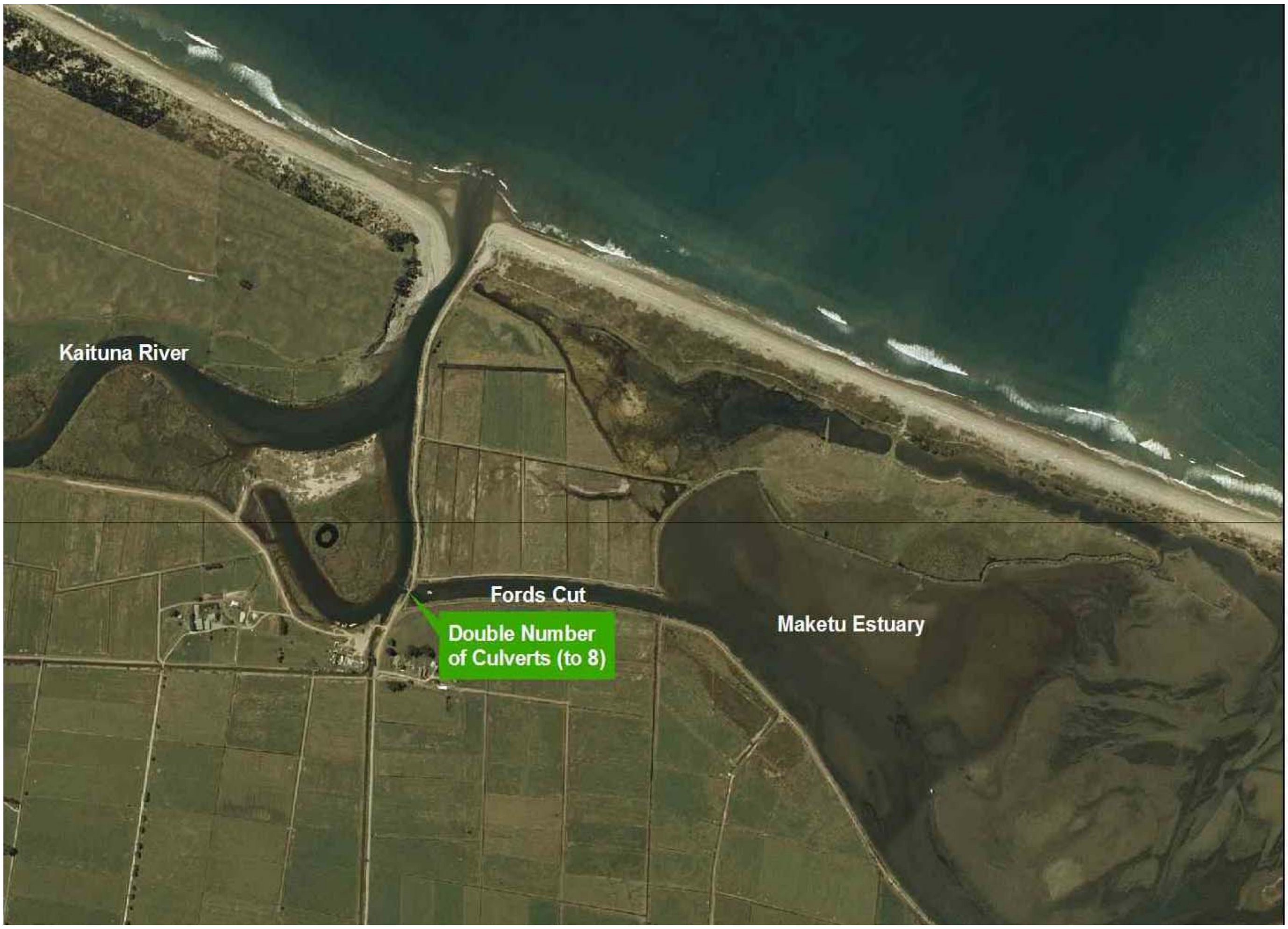
Appendix 1 – Option Layouts

Option H

Key Features and Assumptions

- Existing culverts/floodgates and causeway between river and Fords Cut are removed.
- The Te Tumu Cut is blocked off to prevent flow.
- Papahikahawai Channel is reopened allowing flow from the river, parallel to the spit to enter the estuary This current version of Option H differs from that modelled in 2001-02 by assuming that the channel is parallel to the spit and so enters the estuary further downstream that in the previous option (which had the channel entering the estuary at the downstream end of Fords Cut). This provides slightly more fall, and so allows more flow. The assumed channel is 30m wide in the upstream portion, and widens and depends slightly to fit recorded bathymetry downstream of the second block. In practice, the channel may scour or widen further over time after it is reopened.
- The “Block” in the old river loop upstream of Fords Cut is removed.

Option I



Key Features and Assumptions

- Four additional culverts and floodgates (allowing flow only from the river to the estuary) are added, with the same dimensions (1.8m diameter) and invert level (approximately -0.5m RL) as the existing four.

Option J:

Key Features and Assumptions

- The four culverts and floodgates (allowing flow only from the river to the estuary) are lowered, so that the invert level of the culverts becomes -1.6m RL. (The current invert level is approximately -0.5m RL.) .

Options K, L

Key Features and Assumptions

Option K

- The existing culverts and floodgates between the river and Fords Cut are removed, and a bridged opening of 20m width and 3m depth is created. No gates are provided, so that water is free to flow in both directions. The structure has been modelled as twin 10m wide culverts, with an invert level of -1.5m RL. (Note that in the 2001-02 analysis, twin openings of 15m wide were assumed).

Option L

- As per Option K, except that floodgates are installed to allow flow only from the river to Fords Cut. The size of the gates is such that they would need mechanical control to open and shut properly.

Option P

Key Features and Assumptions

- The existing culverts and floodgates between the river and Fords Cut are left untouched.
- Papahikahawai Channel is reopened allowing flow from the river, parallel to the spit to enter the estuary. The assumed channel is 30m wide in the upstream portion, and widens and depends slightly to fit recorded bathymetry downstream of the second block.
- Flow is also allowed in the southern branch of the Papahikahawai Channel, entering the estuary at the downstream end of Fords Cut.. The assumed channel expands from 30m wide where it leaves the other Papahikahawai branch to 200m wide where it enters the estuary. In practice, both branches of the Papahikahawai Channel may scour or widen further over time after they are reopened.
- The existing stopbanks between the Fords Cut culverts and the Te Tumu mouth are lowered to approximately mid-tide levels.
- The existing stopbanks between the downstream end of Fords Cut and the old southern branch of the Papahikahawai Channel are removed.

Option R

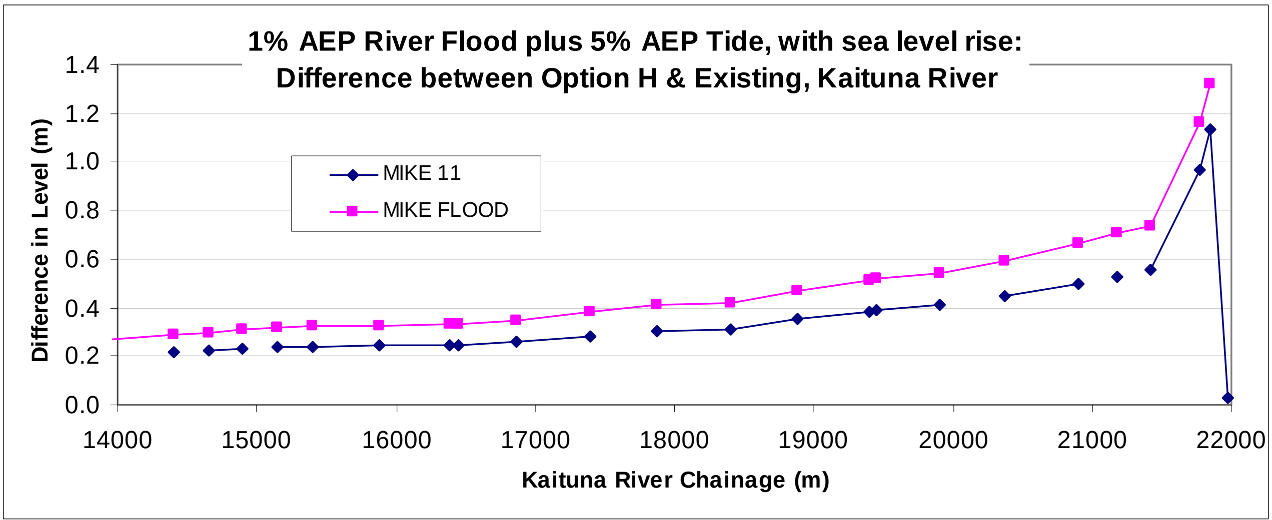
Key Features and Assumptions

- The existing culverts and floodgates between the river and Fords Cut are removed, and a bridged opening of 20m width and 3m depth is created. The structure has been modelled as twin 10m wide culverts, with an invert level of -1.5m RL. Floodgates are installed and are fully opened in normal river flow conditions, but closed when the river is in flood. The size of the gates is such that they would need mechanical control to open and shut properly during times of river flood.
- A second set of floodgates is installed in the Kaituna River, upstream of the mouth. Eight gates are provided, with each opening being 10m wide and 3.5m high. The invert of each opening is -1.5m RL. These gates would be closed in normal river flow conditions, to allow all flow through Fords Cut. The gates would be opened when the river is in flood.

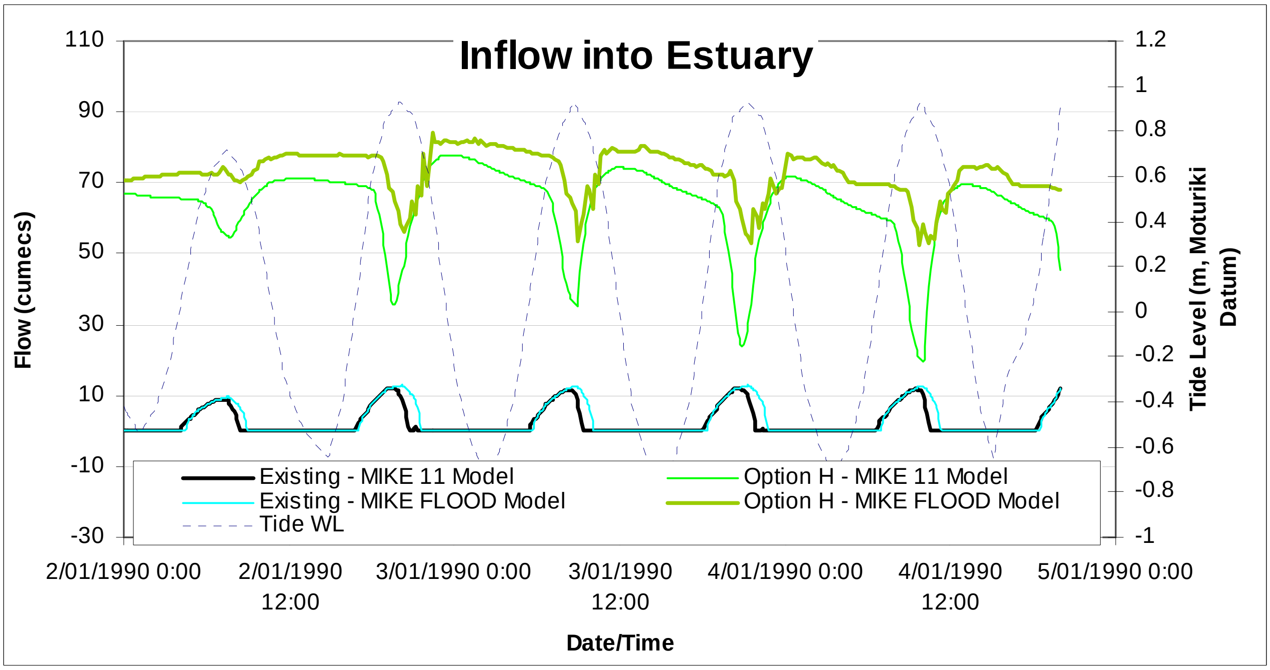
Appendix 2 – Comparison of One-Dimensional Flow Model with Combined One-Dimensional/Two-Dimensional Flow Model

The model results reported upon in the main text are all from a MIKE 11 one-dimensional flow model, as described in Section 3. As a combined one-dimensional/two-dimensional flow model is in theory more suited to this type of problem, involving a wide estuary area, a MIKE FLOOD model was also created. Due to uncertainties in the estuary and mouth bathymetry and limited calibration data, and to due to the substantially longer computer time required for simulations, the MIKE FLOOD model was not used for the final simulations.

It was however used to resimulate the mean flow and 1% AEP flow simulations for the existing situation and Option H, as a check on the MIKE 11 results.



In the 1% AEP flood case, it can be seen that the pattern of the difference between Option H and the existing situation is similar in both the MIKE 11 and MIKE FLOOD models. That the difference is higher in the MIKE FLOOD model may mean that the assumed additional costs for stopbanking have been underestimated slightly in the summary of costs provided in the main text.



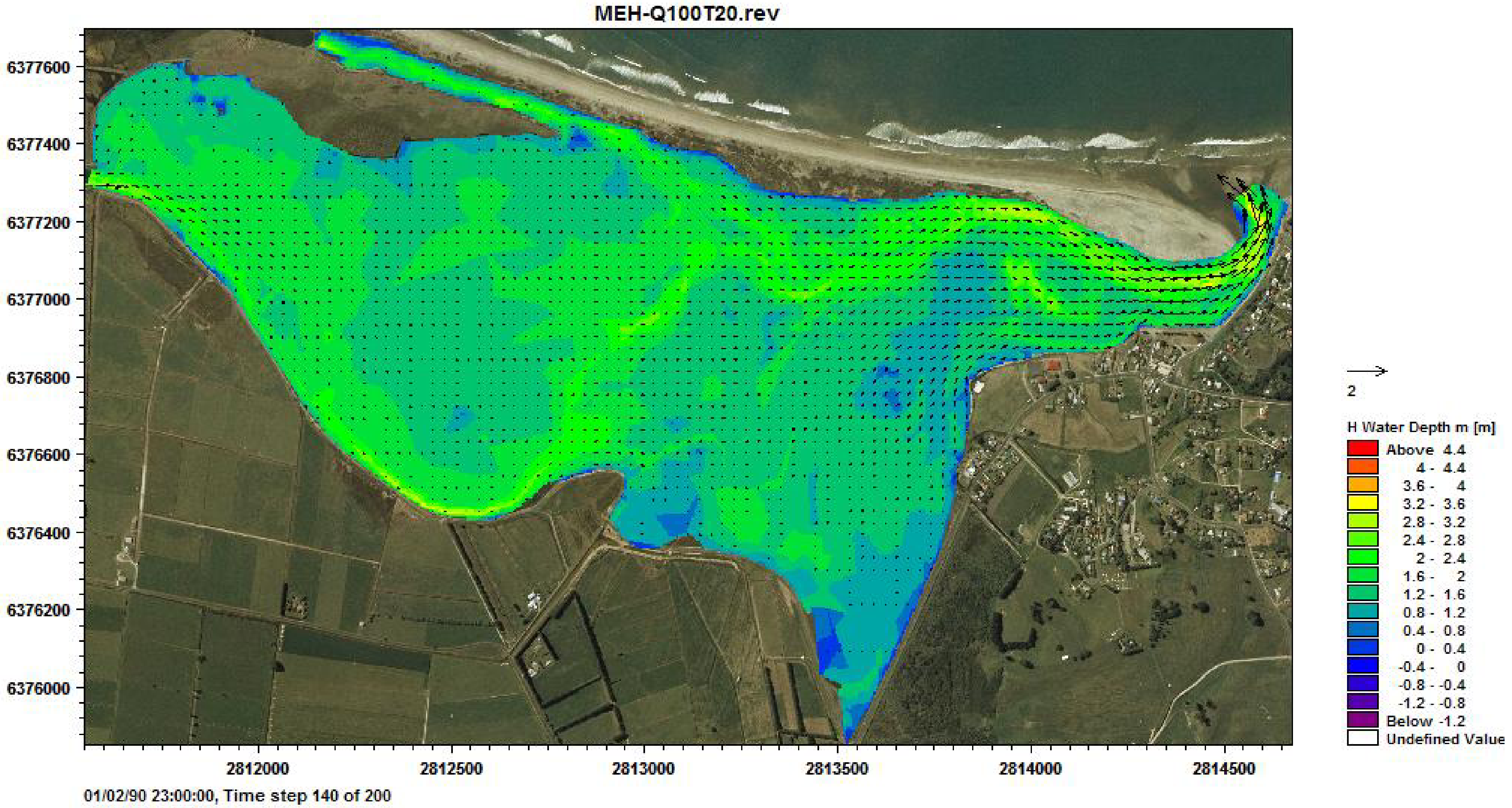
In the mean flow case, estuary inflow hydrographs have been compared. It can be seen that the two models give similar results for the existing case. For Option H, the patterns of inflow are similar, although predicted flows are slightly higher in the MIKE FLOOD model.

These results are considered sufficiently consistent to justify the use of the simpler MIKE 11 model to compare options, at least at this stage. However, more detailed future analysis of selected options should ideally use MIKE FLOOD, but after more bathymetrical and calibration data have been collected.

A resurvey of the Kaituna River cross-sections is due in 2007/08, with the intention that the hydraulic model be updated accordingly. Furthermore, LIDAR data has been collected for the coastal area and processing of the data is due to be completed in 2007. The data from these two projects would significantly improve the MIKE FLOOD model.

The plot below shows the sort of graphical output that can be obtained from the MIKE FLOOD model. It is a snapshot from the Option H 1% AEP flood scenario, showing flow depths and velocity vectors just after the peak of the flood.

Example of MIKE FLOOD Output: Option H, 1% AEP Kaituna Flow + 5% AEP Tide, Shortly after peak



Appendix 3 – Cost Estimates – Details

All costs are in terms of June 2007 dollars. Calculations are stored in the spreadsheet *maketu costs-all components2007AAAA.xls*

Key assumptions include:

- Rock cost (placed) = \$83/tonne or \$103.75/m^3, according to Appendix 4. This is higher than current rock costs elsewhere in the Bay of Plenty, but typical of costs elsewhere in New Zealand particularly where long haul distances are involved (likely to be the case here). The figure will need to be refined once options are refined and rock sizing is confirmed.
- Earthworks excavation cost = \$2.50/m^3 (see Appendix 4)
- Although the use of the "cost construction index", or CCI, has been discontinued, Environment Bay of Plenty estimates that the June 2007 CCI would be 5143. This has been used to scale up costs from earlier contracts to present day values where necessary.
- Design and supervision cost = 15% of contract costs generally, or 10% where the design involved is simple.
- The costs of obtaining resource consents have not been included
- Future costs are discounted at a rate of 6% per annum.
- Ongoing maintenance costs are accounted for over the next 50 years.

Option H

A 200m length of rock protection at the entrance to the Papahahikawai channel has been allowed. Total rock volume = 1442m (200m length, 4m height, 1m thickness, 1.5:1 batter).

The largest components of the costs are the cost of raising stopbanks and providing additional pumping, to restore flood protection and drainage to the current standards.

Any additional maintenance requirements for the raised stopbanks have not been allowed for.

Pumping cost assumptions are as outlined in the 2002 cost estimates (reproduced in Appendix 5).

Capital Works, Option H					
	Papahikahawai excavation			$93,563	
	Remove floodgates etc			$27,862	
	Remove block			$31,250	
	Te Tumu closure			$52,000	
	Riprap at Papahikahawai entrance			$149,630	
	Design, Supervision, 10%			$35,431	
	stopbank raising			$4,758,925	
	Pump (capital works)			$1,409,884	
	Total				**$6,558,544**
Additional Annual Costs					
	Annual Additional costs: electricity			$39,482	
	Pumps Maintenance			$45,113	
	Total			**$84,595**	
NPV of annual costs	@	6%	50 yrs		**$1,333,368**
TOTAL NET COST					**$7,891,912**

Option I

The cost of installing 4 additional culverts is assumed to be the same as the original cost of installing the culverts, adjusted to present day prices. Note also that the sluice gates on the river side of the culverts, installed at the time of construction, were soon considered redundant. The cost of those has therefore been deducted.

Although regular inspection of the culverts and floodgates would occur at the same time as the existing gates, there would also be additional maintenance costs, such as replacement of the gates. The budgeted (according to the Kaituna Asset Management Plan) annual Bell Road culvert/floodgate costs, including renewal costs but excluding inspection costs, are assumed to apply.

Capital Works, Option I					
	Existing Culverts:				
	Cost at time of construction			$283,679	
	less cost of sluice gates			-$2,080	
	Design, Supervision, 15%			$42,240	
	Total cost at time of construction			$323,839	
	Inflation adjustment	1.41			
	Total				**$457,556**
Additional Annual Costs					
	Culvert/floodgate maintenance			$6,963	
NPV of annual costs	@	6%	50 yrs		**$109,747**
TOTAL NET COST					**$567,303**

Option J

The existing culvert/floodgate structure is set into and founded on timber piles. The structure therefore cannot be simply lifted off and then placed onto lower foundations; it would need to be damaged beyond economic repair. Therefore a replacement structure would be required. It is assumed that this would be the same cost as the original, adjusted to present day prices.

While some small savings could be made by salvaging the floodgates and reusing them, and by not having to excavate the bulk of the opening again, these would probably be offset by extra costs in working at lower levels.

No additional requirements are assumed.

Capital Works, Option I				
	Existing Culverts:			
	Cost at time of construction		$283,679	
	less cost of sluice gates		-$2,080	
	Design, Supervision, 15%		$42,240	
	Total cost at time of construction		$323,839	
	Inflation adjustment	1.41	$457,556	
	Plus cost of demolishing existing structure		$27,862	
	Temporary diversion of flow		$5,000	
	Total			**$490,418**
TOTAL NET COST				**$490,418**

Option K

Capital costs are as outlined in Appendix 4.

As design stopbank levels are lower than the existing situation, savings in future stopbank top-up works have been accounted for. In its Kaituna Asset Management Plan, Environment Bay of Plenty assumes that every 20 years, 20% of the length of the stopbanks will need to be topped up, as the stopbanks settle below design levels. The savings are spread over the next 100 years as shown below and discounted (a discount rate of 6% is assumed).

Capital Works, Option K				
	Remove existing structure.		$27,862	
	Gate Structure, including telemetry		$212,949	
	Temporary diversion of flow		$5,000	
	Design/Supervision, 15%		$36,872	
	Total			**$282,682**
Deferred or lesser topups of stopbanks				
	Total saving	-$303,927		
Assume	20% of the total saving in 10 years: NPV =		-$33,942	
	20% in 30 years		-$10,583	
	20% in 50 years		-$3,300	
	20% in 70 years		-$1,029	
	20% in 90 years		-$321	
	Total NPV of reduced stopbank costs			**-$49,175**
TOTAL NET COST				**$233,507**

Option L

Capital costs are as outlined in Appendix 4.

Design stopbank levels are the same as for option K, and the same savings apply.

Without defined guidelines for the operation of the gates, expected electricity costs are uncertain. For now, it has been assumed that these costs are the same as allowed for in the Kaituna Asset Management Plan for the Okere Falls gates. Given however that the Fords Cut gates may be operating twice daily with the tides, whereas the Okere gates are adjusted only intermittently, this is likely to be a considerable underestimate.

Furthermore, no maintenance costs for the gates have been allowed for.

Capital Works, Option R						
	Remove existing structure.				$27,862	
	Gate Structure, including telemetry				$705,449	
	Design/Supervision, 15%				$109,997	
	Total					**$843,307**
Additional Annual Costs, gate operation						
	Electricity (Assume as per Okere Falls Gates)				$694	
NPV of annual costs	@	6%		50 yrs		**$10,934**
Deferred or lesser topups of	stopbanks	Total saving	-$303,927			
Assume	20% of the total saving in 10 years: NPV =				-$33,942	
	20% in 30 years				-$10,583	
	20% in 50 years				-$3,300	
	20% in 70 years				-$1,029	
	20% in 90 years				-$321	
	Total NPV of reduced stopbank costs					**-$49,175**
TOTAL NET COST						**$805,066**

Option P

Riprap is assumed to be needed on the outside of the bend created as the river flows back into the Papahikahawai Channel. Channel excavation requirements are as outlined below. It is assumed that the Papahikahawai channels will self-scour further.

Land purchase or compensation costs (Brains land), if required, have not been included.

Design stopbank levels will be lowered and savings in future stopbank top-up works have been accounted for.

Capital Works, Option P						
	Excavate main Papahikahawai channel				$93,563	
	Excavate secondary Papahikahawai channel				$143,750	
	Remove stopbanks, Kaituna River right bank				$44,100	
	Remove informal "stopbanks", Maketu Estuary				$16,000	
	Riprap at Papahikahawai entrance				$74,815	
	Design/Supervision, 10%				$37,223	
	Total					**$409,450**
Additional Annual Costs, rock maintenance						
	(AMP assumption - 70% topup every 15 years)				$3,491	
NPV of annual costs		@	6%	50 yrs		**$55,031**
Saved Stopbank Renewal Works						
	next top-up, removed section of Kaituna Right Bank)				-$19,874	
	Assume would have occurred in 10 years, NPV =					**-$11,098**
Deferred or lesser topups of other stopbanks						
	Total saving (future value)				-$389,344	
Assume	20% of the total saving in 10 years: NPV =				-$43,482	
	20% in 30 years				-$13,558	
	20% in 50 years				-$4,227	
	20% in 70 years				-$1,318	
	20% in 90 years				-$411	
	Total NPV of reduced stopbank costs					**-$62,996**
TOTAL NET COST						**$390,387**

Option R

Floodgates on the Te Tumu Cut and Fords Cut. The size of these is such that they will need mechanical control and substantial power requirements. Telemetry to allow monitoring from off-site is also assumed.

In the Te Tumu Cut, eight gates, with each opening being 10m wide by 3.5m high, will provide the same level of flood protection as the existing situation.

The electricity requirements and ongoing maintenance costs of the gates for this option have not been included.

Additional pump requirements (capital costs and ongoing electricity and maintenance costs) are as for option H.

Capital Works, Option R					
	Fords Cut gate structure			$705,449	
	Remove floodgates etc			$27,862	
	Te Tumu gate structure			$2,643,749	
	Design/Supervision, 15%			$506,559	
	Pump (capital works)			$1,409,884	
	Total				**$5,293,503**
Additional Annual Costs					
	Pump electricity			$39,482	
	Pumps Maintenance			$45,113	
	Total			**$84,595**	
NPV of annual costs	@	6%	50 yrs		$1,333,368
TOTAL NET COST					**$6,626,871**

Appendix 4 –Cost Estimates, Further Details – Options K,L,R

AC CONSULTING GROUP LIMITED
Consulting Engineers

MAKETU ESTUARY RE-DIVERSION OPTIONS
PRE-LIMINARY COSTINGS

Introduction

AC Consulting Group Ltd (ACCG) was instructed by Philip Wallace, on the 18th June 2007, to assist with the provision of pre-liminary construction costing for the Maketu Estuary Re-Diversion Options.

ACCG have been engaged as a sub-consultant to Philip Wallace who in turn has been commissioned by the 'Maketu Estuary Focus Group'.

Engagement Brief

Our understanding of the engagement Brief is the following:

- Option J (part off): Cost of demolishing and removing existing culvert at Fords Cut
- Option K: Cost of installation of large culverts, down stream of existing culvert at Fords Cut – opening 20m with a depth of 3m, treated as a bridge with a twin span of 10m each, rip-rap protection u/s through and d/s of the structure, including the removal of existing structure
- Option L: Cost of installation of large culverts (=Option K) including the installation of 4 radial gates with remotely controlled telemetry
- Option R: As per Option L and the inclusion of 8 radial gates + civil structure at Te Tumu (mouth of the Kaituna).

In addition to provide comments on:

- The bulk excavation rate of $2.50/m3 – as currently proposed
- Rock costs ex-quarry and delivered on-site

- o Access road costs to the left bank at Te Tumu as assumed in Options H and P
- o Review of Options H, I, J and P

Costing Analysis

Option J – Demolish and Removal of site for existing culvert

Calculation of quantities is based on the original supplied design drawings and the text / methodology in the original Option H from October 2002

DESCRIPTION	COSTS $
Reinforced Concrete Structure	15,237.50
Culverts	2,200
Metal works	1,250
Excavation soft rock	603.75
Removal rock revetment	4,134
Removal of access embankment	3,312
Additional day-labour costs	1,125
TOTAL	27,862.25

Material from the rock revetment will be re-used and therefore a “placing rate” of $13/tonne has been assumed for a total of 150 m3 = 318 tonne.

It is assumed that Greywacke rock is being used with a density of 2.65 tonne / m3. Placed density of rock is assumed to be 80% to a m3 for all Options.

Included in the costs is the removal of part of the cause way with reference to the original design drawings.

Wooden piles will remain in place and will be cut-off below the bed level. Existing sheet piling cut-off wall will remain in place and to be cut-off below the bed level.

Temporary diversion of water during demolition has not been taken into account. However a lump-sum of approximately $5,000 could be seen as an appropriate figure.

<u>Option K</u> – Construction of large culvert including rip-rap protection based on a two span bridge design

At this point no sheet piling cut-off wall has been assumed for the structure. However this will have to be incorporated when Option L is being considered.

DESCRIPTION	**COSTS $**
Excavation works	7,550
Piling: pre-cast concrete	10,500
Road / Cause way construction	24,425
Reinforce concrete structure + form works + slab joints	49,460.10
Testing and pile breaking	3,250
Base / foundation course	11,437.50
Geo-textiles	9,875
Rock rip-rap river bed – supply and placement	91,283.40
Rock rip-rap revetment – re-use of from demolished location	5,167.50
TOTAL	212,948.50

The **total pre-liminary costs for Option K** – including the demolition of the existing structure and temporary diversion works would be:

$ 27,862.25 + $ 5,000 + $ 212,948.50 = $ 245,810.75

<u>Option L</u> – As Option K plus radial gates x 4 and remote controlled telemetry

In the time that is available for this cost estimation it has been found hard to get a suitable, and in time, quotation from manufacturers in New Zealand.

The estimate has been based on: Okere Falls Gate, previous projects that AC Consulting group Ltd has worked on and my previous experience in the UK on similar projects for the Environment Agency.

The cost estimation for remote control telemetry is very much an estimation based on the above experience. This of course also depends very much on what equipment is most applicable as at this stage we do not know who will be operating and maintaining the diversion and flood control structures. Questions would be on: what is the 'norm' for this type of equipment in New Zealand and what is acceptable for the area in question. At this point I have only allowed estimations for the telemetry installation at site and not for the home base.

As we are proposing to have 4 radial gates, due to the large openings and better flow control through the structure, extra piers have been allowed for in the ' bridge structure'.

At this point the total span is still assumed to be 20m. However due to the additional proposed piers the length of this span might be reviewed, i.e. longer to accommodate the 'original' capacity. A sheet piling cut-off wall has been incorporated.

Electricity supply to site has not been incorporated at this stage (limited time and allocation) as the local "availability situation" is not known at the moment, i.e. distance from nearest 'live-line' and the capacity vs requirement.

DESCRIPTION	COSTS $
Demolition works	27,862.25
Temporary Works	5,000
Bridge / Culvert Structure	275,448.50
Radial gates + associated steel and concrete works	360,000
Telemetry	65,000
TOTAL	733,310.75

<u>Option R</u> – As Option L plus radial gates x 8 and remote controlled telemetry (+ civil structural works) at Te Tumu).

This is principally based on the design of Option K with additional bank and river bed erosion protection.

It is proposed to have 8 radial gates each with a width of 10m and an assumed height of 3.5m.

At this point we have assumed to install radial gates to divert the water towards the Fords Cut. The gates will be open during flood events for discharge into the sea. This ofcourse depends on the flood scenario in hand.

No provision has been made for the “reversed scenario” when high tides will be experienced or the probability of high flood levels and a high tide / storm scenario.

A sheet piling cut-off wall has been incorporated into the structure.

Additional various comments are very much in line with Option L in relation to radial gates, telemetry and electricity requirements.

DESCRIPTION	COSTS $
Excavation works	9,765
Piling: pre-cast concrete	32,500
Road / Cause way construction – assumed length 200m	195,425
Reinforce concrete structure + form works + slab joints *	225,500.80
Testing and pile breaking	9,750
Base course	29,137.50
Geo-textiles	19,950
Rock rip-rap river bed – supply and placement	178,299.40
Rock rip-rap revetment – supply and placement	75,559.50
Demolition	27,862.25
Temporary Works (incl. haul road)	85,000
Radial gates + associated steel and concrete works	1,650,000
Telemetry	105,000
TOTAL	2,643,749.45

*Note: * Access to the gates is assumed to be of a maintenance feature and is proposed to be constructed out of reinforced concrete and steel works*

The **total pre-liminary costs for Option R** – would be:

$ 733,310.75 + $ 2,643,749.45 = $ 3,377,060.20

Reference is being made to “Rawlinsons, New Zealand Construction Handbook – Edition 21” for the use of the base rates and the subsequent interpretation for the project and site specific requirements.

Note has to be taken that design and construction supervision has not been included into the above cost calculations. On an average 10-15% of the construction value is to be added to the design. Construction supervision cost being around 5-10% of the construction value.

Part of the temporary works has been included into the above costing exercise, i.e. diversion of the river flows. Temporary access roads site set-up costs and insurances have not been included.

Also not included are the costs related to the resource consent application, related consultation exercises - which can be very extensive – and the Tendering process.

It is assumed at this stage that fill material and rock are available within a reasonable distance, i.e. up to 35 km distance. The same assumption has been taken for the disposal of the demolition material off-site (including the land-fill / tipping tax.

Including the above "additional" costs and the allowance for a contingency the pre-liminary total costs for Option R would be:

DESCRIPTION	COSTS $
Option R – Construction et-all	3,377,060.20
Additional Temporary Works	85,000
Design + Geo-technical Investigations (10%)	334,919.80
Resource Consent + Consultation	13,500
Tender Documents + Process	17,500
Construction Supervision (5%)	167,459.90
TOTAL	3,995,439.90

Costs are based on a structural life cycle span (operation life) of 50 years. No operational and maintenance costs or a "discounted value" over the life span has been included.

Comments on additional points

- Excavation Rates:

The machine excavation rate of $2.50/m3 is a fair assumption and is in-line with "Rawlinsons" which include the disposal off-site – up to a reasonable distance, i.e. 35km. This rate could possibly be slightly reduced when the material is disposed off adjacent to the channels.

Providing the suitability of the material this could be used for the access road or the upgrade of the stop bank.

However, if not suitable for the purpose this could be an unwelcome addition to the flood plain capacity and / or not suitable for the farming practices in the area.

- Rock Supply Costs:

The assumed cost of Greywacke Rock seems slightly low and all depends on the availability in the project area, i.e. quarries. It needs to be suitable for its purpose and a variety of sizes would be required for the project. This would vary between Class A, B and C in relation to Option R.

Based on our experience the minimum rate for supply on site – again this depends on the distance from a suitable source – is $70 /tonne. A placement rate of $13/tonne would be advised to complete this particular task.

- Review of Options H, I, J and P:

Option H: Cost of the haul road, investigations and resource consent has not been included. These costs could be proportionally be used from the calculation above.
Costs for the demolition of the existing structure seems low with reference to the above calculations.
NPV / USPVF have been included though only over a life cycle span of 20 years. It could be more appropriate to use a 50 year life cycle span.

Option I: Reference would be made to the construction cost build- up as above and the estimated total for the replacement costs. I am not sure what the construction cost at the time included. I assume that this also included the purchase of rock for the revetment protection.
I am of the understanding that the CCI value is not valid anymore.
Reference in “Rawlinsons” states that this value has been discontinued since 2006.

Option J: Reference is made to the above pre-liminary construction costs calculations.

Option P: Main observation on this Option calculation is the rock rate. The rate used is $65/m3 compared to the rate that I have used in the above calculations and experienced so far in the Region of $70/tonne. This does make lot of difference in the total costs

Jan J van der Vliet
Project Manager
River, Marine & Civil Works
27th June 2007 – Rev02

Appendix 5 – Extracts from 2002 Cost Estimate

Relevant Extracts from:

Estimate of Cost of Closing Te Tumu Mouth and Rediverting Full Kaituna Flow Through Maketu Estuary. Report prepared for Environment Bay of Plenty by Philip Wallace, October 2002.

Estimate of Cost of Closing Te Tumu Mouth and Rediverting Full Kaituna Flow Through Maketu Estuary

The following is an estimate of the cost of works required to provide the same standard of flood protection and drainage as present if the Te Tumu cut was closed – i.e. Option H as presented earlier. These estimates should be regarded as draft only, and will need some review by Environment B·O·P staff.

All workings are in the attached spreadsheets *maketu costs – all components.xls, maketu drainage.xls* and *Maketu stopbank costs.xls*

1. Cost of constructing Option H itself.

Option H involves

- opening the Papahikahawai channel to the Kaituna
- removing the floodgates and culverts that presently control flow between the river and the estuary
- removing the "block" in the original river channel upstream of the entrance to the Maketu Estuary
- blocking off the Te Tumu mouth.

(Note that it is possible that the first and third items have little effect on the resulting water levels and flows under Option H. Those items were shown to have little effect in other options modelled, but leaving them out of Option H has not been modelled).

Excavation costs for opening the Papahikahawai channel are assumed to be at \$0.75/m^3 in 1993 dollars, as assumed for canal valuations in the Rangitaiki Drainage Scheme Asset Management Plan. However, note that more recent valuations for that Scheme have used a higher rate. A nominal excavation of 40m long by 20m wide by 3m deep has been assumed, but this would need field checking. The assumptions here lead to a cost of \$2,236 (at CCI = 4310). However, this has been increased to \$10,000 to allow for a higher rate, any extra excavation and the cost of removal of any rock that may be present.

Opening up the passage between the river and the estuary will require the culverts and floodgates to be removed. An allowance has been made to place a temporary bund at the entrance (on the river side) in order to prevent flow while culverts are removed. Rock that lines the current entrance will need to be removed, and should be placed on the new entrance to control erosion. A nominal 150m3 of extra rock is assumed to be needed, but it may be that additional rock is needed downstream in the cut to the estuary. No salvage value has been assumed for the culverts and flapgates. The estimated total cost is rounded up to $14,000.

Rates for removing the "block" in the Ford's Loop upstream of the estuary are as assumed for the Papahikahawai excavation. A volume of 50m by 50m by 5m has been assumed. The river could excavate itself to full dimensions over time. The estimated cost is to $12,000.
It would seem more practical to open up the flow to the estuary before attempting to block off the Te Tumu cut. However, as that would remove vehicle access to the cut from the right bank, works on blocking the cut off would have to be from the left bank, requiring a longer route to trucking fill to site. Construction/upgrade of existing tracks into a 4km haul road from Bell Road has been assumed

The estimated volume of the fill required to block off the cut is based on an assumed 20m top width and 1:1 batters at cross-section 21850m. Over time, the block could be expected to silt up from both the sea and river ends – although extra bulk would be desirable to prevent break out in a storm event. No rock work is assumed, although again it would add to the security of the block, as naturally the river did break out directly to the sea at Te Tumu.

(If option G was to be built – ie a lower block at the Te Tumu cut to allow floodwaters to pass direct to the sea but directing all normal flows through the estuary – then rock protection would certainly be required to hold the block.)

The total cost of the works at the Te Tumu cut, at a rate of for imported fill, is $52,000. The cost will obviously be sensitive to this rate. Recent contracts for stopbank works on the Waioeka-Otara were at a rate of $3.80 to $3.90/m^3 – while the same degree of compaction will not be needed for filling the cut, the haul distances are longer. Kaituna stopbank construction some years ago worked out at rates in excess of $15/m^3.

Keeping (for now) to a $4/m^3 rate for filling in the Te Tumu cut, the total construction cost for option H is therefore estimated at $88,000.

2. Stopbank raising

Rediverting the river back through the estuary would have significant impacts on flood levels, and the cost of raising the stopbanks to provide an equivalent standard of protection to the status quo has therefore been estimated, as follows.

The standard of protection for the river and major canals below SH2 is 1%AEP, with various freeboard allowances. The Maketu Estuary stopbanks have a design level of 2.74m. (Refer to Kaituna Asset Management Plan, p21).

In this exercise, Options A (status quo), H (complete block of Te Tumu cut) and G (block of Te Tumu cut for most flows, with overflow weir at cut to allow flood flows to pass directly to the sea) were modelled with two flow and tide scenarios:

- Q_{100} in the Kaituna River, Q_{20} in the tributaries (Raparapahoe, Waiari, Ohineangaanga, etc) and a 20 year tide

- Q_{20} in the Kaituna River and tributaries, with a 100 year tide

Details of the assumptions made and the files used are given in Appendix 1 of this report.

If the stopbank raising required is less than 50mm, it has been ignored. Obviously, in practice any stopbank raising less than about 150-200mm will not be carried out; however when time eventually comes to raise the bank as it subsides, then the bank would be raised to the appropriate height for the option A, H etc that has been adopted.

The modelling showed that the Kaituna River stopbanks would need raising as far upstream as SH2, and the stopbanks of the major canals would also need raising for some distance.

Assume that existing batters and top widths will be kept. Those dimensions may end up being modified in a detailed design, but in general the dimensions are fairly standard.

Three cost rates for stopbank construction have been provided, to provide a range of total costs, as follows:

- Volumetric cost of $8.33/m^3 plus a lineal cost of $16.26/m. These figures are those from the Rangitaiki-Tarawera Asset Management Plan, updated to the current CCI estimate of 4310. These rates produced an Engineer's Estimate for the recent Waioeka-Otara Stopbank Contract 2001-08 similar to the actual successful tender price (i.e. after design costs etc had been subtracted).

  The resulting costs of upgrade are $2.35m.

- As above, but without any lineal component where ΔH is less than 150mm. This is in recognition of the expectation that in practice the stopbanks would not be raised immediately if ΔH is small, but they would eventually be when they had subsided further. In that case, the banks would be raised over such lengths in any case.

  The resulting costs of upgrade are $2.14m.

- A volumetric cost only, of $18.75/m^3 (at CCI = 4310). This is based on the value of the Kaituna stopbanks given in the Asset Management Plan - $27,492,557 (at CCI = 3700) for a total volume of 1 707 235m^3. (Note that in the Kaituna Asset Management Plan valuations are calculated differently – being based on length of stopbank alone. That will obviously not differentiate between different amounts of stopbank raising, and so has not been used in this exercise).

  The resulting costs of upgrade are $3.72m.

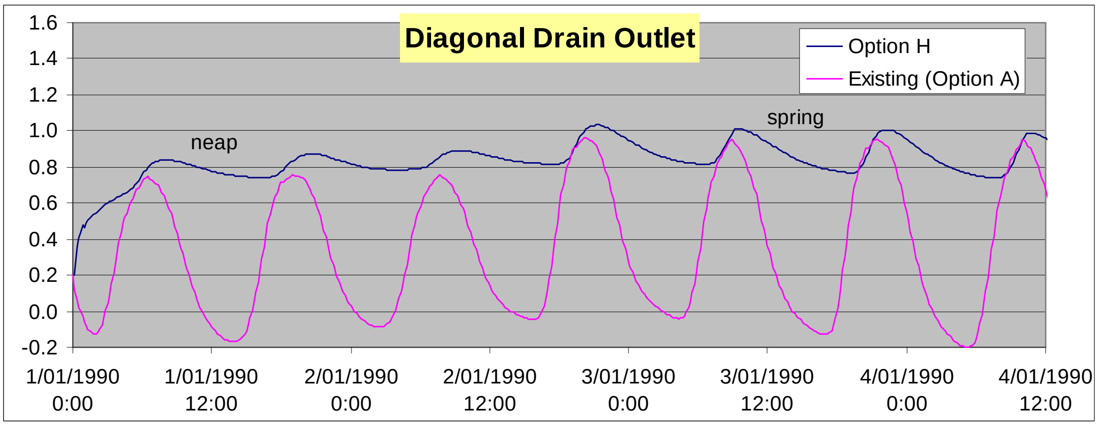
The Kaituna AMP does note that its valuation was based on historic costs of construction, with material sourced from the river, and that future construction may have to rely on imported material at a higher cost.

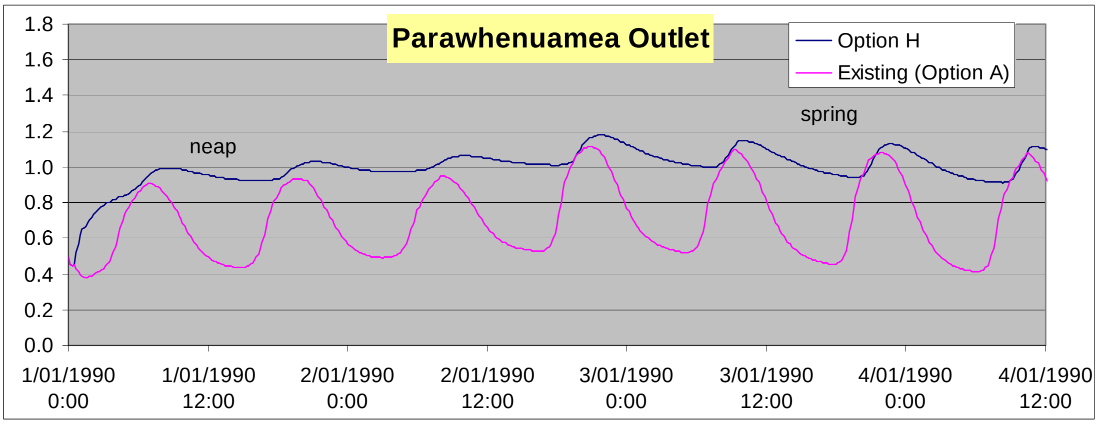
Heavy vehicle traffic will obviously increase significantly during construction. Given that many of the roads have settled unevenly the heavy traffic will cause further deterioration in road condition. It is possible that significant extra costs will be incurred in road repairs. This cost has not been included at this stage.
The higher of the three figures estimated here has been used in the total project cost, but as suggested above it is likely that the actual cost would be higher.

Other additional maintenance and renewal costs should be added, but have not been at this stage.

3. Pumping costs

Option H would raise the river level at low tide to near or above the current river high tide at least as high as SH2, having a significant impact on the gravity drainage of canals etc discharging into the river. Typical river level hydrographs for neap and spring tides, under normal flow conditions, are given below to illustrate the effect of Option H.





Additional pumping requirements would need to be investigated more thoroughly, but at present the requirements are considered to be as follows.

- Maketu Pump Drain (model position: Maketu/Ford Rd drain 880m).
  Gravity outlet does not work well now, and is estimated to function only about 2% of the time. Therefore the Option H requirement would be for some small amount of additional duration of pumping (i.e. for that 2% of the time that it drains by gravity now).

- Maketu Rd Drain (model position: Maketu Rd 1 20m) and Singletons Gravity Drain (model position: Makout 0m).
  All gravity now. Option H would only increase high tide water levels marginally (2-3cm in a spring tide), and there would be no additional requirement.

- Main Outlet (model position: Estuary 605m). .
  This does not function now, and drains instead through the Ford Road Drain. Option H would therefore only affect the Ford Rd Drain performance.

- Ford Rd Drain (model position: Maketu/Ford Rd drain 4100m).
  This operates by gravity about 30% of the time now. It would need to be fully pumped under Option H. Assuming for now that for each pump station, the annual power consumption is proportional to the value of the pump, then the extra power requirements for this pump would be $1060 per annum. (Refer to *Maketu costs – all components.xls).* No additional pumps are assumed to be required, but this assumption will need further checking.

- Diagonal Drain (model position: Kaituna 19400m).
  This gravity outlet currently is open about 50% of the time – ie during the lower half of the tidal cycle. Option H would raise the river level at low tide to near or above the current river high tide. Therefore it can be expected that the pump would need to be operating continuously. Running costs are assumed to double. The extra costs are estimated to be $6000 per annum. Again no additional pumps are assumed to be required.

- Bell Rd A Pump Drain (model position: Kaituna 15880m) and Bell Rd B Pump Drain (model position: Kaituna 16390m) and Kopuaroa (model position: Kaituna 15150m).
  These will continue to be pumped under Option H. However, as the pumps will need to pumping against higher head on average, pump running costs will increase. The quantum of this has not been estimated nor included at this stage.

- Bell Rd No 1 Drain (model position: Kaituna 16390m).
  This outlet is all gravity now, but will need to be fully pumped under Option H. The area drained by this outlet is of the same order as that of the Diagonal Drain pump. Therefore a pump station of the same value is assumed to be needed – i.e $1,147,900. Annual extra electricity consumption costs are estimated at that of the Diagonal Drain pump station under Option H – i.e. $18,000.

- Factory Drain (model position: Ohineangaanga 3028m).
  This outlet is all gravity now and although ideally the outlet should be fully pumped, Option H will raise water levels in the receiving canal by a few centimetres. Therefore no additional requirements have been assumed.

- Borough Drain (model position: Ohineangaanga 2130m).
  Option H has an insignificant effect on water levels in the receiving canal, and there are no additional requirements.

- Seddon St Drain (model position: Kaituna 13674m).

This outlet is all gravity now, but will need to be fully pumped under Option H. Note that a small gravity drain to the north of the outlet exists, but does not function at low tide, and this area will need to be included in the pumped catchment.
The area drained by these two outlets is of the same order as that of the Bell Rd B pump. Therefore a pump station of the same value is assumed to be needed – i.e $375,900. Annual extra electricity consumption costs are estimated at that of the Bell Rd B pump station under Option H – i.e. $3,000.

- Parawhenuamea (model position: Kaituna 13557m).
  This outlet is gravity-controlled now, and is expected to function under Option H at high tide.

(Refer Appendix 2 and the spreadsheet *maketu-drainage.xls*).

Other additional maintenance and renewal costs need to be added. Again, it has been assumed that for each pump station, the annual maintenance (including renewals, excluding electricity consumption but including the staff time associated with the electricity consumption) is proportional to the value of the pump. Those extra costs are estimated at $100,000 per annum.

A preliminary estimate of additional pumping costs is accordingly:
- two additional pump stations, totalling $665,700
- extra maintenance, renewals and electricity costs of $128,500 per annum. At a 6% interest rate and over a 20 year life, that equates to an additional $1.48m in present value terms.

4. Investigations and Resource consent costs

If Option H is to be considered seriously, further investigations are recommended, in particular on the following aspects:
- the estuary flow patterns. The analysis to date has been based on a 1-dimensional computer model of the estuary. A 2-dimensional model would be more appropriate and would give a better indication of the resulting estuary flow patterns. That, coupled with the existing model in the river and canal channels upstream where 1-dimensional flow is an appropriate assumption, would also allow refinement of the estimates of backwater effects upstream. Concerns and issues regarding sedimentation, flow velocity and salinity could then be addressed more thoroughly.
- behaviour of the estuary mouth and general coastal processes in the vicinity – both now and as predicted under Option H. Such investigations would link into those above.
- the current effectiveness of the drainage outlets. While the original design would help in estimating the additional pumping/drainage requirements under Option H, some monitoring of the actual current effectiveness would be much more reliable.

Design costs have been included in the cost estimates above. However, more general investigation costs, such as those just mentioned, will need to be added. A high standard of investigation will be needed given the investment in dairying etc in the area. Costs associated with the necessary resource consent processes can also be expected to be significant.

No estimates of such costs have been made at this stage.

5. Summary

A preliminary cost estimate of implementing Option H is $6m, as in the following table. This should be regarded as a minimum, as such costs as those associated with detailed investigations, with necessary road repairs and with additional maintenance/renewal costs for enlarged stopbanks have not been included.

Option G is not expected to be markedly different in cost. Slightly lower stopbank would compensate for additional protection required at the Te Tumu cut. Costs of investigation, consent processes, additional pumping requirements, removal of the "block", opening Papahikahawai and removing the gates would all be the same as for Option H.

Capital Works				
	Option H construction			
		Papahikahawai excavation		$10,000
		Remove floodgates etc		$14,000
		Remove block		$12,000
		Te Tumu closure		$52,000
	stopbank raising			$3,718,584
		road repair		
	Pump (capital works)			$665,700
	Investigations/Resource Consents			
	Total			**$4,472,284**
Additional Annual Costs				
	Annual Additional costs: electricity			$28,054
	Pumps Maintenance			$100,442
	Stopbanks Maintenance			
	Total			**$128,496**
NPV of annual costs		(USPVF)		
	@	6%	20 yrs	$1,473,839
TOTAL - WORKS PLUS ANNUALISED EXTRA MAINTENANCE ETC				**$5,946,123**