How and Why Christchurch City Council and the Community should Clean Up McCormacks Bay

— McCormacks Bay Steering Group Report

Prepared on behalf of the Steering Group by

Kevin F O'Connor

December 2009

A Prefatory Acknowledgement:

As compiler and writer of this report of a complex and sometimes difficult exercise, I should like to acknowledge in the first place the generous and helpful understanding I have had from Joe McCarthy, Facilitator, and the cooperation I have had from Will Doughty, Project Leader and Eric Banks, Steering Group Convenor, throughout the several months in which I have been engaged in the task. The immediate and capable help that I have had from Vivian Yang, assistant to Will Doughty in the Capital Programme Group, in managing text, tables and illustrations has been of inestimable value.

For background material for the report, I have been in debt to the City Council and the Avon Heathcote Estuary Trust for the work that they had commissioned of Tony Clay, Teacher Fellow at the Dept of Geography, University of Canterbury in 2006, and Paul Corliss in compiling bibliographic and related notes on McCormacks Bay, as a contribution to the work of the Steering Group. In most cases I have been able to sight the original material to which their work has led me. For the historical chapter, this material and the help that I have learned to rely on from Topsy Rule of the Sumner Historical Society have been invaluable. The Documentation Research Centre of the Canterbury Museum has also been of great assistance with early photographs.

I am indebted in different areas to several people for professional information and assistance. John Walter in hydraulics and tidal hydrology has been patient and generous with help to me sustained over several months following the notable contributions he had already made to the formal discussions of the Steering Group. Shelley McMurtie, Jim Robb and Professor Islay Marsden have been of immense value to me in interpreting information on estuarine ecology. Andrew Crossland, Trevor Partridge and Ken Couling have been unfailingly helpful when I have sought advice about birds, plants, sea lettuce clearance respectively. Alisdair Hutchison, Alex Drysdale and Linda Rutland have been loyal and able critics of successive drafts of this report, as well as helping me keep the Group's focus on the main issue of rehabilitation of McCormacks Bay wetlands. In this last respect I especially value the respect and care for the honest integrity of the Group that Joe McCarthy has cultivated. I can acknowledge now that Don Ross, our first Facilitator, stirred my interest in this project when elder years were prompting me to give up the Estuary among my other loves.

I am especially thankful to my wife for the kindness and tolerance which she has shown to me while this research and writing task consumed all my attention and energies. In a special way then I am grateful on our family's behalf to Will Doughty, Richard Holland and the City Council for facing up to my need for some recompense for a portion of the time that I have devoted to this task.

My last work with that great champion of estuaries, Professor George Knox before his death was to join him in writing a terminal chapter for the 3rd edition of the "Natural History of Canterbury". The fact that our effort to envisage the future of conservation became two chapters, one on ecological restoration, the other on conservation in the past and future fabric of land use, is symbolic of what has evolved here from our Steering Group exercise in working through our Charter. The Culvert Replacement Project may well go ahead very much as it would have done if the Steering Group had never existed, a lower culvert of similar dimensions to the one we have replacing an existing structure. Yet the Steering Group's concern to restore the ecological connection between McCormacks Bay and the Estuary has called for a fresh understanding of the essentials of ecological restoration in damaged estuaries. It has also obliged us to understand our past failure to practice conservation in McCormacks Bay when we were so busy crossing it by the Causeway. This same new and lower culvert invites us to harness our future energies of City and Community into restoring and conserving the tidal wetlands of McCormacks Bay. That exercise would be an outstanding contribution in environmental conservation in the future fabric of life in the south-eastern suburbs.

Kevin F O'Connor

Clifton,
31 December, 2009

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THE CONDITION OF McCORMACKS BAY

A wide angle view of the Main Basin of McCormacks Bay, looking northwest from the Sportsfield Reclamation. Photo Copyright EOS Ecology

Northeast basin of McCormacks Bay, looking east from alongside the central culvert. Photo Copyright EOS Ecology

1.0 The Short Report

The McCormacks Bay Steering Group, a joint City Council-Community body, was formed in October 2005. Leading up to that time, CCC staff had identified the need for replacement of the central culvert (there are three in total) in the McCormacks Bay Causeway. At the same time members of the Avon-Heathcote Estuary Ihutai Trust had become increasingly concerned about the poor condition of the wetlands of McCormacks Bay, and the condition of the sea wall at the foot of Mt Pleasant.

Senior Council staff and members of the Ihutai Trust developed the idea of a comprehensive planning approach to the inter-related issues of culvert replacement, sea wall repair and rehabilitation of McCormacks Bay. This led to a jointly hosted Council-Community workshop in October 2005. The workshop was widely regarded as successful, eliciting plaudits from (among others) the chairperson of the Hagley Ferrymead Community Board and the CEO of the Council.

The Steering Group was formed to progress the Action Plan that had arisen from the workshop. Consideration of possible Terms of Reference for this group led to the development and adoption of the simple McCormacks Bay Steering Group Charter in August 2006. The Charter has proved an invaluable guide to continued progress towards formulating and pursuing the goal of the Group. As described in the Charter the **Aims** of the Steering Group are

"1. *To take a comprehensive planning view of McCormacks Bay, and within that view develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values*

"2. *Provide a forum for a partnership process between the Community and the Council, and a model for future projects, as envisaged by the Local Government Act*

"3. *Ensure the Council decision making process for the culvert replacement project is informed by the Community and that there is a two way exchange of information."*

As described in the Charter the required **outcome** of the Steering group is

"1. A report based on research undertaken in collaboration with the CCC, which makes recommendations on:

- *Design scenarios for the culvert replacement and associated natural and recreational values of the Bay; and*
- *Further required investigations.*

"The report will be presented to the CCC with the expectation it will be utilised in the production of design options for the culvert replacement and drawn upon in the preparation for future management and consultation relating to the Bay."

The report now presented is the report envisaged by the Charter, except to say that, as will become evident, it may be necessary to produce a further report based upon ongoing work that is recommended.

Steering Group membership comprises a number of stakeholder groups, a number of private individuals, and four CCC staff. The Group has met on about a dozen or more occasions, nearly always with the guidance of a Facilitator engaged by the Council. There were two periods totalling over two years when the Group did not meet.

In early stages, a great effort was invested in identifying research and investigation needs in different technical fields. Efforts to have such investigations commissioned by Council have not been totally successful, especially in some aspects of hydrology and the investigation of sediments. Furthermore, results of investigations had to emerge before they could be considered. Following delivery of results of ecological surveys and the presentation of tidal hydrography and culvert design possibilities, members of the Steering Group have met and worked more intensively to make the best use of the information available. It has also been made clear to the Group that there would be no more investigations of the Bay done as part of "Causeway Bridge R801 Renewal, WBS Ref 542/001312". Despite submissions made in 2007 and in 2009 to augment and expand this item to provide for further investigative and rehabilitation work in the Bay as part of this Central Culvert Project, no budget provision has been made for work of any kind, beyond the Central Culvert.

Notwithstanding this disappointment, the Steering Group has drawn on its Charter to adapt its goal within these limitations. The Group has carefully investigated the hydraulic outcomes of different culvert designs, to assess their impacts on tidal filling and draining of the Bay and to establish what hydraulic features are consonant with kayakers' needs. It has settled on the same culvert design at the lowest possible invert level as likely to provide optimal tidal filling and draining of the Bay and at the same time to offer the best practical outcome for kayak-training use.

The Group has examined the prospects for emergence of barriers of small and large dimension to optimal filling, mixing and draining of tidal waters in the Bay. It has foreseen monitoring the development of drainage channels as key to the erosion and breakdown of organic micro-barriers to drainage. It has foreseen an important role for sea lettuce removal in this breakdown process. It has identified possible ways to deal with major drainage barriers, both during culvert replacement (such as breaching the great sand and gravel banks on either side of the inflow scour hole of the central culvert), and later as an outcome of drainage pattern monitoring (such as installing lower drainage pipes in the causeway, or modifying channel gradient in the Bay floor, or moving obstacles to drainage channels, such as bird refuge islands).

The Group has collated and reviewed virtually all the relevant ecological research records available, including those commissioned for the Group's needs. From this review the Group has concluded that long submergence in standing water as a consequence of ineffectual drainage of the Bay is at the heart of the ecological problem of McCormacks Bay, manifest in serious decline of normal estuarine benthic fauna and the growth and persistence of great masses of algae with snails grazing through them, each without adequate consumption or predation. Sealing off of organic sediments without oxygen for normal decomposition may result in periodic anoxic decomposition and liberation of hydrogen sulphide. This general finding reinforces the earlier recognition of the proposed central culvert design as the basis for renewing the life systems of the Bay by renewing its twice daily tidal drainage.

Keeping to the mandate of the first aim of the Charter, the Group has integrated all its findings and recommendations in a series of twelve steps to be taken by Council and Community, a scenario which integrates culvert replacement with the stepwise amendment of the Bay life systems by its monitored flushing and drainage and the associated erosion and washing out of accumulated sediments.

This series of twelve steps is the preferred design scenario that the Steering Group recommends to Community Board and Council for adoption in its entirety.

It was believed that stepwise implementation would be consistent with any necessary further procedures for resource consent and related matters that culvert replacement might entail, although recent advice to the Steering Group indicates that resource consent will not be required. It is believed it will establish the grounds for a constructive revision of the Reserve Management Plan. It is envisaged it will provide a scene for continuing monitoring and research, for environmental education, for taking pride in our working with nature rather than for being ashamed of our abuse of a natural system which we acknowledge we should treasure.

The Steering Group is aware that the replacement of the central culvert was initially planned for transport needs without concern for the rehabilitation of McCormacks Bay. It is feared that some may be content with such a single-minded purpose and that once the culvert work is done the pressure will come off and the rest of the work within the scenario will be set aside, forgotten. Such an outcome would be a travesty, completely at odds with the joint comprehensive planning approach that was adopted in 2005 with strong political and senior staff endorsement. It would be a repudiation of the diligent and penetrative work that has been done by the Steering Group. To neglect the opportunity that is created by this scenario of remediation of the Bay as an integrated companion to culvert replacement would be a gratuitous insult to the Bay and its neighbouring residents, the latest in a long line of environmental mishap and neglect.

The Steering Group has investigated the cultural history of McCormacks Bay as well as its natural history. The Group has concluded that it has been dealing with a highly modified, badly degraded natural system that has been abused by neglect while seemingly lawful ambitions have been pursued in other directions. Time and again plans for improvement have only been half done. There are some who believe that the Causeway should be removed totally for the Bay to function at all. There are others who say that the Bay will never come right and that it should be filled in totally. There are those, like members of the Steering Group, who have seen the signs of resilience in the degraded ecosystems of the Bay, those that want the Bay to be allowed to be the best it can be with the Causeway still in place. It is believed that the choice being recommended by the Group is the best economic decision in both short and long term, as well as having the clearest ecological vision.

The twelve steps of the recommended scenario are set out in Section 6.9 of the full report. Their sequence is important to the integrity of the process. In brief, they are:

- Establish a Benchmark Network of 24 representative stations (16 existing and eight new) for monitoring change in physical, chemical and biological conditions in water, sediment and benthic biotic communities as an outcome of new tidal fill and drainage regime from installation of new culvert. Six stations are to represent each of three tidal levels or bathymetric sectors and six to represent the adjacent Estuary.
- Complete Benchmark Network by adding **before culvert installation** eight further stations to 16 already done by EOS Ecology in 2008 for this project.
- Arrange sampling and primary analysis of sediment cores at these 24 stations of the Benchmark Network **before culvert installation.**
- Install replacement culvert 6m width, invert no higher than RL 8.55, with smooth vertical walls and smooth floor, and with generally specified hydraulic performance functions and generally specified expected tidal hydrological outcomes in the Bay.
- Remove major mixing and drainage barriers close to culvert and rebuild kayak facilities close by, as well as using surplus rock for enhancing bird roosts.
- Monitor installed culvert hydraulic performance to "ground-truth" the model.
- Arrange Community monitoring to assess tidal coverage and drainage and to monitor observable biological developments, including bird feeding and roosting behaviour.
- Arrange monitoring of development of dendritic drainage patterns and identify drainage barriers, especially monitoring changes to sediment cores at benchmark stations where they are affected by dendritic drainage development
- Sample tidal water discharge monthly and if possible during major storm events and repeat physical, chemical and biological monitoring of benthos at 24 stations at wide time intervals to be established (every 3 years is suggested).
- Resume macro-algal removal trials with mechanical brush or suction equipment, with a view to composting trials and biological monitoring of effects on re-colonising of underlying sediment.
- Evaluate dendritic drainage development and erosion of sediments with a geomorphologist and assess methods of acceleration and improvement.

Review outcomes of all monitoring programmes with Community within 2 years of culvert installation, in time to plan and fund in next LTCCP any further measures needed.

MICROSYTEMS WITHIN SYSTEMS

Zeacumanthus snails on sea lettuce mat, McCormacks Bay, photographed by Professor Islay Marsden, University of Canterbury

The northwestern corner of the Main Basin of McCormacks Bay, viewed from the western reclamation and showing the gradation from the silty shore to the permanently wet sea-lettuce beds. The NW culvert pipes through the Causeway are above the water level in the left of the picture. Photo copyright EOS Ecology

2.0 Introduction

This is a statement of the intentions of the Report that follows. The reader will probably have reached this point by reading the Short Report. What is there in the pages that follow? Those who want to do something seriously about cleaning up McCormacks Bay will find more explicit justification for what needs to be done. We hope that they will find guidance for their energies in these particular channels. Unfortunately, not every good intention applied to McCormacks Bay has been fruitful for the betterment of the Bay and its neighbours.

Those who want to leave McCormacks Bay as it is, replace the aging central culvert, and leave the tide and the Bay to their own devices won't find any justification for their position in what follows. Nor will they find a great deal to disquiet or unsettle them if the observable condition of McCormacks Bay does not already disquiet them. They may find from reading the next Chapter on the Historical Background that their attitude has its precursors in those that did half of what they began to do and then went on with something else.

The do-nothing option is now recognised in resource management. All sorts of people opt for this approach, in part as a safety option, lest they make such a difference that it becomes difficult to reverse. Current planning for replacing the culvert with the invert lowered by half a metre will make a difference to the Bay and the behaviour of its wetlands. Left to itself the Bay may then quietly heal itself, over the next fifty years or more. It may not. It will almost certainly change but it will not necessarily change perceptibly for the better.

The intention of this Report that follows is to persuade those who read it of the value of seizing the opportunity of the tide that a new culvert presents. The culvert is there to allow the tide to do its work of refreshing and renewing the wetlands that it washes and drains, almost twice in every day. There used to be three culverts. Two of them have been converted to pipes and have little contribution to make to tidal exchange. We now attempt to unfold what we need to do to make the best of the central culvert replacement, to allow the inflow and draining of the tide to do its best to remedy the damage to the natural ecosystem that we allowed to happen by our inadequate management of tidal exchange.

The report examines what has happened in the past that generated the mess that is McCormacks Bay, how our management has since avoided the issues that were confronting us; how the Estuary Trust and some senior officers of the City Council shared an idea of a new kind of joint approach, of linking the remediation of the Bay to culvert replacement; how the Estuary communities of interest and neighbouring communities joined in a workshop to identify and clarify the issues; how a Steering Group was formed from Council staff and community volunteers, how it was empowered with a Charter that it drew on to formulate its goals and objectives; how it then settled into the task of gathering, collating, reviewing and evaluating most of the studies that have gone before as well as the research and investigations that it had commissioned by the Council for this task.

The outcome of their work in the Steering Group is this report, focusing on the evaluation and selection of a preferred scenario among many that it developed for linking the potential natural and recreational benefits of the Bay with the tidal functioning of the replacement culvert. The recommendations that it makes are mostly central to that preferred scenario. They are addressed to the Community as well as the Council for they make demands on both for their implementation.

3.0 Historical Background

3.1 A brief History of the Causeway and McCormacks Bay

3.1.1 The Reason for Examining History

The problem we share as a Council and Community arises from the historical fact that we have improved the connections of the straggling seaside parts of our city with the rest of the city without adequately respecting the natural, functional integrity of the Estuary itself. The provisions we made in the past for connecting McCormacks Bay with the tidal waters of the Estuary itself have been insufficient either in design or performance, or in both, for the bay to function as an integral part of the Estuary. The outcome has been that in many ways Nature has reacted so that the remaining tidal area of the Bay has become a deteriorating public nuisance. Now when we seek to preserve the social, commercial and structural connections of the Causeway, we try to interpret what we did to Nature and how Nature has reacted, so that we might find ways for the Council and Community to plan for future action so that people can live as contented and civilised neighbours to a healthy Estuary.

McCormacks Bay lay on the main land route from Sumner to Christchurch on the southern or Heathcote side of the Avon-Heathcote Estuary. It was named from one of the first European landholders, William McCormack. There are reports that he lived for many years in a hut between the road and the waters of the Bay. For many decades after the arrival of Europeans, the shore here was very sparsely inhabited. Only after the inauguration of the Steam Tram to Sumner in 1888 was there much evidence of closer settlement.

The Bay came into prominence because of the changes made to it by building a causeway across it to shorten that land route. Initially built for a tramway so that it could be electrified efficiently, the causeway was later enlarged to carry other vehicles. Further reclamation was later carried out on the tidal area inside the causeway but was aborted before it was complete.

A similar sequence of events happened elsewhere on the route to Sumner, so embankments and reclamation were not unique to McCormacks Bay. **The much greater scale of works on McCormacks Bay and the fact that the reclamation there**

has not been carried to completion have together led to a problematic set of environmental consequences that continue to this day. While the history of the tramway and causeway is interesting in itself, it is examined here for its significance to the environmental problems we have now to deal with.

3.1.2 Early travel between Sumner and Christchurch

In the 19th century, the primitive road skirting the shore, winding its way around the foot of the hills, connected the small settlements of Sumner, Moncks Bay and Redcliffs through the Heathcote Road District with the town of Christchurch at that time gradually expanding down Ferry Road towards the Heathcote Ferry. Prior to the opening of the railway tunnel to Lyttelton in 1867, this road became the principal route of goods traffic between Christchurch and Sumner to which goods from Lyttelton were brought by sea. In the earlier days of European settlement, boats sailed or steamed on the tide on the Estuary and the Heathcote River as far as Steam Wharf, near the present Tunnel Road roundabout, and even further into Woolston to Christchurch Quay at Radley, providing significant carriage of goods and people from 1851[1].

Until 1888, travellers to Sumner from Christchurch on the steam tram rode it as far as the Heathcote Ferry and then continued by coach or by boat. In 1877 when a speedier means of transit than coach was sought, a tramway was at first considered not suitable and a **light railway** continuing from Ferrymead was thought most desirable[2]. However, the desirability of extending the tramway from the bridge across the Heathcote River was affirmed on 2 June, 1888.

> *"Work commenced on 12 August and the official run was made on 30 October, 1888, to the point up to which the work had then been completed—viz., the first rock before entering Sumner, a distance of 3 miles 10 chains. A special trip was run the next day and the line to the foot of the hills near the baths opened a few weeks later."*[3]

After 1888, the steam tram from the new Heathcote Bridge continued by way of the shoreline of McCormacks Bay to "The Cutting" at Moa Point Cave, the cutting being progressively deepened over the years, into Redcliffs settlement and on around Moncks Bay to Shag Rock. The tramway and the roadway then initially hugged the cliffs of what became known as Clifton Heights, between Shag Rock and Gollan Point where there was a 'natural' bathing pool. From that point the tramway was carried on a timber viaduct constructed in 1888 across Clifton Bay to what has become Marriner Street in Sumner. At that time, the incoming tide washed up to the foot of the hill where Clifton Terrace now climbs it. This tram bridge or viaduct continued to be used after the tramway was electrified in 1907 and was not dismantled and the present road area reclaimed from Clifton Bay until 1952 when the trams were replaced by buses.

The first major causeway for trams was built across McCormacks Bay from 1904 to 1907. Whereas that causeway was built to shorten the route, another smaller causeway past Clifton Heights was built soon after the McCormacks Bay construction, not to shorten the route but to reduce the danger from rock falls. During 1915 and 1916 an embankment of rubble "with openings for tidal flow" was built for the tramway from Shag Rock eastwards to the tramway bridge above the beach, leaving marine pools, in the place now known (apparently erroneously) as Peacock's Gallop, between the tramway and the roadway then still at the foot of the cliff[4]. As progressive sand-building to the foreshore in this sector beneath Clifton had caused the sea to recede from the gap between road and tramway embankment, this tract of land with its more-or-less dried-up pools was transferred to the borough and in part filled by hand labour about 1930. This allowed the road to be located alongside the tramway, like it, free from danger of rock falls.

Storm damage from the sea prompted re-piling of Sumner pier in 1928 and evidently brought on the need to strengthen the Clifton Bay tram viaduct at the same time. During these repairs, the tramway was temporarily routed along the road around Clifton Bay from Gollan Point to Marriner Street, still keeping to the front of the houses at the foot of the hill. A fresh major storm event in 1950 filled the whole of Clifton Bay with sand, including the total stretch of the tram bridge, making its re-piling redundant. The bearers and rails were removed and the piles remain buried under the present beach-front car-park. The new landscaping of Clifton Bay with the direct road for buses and all other vehicles from Gollan Point to Marriner Street was completed by the Christchurch City Council in time for the celebration of the last tram to Sumner in October 1952

In short, a steam tram had followed the margins of the shore for nearly twenty years. At electrification the tram route was shortened by creating an embankment across McCormacks Bay in 1907. A few years later as outlined above, a rubble embankment for the tramway was built for safety reasons at Clifton Heights. **At each site the reclamation for an initial tram-causeway was enlarged a decade or two later to carry a roadway for other vehicles. Further partial or complete reclamation from the Estuary was carried out at each location, with varied outcomes, depending on the scale as well as the completeness of reclamation.**

3.1.3 Stages of construction of the McCormacks Bay Causeway

The steam tram journey around McCormacks Bay cost some time with very little benefit in return to either the passengers or the Tramway owners, who were soon anxious to electrify the line. In 1903 the Lyttelton Harbour Board, then the controlling authority of the Estuary, had approved an application from the Christchurch Tramway Board to build an embankment to carry its trams across the sector of the Estuary known as McCormacks Bay. In 1904 the decision was made to build a tram causeway in a direct line from the foot of Mt Pleasant Road to the Main Road at The Cutting at Moa Point Cave. This was completed in three years and opened for the new electric tram in April 1907. It is noteworthy that its construction occupied three years, in contrast with the laying of the entire shoreline tramway from Heathcote to Shag Rock which required only three months some twenty years earlier!

From the outset three culverts appear to have been provided for tidal flow in and out of the Bay. Andersen refers to them as “tide gates”. We do not have any record of the sill heights of these original culverts. Furthermore we do not know for how long they functioned satisfactorily. For the next 30 years the causeway served as a base for a single tramway only, the growing traffic of other horse-powered and motorised vehicles continuing to use the meandering route around the shore.

The enlargement of the tramway embankment to carry a roadway came as an outcome of a suggestion from a Mr R B Owen[5], perhaps originating with a Mr A Manhire. During the Great Depression of the 1930s, numerous projects were devised for the employment of men out of work. A committee of engineers had volunteered a list of possible works to the Christchurch City Council, including a proposal for reclaiming land from McCormacks Bay for such an expanded causeway.

“Reclamations” of land from the sea or from natural wetlands were by now a popular form of resource development. Sumner Borough Council was at this time involved in such work as “marine protection” between Cave Rock and Scarborough, in the reclamation of a sector of the Estuary shoreline known now as Beachville Road, and it had removed the roadway from the foot of the cliff at Clifton to a safer site by building up land alongside the tramway.

Legal arrangements for the enlargement proposal in McCormacks Bay had already been in some degree provided for under the **Sumner Borough and Heathcote County McCormacks Bay Vesting Act 1924** which had designated the area south of the existing tramway causeway, McCormacks Bay itself, as a reserve for the use, recreation and enjoyment of the local inhabitants.

In the middle of 1932, Sumner Borough Council and Heathcote County Council were engaged in discussions with the Christchurch City Council to enlarge the causeway across McCormacks Bay to provide a 'Marine Drive' that would shorten the drive to Sumner by more than a quarter of a mile, representing some saving in motorists' petrol bills. It was also envisaged at the time that **"closing two of the three sea outlets and putting a weir in the centre to keep the water levels in the bay at ¾ full"** could make a marine lake or lagoon[6].

It was agreed in 1932 that the City Council would be in charge of the project and that assistance would be sought from the Unemployment Board for financing the scheme. In the event of this assistance not being obtained Sumner Borough placed 120 pounds on its annual estimates for its share, a considerable sum for the financially strained borough at the time. Other local bodies were to be approached to take shares. In the final event, the total cost of the causeway was 43,000 pounds of which 40,000 pounds were wages paid by the Unemployment Board[7].

By April 1933 work was underway from three points. Enlargement of The Cutting provided rock for use from the Redcliffs end; from Major Hornbrook Road came material for the Mt Pleasant end; and from what was now the Tramway Quarry in McCormacks Bay came material that was used to reclaim a considerable area in the south east of McCormacks Bay. Built out from this base was a "rock-supply railway" to the main causeway, joining it near to the site of the present central culvert. Photos of the construction show this "temporary reclamation" and also show the use of a supplementary track (alongside and to the south of the existing tram line) to convey rock material east and west. In fact the great volume of rock coming from the McCormacks Bay Tramway Quarry ensured that the enlarged causeway was built principally "from the centre towards both ends". In 1933 and 1934, the Kitson No.7 tram was used to assist in this work, as well as manpower using ballast-tipping trucks on the supplementary rails.

The northerly sector of the "temporary reclamation" or "feeder mole" built out from the Tramway Quarry in McCormacks Bay northwards to the main causeway remains as a recognizable mole or smoothed mound of sand and gravel to the present day, almost entirely inundated at high tide. The southern portion of this "feeder-mole" has been incorporated in subsequent permanent reclamation used now for sportsfields.

Work continued on the widening of the Causeway and the building of the road for several years. In 1936 Sumner Borough Council is recorded as agreeing to the cost of 'finishing' the new road across the Causeway. The first car is reported to have crossed it in 1937 when its completion was reported. However, Sumner Borough was reported to have given 30 pounds in November 1937 towards the cost of finishing the Causeway road. The road was in use by 1939 although it was not officially opened for traffic until December 15, 1941.

3.1.4 Provision for Tidal Exchange

Three culverts were provided for tidal exchange through the original tram causeway and three culverts were built at the same locations through the enlarged causeway. How was this done in relation to the three culverts in the original narrow tram causeway? By extending them at the same levels or by replacing them completely? How well did the new culverts function? How and when were they modified in any way? When and how did the east and west culverts first come to be replaced by pipes? What was the reason for replacing them in 1975 and 1995? Was this the first replacement at each end? These are issues which we have been unable to settle.

Therefore there is some uncertainty i) about the maintenance of all three of the culverts provided for tidal exchange; ii) over the reasons for the later replacement with pipes of the east and west culverts persisting from the 1930s enlargement; iii) about the sill height at which these east and west culverts had been first installed and iv) about the change if any in the heights at which the pipes replacing them were first installed; as well as v) about the final decision on the sill height in the 6 metre centre culvert.

It is unknown whether this apparently changing situation may have been affected by the already-mentioned vision entertained in the early 1930s, that 'closing two of the three culverts and installing a weir in the central one could ensure maintenance of water level at about ¾ full to enjoy a marine lagoon'! The similar but perhaps somewhat smaller culverts to east and west have been replaced with piped culverts set somewhat higher in the west than the level of the main central culvert, such that **they do not function in the final ebbing of the tide**. All three original culverts were functioning early in the history of the road causeway, but there have apparently been times since when the east and west culverts have been at least partially blocked or ineffective.

3.1.5 Connecting other services by the Causeway

Provision of services across the Causeway seems almost as varied as the history of the roadway itself. Poles on the inside or south side of the tram causeway carried electricity and telephone services just for the tramway for they alone are evident in photos taken in 1907. These poles and lines are clearly visible in the same location to the south side of the tram causeway in the 1930s during the enlargement. By 1937 these same poles supplying power for the trams now **appeared** to be located towards the **north** side or estuary side of the enlarged causeway. Some have inferred that they had been moved in that direction but closer inspection of photos in the late 1930's and 1940s's reveals that they remained **on the inside** of the tramway, between tramway and roadway.

Telephone and telegraph service to Redcliffs and Sumner were initially limited to a pair of lines around the shore of McCormacks Bay. We do not know whether they were carried aerially across the Causeway before they were carried underground. Andersen[8] gives some details of the provision of electricity and water services to Sumner:

> *"Sumner was first lit by gas in 1913 and by electricity from Lake Coleridge in 1917. The water supply was inaugurated in September 1893, the first supply being from four artesians in the estuary pumped to a reservoir on Clifton Hill 100 ft. above the Shag Rock, and raised to another reservoir at 400 ft for high pressure. An extension was made in 1920, when five wells were sunk on Rat Island, and two reservoirs, each of 50,000 gal. capacity, constructed at the Cutting".*

In 1924 the Sumner Borough Council was granted permission to lay a 4-inch water main across the Causeway, then only a tramway embankment. In the following year, two deep wells were sunk at Woolston, a pumping station was erected and connected with the reservoirs at the Cutting, allowing more than 250,000 gallons to be pumped daily. Water connections were thus made in 1924 between the City and Sumner-Redcliffs by installation, immediately to the south of the tram rails, of a 4-inch water main, thereby removing the suburban dependence on artesian water from the wells beneath the Estuary. New larger water mains replaced the original 4-inch main in 1968. Three water supply pipelines are now buried in the road shoulder on the Estuary side of the Causeway, two of them closest to the seawall being constructed of asbestos cement (AC), the other of concrete-lined steel (CLS)[9]. Where an AC pipe is required to span between wing walls of the western and central culverts it is replaced by a stronger CLS pipe.

Electricity generated at Lake Coleridge was reticulated to Sumner by 1917. It appears that this power supply was conveyed around McCormacks Bay. In photos during the enlargement of the Causeway in the 1930s, such power lines do not appear on the new causeway, but power and telephone lines appear to be flanking McCormacks Bay Road running past the Tramway Quarry in 1933. By 1941, to the north of the Causeway and set in the bed of the Estuary some metres away from it, a new line of power poles carried electricity for the Borough of Sumner-Redcliffs.

This row of poles on the north side had been replaced by 1979 with underground cables on the northern or Estuary-side road shoulder, two pilot cables and an 11kV cable[10]. On the southern or Bay-side of the Causeway, there are six 100mm ducts beneath the footpath and a low voltage cable supplying power to the single line of lamps on the south side[11]. Telecom underground cables, including fibre optics run beneath the footpath on the McCormacks Bay side of the road. There are no cables or other ducts on the Estuary side of the road for Telecom or for TelstraClear.

The north side is now free of visual obstructions, except for the railings at the main culvert and west culvert and notices attached thereto, Greenspace plans for planting boxes having been abandoned. The only temporary occupation of the northern shoulder has been an occasional long-parked vehicle, sometimes bearing a "for sale" sign, and a temporarily erected wire-netting fence to protect a pair of nesting black-backed gulls!

When sewerage connection was made in 1968 of these south-eastern suburbs to the new Christchurch Wastewater Treatment Plant at Bromley, the new sewers were laid around the Bay, **not through the Causeway**. This wastewater pipe continues around the Bay to Pumping Station 57 (PS57) whence it runs north through the Reserve to the east of the Mt Pleasant Squash Courts and crosses the main road then turns westward parallel to the Estuary seawall[12].

3.1.6 Continuing Reclamation

Unauthorised reclamation in McCormacks Bay inside the Causeway is recorded from as early as 1918 in the vicinity of the south-eastern rock quarries. Reclamation of McCormacks Bay occurred in substantial fashion from what had been the Sumner Borough quarry in the south east, as part of the creation of a feeder-causeway for the enlargement in the 1930s. Reclamation did not stop with the enlargement of the Causeway.

In 1945 the borough of Sumner was incorporated into the City of Christchurch, and an adjustment made to the boundary between the City and Heathcote County resulted in the whole of the McCormacks Bay 'reserve' being transferred to Christchurch City Council for control and management[13].

At the western end of the Causeway a considerable area of the Bay was already being reclaimed. It is widely acknowledged that during World War II, rubbish of all sorts was dumped in McCormacks Bay by public and private bodies, often simply on the ground that it saved gasoline and tyres needed to cart it further away. McCormacks Bay Road from its junction with the main road around the end of the Mt Pleasant spur had earlier been "beelined" across that western sector of the Bay, impounding shallow water to the south as well as deeper water between it and the Causeway. This last area was progressively reclaimed from the Bay, and the Mt Pleasant Community Centre was built there as a War Memorial in 1950, opening in 1953. The CCC met the cost of the building's foundations, seeming to confirm its trust in the permanence of its reclamation!

By the early 1950s, coastal erosion had become a worry in the vicinity of Sumner and Redcliffs. Erosion of the Spit since 1938 and a major storm event during World War II had prompted desperate measures by local residents and the Sumner Borough assisted by the NZ Army to protect the Redcliffs shore. Not only was Redcliffs exposed to the full storm force of the open sea from the changes to the mouth of the Estuary and to Brighton Spit, but Sumner suffered coastal erosion extending from Cave Rock to Scarborough, as well as the massive change to Clifton Bay already mentioned. Further, the relocated road was threatened between Shag Rock and Gollan Point. The public response to such marine erosion has been to dump rock in the path of the eroding waves and to follow it up with increasingly robust defences, such as the sea walls in Redcliffs and Sumner. McCormacks Bay now assumed a fresh importance as the site of more than one of the major rock quarries.

The first two decades after World War II were a time for New Zealand's newly committed belief in the power of the bulldozer. Until the Great Depression had brought a pioneering era to a close, achievement of public works in New Zealand had been the task of labour equipped with barrows, picks and shovels, scoops, ropes, pulleys, horse power and the occasional steam engine. For the citizens of Christchurch, this new mechanised power over nature exhibited by bulldozers on land and in shallow water was to be first expressed in significant new measures for flood control. Major flood protection works were in progress on the Waimakariri River, as well as the Woolston Cut for flood relief in the low-lying borders of the Heathcote River. City Council, Catchment Board and

Drainage Board shared common purpose in attempting to control floods in this naturally wetland environment.

During the first half of the 20th century, there had been no shortage of schemes and proposals for transforming the Estuary into a managed marine system rather than a semi-natural estuarine system. The Port Christchurch scheme[14] which had envisaged the conversion of the Estuary by reclamation, dredging and other major engineering to become a major shipping port had been prominent from the turn of the century. It still had the support of the Port Christchurch League as late as 1922[15], the league in turn being supported by the New Brighton Sailing and Power Boat Club among others.

At this time, apart from its role as the eventual medium for the disposal and dispersion of Christchurch wastes, the Estuary was more and more entering the public mind for its recreational potential. Initiatives continued to arise among resource administrative bodies and recreational organisations to promote recreational development of the Estuary and to control the Estuary itself for that public purpose[16]. The Christchurch City Council, especially through the initiatives of Councillor P J Skellerup, had been prominent in these recreation-promoting developments[17].

In this respect McCormacks Bay had not yet become a focus of Council attention but it was not immune to its action. In the 1950s the issue of reclaiming the tidal area of McCormacks Bay reserve came to prominence. Dumping of rubbish and fill, often on some scale, had been taking place since 1936, apparently without reference to the provisions of the Harbours Act. Some siltation had already occurred from residential development on the neighbouring hills. In 1961 an application for an Order-in-Council by the City Council to reclaim two acres at the western end of the Bay and a further two acres at the south end of the Bay was approved by the Marine Department.

At the same time the Council resolved to apply to the government for special legislation under the provisions of the Harbours Act 1950 to allow the reclamation of the remainder of the Bay. In August 1961 the District Commissioner of Works had recommended that the Christchurch City Council proposal to reclaim the whole bay be approved. Grounds for the recommendation indicate the level and character of public concerns of the time. They were as follows:

> *"McCormacks Bay is a shallow inlet, mainly mudflats at low tide, and already in the process of being gradually reclaimed by dumping of non-perishable rubbish (tree stumps, bed irons, tins, rubble, masonry etc)"*

"New proposals constitute a continuation of this process"

"There is no danger to navigation"

"Provision for drainage will be necessary in determining the levels of reclamation"[18]

In November 1961 Secretary of Marine, G L O'Halloran endorsed the proposal stating that the Marine Department had no opposition to the reclamation.

In November 1964 the Parliament enacted the **Christchurch City Reclamation and Empowering Act**. This Act not only authorised the reclamation of the whole tidal area of McCormacks Bay but revoked the original reservation for recreational purposes that had been imposed by the vesting Act of 1924[19]. Christchurch City Council was thereby enabled to reclaim the Bay to achieve a substantial area of flatland, a resource already at a premium in the south-eastern suburbs for local needs such as playing fields and possibly a post-primary school. As well as being enabled to meet such needs the Council was now free to dispose of any part of the Bay for any other purpose or uses provided for under the Municipal Corporations Act 1954. Residential, commercial or industrial uses could all be considered, as well as connecting streets and services.

The Christchurch Drainage Board had a much more restricted mandate, for the management of stormwater and drainage and the treatment of sewage and other wastewaters. The Drainage Board was concerned at the fickle character of the Estuary entrance as well as being troubled by evidence of shoaling in the lower Avon and in the Estuary itself. In its own judgment on a solution to its problems, the Board favoured a barrage across the Estuary from the Spit to the city side of Moncks Bay, combined with dredging, but it was unsure of the effects of dredging in the conditions as then understood.

In its concern to maintain the Estuary qualities, it had commissioned biological studies of the Estuary from 1951, then renewed and expanded them in the early 1960s. As well as making its own engineering studies, it engaged further engineers in consultations and commissioned further hydraulic model studies from 1963 (the Wallingford model). A great deal of possible engineering change to the Estuary therefore hung on the outcomes of this report commissioned from the hydraulics modelling laboratory at Wallingford in Great Britain. It was 1972 before the report was fully received after being commissioned in 1963[20].

3.1.7 The beginning of the end to reclamation

Everything about the Estuary did not stand still while the Wallingford Report was awaited. Bulldozers excavating sites for water reservoirs or making roads for hill suburbs on the sunny spurs of the Port Hills produced "fill" suitable for reclamation. McCormacks Bay waited as a nearby recipient. In January 1967 Ryan Brothers, already experienced and skilled in earth movement and landscape change, put forward a proposal with developer B D Blogg already involved in Soleares Avenue development. Features of the proposal were included as follows:

- retention of the lagoon area of the Bay for passive water sports
- reclamation of the western part of the Bay to the foot of Soleares Avenue
- retention of the remaining water area, dredging the Bay to five feet and covering the bay floor with 12 inches of gravel
- installing control gates over existing bay outlets to control water level at 3.5 feet at low tide and allowing some flushing by raising the level to 4 feet at high tide, with complete flushing by opening gates as required
- creation of a paddling pond, possibly a lido pool, tea kiosk, canoe rental, picnic and barbecue areas, grading all banks down to the water's edge.

The Christchurch City Council seems to have adopted in principle the proposal put forward by Ryan Brothers and Blogg, but in accepting the proposal in March the Council evidently advised the contractors that their subdivision plans would be delayed for the completion of the Sumner Interceptor Sewer System. Meanwhile further work was continuing at a modest scale with some 7000 yards of loess from the Soleares Avenue subdivision being used in extending the reclamation behind the Mt Pleasant Community Centre.

Doubts began to arise about some of the concepts in such a land-and-water plan as had been advanced. More exploratory work led by Christchurch City Council and the Christchurch Drainage Board prompted concerns over the efficacy of the provisions for "flushing" and the potential problems of algal growth. Christchurch City Council sought advice from marine biologists, even examining an Auckland research report on eliminating algae from the Orakei Basin. At this time, the mid 1960s, the sea lettuce problem in McCormacks Bay was still developing.

In May 1972 the City Engineers Department of the CCC compiled a report[21] containing proposals for dredging the Estuary, outlining the projected use of the spoil for reclaiming

McCormacks Bay. This included a report on some aspects of the biology of the Estuary by C J Burrows and G A Knox. By this time, Professor Knox was beginning to release reports[22] on the now classic ecological investigations of the Estuary which had been substantially supported by the CCC and especially by the Christchurch Drainage Board. It appears that it was agreed at the Board that the Wallingford Report would be withheld from general circulation until the Knox report had been studied.

In 1964 when the City Council had been empowered to reclaim the whole tidal area of McCormacks Bay, the apparent demand for such reclaimed land appeared to be growing in volume and variety. The possibility of some development and subdivision for housing was by no means excluded. The need for flat land suitable for sportsfields and other recreational facilities was locally acute. Perhaps pre-eminent was the possibility of a post-primary school for the area further south and east of Ferrymead.

Choice of high schools for one's offspring seems to be a complex issue and one that can evidently become quite vexatious in an urban scene, not exempting Christchurch. Residential propinquity to a particular school of choice has apparently not been such an issue in the south-eastern suburbs. Perhaps if a post-primary school had been unequivocally demanded for the area, the reclamation of McCormacks Bay might have been persisted with. Perhaps, on the other hand, if such a school had been built, substantial proportions of the young men and women of Sumner, Redcliffs and Mount Pleasant might have still continued to travel in private and public transport across the city to a dozen or more schools, rather as they do at present.

The need for well-drained level playing fields has persisted. McCormacks Bay could make a contribution in this direction by partial reclamation. Total reclamation was not essential for that purpose. The potential for varied multiple use as provided for under the Municipal Corporations Act was clearly not likely to be realised. Accordingly a further possible motive for continuing reclamation to completion ceased from having any persuasive power, least of all amongst the current residential neighbours.

From about 1966, the concerns of the City Council as to the future use of the bay were gradually focusing once more on recreation. By 1974 it resolved to classify the 51 or more acres of McCormacks Bay as Recreation Reserve under the Reserves and Domains Act. It was gazetted in 1975.

The first Council design concept in a "land-and-water" mode for recreational development was prepared for McCormacks Bay in June 1972, containing elements of the Ryan Bros proposals but condensed to "a 7.5 acre water area suitable for small boats, children's play facilities, picnic areas, a natural history centre, ornamental parkland and sports fields".[23] This design had included a possible extension of Soleares Avenue to the Causeway on the land being reclaimed on the western side of the Bay, a feature about which the Parks and Recreation Committee had reservations and which the Mayor, Mr Neville Pickering evidently opposed. Apparently for many different reasons, this plan met with strong opposition at a large public meeting of neighbouring residents.

By the early 1970s, changes were evident in public attitudes to the natural environment. It was now ten years since the publication in Europe and America of Rachel Carson's *"Silent Spring"* and the dawning of a new ecological awareness that it heralded. New Zealand had shown its own awakening in the Save Manapouri Campaign as well as in the engineer-led Physical Environment Conference. For Christchurch citizens young and old, the Estuary became our own *cause celebre.* Whereas Forest and Bird Society, Ornithological Society and birdwatchers' groups of varied character had for decades been committed to preserving birds and their habitats, now all sorts of people started to come alive to the different kinds of birds that used our wetlands. These were creatures they could see. Painstaking biological studies of the wetlands themselves were becoming more frequent. In their turn these studies directed popular attention to appreciating the food chains that supported these differently-feeding varieties of wetland birds. This was a new kind of environmental attention, distinctly ecological in flavour. In this way estuarine Nature was commanding attention. It is also noteworthy that nature conservation concerning the Estuary was now affecting different kinds of estuary-using recreational bodies, even though it would affect their appetites for improving surroundings for their particular recreation. The swing to nature conservation rather than recreational enjoyment was by no means complete, as can be illustrated by the submissions and the activities of the Estuary users.

A Combined Estuary Association (CEA---it subsequently became the Christchurch Estuary Association) had emerged in 1970 from several recreational, residential and environmental bodies of common interest. One of their first major initiatives was to present to the Council in 1973 an Alternative Plan for McCormacks Bay, a modification of the plan that Council had advanced the previous year. This concept plan from CEA proposed reducing the reclamations to a total of 10 acres, and it included the provision of fishing and boating facilities, an island wildlife refuge and a swimming beach. Some dredging was to be included and land modifications were to include car parking and picnicking facilities as well as the naturalisation of the stream channels into the bay. The Council later agreed to this plan and set up a programme to develop and install it.

Meantime, discussion of the emerging Wallingford report[24] appears to have generated grave apprehensions for those who may have still harboured ideas of dredging the Estuary, installing a barrage for tidal management and generally making it over into a controlled water body. The Wallingford Model Studies were themselves primarily studies of flood alleviation, from freshwater flooding, from spring tide flooding, and from combined sources. The studies also investigated the creation of a use-dedicated aquatic playground, through the combination of planned estuary dredging and reclamations.

It was acknowledged that the problems associated with flooding from different sources and the provision of an aquatic playground could not be treated as isolated subjects for investigation. From its first experiments under a fixed-bed regime, Wallingford found in favour of a barrier preferably at Redcliffs, with six movable gates with a sill level no higher than 15ft CDBD, each gate 30 ft. wide. This design would eliminate tidal flooding and could give partial relief from freshwater flooding[25]. The expected benefits from the barrier were offset to some degree by findings from the experiments with a movable-bed regime[26]. Wave activity was expected to have a major influence on the net amount of material being deposited at the seaward side of the barrier when closed, reducing the depth of the channel considerably. With calm seas the barrier could

> *"remain closed for several days without fear of significantly affecting entrance channel depths. If on the other hand, waves in excess of about 5 ft continue to arrive from the north or north-east whilst the barrier is closed then the entrance could become completely blocked at low water in a few days."*

Once the entrance to the estuary is blocked, depths could be restored almost to what they had been by keeping the barrier gates open This restoration could take weeks or even months, depending on prevailing wave climate. The disruption of local coastal processes affecting Brighton Spit or Sumner Beach that might ensue from prolonged barrier closure gave pause to any welcome of its benefits.

The prospects from selective dredging were somewhat clearer. Marked improvements in drainage on the Avon River could be expected from *"dredging the low-water channel to a depth of 22 ft CDBD and a bed-width of 320 ft for a distance of about 2 miles between the corner of Beachville Road and a point 1000ft south of the Street Bridge." (p.69)*

This dredging (Figure 23 *in Wallingford*) off the South Brighton shore also provided for the proposed Commonwealth Games Rowing Course (Figure 32). Likewise on the Heathcote side significant improvements could be expected by

"dredging the low-water channel to a depth of 22ft CDBD and a bed-width of 320 ft for a distance of 1 ¼ miles from Redcliffs to the jetty near Main Road."

This dredging (Figure 29) of the Heathcote low-water channel along the Estuary side of the Causeway also provided the basis for the proposed triangular senior yachting course (Figure 32).

Concerning the aquatic playground proposals, the Wallingford Report endorsed those involving the low-water channels of the Avon and Heathcote rivers to provide rowing and yachting courses as leading also to an improvement in drainage, but stopped short of endorsing dredging and reclamation on Southshore further south than Plover Street, for fear that ebb flow in the Shag Rock area might be redistributed resulting in instability of the entrance channel with consequent erosion of beaches (p.72).

"Overall dredging of the Estuary to a level of 22ft CDBD to give the minimum of 5 ft below low water for aquatic sports would not be compatible with the requirements of drainage. It cannot therefore be recommended." (p.72)

In summary, the full development of an aquatic playground for the whole Estuary was not compatible with other improvements for flood protection nor with the persistence of a stable entrance channel. The installation of a barrage could be effective for spring-tide flood alleviation, but ineffectual for alleviation of freshwater flooding and problematic in its management in the prevailing wave climate for maintenance of a stable channel and existing coastal amenities. It was not surprising that after long delays for the several stages of the model, the Drainage Board should opt for the clear-cut benefits to the middle reaches of the Heathcote of the Woolston Cut and leave the Estuary and its margins in the "complex", "not now" basket.

It appears that the unacceptability of proposals for wholesale dredging for a controlled aquatic sports arena of estuarine dimensions may have had quite an influence on recreational bodies at the time. Their participation in the wider-interest Combined Estuary Association from 1970 indicated some willingness to accept the Estuary on its own terms, at least to some degree. It would seem that the suppression and restriction of motor craft and the eventual elimination of power boat racing led protagonists of yachting and other wind-powered pursuits to find common cause in adapting their demands to time and tide and available space, accommodating canoeists without hazard and eventually welcoming them to the only piece of predictably eddying water in Christchurch, at the central culvert in the McCormacks Bay Causeway.

In effect, the Wallingford report may have had great significance for the future of McCormacks Bay. The City Council, the Drainage Board and their advisers had envisaged that reclamation of McCormacks Bay could make use of the sediments to be dredged from the Estuary and lower reaches of its rivers, if this was to be the outcome of the investigations and consultations that had been commissioned. Among the considerations that emerged from discussion of the long-awaited and partly implemented Wallingford Report was that every cubic metre of tidal space might be valuable in future if the low-lying riparian lands of the lower Heathcote and Avon Rivers and the borders of the Estuary from Southshore through Bexley and Ferrymead to Moncks Bay were to be preserved from **flooding at the combination of high river flows and high tides.** Furthermore, the recent violent coastal storm events in the district at that time would have given reminders to Councillors and Council staff that such natural forces were not lightly and imprudently to be trifled with.

The upshot was that plans for a barrage and for dredging the Estuary were put aside and the zeal for land reclamation was dampened a little. Shifting shoals of deposits from earlier erosion of stream banks and hillsides as well as chemical residues from varied urban and industrial rubbish continued to affect the benthic Estuary habitat of organisms, whether the latter were wanted or despised. Discharge of treated wastewater with its nutrient and organic loads has continued to dominate the Estuary and its requirements for management as a modified but quasi-natural water body to the present day.

The Drainage Board itself along with its drainage and wastewater responsibilities was eventually in 1989 to be absorbed into the Christchurch City Council administration. The Regional Council inherited responsibility for the water body and the City embraced and contained it. McCormacks Bay as a complex of semi-reclaimed lands, permanently inundated areas or lagoons and incompletely tidally draining areas seemed headed for some mixed management of its waters and wetlands.

These wetlands were increasingly affected by growth of sea lettuce and other algae. What were the critical factors that promoted such growth and what should be done to reduce it were issues by no means resolved by research or debate. Integrated Catchment Management or Integrated Environmental Management might appear as a future slogan. For the wet places for the present, management was likely to be at best indecisive.

3.2 Recent History of Management of McCormacks Bay

Included under this heading is an account and primary evaluation of the overall management of the Recreation Reserve as a unique combination of reclaimed land and non-reclaimed but modified tidal estuarine wetlands and waters. This is followed by similar accounts and evaluations of management of four specific features, a] macro-algae, b] wetlands and water bodies, c] wetland margins and islands, d] tidal exchange through the Causeway.

3.2.1 McCormacks Bay as a Land-Water Recreation Reserve

In 1974, the Christchurch City Council had resolved to classify the area of more than 51 acres in the Bay as Recreation Reserve, pursuant to the Reserves and Domains Act 1953. By 1974, the Christchurch City Council had commissioned Davie Lovell-Smith and Partners to prepare plans and specifications along the lines of the Combined Estuary Association's alternative plan. Detailed surveys of water depth and water flows were made and contracts let for filling, grading, cultivation and seeding of the playing field area of about 10 acres. Landscaping and planting was done in this eastern zone and in the south east corner, as well as in the west where consent was granted for construction of a Squash Courts, after a hearing in November 1976. No dredging was recorded as having been contracted or done.

The problem of sea lettuce and other macro-algae in McCormacks Bay was growing worse. Various factors were adduced to explain their growth and the somewhat erratic performance of the principal species of *Ulva*: water temperature, exposure to frosts, nutrient enrichment and physical substrate. Its worst feature for most humans, the liberation of obnoxious-smelling hydrogen sulphide during anaerobic decomposition, was attributed to anoxic conditions of organic sediments, arising from the acute biological oxygen demand (BOD) of inadequately treated wastewaters and the decaying sea lettuce biomass itself. Improvement from one quarter was on its way with the development of the full wastewater treatment regime, including oxidation ponds, of the new Bromley plant but this did not alter the other deleterious environmental effects of *Ulva* and other macro-algae, affecting both aesthetics and the utility of the wetland terrain where it grew or was lodged.

It was not totally resolved whether the factors affecting *Ulva* in McCormacks Bay were the same as in the open Estuary where it was perhaps more studied by experts. Opinion was somewhat divided as to whether it would be promoted or retarded by better flushing of the bay by estuary waters. How such flushing was affected by the arrangement and performance of the "tidal gates" or culverts was itself a matter of some dispute.

The nuisance quality of sea lettuce and the uncertainty as to how to treat it seem to have inhibited both Drainage Board and City Council from decisive action on the wetlands proper in McCormacks Bay. In October 1976 the Combined Estuary Association wrote to the City Council, noting that it had:

> *" complained to the CCC, on several occasions over the last two years regarding the sea lettuce problem and the weed problem in McCormacks Bay....Frankly we are disappointed and concerned at the evasive and half-hearted replies from the Christchurch City Council."* [27]

The Association suggested the removal of the "feeder-causeway" to encourage better water circulation and flushing. It is unclear whether this suggestion received any support or response. Some partial breach of this mole close to the grassed sportsfields appears to have been made at some later date. By 1978, the removal of the McCormacks Bay Causeway itself had even been suggested to the Council with the reinstatement of McCormacks Bay Road as the main road to Sumner! This suggestion was apparently considered seriously by the Deputy General Manager and the City Engineer and his staff but it was rejected as neither practical nor economic on the grounds of excessive curvature in the shore-line road "for roads of this importance". Later suggestions from the Estuary Association to put in more culverts in the Causeway to improve water flows were referred to the Drainage Board but neither body indicated that it believed this would do much for water flows or for abating the sea lettuce problem.

McCormacks Bay was not short of publicity for its long neglect nor for its promise as an attractive "gem in the green girdle of the garden city". The *"Shoreline"* of June 1976 pointed to the 43-year neglect of the already reclaimed area in the south-east of the bay, while applauding the clearing of rubbish by the "hover-craft-type old-cans-remover" and the winter tree-planting of both natives and exotics on "the newly levelled and grassed area". The *"Observer"* of October 1978 championed the prospects with this contrast:

> *"McCormacks Bay has had a chequered past with many on-off schemes which have never come to fruition. Now it is promised as a holiday lagoon for local families, greater Christchurch residents and the visitors who come to sample the delights of the "Garden City girdled with green."* [28]

While reluctant to act decisively concerning water circulation or sea lettuce, the City Council was not idle on other issues. It renewed a spray programme in 1983 to control or destroy *Spartina* which had established in McCormacks Bay and posed a possible invasive threat to the whole Estuary. Proposals for improved sediment trapping were initially rebuffed but were in part installed in the early 1980s. Sufficient sediment trapping seems to have been achieved to prompt the regeneration of *Sarcocornia quinqueflora* or glasswort stands at the upper reach of the tide. Naturalisation of the margins of incoming streams has also been pursued with appropriate planting. Council had been slow to start the rehabilitation of the reclaimed ground as a possible recreation area and to get the surface up to a suitable standard for good sportsfields, but through the 1980s it had made several landscaping improvements in the west as well as in the east and south. In many of these efforts, especially in landscaping, community organisations and service-clubs joined with the parks and reserves staff of Council.

In 1988 the Christchurch City Council published a statement of "management objectives and policies" for McCormacks Bay. The objectives were as follows:

> *"1. To protect and enhance the estuarine/scenic characteristics of McCormacks Bay, to complement the unique estuarine values of the Avon-Heathcote Estuary, and facilitate a greater public awareness of estuarine ecology. Water should be the dominant theme.*
> *2. To facilitate the development of land-based community and aquatic recreational activities which are compatible with estuarine values and surrounding residential areas"*

These objectives were retained and the management policies developed over the next year to appear as the McCormacks Bay Reserve Management Plan in April 1990[29]. These objectives are especially significant to the present from the fact that this 1990 Plan remains in 2009 the operative management plan. The enunciated objectives are especially important to the present Steering Group project for their evident emphasis on **estuarine characteristics** and **estuarine values**, on their role in **facilitating awareness** of **estuarine ecology,** and their complementing the **unique estuarine values of the Avon-Heathcote Estuary.**

The 1990 Management Plan seems admirable in its enunciation of its first objective, to protect and enhance McCormacks Bay for its estuarine qualities, and in its application of compatibility with those estuarine values as primary criterion for selection of recreational activities to be facilitated in its second objective. It should be noted that this was, in some sense, an innovation. For some decades earlier, ever since the Causeway had been built and extended, officers of City and Drainage Board alike had tended to deal with McCormacks Bay as distinct and separate from the Estuary and in no way considered it as an integral part of the Estuary.

The 1990 Plan was also clear in its delineation of four zones: A and D as now reclaimed terrestrial, Zone A being the 'Community Reserve' in the north west with Community Centre and other community buildings and parkland; Zone D being the 'Sports Area' in the east and south; B and C as aquatic, Zone B being 'Estuarine Wetlands', "retaining existing tidal flow to whole area" which extends from the Causeway almost to the southern head of the Bay; and Zone C, being the continuously inundated area in the north-east separated from the main wetland by the remains of the "feeder mole", now designated as 'Aquatic Recreation Lake'!

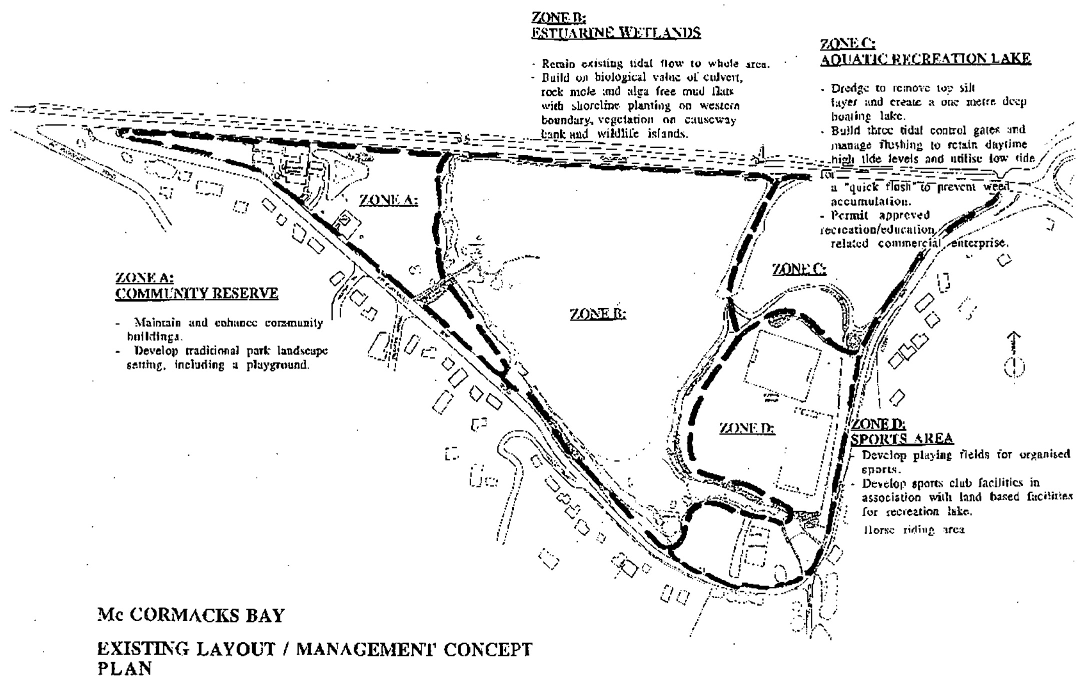

Figure 3.1 The four zones of the Management Concept Plan of the 1990 McCormacks Bay Reserve Management Plan, Zone A: Community Reserve; Zone B: Estuarine Wetlands; Zone C: Aquatic Recreation Lake; Zone D: Sports Area

The 1990 Management Plan, like the 1972 Plan which preceded it, has been clear and effective in its application to the two terrestrial zones, A and D where the landscaping and other measures have given cumulative improvement. The 1990 Plan may be deficient in the enunciation of policies to attain its objectives, as well as being defective in actual performance of what is necessary for its wetlands to attain its objectives. For example:

(1) No policies were introduced to ensure the retention of tidal exchange over the whole of Zone B. This almost certainly would require modification of the then-existing western culvert and perhaps the central main culvert or even the installation of more outlet pipes between them. These are not mentioned.

(2) Policy 2.5 was enunciated: "Islands shall be created on the weed covered central area of the bay to provide a wildlife refuge and create a scenic focus". Two islands were mentioned in comment, one relatively open, one vegetated. Three were built. No attempt is on record of examining their function as refuge in the limited spaces of the bay and with the existence of predators in the urban neighbourhood, nor was the characteristic low relief of the estuary reconciled with the height of vegetated islands. (The loss of Skylark Island from erosion through new channel development as an outcome of the building of the Causeway has been since represented as a loss of roosting and possible nesting opportunity in the southern Estuary.)

(3) Recreational policies (but not estuarine ecosystem policies) were enunciated for the development of the Boating Lake in Zone C, and maps indicated that it would be isolated from the tidal Zone B by increasing the height of the "feeder mole" and the pool in Zone C would be dredged to remove top silt and create a 1 metre deep lake. One map also indicated that "three tidal control gates" would be built for this zone to "manage flushing to retain daytime high tide levels and utilise low tide for a 'quick flush' to prevent weed accumulation."

These concepts for Zone C seem to be fundamentally the same as those advanced for the area in Ryan Bros' proposals in 1967 and the 1972 plans deriving from them. They seem designed to make the most of part of a much altered estuarine system, converting it to a marine lagoon for recreation and making no attempt to reconcile its outcomes with the "unique estuarine values of the Avon-Heathcote Estuary".

In short, although the enunciated Objectives are exemplary, the concept plans and policies may sometimes be inadequate for or partially in conflict with the Objectives they are to attain. However, the Management Plan is to be applauded for its policies giving ecological attention to shorelines, control of the exotic estuarine grass *Spartina*, investigation of ways of reducing the amount of algae, instituting "a water quality programme monitoring any possible biological or chemical changes as a consequence of changes to McCormacks Bay", and improving the stormwater regimes that fed into the Bay. The measures planned and implemented for improving nature walks at the head of the Bay have been highly valued by locals and visitors.

It is noteworthy that the most controversial proposal from an estuarine values viewpoint, the development of Zone C as a boating lake, has not been implemented in any way. It is also noteworthy that while no specific plans were made for kayaking, the use of the "tidal flow" into Zone B through the main culvert for kayak training has become the outstanding active recreational use of the water body.

3.2.2 Investigation and Removal of Sea Lettuce

Sea lettuce has been the obvious bane of McCormacks Bay for at least 30 years. By 1971 green algae (mostly *Ulva* spp.) had been estimated to occupy virtually all of the wet area of McCormacks Bay[30]. At a Public Protest Meeting in the Mt Pleasant Community Centre on 31 March 1971, Professor G A Knox told the 200 people present that it was estimated that in 1970 there were 120,000 tonnes of sea lettuce in the Estuary.[31] In public parlance, McCormacks Bay became a byword for sea lettuce, because in all except the area in the south covered only at high tide, high levels of macro-algal biomass were maintained over winter, in contrast to the remainder of the Estuary where it appeared to be checked by frost.

Sea lettuce in McCormacks Bay likewise showed apparently little annual variation, whereas the problem could vary from one year to another in the larger Estuary. McCormacks Bay sea lettuce was now suspected by some scientists to function as a nursery, harbouring propagules which could be carried off on the tide to recolonise and repopulate the Estuary at large. Within McCormacks Bay, attached macro-algae had colonised the hard substrate of rock and concrete walls to the Causeway and main culvert as well as rocks at the shores of reclaimed areas. Drift algae of various kinds including *Ulva* spp. were suspended as wet blankets in the constantly wet area in the north-west and in the permanently inundated area in the north-east where they were blown about with the wind.

Hopes of abating the smell problem arising from decomposition of the algal mats were included in the justification to the community for the creation of islands in 1993 for estuarine birds to roost[32]. These islands were generally located where the algal mats had been very serious. Chris Freeman of the CCC Parks Unit explained at the time that "the main culvert, next to the rock mole, flushes the immediate area well, but water action barely affects areas away from the culverts". Permanent solutions were discounted and "the only temporary solution was to remove the algae regularly or to dredge. Birds that use McCormacks Bay would lose their habitat if the area were filled. Instead the Council decided to enhance wildlife values at the same time as it dealt with the smell."

Ken Couling (City Solutions now the Capital Programme Group) has been co-ordinator of the Council sea-lettuce project which aimed to assess and find ways to deal with the nuisance issue affecting the whole Estuary, not simply McCormacks Bay. Terry Costello (City Solutions now the Capital Programme Group) had been monitoring *Ulva* and *Gracilaria* at 17 sites in the Estuary and results were assessed by NIWA in 2004. The season 2001-2002 was notably warmer, drier and with longer sunshine in comparison with the next two years. During 2002-03 and 2003-04 plant biomass and drift accumulations did not reach the levels observed during 2001-02.[33] In 2003 Ken Couling was reported to have found that the previous summer (i.e. 2002-03) had been "very uneventful in terms of it accumulating and rotting over summer", with only one complaint being logged with the Council. In that summer "the Council had not found it necessary to remove any from Southshore compared with 600 tonnes being removed the summer before".[34] Ken Couling then ascribed the quiet season to the paucity of "strong sustained southerly storms to dump sea lettuce on Southshore and fewer north easterlies to dump it into Humphreys Drive embayment. Sea lettuce was still growing but it was breaking off and being washed out to sea gradually."

The Council, using a small team led by Lyndsey Saunders from City Care, was at that time trialling different methods as well as "trying to find suitable machinery to remove sea lettuce and gracilaria". The weed harvester had been used in September 2003 and in November of the same year, operating in fully inundated conditions in McCormacks Bay[35]. Some 2.5 tonne of sea lettuce (drained) was removed on one day in McCormacks Bay in September and 8 tonnes on two days in November.

In the following Spring, 2004, the weed harvester worked across the eastern compartment (the permanently inundated area) parallel to the Causeway, and for "one hour each day at the top of the tide in the main compartment of the bay just west of the main culvert". In this combination it was operating for four hours each week day at high tide in McCormacks Bay. The biomass removed was much less than the 8 tonnes removed in two days in November 2003.[36] It was later reported that this operation removed an average 610 kg dry weight per day on several days from 6 to 19 August, 2004[37]. This suggests that the previous year's operation may have had a considerable effect in lowering the level of accumulated biomass.

In the Estuary proper, the focus of small-scale trials at that time was to find a "light footprint" vehicle that could operate safely in soft sediments, brushing or harrowing to dislodge the macro-algae from their bonding to the substrate. The tracked Argo machine appeared to be the ideal vehicle for operating in the Estuary, even in the softest sediments in Humphreys Drive embayment. A hand-held motorised broom was successful on a very small scale in the Estuary north of the Causeway.

Ken Couling and City Care staff have co-operated with graduate scholars at the University in monitoring the effects of a mechanical broom, brushing sea lettuce from the Estuary floor, including at least one study involving McCormacks Bay on a shallow, sheltered mud flat, in comparison with an open, exposed sand flat[38]out in the central Estuary. Removal of sea lettuce in McCormacks Bay resulted in a significant decrease in mobile 'epifauna' such as the snail *Zeacumantus subcarinatus* which graze over the surface of flats and algae, and an increase in abundance of 'infauna' such as cockles which feed within the sediments.

The greatest visual effect of removing sea-lettuce in McCormacks Bay was the stirring up of fine sediments. In his thesis abstract from this study, Murphy concluded:

> *"Removal of U lactuca by mechanical broom was effective and had only low impact on benthic invertebrates and physico-chemical variables, but it should be used only in sandy habitats because of severe disturbance to soft-sediment environments".*

The prospect of composting sea lettuce after removal has been recognized in comment within the 1990 Management Plan. It has been recommended to citizens by one local Christchurch City Councillor[39]. Whether these residues can be de-salted and composted satisfactorily with other organic wastes from the City cannot be confirmed at present. The CCC staff are not pursuing sea lettuce harvesting operations at the present time, pending the observed outcomes of the ocean outfall. If sea lettuce growth persists, harvesting and composting seem a worthwhile prospect. The observed phenomenon of fine sediments being stirred into suspension in McCormacks Bay by such devices as the mechanical broom serves to highlight the value of physical disturbance in reducing sediment deposits. It also serves to emphasise the need to have all culverts working in effective drainage of the Bay and to achieve complete tidal exchange and thorough water circulation and flushing.

3.2.3 Monitoring and Improvement of Wetlands and Waterbodies

Aside from the question of sea lettuce and the creation of island refuges for wildlife, management interventions in the principal remaining waterbodies have been minimal. Control of the level of water in the fully inundated north-eastern zone has been discussed as additional controlled-opening pipes through the Causeway, dredging, and sealing of the "feeder mole" so that it would become a complete water barrier. None of these measures has been attempted. The only intervention that appears to have been made has been the partial breaching of the "feeder mole" towards its southern junction with the sportsfields reclamation. From the evidence of Carver[40] this breach was made prior to 1982.

The lack of clear-cut action to implement the Management Plan1990 with respect to this Zone C (Boating Lake) is hard to reconcile with any lingering wish to make a boating pond or lagoon out of the area. The possibility that the task appeared too expensive or difficult has to be admitted, especially in conditions when algae were not under control. This question might only be resolved when the history of the replacement of the east culvert is unfolded more fully.

The problems of wetland weed invasion and spread in McCormacks Bay have been reviewed as part of a contract study of the Estuary[41]. Spartina (*Spartina anglica*) also known as cord grass, is perhaps the most notorious plant threat. It was introduced by the Drainage Board in 1938 to control erosion. Fears for its spreading led to a control program, which was reported to have been close to completion by 1976, but the program was not sustained because of various factors. Spartina has been earlier reported at several locations in different parts of the Bay but at an inspection five years ago it was confined to two small infestations at the head of the Bay.[42]

3.2.4 Vegetation Management on Wetland Margins and Islands

Planting of riparian land in the southern part of the Bay has been conspicuously successful. These stream margin communities might ordinarily in nature function as nesting zones for duck and other species that seek such cover. In a populated area frequented by people exercising their dogs, aesthetic rather than wholly ecological motives may well be sufficient to support such landscape creativity. Joined with a programme to manage storm flows into the head of the Bay an extended planting programme may contribute to sediment control. The spread of silty sediments over what were sand flats rather than mudflats apparently limits the establishment of *Sarcocornia quinqueflora* in its natural niche at the head of the Bay. It has been suggested that sand replenishment into these small zones may be necessary for such salt-tolerant plants to play their proper role in the aquatic system.

Three wildlife roosting islands were built in the main tidally-affected reach of the Bay. It was planned that two would remain relatively sparsely vegetated to suit waders, terns and gulls, and one would have more cover to suit some other bird species. At the present time, one island is already a shrubland, another has shrubs already established and is apparently heavily turfed, while the third seems fairly well grassed rather than sparse or open. In the absence of frequent flood inundation or other disturbance, one cannot readily expect to maintain sparsely vegetated islands in this kind of situation, without some other managerial intervention. The pleasure derived by local people in seeing scores of pied oystercatchers or terns gathered together in such a roost can only be matched by the satisfaction of the oyster catchers or terns themselves. Over recent years a dozen or more spoonbills have attracted similar admiration to that shown to the oyster catchers. Some kind of decision must soon be made as to the habitat function that the islands are to supply and on vegetation management to achieve that aim. Decisions will become imperative if one of the islands has to be removed to facilitate tidal drainage of the western shore.

3.2.5 Management of Tidal Exchange through the Causeway

Controlling tidal exchange through the culverts of the Causeway is probably one of the most significant factors in the management of McCormacks Bay. It has been one of the most difficult to unfold and understand. The original causeway had reputedly three "tidal-gates" established as the three culverts. Whether these were subject to any manual or mechanical control and down to what level the culverts functioned we have been unable to establish. There is clear evidence in historical photographs and in the present causeway that the east and west culverts were originally constructed in similar fashion to the central culvert. There is also photographic and residual evidence that the enlarged causeway of the 1930s had culverts at the same east and west locations. At some time in their later history, the east and west culverts were replaced by pipes, as indicated in the earlier record (*Section 3.1.4*). We do not know at present whether fitting of pipes in 1975 in the west and in 1995 in the east was the first amendment to or replacement for the original culvert at these locations. We suspect it was not. No reason or explanation has yet been found for these changes nor for the decision to locate the present west pipe culvert in the causeway at a height where it evidently could not contribute to the ebb tide drainage of the adjacent pond.

West Culvert According to the 2004 Maintenance and Development Report[43],

> *"Two 450mm diameter pipes ....replaced the original culvert in 1975, though the recess in the Estuary seawall remained. The recess appears to serve no practical purpose other than to reduce the required length of pipe, and may simply be a relic of the original culvert."*

The two 450mm diameter pipes were reported to be in good condition with no sediment build-up. Information obtained at Steering Group meetings indicates that these pipes are set with their lowest point some 50 centimetres above the sill height of the central culvert. We conclude that they do not contribute to draining this sector of the Bay in the later stages of the falling tide. This ensures that this north western sector of the Bay is never completely drained. The reduced cross section of the two pipes together, in comparison with the original west culvert means that they make only a small contribution to total tidal exchange.

In our present state of ignorance of reasons for their installation in place of the original culvert we can only speculate as to their intended function.

East Culvert At the north-eastern corner of the Bay, "a single 1200mm diameter pipe culvert was built in 1995"[44]. It seems that this may have been done in conjunction with some amendment of the intersection there of Main Road and McCormacks Bay Road. At the 2004 inspection it was reported:

> *There is approximately 400 mm of sediment build-up in the bottom of the east culvert. However given the overall dimensions of the culvert this represents only a small "proportion of the total cross sectional area and does not appear to be adversely affecting the function of the culvert. "[45]*

This quoted assessment gives no attention to the fact that the present east pipe culvert is set too high in the Causeway to make any substantial contribution to the final draining of that low north-eastern sector of the Bay. During the compilation of this report the Project Manager has ensured that the sediment built up in the east culvert pipe has been cleared out, with some effect in the outflows from this impounded area. Although at a similar invert height to the present central culvert, this eastern pipe cannot totally drain the already low–floored pond in this NE Sector.

Together i) the obstruction by the residual mound of the "feeder mole" of water drainage from the east towards the central culvert, and ii) the present effective level of the sill in the central culvert and of the east pipe culvert, relative to the low floor-levels of the north-eastern zone of the Bay, ensure that this zone of the Bay is **never fully drained and that there is minimal exchange of water here with water in the Estuary.** Whether this situation is the outcome of accident or design or a consequence of indecision about the management of the wetland zones is not at all clear.

Overall, there seems to have been little managerial concern for several decades to ensure that exchange of tidal water through the culverts of the Causeway has been as effective as possible. The reduced hydraulic functions of the east and west culverts in current conditions, together with the tolerated persistence of the residual "feeder mole", the creation of the islands and bay-reshaping reclamation, serve to minimise the circulation of waters in the Bay. Whether this is the principal factor leading to their higher temperature, altered chemical composition and higher organic suspension load than the waters of the Estuary proper can only be speculated.

Both the condition of wetlands of the Bay and the Council's engineering control of the supplementary tidal exchange through east and west culverts seem to have been matters of little concern for some decades. The persisting difficulty experienced in our failure to this point to discover the engineering record of culvert replacement in 1975 and 1995 seems to indicate some lack of earlier concern for the **hydrologic and ecological reasons** for full tidal exchange and drainage. Such a past lack of concern or awareness is evident in the comments made at the 2004 inspection of all three culverts when some details of those east and west replacements were apparently known. Whether such lack of concern for the present condition of a second and third culvert still persists is a moot point. It is understandable that kayakers might seek the mobilisation of most of the **inflow** to occur through the central culvert. There is no other justification that we could find for such a situation. Even that would not justify being content with the poor ebb tide drainage of the east and west corners of the Bay. The poor drainage in the western basin occurs primarily because of lack of effective gradient down to the central culvert at its present sill height and because of the apparently irrelevant level of the west pipe culvert.

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4.0 Immediate Background to the Project

4.1 Focusing on Culvert Replacement in a Wider Perspective

4.1.1 Assessing the Condition of Causeway and Culverts

The deteriorating condition of the Estuary seawall at Mt Pleasant was brought to the attention of the Council by Alex Drysdale, Chairman of the Estuary Trust early in 2004. The task of assessing the engineering condition of the Causeway and culverts was carried out by City Solutions (now the Capital Programme Group) in 2004 and a report[46] prepared for Transport and City Streets Unit of Christchurch City Council. The full report covered the whole original extent of the Seawall from what is now a car park in Scott Park to the intersection of Main Road and Beachville Road, a distance of about 1700 m.

The observed condition of the Seawall from Scott Park to the West Culvert of the Causeway as it is at present, indicated repair or maintenance was needed in varying degrees due to seawall disrepair or collapse and subsidence. In this 1000m sector, the seawall had been constructed "from large angular stones and concrete blocks with unreinforced concrete and mortar used to bind the stones together. The slope of the wall is generally 45-80 degrees from the horizontal." In that particular sector, however, the seawall was found to be "near vertical and is being undercut by foreshore erosion in most places".

The remaining 700 m of seawall (i.e. eastwards from the West Culvert) "looks to be in good condition, has been constructed at a gentler slope and generally shows no sign of undercutting"[47]. There appears to be no other comment on the Estuary-side seawall along the present length of the Causeway and no locations identified for detailed description of deterioration at any point eastwards from the West Culvert. Apart from the above comment "shows no sign of undercutting", and the indication that it is only the sector abutting Mt Pleasant where the seawall is "near vertical", no explanation is offered for the satisfactory condition of the Estuary seawall **east** of the West Culvert where it is part of the Causeway, in contrast to the damaged condition **west** of the West Culvert where what was once causeway is now abutting and fused to the foot of Mt Pleasant.

The remaining seawall assessments are of the seawall on the **inside** of the Causeway, termed there "the McCormacks Bay seawall". There were two distinct sectors in the McCormacks Bay seawall, both appearing to be in good condition:

> *"On the **eastern** side of the **central** culvert the wall is well constructed with tightly fitting stones. The wall shows no signs of cracking or instability and the road shoulder shows no signs of subsidence, though it is difficult to be certain because of vegetation growth. The shoreline at the base of the wall shows no signs of erosion."*[48]
>
> *"On the **western** side of the **central** culvert the (McCormacks Bay) seawall appears to be poorly constructed of randomly placed concrete rubble..... Despite this the seawall shows no signs of instability, the road shoulder shows no signs of subsidence and the shoreline at the base of the wall is not eroded."*[49]

While the condition of the seawalls on both sides of the Causeway proper was thereby assessed as good in contrast with the seawall along the foot of Mt Pleasant, the central culvert was identified "for replacement in the near future". As noted there, replacing the culvert would allow overweight vehicles to travel across the Causeway and avoid problems with the alignment of the (eastern) intersection of Main Road and McCormacks Bay Road. Overweight vehicles from Lyttelton have been required to use the shore-line road, since inspection in 2000 had revealed the continued deterioration of the reinforcing in the concrete on the underside of the culvert.[50].

The City Council decided that it had to give some priority to replacing the central culvert in the causeway. In brief, the two-lane causeway culvert/bridge No R801 was constructed in 1935 and needed to be renewed. This had now become a priority with Greenspace Unit as well as with Transport and City Streets Unit.

4.1.2 Sharing an Idea between the Estuary Trust and the Council

Having read in a community newspaper of the intention of the Council to replace the central culvert 'within the next six months', Alisdair Hutchison, a Board member of the Avon-Heathcote Estuary Ihutai Trust (the Ihutai Trust) brought to the Board the idea of seeking some configuration of the culvert that might improve the continuing sad condition of the wetlands of McCormacks Bay. The Board considered these matters along with the news of the need to replace the central culvert. While Council roading engineers might focus on the road for the communications it provided, the Ihutai Trust Board focused primarily on the need for **tidal** communication which the existing culverts only imperfectly provided.

In May, 2005, Alisdair Hutchison, met with Lesley McTurk, CEO of the Council and Jane Parfitt, Environment Manager, to discuss the possibility of a joint project that could become a showcase partnership under the Local Government Act. The Trust proposed a comprehensive planning approach to the inter-related issues of Culvert Replacement and the Rehabilitation of McCormacks Bay. Lesley McTurk championed the idea and entrusted it to Jane Parfitt who was also supportive of the comprehensive planning approach proposed by the Trust and supported by community groups. These senior officers of Council saw this proposed project as a model one and considered appointing an overall project manager. Jane Parfitt was keen to ensure appropriate Council staff and elected representatives on Council and Hagley-Ferrymead Community Board could attend the site visit scheduled for 31 May.

Jane Parfitt further supported the concept of a jointly-hosted public workshop at a suitable Community Centre to scope the needs and issues and draw up a programme or programmes to address them, endorsing the idea of employing a paid facilitator to manage group discussions.

Estuary Trust and Council worked together to achieve these immediate objectives. Don Ross and Shelley Washington of the Landcare Trust were engaged as Facilitators and a Workshop was planned and prepared for 20 October, 2005. In essence, culvert replacement was the agreed focus. The role of the workshop was to supply the perspective without ever losing the agreed focus and without losing concentration on "what can be achieved now".

4.1.3 Inputs and Outputs of a Workshop

The Workshop was an outstanding event for the community and for the Council officers engaged. The participating members of the community brought an immense wealth of personal and often professional experience with environmental affairs as well as some enduring dissatisfactions with the ecological condition of the residual wetlands of McCormacks Bay. Background matters on Causeway and Bay were expertly and summarily presented to the workshop by Council officers. The procedural approach adopted for the workshop of successively identifying issues, desired outcomes and pathways was outlined by Don Ross of the NZ Landcare Trust. With Shelley Washington, he supplied constant back-up facilitation to the several groups of people for each of which a professional officer of Council acted as rapporteur.

The success of the workshop was revealed in its immediate output, an "Action Plan from the McCormacks Bay Workshop"[51]. For an array of issues identified in group discussions, six generic OUTCOMES were distilled from the much longer list of desired outcomes identified by the groups working through the issues. Six general PATHWAYS were also sorted out as ways of attention to achieve desired outcomes. These distilled

Pathways and Outcomes are tabulated below, after the manner of their presentation in the Landcare Trust document.

These distilled products of the Workshop were to function as stimuli rather than as absolutes. Some pathways were intended to be specific to particular desired outcomes. Some are appropriate to more than one outcome. Some outcomes require action on more than one pathway. Pathways to achieve Outcomes became the matter for the ensuing Steering Group to discuss as possible ways and means for each of the main topical areas of interaction between culverts and the ecosystems and uses of the bay.

Table 4.1 Pathways and Outcomes identified in an Action Plan from McCormacks Bay Workshop, October 2005 by Facilitators from NZ Landcare Trust

General Pathways	Generic Outcomes
Exploring infrastructure options	Steady state of siltation is managed
Monitoring, Measuring Knowledge	Knowledge is built and research is effective
Building understanding of recreation needs	Recreation resource is maintained
Understanding ecological needs and effects	Whole ecological system is enhanced
Community consultation	Community consultation is effective and community aspirations are met
Long term planning and funding for Implementation	Best options Identified for structural design of the Causeway culverts beneath roadway

The success of the workshop was also evident in the satisfaction that it gave the participants from the Council as well as from the Community, and in the plaudits that this satisfaction aroused from the Chair of the Community Board and the CEO of Council. Perhaps the most convincing evidence of the value of the workshop was shown in having recourse to the original record of its outcomes when the time came to spell out "Aims and Outcome" in a Charter for the Steering Group set up to achieve this project.

4.2 Forming and Empowering a Steering Group

4.2.1 The Context and Concept of a Community-Council Steering Group

Following the workshop, further meetings were held between representatives of the Estuary Trust [Ihutai Trust] and the Council project team. John Craig, Project Manager, who had been one of the rapporteurs, reworked the notes and outcomes from the Workshop, still retaining all comments. These were circulated in December 2005 to all the participants with an update from Karen Jury, Community Engagement Adviser. The update made several points that clarify the context of the emerging "Steering Group":

> It was acknowledged as an outcome of the workshop that research was required into the current and future state of McCormacks Bay.
>
> To meet this outcome further investigation would "be undertaken about the impacts and effects of current and future structures on the environmental, ecological, recreational [features] and visual appearance of McCormacks Bay. This investigative work will take time."
>
> Transport and City Streets Unit planned to carry out in January one week's maintenance work on the underside of the central culvert.
>
> To "facilitate the investigative work and future [central culvert] project in general it is proposed that a **steering group** be assembled to provide guidance to the project team.
>
> "Members of the Ihutai Trust and CCC staff will meet after Christmas to progress the structure and Terms of Reference of the **steering group** and will present a report early next year to the Hagley Ferrymead Board to update the board and seek their approval for the representation and terms of reference of the **steering group.**"

Editorial Note**: Words in square brackets within quotations have been inserted to clarify intention of the original 'update' from which the quotation is taken. Bold face type is introduced to identify first public use of the term* ***'steering group'.

Some difficulty was experienced in drafting workable Terms of Reference, suitable for a new approach such as this concept of a Council-Community Steering Group. The maintenance work carried out in January on the underside of the culvert gave sufficient relief from the need for urgent replacement to allow time for effects on the Bay to be properly considered. Further meetings of prospective participants in the Steering Group were held in May and June of 2006. At the **May 2006** meeting there was concern with the lapse in time since the October 2005 workshop without much sign of progress. There was also discussion as to how long the Steering Group might expect to continue. While the Council's need for the Steering Group would be met by the replacement culvert being installed, the long-sustained and enduring interest in McCormacks Bay within the Community required that its work should go on. It was left to the Steering Group to review this issue of an end date.

Draft Terms of Reference were further discussed, including the idea of the Group advising the Estuary Trust, advising the CCC as decision-makers concerning the objectives for the culvert replacement, wider issues of the Bay and necessary research. It was emphasised that the driver for the Steering Group was the need to replace the culvert and the Council's need to know the interrelationships between the culvert and the wider functioning of the Bay, including its ecology and use for recreation.

The relationship of the work of the Steering Group to the revision of the Management Plan for McCormacks Bay was raised. It was observed that revision of Reserve Management Plans was provided for under its own statute but that the output of the Steering Group could well provide key material for revision of the Management Plan. On the other hand, it was recognised that failure to revise the Management Plan, which was already out of date in some respects, should not be an excuse for inaction by the Council in implementing the recommended outcomes of the Steering Group.

Issues and answers were exchanged. Was there budget for this work of the Steering Group? Annual budget setting was the answer given to the Group. Was there any provision of dollars for the research and investigation work in the LTCCP? No, but it will be an annual setting of each unit's objectives e.g. Roading, City Solutions (now the Capital Programme Group), Greenspace. The Steering Group would help prioritise issues – this would help the Council units.

The continued viability of the Causeway was raised. Widening might be required in future, or even sooner for the sake of bus-laning. Causeway maintenance itself might become uneconomic with dangers from sea-level rise, from liquefaction from tectonic movements, even from increase in heavy traffic movements. Culvert replacement and focusing on it might then become community time and effort wasted. It was suggested that the Steering Group might discuss these issues, especially as bus-laning would require bridge widening for at least two culverts.

More than a dozen residential, sporting and other community groups were listed as potentially to be represented on the Steering Group. A list of about 24 individuals, many of them from such bodies, some of them subject advisers in various fields was compiled under the caption ***Who is keen***?

At the **June 2006** meeting, some of the above items were again discussed and clarified. In particular the status of the Causeway and its future was emphasised as requiring the attention of Council. The lack of relationship between the existing McCormacks Bay Management Plan and "the causeway and culvert" was recognised and accepted. "Essentially the existing Management Plan appears to set aside the issues of the causeway and culvert." It was noted that "the Steering Group would not be directly influencing any review of the Management Plan as there is a statutory process that this must go through. However, the investigations, research and information that comes from the Steering Group's initiatives for the culvert replacement project will be utilised in the review process."

Concerning the Steering Group itself, it was noted that while accepting that CCC was the final decision-maker, the Steering Group should be able to make its own decisions and push to have these acted upon, either via the Community Board or direct to the Council. The naming was discussed and agreed that this remain as "Steering Group as this suggested 'action' (rather than Advisory or Working Party)". Draft Terms of Reference were again aired. It had been suggested that they should be more reflective of the issues and outcomes of the October 2005 meeting and perhaps include a vision statement. The Terms of Reference could then have a shorter format. The outcome of this suggestion and discussion appeared in the form of a Steering Group Charter, prepared for the next meeting of the Group by Heather Holder-Lunn of CCC, with the assistance of Alisdair Hutchison and Eric Banks.

4.2.2 A Charter for the Steering Group

The Charter was brought to the McCormacks Bay Steering Group in August 2006 and was adopted by it (with some minor typographical amendments). The Steering Group gratefully acknowledged Heather Holder-Lunn's authorship in compiling it. From that point onwards the Charter has been the mandating reference document of the Group. It is set out in full as the Annex to this Chapter.

Of the three **Aims**, the immediate aim was the first: To take a comprehensive planning view of McCormacks Bay, and within that view develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values.

In pursuing that aim it would go a long way to achieving the second aim: To provide a forum for a partnership process between the Community and the Council, and a model for future projects, as envisaged by the Local Government Act.

By keeping in touch with other members of the Community, residential, recreational and environmental, the members of the Steering Group would largely accomplish the third aim: to ensure the Council decision-making process for the culvert replacement project is informed by the Community and that there is a two-way exchange of information.

The Charter sought only one formal **Outcome**, "a report based on research undertaken in collaboration with the CCC, which makes recommendations on: Design scenarios for the culvert replacement and associated natural and recreational values of the Bay; and Further required investigations."

The Charter provided that the Steering Group's report would be presented to the CCC with the expectation it will be utilised in the production of design options for the culvert replacement and drawn upon in the preparation for future management and consultation relating to the Bay. It also provided for its Report and Recommendations be made public to the Community.

The Charter made clear that Steering Group members would include stakeholder groups and individuals who expressed interest in being involved. Such stakeholder groups and individuals at its foundation were identified. The group would be advised by experts in fields such as coastal engineering, hydrology and ecology. Council Staff were to provide information, support and advice to the Steering Group. Four Staff were at that stage named in this role, but others participated in later meetings. It had been earlier envisaged that most Council Staff would be at meetings of the Steering Group to share their expertise and would not be obliged to share in decisions. The Steering Group would try to reach consensus on the recommendations to be put to the Council. The Facilitator of the Steering Group would have a neutral role, serving the Group as a whole, being spokesperson for the Group and overseeing meeting records.

4.3 References

46. Jennings, Jeremy, 2004, *McCormacks Bay Causeway: Maintenance and Development Report,* City Solutions, Christchurch City Council.
47. Jennings, 2004, p. 2.
48. Jennings, 2004, p. 14
49. Jennings, 2004, p. 15
50. Jennings, 2004, pp. 20-21
51. New Zealand Landcare Trust, 2005, An Action Plan from McCormacks Bay Workshop, 21.10.05

Annex 1: McCORMACKS BAY STEERING GROUP CHARTER

August 2006

Aims:

1. To take a comprehensive planning view of McCormacks Bay, and within that view develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values.
2. Provide a forum for a partnership process between the Community and the Council, and a model for future projects, as envisaged by the Local Government Act.
3. Ensure the Council decision making process for the culvert replacement project is informed by the Community and that there is a two way exchange of information.

Outcome:

1. A report based on research undertaken in collaboration with the CCC, which makes recommendations on:
   - Design scenarios for the culvert replacement and associated natural and recreational values of the Bay; and
   - Further required investigations.

   The report will be presented to the CCC with the expectation it will be utilised in the production of design options for the culvert replacement and drawn upon in the preparation for future management and consultation relating to the Bay.

Background:

- In September 2004 Council staff determined that the central culvert needed to be replaced. In May 2005 the Avon-Heathcote Estuary (Ihutai) Trust met with Council staff and proposed that a comprehensive planning approach be taken. A joint workshop was held on 20th October 2005 and identified the following outcomes as desirable for the culvert replacement and the Bay.
  - Identify best options for structural design of the Causeway culverts.
  - Enhancement of the whole ecological system.
  - Management of silt.
  - Recreation resource is maintained and enhanced.
  - Community consultation is effective and community aspirations are met.
  - Knowledge is built and research is effective.

Group Structure and Process

Steering Group Members include stakeholder groups and individuals who expressed an interest in being involved. The group will be advised by experts in fields such as coastal engineering, hydrology, and ecology.

Council Staff will provide information, support and advice to the Steering Group.

The Steering Group Facilitator will be neutral and will serve the group as a whole. The facilitator will be the spokesperson.

Meeting Records will be overseen by the Facilitator. They will include a summary of key action points discussed at each meeting, agenda items for the next meeting, and any other relevant material. These records will be circulated to all Steering Group members and to other interested parties.

The Steering Group will try and reach consensus on the recommendations to be put forward by to the Council.

The Report and Recommendations of the Steering Group will be presented to the Council and the public.

Meetings will normally be held on the second Thursday of every month at the Mt Pleasant Yacht Club, unless the group decides otherwise. The Steering Group will meet up until the delivery of the report.

Group Membership

Stakeholder Groups:

Avon Heathcote Estuary (Ihutai) Trust
Canterbury White Water Canoe Club
Canterbury Windsports Association
Christchurch Estuary Association
North Canterbury Fish and Game
Mt Pleasant Residents Association
Redcliffs Residents Association

Individuals:

Humphrey Archer	(Resident & Environmental Engineer)
Bruce Coleman	(Resident)
Ian Russell	(Resident & Kayaker)
Kelly Hansen	(Resident & Kayaker)
Roy Walker	(Resident)

CCC Staff:	**Title**	**Unit**
Eric Banks	Network Planner	Transport & Greenspace
Matt Cummins	Project Manager	City Solutions
Heather Holder-Lunn	Environmental Planner	City Solutions
Tony Lange	Asset Engineer	Asset and Network Planning

Adopted by the McCormacks Bay Steering Group 10/08/06.
Compiled by Heather Holder-Lunn

Annex 2 PARTICIPANTS IN STEERING GROUP

1] CCC Appointees John Craig was replaced by Matt Cummins early in 2006 who was succeeded by Will Doughty in 2008.

Tony Lange was succeeded by David McNaughton.

Heather Holder Lunn and Eric Banks were members of the Steering Group throughout.

2] Stakeholder Groups listed in Annex 1 have been represented at different times by the following persons:

Avon Heathcote Estuary (Ihutai) Trust: Alex Drysdale, Alisdair Hutchison, Islay Marsden;
Canterbury White Water Canoe Club: Steve Gurney, Ian Russell, Kieron Thorpe;
Canterbury Windsports Association: Murray Sim;
Christchurch Estuary Association: Murray Sim, Sandra Sim, Derek Keenan, Brian Swale, Les Batcheler;
North Canterbury Fish and Game: Tony Hawker, Jason Holland, Murray Snowdon
Mt Pleasant Residents Association: Linda Rutland, Bruce McKessar
Redcliffs Residents Association: Malcom Moore, Peter Croft

The members of the Steering Group shown in Annex 1 at the August 2006 meeting have been joined since that date by representatives of the Sumner Residents' Association.

3] In addition to the individuals shown in Annex 1, the following individuals have participated before or since August 2006 in the work of the Steering Committee: John Goodrich, David Gregory, Andrea Lobb, Kevin O'Connor, Pete Southern and Chris Todd.

4] The following CCC personnel have attended and taken part in one or more meetings: Andrew Crossland, Lloyd Greenfield, Richard Holland, Trevor Partridge, John Walter, Joanne Walton

5] Others who have contributed to or participated in the work of the Steering Group by invitation of its members include Derek Goring, Shelley McMurtrie, Celia King, Grant Campbell, Bruce Arnold and Bruce Coleman;

6] Facilitation was carried out initially by Don Ross and Shelley Washington of the NZ LandcareTrust, latterly by Joe McCarthy

5.0 Goals, Aims and Objectives of the Steering Group Project

5.1 Statement of Goal and Aims

5.1.1 Establishing a Goal

To establish a Goal for the Steering Group was recognised as important, even though it might be difficult to define and even more difficult to attain. We understood that it had to be the kind of ambition that we all shared and that could be shared with the City Council and with the residential and recreational constituents of our Community.

- It would be some condition of the social as well as physical environment that would be attainable for our McCormacks Bay environment in our time, not something reserved for the hope of our grandchildren.
- Our goal statement would keep in focus the immediate task of replacing the Central Culvert and its communication service but it would not lose sight of the other culverts, nor of the tidal waters that went in and out of them.
- Our goal statement would not lose sight of the McCormacks Bay environment on one side and the wider Estuary on the other side of the Causeway. We would be relevant to the estuarine context.

We believed our Goal might not be strictly definable now, with our present knowledge, but we also felt that our Community would be able with some confidence to tell when it had been fairly attained.

Our Goal was not something that we could define *a priori.* The demands of timeliness, focus and relevance that have just been outlined above dictated that our Goal should be articulated to take account of them. It would then be progressively refined by reflecting on the distinguishing features of the several objectives in the work that we did or commissioned from others.

From the outset, the Steering Group recognised that its mandate dealt with complex matter as well as being novel in character. It was complex in that it had to do a relatively straightforward task of selecting the ways of mending vital physical communications of the City along with guiding ways of remediation of a natural but much modified tidal feature of The Estuary. The construction of the Causeway, the deformation of the bed of the Bay and the imperfect tidal flows that followed from the condition of the three culverts through the Causeway all affected the ecological condition of McCormacks Bay and its use for recreational activity.

The mandate we had been given was novel in that it initiated an experimental process of consultation between officers of the Council and representatives of interest groups in the Community, as well as a process of information exchange between Council and Community, all in line with provisions of the new Local Government Act. We had no guidelines for these processes, but we began with goodwill on both sides. When goodwill diminished as an outcome of misunderstandings, goodwill was restored with initiatives from both sides. We have been greatly strengthened and empowered by our Facilitators, both Don Ross and Shelley Washington from NZ Landcare Trust who launched us and by Joe McCarthy who has piloted us home.

In the four years since its inception the project has enjoyed the continuous service of Eric Banks but the Causeway Culvert Replacement Project has had three different Project Managers appointed from City Solutions (now the Capital Programme Group) as Council staff leaders in our project. They have related to the Steering Group with different styles and perhaps with somewhat different briefs of their own task. The three, John Craig, Matt Cummins and Will Doughty, have each in turn won and held the confidence, trust and respect of the Steering Group. Central culvert replacement might not have changed for the Capital Works Project but what seems to have changed for the Steering Group is [a] the specificity of its focus on culvert replacement and [b] the dimensions of the wider planning perspective in which culvert replacement was to be considered.

Arriving at a clear statement of a Goal to be pursued was therefore no easy task for the members of the Steering Group or for those who were assigned to assist them. There may be people in CCC who find it difficult to accept that the Steering Group has had to cope with the equivalent of shifting goal posts. Without complaint, for the Steering Group has <u>now</u> long had a clear goal, we can illustrate how these two features, focus and perspective, have varied in the last four years.

***First**, the specificity of the focus on central culvert replacement.* In the first of the Aims of the Steering Group Charter of August 2006 was our mandate to "develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits ...." This is the only occasion in the mandate where the word 'culvert' is used as a noun. It is used in the plural. Elsewhere it is used as an adjective, 'culvert replacement', applicable to one or more culverts. We understood this, just as clearly as we understood what was written in the Background to the mandate: "In September 2004 Council staff determined that the central culvert needed to be replaced."

In May 2007, our then Project Manager Matt Cummins sent us all an update on the status of the project. Included in that was the following paragraph:

> "A brief is being developed for the Capital Programme Group to produce consultant briefs to investigate the hydrology and ecology of the Bay and their relationship with culvert flows. Following discussions with Transport planners, the briefs produced will now need to take cognisance of the possibility for something other than a single re-modelled central culvert. This will depend on making a bid for additional funding in the 2009 LTCCP."

We were advised in the same letter that funding had been set aside in the 2007/2008 financial year for the above investigations. We have had no further funding beyond that of 2007/2008 for investigative work. Our disillusionment can be appreciated when the Steering Group was rebuffed after having supported unanimously a submission to Council on the 2009 LTCCP to enlarge the budget and widen the brief for the Central Culvert Replacement Capital Works Project so that we could pursue the goal that we had then visualised from our Charter and had been encouraged in by our earlier Project Managers! We don't blame our present Project Manager for the situation. We believe that over the last four years the City Council has changed its ground concerning this Steering Group project and we have had to shift our goalposts !

Second, *the variable dimensions for comprehensive planning* From the outset we have had a mandate to take a comprehensive planning view of McCormacks Bay. For several months, as indicated in the previous chapter, we were encouraged to make a serious study of the future traffic demands on the Causeway and its implications for culvert design and dimensions. The long term viability of the Causeway itself was challenged by some of the information and opinions that came to us. One noteworthy venture at enunciating a Goal for the Steering Group came in the following form:

> "**Goal**: To select the best option for a heavy traffic route between the eastern and western side of McCormacks Bay that maintains or enhances the social, cultural, environmental and economic benefits of McCormacks Bay, in line with a community agreed long term vision for the area."

This goal statement reflected many of our concerns up to that time (April 2007). It was drafted by Kelly Hansen, a Recreation Planner in the Council staff, and was shared with us in May 2007 by our Project Manager Matt Cummins. We found ourselves endorsing most of the objectives that Kelly had identified to contribute to this goal. We generally agreed that a reliable heavy traffic route across or around the Bay was an important issue for Council to attend to, especially before it made major capital commitments to repairing the Causeway proper, if that should prove necessary. Our awareness of our own incompetence to assess current and long-term future traffic requirements told us to widen our view in some different dimension for comprehensive planning. Estuarine and tidal dimensions were more significant for our combined interests. But were they the only criteria for our wider view? It was at times like this that we began to realise the value of the aims of our Charter.

We became more conscious that our stated Goal should embrace all three Aims of our Project, not just the evaluation of scenarios for replacement of Causeway culverts that did most for the natural and recreational benefits of McCormacks Bay. Our Goal should also embrace our aim to provide a model forum for a partnership process between Community and Council, as well as include our aim to ensure that the Council's decision-making was informed by the Community and that information was exchanged. .

In that spirit we were no longer content to be ecologically holistic and idealistically estuarine in our ambition. We dismantled our conventional 'environmentalist' goalposts. We erected new goalposts, stating our goal in a way we hoped would ensure that having Community and Council work as genuine partners in rehabilitating McCormacks Bay would provide a general model for future projects, in this city and elsewhere. In this way we tried to have our environmental concerns reflect the wider image of environment, including social and economic as well as physical and biological aspects, as Environment and Resource Management statutes prescribe.

5.1.2 Stating a Goal and its Aims

Here is our statement of the Goal of our project as we have understood it from our mandate and as we have accommodated it to the time and fiscal limitations imposed on us, in order to serve the needs of the Capital Works Project, the McCormacks Bay Causeway Bridge R801 Renewal.

> **GOAL: To test the effectiveness of a Community-Council partnership in a consultation process evolved between Christchurch City Council staff and representatives of interested parties and citizens in the adjacent neighbourhoods, to make environmentally informed recommendations to Council for the integration of replacing the Causeway culverts with the protection, restoration and enhancement of the estuarine and scenic characteristics of McCormacks Bay as part of the Avon-Heathcote**

Estuary and as a significant amenity and recreation resource area in a wider suburban context.

The above wording is a shortened version of what was put to the Steering Group and endorsed in June 2009, together with the Aims below endorsed unchanged from the Charter received and accepted in August 2006

First Aim: To take a comprehensive planning view of McCormacks Bay, and within that view to develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values.

Second Aim: To provide a forum for a partnership process between the Community and the Council, and a model for future projects, as envisaged by the Local Government Act.

Third Aim: To ensure the Council decision-making process for the culvert replacement project is informed by the Community and that there is a two-way exchange of information.

5.2 Identification of Objectives

5.2.1 Immediate and Long-term Objectives

The task of identifying objectives, like the shaping of our goal, was accomplished progressively as we worked our way through the several topics included in the outcomes of our preliminary workshop [Table 4-1 in Section 4.1.3] and restated in the 'Background' to our Charter [Annex 1 of Chapter 4]. We accepted that "objectives" stand in relation to a "goal" as achievable and often measurable features that contribute to the attaining of the goal. In that light we recognised that one set of objectives might be identified in these several topics and related to our immediate goal as stated above, to be attained with the presentation of our report and recommendations to Council. It is this set of objectives that we identify here in Chapter 5.

A somewhat different set of objectives in similar topics might be specified in relation to the attainment of a ***farther-out goal*** to which we all are working, ***a tidally-functioning healthy ecosystem in McCormacks Bay which local people and visitors could appreciate and enjoy in different ways, an effective traffic and services communication system across that Bay, both systems functioning together to the***

economic and social satisfaction of both Council and residential or recreational Community and as part of an Estuary-in-the-City where its own plant and animal inhabitants flourished and its human neighbours drew wonder and inspiration. A contribution to such a set of objectives will be set out for future attention by Council and Community in our Recommendations in Chapter 7.

5.2.2 Statement of Immediate Objectives

When each of the desirable outcomes was considered in turn and when the relationships between them were also considered the following immediate objectives emerged. It is noteworthy that this list was little changed in June 2009 from what we identified in April 2007. The most common change was to sharpen the immediate objective and assign some of the earlier objectives to the longer term. For example, the first two objectives that we envisaged in 2007, namely "1. Identify current and long-term (30-40 years) future traffic requirements" and "2. Prepare various culvert design options to meet traffic requirements", we have now relegated to the Recommendations of Chapter 7. The immediate objectives that we now identify are more simply stated: "Clarify current and immediate traffic needs that can be met within existing causeway dimensions" and "Identify essential culvert replacement features needed to meet traffic requirements".

The Objectives that we have sought to achieve in order to attain our immediate Goal are as follows:

1. Clarify current and immediate traffic needs that can be met within existing Causeway dimensions.

2. Identify essential culvert replacement features needed to meet traffic requirements.

3. Assess the impact of various culvert designs on the hydrologic and hydraulic features of tidal flows, including extent of coverage and extent of drainage for all parts of the Bay.

4. Identify and describe the physical and biological features of the McCormacks Bay environment viewed as an ecosystem, including its plants and animals of all kinds, its terrestrial and aqueous substrate and especially noting:

   a) urban hydrology, sedimentation and siltation (dynamics, source etc)
   b) bathymetry, including man-made changes to bed contours

c) bed profile at representative locations
d) hydraulics, tidal currents of inflow and outflow, water depths
e) water levels and duration of tidal coverage and exposure
f) salinity, water quality (incl. temperature, turbidity, nutrients, contaminants)
g) benthic flora and fauna, especially in relation to substrate and water depth
h) flora and fauna of tidal and standing water and of islands and shorelines
i) trophic and systems ecology of normal and modified estuarine ecosystem

5. Assess the impact of various culvert design features on the physical and biological environment and on the McCormacks Bay ecosystem.

6. Identify present and future recreation, sport, and related community practices and opportunities, especially those relevant to the culvert.

7. Assess the impact of various culvert design features on recreation, sport, and related community opportunities, especially those related to water and water bodies.

8. Involve and inform the Community in decision-making by discussing proposed plans for culvert replacement in a series of design scenarios that integrate their potential effects on the Bay, with a view to incorporating Community views in report to Council.

9. Identify principles and ways and means for enhancement of the whole ecological system, including building of knowledge and experience by community involvement in monitoring and research.

10. Identify ways and means for effective community consultation in future and for meeting community aspirations.

6.0 Review of Work of the Steering Group

6.1 Steering Group Sessions

6.1.1 The Chronicle of Sessions

It was proposed that meetings of the Steering Group would be held monthly following the Workshop in October 2005. It was later suggested, however, that once the main areas for investigation by expert consultants were identified and studies commissioned, meetings would not need to be so frequent. The first full meeting of the Steering Group was not held until June, 2006. At this stage of the project the Steering Group was most concerned with identifying the needs for information about those conditions of the Bay which were likely to be benefited by change in culvert design and function from the present. Members of the Steering Group who had training and experience in particular areas were called on by the Facilitator to spell out the needs for expert investigation. These were relayed to Council in December 2006 to assist the commissioning of investigations.

A lot of effort went into discussing possible Terms of Reference. Some difficulty arose from different people having different ideas of what our function was to be, advising the Council about possible alternatives to the Causeway, advising Council about design of the culvert, advising Council planners about revisions to the Reserve Management Plan, and so on. The Charter drafted for us and presented to us was welcomed by the Steering Group in August 2006 at our second full meeting. This document had gone back to the novel concepts of our founding and was carefully worded to reflect them. Once we had obtained a clear statement of our mandate in the Charter of August 2006, further discussion of Terms of Reference designed for more conventional advisory bodies seemed unnecessary and irrelevant.

We had three Aims spelled out in the Charter and one expected Outcome. We had identified the major areas in which we believed we needed expert information. We now had to wait for the information. In the meantime, we could now concentrate on grappling with practical issues, such as the influence of culvert design on hydraulic performance and the relationship of training in kayaks to the hydraulic behaviour of 'tidal flows'. We were also able to learn more about engineering constraints and possibilities from Council engineers involved in culvert design. There was little else we could now do.

Between 2 November 2006 and 8 February 2007 we had no meetings. Facilitators were not available at our scheduled December date. We did not meet again in 2007 following the February meeting. In May 2007, we were advised that no funding for investigations would be available until the next financial year, commencing July 2007. This news was confirmed by the Project Manager, by letter instead of a meeting, and we were advised that briefs were then being prepared for expert investigations. When reports became available from expert investigations, some progress could be made on issues involving the influence of culvert design on the waters of the Bay and on the condition of the wetlands. We met again on 13 March 2008, to consider these reports, after more than 15 months wait from our formal identification of our information needs. Such delay as this was not totally avoidable but it explains our lack of session continuity. Such a hiatus also had an effect on the commitment of some of our members.

After a lapse of more than two years with only one meeting called, the Steering Group was again convened by Eric Banks of the CCC. Since his appointment in September 2008 as Project Manager for the Culvert Replacement Project, Will Doughty has led the Council team in its partnership in the Steering Group project. Steering Group meetings never recovered their original numbers but issues which had been held over were now dealt with and consensus reached on most of them. During 2009 participation has been more active and meetings were held every four to six weeks, as frequently as progress in developing the structure of our report would allow.

6.1.2 The Facilitation of Meetings

The task of facilitating our meetings has changed greatly between the earlier period from 2005 to early 2007 and the latter period of late 2008 to 2009. During the first period, facilitation was done initially by Don Ross of NZ Landcare Trust and then by Shelley Washington, also of NZ Landcare Trust. The key task for the Facilitator at that time seemed to be scoping the issues and at the same time maintaining balance and perspective with these issues. Members of the Steering Group each had their particular interests and it was the special task of the Facilitator not only to preserve some balance between these varied interests but to ensure that such individual interests were expounded to the Group as a whole, so that all could appreciate how design and function of the central culvert could affect the behaviour of incoming or outgoing water, how well the Bay was filled and how well it was drained.

Don Ross and Shelley Washington, with their wide exposure to environmental issues of various kinds through the work of NZ Landcare Trust with community Landcare groups, gave admirable guidance in this delicate function. It is a tribute to their skills that members of the Steering Group learned very readily to understand and appreciate one another, even though their interests varied widely. It is also a tribute to the facilitating team and the responsiveness to their influence on the part of the expert advisory team gathered from the City Council that expert advice was quite readily assimilated by the Steering Group.

In the early phase of the project, one or two members of the Steering Group, generally from the Estuary Trust Board, would meet with Eric Banks as convenor of the Group and the Project Manager to discuss with appropriate Officers of the Council the prescription and funding of investigative work previously identified as required or desirable by the Steering Group. This phase of activity is described later in Section 6.3. When called on, our Facilitator, Don Ross, also took an active role in fostering the commissioning of expert investigations, assisting these small meetings of Council staff and Steering Group members in this area.

Facilitation in the latter phase of the Steering Group's life has been carried out by Joe McCarthy, experienced in this role and recognised by the Council for his skills. In the later phase of the Steering Group, members of the Estuary Trust Board felt that they should be able to speak freely for the Trust's view on different issues and were therefore anxious not to be in a potentially dominating role as leaders of the Steering Group. The Facilitator, Joe McCarthy, urged the Steering Group to find its own co-leader, one who could take a co-leadership role in relations with the Council. For want of any other offers but with the consensus of the Group, that role fell to Professor Kevin O'Connor. He had earlier been backed by the Steering Group in making an urgent submission to the hearings on the LTCCP to seek the widening of the brief and the enlargement of the budget allocation for the capital works project concerned, so as to include essential investigative work for the amelioration of the Bay. Kevin now led the Steering Group with co-leaders Will Doughty and Eric Banks of CCC and the assistance of Joanne Walton. It also led to Kevin's taking a lead-role in assembling material for this report and eventually in compiling it on behalf of the Steering Group.

Apparent conflicts of interest within the Steering Group between Community members and Council staff were now taking on a quite different dimension from what had been shown earlier. Previously, the Community members of Steering Group had found it disappointing that the scope of investigations allowed by Council in such fields as sedimentation and tidal hydrology was limited by available funding. Now the Community members were finding itself at odds with what seemed to be core management policy of the City Council concerning both the question of funding any further investigations for our project and the scope of our project in relation to the Capital Works 'structural renewal' Project for the central bridge in the Causeway.

Officers of the Council servicing the Steering Group of which they were members were in an unenviable position in such a situation. They were loyal to Council management policy, but they had to deal with great disillusionment among Community members of the Steering Group. Joe McCarthy as Facilitator in these difficult times was clear, patient and fair. Without being directive, he allowed the Steering Group to make the necessary adjustment to the evident intransigence of Council policy and encouraged the Steering Group to reshape its goal. He then helped Council staff and Community members to new levels of co-operation, revising the Group's programme of enquiries to try to meet the timetable that the needs of the Central Bridge Replacement Project appeared to require. At the same time the Steering Group was reminded to honour its commitment to finding a pathway to the rehabilitation of McCormacks Bay and its aim to demonstrate that some kind of partnership between Council and Community could be effective, no matter how difficult it sometimes seemed.

6.2 Preliminary Appraisal of the Condition and Use of the Bay

Important Notes: *In this large section 6.2 of this Chapter, we describe how we thought about and discussed our information* *__needs__* *in different sectors of interest. In the next section 6.3 we outline why and how we commissioned investigations of chosen kinds and scope.*

We follow that in section 6.4 with an outline of how we proposed to carry out the core of our mandate, "to develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values".

This process involves us in section 6.5 in assessing the range of possible culverts for their hydraulic and tidal hydrologic function.

We apply that assessment in an evaluation for kayak training in Section 6.6.

We then collate our available information on the physical condition of the Bay in Section 6.7 and bring it together with our assessment of the tidal hydrologic performance of the different culvert options to develop and evaluate scenarios for improving the physical condition of the Bay.

We collate that information and assessment with the information and understanding we have gained of the ecological condition of the Bay in Section 6.8, to develop and evaluate different scenarios for the future.

This leads in Section 6.9 to our preferred design scenario, which becomes the core of our recommendations to Council and the Community in Chapter 7.

6.2.1 Learning the Use and Limitations of the Causeway for Traffic and Services

Our earliest Project Manager ensured that the Steering Group should have some idea of likely futures for traffic use of the Causeway. We have not had the benefit of traffic counts through Main Road, as part of the project, Redcliffs but we have been informed that mean daily traffic use of the Causeway may now exceed 17,000 vehicle movements (the latest count on the causeway was in 2008) and numbers have been fairly consistent around 16,000 to 17,000 since 2002[52]. However, in unusual weather conditions, or for special events in summer holidays, this level may be exceeded. Heavy traffic from Lyttelton, such as laden tankers, has been proscribed from using the Causeway because of the condition of the Central Bridge. (Whether this proscription applies since the special maintenance was carried out is uncertain, for large tankers from Lyttelton have been frequently observed crossing the Causeway in 2009).

At the Redcliffs end of the Causeway such extra-long vehicles have difficulty negotiating the left turn into McCormacks Bay Road without encroaching on the built path and plantings. Most drivers of vehicles of any kind from McCormacks Bay Road, and especially those turning right into Main Road, Redcliffs, find the intersection sufficiently hazardous to be frightening, because of their inadequate view of traffic approaching through Redcliffs. This condition exists despite an engineering effort made to improve the situation in the 1990s by moving the intersection further west, perhaps reclaiming part of the NE corner of McCormacks Bay in the process.

Transport officers of Council are aware of this situation and have considered possible ways and means to ameliorate it. Moving the intersection further to the west could require further reclamation of the Bay, this time interfering with the limited function of the 400mm pipe culvert through the Causeway, now at this the site but apparently not at the same height of the original eastern culvert under the tramway. Tidal hydrology and traffic safety could be both improved in any future change to the highway intersection by reclamation, culvert reconstruction and highway reconstruction pursued in concert.

Of the changes to the Causeway at present under consideration, **widening the roadway could be of most significance to its use.** Extending the width of seal beyond the carriageway on to the earlier tram causeway could provide a possible walkway, a wider cycleway and could allow for "bus-laning". Bridge-widening seems desirable for safety reasons even if bus-laning is not pursued on the Causeway, so long as road-widening is sought for cyclists, pedestrians or vehicle parking. We became aware that such a development would not only require that the present **central** culvert replacement should be of sufficient length to provide for this total projected road width, but that engineering to the Causeway itself would have to be carried out at the sites of the **West** and **East** culverts. At the west site, the tram causeway segment is no longer bridged, even where original seawall abutments remain. Wider road bridges will require longer pipes or other culverts to replace or extend what is there now.

Any expanded traffic function for the Causeway will require engineering inspections and tests to assess its load-carrying capacity. There are many issues concerning the traffic-bearing future of the Causeway that we believe are important for the Council to take into account but which we felt were beyond our competence and our mandate as a Steering Group. Our limited appraisal of the future traffic function of the Causeway has indicated quite clearly that **any enlargement of the roadway for bus-laning or other purposes will require re-bridging to a new road-width at all three culvert sites, not just the Central Culvert.** The opportunities for improving tidal exchange and achieving full bay drainage that this road-building requirement could present to the Council in future have not escaped us.

6.2.2 Appraising Information Needs in Hydraulics and Sedimentation

One of the most challenging tasks we found in the early sessions of the Steering Group was to describe the present condition of the McCormacks Bay tidal waterbody. We were aware that the hydrologic and biological conditions of the Bay had been investigated in the past during Christchurch Drainage Board times, but some such information was not part of the readily available institutional wisdom of the Christchurch City Council and we were enabled to access some of it[53] only during the compilation of this report. On the other hand, we had access to that monumental repository of Estuary information[54] compiled by George Knox and Allan Kilner for the Christchurch Drainage Board, which must rank as the most cited unpublished report in the history of science in New Zealand!

Its lack of an index lowered its usefulness to us, but it did serve to remind us how much we have learned and apparently forgotten about the marvellous ways of the Estuary, how much we have already investigated the problem of sea lettuce and how we continue to ignore the lessons we should have learned and applied.

The floor of McCormacks Bay has been markedly deformed, not just by the 'feeder mole' extending from the northern edge of the eastern major reclamation to the Causeway (to the east of the central culvert), but by scouring alongside that mole by the inflow through the central Culvert and re-deposition further into the Bay. Then there has been the creation of islands in the recent past and the partial formation of 'moats' about them for some security against predators. Past sedimentation events, especially in the north-western and north central sectors of the main waterbody, seem to have created some less spectacular changes in contour but they have also differentially affected the texture of the floor. Long periods of stagnation, especially in the north-east sector, would have been conducive to accumulation of fines that might otherwise have been flushed out with the tide. It would seem that silting of some southern and western parts of the floor may have been occurring, whether from loess used in the western reclamation or from storm inflows. We were not sure whether sedimentation was continuing in the southern sector of the Bay following major storm events and we were unsure how much sediment build-up was attributable to partial decay of algal residues.

The current height of the rough floor of the central culvert, together with the installation of the west culvert pipes in the causeway at levels **above the height** of the floor or sill of the central culvert, is evidently responsible for incomplete drainage of the main western and central part of the Bay. The incomplete drainage achieved by this current culvert regime appeared to be the principal feature that we would like to have corrected by culvert replacement. Incomplete drainage is evident in several ways. The most obvious is the quasi-stagnant pool in the north-eastern sector, but incomplete drainage is also evident in the mushy low-tide condition of the more extensive north-western reach. Water at low tide is not as deep there as the pool in the north-east but it is always in effect a zone under water. We became aware that the biological effects of long submergence or inundation had been studied in the NE pool of McCormacks Bay[55] as early as the 1960s.

We also felt that the Bay was suffering from incomplete tidal filling and from poor water exchange and circulation. This has been indicated by earlier observations[56] of slightly higher water temperature in the outflow from the Bay than in the outflow from the

Estuary at Shag Rock, as well as some indications in comparative water chemistry from the 1990s at the same sampling points. There was also the evidence of exposure of the partial barrier to water movement in the smoothed reef of the 'feeder mole'. Appreciable inflow into the NE pool from the central culvert was not evident until the later stages of flood tide. Until that stage was reached the "feeder mole" was apparently impermeable.

Our internal leadership in this topic area at this early stage was found in Alisdair Hutchison. He was deputed to draft some guidelines for our inquiries. He foresaw some objectives providing sufficient information about key parameters of the Bay's existing physical environment to allow us to explore scenarios and management options. Such key parameters would also largely determine ecological processes and usefulness for us humans. Such key parameters: bottom contour affecting bathymetry, depth of water at different tide levels, current strengths and direction of flow, lengths of time for areas exposed to drying after drainage, seem to be the determinants of well-being as well as human utility. We believed also that adequate information on the existing condition of the Bay could come from such investigations to allow a sound basis for an AEE as part of a consent application.

Likewise, with sedimentation, we felt that we needed to have some understanding of where deposition of fine sediments had occurred, where such deposits had been scoured away, where deposition was still occurring and from what causes. We believed we needed this sort of information if we were to understand and appreciate the significance of physical substrate to the various forms of plant and animal life that were involved in the wetland ecosystem. We also needed this kind of information if we were to understand how hydraulic performance of a re-designed central culvert, especially in tidal drainage, might affect the scouring and removal of fine sediments and so affect the quality of ecosystem that the wetlands of the Bay represented. We also thought that this possible scouring of fine sediments (silt and clay and some organic matter) might have possible adverse effects on the quality of waters of the Estuary, and if this were to be tolerated for its beneficial effects, for how long would it have to be endured.

We recognised early in our encounters with the central culvert that it had become by accident a recreational resource of some special significance for training. The leadership of Steve Gurney, Ian Russell and Kelley Hansen helped us understand why this had occurred. The development of a striking eddy from the Central culvert inflow, the duration of flood flow above a certain rate in and out of McCormacks Bay, and the duration of flood and ebb surface velocity above a certain rate have all been special "broken water" features that have led to its use in kayak training and made it recreationally valuable. These features of hydraulic performance are greatly valued for this specific recreation, for there appears to be little matching opportunity anywhere close to Christchurch. The reliability and predictability of this hydraulic phenomenon at the culvert by straightforward reference to tide tables makes for added value for scheduling educational sessions for kayak trainees, over and above what might be found in natural broken waters some distance from Christchurch. We felt we would like to have similar features of hydraulic performance from whatever replacement culvert design proved necessary to achieve improved tidal function for the sake of the McCormacks Bay wetlands.

All this complex mess of historical interference with a natural system we felt we had to have surveyed, quantified and related to the performance of the existing culverts both in mediating tidal inflows as well as in determining tidal outflows. We felt that we needed to have this quantitative description, in order to visualise design scenarios in which changes in culvert design and function could be a start for some further ameliorative effect on the Bay. We felt that we should also learn whether any amelioration of conditions for the Bay wetland ecosystem might require changes in culvert design that could affect its value for kayak training. We hoped to be able to identify design features that were favourable both for kayaking and for enhancing tidal exchange and drainage function to ameliorate the Bay.

6.2.3 Appraising Information Needs re Benthos, Water Quality and Ecology

For most of our existence as a Steering Group, we have been mentally determined not to be dominated by sea lettuce and other macro-algae, which have become the obvious and obnoxious manifestations of a deranged ecosystem. While we were willing to endorse treatments for the removal or destruction of sea lettuce, we did not wish to be pre-occupied with *Ulva lactuca* and its relatives, but preferred to consider them as symptoms of deeper trouble.

With a system-ecologist's guidance, in the person of Kevin O'Connor, we set out some premises for considering McCormacks Bay as an ecosystem. We accepted the definition he favoured of an ecosystem as a "system composed of physical-chemical-biological processes active within a space-time unit of any magnitude". This allowed us to look at systems-within-systems if that were needed, and to see different parts of the water body as together constituting a whole, itself an open-ended exchange system with the Estuary proper, as well as with its catchment. Following the same conventions adopted in Chapter 5, we considered a set of ecological objectives in natural resource management as "a group of ecological states or conditions of some natural entity, considered as an ecosystem, to be sought after and attained as a consequence of management, which together with other sets of objectives constitute the goal or overall purpose of management."

With these premises in mind, we identified some measurable objectives of an ecological kind. The first was to maintain and enhance the fullest possible integrity of the McCormacks Bay water body with the tidally functioning Estuary water body, for the best possible functioning of the desirable aquatic life systems of McCormacks Bay. Our second objective in a systems ecology framework was to establish the quantitative character of the nutrient balance of the Bay, under different culvert arrangements, as a study integrated with the study of a physical water balance. Third, we wished to have control and measurement of nutrient enrichment of the waters of the Bay and sedimentation, arising from storm runoff and other terrestrial influences. Fourth, we sought to assess any especially significant biological features of water-island-shoreline conditions, such as reproductive zones for birds, fish or other organisms significant in the food web, not excluding any potentially deleterious influences on other sectors of the Estuary (e.g. is the Bay a nursery for infesting the Estuary with sea lettuce?). Fifth, we wanted to assess physical and chemical pathways in which benthic and other organisms might improve water quality as well as pathways in which plants or animals might promote water deterioration.

These objectives seemed to be generally of the far out kind, rather than immediate. When the possibility emerged in a suggestion of a pilot study from Shelley McMurtrie, we relished the chance to foster an immediate survey of the benthic fauna, studied and reported in a ecologically-sympathetic way so that we could understand what we had in McCormacks Bay as communities, how they related to their immediate environment, and how changes in that environment arising from differences in culvert design and function might affect these communities, through water depth and duration of inundation and related hydrological features. We were attracted also by the prospect of studying the sediments of the Bay and their possible contamination,[57] done in conjunction with the survey of the inter-tidal benthic invertebrate community. We felt that this information could greatly assist the assessment of the potential effect that could ensue from replacing the central culvert at a lower invert height than at present. We have mentioned in Section 6.2.2 above our concerns about enduring the possible harmful effects of flushing out contaminated sediments through the Estuary.

We wanted furthermore to understand something of the significance of members of these benthic communities to food chains of fish or bird, and indeed their role as indicators of estuarine well-being. We had been working at our environmental goal as "the integration of McCormacks Bay with the life and well-being of the Estuary" and we believed that this condition would be indicated if and when the benthic ecology of the Bay became closely similar to that of the Estuary. At that stage in rehabilitation we hoped we would find, for example, that sand banks predominated rather than mudbanks; that cockles and oyster-catchers feeding on them would become a prominent feature in the Bay; and that sea-lettuce and Gracilaria would no longer hamper the productivity of benthic fauna[58] or the feeding habits of waders. In a practical as well as idealistic way we looked forward to the Bay becoming a part of the Estuary where people could enjoy its life systems and appreciate its intrinsic values. In effect, we found we were revisiting the first but unfulfilled management objective of the 1990 Reserve Management Plan[59].

We had learned that the quality of physical and chemical substrate might materially affect the benthic fauna and flora and we therefore hoped to have the studies of such communities related to a survey of the substrate. We believed such studies might benefit further from taking proper account of the chemical composition of the water column at different stages of the tide at different locations. As mentioned above, we considered at an early stage in our reviews the possibility of carrying out a carbon and nutrient balance assessment for the Bay, taking account of possible nutrient fluxes into and out of the organic sediment pool of nutrients in the benthos, as well as of influxes and effluxes with tidal water and of influxes from catchment drainage, especially as stormwater. We felt that knowledge of actual nutrient regimes would be important for the understanding of aquatic plant behaviour and productivity.

Despite this evaluation of possible investigations in soil and water chemistry and related matters, ***we could not visualise any means for substantially changing such nutrient regimes to reduce, for example, the production of sea lettuce, other than measures for improving water circulation, tidal exchange and drainage and the elimination of stagnant pools.*** For these reasons we came to the position that up-to-date assessment of nutrient regimes should be made as part of a pre-treatment assessment of conditions as they apply **before** culvert replacement and as assessments **accompanying** the tidal hydrologic changes progressively induced by the new culvert. In short, we believed that we could economise on research in water chemistry and chemistry of organic and inorganic sediments as part of our **immediate** investigations, but that we should emphasise them as **required investigations,** to be begun **before** effective culvert replacement and to be carried out **after** culvert replacement **as part of the essential ecological monitoring of outcomes.**

Studies of the benthos and of sediment columns elsewhere in the Estuary have demonstrated that some localities have had substantial sediment changes from physical deposition of water-borne sediments from hillside and stream bank erosion, from urban subdivisions and development, from industrial wastage, and from all manner of urban carelessness. Despite the installation of industrial sewers, the background pollution of the drainage water of our city streets and stormwater channels ensures that our Avon-Heathcote Estuary is enriched with a wide range of contaminants. So long as we treat our stormwater drains as sewers for one kind of waste or another, they will flow to our rivers and our Estuary and escape the benefits that wastewater treatment at Bromley might bring them. Eventually the diversion of treated wastewater from the Estuary to an ocean outfall could prove to be futile for the remediation of the Estuary, if we do not learn to protect our rivers and drains from our own urban carefree carelessness.

Limited investigations in McCormacks Bay suggest that this Bay has not been subject to the full range of urban mal-treatment, although its use as a local body dump for informal reclamation exposed it to some such risks. If we could, we would have its substrate health checked out by examining its sediment deposits for signs of industrial contamination. Regardless of that possibility, it is plain that it is an ecosystem integrated hydrologically with the suburban hillside ecosystems that drain into it and that ecologically it is affected by such influences as stormwater flows.

With its Catchment and Community, McCormacks Bay could well offer an excellent opportunity for **Integrated Environmental Management** at the Catchment level. We suggest that the ecological studies that we have instigated for the benthos of the Bay could become a stimulus for the initiation of ecological studies in all the indicative habitats of the larger ecosystem, the upper reaches of the Bay and its water margins, as well as the natural and reclaimed terrestrial habitats, and especially the "partial contributing areas" of streamsides, drains and stormwater channels that contribute to the inflow to the Bay of nutrients and sediments as well as other possible contaminants from its suburban catchment. We hope to make follow up recommendations to this end.

6.2.4 Identifying Actual and Possible Recreational Uses of the Bay

Recreation interests were well represented on our Steering Group from the beginning. We felt that a formal survey of recreation use of all the recreation resources of the Reserve was hardly warranted since many recreation resources such as sportsfields and extensive reclaimed areas would not be affected by any change in hydraulics from the culvert replacement. We established that kayak training in the tidal flow into and out of the Bay through the central culvert was an important recreational use, not matched elsewhere in the region. The skills and experience of kayakers in our Steering Group, led by Steve Gurney, proved as valuable as skills and experience in different branches of science had been in other fields of our inquiries.

We found almost no conspicuous evidence of any other recreational use of the waterbody or the wetlands. In spring 2009 a solitary fisher has been observed on two occasions, plying his rod and line on the incoming tide from the "feeder mole". Rod fishing used to be a popular recreation especially near Shag Rock some 40 years ago. In those days, fishing the incoming tide from near the central culvert was popular with shags, cormorants and fishers. Now a recreational fisherman is conspicuous.

The potential recreational use of the waterbodies in some sectors had been postulated in the Reserve Management Plan[60]. As outlined earlier in this report, no measures have been taken to implement that part of the Plan and the permanently inundated area in the north-east has clearly remained unattractive for any such boating use as had been visualised.

The wetland margins of the Bay have been considerably enhanced by planting of suitable plants and by the construction of boardwalks, pathway and bridges. Informal recreation use of this area has grown among local residents and among occasional visitors. It is possible that modification of these walkway works in future could provide some protection against flooding that might result from higher "Bay high tide levels" arising from culvert replacement as well as from possible sea level rise. It seems likely that recreational enjoyment of an improving naturalistic environment at the head of the Bay could grow appreciably, if we can ensure a clean-up of the water body and wetlands. Future management planning for the Reserve could be expected to take this potential into account as well as the possible concerns mentioned about the risks of flooding and possible measures for abatement.

It is also possible that improved aesthetic and ecological condition of the main tidal estuarine area consequent upon hydrological improvement could result in extension of passive recreational use and enjoyment, especially on the western shore. This potential improvement might also be significant for birdwatchers, bearing in mind the nearness of roosting islands and the current bird use of wetlands in the vicinity. We have not discussed with any parties where a suitable hide for bird-watching might be constructed. We consider that a matter for revision of the reserve management plan. Our concern has been to ensure that culvert replacement leads to clean-up of the wetland environment and its improvement as habitat for birds native to the Estuary.

Currently sportsfields are no longer used by the Football Association (Soccer), but they are used for senior and junior Rugby football in winter and by Athletics clubs, especially in summer. The Sumner Running Club is considering applying for a lease to place a new building on site as a clubhouse. Development of toilet facilities and of changing sheds may be needed for the future, but can properly be attended to in the revision of Management Plan. The proposed equestrian area in the south-east has not been developed for that purpose. The *petanque piste* is used only sporadically. To what extent these or other uses need to be provided for is also a matter for revision of Reserve Management Plan. They are not likely to be affected by effects of culvert replacement.

The difficulties of parking on the Causeway and immediately off it, conjoined with the need of kayakers for access to toilet facilities, suggest that provision of some parking and kayak-launching facilities on the eastern 'sportsfield' reclamation could well be considered in planning for future recreational use. We do not consider that such a provision would eliminate the need for **some** parking close to the central culvert, because at high tide level and during the ebb, kayak access to **the Estuary side** of the central culvert becomes necessary for kayakers. At high tide level, there is not likely to be sufficient safe headroom (i.e. 0.5 m) for kayakers to paddle **through** the culvert, especially if they are inexperienced. This situation indicates the complex and ramifying issues of continued kayaking use. The implications should not be disregarded.

6.3 Commissioning Investigations

6.3.1 Physical Survey and Bathymetric Inquiries

In the early months of the Steering Group, members of the Estuary Trust Board who were also members of the Steering Group joined with the Project Manager and the Facilitator in discussions with senior officers of Council to make suitable arrangements for investigating the matters identified and generally prioritised by the Steering Group. The Steering Group was eager to have an accurate physical survey of the floor of the Bay available so that tidal volumes, areas inundated and areas exposed, could be accurately known at different stages of flood and ebb tides. Fortunately the Estuary Trust Board was able to make $2,000 available towards this objective, allowing the City Council to meet the substantial remaining portion ($8,000) of the cost of the work carried out by Eliot Sinclair, Surveyors.

At the time when this work was commissioned, we were unaware of any information of this kind being available, but we knew it would be needed for any tidal hydrology data to be interpreted for its effects on the Bay. Subsequently we have learned from the studies for the Christchurch Drainage Board by Derek Carver in the early 1980s that he had used survey data from the CCC at that time. We have been considering the possibility of using a comparison of the two surveys to estimate the volume of sedimentation over the interval of some 25 years.

6.3.2 Hydrological, Hydraulic and Sediment Investigations

Some of the investigations in this broad field were undertaken within the Council's own scientific engineering manpower. The development of hydraulic models for flows through different designs of culvert as well as the integration of Bay floor survey (from Eliot Sinclair) and tidal data (from NIWA) in a model of Bay filling and draining has been done by John Walter CCC and presented to the Steering Group in well-illustrated fashion. John has been generous with his time but he has been still composing his own report as we compiled this, and it has been difficult to do him justice when this report-writer is a layman in hydraulics, working principally from figures and tables supplied.

Some investigations in the field of tidal hydrology and sediment behaviour and other related matters were proposed to be done by contractual arrangements with consultants. In one case in this field in particular, the proposals from one consultant that were brought by way of the Steering Group and Estuary Trust Board to the Council were not followed by the Council, for various reasons. In an alternative proposal arranged by the

Council, the full scale of work proposed by the favoured supplier in an offer of service was not commissioned by the Council, because of financial limitations. The field and laboratory work of proposed hydraulic and sediment study of the Bay was estimated to cost $32,000. "The main objective of the work was to collect data (water level, turbidity, wind, circulation, sediment deposition, sediment load) over a full tidal cycle, from low tide to low tide (the Tidal Cycle Experiment)".[61] This part of the work was commissioned by CCC and it was with data from this part of the study that John Walter built his model of culvert performance. The full cost of the offered investigation which "includes expensive modelling work" was estimated at more than $90,000 and was not approved[62]. Sadly for us, this modelling work was the only investigation in sediment dynamics offered by this party.

Sediment studies have entered into other studies not directly concerned with hydraulics. Samples to 20 mm depth of sediment were collected at ecological sampling locations in the waterbodies of the Bay by EOS Ecology Ltd. This limited surface sediment sampling was a compromise, since funding was not provided for their proposed grid sampling of the Bay, adjacent Estuary and inflow channels with some 34 core samples of sediments, as proposed initially in their Discussion Document[63]. The samples of surface sediments taken with the benthic ecological survey provided data on particle-size analysis which were shared with and reported on by NIWA. NIWA reported no other data on sediment deposition, obtaining only one set of statistics from particle-size analysis of suspended sediments, because total suspended solids content of all ebb tide samples and most flood tide samples was too low for instrumental analysis.

In this report we have made use of sediment data drawn from different sampling points to different sampling depths in the several sectors of the Bay. These were data obtained in conjunction with biological studies, principally the Robb study[64] for CDB in 1989 and the Murphy studies in recent times, for Masters thesis[65] in the University of Canterbury and for EOS Ecology Ltd[66], commissioned for this Steering Group project. As mentioned above, the surface sediment samples taken as part of the EOS Ecology study of benthic fauna were of the top 20mm only. The study of sediments to a depth of 1 metre, with some 34 samples as originally suggested in the EOS Ecology Discussion Document or with 31 samples as proposed in the Pilot Study of sediment contamination[67]has not yet been commissioned, because of sufficient funds not being available.

6.3.3 Ecological Investigations

EOS Ecology made an attractive Offer of Service[68] in response to the Steering Group's enquiries about the possibilities of a thorough benthos-based ecological study. Funding for this study was approved by the City Council and the study was carried out very expeditiously for EOS Ecology by Gerry Alvarez-Murphy. His report was delivered within twelve months of the Offer of Service being taken up by the Council. The speed and comprehensiveness of this work reflected well both on Shelley McMurtrie of EOS Ecology who supervised and edited it and on Gerry Murphy for his application and his familiarity with the scene, having recently worked in the Bay as part of his Master's degree thesis studies. In part because of the above features, in part because these ecological studies have a context of biological studies of the Estuary dating from the times of Christchurch Drainage Board support of the University of Canterbury Estuarine Research Unit, we have been able to treat them with some confidence.

6.3.4 Recreational Use

Present and potential use in recreation was the topic of a general review we asked of Eric Banks. The information on largely terrestrial-based recreation that emerged has been incorporated in the earlier Section 6.2.4 of this report. A specific study of kayaking practice and its needs was requested by the Steering Group of Steve Gurney and Ian Russell. They responded with an excellent tabulated and well-illustrated presentation[69] which we have drawn on for this report. This presentation indicated the environmental features affecting safe access to and safe enjoyment of kayaking as well as demonstrating the key hydraulic features of different bridge and culvert designs that affected their utility for kayak training.

6.4 Developing, Researching and Evaluating Scenarios

6.4.1 Clarifying and Applying the Concept of Scenarios

We did not appreciate how shrewdly chosen was the word "scenarios" in our Charter until we consulted a dictionary. It wasn't a carefree word, used loosely or irresponsibly. The Concise Oxford Dictionary defines 'scenario' as "a postulated sequence or development of events". Our mandate in our first aim was to "develop, research and evaluate a series of scenarios for replacement of the causeway culverts that identify and integrate the potential benefits for natural and recreational values". We therefore had to postulate or suggest a sequence of events that would identify and integrate potential natural and recreational benefits with a given culvert replacement. We were to consider a series of such postulates.

We took three basic designs for the central culvert, a 4-metre culvert, a 6-metre culvert and a 13 metre bridge. These had been proposed for us by our engineering experts and we had them researched for their hydraulic performance. We confronted their performance data with the specified features, velocity and flow volume and duration of these above certain threshold levels, as desired for kayaking. We were thus enabled to evaluate them for the suitability to kayaking of their flood-tide and ebb-tide hydraulic performance.

Our task of developing, researching and evaluating scenarios for possible integration with potential natural benefits to the Bay was more taxing. Whereas we had in the present culvert regime a fundamentally satisfactory regime for kayaking which we could adopt as a criterion or standard to be met or surpassed, our present culvert regime seemed in no way satisfactory for the natural values of the Bay. We had to evaluate model-predicted departures from the present regime that would improve tidal estuarine function in the Bay. We believed that change in a particular direction for some culvert performance features would be desirable. We did not know whether such change would be sufficient to benefit the Bay hydrological system or the Bay ecosystem or whether further changes to the culverts or to the Bay itself would be necessary. If we could postulate a sequence of such changes, that would constitute "development of a scenario".

Our way of going about this was like this. Taking the same three basic central culvert designs, we set about developing for each a postulated sequence of events that might allow us to evaluate each for the natural benefits that we could identify in an ameliorated estuarine system in the Bay. Whereas evaluation for kayaking allowed us to concentrate on the key issues of flow, surface velocity and their duration above certain thresholds, our evaluation for natural benefits seemed more likely to depend on total tidal volume, total tidal coverage, total tidal drainage, duration of exposure, changes induced in sediment properties, and degree of water exchange and circulation. The importance of these features as key issues emerged from our own study of old and new research into the systemic condition of the Bay, both physically and biologically, and the relationship of such condition with duration and degree of inundation.

There was a further difference between our evaluation of scenarios for kayaking and our development and evaluation of scenarios that identify and integrate potential benefit to natural values. Scenario development for evaluation for benefit to kayaking was minimal. There was little specification needed of further steps in development: smoothing of culvert floor and walls, avoidance of sharp rocks or fittings, maintenance of adjoining beach to reinforce and sustain the desired eddy. In contrast, in the case of developing scenarios for potential benefits for natural values, there were further possibilities for specifying further steps. We could postulate the replacement of east and west culverts, for example, especially to promote more thorough drainage of the north-eastern zone and of the north-western zone, zones in which were found the most "un-estuarine" ecological conditions. (See Section 6.8)

There were also further possibilities of re-shaping the already deformed floor of the Bay, of breaching the "feeder mole", of removing or relocating at least one of the refuge islets, of removing some of the accumulated macro-algal biomass, of accelerating the development of dendritic drainage patterns. Theoretically each option for the central culvert could have a suite of such steps developed to be sequenced in a series of scenarios. While we considered such a range of options we decided to make our pivotal choice in favour of the central culvert option that seemed the best compromise between what was good for kayaking and what was good for tidal fill and drainage of the Bay. This process is set out in detail in the sections which follow.

6.4.2 Researching and Evaluating Scenarios

Our researching and evaluation of scenarios has called for more assessment of the natural features of the Bay than it has demanded of us any assessment of the performance of the proposed central culvert in one or other of three configurations. For that side of the evaluation equation to be made we have been on a voyage of trust. We have not had the benefit of a thorough exposition of John Walter's model. (Few of us would understand it if we did!)

We know that others before him, Carver[70] in the CDB and Flanagan[71] at the Engineering School of the University have proposed models that indicate the expected benefit in hydraulic performance from lowering the invert from the present culvert level. We have been prepared to accept the evidence that John Walter has presented of the concurrence of his model predictions with the data of the Tidal Cycle presented by NIWA. Figure 6.1 illustrates this congruence.

We remain aware of some of the peculiarities and limitations[72] of tidal gauging. Likewise we have been aware of the restraints on the data collection project as it was commissioned by the Council and carried out by NIWA and against which John Walter has had to assess his own model. This is an imperfect situation but we live in a quite imperfect city in a very imperfect world.

We acknowledge that we have been carrying out our studies and evaluations in a world of predictive models. We are not in a position to devise quantitatively predictive models of ecosystem behaviour or drainage pattern development that would match the evident quantitative features of predicted hydraulic performance. We believe that our research into these issues has allowed us to identify certain issues as key issues. We shall focus on these key issues in the exposition of our assessment of physical and ecological outcomes that we expect from the adoption of our preferred design scenario. We believe that the direction of change that we predict can be justified from scientific evidence and we would argue that scientific inference in an opposite direction is unwarranted if not impossible. Furthermore, we propose the introduction of pragmatic and incremental steps for continuing that change in the desired direction. We propose such a sequence of steps as an integral feature of the preferred design scenario that we recommend to Council for adoption.

6.5 Assessing Central Culvert Hydraulic and Tidal Function

6.5.1 Predicted Culvert Hydraulic Performance

John Walter demonstrated for us in Figure 6.1 how his model successfully tracked the performance of the present culvert over a tidal cycle as observed by NIWA. Included with that is the prediction of the same model for the proposed new culvert.

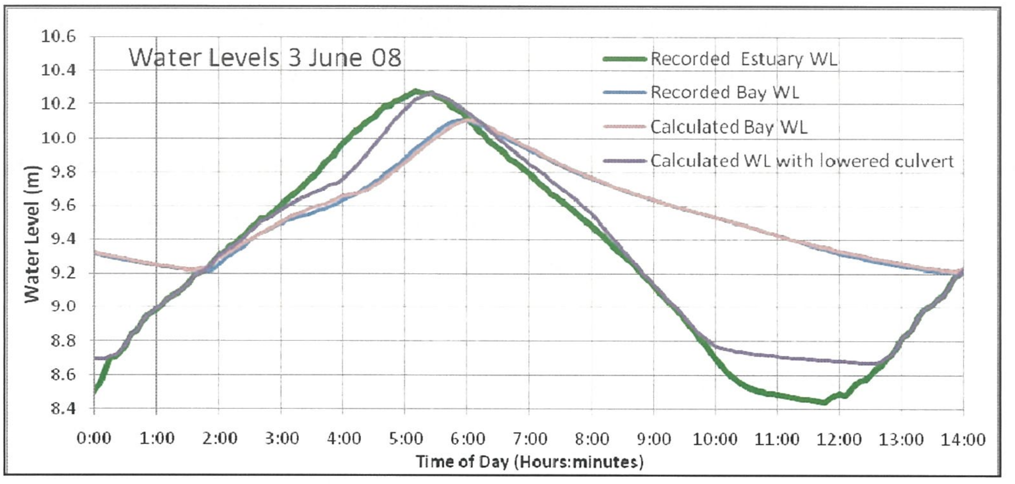


Figure 6.1 Water Levels in Estuary and Bay during tidal cycle, as observed by NIWA, and as modelled by John Walter with existing culvert and with new 6m culvert with Invert level 8.55.

John Walter also produced for us a tabulation of culvert hydraulic performance for three different designs, in response to a typical Estuary high tide to RL 10.29 metres. All three designs were with invert lowered 0.5 metres to RL 8.55 He presented these performance data in comparison with those for the present culvert in the Bay as it is. Table 6-1 presents his data for culvert performance.

Table 6.1 Hydraulic Features of 4m and 6m Culverts and a 13m Bridge, each lowered 0.5m to RL8.55 in Comparison with Existing Central Culvert

[Culvert Response to Estuary Typical High Tide to RL10.29]

Parameter	Existing Culvert	4m Culvert	6m Culvert	13m Bridge
Tidal Volume	85,000m^3	90,000m^3	102,000m^3	105,000m^3
Peak Flood Tide Flow Rate	8.9m^3/s	9.2m^3/s	13.2m^3/s	17.3m^3/s
Peak Ebb Tide Flow Rate	5.7m^3/s	6.5m^3/s	8.7m^3/s	9.7m^3/s
Duration Flood Flow >5m^3/s	1:55 (h:m)	2:20 (h:m)	2:00 (h:m)	2:00 (h:m)
Duration Ebb Flow >5m^3/s	2:00 (h:m)	2:15 (h:m)	2:35 (h:m)	2:20 (h:m)
Peak Flood Velocity	1.74m/s	1.71m/s	1.52m/s	1.36m/s
Peak Ebb Velocity	1.00m/s	1.21m/s	1.02m/s	0.78m/s
Duration Flood Velocity >1m/s	2:25 (h:m)	2:15 (h:m)	1:45 (h:m)	1:00 (h:m)
Duration Ebb Velocity >1m/s	0.20 (h:m)	2:35 (h:m)	1:05 (h:m)	Nil

Source: adapted from data supplied by John Walter, CCC

From the present culvert regime, each of the modelled designs with a 0.5m lower invert results in increased **tidal volume,** the greater width of the structure raising volume through the 6m culvert considerably above the 4m culvert and not far below the 13m bridge.

Peak flow rates for both flood and ebb tides likewise increase above that of the present structure, with these increases growing with width of structure. **Duration of flows**

above 5 cumecs is included here in Table 6.1 because of its significance, along with **duration of surface velocity above 1m/s,** for suitability for kayak-training.

Figure 6.2 illustrates the tidal cycle of flow rates through the lowered 4m, 6 m culvert and 13m bridge while Figure 6.3 illustrates predicted velocities through the same structures for the tidal cycle, each in comparison with existing regime.

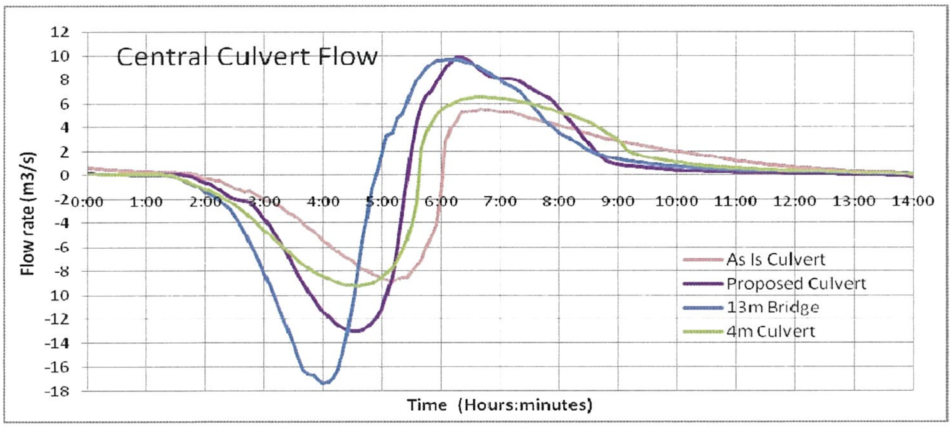


Figure 6.2 Flow rates through 4m culvert, proposed 6m culvert and 13m bridge, each at Invert level 8.55 over a tidal cycle, in comparison with existing regime. (Figure supplied by John Walter)

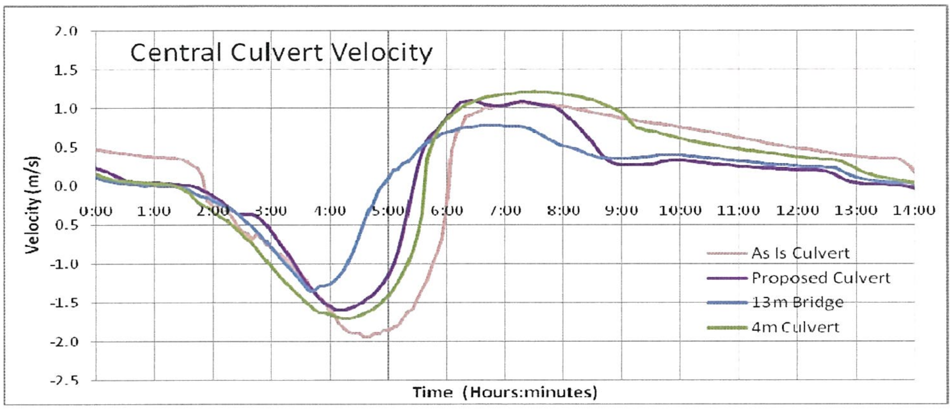


Figure 6.3 Surface velocities through 4m culvert, proposed 6m culvert and 13m bridge, each at Invert level 8.55 over a tidal cycle, in comparison with existing regime. (Figure supplied by John Walter)

Surface Velocities, both in **peak** and **duration** above-a-1m/s-threshold vary from the present regime but vary inversely with width of structure, in contrast with the effect of width on volume and peak flow rate. Flood velocities reach higher peaks and last longer under the present regime but this is not so with ebb velocities. Peak velocities are appreciably lower under a 13m bridge than they are through the constriction of a 4m culvert. The 6m culvert is lower in flood velocity than the 4m culvert which is very similar to the present regime in this parameter. Both 4m and 6m culverts are superior to the present regime in ebb tide velocity.

6.5.2 Predicted Tidal Fill, Coverage and Potential Drainage

Tidal hydrologic functions are collated in Table 6-2 for the three design structures, compared with present regime. Bay high tide levels and low tide levels vary with structure width, in keeping with variations in tidal volume. Predicted Bay tide levels differ little between the 13m bridge and the 6m culvert which is in turn appreciably better than the 4m culvert. The tidal range in the Bay between predicted high and low levels with the 6m culvert is 1.60m, 80% greater than that of the present regime. Some implications of these considerations in tidal coverage at high tide are also indicated in Table 6-2.

It is evident from Table 6.2 that the influence on Bay high tide level and water coverage from any of the possible culverts considered is not very great. In contrast, the much greater change in low tide level from the lowered invert of all the new structures considered indicates that there could be a considerable increase in area of wetland exposed by tidal drainage. The extent to which this potential drainage can be realised in practice will be examined for the preferred 6m culvert in Section 6.7.5.2.

Table 6.2 Tidal Hydrology Features resulting from 4m Culvert, 6m Culvert and 13m Bridge, each lowered 0.5m to RL 8.55, in comparison with Existing Central Culvert

[McCormacks Bay Tidal Response to an Estuary Typical High Tide to RL 10.29 and Low Tide to RL8.45]

Parameter	Bay as is	4m Culvert	6m Culvert	13m Bridge
Tidal Volume	85,000m^3	90,000m^3	102,000m^3	105,000m^3
Percent Volume Change	---	+6%	+20%	+23%
Bay High Tide Level	RL 10.11	RL 10.18	RL 10.27	RL 10.29
Change in High Tide Level	---	+0.07m	+0.16m	+0.18m
Bay Low Tide Level	RL 9.22	RL 8.78	RL 8..67	RL 8.66
Change in Low Tide Level	---	-0.44m	-0.55m	-0.56m
Tidal range	0.89m	1.40m	1.60m	1.63m
Change in Tidal Range	---	0.51m	0.71m	0.74m
Water Cover at High Tide	12.01 ha	12.04 ha	12.18 ha	12.22 ha

Source: adapted from data supplied by John Walter CCC

6.6 Assessing and Evaluating Scenarios for Kayaking

6.6.1 What Kayakers Need

We emphasise that this recreational use is assessed for kayak-training purposes, rather than for kayaking simply as a recreation. Steve Gurney and Ian Russell[73] summed up their needs for the Steering Group with this list:

- Velocity of water flow under the culvert is as large as possible.
- Large flow differential in the eddy
- Depth enough for paddle immersion
- Minimal hazards for beginners. e.g. no tie bars, sharp protrusions, or sharp rocks dumped in
- Parking and safe access without being hit by vehicles whilst unloading a kayak or carrying across road
- Water quality is non-infectious
- That it's fun to paddle there and inspires others to get active.

When it came to evaluation of culvert or bridge models, more attention was given to the **duration of useful surface velocity,** that is, above 1m/s; and **duration of useful flow,** that is, above 5 cumecs. Combining the duration of useful velocity with duration of useful flow indicated that for the present culvert regime about 2 hours were suitable for kayaking each incoming tide. Very little of the ebb tide was suitable under the present regime (Table 6.1).

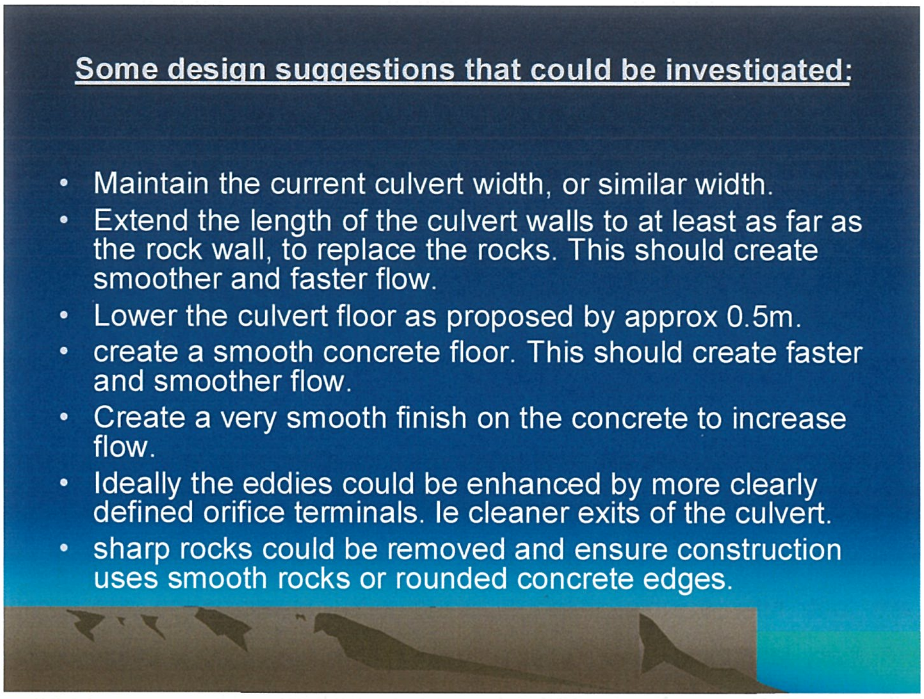
6.6.2 Evaluating Bridge and Culvert Designs for Kayak Training

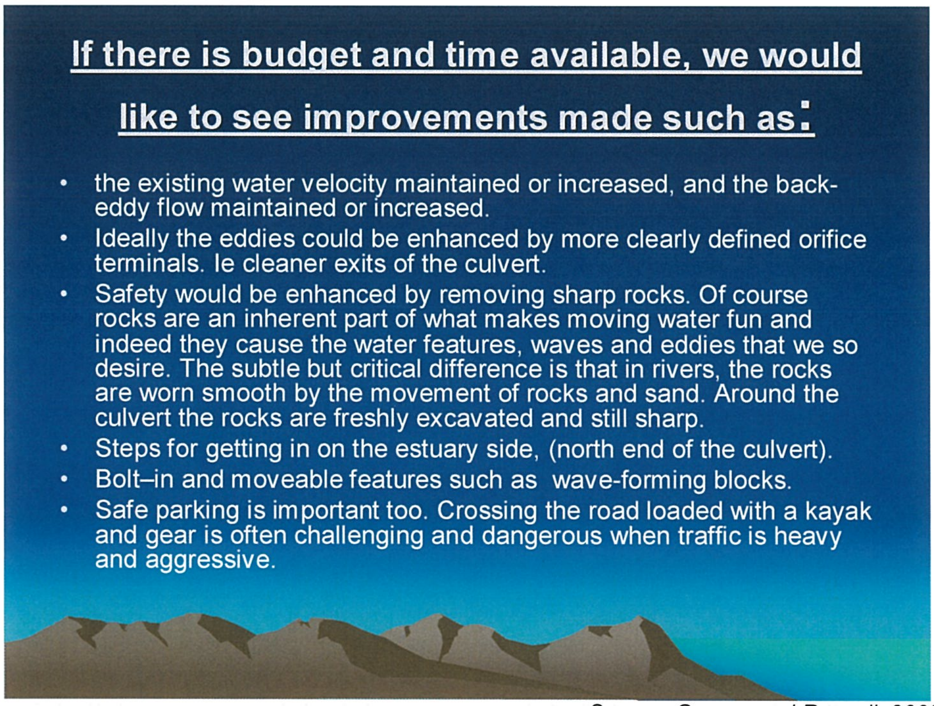
Using the same combination of criteria, we found the 13 m bridge offered useful kayak-training conditions for about one hour on the floodtide and none on the ebb tide. It was judged therefore to be of low suitability for kayak-training. The 6m culvert of new design with invert lowered to 8.55 RL offered nearly two hours suitable kayaking time on the flood tide and more than an hour on the ebb tide (Table 6.1). Together, the use of floodtide and ebb tide could provide at least as much kayaking opportunity with the proposed new 6m culvert as the present culvert. The 4m culvert had even better duration of useful velocity on the floodtide than the 6m culvert, but wasn't quite as good in duration of useful flow. The 4m culvert also posed some difficulty in kayak manoeuvring to enter the eddy. All things considered, the 6m design culvert with invert at 8.55 RL was considered a satisfactory basis for a design scenario to meet the principal current recreational training need.

6.6.3 Developing the Preferred Scenario for Kayaking

For the development of culvert design and site development we can do no better than endorse the submissions that follow, made by kayakers on behalf of the kayaking community. The site suggestions reflect some of the comments we have already made in early sections of this report. Under the predictions of hydraulic features of current preferred culvert design, use of the Estuary side of the Culvert for kayaking on the ebb tide will become almost as important as use of the Bay for kayaking on the floodtide. Access and insurance of safety from traffic hazards become the more important.

We consider these matters of parking of vehicles delivering and servicing kayaks and pedestrian use of the Causeway in the vicinity of the Central Culvert will become more important with growth of traffic and growth in demand for kayak training. We believe they are not fully soluble without taking into consideration the possibilities of supplementary launching facilities from the eastern "sportsfields" reclamation, a matter that calls for attention in the Reserve Management Plan. These issues and the issues around bird roosts on residual rocky islets in the vicinity and the breaching and re-shaping of the feeder mole to facilitate kayaking will also require practical consultation with interested parties at the time of Culvert construction. Their future development will become more important issues in the revision of the Reserve Management Plan. We cannot resolve many such issues in the working out of our present mandate. We believe, however, that kayakers have a point to make when they can observe 'wildlife crossings' and 'school crossings' and seek some like consideration. Perhaps "early warning" cautionary notices for road traffic could be considered for the limited times that they make use of the Causeway. Meantime, here was their last message:





Source: Gurney and Russell, 2009, op. cit.

6.7 Assessing Physical Condition of the Bay and Evaluating Possible Scenarios for its Improvement

In this section we aim to collate the information we have been able to gather on the physical condition of the Bay, the behaviour both tidal and non-tidal of its water-bodies, the physicochemical condition of its sediments, and the chemical condition of its waters.

We then hope to assess the potential benefit to these conditions of the basic scenarios under consideration arising from the improved tidal hydrology promised by the new designs for central culvert. From that basis we propose to develop a sequence of further steps, outlining further measures to be implemented and monitored that are designed on the basis of current information to continue the amelioration of the Bay.

6.7.1 Assessing Physical Geography of the Bay

Construction of the Causeway drastically altered the dynamics of McCormacks Bay and the adjacent Estuary area[74]. Massive and complex deformation of the Bay has followed as a consequence of enlargement of the Causeway, the periodic and partial history of unfinished reclamation behind it, the interruption of designed tidal exchanges through the Causeway, the scouring and depositing of sediments in strange patterns from single culvert function, and the maintenance or erection of further obstacles to tidal diffusion throughout the tidal area. It is questionable whether the reinstatement of a tidal regime through the remaining wetlands will of itself restore genuine tidal hydrology throughout. Assistance to the natural tidal process may be needed in the form of earthworks to the basin floor. Whether a full tidal regime is to be achieved through the hydraulics of one culvert is itself open to doubt. These matters have had to be kept in mind in developing a sequence of steps in the preferred design scenario.

First, the deformed geography of McCormacks Bay is shown in its present shape when viewed from the air. Reclamation at the southern head of the Bay and the large "sportsfield" reclamation have together distorted the basic triangular shape of the Bay. The aerial view in Figure 6.4 also shows up several physical features affecting the principal wetland basin: **A** the fine-sediment deposits near the western reclamation through which a **B** meandering drainage channel has developed; then a little to the east, the three artificial islands **CCC** separated by deeper water from the shoals of generally coarse sediments **D** spilled out from the scour hole **E** at the central culvert; and finally the linear remains of the residual "feeder mole" **F** leading out from the eastern reclamation to the Causeway alongside the central culvert.

Figure 6.4 An aerial view of McCormacks Bay, revealing the deformation of its shape and of its natural floor gradients by partial reclamations. The superimposed letters mark the physical features identified in the text.

The implications of reclamation and movement and re-deposition of sediments are indicated in the next figure (Figure 6.5) showing the general contours of the Bay floor revealed from the Eliot Sinclair survey.

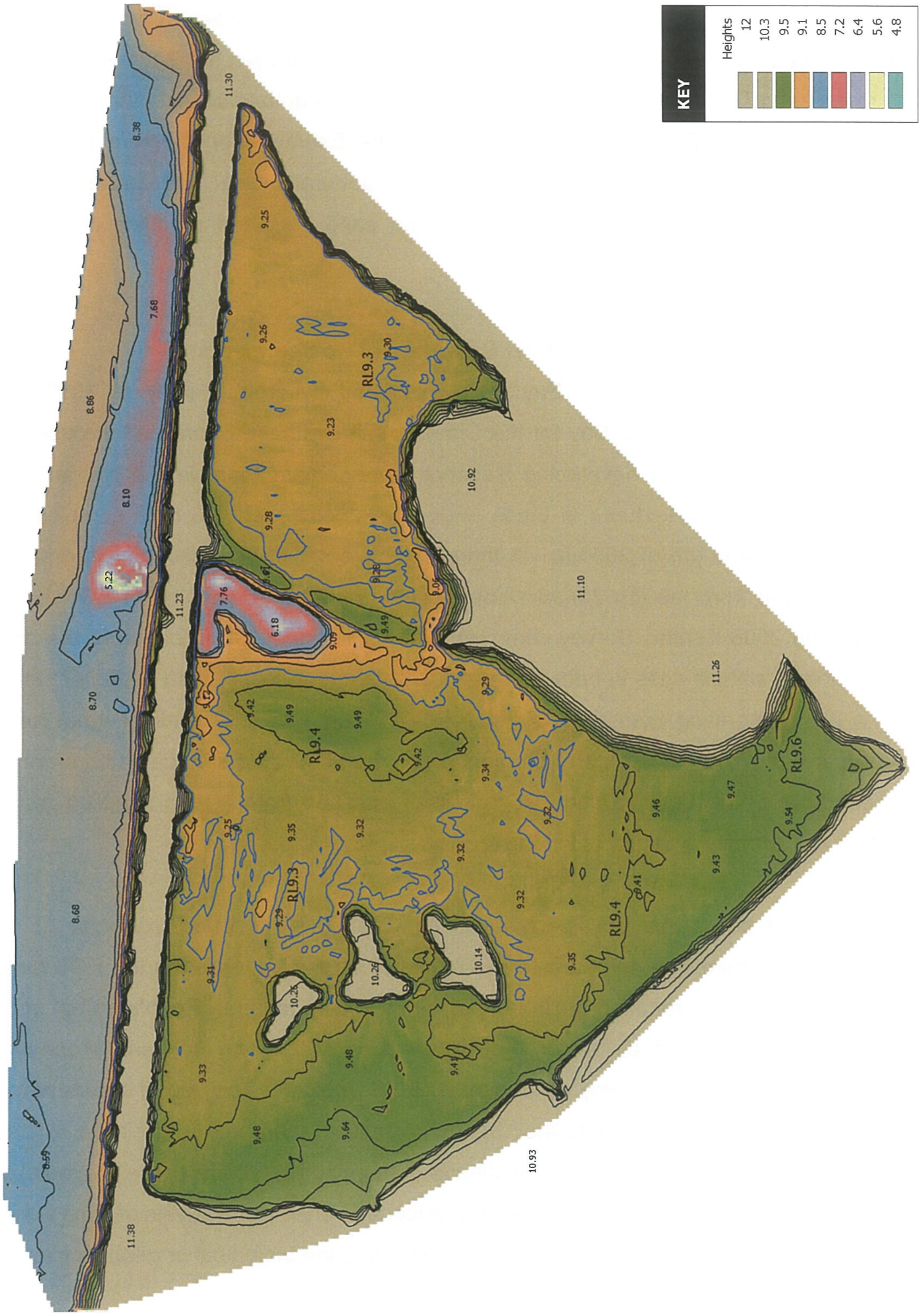


Figure 6.5 A bathymetric survey of surface heights in McCormacks Bay and the adjacent portion of the Estuary, revealing the generally lower channels in the Estuary alongside the Causeway, the prominent scour holes both to the north and south of the central culvert, the generally low surface of the floor of the NE Basin and the Central Basin RL9.2–9.4 (orange-green) and the generally high surfaces RL >9.4 (green) over the western and southern sectors of the Bay and on the shoals and gravel bar on either side of the scour hole. The artificial islands and reclaimed land on the eastern side are also shown. Spot heights derived from the survey of Eliot Sinclair Ltd are shown. The contours for RL9.2, 9.3 and 9.4 are drawn from the survey data.

The dramatic overall effect on sedimentation caused by the Causeway and of our failure over the years to maintain full tidal exchange through it between the Bay and the Estuary is revealed in Figure 6.5. Surface heights indicate substantial build-up in the Bay behind the barrier of the Causeway, in contrast with the Estuary proper where regular tidal action has maintained the Estuary deposits at a generally lower surface height than in the Bay. This condition applies to the broad sand flats and mudflats close to the Causeway as well as to the channels.

6.7.2 Assessing Physicochemical Condition of its Sediments

Twelve sites in McCormacks Bay were examined by Robb[75] early in 1989 in his biological evaluation of the Bay for the Christchurch Drainage Board and the use of the City Council in its then developing Reserve Management Plan. In the course of that survey the sediment textures of these twelve sites were recorded from samples taken apparently to a depth of 250mm. A more complete set of physicochemical data were those derived from the top 20mm samples taken by Alvarez-Murphy for EOS Ecology Ltd for the 2008 Benthic Survey commissioned for this project. Because of the careful recording of sample sites in both surveys, it is possible to locate both series of samples on a plan integrating both studies (Figure 6-6). This plan also outlines what are the principal bathymetric contours of the tidal area. Contours and surface heights are from Appendix 1 of the EOS Ecology Report, itself modified from a map supplied by John Walter CCC from the Eliot Sinclair Ltd survey.

It should be noted that physicochemical condition of sediments has been (i) more thoroughly examined for the surface sediments (0-20 mm) sampled in the EOS survey, (ii) less thoroughly examined for the 0-250 mm samples taken in Robb's earlier survey, and (iii) not examined at all for the sampling to 1000 mm that was proposed to accompany the benthic survey conducted by EOS Ecology. The use of a penetrometer (See Section 6.7.2.2) alongside their benthic sampling has demonstrated the existence of soft sediments over most of the wetlands (excepting the shallow recent shoals) to a mean depth of 670 mm. The deferral of physical and chemical analysis of core samples to 1000 mm has left us with no means of determining the biological or geophysical origin of these soft sediments.

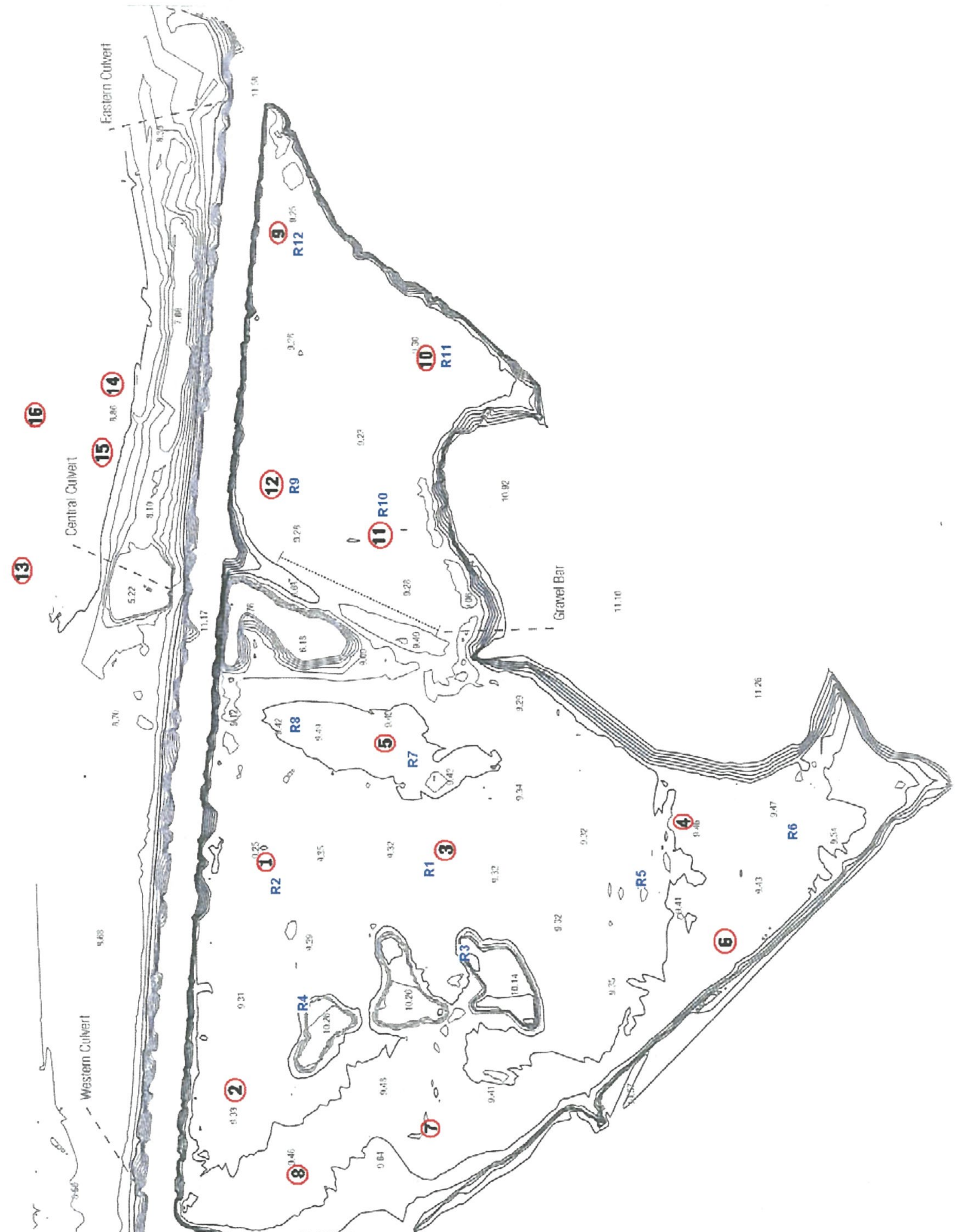


Figure 6.6 A detailed site plan of McCormacks Bay showing surface heights as relative levels and bathymetric contours. Locations of all culverts, islands and other features are shown, along with sampling sites for sediment and benthic fauna surveys of Robb in 1989 (in blue) and Alvarez-Murphy in 2008 (ringed in red). Figure adapted from Alvarez-Murphy (2009).

6.7.2.1 Establishing Bathymetric Sectors for Sediment and Benthic Samples

EOS Ecology for their survey took four samples in each of three tidal areas, (MIA, MHT, and MMT) in the Bay and four samples in an adjacent Estuary area (EMT). Robb in his survey had taken four samples in what was then Zone C (to be made into a "recreation lake"), later designated by EOS Ecology as McCormacks Inundated Area (MIA). In that sector, sampling sites between the two surveys corresponded closely. This sector is treated as a distinct bathymetric entity because it cannot be drained out by the present elevated east culvert and because the gravel bar residue of the 'feeder mole' effectively separates it at low and mid tides from drainage by the main culvert. It is only at higher tide levels that there is any appreciable flow to or from the main waterbody of the Bay.

Robb took six samples in, the northern estuarine wetlands of what was then zone B and two samples in the southern estuarine wetlands of the same zone. Two of his northern wetland samples (R7 & R8) were taken from the sandy shoal developed to the west and south of the central culvert, later sampled as EOS5 in EOS Ecology's MHT class i.e. sites which were covered only at high tide. Robb's two most western samples from northern wetlands and his two southern wetland samples were taken from what the EOS Ecology survey later designated McCormacks High Tide Area (MHT).

Only two of Robb's Zone B northern wetland samples were taken from what later became EOS Ecology MMT sites, i.e. sites covered at mid-tide. The two Robb samples from the central or eastern part of the northern wetland (R7 & R8) were clearly shown to have been taken from the sandy shoal area where the RL is 9.4 or greater. Only one of the EOS Ecology samples (EOS 5) was taken from that sandy shoal. The only other apparent anomaly in the collections is EOS 4, located close to the RL 9.4 boundary between the MMT and MHT sectors. While this sample was included in the EOS Ecology report as the fourth member of the MMT tide level class, it fits better in the MHT class as its bathymetry RL is reported as 9.46. Furthermore, the clustering of sites by mutual similarity (based on Euclidean distance) in terms of physicochemical variables reveals site 4 amongst the MHT sites and well removed from other MMT sites[76]. (A somewhat similar clustering was found in their Figure 10, based on similarity of community composition.)

To amend this less than satisfactory situation, six bathymetric sectors are proposed within the McCormacks Bay present wetlands, as illustrated in Figure 6-7:

1. the north-eastern (NE) sector, designated as MIA in the EOS Ecology report, RL 9.2-9.3;
2. the deeper north-western (NW)and central (C)sectors, designated as MMT, RL 9.2-9.4
3. the shallow western (W), southern (S), and north-central (NC) [sandy shoal] sectors, designated as MHT, RL 9.4-9.5.

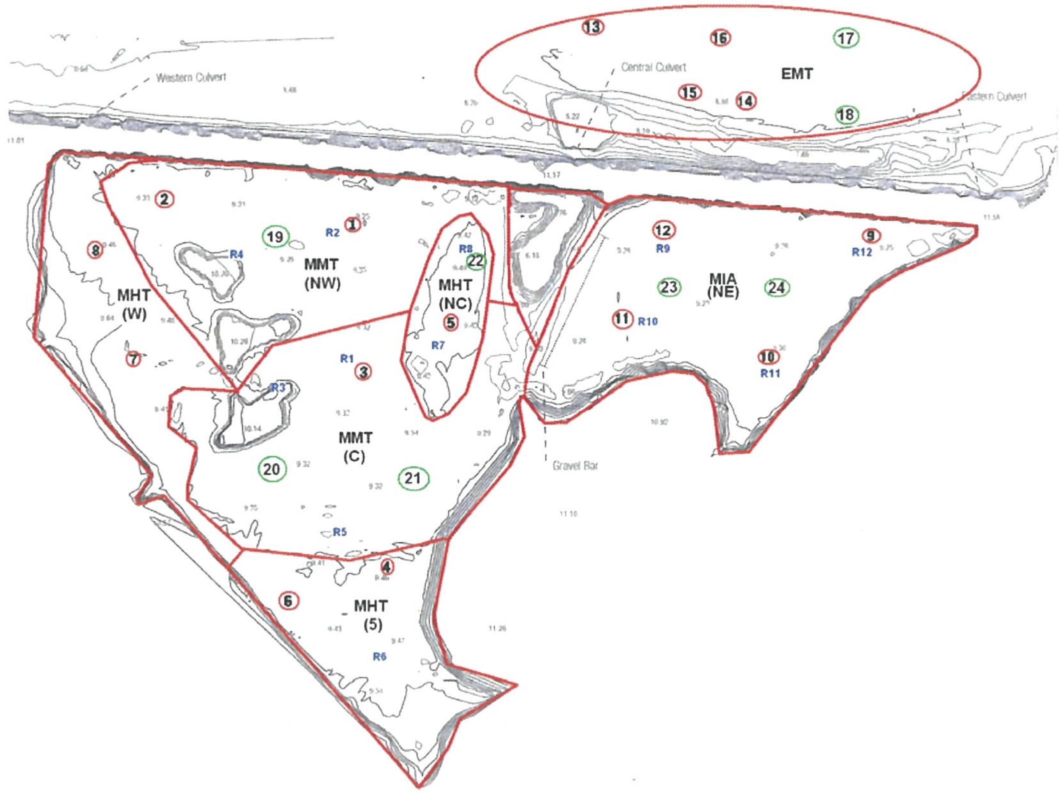


Figure 6.7 showing proposed generalised Bathymetric Sectors, of four revised tidal classes , together with proposed Benchmark Network of 24 sites for future monitoring, including the established 16 sites of EOS Ecology (ringed in red) and the recommended additional 8 sites (ringed in green).

The EOS Ecology report contrasted the adjacent Estuary sites EMT (Estuary Mid Tide) which were all located at RL 8.86 with the three tidal levels in McCormacks Bay. The contrast in biology and physicochemical features was their first and most important finding. The EOS Ecology study then went on to interpret the variation among sites in the Bay. For this purpose, tidal levels, each represented by four sites, were compared with one another. As we indicate in our comments above, we were not altogether happy with the tidal classification of some particular sites. Accordingly, we sought an improved basis for using site information in establishing benchmarks for future monitoring.

We do not dispute the findings of the EOS Ecology study. Indeed we endorse them for they establish the significance of duration of inundation (or tidal level) in affecting the composition of fauna and the physicochemical properties of the benthos. These bathymetric sectors as revised above are proposed here for use in defining benchmarks in subsequent development and recommendation of design scenarios. We found it necessary to carry out this refinement because of the difficulty we experienced in accepting EOS Ecology's classification of its own sampling sites.

Our discussion of sediment features and later of benthic parameters will be principally on the basis of individual sites and the relationships discerned between such properties; we shall attempt to describe and interpret recent historical trends in the bathymetric sectors as here identified; and we shall propose that the recent samplings by EOS Ecology should be augmented with additional sample sites to provide a firm benchmark as basis for further monitoring of effects of culvert replacement.

6.7.2.2 Examining the properties of sediments

a) *Texture* The silt/clay fraction was high (>80%) in surface sediments at nearly all the EOS Ecology McCormacks Bay sites in comparison with the adjacent Estuary sites where the mean value was 11.5%[77]. The only site in the Bay that resembled the Estuary sites was EOS 5 on the sandy shoal where silt/clay fraction was 19.1%. EOS 1 was from a site close enough to the central culvert to be subject to some flushing away of fines. There the silt/clay fraction was 39%. For all other Bay samples the mean value for silt/clay fraction was 81%. We conclude the Bay floor is mostly mud_whereas large tracts of the Estuary are now apparently being restored to sand.

This accumulation of fines in the Bay does not seem to be a recent phenomenon. Twenty years ago, using less sophisticated techniques, Robb found that the silt/clay fraction of the top 250mm at two sites on the sandy shoal averaged 20.4%. For all other sites the mean value of ten samples was 93.2% silt/clay[78]. A direct comparison is not valid, because of differences in sampling depths between Robb's survey and the EOS Ecology Survey as well as differences in analytical technique, but we venture that there may even have been some relative reduction in fines over the last two decades.

b) *Soft sediment depth* EOS Ecology measured the depth of soft sediment by use of a penetrometer. The mean of four samplings from adjacent Estuary sandbanks was 15 mm. On the sandy shoal (EOS 5) the depth of soft sediment was 30 mm. The mean of all 11 other measurements in the Bay was 670 mm. The floor of most of the Bay is covered in spongy soft sediment to an average depth greater than 0.5m!

c) ***Chemical composition of sediment*** EOS also collected surface sediment samples for analysis of Carbon, ammonium-N, and total recoverable heavy metals: copper, lead and zinc. In the EOS Ecology study, no differences were reported between the tidal levels within the Bay in these parameters but significant differences were reported between the Estuary and Bay samples in heavy metals, organic material and ammonium-N. It should be noted that these were samples from the uppermost 20mm of sediment, primarily intended to detect any recent accumulation of heavy metal contaminants. Table 6-3 summarises these results.

Table 6.3 Some Chemical Constituents of Surface Sediments in McCormacks Bay and adjacent Estuary

Location	**Org C** g/100g	**NH4-N** Mg/kg	**Cu** mg/kg	**Pb** mg/kg	**Zn** mg/kg
Estuary (n=4)	1.7	5.4	4.1	9.2	46.0
Bay (n=12)	6.5	54.0	12.9	21.8	97.5

Source: from data in Table 9 and Table 10 in EOS Ecology Report[79]

The original main objective in chemical characterisation of sediments in the EOS Ecology study was to attempt to relate variations in benthic faunal communities to their physicochemical environment. Their study has made some headway in that direction and we shall return to it in our ecological assessment in the next major section. An important part of the study, analysis of sediment cores, had to be deferred because of efforts to minimise costs. Our principal concern in referring to these limited data here is to demonstrate that the net accumulation of silt/clay material and organic material in the Bay, reported in the first paragraph above, has grossly exceeded what has occurred in the adjacent Estuary, and that soft, spongy, nutrient-enriched sediments, sometimes with heavy metal enrichment, may be characteristic of accumulations occurring in this fashion. It may be noted that all concentrations of heavy metals are below trigger levels of current sediment quality guidelines[80].

Accumulation of silt/clay fines may not necessarily reflect high inputs from erosion of hills and gardens in the catchment. The Bay has been a very effective "silt-trap" in that a high proportion of incoming fine sediments have not been moved on, thanks to limited tidal flushing and drainage. The accumulation of organic matter to high levels in such situations is also a function of primary production at these sites, perhaps mostly by macro-algae such as *Ulva* and *Gracilaria,* and also of low decomposition of biomass, because perpetual wetness reduces its oxygen supply and inhibits the work of most micro-organisms.

Regular and thorough tidal drainage has become a compelling necessity for any improvement of physical condition. ***"Drain the Bay, Twice a Day!"*** has been a very easy response. It is easy to reach the conclusion, but it will be more difficult to achieve its aim, in part because of our inclination to look for easier alternatives.

6.7.3 Assessing Chemical Condition of Bay Waters

No regular sampling station for water quality is maintained in McCormacks Bay. Fortunately Environment Canterbury during the 1990s maintained monthly sampling for nitrogen and phosphorus contents, generally on the ebb tide at four sites in the Estuary. One of these four sites was the outflow from McCormacks Bay. Table 6-4 presents the means for the N and P contents analysed, derived from close to 100 samples, compared with Estuary outflows sampled at the same time at Shag Rock.

Table 6.4 A Comparison of Physicochemical Parameters of Out-flowing Water from the Central Culvert at McCormacks Bay and from the Avon-Heathcote Estuary over the period from 1991-1999

[Means of concentrations as g/m^3 *of ca.*100 samples, taken at monthly intervals]

Location	NH_4-N	NO_2+NO_3-N	Total N	Reactive P	Total P	pH	°C
Central Culvert	0.12	0.08	0.55	0.045	0.073	8.35	14.1
Shag Rock	0.40	0.12	0.92	0.091	0.143	8.17	13.5

Data courtesy of Lesley Bolton-Ritchie, Environment Canterbury

These limited data indicate that water leaving McCormacks Bay has not been markedly different chemically from what at comparable times was leaving the Estuary for the ocean. It was slightly warmer and somewhat lower in soluble N fractions as well as having about half the concentration of total N, reactive P and total P. This suggests incomplete exchange with Estuary water which would have been more enriched with nutrients from Bromley-treated wastewater. These data also suggest that the greater biomass of macro-algae which characterises McCormacks Bay in comparison with the main Estuary can hardly be attributed simply to higher nutrient availability in the Bay. Nor can we infer that any elevated levels of nutrients in the soft sediments of the Bay have been grossly enriching the drainage waters from the Bay to the main Estuary. In view of the imminent diversion of treated wastewaters directly to the ocean instead of through the Estuary, it appears there could be soon some available capacity in the Estuary to accept enhanced drainage water and nutrient-containing sediments from McCormacks Bay for an extended period, if this is needed to bring McCormacks Bay back closer to a genuine estuarine condition.

6.7.4 Evaluating Tidal Hydrology of Culvert Designs as Basis for Scenarios

All of the above assembly of information on Bay sediments and water bodies and their physicochemical properties is intended for evaluating culvert designs as the basis for a scenario that links the improvement of the Bay with the replacement of the central culvert. From the comparison of bridge and culverts for their hydrologic effects in the Bay in Table 6-2, we can see that a 13m bridge or a 6m culvert, both with invert lowered to RL 8.55, provide substantial increase in tidal influence in both flood and ebb behaviour over what we experience in the current culvert regime. It would not be easy to choose between these two replacement options on the grounds of hydrologic behaviour in the Bay. The fact that the bridge option offers a very unsatisfactory prospect for kayak training is sufficient to recommend against it, so long as it is only marginally superior to the 6m culvert in other effects for the Bay.

We emphasise that we are making our evaluations within the limits of the information we have received in the Steering Group. We are aware of some of the difficulties of predicting drainage behaviour in even a small basin from a change in culvert hydraulics, especially the time limitation for drainage gradients to take effect in a tidal-switching situation[81] [82]. As mentioned elsewhere, we are aware that some earlier models of tidal hydraulics have been developed for McCormacks Bay, notably by Carver in the CDB and by Flanagan[83] as a thesis report for Master of Engineering at the University of Canterbury. Reference to Flanagan's model has explained for us the importance that Alvarez-Murphy ascribed to Flanagan's examination of the effect of depth in the culvert:

> *"The results indicated that [by] lowering the floor of the central culvert by 0.8m would result in a 0.2m increase in tidal range in the bay (increase from 0.88m to 1.08m) effectively emptying the bay at low tide."*
>
> Alvarez-Murphy 2009, p.24

Reference to Flanagan's thesis hasn't helped us to uncover the basic assumptions of Flanagan's model, especially the defined reference level he adopted and his reasons for settling on his value for the present culvert invert. John Walter[84] has shown us how he encountered similar difficulties in interpretation of Flanagan's work. In essence, like

John Walter we can accept Flanagan's basic methodology, but have some doubts about some of the approximations he made in deriving bay area, tidal volume and culvert performance.

We observe that the increase in predicted tidal range from John Walter's data, which are reported in Table 6-2 earlier, is greater than the gain predicted by Flanagan. We are not comparing models. We note the evident importance of lowering the invert as much as is feasible. We emphasise that we have considered culvert design options that were available with invert lowered by 0.5m to RL 8.55. We have not considered options with invert lowered by 0.6m, 0.7m or 0.8m to RL 8.45, RL 8.35 or RL 8.25. We are not operating a model ourselves. So far as we could find out from our CCC sources, such assumptions were not feasible in the current Estuary situation. We accept that at this time RL8.55 is a compromise between considerably improving the potential for draining out of the Bay and other engineering considerations. We air this matter in this way because design features of the proposed culvert are not yet finalised and we believe Council ought to be well assured on this matter, as it is patent that invert height and the relative levels of Bay and Estuary may have great significance to what happens in the Bay.

We note also that the east and west piped culverts play only a minor role in current tidal exchange and that their role could be even less with a new 6m central culvert installed and the feeder mole barrier breached down to the new culvert level. We have been confirmed in our understanding that the failure of the pipe culverts to contribute in the future to terminal drainage of the portions of the Bay which they adjoin is attributable to installation at invert heights **RL9.65** in the west and **RL8.83** in the east, both above potential low tide water levels in the pools adjoining them. We expect that any future consideration of east and west culverts will be of such culverts replaced with invert heights close to RL8.55 (or the invert level of new central culvert) so as to be relevant to drainage of the Bay.

6.7.5 Developing Preferred Scenario for Improving Physical Condition of Bay

A 6m culvert is preferred, for the reasons given above, as our best option for a single central culvert replacement. Not only is it better in hydraulic performance for kayak training than a bridge but we understand also that it is a more feasible construction option. Flanagan has argued with his numerical model and John Walter has argued from his model that there is no material advantage in greatly exceeding 6m in width, but again we note that the demonstrated significance of the depth of the culvert may need to be further considered.

There are many possible limitations on a single culvert solution to the need for thorough twice daily filling and drainage of the Bay. These limitations cannot be readily quantified in advance, but they may be listed, for dealing with each of them in turn could provide the steps in the sequence of our design scenario. Along with each feature that we identify as a limitation to improvement, we identify the kinds of steps that might be taken to improve the physical functions of tidal water in the Bay: Further than that, the effectiveness with which twice daily tidal filling and drainage of the Bay alters the sediment situation may also be limited in different ways. We will also attempt to identify ways in which this phase of improvement may be achieved by monitored steps.

6.7.5.1 Monitoring Tidal Fill and Coverage

Our first concern is establishing the levels of tidal fill and the area covered. The approximate area of coverage that can be expected with the predicted tidal fill is indicated in Table 6-5. We shall have to establish that these expectations from the hydraulic model are fulfilled as far as is practicable and we should also establish what local effects this extra coverage might bring about, creation of fresh habitat for wetland vegetation, improvement of headwater areas for natural fish breeding, better feeding habitat for waders. Benefits such as these have been observed in recent months in the Charlesworth wetlands but under different conditions to start from. We would have to monitor them to know whether they occur in McCormacks Bay.

We should also be concerned for possible effect of spring tide flooding or even of possible further effects with sea level rise from global warming. We shall also need to know that the possible benefits of increased flushing from greater tidal coverage are not counteracted by avoidable deposition of sediments in headwater zones by periodic storm events. As coverage levels become established for tides of known level, other stepwise events that we might plan could include

a] manipulation of surface soils and vegetation at watermargins to create new wetland habitat in western and southern sectors;

b] distribution of sandy material to improve establishment of *Sarcocornia* in such headwater areas;

c] joint design of walkway paths and sediment traps to avert flood damage and storm deposition of sediments in the Bay itself.

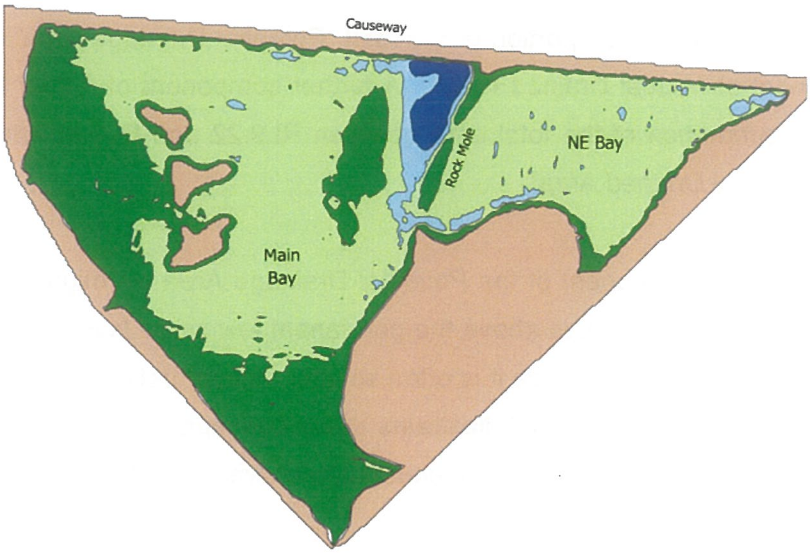
6.7.5.2 Assessing Extent of Drainage, Development of Dendritic Drainage and Erosion of Sediment

Although degree of tidal fill is important to flushing capacity, **thoroughness of drainage is expected to be of much more critical importance to the condition of the Bay** than is degree of tidal fill. Drainage effectiveness is dependent on relative levels of ground surface and at the culvert invert, but also on the distance, directness and ease of passage of water draining between such points, especially under the time limitations of a tidal system. The Drainage Potential of the Bay according to the model that we have used from John Walter is illustrated in Figure 6.8.

Permanently Ponded Water and Drainage Potential The first component of the total pool of water in the wetland that may be considered is that which remains there, even at low tide. This permanently ponded water, is water in holes below the level of the culvert sill, i.e. below RL9.22 under the present regime. Even with a new 6m culvert installed at RL8.55, we may expect to find ponding areas at low tide, with lowering of the ground surface or Bay floor level from erosion of organic sediments in the north-east basin, even after the "feeder mole" is breached to allow it to drain to the central culvert. We also expect the scour hole beside the culvert to behave as a ponding area. We don't expect to try to alter the latter, because it is a function of the tidal inflow itself. If however, pools emerge as persisting ponding areas whose floor is below the level of the culvert invert, we believe we may have to consider filling them by re-grading the floor, if that becomes physically possible.

The ponding area under the present regime extends to the limits shown by two shades of blue on Figure 6.8, 5360m ^{2} in the main basin, 1300m^2 in the NE basin. The darker blue represents the area that will still be below the new RL8.67 in the proposed new culvert regime, 2170m^2 in the scour hole of the main basin, and none in the NE basin, unless it be generated by destruction of organic sediments.

Area of Potential Drainage The Potential Drainage Area as shown at present in Figure 6.8 is made up of 8.63 ha in the main basin and 2.72 ha in the NE basin, a total of 11.35 ha. Under the new regime from the recommended new culvert, the total Potential Drainage Area will be augmented by the small area (in white) from higher tides and by the somewhat larger area (in pale blue) from lower sill height at the central culvert, to give an overall total of 11.96 ha



Key

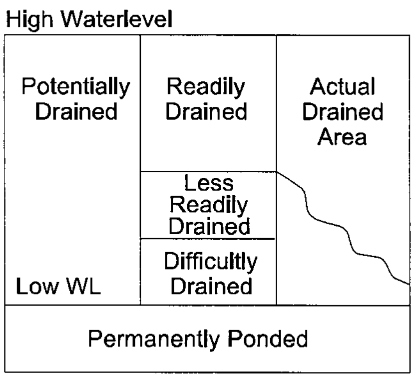
> RL10.27	High and dry
RL10.1-10.3	Readily drained with lowered culvert
RL9.4 – 10.1	Readily drained with present and lowered culvert
RL9.2 - 9.4	Less readily drained and difficultly drained present
RL8.7 - 9.2	Permanently ponded with present culvert
< RL8.7	Permanently ponded with lowered culvert

Figure 6.8 The present wetland area of McCormacks Bay divided into major drainage phases by RL contours: the deep scour hole in dark blue below RL 8.7 governed by the sill height for new culvert; the present remaining ponding area in light blue below RL 9.2; the extensive area of potential drainage in two shades of green between RL9.2 and RL10.1, the present level of high tide; the small marginal areas in white where potential drainage will be extended to the higher full tide level of RL 10.27 under the new culvert regime; and the high and dry areas of islands and reclamations above RL 10.27

Components of Potential Drainage and their Conversion to Actual Drainage While we may hope to have nearly all the Potential Drainage Area drain naturally at tidal intervals at some time in the future, we cannot expect that condition to happen at the outset. There are differences in the readiness of wetlands to drain, even within the large area of potential drainage. Figure 6.9, illustrates some concepts of actual and potential drainage.

Actual drainage of an area occurs as some proportion of potential drainage when water has time to move through gradients to the central culvert. Using RL9.22 as the present upper level of "permanently ponded areas" and RL 10.11 as the present high tide limit we have described all the wetland area between those two levels as "Potential Drainage Area". Observing that water drains readily at present from all areas above RL9.40, we can define as "Readily Drained Area" at present all the wetland between RL9.40 and RL10.11. This area as a proportion of the total "Potential Drainage Area" becomes the first component of "Actual Drained Area". A further component of Actual Drained Area will be some proportion of the total area between RL9.22 and RL9.40 which we might term "Less Readily Drained Area".

The last remaining component of the Potential Drainage Area we might term "Difficultly Drained Area". Since it remains above the permanent low water level, it remains part of Potential Drained Area. In practice it is often so little drained between tides that we may treat it as "undrained". Figure 6.9 illustrates these concepts schematically. The wavy line in the third column signifies the indeterminate character of the separation between the actually drained and the undrained.



Actual Drained Area = Readily Drained Area +
% (Less Readily Drained Area + Difficultly Drained Area)

Figure 6.9 A schematic representation of the resolution of potential drainage area through different degrees of difficulty in drainage to actually drained and undrained areas.

Direct gradients from all points of the Bay wetlands to the central culvert may not be followed by water in the ebbing tide because of sponginess causing water retention, lack of transfer time before tidal return, or because of surface detention caused by surface roughness or physical barriers including algal biomass. These barriers may need to be removed or suppressed. Reducing obstructions or delays in drainage can diminish the "difficultly-drained area" in favour of the "less-readily-drained" fraction and so increase in practice the "Actual Drained Area".

It is a difficult and indeed futile exercise at this stage to try to determine the various levels at which residual water sits at different parts of the Bay. Thanks to the excessive flow drag of sea lettuce on water struggling to gravitate to a channel, the resulting hydraulic surface may be sloping even though the water surface looks static and totally flat. Confronting this kind of situation, John Walter has suggested to us[85] that we might estimate the proportion of the combined area of "less-readily drained" plus "difficultly drained" wetlands that will actually drain between tides, taking account of the physical conditions of the surfaces as described above.

For example, he estimates that a very high proportion (95%) of the land between RL 9.40 and RL 9.22 in the NE lagoon area does not drain out at present. For the remaining wetlands of the main part of the Bay he estimates that the corresponding portion of the area between RL 9.22 and RL 9.40 that does not drain out is 50 %. These estimate values, along with the areas of wetland above RL9.40, are used to partition the Actually Drained area from Undrained Potential area in the different sectors of the Bay as shown for the Existing Regime in Table 6.5.

The proportion of the NE basin which is permanently ponded (<RL 9.22) under the present regime is also higher than for the remainder of the wetland. Hence the proportion of total wetland area in the NE basin which is "Actual Drained Area" is quite small in comparison with the corresponding proportion in the remainder of the wetland in the main basin of the Bay. The Total Undrained which includes the Ponded Area is correspondingly large in the NE basin, a situation which we expect to change appreciably if the rock and gravel barrier is thoroughly breached at the installation of the new culvert.

Thanks to the persistent help of John Walter, we can now also present in Table 6.5 our estimates of areas in the principal drainage categories in the NE basin and in the Main basin remaining wetlands of the Bay, under existing conditions and in the future with a 6m culvert installed at RL 8.55.

Assessing Effects on Drainage of Lowering Culvert A different partition of "Potential Drainage Area" is expected to result from replacing the central culvert. Lowering the Invert RL of the central culvert by half a metre can have more than one effect. It can lower the upper level of permanently ponding areas (holes in the floor of the Bay) from RL 9.22 to RL 8.67 and thereby increase the Potential Drainage Area. The small increase in high tide level to RL 10.27 has a further additional effect on Potential Drainage Area. Lowering the invert RL of the central culvert may also steepen the gradients to it from most parts of the wetlands, thereby speeding up drainage.

Table 6.5 Estimated Area in hectares of different drainage phases of the Bay wetlands under present culvert regime and after installation of 6m central culvert at Invert RL 8.55

		Existing Regime				*Expected Regime*		
Drainage Category	RL 's	Main Bay	NE Bay	Total Bay	RL 's	Main Bay	NE Bay	Total Bay
[a]High and Dry*	>10.11	0.39	0.03	0.42	>10.27	0.26	0.00	0.26
[b] Total Tidal Fill		9.17	2.85	12.02		9.30	2.88	12.18
[c]Readily Drained	9.40-10.11	3.90	0.29	4.19	9.40-10.27	4.03	0.32	4.35
[d]Less-readily Drained + [e] Difficultly Drained ***of which % drained***	9.22-9.40	4.73 **50%**	2.43 **5%**	7.16	8.67-9.40	5.05 **67%**	2.56 **50%**	7.61
So Actually Drained C+ % (d+e) =		6.26	0.41	6.67		7.40	1.60	9.00
Undrained Potential		2.37	2.31	4.68		1.68	1.28	2.96
Permanently Ponded	<9.22	0.54	0.13	0.67	<8.67	0.22	0.00	0.22
Total Undrained		2.91	2.44	5.35		1.90	1.28	3.18
Total Area *		9.56	2.88	12.45		9.56	2.88	12.44

* Area includes 0.26ha. in islands in main bay

An initial problem might be to forecast the future RL separating the "Readily-drained area" from the "Less-readily drained-area". It is reasonable to suppose that it will be lower than RL 9.40 but difficult to estimate by how much. At the present time, for the purpose of Table 6.5, we have not made any adjustment to the RL 9.4 used as the present criterion. The cumulative effects of such factors and of the changes in the surface conditions that might be expected from increased tidal exchange may be very considerable but they will have to be monitored to become measured as "Actual Drained Area" under the developing regime of the new culvert.

Changes in effective conversion of potential drainage to actual drainage under the recommended regime of a culvert with lowered invert can be expected from development of dendritic drainage channels, accelerated by storm events, and by changes in surface detention and water retention in algal residues that will arise from any measures to remove or gather sea lettuce and from any form of treading traffic that is introduced to the floor of the wetlands.

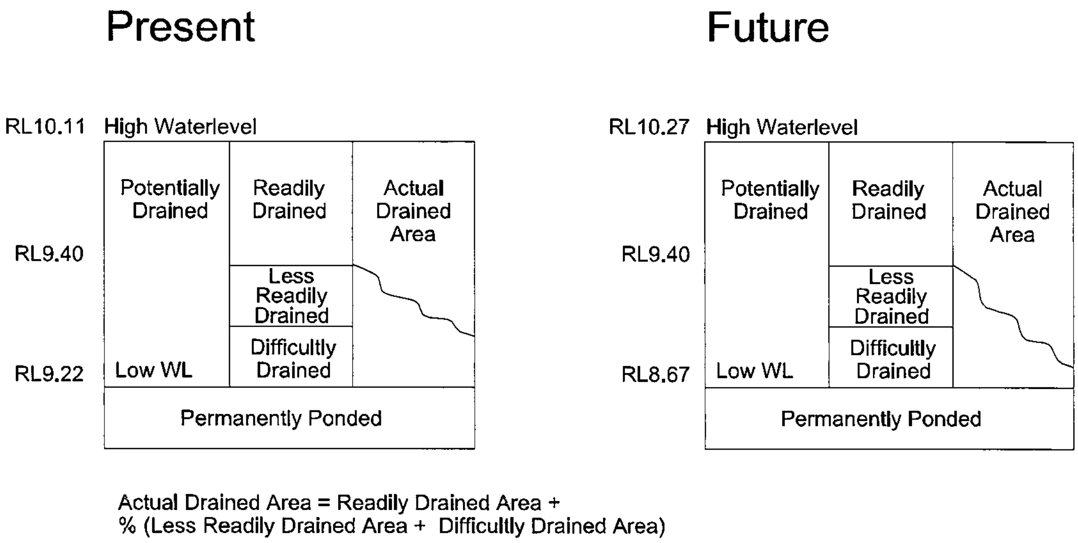


Figure 6.10 The relevant levels for definition of drainage phases at present and in the future regime in McCormacks Bay, following the installation of 6m culvert with invert level 8.55 and associated works.

Larger Barriers to Drainage There are other larger barriers to drainage that have much more dramatic effects than the features of surface roughness and sponginess affecting water detention and retention. Some examples are obvious. The gravel bank remaining from the "feeder mole" is one. It may not have been always impermeable, but it is now, and it will have to be breached and removed **down to the level of the new central culvert invert**, probably in more than one place for it to cease to act as a major barrier to drainage of the NE pond. In his evaluations of tidal coverage and drainage for the Steering Group, John Walter has assumed the removal of this barrier in more than one place as a basis for his predictions. Will Doughty, Project Manager for the Culvert Replacement Project, considers dealing with the "feeder mole" an integral part of that project, subject only to financial limits. The Steering Group likewise sees it as an integral part of the Preferred Design Scenario.

We expect that substantial rocks may have to be removed in the process, for this mole was created with material direct from the Tramway quarry. Such rocks will have to be removed from the vicinity of the culvert because of their danger to kayaking. They may be useful if further emergent features are to be created for shags or terns, as is later suggested. We have envisaged that the gravel to be moved might serve to fill the holes in the floor of the NE pond or be used for enhancing the adjacent off-causeway parking and beach-launching site for kayaking. Clearly, the more of the rock and gravel barrier that can be removed without adversely affecting the eddy beside the inflow channel, the greater is the improvement that can be carried out to the floor of the NE pond and to the kayaking facilities. On-site consultation will be needed between Steering Group representatives, kayakers, wildlife rangers and project engineers.

Another kind of possible drainage barrier that has been identified by John Walter is one or more of the "bird refuge islands" that were created in the 1990s. In his view, one of them may need to be removed for the drainage potential of the new culvert to be realised. At the present time, it appears that drainage from the north-western edges of the main water body is obstructed by one or more of the islands.

We urge that overdue maintenance work on the vegetation of the islands be carried out as soon as possible and not be delayed for the sake of settling on the number and location of islands to remain. We believe that in this issue of island location the most prudent sequence of events might be to monitor the development of drainage patterns before and after the installation of the new central culvert and make a decision later to remove or re-site one or more of the islands. Any alteration to location of islands should be done so as to ensure ready renewal of the sparsely-vegetated open gravel and sandy grit surface best suited to this bird habitat enrichment program. [*cf.* 6.8.3 below].

Relatively great length of a shallow drainage gradient is now a feature of the deformed geography of McCormacks Bay with its effective reduction to just one drainage outlet. This condition affects the southernmost headwaters of the Bay, but it also affects the NW and NE corners of the Bay right alongside the Causeway itself. It is ironic that the two areas of the Bay now worst affected by poor tidal drainage are the NW and NE "corners", **closest to what were once constructed as fully functional tidal exchange structures!** We can only echo our earlier frustration at our inability to discover details of the historic occasions on which someone must have offered some justification for installing the current pipe culverts at heights above the level at which they could provide effective terminal drainage. While we recognise the value to water circulation from cleaning out such pipe culverts, we foresee no tangible benefit to terminal drainage of the Bay unless they are re-installed at RL.8.55 (the proposed invert height of the preferred central culvert) or lower if that were feasible. Their present role in drainage is to join in emptying water from the Bay when it is easy and to cease from that function before drainage becomes physically and ecologically effective!

Monitoring Dendritic Drainage Development Whether anything should be done about re-installing the east and west culverts or installing other drainage pipes in the Causeway depends in our view on the outcome of monitoring the development of the expected dendritic drainage pattern, the development of shallow channels draining the extremities of the Bay towards the central culvert. We might expect that storm flows from the 200 hectare hill catchment discharging via Basil Place, Aratoro Place and Maffeys Road will enhance the development of such drainage channels. Whether any assistance to such an evolution could be offered with some lines carved in the mud is a matter that a geomorphologist might soon take up with the engineers involved in the future monitoring program. The essence of the preferred scenario in this respect becomes monitoring the evolution of a dendritic drainage pattern, with responsive action if it fails to develop.

We believe monitoring can be done simply with good photography and remote-sensing, perhaps using both land-based and satellite imagery, with some back-up ground surveying. What we insist on is that a commitment to a monitoring program and a proper start to it have to be made **before** the central culvert replacement becomes effective. We consider that the essence of such a monitoring program lies in defining the location and dimensions of the main storm-defined channels and their tributaries or branches and in continuing to monitor their evolution and development, including the erosion of sediments. It is because the erosion of soft sediments is seen as so central to the restoration of estuarine conditions in the Bay that we place such emphasis on the monitoring of the development of tidal drainage. For this reason, we emphasise the need to form a real, grounded linkage between the monitoring of drainage development and the monitoring of distribution, physicochemical condition and erosive change in sediments.

Another important consideration in monitoring the evolution of drainage might be to monitor the relationship of the drainage regime to sediment balance. The Steering Group has taken advice from experienced consultants in Landcare Research about the prospects of establishing a quantitative sediment balance for McCormacks Bay. We learned that it would take some years of monitoring suspended loads in and out with the tide and periodically in with storm inflows from the Catchment, before a genuine balance could be arrived at, We don't discount the wisdom or possibility of doing this as part of a longer term Integrated Environmental Management Programme.

Monitoring the Fate of Sediments We also see the need for taking some urgent and much more pragmatic steps, **as part of our preferred design scenario**. We believe that Council and Community should commit themselves to a monitoring programme, to assess what happens to the sediments at present in the Bay by establishing benchmarks in height and depth and elementary physicochemical composition **before**

the new culvert alters the drainage regime and then continuing to measure both height and composition at regular intervals thereafter. **Especially we see the need to monitor them frequently where sites are affected by the developing dendritic drainage.** Such changes in surface height and sediment core composition would have their own significance for those concerned with estuarine processes. **We expect these changes to have major significance for the improvement of the physical and ecological condition of the Bay.**

We consider that the basic sampling grid of 12 sites in the Bay and four in the Estuary used in the EOS Ecology survey can form the kernel of this benchmark, but because of the variation that we believe exists in the soft sediments in different sectors of the Bay and because the dendritic drainage pattern is not random in its development, it will require extension by a further eight sites and immediate sediment core sampling and measurement for an adequate benchmark to be established. We note that the total of 24 sites that we propose is less than the 34 or 31 sites earlier proposed by EOS Ecology. We detail steps of our preferred design scenario in Section 6.9.

6.8 Assessing Ecological Condition of the Bay and Developing Possible Scenarios for its Improvement

6.8.1 Reviewing Condition of the Water Body in different Sectors

Our earlier Section 6.7.3 notes that monitoring the chemical or physical condition of the water bodies of McCormacks Bay has not been a regular feature since the 1990's when Environment Canterbury included the outflow of the Bay as one of the four sites in the Estuary which were sampled monthly. The comments that follow are intended for setting up a benchmark of incoming and out-flowing water quality for nutrient balances in any longer term evaluation or assessment. (*Cf.* Section 6.2.3) Apart from that role they would not play a separate part in our preferred design scenario.

If water columns are to be studied, the physical condition of the water column calls for almost as much concern as the chemical condition. Quite apart from the large rafts of macro-algae which dominate our vision of the waters of the Bay in spring and summer, there is a considerable mass of suspended solids, especially in the NE and NW areas of the Bay. This is indicated by its turbidity but it is also indicated by the inferred levels of organic nitrogen, the relatively high proportions of total nitrogen which are not accounted for by the dominant mineral N components, ammonium-N and nitrite-N plus nitrate-N. Reference to Table 6-4 above indicates that whereas organic N may constitute 43% of the total N discharged at Shag Rock, organic N made up about 64% of the total N flowing out through the central culvert of McCormacks Bay. If breakdown of algal mats follows drainage development, discharge of organic material into the Estuary can be expected to increase and its presence should be part of regular water monitoring.

It may be necessary or advisable to establish some sector baselines by sampling the water column in six different sectors of the Bay NE (MIA); N (MMT); Central (MMT); NC (MHT); W (MHT); and S (MHT). These correspond to the revised grouping of sampling points outlined as bathymetric sectors in Section 6.7.2.1 above. Sampling should be at high tide for turbidity (as with a modified Secchi disc) and for standard chemical properties of C,N and P as in Table 6-4. Results would indicate whether water quality differed from one part of the Bay to another. If such differences diminished over time following installation of the new culvert, it would indicate that better water circulation was occurring. If such samplings were accompanied by sampling of the effluent from the new culvert after the tide had begun to ebb, it would be possible to discern what changes might be occurring in overall water quality and where such changes were being induced. Such a study of physical and chemical properties of water columns at different sectors of the Bay might be proposed as suitable for a University research project.

Regardless of whether or not a sector study of water columns is developed, the organic and inorganic inflows and outflows of N and P in tidal water exchanges will need to be monitored as part of the remediation process of the Bay. The possibility of including the monitoring of storm inflows is discussed later, as part of Integrated Environmental Management. (See Section 7.4) The high proportion of total N which organic N appears to constitute in waters from the Bay as noted above may be attributable perhaps to residual tissues of biota, whether alive or dead. It may be due to substantial amounts of living micro-algae or other organisms as well as fragments of the likes of *Ulva* or *Gracilaria*. Experienced algologists and water quality chemists know how to set and maintain consistent filtering standards to assist such determinations. Since so little assessment of water quality has been done it is scarcely appropriate to set standards and procedures here. We suggest that different protocols might apply to regular monitoring of chemical and physical properties of tidal inflows and outflows from those that would apply to water column studies in different sectors of the Bay. Protocols will have to be researched and adopted as part of a scenario before a programme is begun.

6.8.2 Reviewing Condition of Benthos

6.8.2.1 Physical and chemical condition of the benthos

Results of the physicochemical samplings and analyses carried out as part of the survey of benthic invertebrate fauna[86] have been discussed in Section 6.7.2 above. It should be emphasised that the analyses made were of surface sediments only, because of insufficient funding for analytical studies of sediment cores as had been proposed. As well as the striking difference in the benthos between the adjacent Estuary (EMT) and the three tidal levels in the Bay, (MIA, MMT, MHT), there were differences between tidal levels in some properties of the surface sediment, as well as the striking difference in depth of soft sediments. Tidal levels MIA and MMT were found to have the most similar physicochemical variables. These were less closely linked to MHT within the Bay and most strongly differentiated from the Estuary (EMT) group[87].

When individual sites were used for analysis of all their physicochemical properties in Principal Components Analysis, a high proportion of the sample variability (>85%) was accounted for by the two principal components. Estuary samples were strongly differentiated from most other Bay samples and heavy metal contents, soft sediment depth and clay/silt percentage were each associated with bathymetry RL. Separate analyses have not been presented of the relationship of bathymetry RL to these other variables measured, but their association with depth and duration of inundation appears impossible to ignore.

6.8.2.2 Condition of Benthic Biota in relation to Duration and Depth of Inundation

In fact, bathymetry RL was found to be the key environmental variable among those that correlated best with the patterns in benthic invertebrate community structure discerned for each of the four tidal level classes examined[88]. The dramatic contrasts observed between benthic fauna in the Estuary and in the Bay were at least as great as the differences observed in macro-algae, described here from studies over the last 20 years, in relation to bathymetric sectors.

NE Sector [MIA] This permanently inundated area has had soft and muddy substrate for at least forty years. It has been noteworthy for its abundance and variety of macrophytic algal species as well as micro-algae. Pollution indicators such as *Euglena* sp. have often been recorded there, but the pollution may be generated *in situ* by the decay of algal mats. When Graham studied it as an impounded area in the 1960s[89], *Ulva lactuca* was moderately abundant and a fine filamentous green alga, then probably *Lola littorea,* formed dense tangled mats of a metre in diameter, weighing up to 5.7 kg per m^2. Within the algal mat, the snail *Zeacumantus subcarinatus* was the most abundant species, in places reaching a density of >18,000/m^2. Other Gastropods recorded were the mudflat topshell, *Zediloma subrostrata* and *Micrelenchus huttoni*, not in the algal mat but both associated with *Ulva* on which they are alleged to graze[90]. Beneath the algal mats the substrate was devoid of infauna. No cockles, other bivalves or polychaete worms burrowed in the deposits and there were no mudflat snails on the surface. In comment a little later by Knox and Kilner, the exclusion of fauna was principally attributed to the decomposition of algae adjacent to the sediment surface, inducing anoxic conditions in the water there. Elsewhere in the limited algal-free area in the same impounded pool, cockles, wedge shell *Macomona liliana,* mud-flat snails and crabs were present in small numbers.

When Robb sampled it in February, 1989, *Ulva lactuca* was well represented and usually in nuisance proportions. Another green alga, *Enteromorpha ramulosa*, now included in *Ulva*, had been often prominent but was not then seen. At the time of sampling, the red alga, *Gracilaria secundata* had assumed the dominant role. The grass *Spartina* was then prominent along the eastern margin. At that time cockles, then referred to as *Chione,* now called *Austrovenus stutchburyi*, were abundant at all four sampling points and estimated to be the most prominent contributor to benthic faunal biomass. Their shell also provided an important substrate for *Gracilaria* and for the estuarine anemone, *Anthopleura aureoradiata.* At that time the snail *Zeacumantus subcarinatus* was not recorded in the NE Sector, although it was prominent in the MMT area of the Bay.

In recent months, the NE Sector has demonstrated continuing variation in macrophytic algae. At the time of EOS Ecology sampling *Ulva* or *Enteromorpha* was present in three of the four sites sampled, but no record was made of *Gracilaria*. Of the benthic fauna, cockles were now absent. Gastropods, especially *Zeacumantus subcarinatus*, polychaete worms, the bivalve *Capitella capitata* and amphipods made up most of the numbers of species and individuals[91].

NW** and **C Sectors [MMT] These constantly wet but not deeply inundated areas were represented in Robb's survey by site R2 and R1, and in the EOS Ecology survey by sites 1, 2 and 3. In 1989 R2 was a dense mat of *Ulva lactuca* and *Gracilaria secundata* with some *Chaetomorpha linum.* The red alga *Gracilaria* was much less conspicuous at site R1. At both sites, the small conical snail, *Zeacumantus subcarinatus*, was noted by

Robb to be "prolific amongst the *Ulva.* Very little life was noted within the substrate which was very muddy, black and highly sulphuretted. This area has long been a source of offensive sulphide odours."[92] The only other organism that Robb recorded as present in this MMT sector in moderate numbers was the whelk *Cominella glandiformis.* There were very few cockles in this sector, and then only at site R1. In contrast to the poverty of infauna, the density of the snail *Zeacumantus* was very high on the *Ulva* in this sector.

Twenty years after Robb's observations and comments, the dense mats of *Ulva, Enteromorpha* and *Gracilaria* remain, the *Gracilaria* suppressing all sorts of organisms under it,[93] the *Ulva* and *Enteromorpha* providing a grazing substrate for immense numbers of *Zeacumantus* snails, dominating both the total gastropod population and the total benthic fauna of the combined MMT sectors[94]. *Zeacumantus* spp. accounted for 93% of the total number of individual organisms counted from this MMT tidal level.[95] Cockles were in low numbers at one site and small in average size.

W, S and NC Sectors [MHT] In Robb's survey the western (W) sector was represented by sites R4 and R3, the southern (S) sector by sites R5 and R6, the north central (NC) sector on the sandy shoal by R7 and R8. In the EOS Ecology survey, the corresponding sites were site 8 and site 7 in the western sector, site 4 and site 6 in the southern sector, and site 5 in the north central sandy shoal. The anomalous inclusion of EOS 4 in the MMT grouping by EOS Ecology has already been discussed. All the other sites here classified as belonging to these better drained sectors were designated MHT in their report.

At Robb's sampling in 1989, macrophytic algal growths in the western sector were not as prolific as they were further out on the mudflat; *Ulva* was predominant and *Gracilaria* was well represented. The cordgrass, now *Spartina anglica* was well established along the neighbouring western margin. The mud snail *Amphibola crenata* was abundant and dominant but "the substrate is very muddy and does not support a great deal of burrowing animal life although several species of polychaete worm, notably *Scoleolepides benhami* were found at site 4."[96] The snail *Zeacumantus* spp. (associated with *Ulva*) was in moderate numbers at both sites but was far from dominant. So too was the whelk *Cominella glandiformis.*

In the southern sector of what is now designated MHT, Robb noted that the substrate was a little firmer though just as muddy as were sites R1 to R4. Very little drift algae were noted at either R5 or R6, the microscopic alga *Euglena* was abundant at site R5, *Ulva lactuca* was present in small quantities at both sites, but *Gracilaria* was prominent, especially at site R6, much of it growing attached to buried cockle shells. The burrowing mudsnail *Amphibola crenata* occurred in moderate numbers at both sites. The cockle, now *Austrovenus stutchburyi* and the whelk *Cominella glandiformis* each occurred at both sites, sparsely at R5, in moderate numbers at R6. *Zeacumantus* spp. were absent from both sites although another gastropod, the estuarine limpet *Notoacmea helmsi* was in moderate numbers at site R6, along with the Polychaete worm *Orbinia papillosa* and some other unidentified *Polychaeta*[97].

In the north-central sector of this class of sites designated MHT, Robb found on this sandy shoal some sparse *Enteromorpha ramulosa* and moderate amounts of *Ulva lactuca* and *Gracilaria secundata,* especially at R8 the more northerly site. He suggested that drift algae accumulates here intermittently but does not persist for prolonged periods as it does elsewhere, being exposed to wind and currents from the culvert. The small snail, *Zeacumantus* spp., so abundant at sites in MMT sectors, was absent from this sandy shoal MHT sector as was the mudsnail *Amphibola crenata.* The sediments, being much firmer and sandier than the rest of the Bay, supported large numbers of cockles, whelks, wedge shells *Macomona liliana,* and several species of *Polychaete worms* including *Orbinia papillosa* and a few of the bivalve *Haploscoloplos cylindrifer* and the occasional crab *Halice crassa.*

Nearly 20 years later, when EOS Ecology came to assess the combined sectors of what was termed high tide level (MHT), there was still little sign of sea lettuce in this tidal zone. *Ulva* was found to have very low percentage cover at one site, EOS 6, while *Enteromorpha*, apparently as drift algae occurred at EOS 8. Otherwise, sea lettuce was absent from the sector. No record was published of *Gracilaria*.

Some dramatic changes might at first appear to have occurred in the benthic fauna in the last two decades, even in this the sector least affected by prolonged inundation. The benthic fauna of this combined MHT sector had markedly differed in 1989 from the MMT sector, *Zeacumantus* spp. being absent from four of the six sites and being present in only moderate numbers at the other two sites (R3 and R4). Table 2 indicates that gastropods numbering 10,480 now constitute 73 percent of the total 14,367 individual animals found at this MHT tide level, slightly lower than 77 % at the MIA level and 93% at the MMT level. The summary evidence in Table 3 of the EOS Ecology report is that *Zeacumantus* spp are now numerically dominant in this MHT tidal level, as in all other tidal levels within the Bay[98]. The summary evidence is misleading. Closer examination of individual site data reveals that the high proportion of gastropods at MHT is attributable to the more than 9,000 *Zeacumantus* snails found at EOS 8, the only site in the MHT class with appreciable sea lettuce. All other sites in that tidal class lacked *Enteromorpha* and were also lacking in the *Zeacumantus* snails that grazed over it. (Shelley McMurtrie, *pers. comm.* October, 2009)

Figure 7 in the EOS Ecology report demonstrates graphically this dominance of gastropods at each tidal level in the Bay, in contrast to the adjacent Estuary, where they make up just 32 percent of the community. That tells only some of the story. Gastropods in the Estuary samples are made up principally of the snail *Micrelenchus tenebrosus* and the pulmonate *Amphibola,* molluscs which can hardly tolerate the conditions of long submergence in the Bay. Snails of *Zeacumantus* spp. which dominate the gastropods of the Bay were absent from the adjacent Estuary.

6.8.2.3 Integrated Review of the Ecological Condition of McCormacks Bay

For many people, even sometimes for Knox and Kilner, McCormacks Bay is not part of the normal context of the Estuary. Time and again, we find it omitted from mapped reports of surveys as being far removed from normal. For sure, when it's sea lettuce that is being mapped, McCormacks Bay will be seldom excluded. So it has become at best simply a particular part of the Estuary, different insofar as it grows a lot of sea lettuce, floats off great rafts of green algae of some kind or other, sometimes with large patches of *Gracilaria* to go with it, and noisome smells withal:

> *"Dense beds of sea lettuce, a fine filamentous green algae, and a red algae called Gracilaria, thrive in the sheltered shallow water and warm sunny microclimate of McCormacks Bay. These algae beds are important, because not only do they form the main food source for various grazing snails, but they also control what can survive beneath them".*
>
> *SJ Owen :" A Biological Powerhouse: The Ecology of the Avon Heathcote Estuary" p.51*

This picture is one we have shared with a great many who have learned to value the book in which it is printed[99]. In the Steering Group we have found evidence to support some elements of this picture. We have learned the special significance of the mats of *Gracilaria* and other macro-algae in suppressing most benthic life forms under them[100]. We have learned how mats of sea lettuce may have similar, severe effects on the infauna of the benthos[101], while favouring snail species of epifauna. We have learned how experimental mechanical removal of mats of sea lettuce can, even in McCormacks Bay, lead to at least temporary increase in infauna and reduction of the epifauna[102]. We have yet to find any hard evidence of macro-algae in these beds themselves providing a substantial food source for any of the grazing snails that live amongst them. From what we can discover, such algal grazers or browsers as they are termed consume diatoms and other micro-algae which are abundant on the surfaces of the macro-algae, but do not consume the macro-algae, except perhaps some of their zoospores. We haven't discovered with confidence which if any organism consumes *Ulva* in our Estuary, or does it all get torn up by winds and currents or wait to rot?

Zeacumantus snails have now reached very high abundance in recent years in the sea lettuce beds of McCormacks Bay. Two species of the genus have been recorded and counted in McCormacks Bay, *Z. subcarinatus* and *Z.lutulentus,* but in the same study neither species was recorded at any of the six other study sites in the Estuary[103]. Knox and Kilner refer to *Zeacumantus* as though it belonged to McCormacks Bay, not to the Avon-Heathcote Estuary. To reach high density, even in the mild waters of McCormacks Bay, *Zeacumantus* appears dependent on large masses of sea lettuce or some similar tangled mat of filamentous green algae to provide a sheltering substrate for this cute little snail to graze on diatoms and other micro-algae. Some observations of Jim Robb and of Graham before him of wide distribution of shell fragments in the sediments of the Bay suggest that it may have grown to great numbers quite widely in the past[104].

This may not be therefore the first time that these snails have grown to such abundance but they provide a puzzle to predict what will happen to them. They appear to be of no interest or value as food to the birds or fish of the Estuary, although there are indications from Otago harbour studies that predation may change under some forms of parasitism. It is a strange animal, perhaps better suited to fairly constant submergence in a marine lagoon habitat, than to a tidally draining estuary. In that respect, it resembles the *Ulva* with which it lives, for we forget that *Ulva* must be covered in water to photosynthesise! **The current remarkable success of *Zeacumantus* unpredated, and the matching magnitude of accumulation of macro-algae unconsumed together demonstrate how well we have contrived to create in the Bay an environment quite unlike the Estuary from which it was derived**. Together these gross indicators of an estuarine ecosystem becoming a wetland compost pit tell us that we have not been doing enough to keep the Bay as part of "the jewel in the Crown".

There are some further lessons that we have learned from the detailed record of the ecology of McCormacks Bay that we have summarised in this section.

- The first lesson is that there is a cause in common in the deterioration of the different sectors of the Bay. It is submergence, duration of inundation, often leading to shortage of oxygen, like being held down under water for too long at a time. It is a cause in common with a common solution: Drain the Bay! Twice a Day!

- The second lesson is that it is not hopeless. The record that we have detailed from each sector of the Bay has a special purpose. The record of species and communities shows that there is still life and hope for recovery, even in the worst affected areas. It is like the record of some famous human communities under siege. Given a chance, given even a sniff of victory, they will survive, they will overcome.
- The third lesson is one that we can together work out for ourselves, not just people, but the communities of tiny creatures and the communities of people. We communities of people in the city and on the land have to work with the communities in the benthos. The remediation of the Bay is not going to be done with conventional machinery, moving great loads of rocks and earth. There may need to be a little of that, but the forces that we shall work with are the force of the tide and the life force of tiny organisms doing their own interactive, community-serving thing in circumstances that we and the tide make good for them.
- The last lesson we would observe is that remediation of the Bay is well begun when it starts on the basis of sound ecological understanding. To continue on the same lines requires that we make ecology the linchpin of our integrated monitoring and response programme.

6.8.2.4 Devising a scenario for return of the Bay to an Estuarine Ecosystem

We have had before us in the primary objective of the McCormacks Bay Management Plan that "water must be the theme." On its own, the theme of water is insufficient to ensure restoration of an estuarine system. Water must pulse with the tide. Mixing and exchange must be part of the daily trading of waters. Ebb must alternate with flood. Draining away must alternate with flowing in.

Just as in Section 6.7.5 and its following subsections we set out the basis by which we would hope to assess the physical effects on the Bay of a new and lower central culvert, so too would we hope to monitor the ecological effects of a new central culvert regime. We believe that we should set up our monitoring programme on the basis of the six bathymetric sectors proposed as a network of benchmark sites. These same benchmark sites should be used for assessing changes

1. to the physical environment,
2. in water chemistry,
3. in physicochemical properties of sediments
4. in algae and in benthic fauna.

The network of sites should be built up by expanding on the number of sites in the recent EOS Ecology survey in each sector for the three tidal fill classes within the Bay, as well as the mid-tide Estuary comparison. We have proposed the following :

- **MIA Class: NE Sector** *Existing Sites:* 9, 10, 11, 12; *Additional Sites:* 23, 24.

- **MMT Class: NW Sector** *Existing Sites:* 1, 2, *Additional Site*: 19;
  C Sector *Existing Sites:* 3; *Additional Sites:* 20, 21.

- **MHT Class: W Sector** *Existing Sites*: 7, 8;
  S Sector *Existing Sites*: 4, 6;
  NC Sector *Existing Site*: 5; *Additional Site*: 22

- **Estuary MT: Sector** *Existing Sites*: 13,14, 15, 16; *Additional Sites*: 17,18.

We note that this arrangement of Bay sites into tidal classes follows the revision of sites we proposed in Section 6.7.2.1 above. **The effect would be that each bathymetric sector would have at least two sites to represent it, each tidal class would be represented by six sites. We recognise that the definition of each site involves determining its Bathymetry RL and that this parameter can be used as a reference in analysis. We point out that we shall have to depend much more on that variable for future analyses, because not all sites in a tidal class will be affected equally by changes in tidal drainage in the future. For this reason we confidently predict the need for more sites in the total benchmark network and recommend now the establishment of additional reference sites. Refer to Figure 6.7 on page 97.**

We propose that for the establishment and use of an ecological benchmark network the City Council should commission EOS Ecology:

- To carry out the full physicochemical assessment of sediment cores at all 24 sites, carrying out sampling and analysis as originally proposed, and
- To survey benthic biota for the eight additional sites to supplement the data recorded from their original survey in 2008.

- To cooperate with the appropriate Council and Community parties in planning the co-ordination of ecological monitoring with physical monitoring of the effects on the Bay of culvert replacement.

On the foregoing basis, we believe that our preferred design scenario to be set out in Section 6.9 will be valuable to science, of practical educational value to the Community, and of economic, social, and continuing resource management value to the Community Board and City Council.

6.8.3 Reviewing Condition of Islands and Birds

We have nearly all come to depend on Andrew Crossland for collating results of his continuing monitoring of bird feeding, roosting and nesting habits in the many different sectors of the Avon Heathcote Estuary. When he wrote his contribution[105] to SJ Owen's Estuary book, the islands in McCormacks Bay had not yet been built. Little Cormorants and Black Cormorants perched on the "feeder mole" reef or on emergent rocks, alert for yellow-eyed mullet coming in on the tide from the central culvert. White-Faced Heron and the occasional Royal Spoonbill selected their prey on the shallow reaches of the western shore. A Kingfisher would swoop from the eucalypt where they nested. Grey Teal duck or the occasional Mallard might swim about the open water as the tide filled, and pick prey off the beds of sea-lettuce or *Gracilaria.* As the tide receded, Pied Stilt and Red-Bill Gull might be seen picking among the algal debris of the north-western corner. Across the Causeway, on the more food-generous sandflats of the Estuary proper, SIPO (South Island Pied Oyster-catcher) and Godwit would gather in small flocks to follow the receding line of the tide.

Over recent years the wetlands of McCormacks Bay have retained their importance as feeding areas for shags and cormorants, white-faced heron, spoonbill and kingfisher. They have become less significant for feeding most wader species of the Estuary but perhaps more significant for feeding waterfowl, especially grey teal. The creation of the roosting islands in the early 1990s has played some part in increasing numbers of waders, terns and gulls in the Bay but without increasing their feeding or food resources. In 1993 Andrew Crossland[106] noted:

> *"the McCormacks Bay roost islands were 'discovered' by birds in the winter of 1992 and have become important for Variable Oyster-catcher (up to 30), South Island Pied Oyster-catcher (up to 350) and White-fronted Tern (up to 200) Numbers of birds using these islands will increase after completion."*

Since that initial record of colonisation, greater numbers and more bird species have been recorded[107]:

> *"In summary, numbers of birds using the islands increased to up to 50 Variable Oyster-catcher, up to 3000 South Island Pied Oyster-catcher, up to 30 Pied Stilt, up to 350 Grey Teal and up to 30 Royal Spoonbill by the early 2000's"*

Andrew Crossland also noted that up to 400 White Fronted Tern roost within the Bay, but they appeared to prefer the residual "reef" of the "feeder mole". If they are pushed out of McCormacks Bay by big tides, they relocate on the jetty on Celia Street in Redcliffs. He notes that since that peak was reached numbers of White Fronted Tern have declined.

A general impression exists among the Steering Group that numbers of birds using the islands as roosts have declined in recent years, apparently with the successional build-up of vegetation on all three of the Islands. Predation by rats (against whom the short moats are inadequate defence) and by Black-Backed Gulls (including perhaps the small family befriended on the Causeway!) has militated against nesting use by Black-Bill Gulls and Red-Bill Gulls.

Since 2004 a wildlife management exercise has been conducted to "wean" wader species off these islands and to have them "colonise" the wetlands newly created for them at Bexley and at Charlesworth. This exercise has been successful and Andrew Crossland would be happy now[108] for attention to be turned back to managing the islands to make them ideal for roosts.

The original plan for the islands was to keep vegetation on them all sparse. Then one of them was to have shrubs to favour wildfowl, the others kept open or bare for the sake of waders, terns and gulls. Andrew Crossland[109] now considers that

> "the island covered in shrubs can be left for waterfowl. The other two need to have sizeable parts of them returned to bare substrate, low-growing salt-marsh plants or covered in stones/shells."

For the present, they all have shrubs, and ways have not yet been evolved to ensure that sparse low-growing vegetation remains as sparse low-growing vegetation. The Steering Group believes that it is now a case for vigorous "weeding" in the non-nesting season. At several stages in this report we have stressed the urgency of restoring the original bare condition for roosting by wader species. The importunate requests that we have had late in our history for new and renewed rock roosts for terns and other visitors reinforces the case for restoring bare condition to the islands already built for them.

If one of the islands eventually has to be removed to make drainage of the western sector effective, then we believe the shrubland compromise should be abandoned and all the vegetation management effort directed to maintaining island roosts suitable for compatible gulls, terns and waders. Our priority has not been for roosts for birds but for estuarine feeding grounds for birds that depend on them. The recommendation that Andrew Crossland made years ago[110] to provide an observation platform overlooking the roosting islands could well be implemented as an integral feature of the involvement of the Community in monitoring the remediation for birds as well as people of the McCormacks Bay wetlands.

6.8.4 Reviewing Condition of Use of Shorelines

Shorelines of McCormacks Bay are nearly all the outcome of reclamations. Botanists, benthic zoologists and ornithologists join in pleading for the generation of typical low wetland vegetation such as appropriate species of *Juncus, Apodasmia* and *Sarcocornia.* The recreation of the Charlesworth wetlands by the physical initiative of a scrape and the introduction of such wetland species is stimulus for such joint work of micro-engineering and ecological botany to be promoted, especially on the western and southern margins of the Bay. We recall Trevor Partridge's earlier warning of the need for amending excessively fine substrates with sand to secure establishment of *Sarcocornia.*

The recreational use of shorelines may take on a new dimension when the wetlands themselves are being remediated by proper tidal function. In parkland settings, the shoreline is generally an attractive zone, for passive recreations in particular. In the case of McCormacks Bay, the creation of parkland settings has had only localised benefit in this way. Apart from the southern extremity, the wetlands are often so affected by drift mats of macro-algae as to repel recreational visitors. Improvement in the visual and olfactory condition of the wetlands, no matter what the state of the tide, could bring substantial benefit to their value for passive recreation, ranging from contemplation to bird-watching. For good reason then we have endorsed the earlier proposal of Andrew Crossland for the erection of a bird-observation platform above the western shore and adjacent to the roosting refuge islands. We also endorse his more recent comment[111] that the future of the shoreline vegetation of the Bay be as vegetation in its own right rather than as nesting sites for birds, because of the high risk of disturbance or predation. Eventually perhaps, the principal recreation use of shorelines of the Bay may become observation and enjoyment of all aspects of its natural history, not solely its birdlife.

6.8.5 Reviewing Recreational Use of the Water Bodies of the Bay

It will be obvious to the reader that we do not visualise the retention of a pool in any sector of the Bay to provide for recreation as was visualised in the 1990 Reserve Management Plan, for no other reason that we cannot foresee how we could retain such a pool and at the same time avert the sorry fate that befell the NE Sector. We foresee the present kayak-training use of the culvert inflow may be extended into greater use for the same purpose of the culvert outflow, if the culvert performs as we now expect. *Cf.* Section **6.6** to Section **6.6.3.** This may or may not lead to greater quiet-water use of the Bay for kayaking or other aspects of kayak-training. Like the current kayak-training, any future recreational use of the water-body of the Bay we envisage will be on the terms of the tide.

Like many bird-watching enthusiasts, we believe that the priority for use of the water bodies and wetlands of the Bay should be as "natural area" for the restoration of estuarine natural processes, including the enjoyment of the recovering estuarine environment by the birds that belong to it. Only by considering their welfare in the use of the wetlands and waterbodies will they be able to provide the subject matter for bird-watching as a feature of natural history enjoyment for the future. These priorities and their Implications should rank highly in demand for attention in revision of the Reserve Management Plan.

6.9 Developing and Evaluating Preferred Design Scenario

- As the people of first Sumner and then Christchurch, we have spent nearly a 100 years in constructive deformation of the estuarine element in McCormacks Bay. We have intensified that deformation with every step that we have taken that limits its effective drainage by the twice daily tide.
- In the last twenty years while we espoused an objective of "enhancing the estuarine/scenic characteristics of McCormacks Bay", hoping to "facilitate a greater public awareness of estuarine ecology", we appear by the evidence of sustained deterioration in physical and ecological condition, to have almost finished the process in the opposite direction to that to which we aspired.
- Yet the life forces of McCormacks Bay have not yet capitulated. At the same time as we see and understand the ecosystem damage that we have done, we find signs of resilience, signs that elements of the ecosystem that we have deranged can be brought together in a constructive, even restorative way, so

long as we restore the essential forces of tidal flooding and drainage that led to the evolution of the original Bay ecosystem in the first place.

6.9.1 Reviewing Key Issues

In focusing on the connections that we could make between the design of a replacement central culvert and the recreational and natural values that the Community shared, there have arisen several issues which critically influenced our thinking, leading us into selecting the series of events we postulate in our preferred design scenario. They have all been raised in the course of the report. We list them again to emphasise their influential role on our design scenario.

- Optimising the benefit of culvert design for tidal hydrology of the Bay could likewise provide for very good hydraulic conditions for kayak training, with minimal gains for either objective from widening the culvert beyond 6m.
- Lowering invert of Central Culvert to RL 8.55 <u>or more</u> became the essential feature of culvert design for the good of the Bay.
- Thorough drainage of the Bay became the most significant measure in restorative management in the Bay, because of cumulative evidence of the effects of long submergence:
  - a] damaging natural estuarine ecosystems;
  - b] favouring sea lettuce photosynthesis, growth and persistence;
  - c] inhibiting decomposition of biomass and
  - d] creating some depth of spongy, malodorous, anoxic organic mud.
- While lowering of the invert in the main culvert is the principal determinant of drainage gradient, effective drainage will be greatly influenced by removal of major and minor barriers and development of dendritic drainage pattern down to the point or points of outflow
- Development of effective drainage pattern cannot be readily predicted and monitoring of it and its physical and ecological consequences may indicate the need to develop new drainage outlets at the level of the new central culvert.
- Effective monitoring of physical, chemical and ecological conditions depends on the **prior** establishment of Benchmarks, the commitment to support the monitoring, and the effective co-ordination of the monitoring fields.

6.9.2 Identification of Preferred Design Scenario

Our preferred scenario is a sequence of events that we recommend should be driven by the Council and Community (including the Estuary Trust, Estuary Association and their constituents) to achieve the necessary and effective replacement of Causeway culverts and the beneficial improvement of waterbody, wetlands and watermargins of the Bay

6.9.2.1 Core Features

The core features of the design scenario are the following steps we recommend in the order in which they should occur: **Council, Estuary Trust, Community** and **Service Providers** may be identified for appropriate roles.

1. Establish benchmark network for assessing and monitoring change in physical, chemical and biological conditions of Bay floor, to discern condition of and change in physicochemical features of sediment cores, change in condition of plant and animal benthic communities, and possibly, changes in quality of the water column, as an outcome of central culvert change. The benchmark network would consist of 24 stations, six in **each** of three tidal levels and six in adjoining Estuary sandbanks. (Detail of network is collated in Section 6.8.2.4)

2. Arrange the completion of the above benchmark network by establishment and ecological assessment of a further eight stations at identified locations to supplement those already established by EOS Ecology.

3. Arrange sampling and analysis at all stations for physicochemical features of sediment cores, as originally proposed.

4. Install replacement central culvert designed to have these properties:

a] 6m width,
b] invert no higher than RL 8.55,
c] smooth vertical walls and smooth floor;
d] full width of causeway

and to achieve in general the following performance functions:

d] peak flood tide flow rate of 13.2 m^3/s,
e] peak ebb tide flow rate of 8.7 m^3/s,

f] peak flood velocity greater than 1.50m/s
g] peak ebb velocity greater than 1m/s
h] Bay high tide within 2mm of Estuary high tide,
i] 0.5m lowering of Bay low tide level below present,
j] more than 100,000m^3 tidal volume, approx 20% increase;

with the following outcomes to the Bay:

k] water body to RL10.27 at full tide covering 12.40 ha.;
l] water body drained to RL 8.67 at total ebb tide;
m] total area of actually drained bay floor 9.0 ha, a 35%.increase.

5. During installation of central culvert, ensure the following works are done:

a] breach and remove rock/gravel barrier remaining from the "feeder mole" beside central culvert, to the full depth of the barrier, at its central area and at the southern end where it adjoins the eastern sportsfield reclamation;
b] use suitable rock from feeder mole for providing high tide roosting on residual mole for enhancing cormorant and tern roosts at safe distance from kayak zone;
c] clearance of both east and west culverts and their entrances and outlets of all obstructions;
d] maintain or rebuild kayak access and launching beaches at both north and south ends of the central culvert, removing rocks from estuary floor adjacent to northern end of culvert to assist kayak use;
e] restore vehicle access and parking facility for kayak-service vehicle on south side of Causeway beside central culvert;
f] with supervised volunteer help clear exposed floor of Bay wetland from all obstructions to drainage development

6. Monitor culvert performance over lunar cycle to establish that its performance is in line with model predictions. (It has been suggested that water level recorders on either side of the causeway might be used to calculate tidal change through all three culverts, these data being used to recalibrate hydraulic model and to determine net culvert flow rates from rate of change of water level in Bay.)

7. Arrange Community Monitoring Programmes

- to assess over lunar cycle the actual attainment of tidal coverage and tidal drainage
- to continue periodic monitoring to ensure maximum feasible actualisation of potential drainage including noting of water retention phenomena;
- to assess sea lettuce and other algal coverage and effects on drainage;
- to commence soon and continue over a number of seasons to monitor bird species use of wetlands for feeding and of reefs and islands for roosting.

8. Arrange a] Photographic Monitoring of development of dendritic drainage;
b] Establishment of survey marks in drainage channels for monitoring any further depth change in erosion of sediments;
c] Coordination of dendritic drainage monitoring with repeated analysis of sediment benchmark sites where these are affected by drainage.

9. Arrange repeat monitoring of physical, chemical and biological condition of benthos by change from benchmarks established as events 1 & 2 above and arrange Community participation in regular monthly water sampling of tidal inflow and outflow for physical and chemical quality analysis.

10. Resume macro-algal removal trials with mechanical brush equipment or suction equipment, and monitor outcomes, including re-infestation if any, as well as physical and biological changes in underlying sediments.

11. Evaluate dendritic drainage development with geomorphologist, assessing the possible value of accelerating drainage and erosion of sediments by marking of drainage lines or other measures.

12. Review outcomes of all monitoring programs with Community within 2 years of culvert installation, in sufficient time to plan and fund in next LTCCP further developments if needed such as

a] reconstruction of east and west culverts,
b] installation of further low drainage pipes,

c] removal or relocation of one or more refuge islands,

d] reshaping of floor of Bay

6.9.2.2 Supplementary Features

These are features which might well accompany some of the steps outlined in the core features but which, unlike them, are not considered essential to the stepwise process of recovery of the Bay. They may have substantial natural history or recreational value. Some of them may be especially valuable for involving members of the local community. Many of them will be of value for the wider Estuary and its neighbours and users. They are not listed in order of priority or in any chronological order.

- Promote involvement of ornithologists and bird-watchers with Andrew Crossland in intensively monitoring temporary changes in feeding behaviour of different species of birds, during the period of accelerated drainage of the NE, NW and NC sectors of the Bay that may be expected soon after the installation of the new culvert.
- Have engineers and construction workers be alert for opportunity to create new roosts south of the main culvert for shag and cormorant and for other observed visitors such as Caspian tern.
- Have engineers consider lowering and reshaping the sandy shoal to the south and west of the scour hole at the main culvert, especially with a view to improving drainage lines to the central culvert and possible use of this sandy material as coarse supplement for the enhancement of potential *Sarcocornia* beds at the head of the Bay.
- Promote possible water column studies adjacent to benchmark network reference sites, and possible suspended sediment sampling of the outflow of the main culvert, during and after construction period as a crude way of estimating the long-time-deferred contributions of the Bay to the Estuary discharge.
- Promote further trials to involve sea lettuce residues in the composting processes for which the City of Christchurch is increasingly renowned, even considering the already partly decomposed residues that may be revealed with better bay drainage and which may cause great nuisance if removed at the whim of the tide.

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7.0 Recommendations to the Council and Community

7.1 The Purpose of these Recommendations

Our immediate purpose, achieving the desired outcome of our Steering Group Charter, is to persuade Community Board and Council to adopt our preferred design scenario. The nature of the scenario is such that it includes a series of recommended investigations and consequent actions. These feature co-operation between Council and Community in furthering greater understanding of the Bay as part of the Estuary and of our influence on it. We believe this sequence of steps will:

- ensure the continued use of the Causeway for transportation and services;
- make best use of the new culvert inflow and outflow for kayak-training;
- achieve the best possible centre culvert function for the tidal filling and draining of the Bay;
- establish benchmarks for assessing trends in remediation of the Bay as an outcome of new culvert tidal regime to allow timely planning and budgeting for whatever measures are found to be still needed for further Bay drainage;
- have enabled most essential assessment and monitoring requirements if needed for compliance with Resource Management Act to be met without further duplication of effort;
- set in motion an ecologically designed and tidally driven process for the restoration of the Bay to estuarine function which in the future can serve
    1. as a vehicle for environmental education for the Community,
    2. as an area for Community and Council pride and pleasure in joint achievement of remediation, and
    3. as a basis for revision of Reserve Management Plan for the further enhancement of the Bay and its environs as habitat for Estuary wildlife and as a parkland resource for compatible recreation.

7.2 Recommended Adoption by Council and Community of Preferred Design Scenario

Our first recommendation to the Community Board and Council is that they should **examine, debate and adopt** what we have designed as a preferred scenario, spelled out in a sequence of events in Section 6.9, including its subsections, especially 6.9.2.1, the twelve steps thereof being the core features of the design scenario.

7.3 Immediate Actions and Investigations Needed of the Council

Adoption of that preferred design scenario would open up the path to whatever might be called for to have culvert replacement comply with the requirements of the Resource Management Act. These are matters beyond the brief of the Steering Group. We have been advised in December 2009 that a Resource Consent would not be required for the culvert replacement as it is proposed to be done. Our comments on assessment of environmental effects might be more prudently directed therefore towards some aspects of good environmental practice. We estimate some environmental effects would follow from a new culvert design at a new low invert level. We have recommended such a new low invert level as the essential culvert feature in our preferred scenario. We therefore illustrate the kind of effects that we believe should be given Council attention.

An obvious example of an expected environmental effect is the increase in suspended material that may be expected to exit from McCormacks Bay to the outgoing tide from the Estuary. This is to be expected consequent on the establishment of fresh drainage gradients and erosion of what we believe are mostly organic sediments in the Bay. We suspect that these suspended sediment loads will be quite noticeable and will persist in some degree for some time. We cannot estimate the effect more closely because we have not had the survey and analysis of sediments done that we would have liked. There are two comments that we would like to make concerning this example:

1, The first is that the erosion of organic sediments built up in the Bay that is to be expected from the new lowered culvert may be substantial; it may be somewhat unpleasant; and it may continue for some time; but we believe that it is not likely to be environmentally hazardous, as might be alluvial sediments from industrial Christchurch, as three[112] relevant EOS Ecology reports on sediments have already discussed. We emphasise that the examination and analysis of sediment cores that we have sought would have dispelled any doubts on this matter and for this additional reason we renew our recommendation of that work to be done urgently in Section 7.3.1. Subject to the caveat that this analysis would dispel any lingering doubt on the hazards that erosion of these sediments might present, we consider that the expected erosion of soft organic sediments should be sought after and accepted as essential to the process of remediation of McCormacks Bay.

2. The second comment we would make is that the steps in our recommended design scenario include the early establishment of **pre-culvert-renewal** Benchmarks for monitoring the effects of new culvert invert level on the chemistry and physics of water outflows and sediments in the Bay. Therefore it becomes logical for both implementing the adopted scenario and for assessing environmental effects of the proposed new culvert level, to carry out this set of benchmark analyses of water and sediment. We have outlined them earlier in Sections 6.8.1 and 6.8.2 and we have set them at the head of the core features of the Preferred Design Scenario in Section 6.9.2.1. We identify them here as Recommendations in Section 7.3.1 that follows.

7.3.1 Establish Pre-Culvert-Renewal Benchmarks in Water and Sediment Physics and Chemistry

The essence of our recommended integration of monitoring of environmental change in our design scenario is to establish a Benchmark Network of Sites for sampling of water inflows and outflows and for sampling sediment and benthic communities. Water sampling and sediment core sampling has not yet been done, whereas benthic communities have been sampled and described at 16 of our proposed 24 sites.

Water sampling and analysis has not been done in the recent past. (cf. Section 6.8.1) It may not need to be done recurrently except as a special purpose study, as a sampling of the water column at our 18 Bay sites and six Estuary sites (Section 6.8.2.4) at full tide, along with an integrated sampling of the ebb tide from the Culvert. Such a primary sampling should be done as soon as can be arranged, **before** culvert replacement work commences. How frequently water-columns are to be sampled subsequently should be a matter of negotiation with the contracting service provider or University party. Regardless of such a sector study of water columns, integrated sampling of the tidal inflow and outflow should be done at least monthly. It may be ideal to expand it by study of storm inflows as part of integrated Environmental management. As discussed briefly in the text, physical quality, especially suspended load should be included in analysis, as well as standard water chemistry.

Sediment **core sampling and analysis have been avoided** up to this point. This work cannot be deferred any longer because it may be now as important to the "assessment of possible environmental effects" as it is to the attainment of the goal of our Steering Group project. The Steering Group is on record as already recommending acceptance of an EOS Ecology Offer of Service for sediment core sampling and analysis. Because of its close linkage with benthic survey, it is desirable that sediment core sampling be at the same sites and ideally done by personnel in the same survey party. Establishing the physicochemical Benchmark Network for all 24 sites should now have a priority for arrangement of service and provision of physical and financial support, so that sampling is complete before there is any possible influence of culvert destruction or replacement.

It is emphasised that this recommended work is distinct from and of more urgent priority **before** culvert replacement than the photographic and other monitoring of development of dendritic drainage, which can only be begun **after** the new drainage regime of the replacement culvert is begun. (See item 8 in 12 steps of Preferred Scenario in Section 6.9.2.1.)

7.3.2 Establish Pre-Culvert-Renewal Biological Benchmarks at defined Locations

The regrouping of existing EOS Survey sites and their supplementation with a further eight sites, two in the Estuary and six at defined locations in the Bay has already been set out in detail in Section 6.8.2.4. This expanded grid of 24 sites, each confirmed in GPS, should become the **Benchmark Reference Network** for all repeat monitoring samples in the future, whether in water, sediment physics or chemistry, or biological parameters. It is recommended that an offer of service from EOS Ecology be sought for a] expanding the existing network from 16 to 24 by doing the same sampling of the eight new sites as was reported for 1-16 by Alvarez-Murphy for EOS Ecology and for b] carrying out "biological indicator assessments" at the original 16 sites. The purpose of these would be to indicate the variation over time (2+ years since Alvarez-Murphy sampling) in likely benthic variables. This information could greatly assist the later determination of the frequency of monitoring.

7.4 Early Actions and Commitments Needed of the Community

7.4.1 Take an Active Share in Owning the McCormacks Bay Problem

The Steering Group envisages that the local communities of Mt Pleasant, St Andrews Hill, McCormacks Bay, Glenstrae, Balmoral and Redcliffs, the communities of interest involved in the Estuary Trust and the Estuary Association, as well as the commercial community of Ferrymead might well renew their previous interest in "the McCormacks Bay problem', if they can be assured that the Community Board and the City Council are of a mind to deal with it.

If the Community Board or the City Council were **now to avoid** making any real commitment to follow through the scenario we have outlined, then we believe that the past apathy of the silent majority will return, at least until the smell breaks out again. If the City Council attitude were to be simply one of "wait and see" the outcomes of a new

culvert, we believe the experimental journey we have taken together on this Steering Group comes to an unfruitful end.
If on the other hand the City Council demonstrates its ongoing support, involvement in and commitment to the scenario process, then it becomes demanding on the local communities outlined, the community of the Estuary Trust and its supporters, the community of the Estuary Association and its member bodies both residential neighbours of the Estuary and recreational users. The demand on these citizens will be to take an active share in ownership of the problem. We believe that the commercial community of Ferrymead might want to share leadership in this matter of Estuary welfare, since Ferrymead is virtually an artificial island in an extended wetland. Community ownership of the problem will express itself in many different ways. Some possible ways are indicated.

7.4.2 A Landcare Group Monitoring Outcomes of Adopted Scenario

There are many tasks involved in monitoring improvement in one's neighbourhood environment. Landcare Groups are not necessarily rural, just as Neighbourhood Watch is not just an urban affair. There is a real opportunity that the local community in the vicinity of McCormacks Bay now has of forming a Landcare Group under the skilled guidance of the New Zealand Landcare Trust, as a way of bringing together the volunteers who will emerge to join in monitoring, monitoring of the tidal progress, monitoring of drainage and its development, monitoring of the green and white rafts of sea lettuce and its fellows, where they beach and where they drift, monitoring of the birds that will come back to explore the wetland that is drained once again, to be rinsed again with the tide and drained once more, monitoring where and how different birds feed and gather and squabble and go elsewhere.

Our first facilitators for the Steering Group were from NZ Landcare Trust. We are confident that the Landcare Trust could help develop a community that wanted to own its share of an environmental problem, especially if its development were in ways of working with Nature, now when we're prepared to give Nature half a chance. Not everyone in a community is able to take up the responsibilities of sharing in environmental monitoring programmes. We suggest in Section 7.4.4 below that there other educational opportunities that may be created for wider enjoyment and practical application that can assist a Community to develop conscious and responsible ownership of its problems.

7.4.3 Residents, Community Board and Council in a Joint Venture in Integrated Environmental Management

Integrated Environmental Management became a catchword in Christchurch City Council circles a few years ago. It is a principle enshrined in the Estuary Charter of the Estuary Association, as well as being articulated in the Deed of Trust of the Avon Heathcote Estuary Ihutai Trust. Earlier in our report we have mentioned the special opportunity that McCormacks Bay and its catchment provide for such a venture. It has become clear to us in the compilation of this report that in recent years hillside residential land developers have been demonstrating a new sense of responsibility in averting downstream adverse influences. Installing and cleaning silt traps is now an accepted responsibility. This is quite a change from a couple of decades ago when a Council engineer could volunteer the comment: "The Estuary didn't need small silt traps. It already functions very well as a large one!" Now we even have ordinary citizens concerned about where their garden over-watering and the car wash are entering the stormwater system.

Yet there is a need for something more than precaution on the Port Hills of Christchurch. Hydrological events of low frequency and some magnitude do so much more than the average event, in reshaping the earth, in scouring hillside streambeds and filling the bed of the Heathcote and the bays on the Estuary's southern shore. A few years ago the Estuary Association and the Estuary Trust were approached by a young hydrologist who wished to start up PhD research, setting up neighbourhood systems for monitoring the impact of storm events, which bring silt and debris and contaminants into the Estuary. Now might seem a good time to renew this approach, to have the Community Board, the Estuary Association and the Trust examine with residents in the McCormacks Bay watershed whether they need to own their catchment problem as well as the problem in the Bay, or whether they wish to leave it become the post-event concern of City Council and Regional Council.

7.4.4 Develop Community Education for Young and Old

The evidence of kayak-training being a premier outdoor educational opportunity provided by the central culvert and the Bay and the lack of any prominent recreational activities making use of the wetlands of the Bay have together prompted us to think of the Bay-in-Recovery becoming an important resource in Environmental Education. The fact that its reclaimed land already provides space for a Community Centre and a Child Care Centre has itself recommended the Bay as an education opportunity with some facilities and with some clients young and old. With Professor Islay Marsden's leadership, University students in Biological Sciences have already been fruitful in their work here. Their counterparts in the immediate future will find fresh research opportunity in ecosystem recovery. Geography students in coastal processes may find similar opportunity in geomorphic phenomena.

There are undiscovered opportunities that students in primary and secondary schools may have with good teacher leadership to learn the processes by which the forces of Nature, in tidal renewal and ecosystem processes, restore the elements of estuarine ecology. There are so many examples in these times of "some darkly clouding skies" when children are confronted with the debilitation of Nature through the forces of commerce and civilisation as they know them. It would be good for teachers and children of this and coming generations to be able to get to grips with a real world experience where local government and citizens are determined to work together with Nature to rehabilitate a mess left for them by their predecessors.

The Mt Pleasant area is already the source and fount of a vigorous U3A (University of the Third Age) community in which programmes in various aspects of natural history and environmental welfare are widely supported with some enthusiasm. We are conscious that U3A programmes are worked out in responsible fashion, calling on scholarly skills in the larger community as intellectual resources to serve them. It would not be for the Council, Community Board or indeed other organisations in the larger community to attempt to plan their use of McCormacks Bay as subject matter for one of the U3A courses. It would be surprising, however, if the Council, the Community Board and leading community bodies indicated their interest in supporting such courses for U3A members and the Mt Pleasant U3A showed no response. Taking into account the wide range of potential demand for learning and the many aspects of nature rehabilitation that the Bay may offer, McCormacks Bay could eventually become a famous medium in environmental education.

7.5 Commitment to Further Investigations Required of Council

7.5.1 Commit Long term Funding for Monitoring Long Term Effects of Culvert Change

Adopting the Recommended Scenario with all its twelve steps will require some longer term funding commitments. Those of us from the Community have very little understanding of how the Council manages the City's funds with respect to future commitments to action. We had visualised that the immediate exercises in establishing a Benchmark Network might well be funded from Council's provisions for Assessment of Environmental Effects. However, we are now (December 2009) advised that the changes involved in the design of the replacement culvert are such that a Resource Consent will not be required and that an Assessment of Environmental Effects will not be needed for that purpose. There is no longer the prospect of killing two birds with one stone. The establishment of a Benchmark Network for future monitoring will have to be funded, justified by the need for and value of monitoring.

The Steering Group can assist the Council in estimating the funds that will be required for establishment of a Benchmark Network as well as essential periodic monitoring. It is not in a position to advise Council on where it might source such funds, but it is led to believe that if Community Board and Council are convinced of the urgency and value of this work, the funding will be found.

Additional to the establishment costs for environmental monitoring is the recurrent cost of carrying out the monitoring itself, referred to in the Preferred Scenario as Item 9. We have already drawn attention to the Dendritic Drainage Monitoring (Item 8). The Steering Group would be able to offer guidance to the Council in estimating to meet these needs.

7.5.2 Commitment to Renewing Sea Lettuce Removal Trials

We have identified the resumption of macro-algal removal trials in Item 10 of the Preferred Scenario. We cannot over-emphasise the potential significance of such work, well-managed and effectively done, (a) in improving the effective drainage of the wetland exposed in the new tidal regime created by the lowered culvert; (b) in creating a positive attitude among the neighbouring residents, in addition to (c) the beneficial effects we may expect for benthic infauna and the birds dependent on them.

Only by the active removal of sea lettuce and sea lettuce residues will people get the idea that this material is not going to be left to rot or keep on growing. The difference about removing it this time is that we are also taking measures to drain the bay twice daily, as thoroughly as we are able, thereby greatly reducing the capacity of *Ulva* and its like to grow and produce more material. One cannot expect positive attitudes from the community, from the young joining in environmental education, from the older sharing in environmental monitoring, unless the Council is taking visible measures to deal with the visible problem. We believe from the published accounts of the effects of sea lettuce removal that the erosion of accumulated sediment can be accelerated by accompanying managed human intervention, as well as the improvement of the benthic habitat for infauna. We also consider that renewal of sea lettuce removal trials with mechanical brush or suction or any other equipment might be linked to further trials with leaching and composting this material, as an accessory feature of our Preferred Scenario. (See 7.5.4 below)

7.5.3 Commitment to Review Outcomes of Monitoring

Our step 12 in our preferred scenario called for a review, within two years of installation of the new culvert, of the outcomes of all monitoring programmes. This review we would like to see done in sufficient time for the planning and budgeting in the following LTCCP of the further developments needed for effective remediation of the Bay. It is for that reason that we originally intended to recommend the comparatively short interval of two years from adoption of the scenario. Careful reading of this report would leave no one in doubt about our concern that effective drainage of the Bay may not ensue simply from replacement of the central culvert. Included in that central measure is the breaching to full depth in two places of the rock and gravel barrier from the old "feeder mole" of 1930s causeway construction. There may be other barriers to effective drainage that only time will reveal. Of other possible measures we have identified four where action might be needed:

- a] reconstruction of east and west culverts;
- b] installation of further low drainage pipes;
- c] removal of one or more refuge islands;
- d] reshaping of the floor of the Bay.

7.5.4 Commitment of Support for Adoption of Supplementary Features of Preferred Scenario such as Composting

Perhaps the most significant area for making commitments for future support that is outside the core features of our preferred scenario is the promotion of further trials to incorporate sea lettuce and related organic residues in Christchurch composting processes. The carbonaceous residues on the floor of McCormacks Bay are almost certainly rich in nitrogen, phosphorus and sulfur. If they could be limed or leached with fresh water from saline contamination or sufficiently diluted in the pile with non-marine material, they would probably contribute to the quality of the compost. They may even have a role in association with the disposal of residues from the algal biofuel extraction process currently being developed at Bromley.

It is valuable for us to realise that an Estuary such as ours does not decline greatly in biological productivity when crude mismanagement of the physical and chemical environment diverts it into growing sea lettuce and the like. The bulk of carbon fixation through photosynthesis simply accumulates in algal tissue that seems useless for humankind and of little or no value for the customary denizens of our Estuary. It behoves us to abstract that carbon and make some use of it rather than leave it to accumulate and suppress the life-forms that make our natural Estuary tick.

Likewise while we have bathed the freshwater algae of our oxidation ponds with our discarded nutrients we have been dealing in high productivity with no other purpose than sanitising our wastes. An enlightened civic society that is eager to gain carbon neutrality will search for ways and means of recycling that productive algal carbon which will otherwise encumber our living environment.

We have indicated that we do not consider that these algal residues in McCormacks Bay will be eroded and washed out so quickly as to constitute a grave nuisance in the Estuary. They can certainly not be expected to contribute positively to the quality of the Estuary, nor to the Sumner beaches where they can be expected to appear. Learning to make them into a contributing resource for the City's compost could be a valuable outcome.

We have suggested that support might be found for the study of changes in water columns subtended by different algal masses and benthic biota. There are other supplementary features of our preferred design scenario for which we recommend that Council might make a commitment to support. One that we would single out for special attention is longer-term planning for transport use of the causeway and for the further engineering assessment of its needs and capabilities. (See 7.5.7 below) Most matters that are not covered under Core Features of our preferred design scenario could be included in the revision of the McCormacks Bay Reserve Management Plan. Since it is unlikely that this revision will be undertaken in advance of the projected monitoring review of the Bay which is planned for two years from culvert installation, say 2013, there are some matters which should receive attention now, rather than wait for Management Plan Revision. Some of these are noted in what follows.

7.5.5 Commitment to Revision of McCormacks Bay Reserve Management Plan

Council will need to give some priority to activating some aspects of reserve management as well as to revision of the Reserve Management Plan for this area. Earlier in this report we pointed out what we considered to be some weaknesses or deficiencies of the existing Reserve Management Plan. The Plan had very laudable objectives but it had found no way of introducing measures, especially affecting the wetlands or waterbody, which contributed to the laudable objective of promoting estuarine character. As we observed at the time, the evident futility of attempting to deal with the sea lettuce problem seems to have acted as a kind of paralysis preventing any sort of positive action on wetlands or waterbody.

Reducing Macro-algae We believe that this situation can be dramatically changed by the new drainage regime which will come into effect from the proposed new culvert. We believe the greater area drained for a longer time with each tide will greatly increase the drainage potential as well as greatly lower the production potential of sea lettuce and other macro-algal stands in McCormacks Bay. We consider the drainage regime that we are forecasting will provide a much improved basis for estuarine wetland management, even if such micro-barriers to rapid effective drainage as we have mentioned delay its full achievement. Physical disturbance of the residual mass of macro-algae, mechanically or by direct human intervention, can be expected to accelerate its disappearance with improved tidal drainage gradients There are many other features of wetland reserve management that can be adopted that will accelerate tidal drainage.

Improving feeding habitat for Wading Birds One feature common to improved management and Management Plan revision should be a major effort to put management for the welfare of estuarine birds on a sound systems ecology basis. Late in the history of compiling this report we have had a suite of suggestions for improving the roosting opportunities for different species of birds which regularly use or occasionally visit our Estuary. The Steering Group has consistently attended to the observed use of the Bay by birds of different species and habits and we have sought expert advice from local authorities to keep the interests of the estuarine birds high in our reckoning, in no way subordinate to the interests of recreation.

We have recommended that rock excavated from the barrier separating the NE pool from the main waterbody be used to enhance high tide roosting on the remnants of that barrier. We have been concerned that measures set in the Bay for the benefit of waders, terns and gulls, like the refuge or roosting islands, had not been managed to suit their needs and **we recommend that immediate action be taken to restore the original bare character** of two islands, rather than wait for revision of the Management Plan. Most of all, we have been concerned that the environment of the Bay has deteriorated as feeding habitat, for waders in particular. We suggest that it may be ecologically unsound to provide island roosts for birds without attempting to improve their feeding habitat.

We have learned from our studies that this deteriorated feeding habitat for birds was attributable to decline of infauna in the kind of sediments that had been building up in the constantly submerged sectors of the Bay where macro algae were rampant. Our priority therefore has been to secure effective tidal filling and tidal drainage of the Bay ***as a consequence of installation of a new Central Culvert.*** In this way, we believe that even while adhering strictly to the terms of our charter, we shall have made the beginnings of a process of restoring estuarine bird habitat. We consider that our preferred design scenario establishes the basis for effective reserve management planning to implement that habitat restoration, in the midst of the multiple use already in vogue in the Bay.

We suggest that when the review of monitoring is undertaken a draft revision of a Reserve Management Plan might also take shape, with ecological revision of its planning for birds as a core element of the revised Plan. We would recommend that the ecological welfare of estuarine birds be kept in mind in all aspects of plan revision.

Further features in Management Plan revision There are some further features that can now be identified from within this report that should be dealt with as part of a revised Reserve Management Plan:

- Location of Kayak-launching facilities: current practice involves both sides of the road at Central Culvert, with some traffic safety risk, but unavoidable in future if both inflows and outflows are to be used for kayak-training and the new culvert, like the present, lacks headroom for safe paddling through.
- Vehicle parking on the Causeway adjacent to Central Culvert: current practice involves some off-road parking close to the culvert. Planning should provide for at least one kayak-servicing vehicle to be parked on berm of Causeway, as at present, this berm being reconstructed as part of the culvert replacement project. We consider this close parking of a kayak-servicing vehicle as probably an essential safety feature for kayaking, for quick access to communications, first aid equipment etc in the vehicle. We believe the revision of the Management

Plan should carefully assess aspects of traffic safety that may be expected on the Causeway in the medium term.

- Supplementary kayak-launching locations (and associated vehicle parking): no plans exist at present but suggestions have been made that some facility for kayak launching and associated vehicle access might be developed on sportsfield reclamation at some location to be settled.
- The implications of kayak-launching site to bird-roosting use of shorelines, rock islets and planted roosting perches for shags and cormorants should be taken into account in plan revision.

The recreational use of the western reclamation and tree-planted area east of the Community Centre should become a feature of plan revision, including the possible provision of a "hide" for observing bird behaviour on the adjacent rooting islands and the intervening wetlands.

7.5.6 Provision for Continuing Financial Support of Research for Unforeseen Information Needs

The Steering Group has not had happy experiences with higher officers of the Council concerning the funding of what we have seen as essential research. The difficulty that Council appears to have in finding in any one year the sum of say $200,000 for researching the basic issues of a problem area like McCormacks Bay suggests to some of us that there may be some underlying deficiencies in the culture of science and research in the governance of the city and its environment. It may be appropriate for the City Council to reconsider this question at the highest level. That is a matter for Council to decide. We have no recommendation to make concerning that issue.

The writer of this report has sought advice from some others familiar with the more specific kind of issue of providing for financial support for scientific research into unforeseen problems in a city or community such as ours. It is suggested that the Council of a city such as ours might consider making an annual budget commitment of say $1m for what we would term **"scientific research contingencies"**. This financial provision would not be for the regular scientific servicing of various projects, largely done by skilled Council staff, which can be budgeted for fairly well. Nor is it for "blue skies" research of some kind to be imagined. Nor indeed is it for scientific monitoring which can be budgeted for quite accurately, for which arrangements can be made with service providers, often with the involvement of volunteers from the Community, and for which sums can be committed, and which can then be carried out expeditiously and effectively.

It is suggested that almost every year one or more critical issues will emerge in a City of our size which the Council has not foreseen and could not be expected to foresee as part of that year's expenses. Some of these critical issues are amenable to scientific research. Those that are should have first call on this budget item of $1m. Unexpended funds in any year might go to a pool for funding of post-graduate research in our Universities, in this case for planned research on topics of interest and value to the Council. Funding post-graduates in research projects of interest to Council will always be one of the most cost-effective ways of getting problems investigated and sometimes solved, all in a medium time frame, but it is **not often the way to cope with emergencies.**

In summary, it is suggested that there are at least four different categories of scientific enquiry which a City Council such as ours might expect to call on Council funds.

- The first is enquiry of various knowledge deposits e.g. libraries, websites, scientific authorities personal and institutional for information which might be expected to be available "from the shelf" without research beyond "looking it up". These enquiries would ordinarily be made by members of Council staff who are educated in science sufficiently to know what they need to know and where to seek. My impressions are that Christchurch City Council functions rather well in this category.
- The second category of scientific enquiry is for regular or foreseeable information needed for the normal servicing of Council functions or activities. The information sought usually requires some research activity by parties not on Council staff but who might provide such a straightforward research service, such as counting, measuring or analysing, by arrangement with officers of Council who have foreseen the need. Included in this category are a high proportion of environmental monitoring exercises where what is principally sought is evidence of direction of trend or change in trend in some known phenomena. My impressions are that CCC has been quietly building a pool of such scientific service-providers with whom Council staff can confidently deal.
- The third category of scientific enquiry is for new levels or planes of understanding of existing phenomena or for understanding of new phenomena where the changing conditions of the City have prompted staff of Council or Council itself to foresee the need for a new understanding, a "different picture" rather than new dimensions of the existing picture. This is the kind of enquiry that is often asked of an existing service-provider. It is the kind of enquiry which

is often difficult to estimate for, whether as seeker or provider of the service. It is the kind of scientific enquiry that can often be well carried out with grants-in-aid by post-graduate students as thesis topics, especially if their potential University supervisors are already actively involved in the same field of research. It is the kind of new understanding of the Estuary which was promoted in the 1960's-1970s by the subventions of the Christchurch City Council and the Christchurch Drainage Board. The development of a strong culture of this form of research support is one of the best signs of a happy and constructive town & gown coexistence.

- The fourth category of scientific enquiry is for some understanding of an issue which has not been foreseen of expected as a direct and immediate concern of the Council. In many cases where such issues arise, the Council could not be expected to foresee the issue. In other cases, the Council may not have foreseen the issue as a problem of significance or urgency. In any such case financial provision will not have been made unless it is made as provision for the unknown and unexpected. Without such budgetary provision the temptation will arise to misrepresent the issue to justify "nibbling away at some other cheese", or to skimp on or defer support for the needed research. Lack of provision for the unexpected may have been one of the principal reasons for the declining reputation of New Zealand central government support of scientific research. It may now be widespread as cause for a systemic failure in timely support of research in local government. Provision of a budget item is suggested therefore for **"scientific research contingencies"** where such provision does not exist. If alternative possible methods of funding unexpected research priorities already exist in this city they have not been made known to the Steering Group.

There are other possible categories of scientific enquiry that have less significance for local government budgeting and support. One of them surely is "Blue Skies Research" where research is competently conducted but with no conceived application of its outcome to any defined real world issue. It is not that such "Blue Skies Research" will never be relevant to the governance of cities such as Christchurch. It is simply that such research probably has no legitimate call on local government for financial support.

7.5.7 Planning for Future Use of the Causeway for Transport

We recommend that the Council should take this opportunity, without delaying the culvert replacement, to review future long term transport use of the Causeway. We noted in 2007 that the first two objectives that we envisaged then "1) Identifying current and long-term (30-40 years) future traffic requirements and 2) Preparing various culvert design options to meet traffic requirements" could be relegated to the Recommendations of this Chapter. We adopted immediate objectives that were more simply stated: "Clarify current and immediate traffic needs that can be met within existing causeway dimensions" and "Identify essential culvert replacement features needed to meet traffic requirements".

Early in this report we noted how an engineering inspection of the condition of the seawall on both sides of the Causeway, Estuary and Bay, had revealed generally sound condition, despite the revelation of less than satisfactory condition of the seawall of that portion of the original causeway which by reclamation has now been integrated with the land at the foot of Mt Pleasant Road. Evidently we can take satisfaction in the work of our pioneering causeway-builders, and apparently in the work of their successors in the 1930s who built the seawalls in a different style on the Bay side of the widened causeway. If the original tram causeway is to be used for vehicular traffic in any way in the future, we believe that the Causeway and its walls will require a more stringent engineering assessment. We recommend that provision be made for this assessment.

The longer term forecasts and longer range planning for transport use that we recommend might well take some account of this small acquaintance that some of us have had with transport planning beyond Steering Group sessions. The dimensions of longer term transport planning might well be widened beyond the conventional vehicle movements per household and vehicle densities for different classes of urban streets. Some of us don't consider conventional buses as a very satisfactory alternative to private motor vehicles for the maritime hills, Scarborough, Richmond Hill, Clifton, Moncks Spur, where primary access from the flat to the hills is an acute problem for large vehicles such as buses and for every other hill road user in consequence. Light rail has been whimsically suggested as a solution for these south eastern suburbs and the northern side of the Causeway is apparently just made for it!

It is suggested that greater attention to the planning of settlement of the south eastern suburbs might well take precedence if traffic congestion and even gridlock is to be avoided. At the present time the City is facing a major bridge re-construction at Ferrymead and in the opinion of some parties, only a world wide recession saved us from a sustained hill housing construction boom that would have made the proposed new traffic routes at Ferrymead inadequate. We would not like any one in Council to think that we didn't take seriously the transport problem and opportunity that the Causeway connection posed.

We have recommended that the new culvert be designed for the full width of the causeway so that the length of the culvert would not limit the development of the bridge-site for possible vehicular use or for the installation of footpaths and ample-width cycle-ways on both sides of the causeway highway.

Our recommendation about transport planning is included here and not in our recommended scenario because we found when we analysed the Causeway situation that traffic use of the Causeway had little significance to the connection that we found between culvert replacement and the physical and ecological condition and use of the Bay. The significance that traffic use had to recreational use was the hazard to kayak-portaging pedestrians and cyclists. We have already recommended attention to those problems in Reserve Management Plan revision and in designing the use of the width of the causeway.

7.6 The Future of McCormacks Bay

McCormacks Bay has two possible futures. The one deriving from adoption by Council and Community of our recommended scenario is of some kind and degree of estuarine wetland restoration, the pace and degree of which cannot be forecast in advance. The alternative future, deriving from a do nothing, "wait and see" attitude in Council and Community will ensure the persistence of the civic disgrace and ecological disorder that has taken so many different forms in the last seventy years.

We are eager to promote a positive future for McCormacks Bay, so we do not want to dwell on the possibilities of our recommendations being rejected and of us and the goodwill and work of our report being rejected with them. Earlier in this report we idealised about "the attainment of a ***farther-out goal*** to which we believe we all are working,

> ***a tidally-functioning healthy ecosystem in McCormacks Bay which local people and visitors could appreciate and enjoy in different ways, an effective traffic and services communication system across that Bay, both systems functioning together to the economic and social satisfaction of both Council and residential or recreational Community and as part of an Estuary-in-the-City where its own plant and animal inhabitants flourished and its human neighbours drew wonder and inspiration.***

We are conscious that it is easy for people with ecological ideals to hare off in doing one thing after another with the best of intentions for bird, beast or native insect. With these possibilities in mind, we offer a start-up list of measurable objectives of an ecological kind that as members of a local community we might subscribe to, to avoid the perils of hare-brained enthusiasm in a small "natural area" and at the same time to pursue the far out goal described:

1. The first objective would be to maintain and enhance the fullest possible integrity of the McCormacks Bay water body with the tidally functioning Estuary water body, for the best possible functioning of the desirable aquatic and estuarine life systems of McCormacks Bay.
2. The next objective in a system ecology framework would be to establish the quantitative character of a carbon balance and a nutrient balance of the Bay, under a new culvert regime, as a study integrated with the study of a physical water and materials balance.
3. In the same context we would wish to have control and measurement of nutrient enrichment of the waters of the Bay and sedimentation, arising from storm runoff and other terrestrial influences. We would look into this as a possible Integrated Environmental Management Project of local significance.
4. We would seek to assess any especially significant biological features of water-island-shoreline conditions, such as reproductive zones for birds, fish or other organisms significant in the food web. We would observe these sites, monitor them if need be but be loath to tamper or experiment with them , as these would remain the natural history study sites of generations to come.
5. We might want to join in identifying possible physical and chemical pathways in which benthic and other organisms might improve water quality and possible pathways in which plants or animals might promote water deterioration.
6. We would be especially keen to assist and if possible take part in periodic monitoring activities with skilled and trained "service providers", in assisting in properly supervised research into different aspects of ecology or coastal processes, and in implementing agreed management prescriptions for the reduction of algal biomass and the rehabilitation of the benthic ecosystem as an integral part of estuarine well being .
7. We would recognise that these are only suggestions and probably not as good as the ones that we could generate ourselves by sharing in a Landcare Group or working in a planned and properly managed environmental education experience

7.7 References

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8.0 Conclusions

8.1 Review of achievement of goal, aims and objectives

8.1.1 What were our goal, aims, objectives?

Here was our goal to be reached, embracing the three aims of our charter, filled out with a series of objectives whose attainment we could verify.

GOAL: To test the effectiveness of a Community-Council partnership in a consultation process evolved between Christchurch City Council staff and representatives of interested parties and citizens in the adjacent neighbourhoods, to make environmentally informed recommendations to Council for the integration of replacing the Causeway culverts with the protection, restoration and enhancement of the estuarine and scenic characteristics of McCormacks Bay as part of the Avon-Heathcote Estuary and as a significant amenity and recreation resource area in a wider suburban context.

First Aim: To take a comprehensive planning view of McCormacks Bay, and within that view to develop, research and evaluate a series of scenarios for the replacement of the Causeway culverts that identify and integrate the potential benefits for natural and recreational values.

Second Aim: To provide a forum for a partnership process between the Community and the Council, and a model for future projects, as envisaged by the Local Government Act.

Third Aim: To ensure the Council decision-making process for the culvert replacement project is informed by the Community and that there is a two-way exchange of information.

Objectives :

1. Clarify current and immediate traffic needs that can be met within existing Causeway dimensions.

2. Identify essential culvert replacement features needed to meet traffic requirements.

3. Assess the impact of various culvert designs on the hydrologic and hydraulic features of tidal flows, including extent of coverage and extent of drainage for all parts of the Bay.

4. Identify and describe the physical and biological features of the McCormacks Bay environment viewed as an ecosystem, including its plants and animals of all kinds, its terrestrial and aqueous substrate and especially noting:

   a) urban hydrology, sedimentation and siltation (dynamics, source etc)
   b) bathymetry, including man-made changes to bed contours
   c) bed profile at representative locations
   d) hydraulics, tidal currents of inflow and outflow, water depths
   e) water levels and duration of tidal coverage and exposure
   f) salinity, water quality (incl. temperature, turbidity, nutrients, contaminants)
   g) benthic flora and fauna, especially in relation to substrate and water depth
   h) flora and fauna of tidal and standing water and of islands and shorelines
   i) trophic and systems ecology of normal and modified estuarine ecosystem

5. Assess the impact of various culvert design features on the physical and biological environment and on the McCormacks Bay ecosystem.

6. Identify present and future recreation, sport, and related community practices and opportunities, especially those relevant to the culvert.

7. Assess the impact of various culvert design features on recreation, sport, and related community opportunities, especially those related to water and water bodies.

8. Involve and inform the Community in decision-making by discussing proposed plans for culvert replacement in a series of design scenarios that integrate their potential effects on the Bay, with a view to incorporating Community views in report to Council.

9. Identify principles and ways and means for enhancement of the whole ecological system, including building of knowledge and experience by community involvement in monitoring and research.

10. Identify ways and means for effective community consultation in future and for meeting community aspirations.

It is for readers of this report rather than its authors to assess how well we have attained these objectives, how well we have fulfilled our aims, whether we have reached our immediate goal. We are not wishing to be judges in our own cause, but we might point to some of the areas where we believe we have been successful and some of those where we have deficiencies. First let us examine the individual objectives.

8.1.2 Did we attain our objectives?

Traffic Concerning objectives 1 and 2, we spent a lot of time early in our history but we haven't really much to contribute. We know current use by motor-vehicles but have only impressions of cycle use. We know nothing as a Group of projected future use for motor-vehicles or for cycles. Some of us suspect that cycle use may increase even more than motor vehicles, both for recreational use and for travelling to place of work. We note that the limited width of the carriageway and cycle lane can make cycling hazardous, especially in strong winds. We are agreed that wider cycle lanes are needed on both sides of the causeway. We believe that footpaths are also desirable on both sides of the causeway, not simply on one side. We have made clear in our report that the use of the central culvert area for kayak training results in hazard to pedestrians especially if they are carrying a kayak. We have identified this as an area for close attention in reserve planning as well as traffic planning.

It has been made clear to us late in our session history that bus-laning is not at present under consideration for the Causeway proper. The fate of the northern or Estuary side of the causeway, at present unsealed (and unbridged at three culverts) has not been thoroughly examined, but we have generally presumed that it would be part of cycleway and footpath development. Many of us have been involved in submissions against proposals for pohutukawa planters on this space. Most of us object to its becoming a site for display of vehicles for sale. Some of us would also object to the use of bridge railings as advertising hoardings, even for welcome home parties and local events.

Christchurch shares in a widespread problem of what to do with vacant space. The writer fancifully imagines that this space might be kept vacant for the coming of "Light Rail to Sumner". This form of transport was envisaged for this route before the steam tram, and this first part of the causeway was built so that we could have electrified trams. Perhaps history is coming true!

Culvert hydraulics We suggest we have done an adequate assessment of likely culvert performance, the subject matter of objective 3, thanks to the sustained inputs of CCC staff, especially John Walter. If we were to have examined this issue more thoroughly we would have needed more thorough tidal hydrology than what we had. Our greater problems arose in forecasting the changes in tidal drainage in the Bay and these problems derive from the deformed conditions of the floor of the Bay. Our solution is to suck it and see; choose the best prospect and monitor its effects.

The Bay Ecosystem With respect to objectives 4 and 5, we believe we have made a rather comprehensive and intelligent description of what we have in McCormacks Bay as an outcome of the way we have treated a natural system over the last 100 years. We haven't established much clear information on the bed profile and we are lacking in quantitative assessment for most of the ecosystem processes involved. We believe we now know the system well enough to forecast the directions that we expect it to take in response to the changes in water inflow, circulation and drainage that we expect from the work for installation of a replacement culvert. We would like to improve the basic benchmarks for monitoring the improvement that we expect and we have spelled out quite carefully how this benchmark network should be established.

Recreational Use We have treated objectives 6 and 7 in the primary guise of resource-based recreation rather than user-oriented recreation, and we have concentrated on the wetlands as resource rather than the reclaimed lands, although we have kept the latter in our perspective. We have given very careful attention to the use of culvert flows for kayak-training, in part because it is "culvert-specific" and design features of the culvert could greatly affect value for kayak-training, and in part because this specific resource of a tide-predictable kind is rare, valuable, and reliable. We are satisfied that we have the best outcome possible from our resource evaluation and we have noted that the culvert design most satisfactory for kayak-training is also the most valuable for generating improvement in tidal hydrology within the Bay.

We have proposed that the rehabilitation of McCormacks Bay wetlands as a feeding-ground for estuarine waders and the management and maintenance of roosting areas for such species can lead to the development of bird watching as a significant recreation in this district. We have also noted the public enjoyment of the developing parkland on all sides of the Bay, generally on reclaimed land. This joy can be enhanced, we expect, from the improvement in adjacent wetland conditions through reduction in macro-algal abundance and odour.

Community Involvement Apart from our planning for recreational enjoyment, most of our involvement of community in objectives 8, 9, and 10 has been hitherto informal. We have kept neighbouring and other related communities very much in mind when we developed our preferred scenario and outlined our environmental monitoring elements in that scenario. Likewise we have had different kinds of educational communities very much in mind when we have discussed the educational opportunities that we can expect to have from remediation processes at work in the Bay. Our major formal involvement with the community is still ahead in the expected interactions with the Community Board and with different recreational residential and interest communities to whom our report is also addressed. We may be disbanded as a "steering group" but the voyage is just begun.

8.1.3 How well did we fulfil the Aims of our Charter?

Our first Aim In the Steering Group, we are very much in agreement that we have fulfilled the first aim of our Charter. We have devised and tested a series of scenarios that we have developed in a comprehensive planning view of McCormacks Bay. We have based every scenario on some replacement or other for the central culvert. Once we had that design of the culvert issue settled (and kayak-training was a good catalyst in that process), the identification of key issues in the future of the Bay ecosystem became critical to the design and evaluation of further steps in the scenarios that we were considering. Especially important was our recognition from study of all the works that had preceded and accompanied us that the failure to drain out the Bay with every tide was the source of the oxygen depletion that had so altered its life systems and given rise to periodic bad odours.

For those closely involved in this scenario development process, the comprehensive planning view that we began with became more and more significant. It seemed remarkable to us how the function of the Causeway had been the connection of places **outside** the Bay and how the function of the culvert was to prescind from that connection and restore and maintain connection of the Bay with the Estuary. The comprehensive planning view that we had taken on the one hand reminded us of the Sumner-Christchurch connections and on the other hand had us more and more oriented to the Catchment of the Bay and its residential communities.

There was a kind of inevitability about the progressive steps that we found ourselves taking in the scenario development. There were not many options to be evaluated at the finish. The uncertainties that we had about the response of the floor of the Bay to a new series of drainage gradients towards a lower culvert served to emphasise the importance of monitoring and the need to make a prior commitment to monitor. Again we found our way guided by key issues. Our preferred scenario is the only one that we found we could work our way through to an effective outcome. We are confident that we fulfilled the first aim of our Charter.

The Second Aim Did we establish a forum, a marketplace for workable ideas? Were such ideas exchanged in a genuine partnership between City Council and Community? On balance we might have reached the threshold of such a partnership. Over the last nine months of our history we have worked well together, Council staff and people from the Estuary Trust, Estuary Association, south-eastern suburbs people of different ages, professions and avocations. Some members of Council staff who were not designated members of the Steering Group gave of their time and talents in different ways.

There are some from Council and some from the Community who were irregular in participation and others who came consistently to meetings and rarely ventured to offer an opinion or item of fact. Such morsels have been found to have great value. If one considers the great hiatus in the midst of our task when it was by no means clear whether we were to press on towards our goal or sink without trace, such uneven participation is understandable. There is no doubt that some topics were difficult for some people to get to grips with, others where such people shone with the glow of authoritative information.

On balance then we did form a partnership of some productive character, but scarcely a model for future projects. There are some lessons which we might point to a little later that could assist further projects of a similar character.

The Third Aim The Community in a broad sense has contributed enormously to this project. This contribution is shown first in the time and thought, written and spoken that has been given by individuals at meetings, between meetings, at different stages in the compilation of this report and in several meetings to discuss its progress. The compiler of this report is aware of the helpful criticisms that keep coming through to him in various positive ways from several parties. He is also gratefully aware of the continuing flow of information from Council staff who are not among those designated as members of the Working Group, but who continue to assist the group both by volunteering information and by responding to further enquiries. In this respect there has been genuine two-way information exchange.

The Community also contributes in the continuing support of its representatives, support which shows in various ways, including an evident interest in the outcome of the project. These all constitute contributions of the Community to the Steering Group. Whether this contribution to the project and its nominated outcome in this report constitutes an information flow from the Community to the Council is not something that can be determined at the present time. The wider Community has not yet had the opportunity to endorse or repudiate the report although different members of the wider Community have been invited to offer comments on different stages of development of this report. The larger Community soon will have that opportunity, both in a popular sense as well as through the good offices in the Community of the Hagley-Ferrymead Community Board. The Council has not yet had its opportunity to demonstrate that it can benefit in its decision-making from a substantial contribution of well-organized information made to it in the form of this report.

8.1.4 Have we reached our Goal?

Our goal was to test the effectiveness of a partnership to achieve our first aim in particular, to make environmentally informed recommendations to Council on making the connection between culvert replacement and the remediation of the Bay for its natural and recreational values. We believe that the quality of our report and the explicit worth of the preferred scenario we have recommended indicate quite clearly that the partnership has passed that test. We claim that we have reached our immediate goal. It would be ultimate proof that indeed we had done so if the history of a later time were to show that our "far out goal" had been achieved as a consequence.

8.2 Lessons for Council and Community

This project has almost certainly been a far more demanding exercise for those involved in it than either the senior Council officers or the officers of the Estuary Trust who initiated it had imagined. It was begun with a great deal of enthusiasm and good will, but without sufficient clear understanding of the resources that needed to be committed for it. The lack of planning for financing of the joint research that was to sustain the project was an example. So too was the lack of foresight of the necessary delays between agreeing to commission research and getting results from it. Almost certainly most participants had little idea at the outset of the scope and depth of enquiry that would be needed for comprehending the issues, let alone the hours that would be necessary for digesting them and compiling the report.

There are many other features which a serious post-project workshop would almost certainly reveal, especially if it were conducted with the same enthusiasm and cooperativeness as the one which began the project. It would be valuable for the Council and the Community if such a workshop were competently planned and conducted to evaluate the project and the Steering Group's work in carrying it out.

There is a greater lesson which Community and Council can learn from the success of this project, despite the difficulties and hurts that were endured in sustaining it. It is the lesson of trust, trust especially in people, people in the Community and people working in Council. When the going grew rough, it was only by a renewal of personal trust in people rather than by adherence to any particular protocol that the rough going was crossed over and the project was brought through to completion. It is in the same spirit of trust in the Community and trust in the Community Board and Council that the Steering Group now commits the future of McCormacks Bay to their acceptance of this report and the implementation of its recommendations.

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