ENGINEERING THE LIFE BACK INTO MAKETŪ ESTUARY

Mark Townsend (Engineering Manager at the Bay of Plenty Regional Council, BoPRC) & Jacob Steenkamp (Engineer at Beca Ltd)

ABSTRACT

The Kaituna River, located in the Bay of Plenty, originally entered the sea via the estuary at Maketū. Since 1926 there has been major work undertaken in the catchment to reduce flood risk and improve drainage for surrounding land. This has included the construction of stopbanks along parts of the estuary margin, and the 1956 Te Tumu diversion which directed the river out to sea before it reached the estuary. While this work did improve land drainage, it substantially degraded the ecological and cultural values of Maketū Estuary (the estuary), including:

- Accelerated in-filling of the estuary (largely due to increased water volume and speeds through the estuary entrance on the incoming tide) with almost two-thirds of the tidal prism lost since 1956,
- Loss of wetland habitats in and around the estuary due to changed salinity, hydrology, and encroachment of farmland,
- Reduction in shellfish and finfish populations, and harvestable individuals, resulting in a decline in the mauri (life force) of the estuary and lower river, with associated impacts on tangata whenua (people of the land) relationships with the area.

The Bay of Plenty Regional Council (BOPRC) awarded a $13.5M contract in 2017 for the physical works to re-divert almost a quarter of the Kaituna River's flow back into the estuary. The extra water is predicted to improve the estuary's health and will restore some of the ecology of the area by allowing salt marsh and other wetlands to return. This will also create more suitable conditions for a range of shellfish and fish species and will halt the in-filling of the estuary. In fact, the increase from 12:10 to 19:10 in the ebb/flood tidal volumes will increase the rate at which the estuary's water flushes (reducing from 15 to 2.5 tidal cycles to replace the entire tidal prism volume) and will likely lead to long-term gradual erosion of the flood-tide delta sand. According to modelling predictions from DHI Water and Environment (DHI), the re-diversion will increase Kaituna River inflow to the estuary from 100,000 m^3 per tidal cycle (mean river flow and mean tide), to nearly 600,000 m^3, including 76% fresh water.

This paper reports on some of the project challenges and successes during the design and construction phases. The challenges included:

- Creating 22 ha of new wetlands,
- Improving the ecology in the estuary,
- Restoring cultural connection with the area, all while managing cost,
- Removing causeways which impede water flows,
- Optimising the new inlet position, size and diversion controls for freshwater,
- Value engineering, especially focused on the structural elements of the design.

KEYWORDS

- **Managed coastal realignment**
- **Estuary health**
- **Improving environmental performance**
- **Monitoring**
- **Value engineering.**

PRESENTER PROFILE

Mark is the Engineering Manager at Bay of Plenty Regional Council (BOPRC). He has been working in the engineering field for over 25 years. Mark and the BOPRC Engineering Team have overseen the technical aspects of this project. Mark is now the Engineer to Contract for the construction contract.

Jacob has over 20 years' experience as a civil engineer, predominantly in the design, management and implementation of stormwater projects. Jacob has been the project manager for the design team during the detailed design phase of this project and provides technical support to the construction team.

1 INTRODUCTION

Historically the Kaituna River entered the sea via Te Awa o Ngatoroirangi/Maketū Estuary. Since the passing of the Kaituna River District Act in 1926 there has been major work undertaken in the catchment to both reduce flood risk and improve land drainage. This included the construction of stop banks along parts of the estuary margin and the 1956 Te Tumu diversion which directed the river out to sea before it reached the estuary. Interestingly, this work was predicted by the district engineer in the 1950s to have negative effects on the estuary, so he recommended only a partial diversion of the Kaituna River. However, in order to receive a 7:2 government subsidy, all the river's flow was diverted out to sea upstream of the estuary. As predicted, subsequent negative ecological and cultural effects have since degraded the estuary, including:

- Decline in the mauri of the estuary and lower river, with associated impacts on tangata whenua relationships with the area,
- Accelerated in-filling of the estuary (largely due to increased water volume and speeds through the estuary entrance on the incoming tide) with up to 70% of the tidal prism lost since 1956,
- Reduction in the habitat for native plants and animals with 95% of estuarine vegetated wetland disappearing since 1956,
- Decline in the size and abundance of kaimoana species.

These effects resulted in calls from the Maketū community for the Kaituna River to be re-diverted back into the estuary as early as 1979. As part of a process to address these negative effects of historical activities, BOPRC and other agencies together with the community developed the non-statutory 'Kaituna River and Ongatoro/Maketū Estuary Strategy' in 2009. The Kaituna River Re-diversion and Wetland Creation Project is the first significant step in a staged approach that is required to implement the strategy.

The goal of the Kaituna River Re-diversion and Wetland Creation Project is:

To significantly increase the volume of water (particularly freshwater) flowing from the Kaituna River into Ongatoro/Maketū Estuary in a way that maximises the ecological and cultural benefits (particularly wetlands and kaimoana), while limiting the economic cost and adverse environmental effects to acceptable levels.

2 DESCRIPTION OF THE PROJECT

The proposed river re-diversion option attempts to maximise the total volume of water which flows into the estuary from the river during each tidal cycle, while also maximising the freshwater component of water flowing into the estuary. The proposal also has the benefit of the creation of new wetland areas. The main features of the proposed option are:

- Widening of the existing Ford's Cut channel,
- Construction of a new channel on the river side of Ford's Cut, utilising and extending the pre-1981 river loop south of Ford Island (Ford's Loop), along with a new entrance to the river some 1,000m further upstream to maximise the freshwater component of water flowing into the estuary and minimise saltwater intrusion into the new channel,
- Construction of additional culverts either side of the existing Ford's Cut culverts,
- In-filling of a section of Ford's Loop to prevent saltwater intrusion into the new channel,
- Removal of stop banks and causeways impeding water flows through the upper estuary,
- Provision of a public boat ramp and new moorings for the Coastguard and commercial fishing boats,
- Creation of 22ha of wetland.

Figure 1: Kaituna River Re-diversion and Wetland Creation Project concept design.

3 ASSESSMENT OF EFFECTS ON THE ENVIRONMENT

The environmental assessments undertaken for the project involved collaborative input from a broad range of engineering, environmental, social and cultural specialists. The project team worked together to identify the potential negative and positive environmental effects of the construction work, river re-diversion, and wetland creation. This included developing measures to ensure that any negative effects are appropriately avoided, remedied or mitigated.

To assess the potentially positive and negative effects of the proposed option, field work was undertaken and a suite of numerical models were developed. The numerical models were utilised to assess the hydrodynamic (how the water moves and what levels it comes to), morphological (form and shape of the river and estuary), and water quality (salinity, nutrients and bacteria) effects of the proposed option.

When the Kaituna River was diverted in 1956 some changes occurred rapidly but others took some 20 years to become evident. It is likely that some of the changes arising out of this project may also take place over a long timeframe as the system adjusts to a new equilibrium. The assessments have found a number of positive, neutral or negative effects.

3.1 CULTURAL IMPACTS

The relationship between tangata whenua, the Kaituna River, and the estuary is culturally and historically very significant. It has sustained the people since the landing of the Te Arawa waka at Maketū. BOPRC has engaged with tangata whenua in several ways

throughout the development of the project, and commissioned cultural impact assessments (CIA) to better understand the cultural values and report on the cultural impacts of the project. The CIAs cover the interests of Ngati Whakaue ki Maketū and its hapū Ngati Tunohopu, Waitaha, Tapuika, Ngati Rangiwewehi, Ngati Makino and Ngati Pikiao. Key recommendations and outcomes sought are:

- General support for the project from tangata whenua, in some cases conditional on other environmental management considerations such as water quality improvement, or preference towards a greater re-diversion,
- Acknowledgement of the negative impacts of historical modification,
- Monitoring during earthworks and post re-diversion, both of physical works and of mauri,
- Consideration of staging of works to minimise impacts on fish passage, habitats and spawning areas,
- Ongoing involvement in restoration and enhancement of resources,
- Continued work towards full diversion of the river.

3.2 NATURAL HAZARDS

One of the key outputs of the modelling are the results related to existing natural hazards and the predicted changes due to increased flows from the re-diversion. The modelling report and associated analysis concludes:

- Flooding is an existing hazard in the Kaituna River and at Maketū;
    - The flood risk assessment indicates that the project will decrease peak water levels within the Kaituna River upstream of Ford Road and therefore will not have a negative impact on river floods or drainage into the river (positive),
    - At Maketū, the project will not significantly increase the risk associated with extreme floods. The most serious flooding risk to the township is associated with rare and extreme sea flood events, during which flood levels exceed ground levels over much of the town. Modelling indicates that the proposed re-diversion would have only a negligible effect (increase of 0.05 m) on these flood levels and only if the extreme sea flood coincides with high river flows (neutral),
    - The re-diversion will increase flood levels at Maketu for lower and more common sea flood events if they coincide with high river flows by up to 20cm, unless the high river flows are restricted. This will increase the flood risk for the limited areas of the town with low ground levels, and slow down land drainage into the estuary after floods (negative unless mitigated).
- Shoreline erosion is an existing hazard around much of the estuary;
    - The additional flow through Papahikahawai Creek will encourage erosion of the channel (positive) but will not increase the risk of serious erosion of the spit to the seaward side of the Creek (neutral),
    - The risk of the Maketū Spit being breached is currently high due to erosion accompanying ongoing expansion of the flood tide delta, a negative effect arising from the 1956 diversion. Over time, the proposed re-diversion will significantly decrease the risk of serious erosion along the landward side of the spit and the associated risk of breaching (positive medium/long-term) –

even though it may slightly increase erosion risk for a short period immediately following re-diversion (negative short-term),

- The current expansion of the flood tide delta will stop and over time the delta will reduce in size. This will reduce coastal erosion risk along the main foreshore of the township to beyond the marae and may encourage natural recovery of a beach in some areas along this shoreline (positive),
- In recent years, Beach Road has been widened into the estuary, with associated upgrade of the rock protection. The modelling predicts a significant increase in maximum current speed adjacent to the more seaward areas of this rock wall during extreme flood events. If constructed according to the design, the wall is adequate to accommodate the increased velocities, however, channel depths adjacent to the wall will be monitored (neutral),
- Seaward of the surf club water speeds are relatively unaffected and the project is not likely to aggravate erosion in this area. Similarly, shoreline erosion along the ocean shoreline seaward of the camp ground will not be affected (neutral). There are existing flood and erosion hazards. The project will not significantly change the flood risk or risk of erosion.

3.3 NAVIGATION

The modelling has considered the effect of the re-diversion on water depths, sediment transport and currents, both at the estuary entrance and at Te Tumu Cut, to assess any effect on the morphology and navigability of the entrances. To determine the extent of any changes the bathymetry (depths/bed levels) were modelled and compared for the existing and proposed situations. There are only small differences in the predicted bed levels for the existing and proposed situations. In particular:

- At Te Tumu Cut there will be no significant change to channel depth, and there will be no increased navigation risk (neutral),
- At the estuary entrance the channel depth will stop silting up and may deepen over time (positive),
- The estuary entrance will change from a flood tide to an ebb tide dominated system (positive),
- the project will reduce in-filling of the estuary and is likely to flush some sediments out (positive),
- there is the potential for shallowing of the channel near the Maketū boat ramp, channel depths in this area will be monitored (negative).

Recreational boaties, the Coastguard, and commercial fishers will still be able to use Te Tumu Cut. A new public boat ramp will be constructed between Ford Road and Ford Island. To address safety concerns raised during consultation, two new moorings are to be provided in the vicinity of the proposed new public boat ramp. The two boats are currently moored at private jetties near the Ford Road culverts, and belong to the Coastguard and a commercial fisherman. Moving the mooring location will remove the risk of debris from the river hitting boats, reduce the distance to travel, and eliminate concerns regarding navigation to the cut.

3.4 WATER QUALITY

The re-diversion of Kaituna River flow into the estuary will cause a range of physical and chemical changes to the estuary and its environment.

Since 1989, bacteria levels in the river have decreased significantly, demonstrating that this aspect of water quality is improving. However, the changes in bacteria and nutrient levels from the river (external load) and estuary (internal load) need to be considered separately. The key chemical changes are shown in Table 1 below.

Table 1: Key chemical changes in Ongatoro/Maketū Estuary predicted by numerical modelling for the Kaituna River Re-diversion and Wetland Creation Project

	Chemical changes
Salinity	*Salinity will decrease at most locations in the estuary (positive). The maximum extent of the salt wedge in the Kaituna River will be 200-250 m further upstream which is negligible compared to the variability due to river flows and tides (neutral).*
Oxygen	*Improved dissolved oxygen regime in many locations of the estuary due to increased flushing of algae and anoxic muds (positive).*
Nutrients	*An increase in the concentration of nitrogen due to external loads in the mid and lower estuary (negative).* *The modelling showed that under mean river flow conditions there will be a small decrease in nutrient concentrations in the upper estuary and a small increase in the mid-estuary and lower estuary.* *Phosphorus and nitrogen levels will remain highest in the southern-most parts of the estuary adjacent to Maketū Road (neutral).* *The general increase in external (e.g. rivers and drains) nutrient load will be balanced by a decrease in internal (e.g. release from sediment) nutrient load due to the flushing of anoxic muds and algal accumulations from the upper estuary, mid-estuary and Papakahawai Lagoon (positive).*

Bacteria	*Blue green algae (Cyanobacteria) - there is not a significant increase in risk for potential blue-green algae blooms within the lower estuary (neutral).* *Bathing water – there will be a small impact on the percentage of time (from 2% to 3.3%) that the New Zealand guidelines for bathing suitability will be exceeded within the lower estuary (negative).* *Shellfish gathering – bacteria levels in the waters of Ongatoro/Maketū Estuary are currently higher than the Ministry for the Environment's shellfish gathering guideline of 43 MPN/100 ml about 20% of the time instead of the allowable 10% of the time down by the boat ramp. High values are mostly associated with rain events.* *The bacteria come from a number of sources including rural and urban drains and streams, waterfowl, septic tanks, run-off from grazed land and directly from the Kaituna River. We don't know exactly how much comes from each source (but some work on this is underway). Our studies for this project so far have only looked at the change in bacterial load coming from the Kaituna River. The modelling indicates that water from the Kaituna River alone causes shellfish gathering guidelines to be exceeded in the estuary 3% of the time now, and this will increase to 10% of the time as a result of the re-diversion. However, median bacteria concentrations in the Kaituna River have declined nearly 500% since the late 1980s and the Regional Council expects a slow downward trend to continue due to improvements in the way that discharges are managed. If this happens then the shellfish gathering risk will also decrease over the long term.* *In summary, this is a negative effect, but likely to improve over time.*

In summary, the increase in flushing and subsequent re-oxygenation will be overwhelmingly positive for the estuary, but further reductions in bacteria, and a reversal of the increasing nitrogen trend in the lower Kaituna River, will be required in order to maximise estuarine health. This work is the subject of BOPRC's work to implement the National Policy Statement for Freshwater (called Plan Change 12) as well as a number of regulatory and non-regulatory methods to improve land and water management.

3.5 ECOLOGY

As a consequence of the physical and chemical changes there will be changes to estuarine margin vegetation, and the species that live in and/or rely on that vegetation, as a consequence of altering the freshwater inflow.

Large areas of the estuary are in very poor ecological condition characterised by dense accumulations of algae, anoxic sediments, dissolved oxygen dropping to very low concentrations on a daily basis and a lack of shellfish and benthic fauna. The worst

areas are in the upper estuary where there is no benthic fauna. The re-diversion will improve this situation. It will also cause changes to estuary margin vegetation.

3.5.1 ESTUARY AND LOWER KAITUNA RIVER

Table 2: Ecological effects predicted for the Kaituna River Re-diversion and Wetland Creation Project (see text below table as well).

	Likely effect
Algae and seaweed	*The increased current speeds of the water will substantially increase the flushing from the estuary of algae accumulations and associated anoxic, organic muds (positive).* *The improvements in flushing will occur in the upper estuary, south of Papahikahawai Island and in Papahikahawai Lagoon.*
Shellfish and benthic macrofauna	*A general decrease in salinity in the estuary is expected to have only minor effects on the distribution of shellfish and cockle in the estuary (neutral).* *A general increase in current speeds across most of the estuary, and in particular an increase in residual current speed towards the ocean, will have overall positive impacts on benthic invertebrate fauna by improving the rate of food supply for filter feeders such as cockle, and by reducing the extent of the estuary that is currently degraded by accumulations of free floating algae and the associated anoxic muds (positive).* *Improvements will be particularly evident in the upper estuary, mid-estuary south of Papahikahawai Island and in what is currently Papahikahawai Lagoon. The effect on the southern estuary, near the Waitipuia Stream, is expected to be small.*
Fish	*The extent of habitat suitable for fish in the estuary is currently reduced by low dissolved oxygen concentrations and suitable feeding habitat is indirectly reduced by extensive areas of anoxic sediments.* *It is expected that reducing algae biomass and anoxic muds will both improve dissolved oxygen levels and improve habitat for benthic invertebrate fauna, which in turn provides fish habitat and feeding areas (positive).* *The increased salinity downstream of the proposed intake is not expected to have a significant impact on fish (neutral).* *There will be a negligible impact on potential īnanga spawning sites (neutral).*

Macroinvertebrate fauna of lower Kaituna River	*Below the new intake the river will become more saline. This section is a zone of transition and dominated by saline tolerant species. The change is likely to result in a shift in the composition of invertebrate species on the river edge towards more saline tolerant species, but the overall effect is expected to be minor (neutral).* *The bed of the main river channel is already saline in this section so there will be negligible effect on river bed fauna (neutral).* *The spatial extent of pipi beds in the lower Kaituna River may extend further upstream towards the proposed intake (positive).*

	Likely effect
Lower Kaituna Wildlife Management Reserve	*The modelling shows a 10% reduction in water flowing from the Kaituna River into the wetland due to reduced flood and high tide peakwater levels. However, this will be mitigated by installing an extra culvert to increase capacity (neutral), and there is another BOPRC capital project to further improve this situation in the next three years (positive).*

3.5.2 VEGETATION

None of the predicted physical and chemical changes as a result of the re-diversion are expected to have significant negative effects on the vegetation on the edges of, and surrounding, the estuary. The potential ecological effects can be summarised as:

- The two main areas of remaining salt marsh and wetland linked to the estuary should remain intact and healthy following river re-diversion (neutral),
- Changes to salinity and removal of stopbanks in the north-western corner of the estuary (Papahikahawai Lagoon) may create conditions suitable for salt marsh or salt/freshwater wetland species to establish naturally or be replanted (positive),
- The wetland area just west of Ford Island, is the largest remaining freshwater wetland area downstream of the Kaituna Wildlife Management Reserve that is hydraulically connected to the estuary. It is likely that there will be some changes in species composition of the vegetation in response to the predicted increase in salinity in the Kaituna River adjacent to this wetland. A monitoring programme has been recommended to track any vegetative changes and contingency mitigation measures proposed should they be necessary,
- Predicted increases in current flow may continue to make the conditions in the area of the large salt marsh (southern edge of Papahikahawai Island), that has since disappeared, unsuitable for the re-establishment of salt marsh or for freshwater wetlands (neutral),
- Modelling predicts areas of increase and areas of decrease in nitrogen and phosphorus concentrations in the estuary after re-diversion. These changes are unlikely to impact negatively on any estuary margin vegetation - in fact, it is conceivable that moderate increases in nutrient concentrations may benefit marshland/wetland plant growth, promoting productivity (positive).

3.5.3 BIRDS

The number and diversity of shorebird and water species occurring in the Maketū Estuary and Kaituna River near its mouth does not appear to have varied greatly over the past 30 years. The project will not result in significant negative effects on birds. As the project is increasing the area of wetlands, this will in turn increase the available habitat for wetland bird species and quite possibly lead to an increase in wetland bird diversity and abundance (positive).

3.5.4 ECOLOGICAL EFFECTS SUMMARY

The project will result in significant positive benefits to the ecology of the upper estuary and Papakahawai Lagoon area, although there may be a short term risk to water

quality from flushing of the lagoon area. There will be overall positive effects on filter feeders due to improved habitat and greater food supply.

Of the physical and chemical changes that are likely to occur, none are expected to have significant negative effects on the vegetation on the edges of and surrounding the estuary.

3.6 ARCHAEOLOGY

The project area is known to have been occupied by Māori for a significant period of time with a number of archaeological sites in the area. An archaeological authority to destroy, damage or modify an archaeological site was obtained under the Heritage NZ Pouhere Taonga Act, and earthworks have been monitored by both archaeologists and cultural monitors in higher risk areas. Nearly 400 archaeological finds have been recorded since construction began in June 2018, the majority of which lie in what is known as Otaiparia Pa site.

3.7 SOCIAL AND RECREATIONAL

A survey was undertaken to learn more about how people use the lower reaches of the Kaituna River, the estuary and Maketū beach areas for social and recreational purposes, and to assess the impacts of the project on users. Overall there was support for the project. In summary, the survey showed:

- The most popular activities were walking and picnicking, followed by swimming (in summer) and fishing,
- Te Tumu Cut was the most popular spot for fishing, with people observed there at all tide times and even in poor weather,
- Boats are going out to sea through both the estuary entrance and the Te Tumu Cut - both of these bars are only navigable around high-mid tide times and when the sea is fairly flat, except for highly skilled operators of vessels with shallow draughts, such as the Coastguard jet boat,
- On a scale of 1 to 10 (very poor - excellent) the health of the estuary (4.75) was rated slightly lower than that of the lower Kaituna River (5.26),
- Māori respondents highly valued the access to kaimoana, cultural, followed by fishing, recreation, family and home,
- 50% of people thought the project would have a positive effect, while only 5% thought it would have a negative effect. 13% of people thought that the project would not change the environment and 29% said they did not know what would happen.

The project will result in the following positive effects:

- Improved recreation access with a new public boat ramp at Ford Road. Pedestrian and vehicle access to and from the parking area to the boat ramp will be designed in a way to reduce the potential traffic and safety effects on users of Ford Road,
- Improved public foot access to the upper estuary from Ford Road as part of the wetland restoration,
- No change to swimming safety in the lower estuary and over time areas may get deeper.

The Maketū and Te Tumu areas are very popular for visitors, especially over summer. Fishing and kaimoana gathering are popular and valued activities. Overall the recreational and social survey showed there was general support for the project.

3.8 NATURAL CHARACTER

The re-diversion will result in changes to the existing character, particularly to the low-lying land north of Ford's Cut. The establishment of new wetland will create a more natural landscape over time as pastoral land becomes wetland.

3.9 PROPERTY

The project will affect some private landowners (5 affected, 16 parcels), including parts of two farms in particular. BOPRC is working through options with the landowners and is seeking to purchase land where necessary. The loss of property will be mitigated by compensating property owners. Other landowners such as Papahikahawai Trust are working with BOPRC to change land use and restore biodiversity through suitable partnership arrangements.

3.10 CONSTRUCTION EFFECTS

Construction of the project has the potential to cause short term negative environmental effects. A number of construction and staging strategies have been identified to minimise the disruption and effects caused during construction. The key construction effects relate to earthworks and stockpiling, access along Ford Road, and general amenity effects on landowners and recreational users.

A significant volume of earthworks is required to create the new channel, move stopbanks, widen Ford's Cut, in-fill a section of Ford's Loop and remove the causeways in the upper estuary. Erosion and sediment control will be critical, and it is proposed to stop the flow of water into the estuary for the duration of construction, as this is seen as having less effect than releasing dirty turbid water from in-channel works.

Staging the works and timing key parts to avoid disruption to public access and recreational use is proposed. For example, the culvert work, which will require Ford Road to be closed for a period, will be timed to avoid whitebait fishing season.

4 DECREASING SALINITY WITH RE-DIVERSION CHANNEL

BOPRC and DHI investigated and completed at the early stages of the project, salinity profiling around the project area which included the river and estuary areas.

From these results the following can be concluded when comparing the existing and re-diversion scenarios of the predicted volume of water, and associated freshwater, as a fraction for two river flow situations:

4.1 SEVEN DAY FIVE YEAR LOW RIVER FLOW:

- The re-diversion will increase freshwater inflows to the estuary between 127,000 m^3 to 171,000 m^3 per tidal cycle, and,
- The ratio of fresh to saline water entering the re-diversion channel will range from 0.21 to 0.80 for the re-diversion option, compared with 0.14 to 0.75 for the existing situation.

4.2 MEAN RIVER FLOW:

- The re-diversion will increase the freshwater inflows to the estuary by between 202,000 m^3 to 303,000 m^3 per tidal cycle, and,
- The ratio of fresh to saline water entering the re-diversion channel will range from 0.47 to 0.96 for the re-diversion option, compared with 0.54 to 0.99 for the existing situation.

5 REFINEMENT OF INLET POSITIONS

BOPRC was requested to consider moving the inlet away from the current wetland area. Three positions for the new re-diversion inlet were investigated. Refer Figure 2:

- Position A - Current designed inlet location on the outside of the bend,
- Position B - Inlet upstream (~50 m) of current location to avoid the wetland area but still on the outside of the river bend, and,
- Position C - Inlet downstream of bend on the straightest part of river before next bend.

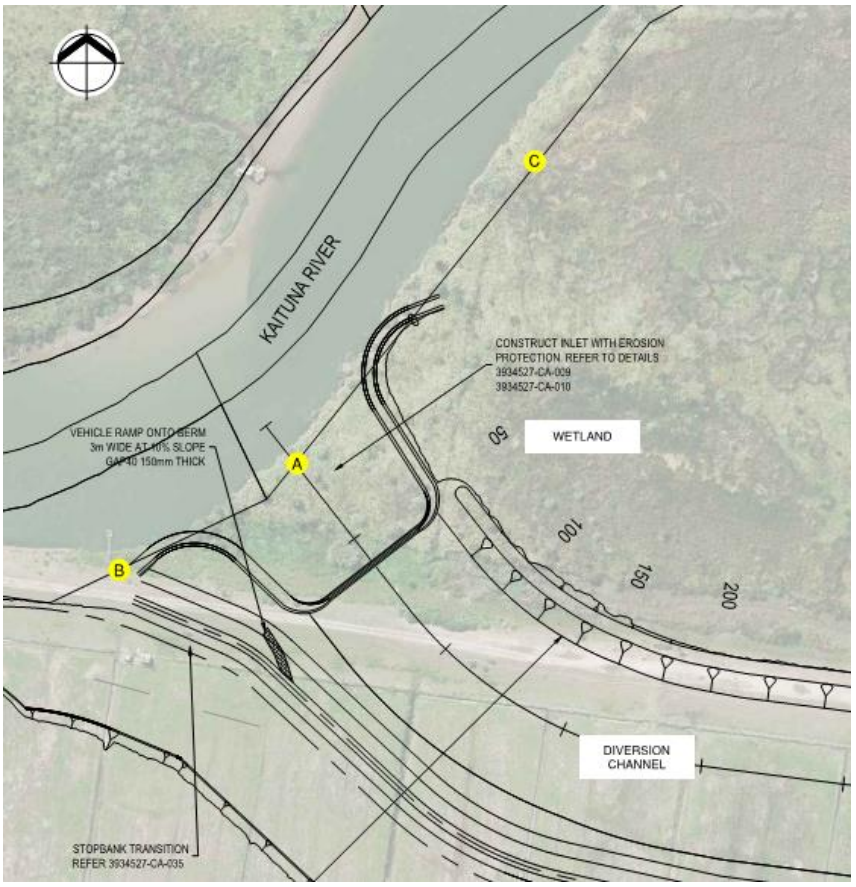

Figure 2: Inlet Positions A to C

The following issues were considered in the decisions of the re-diversion inlet Position A.

- Bed load into re-diversion channel,
- Debris into diversion channel,
- Freshwater ratio into estuary,
- Area of wetland lost,
- Suspended load into diversion channel, and,
- Erosion protection.

6 VALUE ENGINEERING

Once the detailed design progressed an engineer's cost estimate was completed. This cost was significantly higher than what BOPRC had budgeted. A value engineering workshop was held where a number of design elements were identified to be investigated to see if there was scope to reduce the costs. The following are some of the items that were investigated and incorporated in the design and tender stages to reduce the estimated physical work costs:

- Sourcing stopbank material from sources closer to site,
- Reduce rock riprap specifications and look for alternative sources,
- Stopbank design - potential to reduce level of protection,
- Reduce dredging activity – reduce Ford cut widening, and,
- Reduce number of box culverts.

6.1 ALTERNATIVE MATERIAL SOURCES

The bulk fill for the new southern stopbank formed a significant part of the material and had specific design characteristics that included a relatively low permeability, enough plasticity to minimise the risk of cracking due to settlement and the ability to withstand heavy traffic without excessive heaving.

Overlay material is required behind the stopbank to reduce seepage under the stopbank during flooding of the river. The characteristics for this material had to have a reasonable bulk density, free draining permeability, and be easily workable.

Six alternative sources of fill material were identified that were in close proximately of the site. Tests were carried out to confirm the suitability of the material and a further potential two overlay sources were identified but not tested. These sources included dredging material from the Kaikokopu and Pongakawa streams.

The test results and estimated available volumes from these sources were documented and provided during the tender stage to assist the contractors in pricing of the works.

6.2 ROCK RIPRAP

Good quality rock riprap with various gradings is required around the inlet, along the new widened channels, and other areas within the project. It was found there is a shortage of good quality rock to meet the specifications close to the project site and importing the rock was expensive.

The BOPRC has previously sourced rock riprap from Matahina at a rate lower than could be obtained close to the project site. Based on previous use it was considered and

accepted that the contractors can take into account importing rock from Matahina during the tender stage. The rock solid density was adjusted to meet the expected Matahina rock.

6.3 STOPBANK DESIGN

Staging of the stopbank work was developed to reduce the import of suitable material for the construction of the new southern stopbank. A concept was discussed and agreed with the BOPRC asset team. The concept was that a temporary stopbank can be built to the same level of flood protection as the current stopbanks. Once the new southern stopbank was in place, the existing stopbank (located north) can be removed, and the material used to support finalising the second stage of the stopbank construction which is up to the required design finished level and standards.

6.4 REDUCE DREDGING

The option to remove the remnants of the Ford Cut central ridge via dredging was identified as expensive. It was proposed, assessed and accepted to leave the central ridge as it did not provide much hydraulic improvement. Instead the additional flow conveyance area can be provided by widening the channel along the northern edge of Ford Cut. This widening work can be undertaken with normal earthmoving equipment.

6.5 REDUCE NUMBER OF CULVERTS

The cost of the 21 x 2.5 m x 2.5 m box culverts plus their flow control gate was considered expensive.

BOPRC and DHI investigated the option to reduce the number of culverts. The basis of the assessment was a mean river flow (40 m^3/s), mean tide and the present volume per tidal cycle of 100,000 m^3 which is increased to 600,000 m^3 with the 21 box culverts. It was found the optimum number of box culverts is between 9 and 12. Beyond 12 box culverts it was found a diminishing return as more culverts are added. Based on this information BOPRC decided to reduce the number of culverts and flow control gates from 21 to 12 x 2.5m x 2.5m box culverts.

7 OVERALL SUMMARY

The positive effects of the project are:

- A step toward addressing past modifications that have led to the degradation of the mauri of the river and estuary over time,
- Significant improvement in the ecological health, particularly in the upper estuary:
    - the flushing of algae and improved food supply for kaimoana such as cockles,
    - an increased likelihood of sea grass establishing,
    - improvement in the extent of habitat suitable for fish,
    - the increase in wetland area will provide the potential for increase in wetland bird diversity and abundance,
    - 22 ha of wetland will be created,

- Stopping and partial reversal of the sedimentation issues in the lower estuary,
- Significant reduction in the erosion risk on the shorelines adjacent to the flood tide delta,
- Maintenance of the existing navigability of Te Tumu Cut,
- Improved recreation access with a new public boat ramp at Ford Road and improved public foot access to the upper estuary from Ford Road as part of the wetland restoration.

The project is a step towards partial restoration of a badly degraded estuarine environment and a key step in implementing the Kaituna River and Ongatoro/Maketū Estuary Strategy.

There are some negative effects that have been identified and will be managed, but there are also significant positive effects created by the project. Some positive effects will be immediate like provision of the public boat ramp, while others will take time and require a long term stepped view. Overall the project will lead to improved cultural, ecological and social conditions, especially over the longer term.

8 CONCLUSIONS

- Following an international trend towards managed coastal realignment, and in response to nearly 40 years of lobbying for improved estuarine health, BOPRC, in partnership with tangata whenua and the local community, have attempted to restore some of the historic Kaituna River and Maketū Estuary flows combined with the creation and enhancement of natural habitats surrounding the estuary.
- The project is an example of acknowledging multiple values in a catchment where land drainage has been given primary importance for the past 93 years, and attempting to find a balance that provides for as many of those values as possible.
- The project has already restored some of the ecological and cultural values in 13ha of estuary and on 15ha of land and will, in coming years, monitor changes in the remainder of the estuary.
- Given the number of iwi and community stakeholders involved, and the importance of the values potentially affected by the project, it was of critical importance to ensure a comprehensive engagement process from early concept and option testing, through detailed design and consenting, and into construction and post-construction monitoring.
- The project provides an example for other highly modified river and coastal systems to be re-engineered to recognize and provide for multiple values without creating a whole new set of environmental issues.

ACKNOWLEDGEMENTS

- Pim De Monchy, Coastal Catchments Manager, Bay of Plenty Regional Council
- Steve Everitt, WaterLine
- Marianne O'Halloran, Ice Geo Limited
- Stephanie Brown, Principal Environmental Consultant, WSP Opus
- Dean Hassall, Senior Mechanical Engineer – Hydropower and Dams, Norconsult NZ