

TWEED SHIRE COUNCIL



**TERRANORA BROADWATER
MANAGEMENT PLAN**



NOVEMBER 1994

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v4

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ACKNOWLEDGMENTS

This Terranora Broadwater Management Plan was prepared by the Tweed River Management Plan Advisory Committee. The Committee reported directly to Tweed Shire Council.

The Plan expands upon the management initiatives of the Lower Tweed River Management Plan, which was prepared by Public Works in 1991, under the state government's Estuary Management Programme.

The preparation of the Terranora Broadwater Management Plan was funded from state government revenue collected from royalties on sand and gravel dredged from the Tweed River. Public Works and Council jointly administered the expenditure of the funds.

1 INTRODUCTION

1.1 PREVIOUS LOWER TWEED RIVER MANAGEMENT STUDIES

In July 1990 the Lower Tweed River Management Studies were initiated by Public Works. These studies set out the intrinsic natural values of the lower Tweed estuary reflected by its variety of habitats and wildlife, scenic qualities and various opportunities for recreation. The studies also identified the demands being placed on the waterway by an expanding population base. It was clear that a comprehensive river management plan was required to protect the valuable attributes of the waterway and to ensure that present and future residents would be able to enjoy them to the full.

The studies culminated in the Lower Tweed Estuary Management Plan (September 1991) which set out an overall concept for environmentally sustainable management of the waterway. The Plan distinguished between the different character of the Main Arm of the Tweed River and the Terranora System.

The Terranora Broadwater was identified as one of the few remaining rich and diverse habitats whose continued existence is crucial to the ecology of the bird and marine life of the Tweed River. Consequently, habitat conservation was seen as the primary management objective of Terranora Broadwater. At a

conceptual level, the plan identified the need to provide recreational opportunities and to manage ongoing commercial activities (eg fishing, river cruises and oyster culture) in a manner consistent with habitat conservation.

The Plan was widely distributed in the community and feedback was sought on the concepts of the Plan. The Plan was heartily endorsed by the community.

1.2 TWEED RIVER MANAGEMENT PLAN ADVISORY COMMITTEE

In 1992, the Tweed River Management Plan Advisory Committee was formed to provide advice to Tweed Shire Council on the detailed implementation of the Lower Tweed Estuary Management Plan. The Committee is multi-disciplinary comprising representatives from various government agencies, commercial river users and interested community groups viz:

- Tweed Shire Council:
 - 3 Elected Councillors;
 - 3 Council officers.
- Public Works;
- Department Conservation and Land Management;
- N.S.W. Fisheries;
- Maritime Services Board;
- National Parks and Wildlife Service;
- Environmental Protection Authority;
- Caldera Environment Centre;
- Tweed River Advisory Committee;
- River Dredging Industry;

In the development of this management plan the Committee invited the following special interest groups to participate:

- River Charter Boat Industry;
- Terranora Lakes and Bilambil Heights Progress Association;
- Terranora Oyster Farmers;

Mr. D. Beck M.P., Member for Murwillumbah, regularly attends meetings at the invitation of the Committee.

Since its formation, the Committee has assisted Council to implement a number of foreshore improvements and recreation facilities in the Lower Tweed River and Terranora Creek.

In respect of Terranora Broadwater, the Lower Tweed Estuary Management Plan (1991) did not identify a specific plan of action. Hence, the Committee's starting point was the preparation of detailed Terranora Broadwater Management Plan.

1.3 OBJECTIVE

The objective of the Terranora Broadwater Management Plan is to provide an integrated programme of works and measures which will:

- protect and extend significant habitats;
 - protect heritage areas;
 - increase foreshore facilities for walking, fishing and picnicking;
 - provide opportunities for wetland enjoyment eg. boardwalks, bird watching sites as well as the development of environmental awareness/education facilities;
 - improve navigation channels for general navigation including charter boats and the local Oyster Industry.
 - encourage low key boating;
-

2 MANAGEMENT FRAMEWORK

2.1 SOURCE STUDIES

As part of the Lower Tweed Management Plan, a number of technical studies were carried out in respect of:

- Hydrodynamics;
- Influent Audit;
- Ecology;
- Archaeology;
- Visual Quality;
- Recreation.

A summary of relevant portions of the source studies are included in the latter part of this document.

Additional technical studies were carried out to facilitate the development of the Plan:

- Study of Mixing and Flushing of Terranora Broadwater due to Winds and Tides;
- Environmental Enhancements;
- Trutes Bay Flushing Study;
- Terranora Broadwater - Tidal Delta Sedimentation.

These studies are presented, in full, in the volume of "Technical Support Studies" which accompanies this document. Salient details are provided herein following the source study summaries.

2.2 MANAGEMENT CONSTRAINTS AND OPPORTUNITIES

The source studies identified a range of management constraints and opportunities:








- Trutes Bay is the most important site for foraging, roosting and breeding of estuarine birds in the Lower Tweed, in terms of species diversity and average numbers;
- The mouth of the Broadwater and Big and Womgin Islands, and their sand flat habitats, are important feeding and roosting areas for estuarine birds, some of which are rare and vulnerable. More than 10% of all shorebirds of the Tweed Estuary roost on these islands;
- Surrounding lowland at Trutes Bay and Bilambil Creek are the only freshwater swamps in the Lower Tweed;
- Mangroves on Womgin and Big Islands and along the southern shore of the Broadwater provide important habitat for a wide variety of aquatic fauna, particularly fish, crustaceans and birds;
- Continued inaccessibility and seclusion of the southern areas of the Broadwater are essential for the long term integrity of bird habitat areas.
- The central basin is shallow and suitable only for small boats or "tinnies"; this has the benefit of maintaining a buffer to the southern habitat areas;

- Catchment runoff contributes to the silting of the mud basin, south of the delta islands. The rate of sediment build-up, however, is offset to a degree by long term consolidation of the total thickness of the mud deposit;
 - Future development of South Tweed Heads has the potential to create acid runoff and nutrient problems in Trutes Bay;
 - The eastern foreshore of Terranora Broadwater has a number of highly significant archaeological sites. Measures are required to protect these sites;
 - Whilst shallowing of the lake margins over recent years, has increased the area of intertidal sand flats, it has created valuable habitat for marine birds.
 - There is a strong public need for integrated foreshore and waterway recreation facilities in the vicinity of developed foreshores in the northern and western portions of the Broadwater;
 - Dredging of the main navigation channel (*through the centre of the entrance delta, the perimeter of Birds Bay and across Bingham Bay*) is required to provide general boating access and re-establish scenic charter boat tours.
 - Sediment control within the catchment is required to minimise sediment runoff.
 - Mosquitoes and biting midge infest many of the intertidal foreshores and fringing wetlands of the Broadwater. Activities should be promoted which prevent proliferation of this pestilence;
 - Foreshore facilities should be located on public land as much as possible;
 - Because of development pressure in South Tweed Heads, recreation facilities and planned access to the Broadwater are required along the eastern foreshores;
 - In key habitat areas, priority must be given to habitat conservation. However, there is opportunity for combined habitat conservation and ecological appreciation/education;
 - Wind mixing and tidal flushing of the Broadwater is optimal because winds set up large scale water circulations which penetrate all side bays. Hence any works must not alter water circulation patterns;
 - Water quality in the Broadwater is quite good apart from turbidity which is endemic due to the shallow muddy substrate;
 - Sediment transport rates within the tidal delta are relatively high and dredged channels will infill over periods which would vary from 5-10 years in the main channel to over 30 years on the periphery of Birds Bay.
-

TERRANORA BROADWATER MANAGEMENT FRAMEWORK

Scale 1:15 000



- 
 CONSERVATION
Bird Roosting & Foraging Habitat
- 
 Area To Remain As Is
For Shallow Draught Boating
- 
 Indicative NAVIGATION CHANNEL
 and Potential DREDGING Area
- 
 OYSTER LEASES
- 
 Integrated FORESHORE RECREATION
 and BOATING
- 
 Foreshore and Nearshore (non power boats)
 EDUCATIONAL RECREATION Opportunity
- 
 Possible Islands and Channels to Enhance
 Wind Mixing and Water Quality

The residual patch of rainforest on the slopes of the north western shores of Birds Bay is one of the few remaining areas of suitable habitat in the Tweed Valley for the Richmond Bird Wing Butterfly. In conjunction with the national parks and Wildlife Service, it would be possible to introduce a programme to re-introduce the butterfly to the area.

- The narrow tract of bush on the eastern shore is thought to harbour a koala colony. Facilities in this area should be compatible with koala conservation.

2.3 MANAGEMENT FRAMEWORK

The Committee considered all the management constraints and opportunities. Potential conflicts were resolved and priorities assigned to establish a Management Framework as shown opposite.

The Committee received assistance in the assessment process by means of early feedback from the Terranora Lakes and Bilambil Heights Progress Association and representatives of the local Oyster Industry.

The Management Framework embodies the following broad management objectives:

- The southern and western portions of the Broadwater, and the tidal delta islands are to be dedicated to conservation of wildlife habitat.
- The central basin is to be left untouched so as to maintain a buffer to habitat areas.
- The north western portion including Dog Bay is to be developed for boating and foreshore recreation. The facilities are to be integrated, incorporating foreshore facilities and destination points which provide a variety of experiences. Dog Bay area is to be made accessible for small boats only (*ie "tinnies"*).
- A continuous foreshore recreation facility is required to link Charles Bay to existing foreshore facilities along Kennedy Drive via the foreshore reserve along Sunset Boulevard.

-
- There is to be a wildlife appreciation and education theme. Oyster culture would be included.
 - Integrated foreshore and water recreation facilities and archaeological appreciation opportunities are to be provided on the eastern foreshore and northern edge of Trutes Bay. However, the facilities are to be low key, recognising the proximity of sensitive habitat areas and the need to protect archaeological sites.
 - Sand dredged from the north western area is to be used to create artificial islands in Trutes Bay and Charles Bay to enhance wildlife habitat.
-

3 TERRANORA BROADWATER MANAGEMENT PLAN

3.1 OVERALL LAYOUT AND DESCRIPTION

The Terranora Broadwater Management Plan is set out in detail on the plan opposite.

The Plan incorporates a number of specific features which are described briefly. Detailed concept designs of all the main features are provided in the following pages.

In broad outline, the plan achieves the following:

❑ CONSERVATION AREAS

It is proposed that the wetlands surrounding Trutes Bay, the mouth of Bilambil and Duroby Creeks, Charles Bay, the various islands of the entrance delta and proposed artificial islands are to be recognised in Council's planning instruments as conservation areas.

It is proposed that the area of residual rainforest on public land on the edge of Birds Bay is to be similarly set aside for conservation and a programme of rehabilitation designed to re-establish the Richmond Bird Wing Butterfly.

It is proposed that the central basin be left as is, to retain seclusion of bird habitats.

❑ INTEGRATED BOATING AND FORESHORE RECREATION ON NORTH - WESTERN FORESHORES

A walking and cycling track, suitable for disabled access, is proposed to run the length of the foreshore. It will provide a variety of experiences by linking a bird watching facility and forest walk in Charles Bay with a recreational beach, tombolo feature and picnic facilities in Dog Bay with a public wharf and picnic facilities at Peninsula Drive point and a variety of opportunities around Bingham Bay and Bird Bay comprising a mangrove boardwalk, picnic areas, informal playing areas and rainforest and waterway viewing opportunities. The walkway experience would be enriched with a co-ordinated interpretative signage program.

It is proposed that the walkway continue across the mouth of seagulls canal estate with a special interest hand operated ferry crossing.

The western and northern foreshore track would be integrated with boating by way of a public wharf at Peninsula Drive point, and sandy beaches for the landing of small craft at Dog Bay and at the western end of Birds Bay. Channel dredging would extend from Dog Bay (*shallow draft only*) to the main delta channel and a navigation loop around Birds Bay, to link with the existing wharf at Seagulls and the main channel. This would provide the opportunity for the boating public and charter boats to take people to a destination picnic area or drop them off at a particular landing point and arrange to pick them at another. This

could be done with and without bicycles.

The variety of waterway and foreshore walking/cycling experience, within an overall theme of environmental (*natural and cultural*) awareness and education, should generate much interest among the local community as well as visitors to the area. It will have significant tourism potential.

❑ COMBINED FORESHORE RECREATION AND LOW KEY BOATING ON EASTERN FORESHORE

It is proposed that the majority of the eastern foreshore be devoted to low key recreation; blending habitat conservation and educational experience. The hiking track would provide a "tall timbers" walk and mangrove forest experience which would be different in character to the western and northern walkway.

A non intrusive canoe and row boat route, with interpretative material, is proposed. The route would be centred about a proposed picnic area, with an artificial sand beach and road access, located in the centre of the track.

Additional tree planting would be carried out to screen future residential development along the crest of the ridge.


It is proposed to provide a low key picnic area with pedestrian and canoe access (*ie. no vehicles*) at the point near Tommys Island. This area provides panoramic views of the Broadwater.

Depending upon the outcome of negotiations with the land owner, a walkway and cycling track is proposed along the fringe of the habitat area on the northern side of Trutes Bay. From a detailed urban planning perspective, there would be opportunity to integrate the track with the public open space provisions of the adjacent development. The walkway would link up with a mangrove boardwalk and bird watching hide, positioned to take advantage of one of the proposed artificial islands.

The northern portion of the eastern foreshore would have a walkway and cycling track linking to the existing facilities along Dry Dock Road. A mangrove boardwalk near Daveys Island is proposed.

TERRANORA BROADWATER MANAGEMENT PLAN




Features

- A** BIRD WATCHING HIDE OPPOSITE ARTIFICIAL ROOSTING ISLAND WITH OSPREY NESTING POLE, VARIABLE TERRAIN AND TREE DEBRIS HABITAT, INTERPRETIVE SIGNAGE. LOOP TRACK PROVIDING FOREST EXPERIENCE
- B** HEADLANDS ANCHORING A SAND/SHINGLE TOMBOLO BEACH, PARKING, SMALL BOAT LANDING AND LAUNCHING, PICNIC FACILITIES, TOILET BLOCK
- C** WHARF FOR TOUR BOAT DOCKING, LANDSCAPED PICNIC FACILITIES, TOILET BLOCK, INTERPRETIVE SIGNAGE
- D** INFORMAL PICNIC/REST AREA AMONGST HOOP PINES AND BOARDWALK ACCESS THROUGH MANGROVES TO WATER, INTERPRETIVE SIGNAGE
- E** SAND BEACH FOR LANDING SMALL BOATS, PICNIC FACILITIES, ACCESS TO LARGE OLD FIG TREE AND SECTION OF RAIN FOREST, INTERPRETIVE SIGNAGE
- F** DREDGE 20M WIDE NAVIGATION CHANNEL TO 2M BELOW LOW WATER TO PROVIDE ACCESS FOR TOUR VESSELS AROUND BIRDS BAY AND ACROSS BINGHAM BAY. DREDGE 10M WIDE CHANNEL TO IMBELOW LOW WATER ACROSS AND INTO DOG BAY FOR SMALL CRAFT ACCESS. DREDGE ADDITIONAL SAND FROM EDGE OF DELTA AS REQUIRED FOR FILL. LINK NAVIGATION WITH EXISTING SEAGULL'S WHARF.
- G** INFORMAL PLAYING AREA, SEATING AND SMALL HAND OPERATED FERRY ACROSS CANAL
- H** FOOTBRIDGE OR SMALL HAND OPERATED FERRY ACROSS CANAL TO WILLIAM CAMPBELL PARK
- I** BOARDWALK THROUGH MANGROVES TO VIEWING PLATFORM, INTERPRETIVE SIGNAGE
- J** SMALL FOOTBRIDGE TO CONNECT PATH ACROSS DRAINAGE CHANNEL, VEHICULAR ACCESS AND PARKING, ROW BOAT AND CANOE LAUNCHING, INTERPRETIVE SIGNAGE
- K** END OF WALKING TRAIL WITH ACCESS UP SCARP TO RESIDENTIAL AREA
- L** SECLUDED LOW KEY PICNIC AND BEACH RECREATION FACILITIES, TOILET BLOCK, ROAD ACCESS, PARKING, AND ROW BOAT AND CANOE LAUNCHING, INTERPRETIVE SIGNAGE
- M** LOW KEY PICNIC FACILITIES, ROW BOAT AND CANOE LAUNCHING BEACH, INTERPRETIVE SIGNAGE
- N** BOARDWALK ACCESS THROUGH MANGROVES TO BIRD WATCHING HIDE, INTERPRETIVE SIGNAGE
- O** ARTIFICIAL BIRD ROOSTING ISLANDS FOR INTERNATIONAL MIGRATORY WATER BIRDS
-  FUTURE CONSERVATION AREAS. INCLUDES RAINFOREST CONSERVATION AND COMMUNITY REHABILITATION PROGRAM TO ENHANCE HABITAT FOR RICHMOND BIRDWING BUTTERFLY ALONG NE SIDE OF BIRDS BAY. INTERPRETIVE SIGNAGE.



Interpretive Program

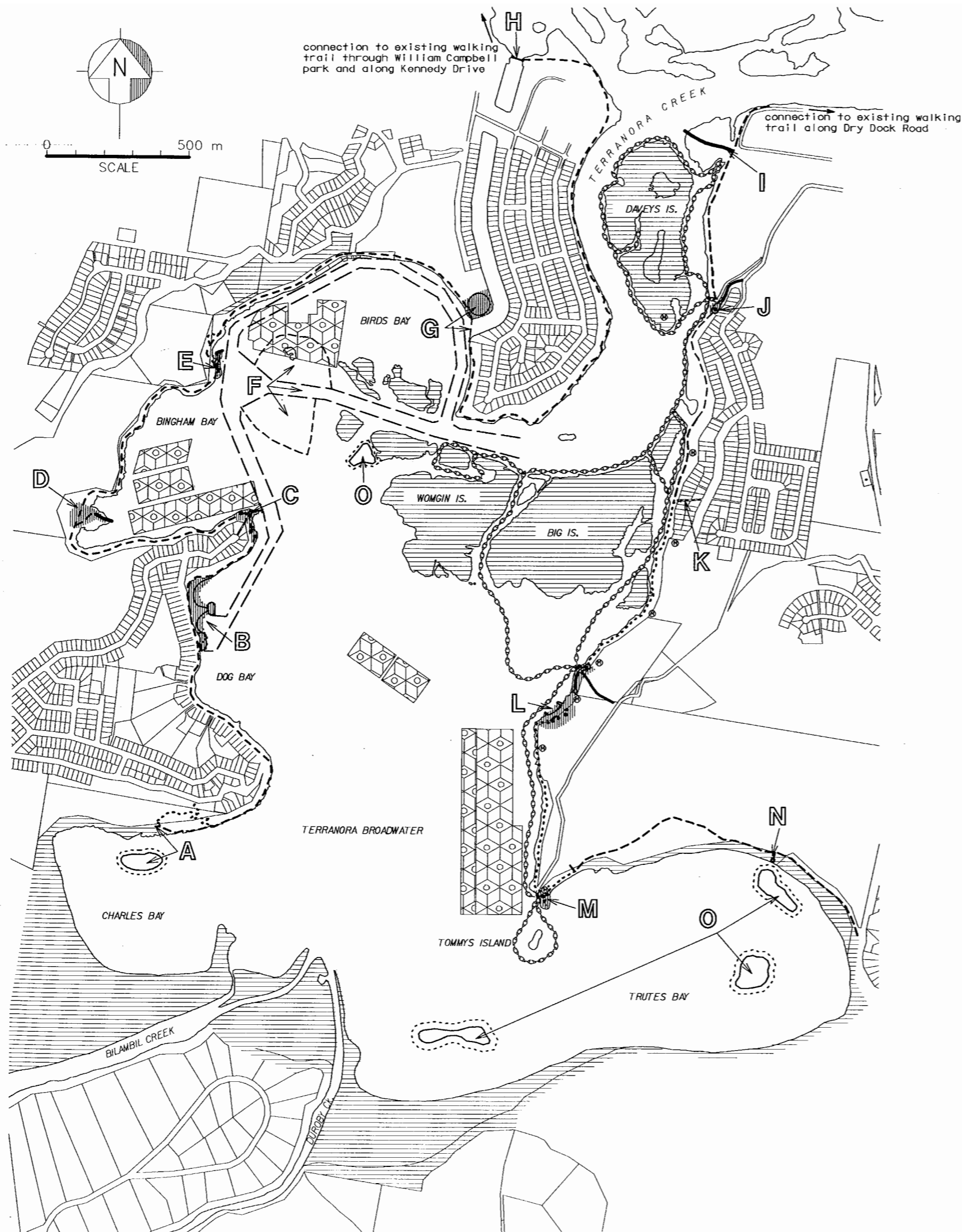
A CO-ORDINATED INTERPRETIVE SIGNAGE PROGRAM WILL LINK THE VARIOUS NODES AND ASPECTS OF THE WALKS TO ENRICH AND EDUCATE USERS. THE PROGRAM WILL COVER ASPECTS ON WILDLIFE, WETLANDS, FLORA AND CONSERVATION, ABORIGINAL HERITAGE, EARLY SETTLERS HISTORY, THE OYSTER INDUSTRY, EARLY BANANA PLANTATIONS, THE STEAM POWERED DREDGES, CREAM BOATS PLYING BILAMBIL CR., ETC.

Walking & Hiking Trails

-  WALKING / CYCLING TRACKS SUITABLE FOR DISABLED ACCESS
-  HIKING TRACKS. ROUGHER BUSH TRACKS NOT SUITABLE FOR DISABLED ACCESS
-  ABORIGINAL MIDDENS INTEGRATED TO HIKING TRACK WITH INTERPRETIVE SIGNAGE

Canoeing & Row Boating

-  CANOE AND ROW BOAT ROUTES. ROUTE PLAN AND EXPERIENCES DESCRIBED ON A BROCHURE.
-  OYSTER LEASES



3.2 OTHER MANAGEMENT ACTIONS

Total Catchment Management (TCM)

Council will expand TCM practices to minimise sediment input to the Broadwater. These practices could include:

- enforcement of sediment runoff preventative measures during all phases of construction and domestic building activities;
- construction and maintenance of silt traps at appropriate locations on main drains;
- construction of wetland filters, where practicable, at the outlets of main drains.

Western Drainage Scheme

A comprehensive drainage strategy will be devised for the low lying areas of Tweed Heads West and West Banora Point so as to avoid potential pollution of Trutes Bay in respect of:

- acid soils;
- sediment runoff;
- nutrient inputs.

South Tweed Heads Development Options

Current development proposals in the South Tweed Heads area will be integrated with the Terranora Broadwater Management Plan. The Trutes Bay walkway and cycling track could link with possible community

open space facilities within the adjacent development areas.

Archaeological Sites

Highly significant archaeological sites exist along the eastern foreshore of the Broadwater. Known sites will be protected and incorporated into the cultural/educational theme of the hiking track by means of interpretive signage. The protection of known sites, and all works in the area, will be carried out in close collaboration with the National Parks and Wildlife Service.

Eastern Foreshore Koalas

There have been unofficial sightings of Koalas in the eucalypt forests of the eastern shore of the Broadwater. The Koala status of this area will be established as part of Council's current shire-wide Koala survey. The final design of facilities in this area will be subject to the specific recommendations of that survey.

Mosquitoes and Biting Midge

The western and northern foreshores are relatively free of midges because of the lack of breeding habitat. The sand islands of the tidal delta are infested with midges. The proposed recreation facilities largely avoid the heavily infested areas. The canoe and row boat course should not pose a significant problem to users during daylight hours.

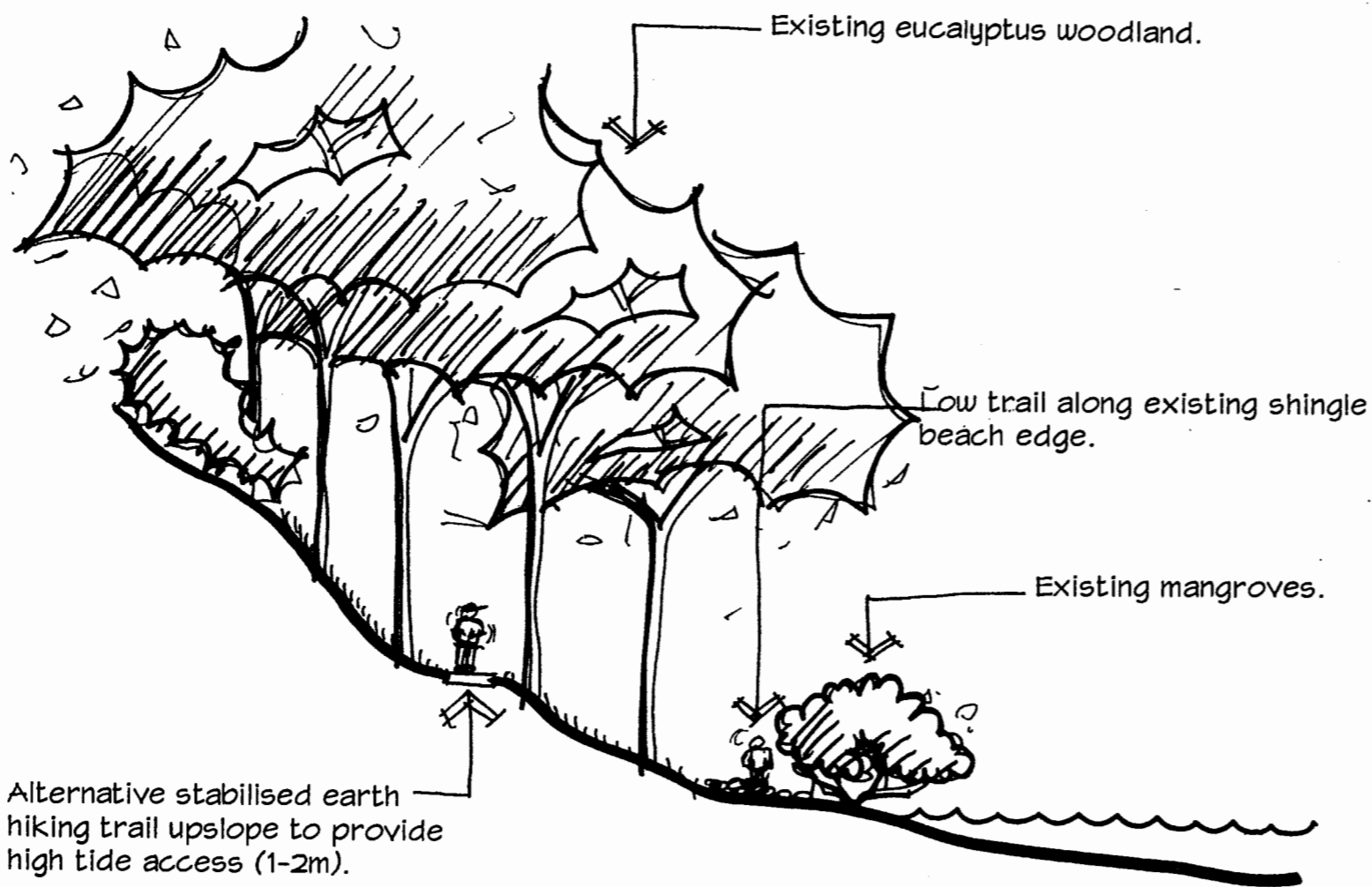
The artificial islands and beaches incorporate shingle layers, in the intertidal zone, to eliminate potential midge breeding.

The walkway and cycle track will incorporate surface drains to prevent the formation of pools which would promote mosquito breeding.

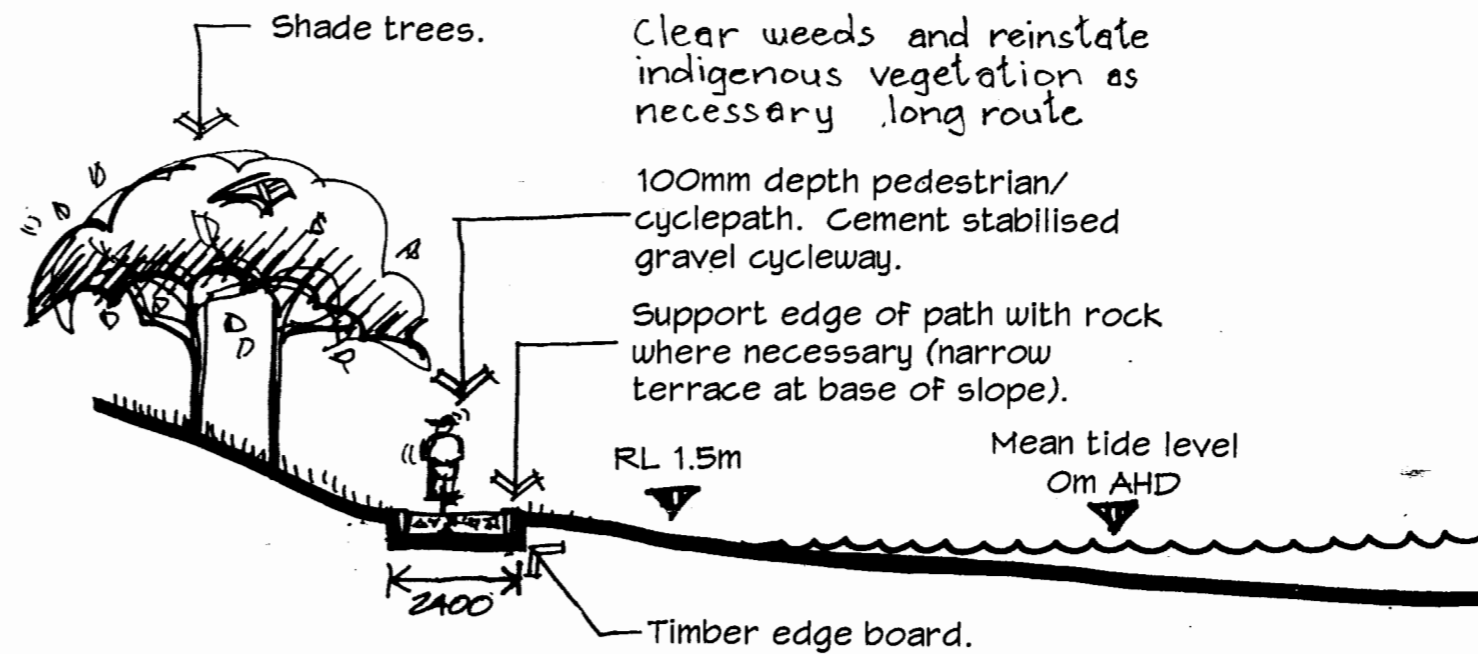
Council will continue to map major midge breeding areas and maintain control programmes in sensitive areas. Future residential development will be separated from midge breeding areas by a suitable buffer.

3.3 DETAIL CONCEPT DESIGNS

Detail Concept designs of the various components of the plan follow. Non site specific components such as walkways and hiking trails are shown in typical sections only.



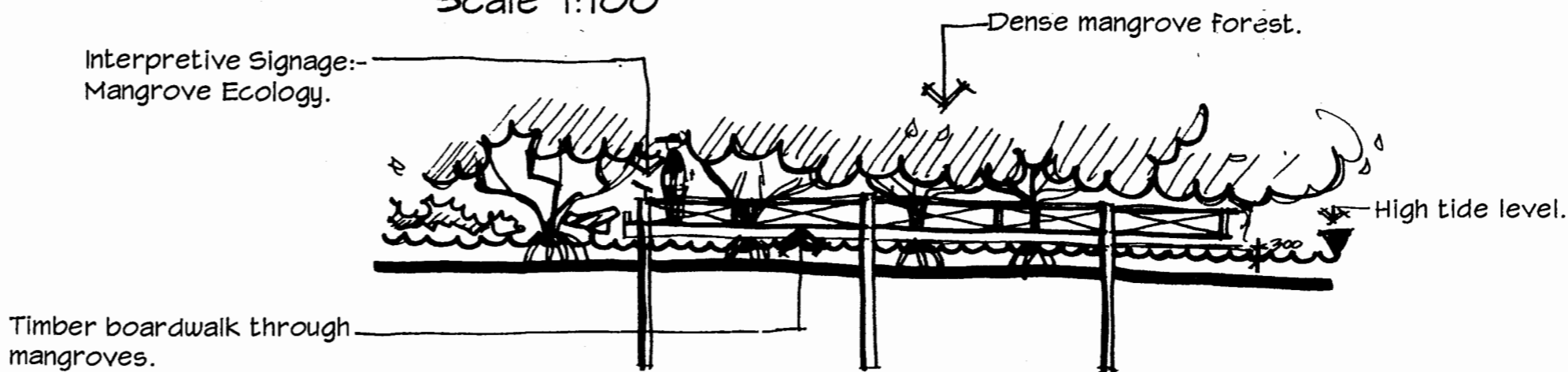
HIKING TRAIL- TYPICAL SECTION
Scale 1:200



DUAL PEDESTRIAN/CYCLEWAY-SECTION
Scale 1:200

Provide maintenance vehicle turnaround bays at approximately 500m intervals.

MANGROVE BOARDWALK- TYPICAL SECTION
Scale 1:100



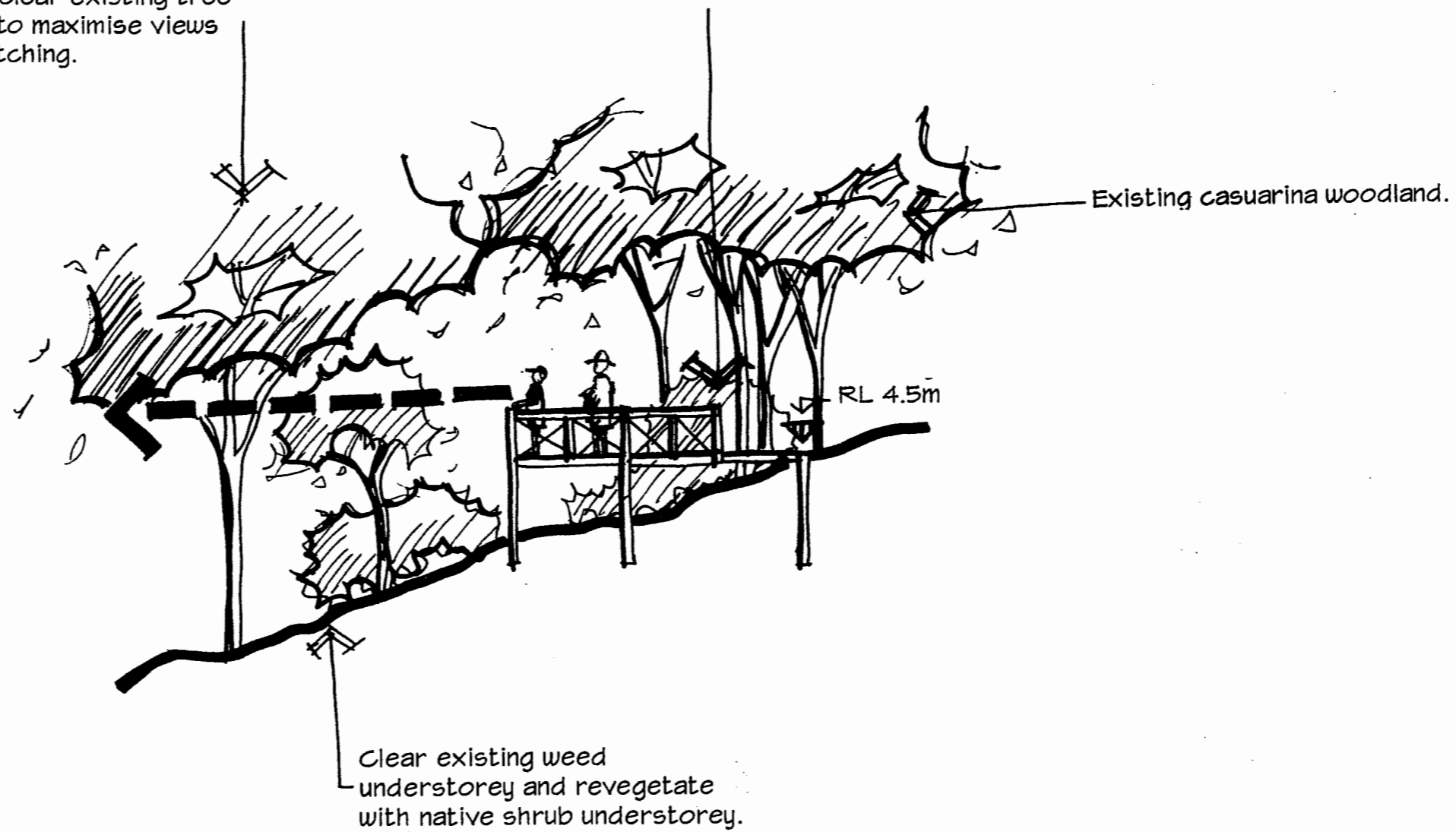
TERRANORA BROADWATER

MANAGEMENT PLAN

SECTION
TYPICAL SECTIONS

Timber bird watching platform.
Interpretive Site:-
Wading Birds.

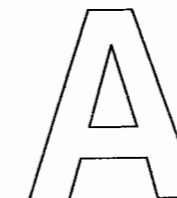
Selectively clear existing tree
vegetation to maximise views
for bird watching.



TIMBER BIRD WATCH- SECTION
Scale 1:100

TERRANORA BROADWATER

MANAGEMENT PLAN



SECTION
CHARLES BAY

Note: land between road and foreshore is public land under Council's jurisdiction.

Upper wooded slopes with native casuarinas and established Camphor Laurels to be retained.

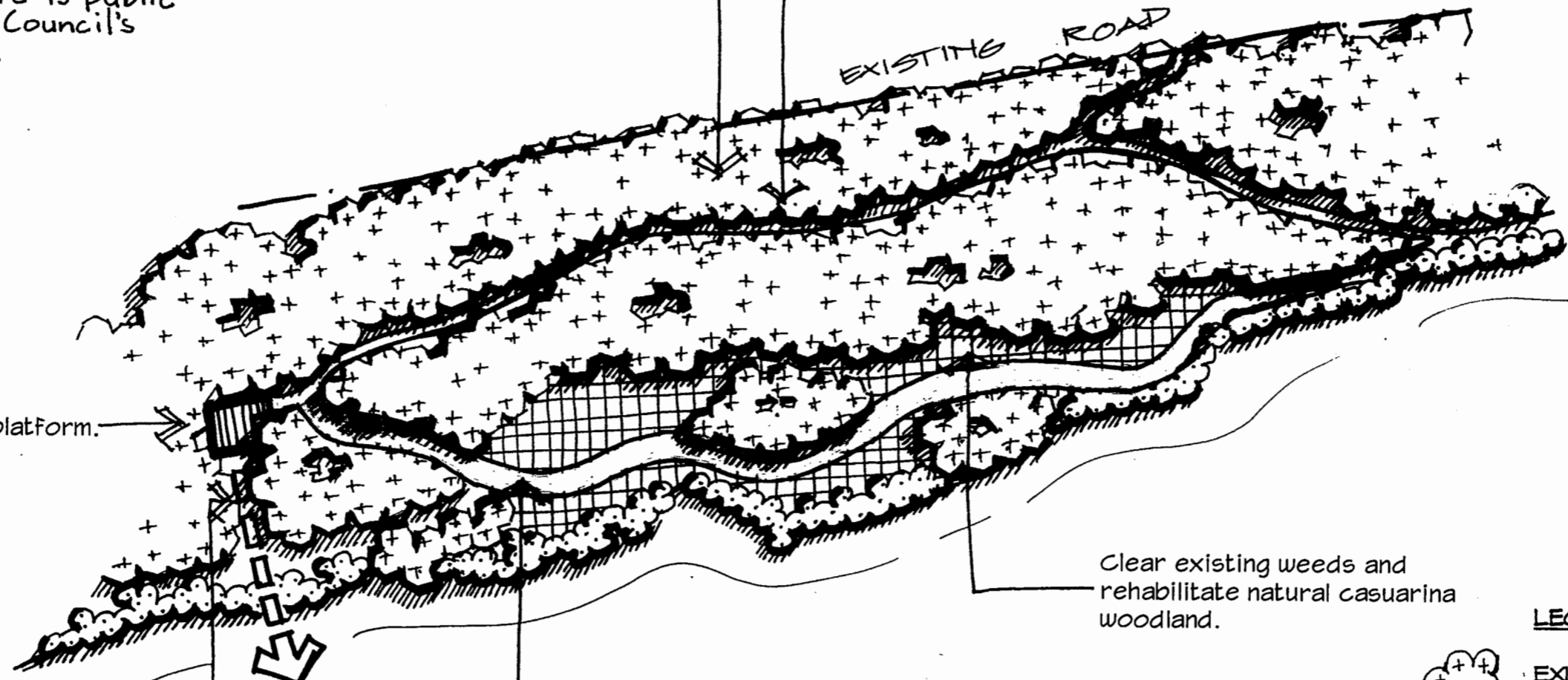
Upper trail 'loop' connects to road above and to trail below.

Bird viewing platform.






Selectively clear existing vegetation to allow view from bird viewing platform.

2.4m width stabilised earth pedestrian track along waters edge amongst mangroves and meandering inland in small valleys.

Clear existing weeds and rehabilitate natural casuarina woodland.



LEGEND

-  EXISTING WOODLAND
-  PROPOSED WOODLAND
-  EXISTING MANGROVES
-  FEATURE TREES
-  CASUARINA WOODLAND

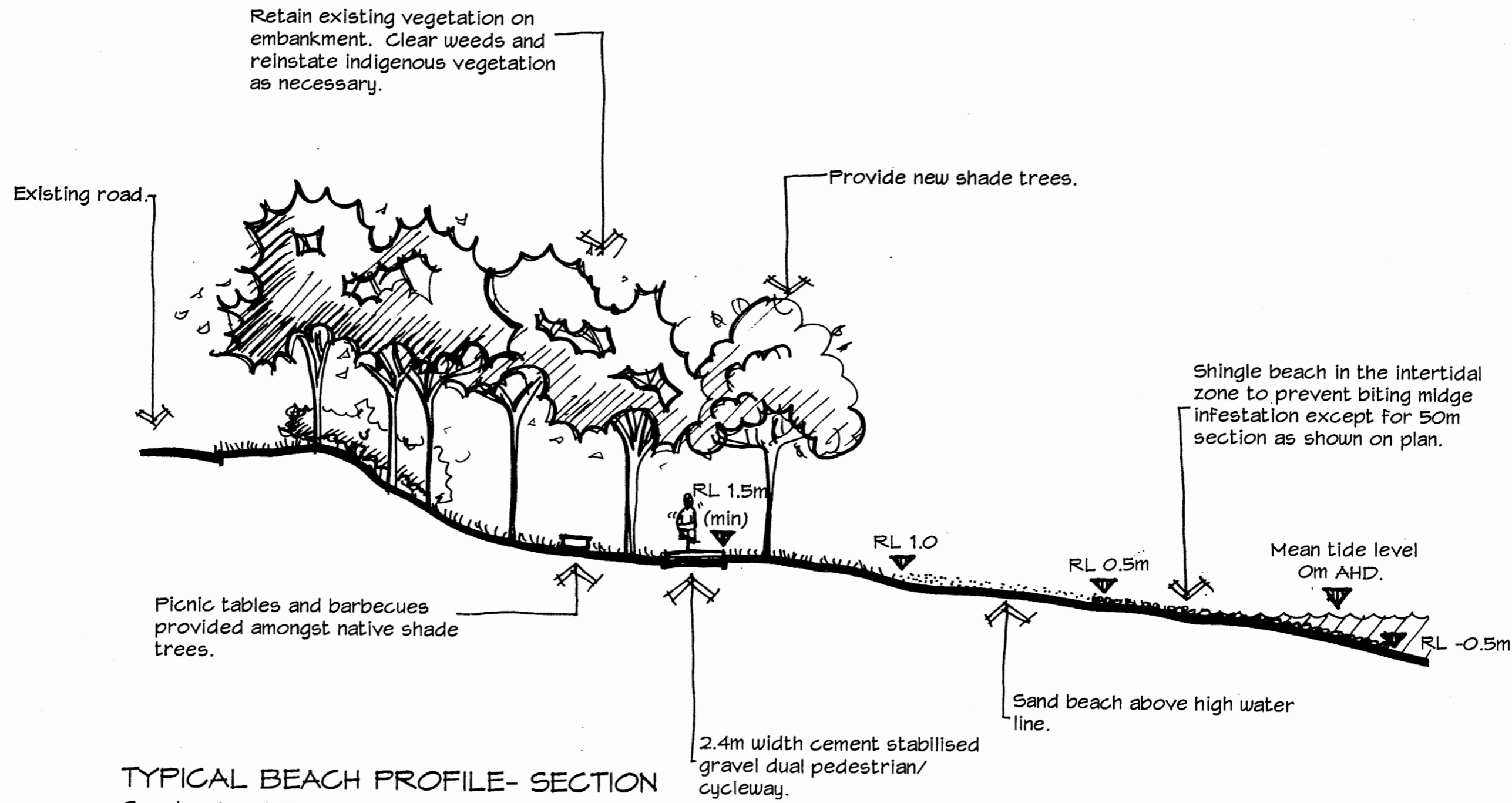


TERRANORA BROADWATER

MANAGEMENT PLAN



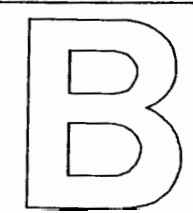
SCHEMATIC SKETCH
CHARLES BAY



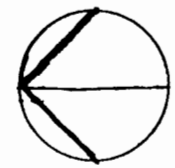
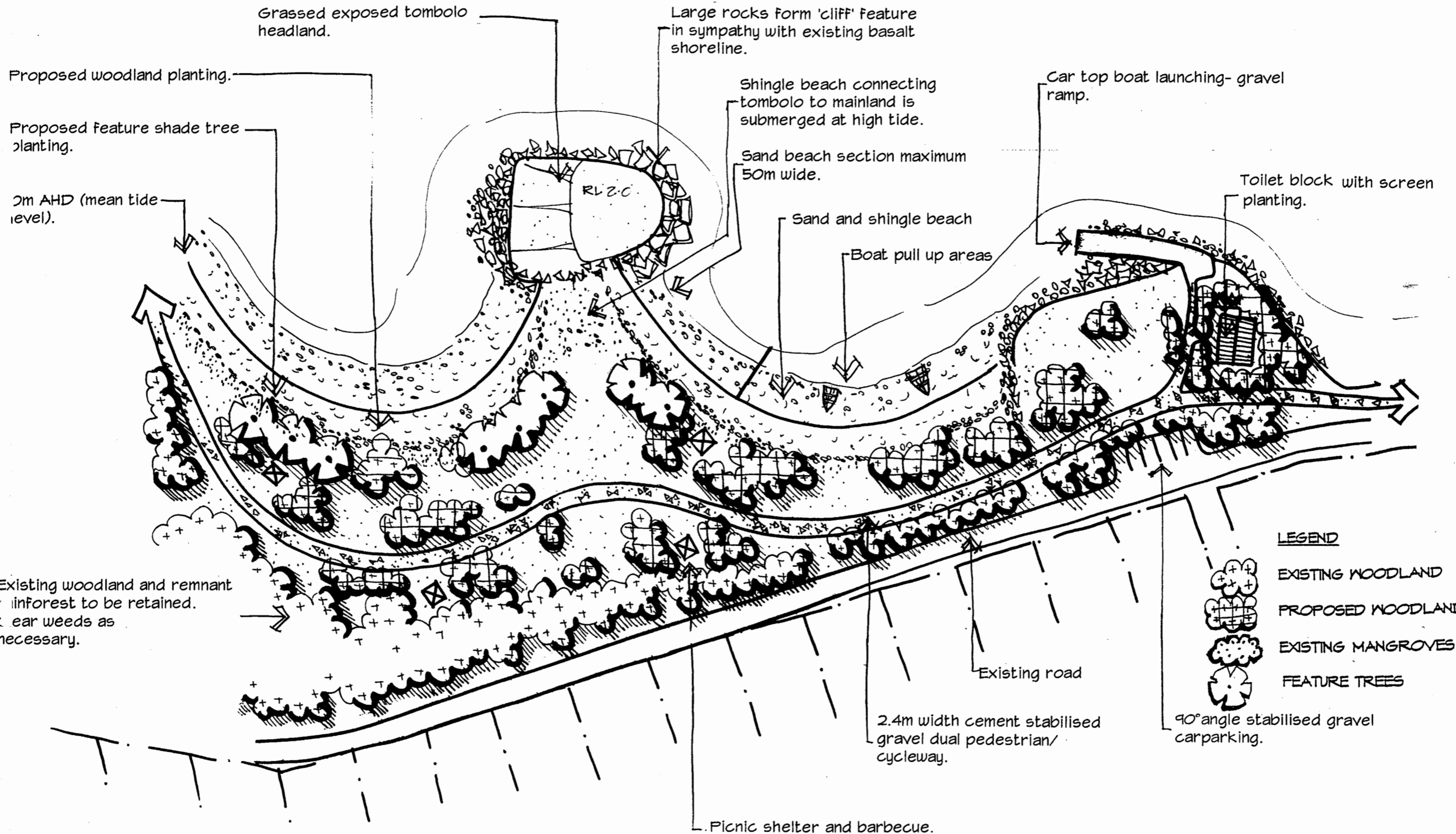
TYPICAL BEACH PROFILE- SECTION
Scale 1:200

TERRANORA BROADWATER

MANAGEMENT PLAN



SECTION
DOG BAY



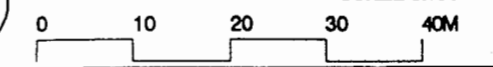
TERRANORA BROADWATER

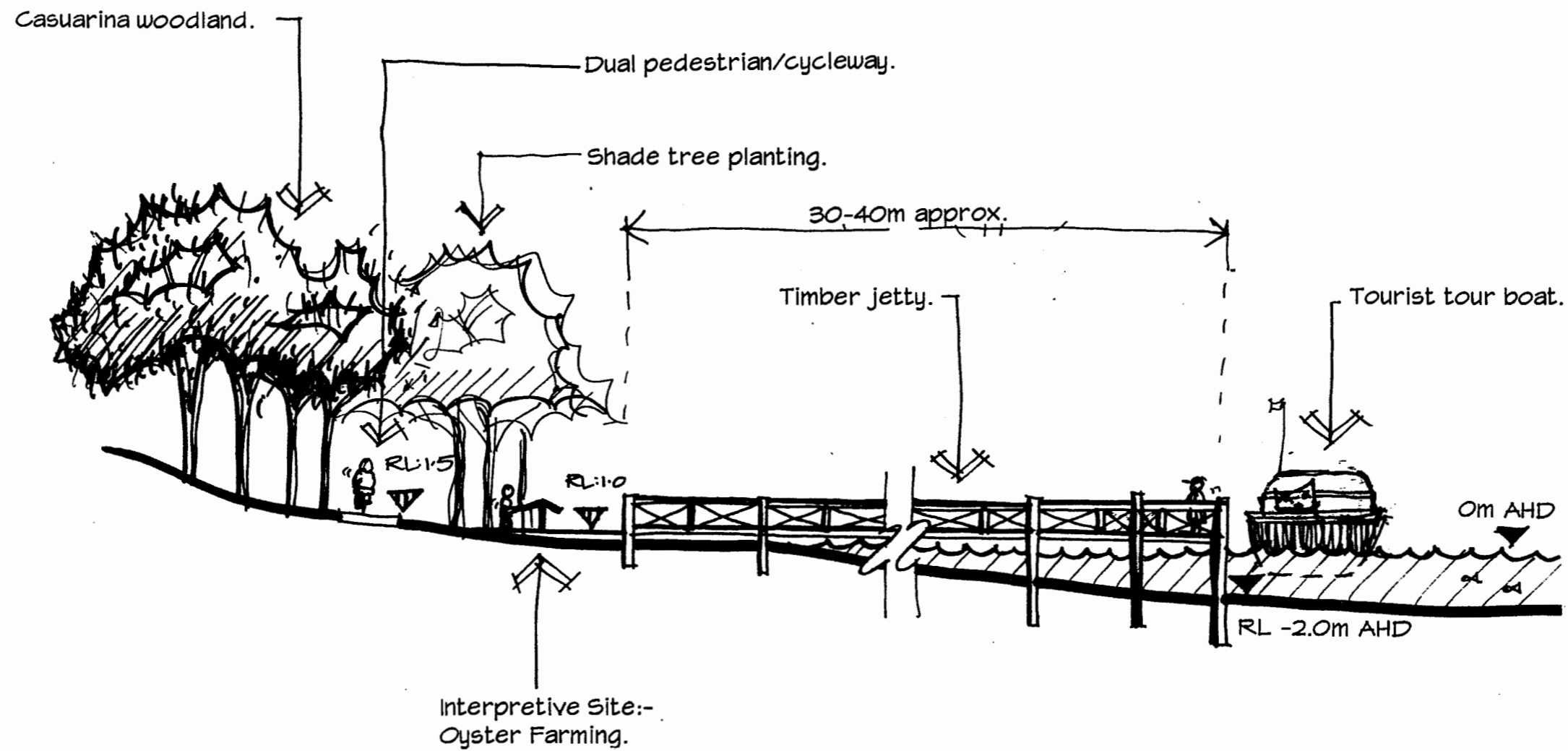
MANAGEMENT PLAN



SCHEMATIC SKETCH DOG BAY

SCALE 1:750

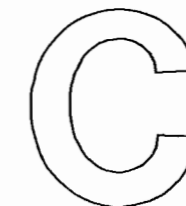




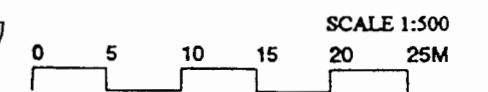
TIMBER JETTY- SECTION
Scale 1:200

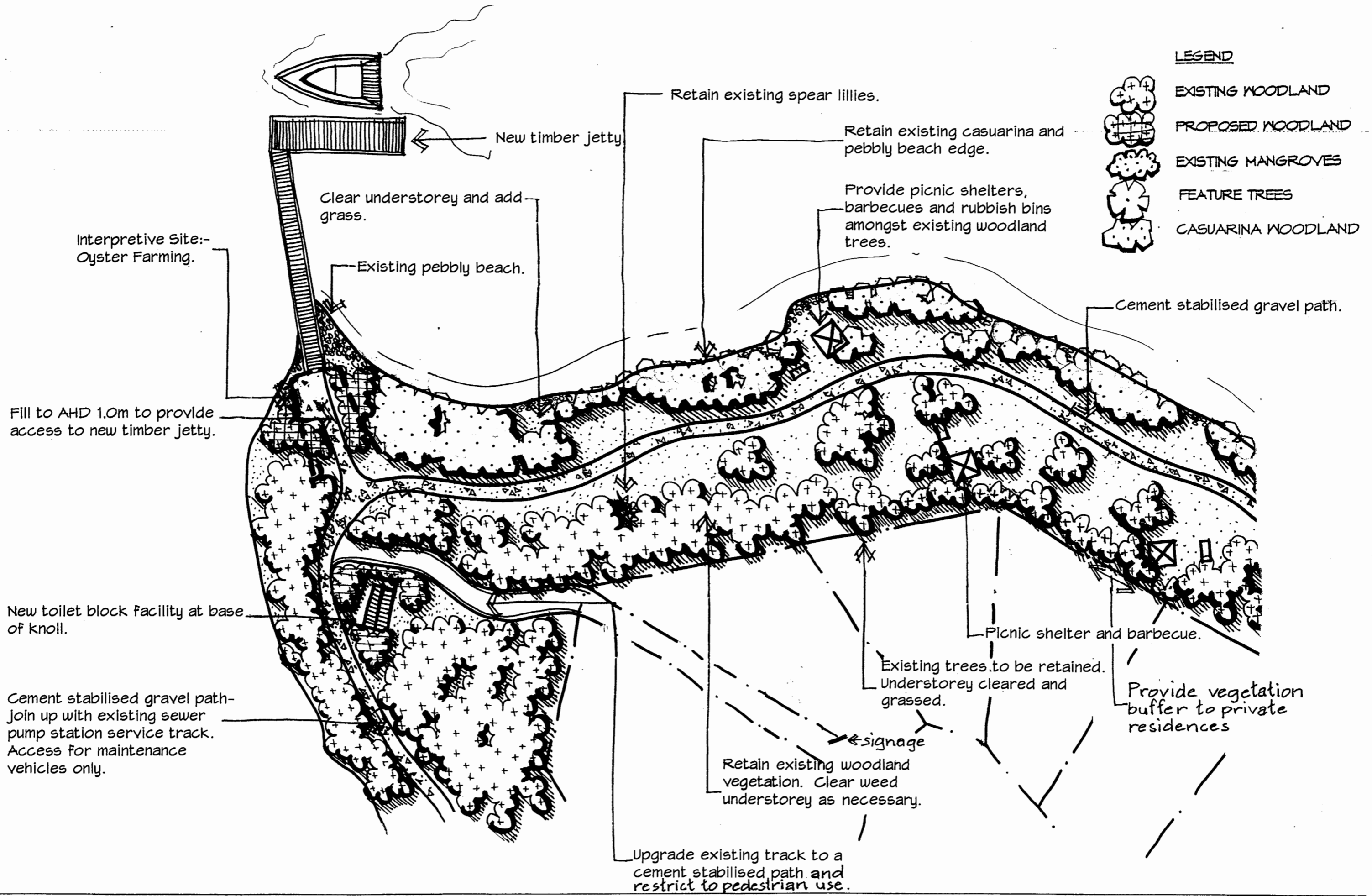
TERRANORA BROADWATER

MANAGEMENT PLAN



SECTION
PENINSULA POINT



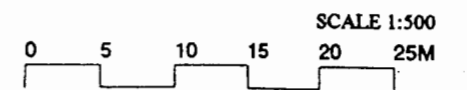


TERRANORA BROADWATER

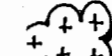



MANAGEMENT PLAN

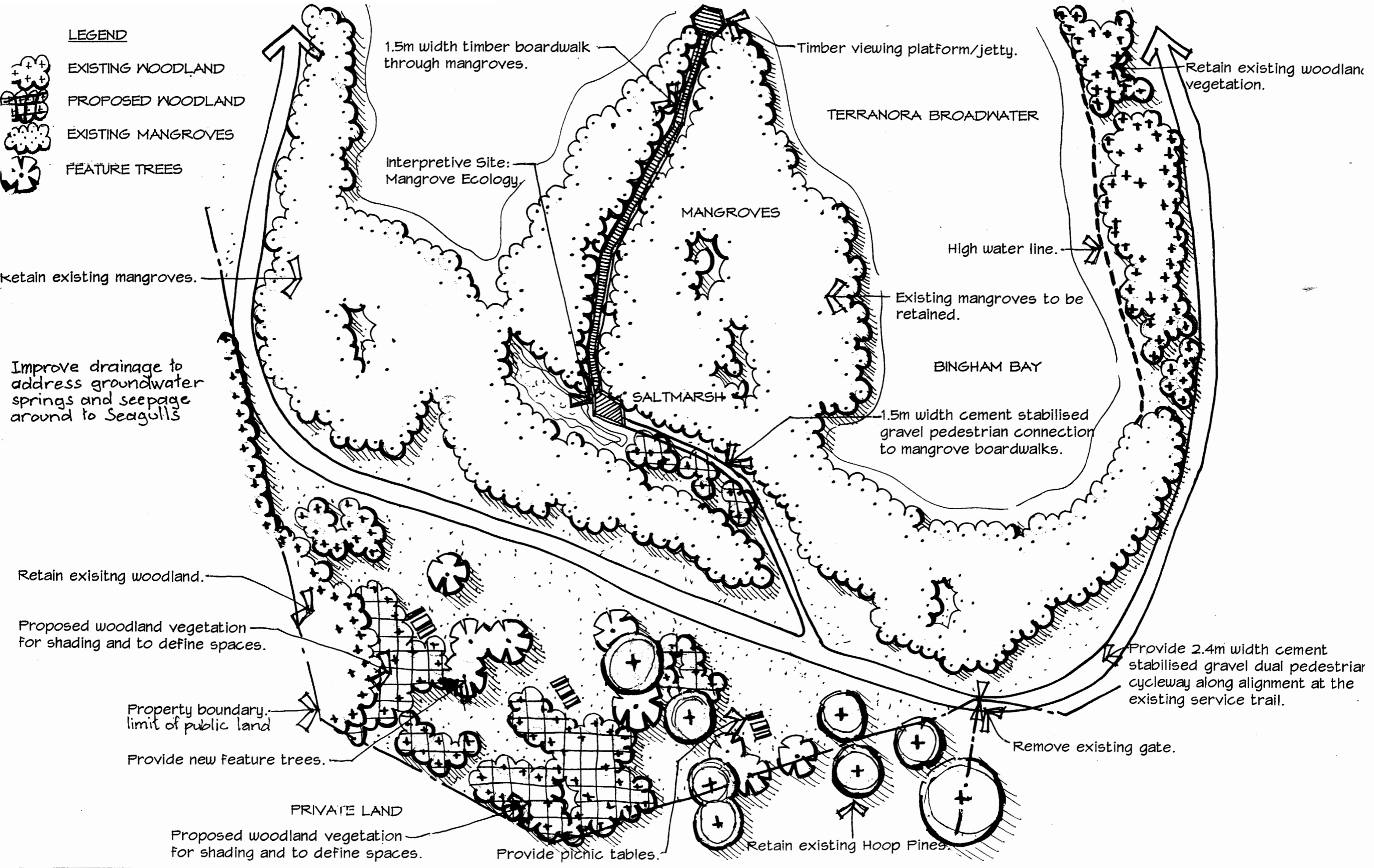


SCHEMATIC SKETCH
PENINSULA POINT



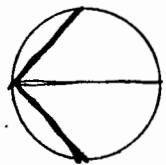
LEGEND

-  EXISTING WOODLAND
-  PROPOSED WOODLAND
-  EXISTING MANGROVES
-  FEATURE TREES



TERRANORA BROADWATER

MANAGEMENT PLAN



SCHEMATIC SKETCH
BINGHAM BAY

SCALE 1:750
0 5 10 20 30M

Connecting pedestrian track with boardwalk if necessary.

Rock crescent to anchor sand beach.

New sand beach.

Feature shade tree planting.

Picnic table facilities and litter bins.

2.4m width cement stabilised gravel dual pedestrian/cycleway.

Tide gauge.

LEGEND

Proposed woodland.

EXISTING WOODLAND

PROPOSED WOODLAND

EXISTING MANGROVES

FEATURE TREES

Existing mangroves to be retained.

Large fig tree.

Interpretive Site:- Fig Tree and Rainforest.

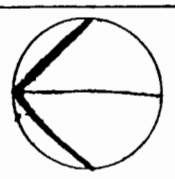
Possible pedestrian and service access to the road above.

Barrier to public vehicle access.

Improve drainage to address groundwater springs and seepage around to Seagulls and site D

Existing woodland to be retained.

Property boundary. limit of public land



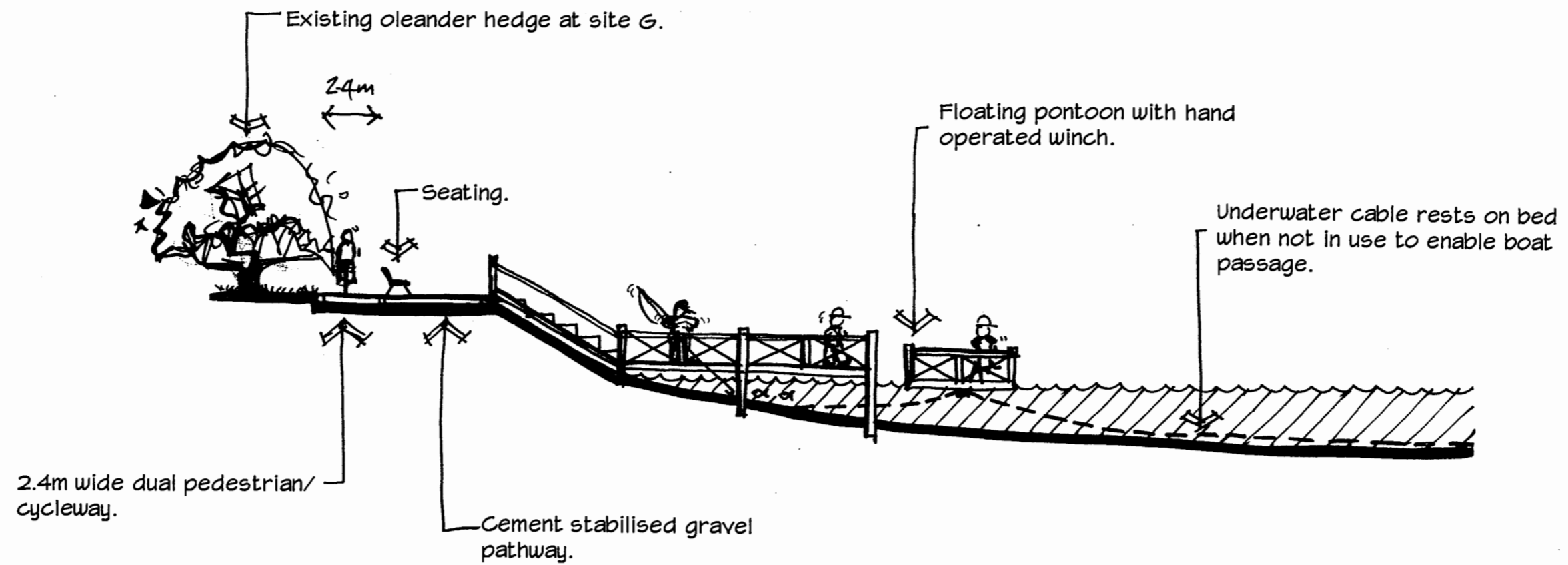
TERRANORA BROADWATER

MANAGEMENT PLAN

SCHEMATIC SKETCH
TIDE GAUGE

SCALE 1:500

0 5 10 15 20 25M



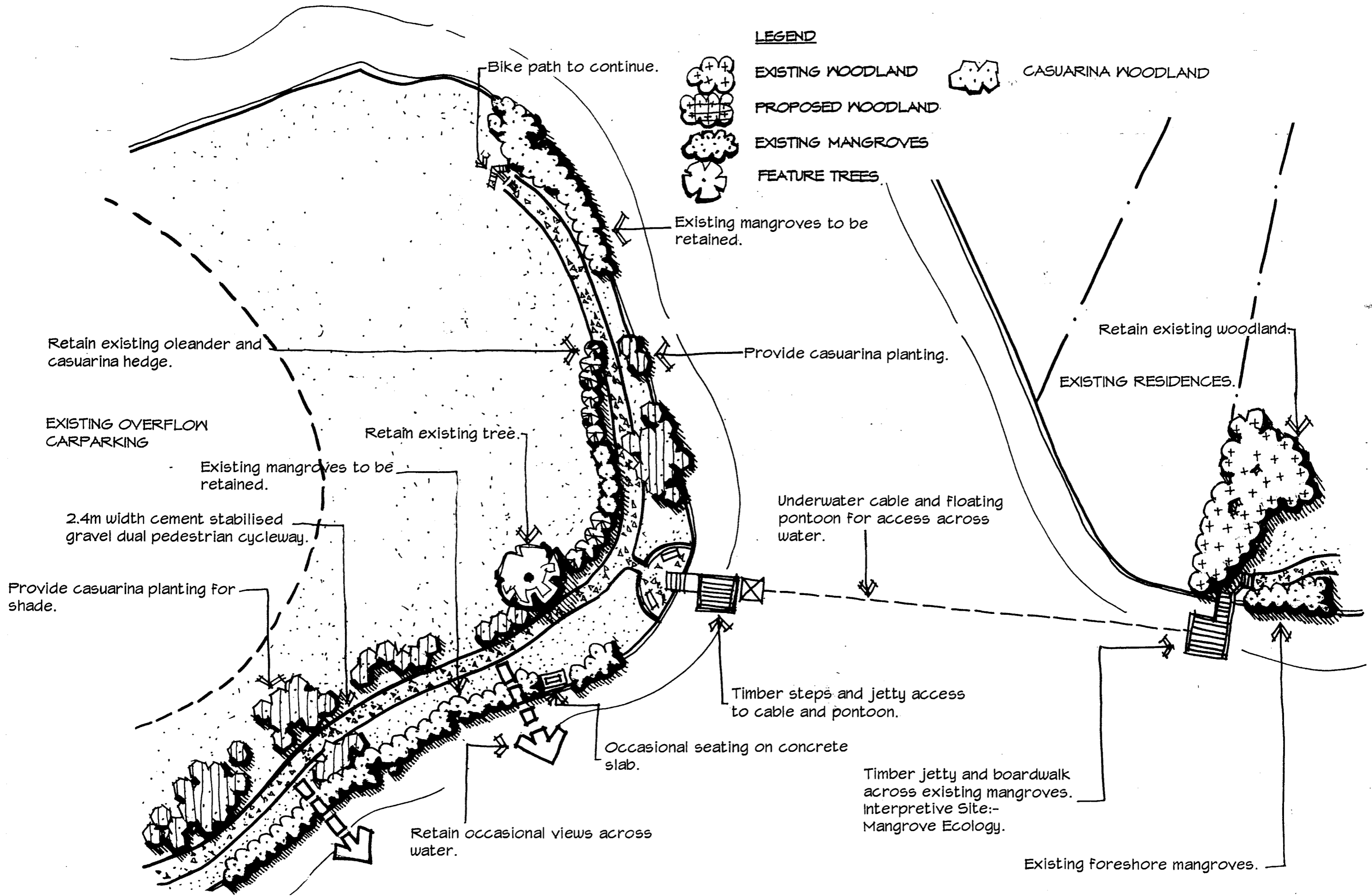
TIMBER JETTY AND PONTOON- SECTION
 Scale 1:200

TERRANORA BROADWATER

MANAGEMENT PLAN

GH

SECTION
 SEAGULLS



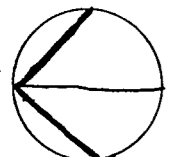
TERRANORA BROADWATER

MANAGEMENT PLAN

G SCHEMATIC SKETCH
SEAGULLS

SCALE 1:500

0 5 10 15 20 25M



TERRANORA CREEK

Timber viewing platform/jetty.

Possible canoe rowboat access.

MANGROVES

1.5m width timber boardwalk.





Interpretive Site: Mangrove Ecology.

MANGROVES

Property boundary.

2.4m width cement stabilised gravel dual pedestrian/cycleway.

LEGEND

-  EXISTING WOODLAND
-  PROPOSED WOODLAND
-  EXISTING MANGROVES
-  FEATURE TREES

Retain existing woodland planting and exotic trees. Remove existing garden shrubberies and borders within the public land boundaries.

Property boundary. limit of public land

FUTURE CONSERVATION AREA

DAVEYS ISLAND

TERRANORA BROADWATER

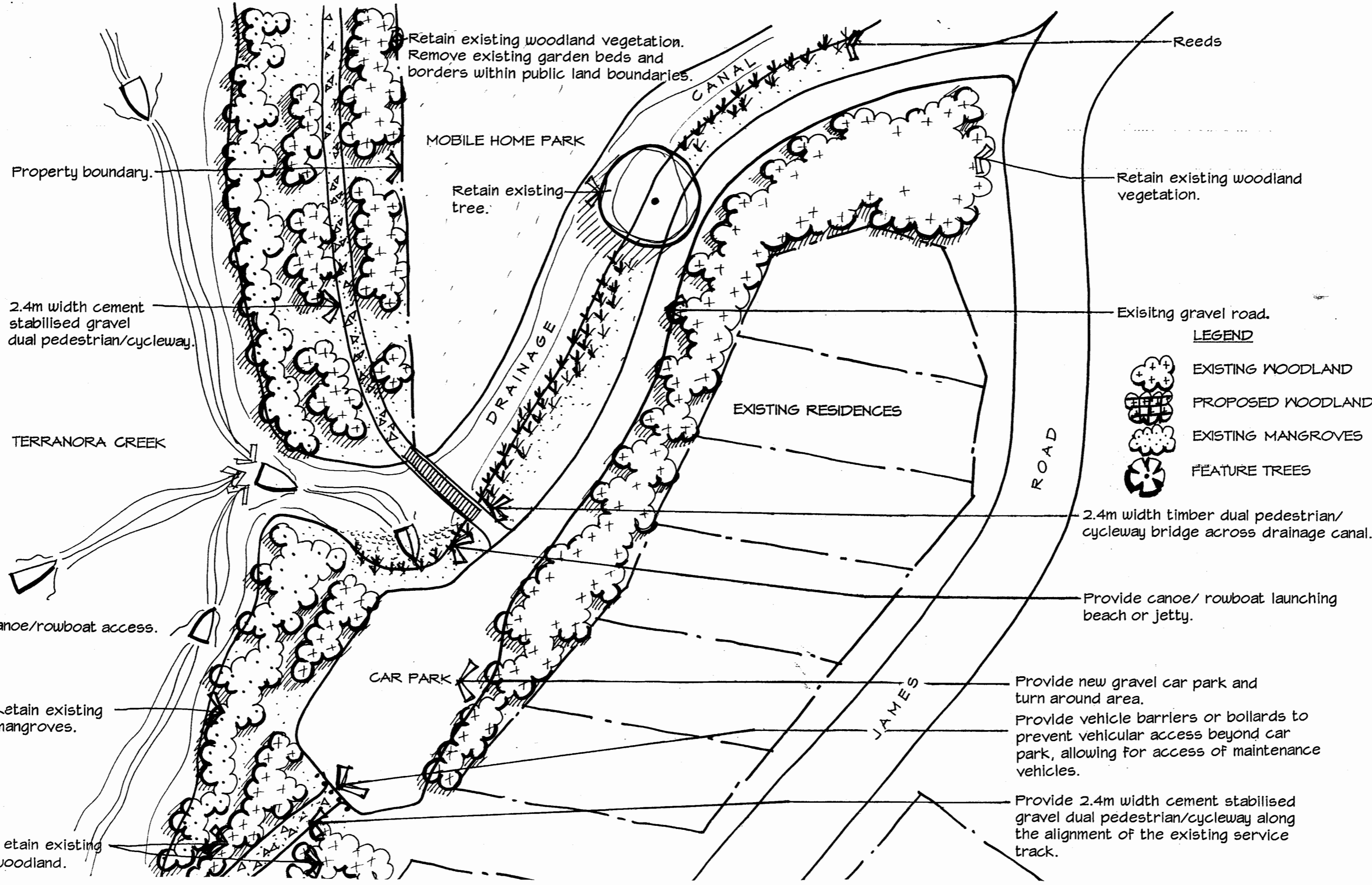
MANAGEMENT PLAN

SCHEMATIC SKETCH MANGROVES

SCALE 1:750

0 5 10 20 30M



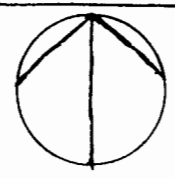


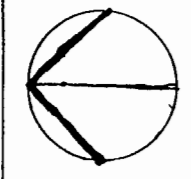
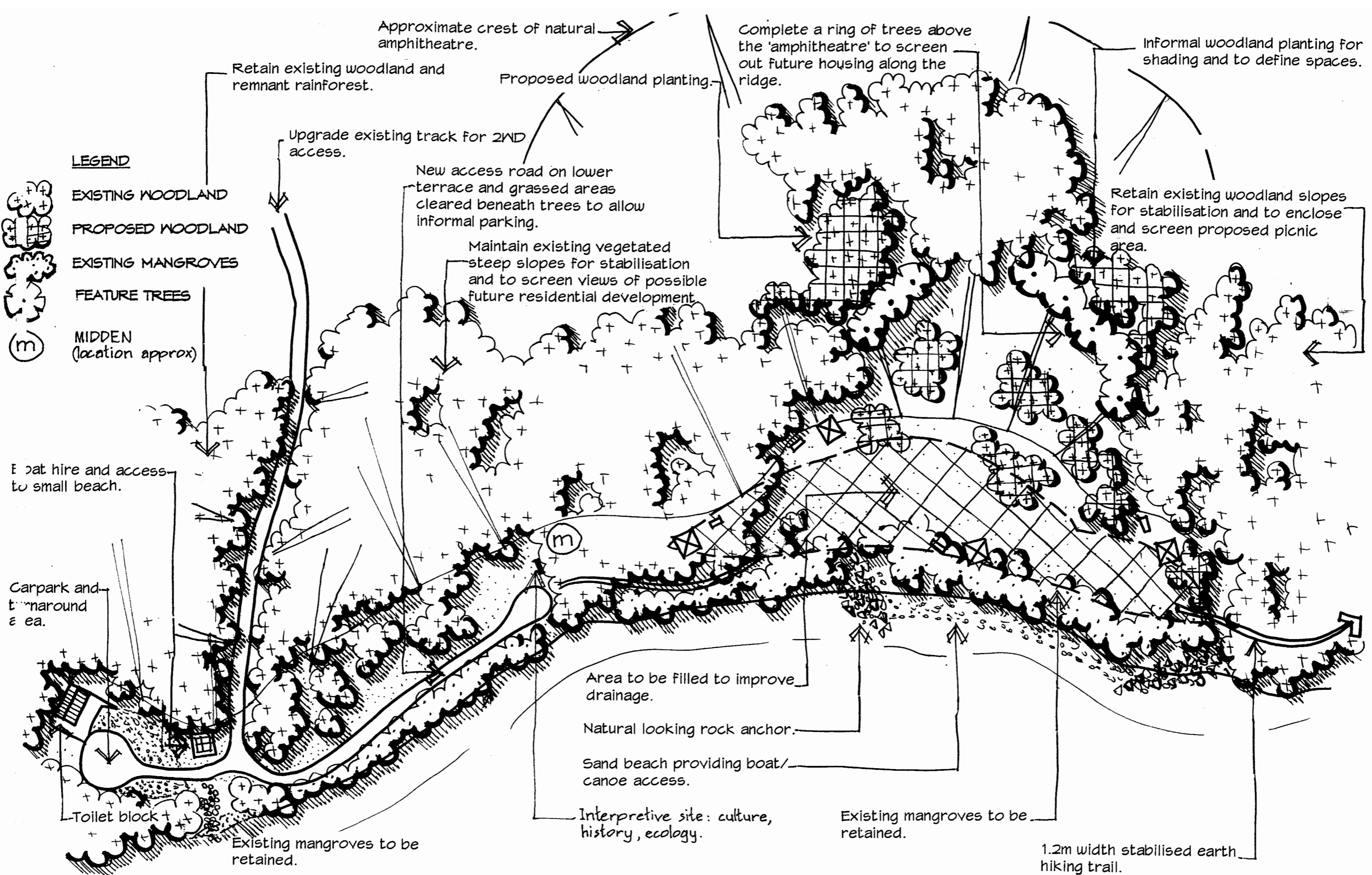
TERRANORA BROADWATER

MANAGEMENT PLAN

SCHEMATIC SKETCH
JAMES ROAD

SCALE 1:500

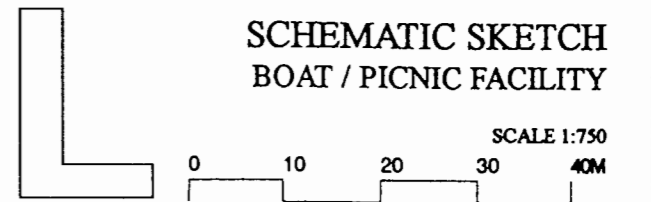


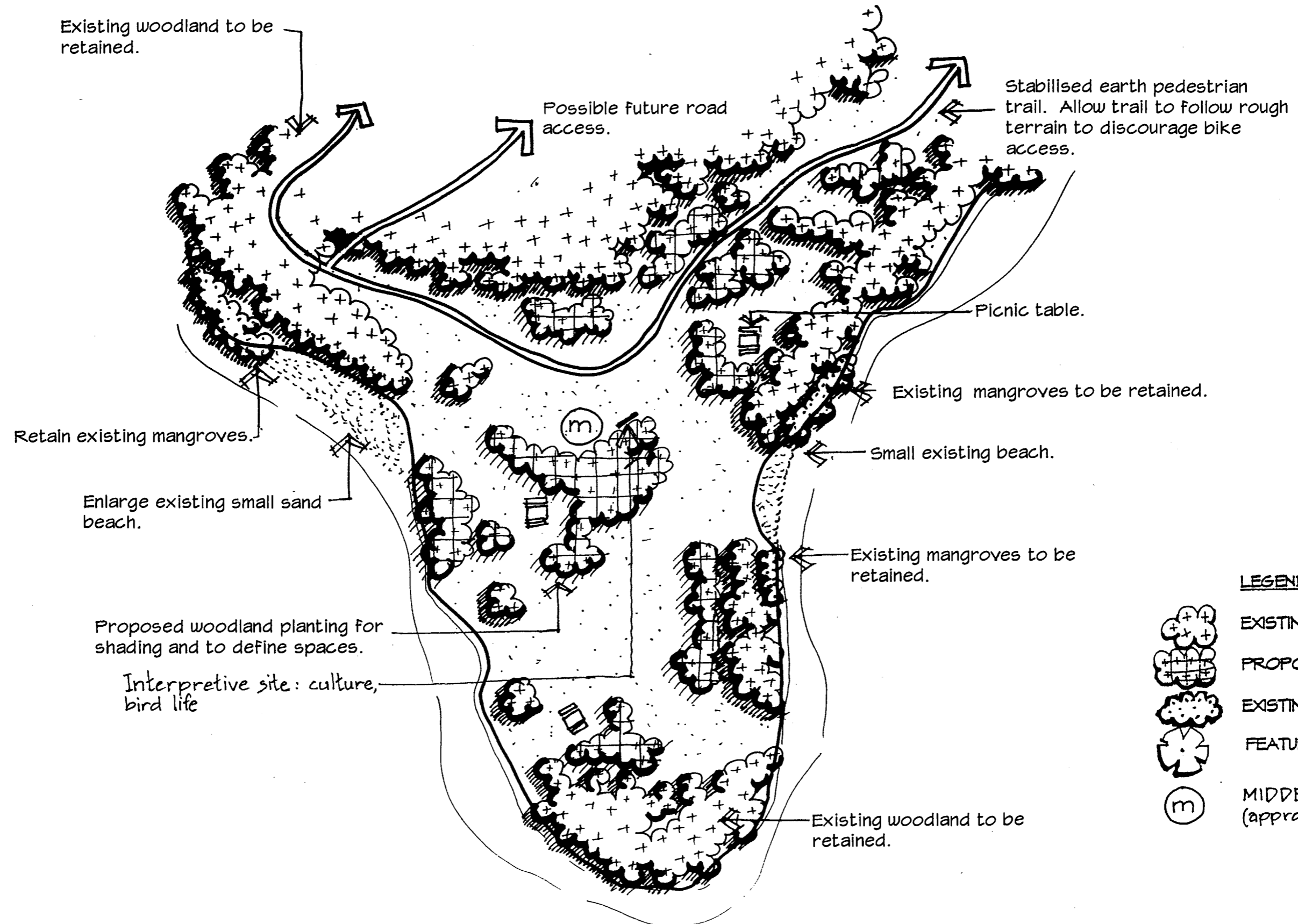







TERRANORA BROADWATER

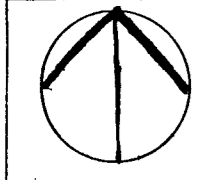
MANAGEMENT PLAN

SCHEMATIC SKETCH BOAT / PICNIC FACILITY



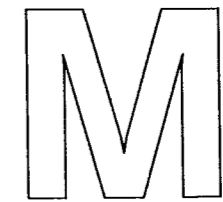


- LEGEND**
-  EXISTING WOODLAND
 -  PROPOSED WOODLAND
 -  EXISTING MANGROVES
 -  FEATURE TREES
 -  MIDDEN (approx location)

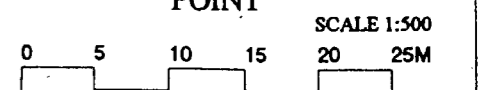


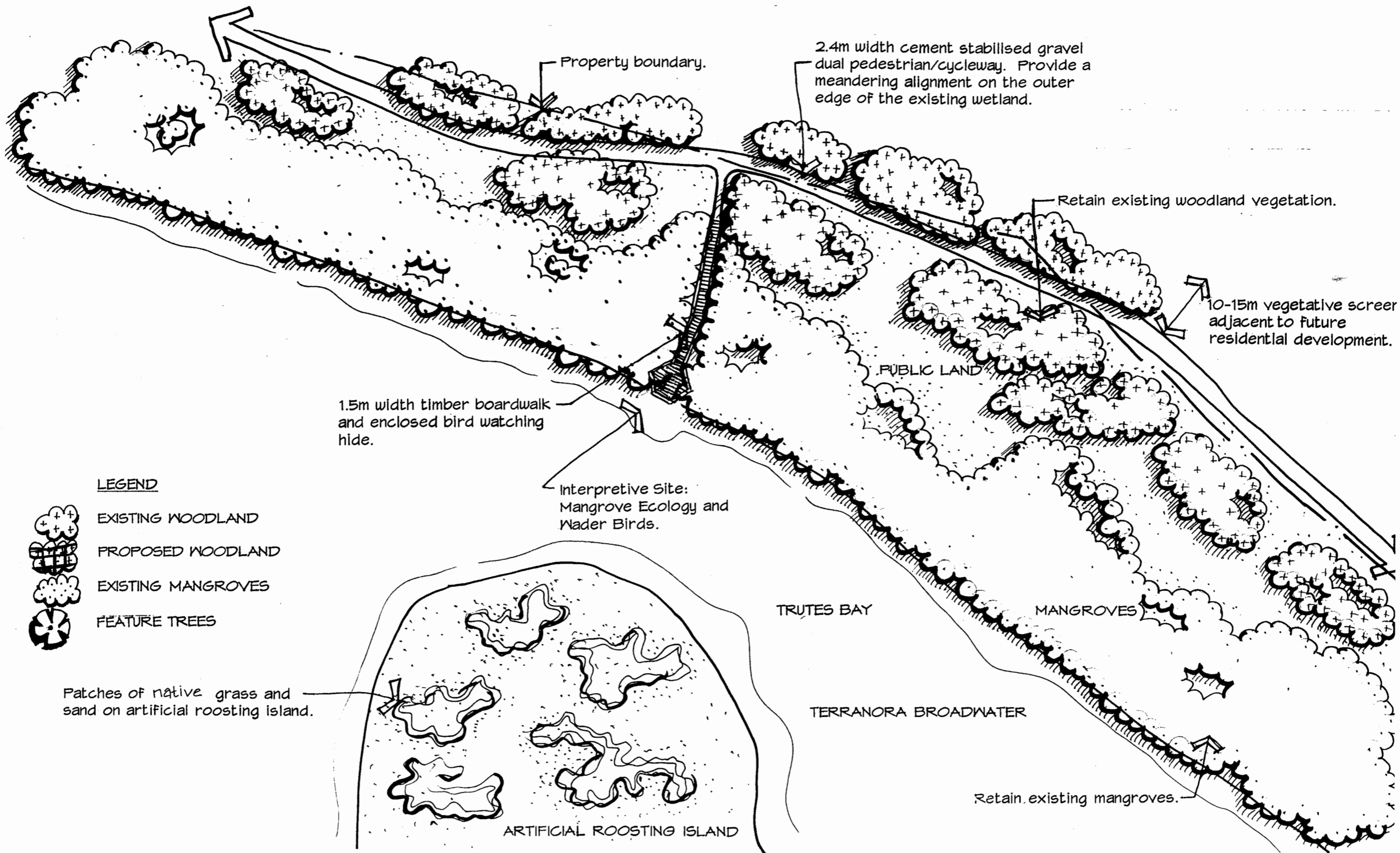
TERRANORA BROADWATER

MANAGEMENT PLAN







SCHEMATIC SKETCH
TOMMY'S ISLAND
POINT





LEGEND

-  EXISTING WOODLAND
-  PROPOSED WOODLAND
-  EXISTING MANGROVES
-  FEATURE TREES

TERRANORA BROADWATER

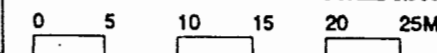
MANAGEMENT PLAN

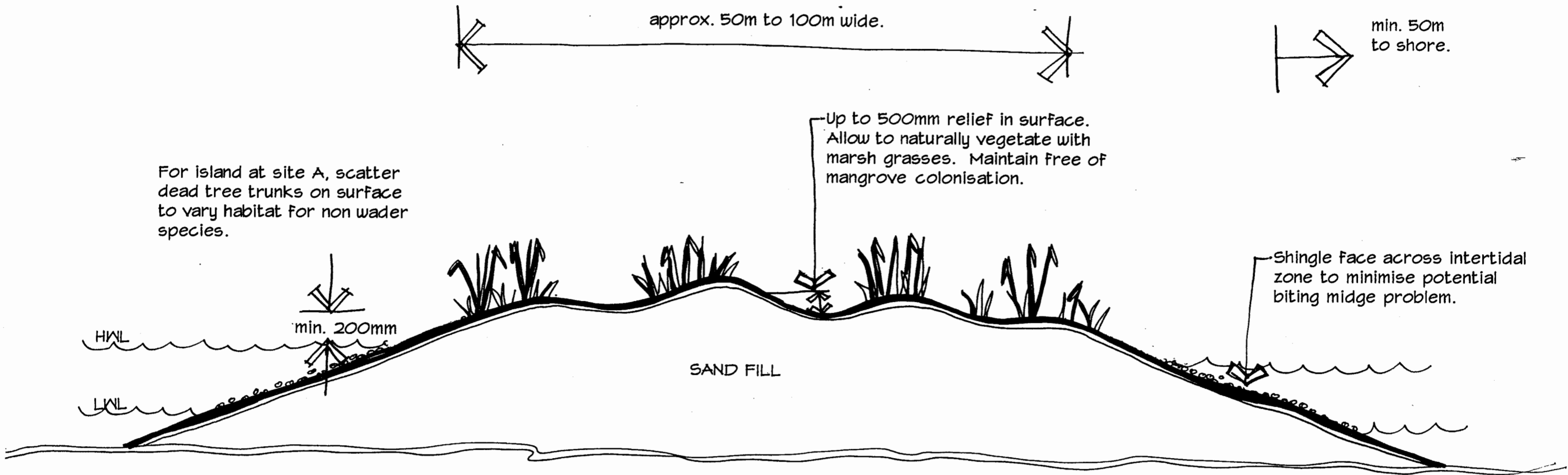


SCHEMATIC SKETCH

TRUTES BAY

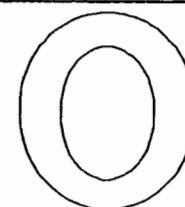
SCALE 1:500





TERRANORA BROADWATER

MANAGEMENT PLAN



SECTION
ARTIFICIAL BIRD
ROOSTING ISLANDS

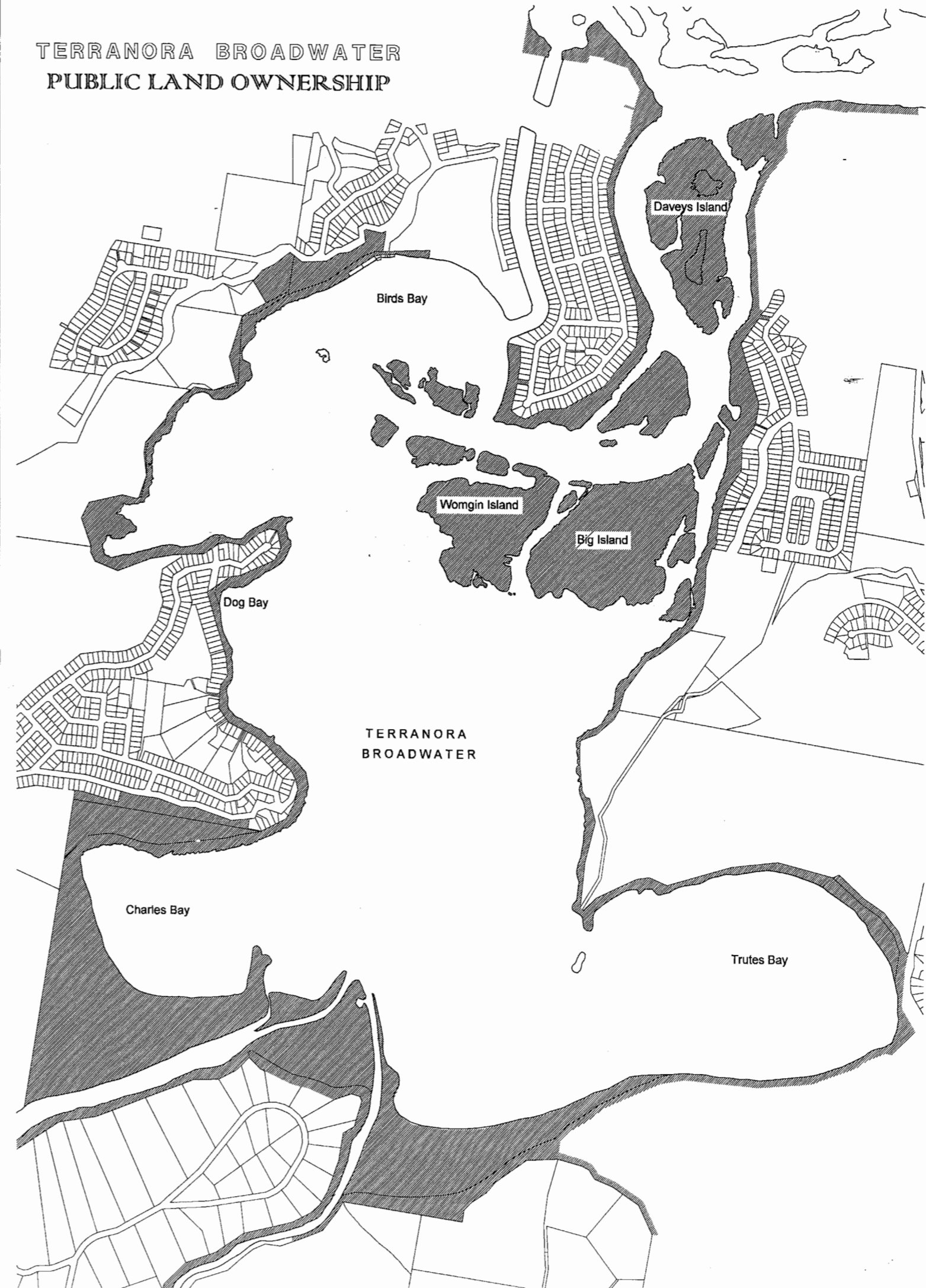
SCALE 1:25

4 LAND OWNERSHIP

The Management Plan aims to avoid planning constraints on privately owned land.

The plan opposite shows all foreshore land in public ownership, and as can be seen, the Management Plan is almost wholly contained on public lands.

TERRANORA BROADWATER PUBLIC LAND OWNERSHIP



5 COSTS, FUNDS AND TIMING

5.1 COSTS

Preliminary costings have been prepared. The following is a breakdown of the components of the Plan:

• Navigation channels & formation of bird habitat islands (ie. "F" and "O")	\$600,000
• Walking/cycling tracks	\$540,000
• Hiking tracks	\$40,000
• Site A	\$36,000
• Site B	\$355,000
• Site C	\$243,000
• Site D	\$62,000
• Site E	\$69,000
• Site G	\$88,000
• Site H	\$80,000
• Site I	\$162,000
• Site J	\$132,000
• Site K	Nil
• Site L	\$197,000
• Site M	\$22,000
• Site N	\$59,000
Total	<u>\$2,685,000</u>
+15%	\$3,088,000
say	<u>\$3.1 million</u>

Final pre-construction costs will depend upon detailed designs including site surveys, geotechnical assessments and the style and materials proposed in picnic facilities and interpretive signage.

5.2 FUNDS

Funds for the implementation of the Terranora Broadwater Management Plan will become available from revenue generated through State Government royalties on sand extraction from the Tweed River. As part of the overall management of the River, the State Government has set aside this source of revenue for the implementation of a River Management Plan.

Whilst this annual source of funds is substantial, it is required to fund improvements across the entire Tweed estuary. Consequently, it will not be possible to fully fund the Terranora Broadwater Management Plan from this source. Tweed Shire Council will contribute funds but the funds available to Council are limited. Hence other sources of funds will need to be acquired.

Many of the small facilities/measures, such as weed clearing, construction of hiking trails and walkways could become eligible for State and Federal grants under various funding programmes such as unemployment relief and regional development. Also those portions of the Plan associated with habitat regeneration, interpretive/educational facilities and picnic facilities could be taken up by voluntary community groups and as part of school projects. The historical cemetery and interpretive trail at Tumbulgum, recently completed with the assistance of the Murwillumbah Youth Enterprise Scheme and the Landcare Environment Action Program, is an excellent example.

The cost of maintaining all facilities will be borne by Council.

Consideration is being given to the appointment of a Project Co-ordinator who would pursue potential avenues for project funding and promote and co-ordinate voluntary community input.

5.3 TIMING

The timing of the Plan will be determined largely by the availability of funds. It is expected that overall, the Plan will take many years to implement.

Many of the minor facilities could be implemented at short notice when grant funds become available. Council has already constructed the walkway along Sunset Boulevard, and funds have been set aside in the 1994/95 project budget to continue with implementation of other components of the Plan.

6 SOURCE DOCUMENTATION

The source studies from the Lower Tweed Management Study are summarised in the following pages. The studies comprised the following:

□ **Hydrodynamic Study and Influent Audit**

A mathematical model study of the Lower Tweed estuary was carried out to determine the hydrodynamic impacts of dredging options in the lower Tweed. The study provided a broad appreciation of tidal behaviour in Terranora Broadwater.

The influent audit identified all point and diffuse sources of pollution in the lower Tweed estuary, potential changes due to urbanisation and an evaluation of existing estuarine water quality.

□ **Ecological Study**

A baseline field study of the lower Tweed estuary was carried out to obtain an understanding of aquatic and wetland habitats and establish a monitoring base for assessing the impacts of future estuary dredging.

Pollutant loadings of sediments were investigated.

□ **Archaeology and Visual Quality Studies**

An archaeological survey of the lower Tweed estuary was carried out to provide information about the presence and significance of archaeological sites on the estuary foreshores. The survey included consultation with members of the Aboriginal Community through the Tweed Byron Local Aboriginal Land Council.

A visual assessment of the land/water interface along the foreshores of the lower Tweed estuary was carried out. The objective was to assist in the preservation and enhancement of foreshore environments and protect foreshores from inappropriate development or other practices that could lead to a degradation of visual quality.

□ **Recreation Study**

A profile was prepared of the current recreational activities and opportunities for improvement/expansion. The recreation needs of the expanding population base were considered and specific recommendations were made.

TERRANORA BROADWATER

HYDRODYNAMIC STUDY AND INFLUENT AUDIT



DREDGING

Notional Dredge Plan Impacts

- existing bank erosion due to tidal currents adjacent to Seagulls Estate may be exacerbated by the increase in tidal range following dredging.
- peak tidal velocities will increase by 15%.
- Options to prevent increased bank instability will require further design and assessment and include:
 - dredge within the channel adjacent to Seagulls Estate.
 - upgrade bank protection with revetments and toe protection.
 - dredge the eastern channel linking Dry Dock to Terranora Broadwater.

Broadwater Hydraulics and Sedimentation Processes

- Terranora Broadwater suffers from problems of shallow depth, poor water circulation and tidal flushing, high turbidity, accumulation of fine sediments and effluents, relatively low fisheries productivity, and low recreational useage.
- Considerable areas of lake bed and foreshore have been reclaimed and extensive mangrove forests have developed.
- The Broadwater has been accumulating sediment at a significant rate over the past century, and past dredging downstream has increased the upstream movement of sediments into the Broadwater. Growth of the entrance delta is expected to continue.
- Computer modelling suggests that whilst the Broadwater is accumulating sediments, the rate of deposition is matched by the overall consolidation of the total mud mass in the lake.

Broadwater Dredging Options

- Option 1 - Small channel dredging
 - spoil disposal not specific and option not recommended.
- Option 2 - Large area dredging
 - excess spoil disposal to land, only viable if dredge spoil has commercial value.
- Option 3 - Large area dredging
 - spoil disposal to land and for artificial island creation.
- Option 4 - Large area dredging
 - use spoil for foreshore reclamation ie infill embayments.
- Option 5 - Small channel dredging
 - use spoil for artificial island creation.
 - option not discussed in source documents.

Opportunities

- Create mangrove habitat islands for bird roosting with dredge spoil. This will also reduce wind fetch and hence turbidity.
- Should enhance mixing and hence the efficiency of tidal flushing.
- May improve water quality in Trutes Bay and seagrass growth in the Broadwater.

Constraints

- Island creation may be difficult with this spoil.
- Need to avoid the introduction mosquito and/or biting midge breeding areas.
- Increased navigational conflicts with habitat and wildlife refuges.
- High maintenance and bunding costs.
- Excess spoil not likely to have any commercial value, disposal may be a problem.
- Major habitat alteration.

BANK INSTABILITY

Seagulls Housing Estate

- erosion due to boat wash, tidal velocities, and flow concentration from unnamed island.
- proposed Notional Dredge Plan dredging will worsen erosion.
- proposed bank protection works in hand.

INFLUENT AUDIT

Water Quality

Sampling and testing indicated that water quality in Terranora Broadwater is generally acceptable, although regularly turbid.

- The high turbidity is due to the broad and shallow nature of the Broadwater, exposing it to prevailing winds which cause the resuspension of fine sediments.
- There are several sources of natural and man-affected discharge carrying sediments and increasing amounts of water-borne contaminants. No action was recommended.
- Tidal flushing is poor and water-borne contaminants from downstream may be accumulating in the Broadwater.

Acid Sulphate Soils

The soils of the Broadwater floodplain are potentially acid sulphate. At present they have no apparent environmental impact, but future drainage or aerial exposure of these soils for urban development or agriculture could result in acid sulphate soil conditions with the resulting acid runoff discharging into the Broadwater.

Opportunities

- Institute a mapping and information service within the catchment to enable Council, farmers and developers to make informed decisions as to acidity potential and treatment.
- Potentially acid-sulphate soils could be used as conservation reserves or urban parks, with minimal or no disturbance.
- If urban development is to proceed on these soils the decision should be based on the knowledge that treatment is both difficult and expensive.
- Treatment methods include liming (expensive), deep soil mixing, salt water leaching, and seawater slurring. The proposed technique should be trialed to determine any adverse impacts.
- Geotechnical investigations should accompany any proposed development.

WATER QUALITY MANAGEMENT

The Terranora Broadwater catchment has been extensively cultivated and urban development limited. The clearing of land, particularly for banana cultivation, is the probable origin of growing stream deltas and the fine sediments dominating the southern parts of the Broadwater. The resuspension of these sediments due to wind/wave action causes turbidity in otherwise generally good quality water. Drainage systems are discharging into the Broadwater and a significant pollution carrying drain discharges into Trutes Bay.

Opportunities

The baseline studies identify a number of water quality management objectives for Terranora Broadwater:

- Monitor rate of delta growth on all incoming streams.
- Examine the origin of pollution entering Trutes Bay.
- Investigate methods of improving the quality of stormwater discharging into the Broadwater.
- Notional Dredge Plan and river entrance dredging will enhance mixing and hence the efficiency of tidal flushing.
- No specific recommendations were made.

Scale 1:20 000

TERRANORA BROADWATER ECOLOGICAL STUDY



Scale 1:20 000

VEGETATION

NSW NationalParks and Wildlife Service has compiled a list of rare and threatened plant species for the Tweed Shire. Several species in the Tweed Estuary, whilst not rare or endangered, are considered significant because they are either limited in geographic distribution or uncommon in central eastern Australia. A survey of classified vegetation recorded the following species in the Birds Bay area:

- 1 species is endangered, it is inadequately reserved and has a geographic range > 100 km.
- 4 species are vulnerable, 3 of which are reserved have a geographic range > 100 km, the other is inadequately reserved and has a geographic range < 100km.
- 3 species are rare, their populations are reserved and all have a geographic range < 100 km.
- 4 species are significant and exist in subtropical and littoral rainforests.

Seagrass

Seagrass beds are important fish nursery and animal habitat areas, act as substrate stabilisers, and provide food and shelter for a variety of fish and prawn species. The best conditions for seagrass growth are broad shallow areas with high clarity.

Areas of subtidal seagrass have reportedly been removed from the Seagulls Estate to avoid disruptions to swimming and boating.

No opportunities to protect or enhance seagrass were identified.

Important vegetation sites

SEPP 14 Wetlands. These areas are preserved and protected. No clearing, leveeing, draining or filling is permissible without an Environmental Impact Statement.

Mangroves on Womgin and Big Islands and along the southern shore of the Broadwater provide important habitat for a wide variety of aquatic fauna, particularly fish, crustaceans and birds.

Littoral and lowland subtropical rainforest covers a few hectares at Birds Bay. It contains many rare and vulnerable species.

Mangroves and saplings at Seagulls Estate have been lopped and removed by residents.

No opportunities to protect or enhance mangroves were identified.

Opportunities

NPWS Tweed Estuary Nature Reserve Proposal

PESTS

Biting Midges and Mosquitoes

Problems are often man-induced as a result of poorly planned and implemented development in wetlands and other low-lying areas. Chemical treatment can be expensive and may adversely affect the environment.

- planning using legislation and land zoning may be the most appropriate control methods at large breeding sites.

Biting Midges

the heavy muds impregnated with leaf litter in forested wetlands, and the clean flocculated sands of light mangroves, are affected by 3 biting midge species.

Opportunities

- remove "dry" sand beaches and establish only permanently "wet" beaches in which sand above mid-tide level is not exposed.
- remove a layer of sand/mud from sandbanks down to mid-tide level to eliminate breeding habitat.
- ensure that artificial islands created from dredge spoil are revegetated between mid-tide and highest tide levels, thereby creating useable space for fauna.
- ensure that future residential development is suitably separated from natural wetland breeding areas by land zoning, rather than the methods above which adversely impact upon biota.
- develop an experimental management programme and evaluate short term chemical and long term environmental control techniques.
- a detailed survey and mapping of major breeding areas is required.

Mosquitoes

large numbers of saltmarsh mosquitoes breed in temporary shade pools on the landward side of mangrove forests.

- 3 saltmarsh species naturally breed in pools created after the highest spring tides, and heavy rain can increase these areas. The most commonly occurring species readily breeds in man-made pools created in low lying land, such as Trutes Bay swamp.
- control of the widely dispersed adult mosquito is generally not economically or environmentally justified unless an outbreak of a life threatening disease has occurred.

Opportunities

- as with biting midge control, appropriate planning and design can reduce and eliminate mosquito breeding sites, although the wide distribution of the species limits this option.
- use a technique known as runelling where low impact shallow drains are tidally connected to isolated pools. This allows flushing and access to aquatic predators.
- use biological larvicides.

FAUNA

NSW NationalParks & Wildlife Act (1974) Schedule 12 classifies threatened, rare and vulnerable terrestrial fauna and shore/seabirds, some of which are found in the Tweed region.

- Threatened: 6 bird, 2 mammal and 3 reptile species.
- Vulnerable & Rare: 2 bird and 2 reptile species.
- Rare: a number of butterfly species, but these are not protected under the Act.
- Special Concern and Significant: 2 reptile, 8 bird and 2 mammal species.

Terrestrial

The paperbark teatree forests which fringe the Broadwater are valuable for resident and migratory nectar feeding terrestrial birds, such as Little Tern (threatened), Mangrove Honeyeater, Sacred Kingfisher (vulnerable and rare), Collared Kingfisher and Mangrove Gerygone. Mangroves are also used as corridors between major habitat areas and for foraging on insects and nectar.

Shore/Seabirds

Estuaries often support unique assemblages of birds, many of which are highly specialised for life in the intertidal wetlands, rocky shores, sandy beaches and various waterway habitats. Australia is a signatory of two international treaties - JAMBA and CAMBA, which protect the environment of migratory shore/seabirds and the birds themselves. Between 150 and 200 individuals of "resident" species were counted in the Upper Estuary in Feb 1992.



Major roost site



Minor roost site



Osprey Nest



Foraging area for shorebirds and other waders

Trutes Bay is the most important site in the Lower Tweed for estuarine birds in terms of species diversity and average numbers. Migratory birds, some rare and vulnerable such as Cattle Egret and Black-winged Stilts (only found in Trutes Bay), use this habitat for foraging and breeding. Lowland at Trutes Bay and the mouth of Bilambil Creek are the only freshwater swamps in the Lower Tweed.

The mouth of the Broadwater and Big and Womgin Islands and their sandflat habitats are also important feeding and areas for estuarine birds, some of which are rare and vulnerable. More than 10% of all shorebirds of the Tweed Estuary roost on these islands.

Opportunities

- Protect water quality throughout the estuary, particularly in the important habitat areas of Trutes Bay and around Big and Womgin Islands.
- As a general opportunity, the provision of specialised habitat requirements is a major determinant factor for the successful conservation of threatened, vulnerable and rare species. For example, Osprey, Brahminy, Whistling Kites and the White-breasted Sea-eagle are regularly observed around the Tweed. They are territorial and hence require large breeding/foraging habitat areas which may be enhanced by active management, such as relocating nests to purpose built nesting poles.

BENTHOS

Estuarine macro benthos (bottom-dwelling or burrowing animals greater than 1mm in size), perform important ecological functions, including nutrient recycling and providing a food resource for fish and crustaceans. Observed levels of, and changes in, benthic faunal abundance and distribution may also be used to monitor aquatic ecosystems and assess the biological effects of disturbance and/or pollutants.

Benthic Abundance and Diversity

- the Broadwater has the highest total diversity and total abundance of sampling undertaken in the Lower Tweed Estuary.
- stable substrates, low tidal flushing and the resulting accumulation of detritus provide suitable habitat for a large variety of benthos.
- seagrass beds generally contain the richest benthic fauna. The Broadwater and seagrass beds would also act as benthic refuges during floods, and rapid recolonisation of the main channel after floods would be enhanced by these refuges.

Sediments

The presence of pesticides and heavy metals in sediments may adversely impact aquatic fauna. Dieldrin levels were low and indicate recent usage (<5 years).

- the very low levels of contaminants detected in the sediments are negligible and likely to have minimal impact on the ecology of the Broadwater.

TERRANORA BROADWATER

ARCHAEOLOGY AND VISUAL QUALITY STUDIES



ARCHAEOLOGIC SITES

- Site 6 - Daveys Island
 - * Highly significant site - shell midden, one of the few remaining island sites in the Tweed Estuary.
 - * Relatively undisturbed, has potential for future scientific research.
- Site 7
 - * Highly significant site - shell midden, stratified and eroding from a high river bank.
 - * Significant as it is part of a group of at least six sites in this section and as it has potential for future research.
- Site 8
 - * Highly significant site - low density shell midden.
 - * Significant as it is part of a group of at least six sites in this section and as it has potential for future research.
- Site 9
 - * Highly significant site - shell midden with concentrated deposit.
 - * Appears undisturbed, has potential for future scientific research.
- Site 10
 - * Highly significant site - shell midden with concentrated deposit and artefactual material.
 - * Relatively undisturbed, has potential for future scientific research.
- Site 11
 - * Highly significant site - shell midden with concentrated deposit.
 - * Site is dissected by gully and is very disturbed, has potential for future scientific research.
- Site 12
 - * Highly significant site - shell midden with concentrated deposit.
 - * Undisturbed except for cattle track across it, has potential for future scientific research.
- Site 13
 - * Highly significant site - shell midden with concentrated deposit.
 - * Appears undisturbed, has potential for future scientific research.

VISUAL QUALITY CLASSES

- 1 Highest
- 2 High
- 3 High/Moderate
- 4 Moderate
- 5 Moderate/Low
- 6 Lowest

VISUAL QUALITY RECOMMENDATIONS

The visual quality assessment of the Terranora Broadwater foreshores revealed most areas were of "Highest" or "High" visual quality and no areas were considered to be "Low" in visual quality.

- In order to enhance and protect the landscape and scenic qualities, the source study notes that it is important to:
- * consider the visual impact of any development on the foreshore or adjacent land.
 - * control height, density, form, colour and character of any waterfront development.
 - * limit development on the foreshore to those warranting this position to avoid alienation of public from waterway.
 - * create policies to protect significant wildlife areas from development.
 - * identify high visual quality and environmentally sensitive areas susceptible to adverse impacts from recreation use, then protect by strategic placement of recreational facilities.
 - * create policies to promote public education and participation in order to reduce adverse impacts and maintain high visual quality.
 - * enhance and make available all foreshore areas zoned "proposed open space".

Opportunities

- Implement and promote a programme to encourage improvement of existing moderate visual quality area.

ARCHAEOLOGIC RECOMMENDATIONS

Archaeologic potential is high along the eastern foreshore of the Terranora Broadwater.

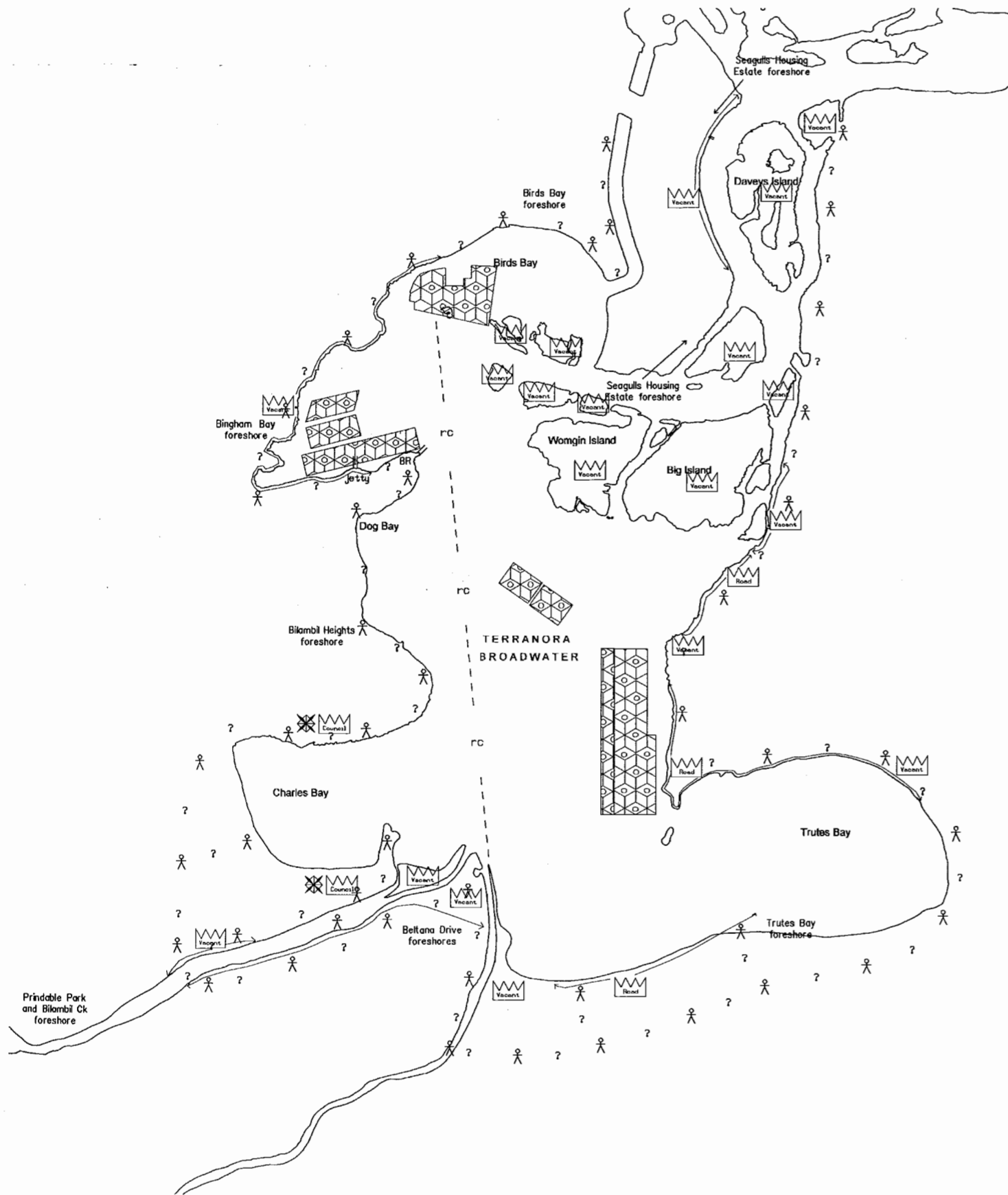
The NPWS Act (1974) contains provisions aimed at preventing disturbance of archaeological sites, without consultation with the Service.

Before any earthworks are carried out as part of the Plan, it is recommended that all workers be briefed on the possibility of uncovering shell, stone artefacts, or bone remains.

If remains are exposed work should stop immediately and NPWS notified. Work may only proceed after NPWS authority is given.

Prior to works commencing discussions between those responsible for the proposed works and the Tweed Byron Local Aboriginal Land Council must take place. The Land Council must be satisfied that significant sites are recognised and their protection assured.

TERRANORA BROADWATER RECREATION STUDY



Scale 1 : 20 000

PROPOSED FACILITIES

Walking Trail

A continuous foreshore walking and cycling trail could be developed, around the Broadwater perimeter outside the mangrove boundaries but possibly with diversions to a section of boardwalk through the mangroves and with pedestrian bridges over Bilambil and Duroby Creeks.

Seagulls Housing Estate foreshore

- Prevent erosion of foreshore adjacent to Sunset Boulevard. Works in hand.
- The landscaped foreshores of Seagulls Housing Estate could easily be mistaken for private land. Clearly designate boundaries and signpost the public reserve and encourage the public to use the land.

The Lakes Drive boatramp and jetty

- Boatramp and jetty will probably need to be relocated when the proposed new bridge connecting Seagulls Housing Estate with Kirkwood Road is built. An alternative site may be at the "unofficial" sand boat launching area at the northern end of Jacaranda Ave, which will require dredging in the channel leading into Terranora Creek. Other sites may need to be investigated.
- At new site, provide a fish-cleaning table, boat wash-down facilities, and signs stating boating and fishing regulations.

Birds Bay foreshore

- Recreation (special purposes) zoning. No action was recommended.

Bingham Bay foreshore

- Foreshore is virtually inaccessible due to steep terrain. No action was recommended.

Bilambil Heights foreshore

- Improve maintenance and public accessibility to foreshore reserve around north-eastern end of Peninsular Drive.
- Foreshore along inner Bingham Bay portion of reserve is cluttered with oyster farming equipment. No action was recommended.
- Boatramp east of Bingham Bay oyster lease at northern end of Broadwater Esplanade is defunct. No action was recommended.
- On Broadwater Esplanade at Bilambil Heights the prime bird-watching site should be clearly signed to warn against interference with estuarine, shore and migratory birds and their habitats.

Prindable Park and Bilambil Creek foreshore

- Foreshores eroding and water covered in scum. Clean and stabilise foreshores of Bilambil Creek adjacent to park.

Beltana Drive foreshores

- Enhance public reserve lands for recreation at Duroby Creek along Beltana Drive to cope with predicted population growth. No specific action was recommended.
- Access to Bilambil Creek and Duroby Creek foreshores is difficult. No action was recommended.

Trutes Bay foreshore

- No road access to southern and south-eastern foreshore. No action was recommended.

Rowing and canoeing facilities

The 2000 m rowing course proposed by the rowing club is not considered to be appropriate for the Terranora Broadwater and was not recommended.

CROWN LAND

Tweed Council Responsibility

- Public recreational crown land
- For preservation of native flora and fauna

Vacant

- Vacant crown land

Road Lease

- Crown road held under road permit

OTHER OPPORTUNITIES

Wherever and whenever possible, Council could acquire parcels of land suitable for foreshore recreation.

Proposed developments which would reduce public foreshore area should not be approved.

Public land should be clearly designated, boundaries well defined, signs erected and the public encouraged to use same.

Public wharves and jetties could be developed parallel to the foreshores in as many public parks and reserves as possible to provide a link at the land/water interface.

Client parking areas and toilet facilities should be provided by all commercial operators who conduct their business on or adjacent to public land.

A brochure could be printed on the walking trails in the area.

No changes in boating speeds is recommended but MSB could be encouraged to consider increasing the policing of speeds and other regulations during peak periods.

Develop an educational programme for schools to alert children to the dangers associated with boats.

Signs could be placed at public wharves and jetties warning of the dangers associated with swimming near, and diving from, these structures.

Fisheries could investigate diminishing fish stock claims and implement controls if necessary.

A database could be setup and maps printed containing all facilities, community clubs and contact persons.

Schools could be encouraged to use the estuary to educate students in botany, ecology, erosion, flooding, boating, swimming, etc. Support material could also be provided.

Oyster, mangrove, mudflat and wetland areas, such as those in Terranora Broadwater, are not suitable places to encourage public recreation.

COMMERCIAL FISHING

The Tweed River supports a commercial fishery worth \$12 million which employs 250 people, directly and indirectly (1989). The economic importance of recreational fishing in the Tweed has not been studied, although studies in southern Queensland note that the economic value of recreational fishing may equal or exceed that from commercial fishing.

- degradation of habitats would be reflected in decreased commercial and recreational catches.
- catches have decreased over the past few decades.



Commercial oyster lease

- The health and future marketability of oysters depends upon the water quality since they accumulate contaminants. According to oyster farmers, runoff from urbanised areas, flood waters and pesticide/herbicide contamination has affected production rates and quality.
- Professional thieves are stealing large quantities of oysters and selling them at lower prices than the growers. No action was recommended.
- Amateur fishermen are legally allowed to fish amongst oyster leases but their boats damage shadecloth and other equipment. No action was recommended.
- Dredging should only proceed after consultation with oyster farmers.

CONFLICTS

Nature Reserve Proposal and Foreshore Recreation demands

- in the Bilambil Creek and Duroby Creek area a conflict could exist between the NPWS Tweed Estuary Nature Reserve Proposal and the expanding population demands for foreshore recreation facilities.

7 HYDRODYNAMIC MODELLING OF TERRANORA BROADWATER

7.1 OBJECTIVES

A hydrodynamic model of Terranora Broadwater was developed to assist in the development of the Terranora Broadwater Management Plan. The objectives of the model study were:

- to determine the existing hydrodynamic flow regime of the Broadwater, and to assess the relative effects of tides and wind on mixing and flushing of the system;
- to assess the potential benefits to mixing and flushing characteristics of the Broadwater through the inclusion of small artificial islands ie. feature "O" of the Management Plan;
- to assess the potential benefits of dredging navigation channels within the Broadwater on the mixing and flushing of the system;
- to determine the combined effects of navigation channels and islands on the mixing and flushing characteristics of the Broadwater (ie features "O" and "F");

The results of the study are presented, in full, in the volume of "Technical Support Studies" which accompanies this document.

7.2 MODEL DESCRIPTION

A two-dimensional hydrodynamic model was developed so that water circulation patterns around the islands and indented foreshores of the Broadwater could be simulated. The model covered the whole of Terranora Broadwater, Terranora Creek, the Tweed River from its mouth to the confluence of Terranora Creek and Cobaki Broadwater. Only Terranora Broadwater was modelled two-dimensionally. The other elements in the model were modelled as one-dimensional elements. They were included to ensure the correct exchange with oceanic water, each tidal cycle which is essential for long term simulation of the flushing of pollutants from the system.

Water currents generated by winds blowing across the water surface are an important mixing process within lakes. Therefore the effects of prevailing winds were included in the model. Several combinations of wind directions and tides, under a variety of potential improvement options, were modelled. For simplicity, only a brief discussion is provided herein.

7.3 EXISTING TIDAL AND WIND CIRCULATION PATTERNS

The figures opposite show water circulation patterns at peak flood tide and slack water under the influence of a steady north easterly wind blowing at 4 m/sec. The velocities associated with wind circulations are much less than tidal velocities, hence they dominate only at slack water.

The majority of the tidal flow into the Broadwater occurs through the main channel. Strong tidal flows are directed to the western shoreline before they split northwards to move into Birds Bay or south into the main basin of the Broadwater. The vast majority of flow into and out of the Broadwater is through the western passage.

A northeast wind generates a large circulation cell that stretches the length of the Broadwater, and several separate cells are set up within the peripheral bays of the Broadwater. The speed of the currents generated by the north-easterly wind regime are very small compared to tidal velocities at the end of the main delta channel. However, away from the delta, such as in Trutes Bay and Charles Bay, the wind generated currents are significant compared to the small tidal velocities.

The modelling showed that the Broadwater has a "half life" of about 30 days (ie. time for an initial dispersed pollutant concentration to drop by 50%). This is relatively good and can be attributed to the shallow nature of areas such as Trutes Bay and Charles Bay, which retain only relatively small volumes of water at low tide, and have extensive areas of mud flats exposed at low tide.

The modelling also showed that even though wind driven currents are subtle, they nonetheless provide an effective mixing mechanism. They create large eddies which circulate water from south to north and they penetrate Trutes Bay and Charles Bay. The modelling found that in the southern

bays, such as Trutes Bay, wind circulation improved the flushing of pollutants by about 20-30%. Any proposed works, therefore, should be designed so that they do not detract from the large scale circulation patterns associated with the dominant winds.

7.4 ARTIFICIAL ISLANDS AND DREDGED CHANNELS

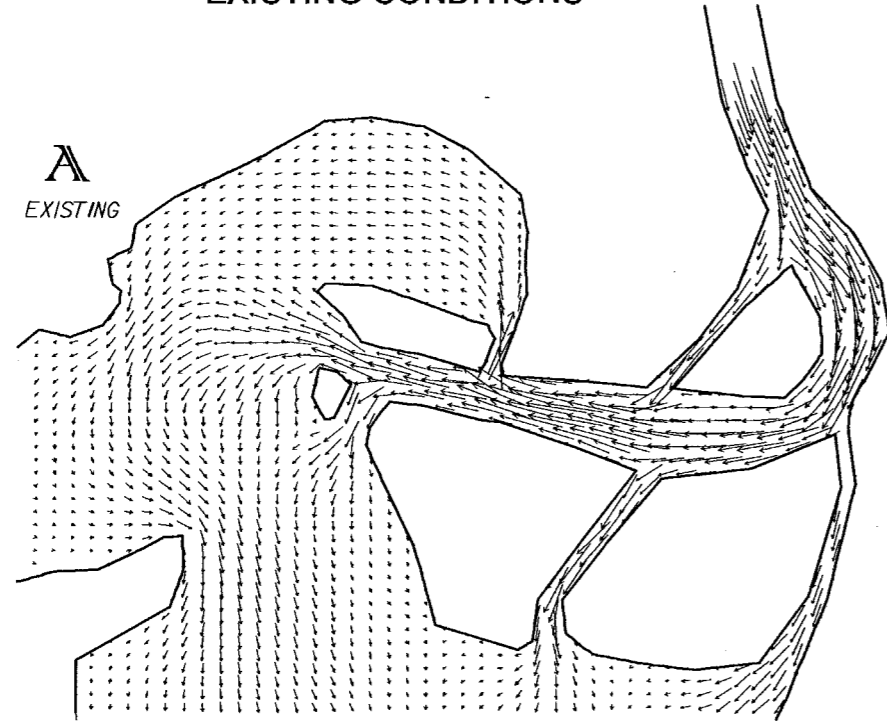
A number of potential island shapes and sizes were tested to examine the impact on mixing and tidal flushing of the Broadwater. However, it was found that the existing geometry of the Broadwater optimises the wind driven circulation patterns. No combination of islands and channels was able to improve upon the natural mixing and flushing of the Broadwater.

The figures opposite show water circulation patterns associated with the proposed Management Plan (ie. islands "O" and channels "F") under the same tide and wind conditions as the existing case. The proposed islands and channels preserve the basic flow patterns. However, the dredging of the main channel would slightly reduce the speed of the flood tide "jet" entering the Broadwater.

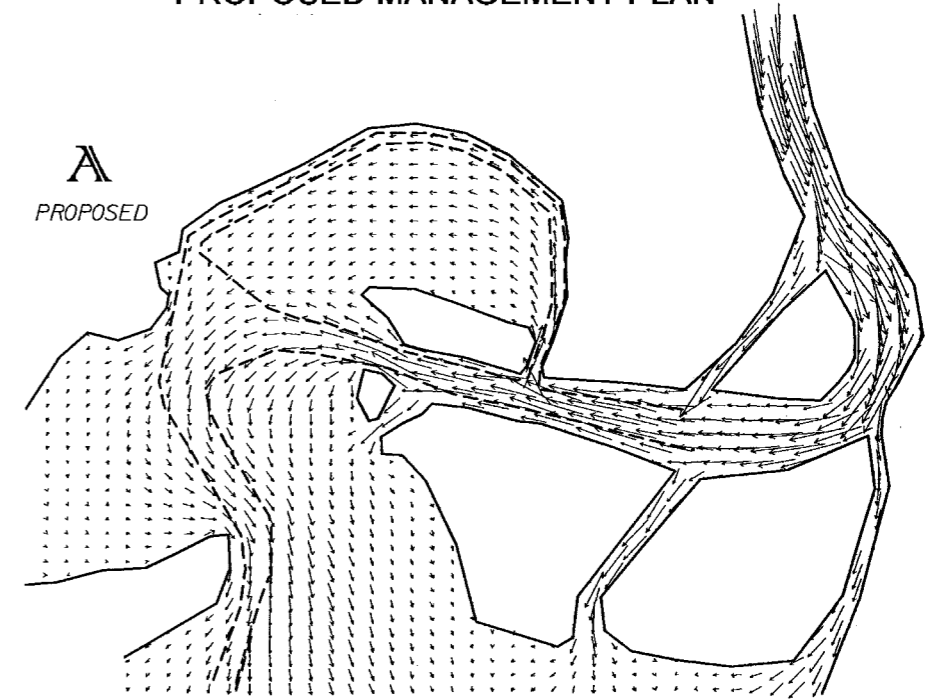
The modelling showed that this slower "jet" would reduce tidal flushing of the main body of the Broadwater, however, the effect would be minor and the impact on the water quality of the Broadwater would not be significant.

TERRANORA BROADWATER
HYDRODYNAMIC MODEL RESULTS

EXISTING CONDITIONS

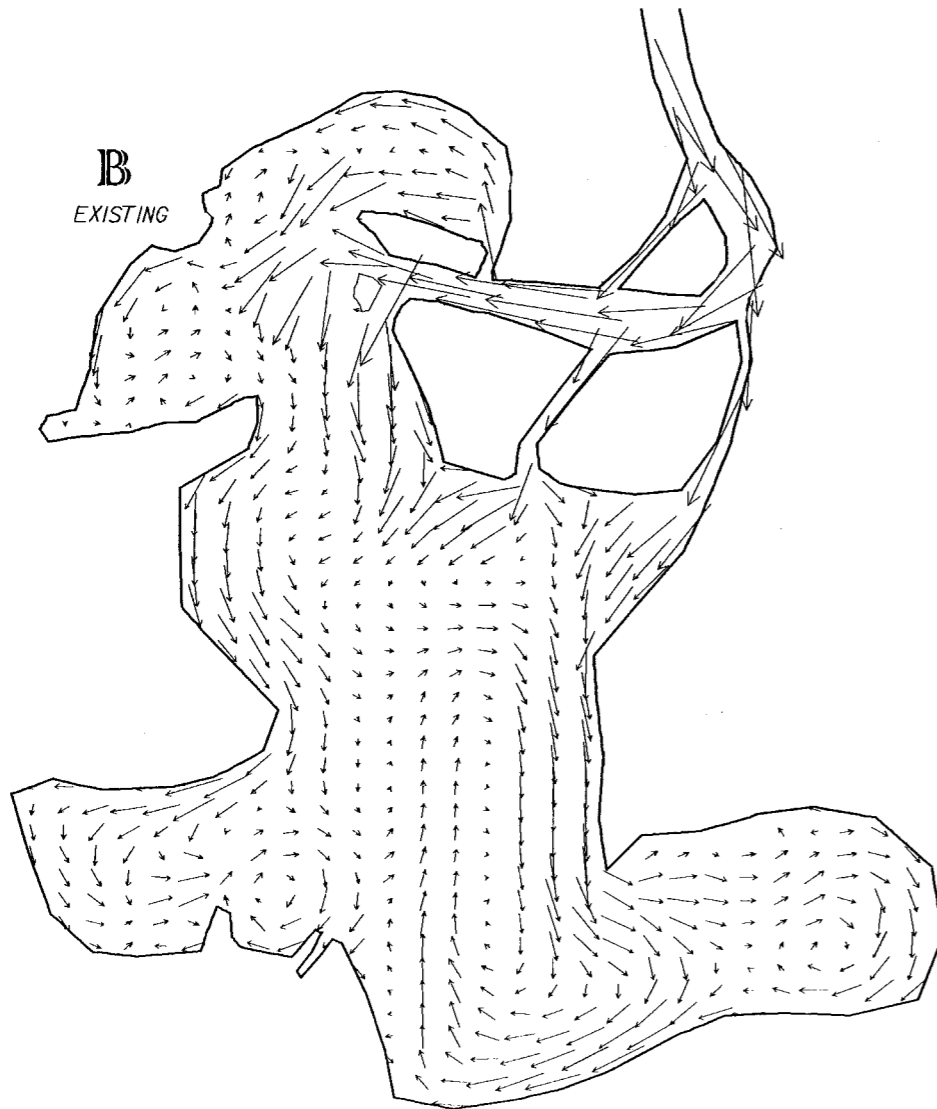


PROPOSED MANAGEMENT PLAN

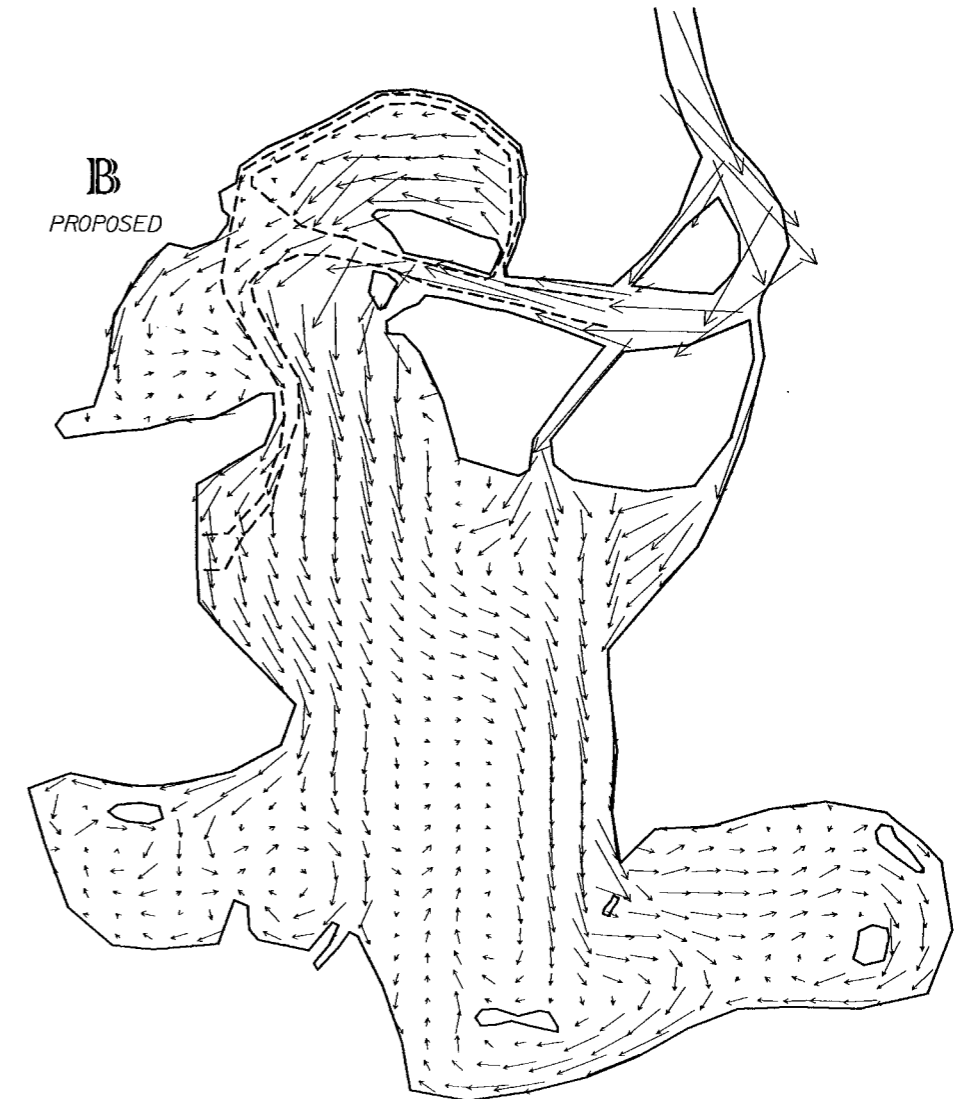


< PEAK TIDAL CURRENTS ON A FLOOD TIDE >

B
EXISTING



B
PROPOSED



< WIND CURRENTS AT LOW WATER SLACK >

Arrows represent current direction and magnitude.

Arrow magnitudes in sketch A are 10 times those of sketch B.

8 TRUTES BAY DRAIN - FLUSHING AND WATER QUALITY IMPLICATIONS

The detailed two dimensional model of Terranora Broadwater was used to simulate the dispersion of an influent plume originating from the small drain which exists on the northern shore of Trutes Bay and drains the South Tweed Heads lowlands. Council is developing a drainage strategy for the future development of this area (*the Western Drainage Scheme*).

Detailed model results are provided in the accompanying volume of "Technical Support Studies". The modelling examined the dispersion of both conservative (*non-decaying*) and non conservative (*decaying*) pollutants.

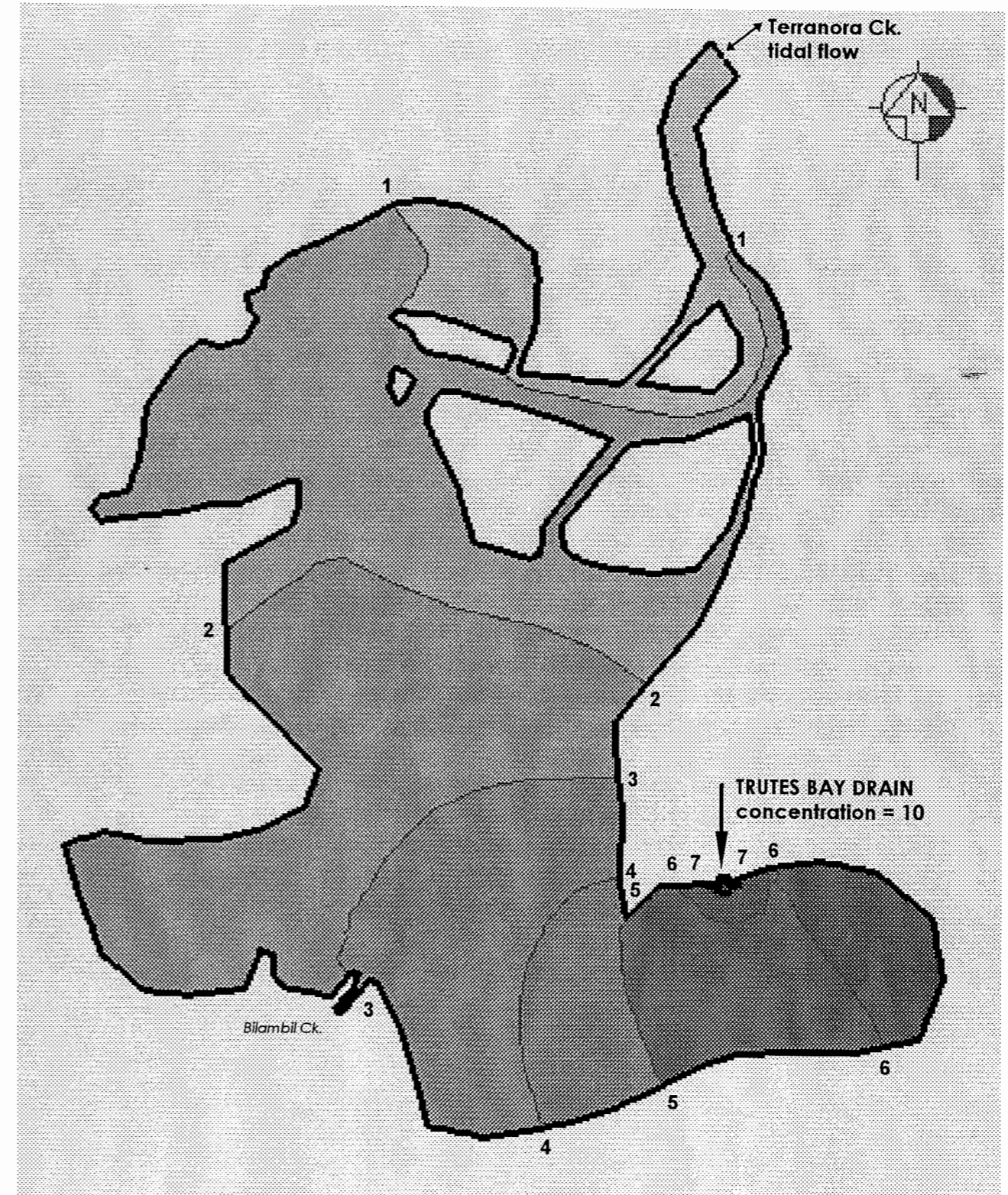
The figure opposite shows the concentration contours of a conservative pollutant discharge, with a notional concentration of 10 units, after 30 days under the action of tides alone. Trutes Bay increased in concentration to a steady concentration over the 30 days, of 60% of the inflow concentration. The main body of the Broadwater reached a steady state concentration of 20-40% of the inflow concentration, after 30 days.

The modelling showed that the overall effect of tide and winds is that Trutes Bay holds effluent for 3 to 4 days.

Hence, there is potential for any contaminated discharge to build up concentrations in Trutes Bay.

Because of the effective mixing of the shallow waters of the Broadwater, by the combined action of winds and tide, any contaminated discharge into Trutes Bay will be dispersed across the Broadwater. This would have significant implications for potential pollution of oyster leases.

The Trutes Bay study was a preliminary modelling exercise as it was carried out to provide input for Council's current revision of the western drainage scheme and specific water quality data does not exist. If a significant discharge, containing contaminants, is to be discharged into Trutes Bay, a detailed water quality study would need to be carried out.



**POLLUTANT DISPERSION FROM TRUTES BAY DRAIN
AFTER 30 DAYS OF TIDAL FLUSHING**

9 BROADWATER SEDIMENTATION

9.1 SOURCES AND GENERAL DISTRIBUTION OF SEDIMENTS

Information on sedimentation of the Broadwater is examined and reported upon in the technical studies volume.

Figure A opposite, shows that the Broadwater has two distinct sedimentary units:

- **Mud Basin** - shallow main body of the Broadwater comprising a bed of soft, organic shelly mud. These sediments are derived directly from the catchment via diffuse runoff and the suspended sediment load associated with discharges from Duroby and Bilambil Creeks.

The mud surface is stirred often by wind waves and hence turbidity is endemic to the Broadwater.

- **Sandy Entrance Delta** - comprises the many elevated sand islands and channels in the northern quarter of the Broadwater. In earlier geological times, these sands were transported directly from the active littoral system of the open coast beaches. In contemporary times, however, the lower Tweed estuary has become too choked with sand and the present day build-up of sand is derived from reworking of bed sediments, immediately downstream in Terranora Creek.

9.2 MUD BASIN

A limited number of depth probes were collected as part of the technical studies for the Terranora Broadwater Management Plan. The probes indicated that the very loose, shelly muds exist only as a relatively thin layer approximately 1.5 metres thick.

Beneath the soft surface mud, is a stratum of relatively firm black mud with less shell. Whilst the interface between the two sediments was not sharp, it indicates a possible break point in the recent sedimentological history of the Broadwater. It is known from the coring of other NSW estuaries that a firm underlayer usually represents a much older, consolidated sediment, possibly relating to a former period of high sea level.

An inference can be drawn that the top 1.5 metres of the mud basin represents sediment build-up since sea level stabilised at its present level about 6000 years ago. The sedimentological appraisal was brief, however, and this inference is preliminary only.

Such a small rate of sedimentation in the mud basin is consistent with the known build-up of the mud basins of other tidal lakes in NSW. These have average sedimentation rates of the order of several millimetres per annum and they have much greater catchments than Terranora Broadwater eg. Tuggerah Lakes and Lake Illawarra.

9.3 ENTRANCE SAND DELTA

The sands of the entrance delta are gradually extending over the surface of the mud basin. Probes on the edge of the active sand dropovers, intersected estuarine mud 1.5 to 2 metres below mean lake level.

Figures B and C, opposite, show that the sand shoals have extended significantly over the last 40 years. The build-up has been biased to the west because of the effect of channel dredging. The sand delta has extended more than 200 metres westwards over this period and it is now very close to the promontory which separates Birds Bay and Bingham Bay.

The contemporary growth of the entrance delta was rejuvenated by the substantial dredging of the lower Tweed estuary, commenced in the 1960's. Dredging has increased the strength of the flood tide flowing into the Broadwater and, as a consequence, the rates of sediment movement throughout the delta have increased. The increased transport of sand will continue for many years.

9.4 CONTEMPORARY LOSS OF DEPTH

There is a common belief in the community that the depth of the Broadwater has reduced in the last two decades or so, due to perceived excessive sediment runoff from the catchment., associated with urban development. Flat bottomed cream boats and sugar cane barges once plied the Broadwater whereas these days, this would not be possible except

at high tides. This is often cited as proof of loss of navigable depth.

Whilst recent catchment runoff has aggravated the situation, the main reason for the loss of depth can be attributed to a substantial shift in the tidal regime of the Broadwater.

Figure D, opposite, shows the results of studies (*PWD*¹) which show that 100 years ago, low water in Terranora Broadwater was 0.2 metres higher than today. This change has come about because of profound alterations to the lower Tweed estuary, in the form of entrance works and dredging. These alterations opened up the estuary, allowing low tides to drop and tidal ranges to increase.

A drop of 0.2 m in the level of low water would be very significant in respect of the flat bottomed vessels which used the Broadwater earlier this century.

It appears that the bed of Terranora Broadwater has undergone very little sedimentation over the last 100 years, which is consistent with the preliminary sedimentological evidence discussed above. Only on the intertidal margins has there been some build-up of mud flats. It was found that even the digitate deltas of Duroby and Bilambil Creeks have not advanced significantly as gleaned from aerial photographs spanning the last 50 years.

¹ Reference : Public Works (1991) - "Reviewing the Tweed - Feasibility Study, Technical Reports - Sediment Transport". Report No. 3.2.2.

PWD¹ also suggests that the propensity for sediment build-up on the bed of the mud basin, could be offset by consolidation of the underlying mud mass. Whilst not proven, this concept is feasible. However, the change in tidal regime is the most significant factor in the contemporary loss of depth in the Broadwater.

9.5 CHANNEL INFILLING RATES

The contemporary rates of sediment transport will determine maintenance requirements for the proposed channels of the Management Plan ie. component "F". An analysis of contemporary sand transport rates was carried out and it was concluded that a channel maintenance program would involve:

- Main navigation channel through Entrance Delta - approximately 15,000 to 20,000 m³ would need to be dredged every 5-10 years;
- Birds Bay perimeter channel - once off dredging; no maintenance would be required except where the channel rejoins the main channel. At that point, a small quantity may need to be dredged every 5-10 years;
- Dog Bay access channel - stability would depend upon the engineering properties of the surrounding muds. The channel is unlikely to require frequent maintenance dredging.

