LAKE CONJOLA
ENTRANCE MANAGEMENT PLAN

Report No. MHL1159

NSW Department of Public Works and Services
Manly Hydraulics Laboratory

Report No. MHL1159
DPWS Report No. 01113
ISBN 0 7347 4130 8
MHL File No. LRE6-0115
First published January 2003

Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:1994.

Foreword

This Entrance Management Plan has been prepared by Manly Hydraulics Laboratory (MHL), NSW Department of Public Works and Services, on behalf of Shoalhaven City Council. The management plan describes the system for management of the entrance of Lake Conjola on the NSW south coast to ensure a permanently open entrance.

Executive Summary

This Entrance Management Plan describes the procedures for managing the Lake Conjola entrance under the Managed Entrance policy adopted by Shoalhaven City Council and the Lake Conjola Estuary Management Task Force. The aim of the policy is to ensure a permanently open entrance with minimal interference with natural environmental processes. Under the policy the entrance constriction will be monitored and entrance works implemented when necessary to prevent closure. The works will comprise dredging a volume of sand of the order of 100,000 m^3 from the entrance channel and depositing it on the entrance spit. The sand will be placed and stabilised so that it restricts waves washing over the spit and depositing sand in the channel.

Lake Conjola is a coastal lake with a surface area of approximately 4.3 km^2 and a catchment area of 145 km^2. A sandy inlet some 3 km long separates the main lake, which has water depths up to 10 m, from the ocean. The inlet is shallow, with an average channel depth of the order of 1 m and extensive intertidal muddy sand flats. Tidal flows maintain a relatively small entrance channel which is typically located against the northern foreshore. The entrance is prone to periodic closures - over the last 60 years there have been eight closures. The entrance can remain closed for years until opened by floods, usually assisted by mechanical excavation of a pilot channel. When the entrance is closed, the lake level builds up in freshes and there can be a marked decline in overall water quality. In addition, some properties are flood-affected, resulting in inundation of septic disposal systems and dwellings.

Closure of the lake entrance occurs over a relatively long period of time. In order to ensure the entrance remains permanently open the management plan includes measures to maintain a commitment to an open entrance by Council and government agencies, a decision support system to provide adequate warning of closure, and procedures for pre-construction activities so that entrance works can be commenced prior to closure.

The managed entrance policy and the Entrance Management Plan have been based on a number of previous studies. The most relevant of these are:

- Patterson Britton and Partners 1999, *Lake Conjola Entrance Study, Shoalhaven City Council*, Issue No. 2 May 1999
- Shoalhaven City Council 1999, *Lake Conjola Estuary Management Plan*, June 1999
- Shoalhaven City Council 1999, *Lake Conjola Entrance Stage 1 (Interim) Works, Review of Environmental Factors*, Issue No. 1 November 1999.

The Commitment Document

The commitment document is included as Appendix B. The document is provided for submission to Council and relevant government agencies for their comment, revision and ultimate endorsement. It is an agreement in principle to the plan by all parties and a clear description of the actions and funding required. The document will be held by Council and will be made available to the Task Force and general public, as well as Council and relevant government agencies.

To ensure the plan operation remains in the minds of stakeholders, an annual report on the operation of the plan will be produced by Manly Hydraulics Laboratory. This annual report would be submitted to stakeholders by Council with a response form to be returned by stakeholders covering, inter alia, any non-conformance with the endorsed actions/strategy set out in the document.

The Decision Support System

The decision support system is the key to maintaining a permanently open entrance. The system will provide advance warning of entrance closure so that the essential activities that have to be carried out prior to the entrance works can be set in train to enable dredging to commence before closure.

The restrictive effect of the shallow inlet plus storage attenuation of the main lake reduces tidal range in the lake to approximately 20% of the ocean range under typical entrance conditions. The range slowly declines as the entrance becomes more constricted. The system will carry out a running harmonic analysis of the Lake Conjola tidal data over a 30-day period. The harmonic analysis will yield the principal lunar semi-diurnal tidal constituent M2 which has been shown to provide a good indicator of entrance constriction. The method overcomes the difficulty in identifying the slow decline in range due to shoaling within tides that vary in range from tide to tide.

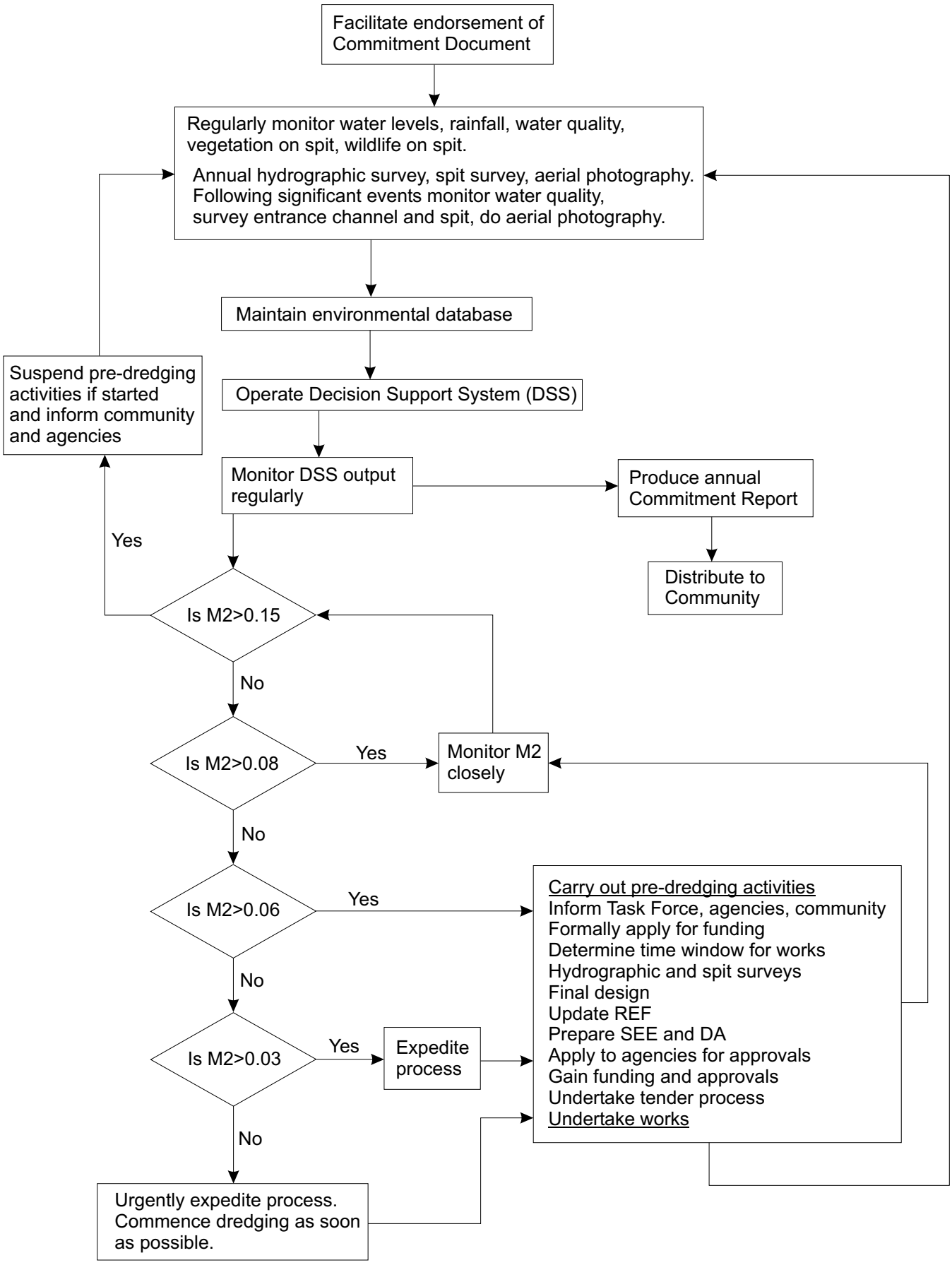
The system will be hosted on Shoalhaven City Council's web page on the MHL web site. This web page has password-protected access for Council officers.

Review of Environmental Factors

A Review of Environmental Factors (REF) has been prepared to accompany this Entrance Management Plan (MHL1161 2003). The REF may have to be revised prior to entrance works to accommodate changes that have taken place since its preparation. A Development Application and accompanying Statement of Environmental Effects will also have to prepared for depositing sand on the spit.

The Management Plan

The Management Plan describes the ongoing management activities that should be carried out until it becomes necessary to implement entrance works. It then describes the pre-construction activities required prior to dredging, and procedures for dredging and placement of sand. The Management Plan is summarised in the flow chart in Figure ES.1.



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW CHART SUMMARY
OF THE ENTRANCE MANAGEMENT PLAN

MHL Report 1159

Figure ES.1

DRAWING 1159-ES-01.CDR

Table of Contents

Appendices

List of Tables

List of Figures

1. Introduction

1.1 Aims and Objectives

This Entrance Management Plan describes the procedures for managing the Lake Conjola entrance under the Managed Entrance policy adopted by Shoalhaven City Council and the Lake Conjola Estuary Management Task Force. The aim of the policy is to ensure a permanently open entrance with minimal interference with natural environmental processes. A Review of Environmental Factors (REF) has been prepared to accompany this plan, MHL1061, *Lake Conjola Entrance Management Works, Review of Environmental Factors*. The REF assesses the potential environmental impacts of works that will be implemented at some time in the future to prevent closure of the entrance.

The management plan describes:

- the background to the project and the planning framework (Chapter 1)
- entrance physical processes (Chapter 2)
- entrance works to be initiated to prevent entrance closure (Chapter 3)
- ongoing monitoring of the entrance (Chapter 4)
- operation of a decision support system to warn of closure (Chapter 5)
- the procedure for initiating works and the responsibilities for management of the entrance (Chapter 6)
- a commitment document to ensure ongoing commitment to the plan (Chapter 7)

1.2 Background Information

Lake Conjola is a coastal lake located about 50 km south of Nowra on the NSW south coast (Figure 1.1). The lake has a surface area of approximately 4.3 km^2 and a catchment area of 145 km^2. A shallow sandy inlet some 3 km long separates the main lake, which has water depths up to 10 m, from the ocean. The inlet is shallow with an average channel depth of the order of 1 m and extensive intertidal muddy sand flats (Figures 1.2, 1.3).

At the entrance to the inlet there is a tidal delta of clean marine sand with pronounced sand lobes which are elevated up to 1 m above mean sea level. The entrance shoals constantly change due to the dynamic interchange between floods, tidal flows, storm waves, littoral sand supply and wind-blown sand from Conjola Beach. The restrictive effect of the shallow inlet plus storage attenuation of the main lake reduces tidal range in the lake to approximately 20% of the ocean range under typical entrance conditions.

Average tidal flows maintain a relatively small entrance channel which is typically located against the northern foreshore. The entrance is prone to periodic closures - over the last 60 years there have been eight closures. The entrance can remain closed for years until opened by floods, usually assisted by mechanical excavation of a pilot channel. When the entrance is closed, the lake level builds up in freshes and there can be a marked decline in overall water quality.

Several villages and caravan parks line the lake shoreline and are popular tourist destinations during summer holiday periods. Some properties are flood-affected, resulting in inundation of septic disposal systems and dwellings. The area is subject to continuing urban growth and the lack of a modern sewerage system results in sewage pollution during peak occupational periods and overflows due to rainfall events. As a result Shoalhaven City Council currently has a policy of opening the lake when water levels reach 1 m AHD, principally to relieve flooding, and to improve lake water quality.

Towards the end of 1994 the entrance, having been open for approximately five years, closed and remained closed until the entrance was successfully opened in June 1998. Closure caused considerable concern to the local communities, generally related to the potential danger of flooding and public health concerns related to elevated bacteria and virus levels from inundation of sewerage systems.

The draft Estuary Management Plan (SCC 1998*)* was amended to reflect the community's heightened concern about entrance stability and called for an investigation of the costs and benefits of various strategies to alleviate flooding and water quality concerns. Council subsequently undertook to address the particular needs of the Lake Conjola community in regard to managing flooding and sewage impacts by adopting an interventionist approach to entrance management.

1.3 Existing Studies and Plans

A number of studies of the natural processes occurring within the lake and entrance and development of management options have been undertaken. The most significant to the entrance management procedures are listed below.

- Patterson Britton and Partners 1999, *Lake Conjola Entrance Study, Shoalhaven City Council*, Issue No. 2 May 1999.
- Shoalhaven City Council 1999, *Lake Conjola Estuary Management Plan*, June 1999.
- Shoalhaven City Council 1999, *Lake Conjola Entrance Stage 1 (Interim) Works, Review of Environmental Factors*, Issue No. 1 November 1999.

The Managed Entrance Policy was selected from a number of entrance management options put forward in Patterson Britton and Partners (1999). A full list of studies and investigations is included in the bibliography.

1.4 The Selected Management Strategy

Six basic options for the long-term management of the entrance to Lake Conjola were identified in Patterson Britton and Partners (1999). These were:

1. entrance breakwaters
2. stub groyne and internal training wall
3. stub groyne and internal groyne field
4. stub groyne with partial spit stabilisation
5. managed entrance
6. existing opening policy.

These are shown schematically in Figure 1.4.

The works associated with each option had the possible extra feature of a wave trap/sand trap. This comprised a deepened basin of designed shape which would direct a significant portion of the flood tide away from the main ebb channel and dissipate wave energy, thereby capturing marine sand feeding in through the entrance.

The sustainability of the entrance options is impossible to predict because it depends on the occurrence of floods and severe ocean storms with waves with a southerly directional component. Analysis of environmental records has shown prolonged periods with both frequent occurrences and absence of storms and floods.

Table 1.1 provides an approximate guide as to the likely time between corrective dredging for each entrance option taking into account the 1999 condition of the entrance and analysis of past entrance behaviour.

Table 1.1 Dredging Frequency to Maintain Entrance Stability

Entrance Option	Approximate frequency for corrective dredging works
Entrance Training Walls	>> 20 years
Stub Groyne and Internal Training Wall *(without wave/sand trap)*	≈ 15 years
Stub Groyne and Internal Training Wall *(with wave/sand trap)*	15-20 years
Stub Groyne and Internal Groyne Field *(without wave/sand trap)*	≈ 15 years
Stub Groyne and internal Groyne Field *(with wave/sand trap)*	15-20 years
Stub Groyne with Partial Spit Stabilisation *(without wave/sand trap)*	≈ 10 years
Stub Groyne with Partial Spit Stabilisation *(with wave/sand trap)*	≈ 10 years
Managed Entrance *(without wave/sand trap*	> 10 years
Managed Entrance *(with wave/sand trap)*	10-15 years
Maintain existing protocol	≈ 5 years

Source: (Patterson Britton and Partners 1999)

The managed entrance option, which has the lowest cost and a positive flood mitigation benefit, was the only option which returned a positive net benefit in the entrance management study, i.e. the managed entrance option was the only option which had a benefit:cost ratio greater than 1.0.

After evaluating the options the managed entrance was selected as the preferred option by the Lake Conjola Estuary Management Task Force. The majority of the Task Force are community members representing all major interest groups from the various communities around the lake. A public meeting held on 25 August 1999 to consider the findings of the Entrance Study unanimously endorsed the preferred option, provided urgent Stage 1 interim entrance works were carried out. The interim works are shown in Figure 1.5 and the works to be implemented at the appropriate time under the Managed Entrance policy are shown in Figure 1.6.

1.5 Planning Issues and Land Zoning

The managed entrance option (without wave/sand trap) is not inconsistent with Council's current entrance policy. Adoption of the managed entrance option requires revision of the policy and preparation of a Review of Environmental Factors (REF) under the provisions of State Environmental Planning Policy 35 (Maintenance Dredging of Tidal Waterways) (SEPP 35). A Review of Environmental Factors to accompany this Entrance Management Plan has been prepared (see MHL Report No. 1161). The REF will most likely require revision at the time of any entrance works to reflect the requirements for environmental assessment and physical conditions at that time.

The bed of Lake Conjola, including the delta, is Crown land in the care and control of the State Government. The bed of the lake to a line approximately 100 m west of the end of the spit is subject to Amendment 127 under the Shoalhaven City Council Local Environmental Plan 1985 (LEP 1985). The objectives of the plan under Amendment 127 are:

a) to provide an overall city-wide rural planning framework which is based on recognised land use principles and underpinned by the principles of ecologically sustainable development
b) to implement national, State and regional policies in a manner which enhances the unique characteristics of the City of Shoalhaven to the advantage of its present and future residents and visitors
c) to implement Shoalhaven City Council's various policies and strategies for rural areas which have evolved through public consultation, and
(d) to introduce new definitions and provisions, and to rename certain zones, to assist in interpreting City of Shoalhaven Local Environmental Plan 1985.

The spit, including the southern high dunes, is Crown Land Reserve gazetted on 26 September 1930 under the care and control of Council. Under LEP 1985 the land is zoned 6(a) (Open Space – Recreation 'A' (Existing)). The objectives of the zone are to identify land where existing recreation facilities for the general use of the community are provided.

As the bed of Lake Conjola and the spit are Crown land, the entrance works will require a lease or licence which would require a land assessment or a waiver from the DLWC. This is covered more fully in Section 6.2.

Under LEP 1985 works on the spit would also require submission of a Development Application to Council, accompanied by a Statement of Environmental Effects (SEE). The REF prepared as MHL1161 will provide a basis for the preparation of the SEE.

1.6 Interim Works

The 1999 Entrance Study (Patterson Britton and Partners 1999) recommended that immediate action needed to be taken to raise the level of the entrance sand spit to inhibit wave washovers. The Stage 1 Interim Works, carried out from November to December 1999, were a one-off venture designed to address these concerns. The main steps involved:

1) realigning the main ebb channel by dredging through the internal delta shoals in alignment with the southern boat ramp and the northern entrance channel. Approximately 9,500 m^3 of sediment was removed
2) creating an artificial entrance dune by raising the dune to a crest level of approx 3.0 to 3.5 m AHD with side slopes 1 in 5, over a length of approximately 200 m
3) improving navigable access to the northern boat ramp at Cunjurong Point by dredging a channel with a width of 20 m at a bottom depth of approximately 2 m below AHD and length of approximately 100 m.

1.7 Legislative Framework

The following environmental planning instruments potentially apply to the entrance works that will be carried out at some time in the future under the managed entrance policy. Further information is contained in the accompanying Review of Environmental Factors.

- *Shoalhaven City Council Local Environmental Plan 1985*
- *Environmental Planning and Assessment Act 1979*
- *State Environmental Planning Policy 35 (SEPP 35) – Maintenance Dredging of Tidal Waterways*
- *Crown Lands Act 1989*
- *Fisheries Management Act 1994*
- *Coastal Protection Act 1979*
- *Protection of the Environment Operations Act 1997*
- *River and Foreshores Improvement Act 1948*
- *National Parks and Wildlife Act 1974: Protection of Aboriginal Objects*
- *Heritage Act 1977*
- *Water Management Act 2000*
- *Local Government Act 1993*
- *Threatened Species Conservation Act 1995.*

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
LOCALITY PLAN

MHL Report 1159

Figure 1.1

DRAWING 1159-01-01.CDR

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
OBLIQUE AERIAL PHOTO - PRE-1998

MHL
Report 1159

Figure
1.2

DRAWING 1159-01-02.CDR

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

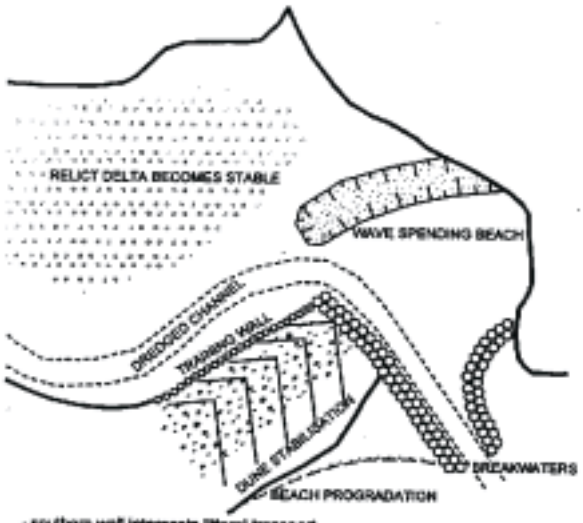
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
OBLIQUE AERIAL PHOTO - 31 AUGUST 1999

MHL
Report 1159

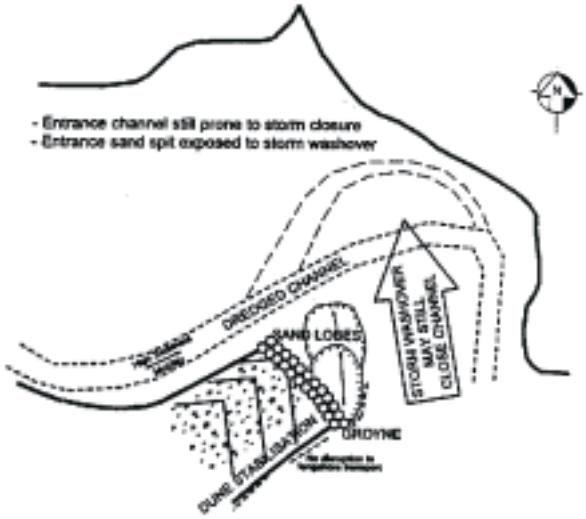
Figure
1.3

DRAWING 1159-01-03.CDR

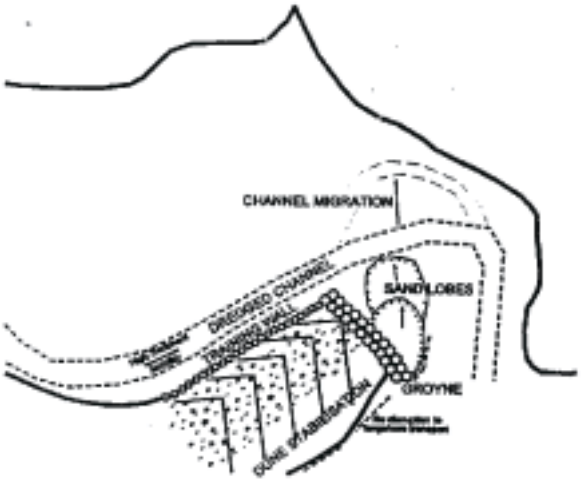


- southern wall intercepts littoral transport
- twin walls to reduce wave penetration
- entrance spit built-up to eliminate closure by storm washover
- channel dimensions maintained as per past flood scour

ENTRANCE WALLS

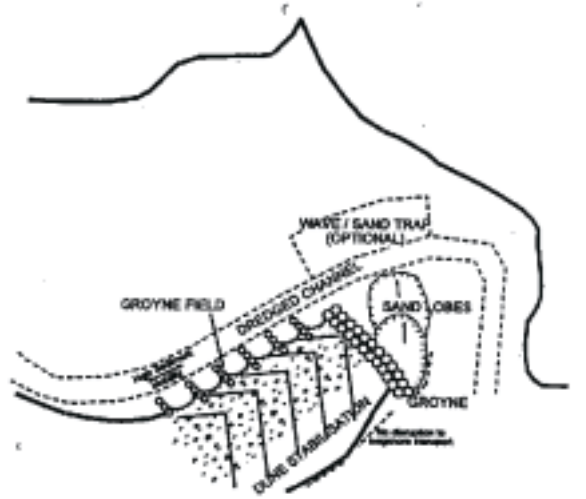


STUB GROYNE AND
PARTIAL SPIT STABILISATION



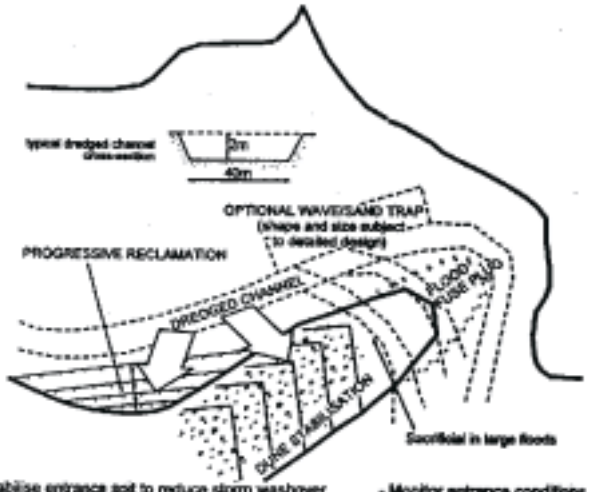
- Construct minimal groyne to provide hard point to support elevated entrance spit
- Stabilised entrance spit prevents storm washover
- Main channel could still choke tidally under prolonged dry spells and entrance storm slugs

STUB GROYNE AND
INTERNAL TRAINING WALL



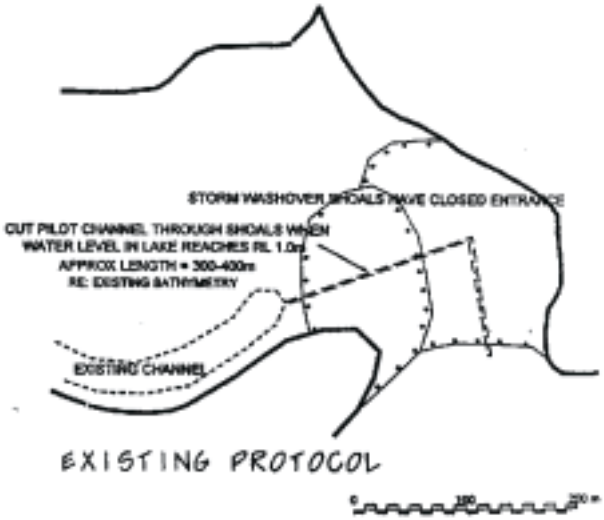
- Stabilise spit with groyne field
- Build up entrance spit to prevent storm washover
- Utilise sand from sand trap in spit stabilisation
- Extract sand from wave / sand trap (optional)

STUB GROYNE AND
INTERNAL GROYNE FIELD



- Stabilise entrance spit to reduce storm washover
- Monitor entrance conditions
- Maintain fuse plug at northern tip of spit to suit flood flows (1.0 - 1.5m AHD)
- When close to closure according to a new Entrance Management Policy, dredge new channel along path of historic flood cuts to substantial dimensions, ie 40m x 2m deep

MANAGED ENTRANCE



EXISTING PROTOCOL

Source: Patterson Britton & Partners Pty Ltd 1999

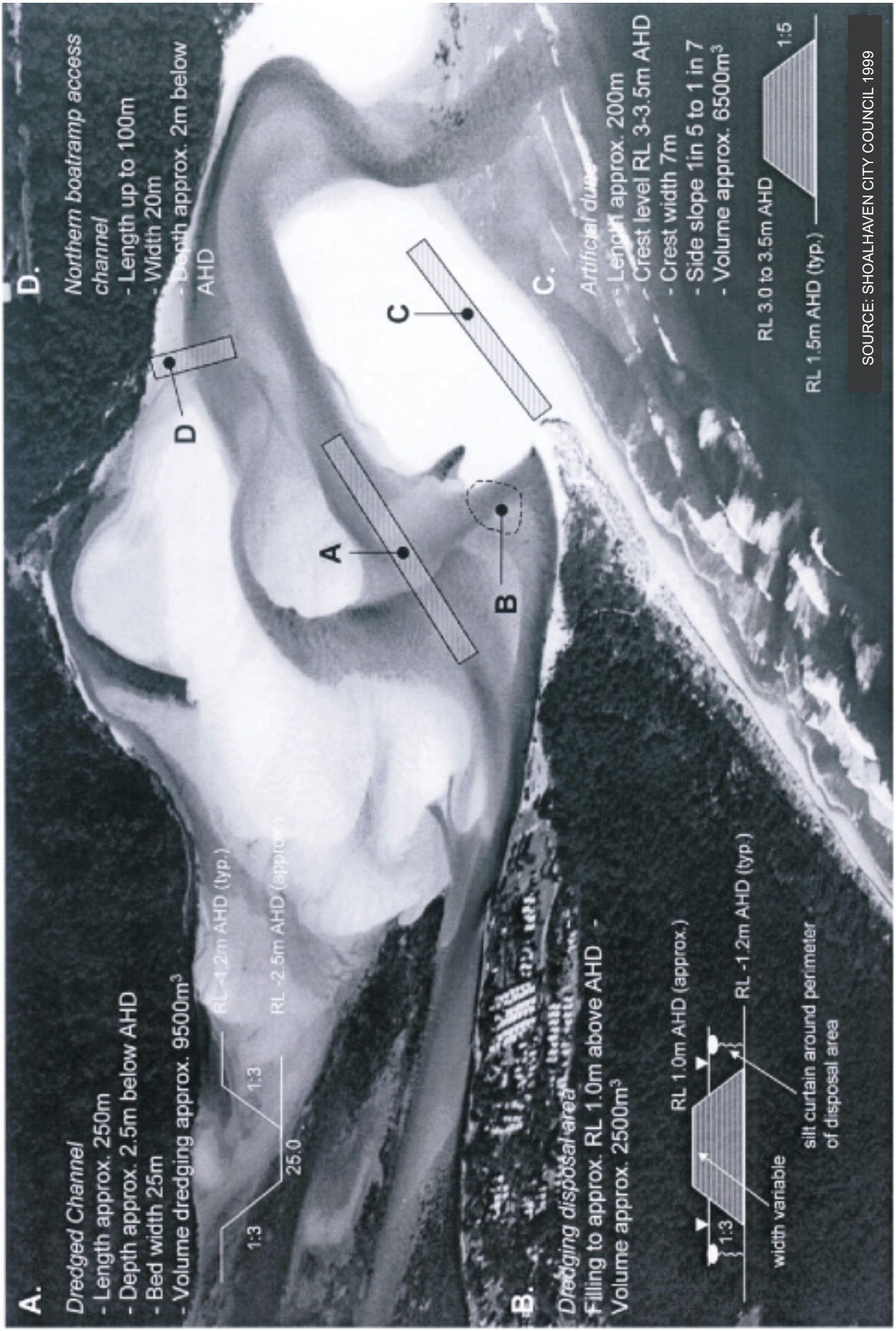
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
ENTRANCE MANAGEMENT OPTIONS

MHL Report 1159

Figure 1.4

DRAWING 1159-01-04.CDR



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

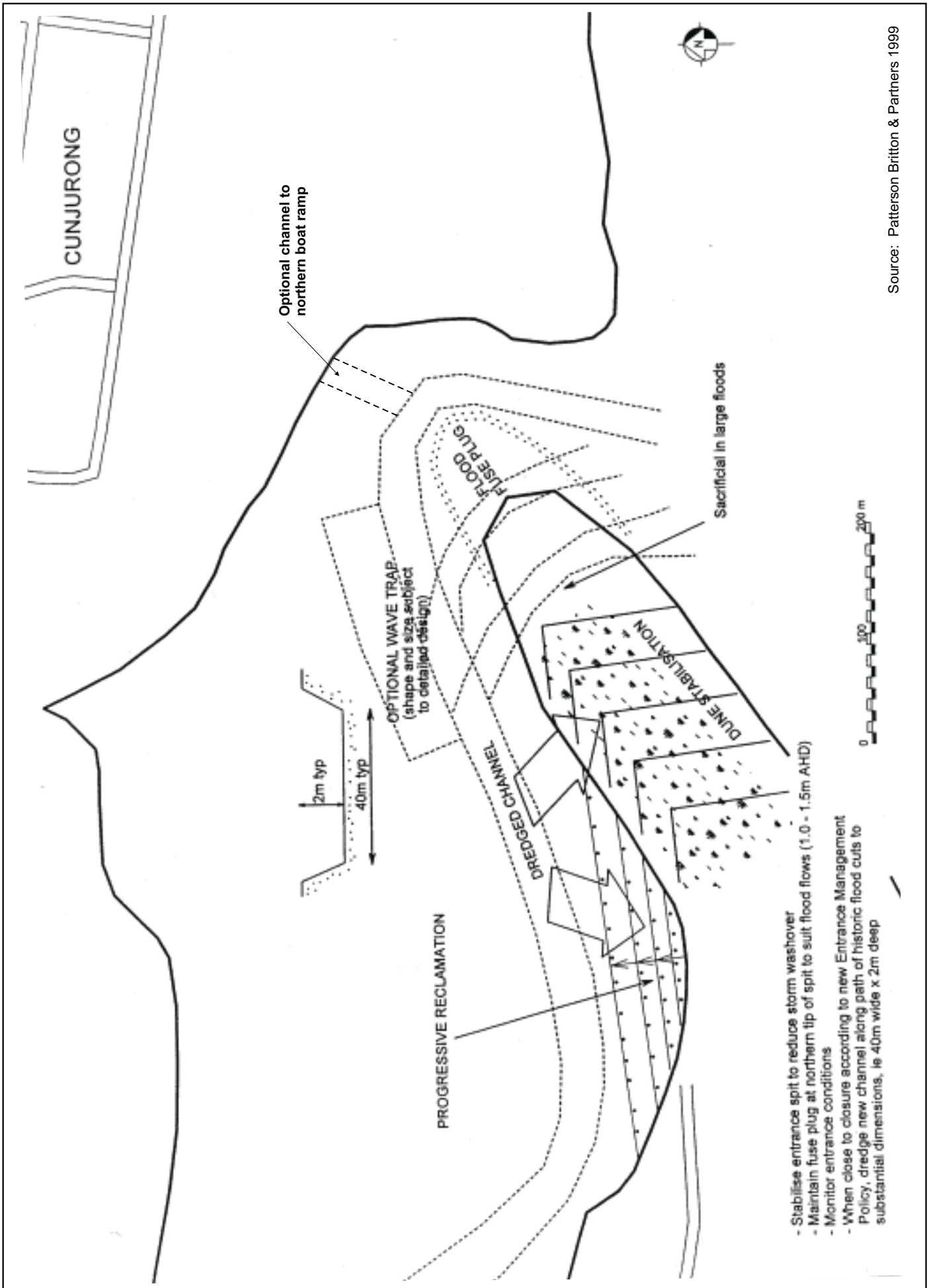
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
STAGE 1 ENTRANCE WORKS 1999

MHL Report 1159

Figure 1.5

DRAWING 1159-01-05.CDR



Source: Patterson Britton & Partners 1999

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
PROPOSED WORKS

MHL Report 1159

Figure 1.6

DRAWING 1159-01-06.CDR

2. Entrance Physical Processes

2.1 Description

Lake Conjola is a relatively deep barrier estuary with steep valley sides and central basin that formed when sea level rose to drown the pre-existing river valley. It is an immature estuary that has remained little modified by fluvial deposition. This is largely because its catchment consists mostly of slowly weathering grits and conglomerates (Shoalhaven City Council 1996). Patterson Britton and Partners (1999) reviewed previous studies and undertook further investigations of the entrance processes at Lake Conjola.

The aerial photograph analyses undertaken by Patterson Britton and Partners (1999) identified four basic entrance states (other than the closed state) of Lake Conjola. These are the *Regime State*, *Flood Scoured State*, *Intermediate State* and *Storm Washover State*. Each of these states are described in Table 2.1.

Table 2.1 Entrance States of Lake Conjola

State	Description
Regime State	The steady end state that the entrance naturally and gradually establishes in the absence of any sudden changes caused by major floods and storms. • Entrance is hard against the northern shoreline and channel is quite small • Small tidal exchange with limited tidal range in lake (average lake level above sea level) • Flood tide delta and low level entrance spit relatively stable but prone to instability.
Flood Scoured	Sudden change caused by a significant flood leading to a net loss of sand from the entrance shoals and widening of the entrance. • Scour enlarges entrance throat, enlarging channel more to the south • Flood tide delta scoured at southern edge and over entire surface • Flood scour deposits placed in nearshore zone as large shallow bar • Due to proximity of flood sediment deposits and increased tidal flows, the entrance is primed for : - rapid onshore movement of previously flood scoured deposits combined with normal longshore transport of sand from Conjola Beach into the entrance area - pronounced net infeed of sediment thereby increasing shoal buildup across flood tidal delta.

State	Description
Intermediate	Characterised by rapid infilling of entrance shoals after a major flood and before reaching regime conditions (1-2 years). • Sediment has mobilised into entrance via onshore movement of flood deposits as well as longshore and wind transport: - entrance spit has migrated northwards - flood tidal delta lobes have built up significantly • These changes combine to reduce tidal flows, though there is still a net infeed of sediment • Entrance will gradually reduce unless reopened by flood • Closure may be catalysed by storm supply of large amount of sediment
Storm Washover	Sudden change caused by major to severe storm waves washing over the entrance spit leading to blocking of the entrance channel. Entrance closure is likely to ensue. • Washout deposits i.e. 'fans' cut off fluvial channel/primary ebb channel • Ebb channel becomes perched on flood delta lobes leading to suddenly and substantially diminished tidal flows • Flood tide tends to re-establish northern perimeter channel • Sediment infeed is reduced but continues to pinch primary ebb channel which eventually disappears • Further washover leads to closure.

Source: Modified from Patterson Britton and Partners (1999)

Photogrammetric analysis undertaken by the DLWC Coastal Branch (cited in Patterson Britton and Partners 1999) revealed that a very high entrance spit evident in the 1940s does not currently exist. The analysis demonstrated an average present infilling rate for the tidal delta of 10,000 m^3 p.a. and an average erosion rate for the entrance spit of approximately 2,000 m^3.

Analysis of entrance surveys taken before and after the August 1998 flood (Patterson Britton and Partners 1999) showed that a flood scoured horizontal distance into the high dunes of up to 30 m. The analysis indicated that the flood of 1998 caused 35,000 m^3 of dune erosion and 17,000 m^3 of channel scour.

Wind data analysis (Patterson Britton and Partners 1999) showed that there is a very strong sand transport potential along Conjola Beach and onshore at a resultant transport direction of 15 degrees east of north. The volume of wind-blown sand ranges from less than 4,500 m^3 p.a to 13,500 m^3 p.a. Wind blown sand reportedly accounts for 50% of the annual growth of the entrance tidal delta.

Investigation of wave data (Patterson Britton and Partners 1999) suggested a longshore transport regime characterised by an average buildup of 50,000 m^3 sand per annum in the northern half of Conjola Beach. At the northern end of the coastal compartment known as Cunjurong Beach, a northerly leakage of the order of 9,000 m^3 sand per annum was estimated.

Tidal hydrodynamics were assessed utilising plots of velocity patterns, RMA modelling and the results of a tidal gauging exercise undertaken on 22 September 1998 (Patterson Britton and Partners 1999). Tidal simulations are reported to have compared very well with the 1998 tidal flow results. Velocity plots showed that under heavily shoaled entrance conditions, peak

tidal velocities do not exceed 0.5 m/second (except near the boat ramp and entrance throat). Tidal velocities are therefore insufficient to cause significant scour of the bed and banks upstream of the boat ramp. The hydrodynamic model results indicated that during the ebb tide, flow is largely confined to the main channel. This results in the ebb tide having a greater duration of about two hours than the flood tide during which flows access minor channels.

Data interpretation presented by Patterson Britton and Partners (1999) indicates that the present annual growth of the tidal delta is 10,000 m^3 per year. Present day erosion of the high dune by tidal scour is adding 2,500 to 5,000 m^3 p.a. to the growth of this tidal delta, while wind-blown sediments contribute approximately 50%. The western edge of the flood tidal delta is currently advancing upstream at 10-30 m a year. A shell layer indicates that the depths of the bends in the main channels upstream of Chinamans Island are caused by periodic flood flows.

An analysis of entrance stability was undertaken by assessing entrance states, monthly rainfall and occurrence of storms (Patterson Britton and Partners 1999). The investigation revealed that each of the eight times the entrance has closed since 1937, closure was triggered by a severe storm. The closures typically last for several years until a large flood scours a substantial entrance channel. It was concluded that periods of entrance stability correspond with periods of little storm activity and the key to improving entrance stability is reducing the destabilising impact of severe storms. This is discussed further in Section 2.2.

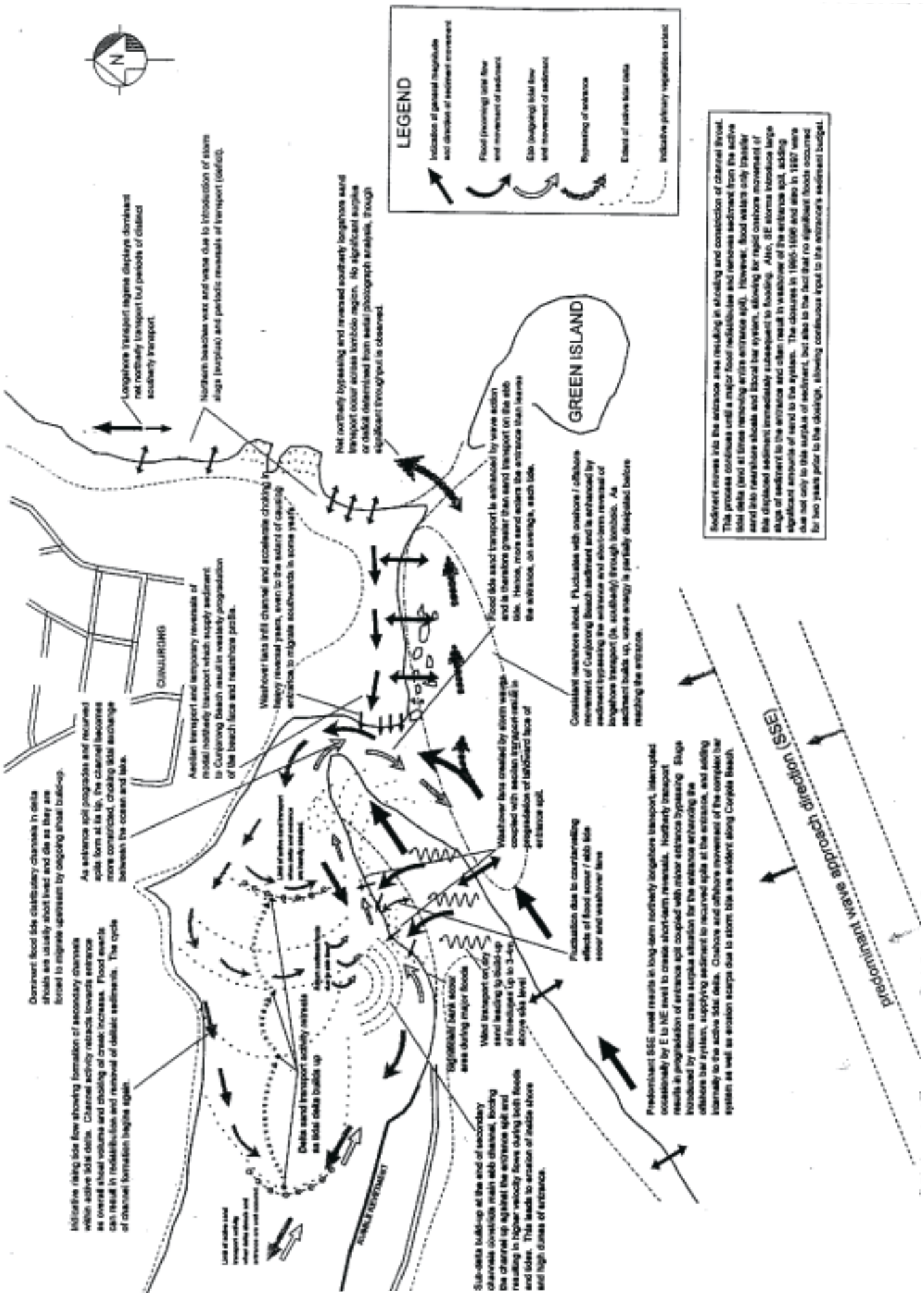
The conceptual model of coastal processes produced by Patterson Britton and Partners (1999) for Lake Conjola entrance is illustrated in Figure 2.1.

2.2 Key Strategies to Maintain an Open Entrance

Based on the entrance process studies and investigation of the causes of past entrance closures, any options for improving entrance stability must utilise as many of the following strategies as possible:

- *Reduce susceptibility to storm washover* - this is the dominant factor in all previous entrance closures.
- *Manage and contain wind-blown sand* – wind-blown sand can contribute half of the sand supply to the entrance shoals unless effectively trapped.
- *Reduce littoral sand infeed* - there is a strong northerly longshore sand supply which enhances flood tide transport into the entrance.
- *Locate entrance to the north* - the northern foreshore has least exposure to wave energy because of the Green Island waveshadow and the wave energy dissipation caused by the nearshore shoals.
- *Reduce or modify wave penetration of entrance* - wave stirring enhances ability of flood tide to transport sand across tidal delta surface.
- *Don't let entrance close* - once the entrance closes, subsequent sand build-up across the delta surface necessitates high lake levels to effectively re-open the entrance.

- *Nullify effect of storm washover* - in the event of a storm washover which cripples the entrance, by perching the main channel, immediately cut a new channel through or around the washover. Otherwise the entrance will close and subsequent sand build-up will necessitate a substantial rise in lake level to scour a new entrance. The channel cut should be of sufficient size to effectively re-open the entrance. The new channel should be cut as far to the north as is practicable.



Source: Patterson Britton & Partners Pty Ltd 1999

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
CONCEPTUAL MODEL OF COASTAL PROCESSES

MHL Report 1159

Figure 2.1

DRAWING 1159-02-01.CDR

3. The Entrance Management Works

3.1 Dredging

The managed entrance policy requires that at the appropriate time a new channel be dredged along the path of the historic flood cuts. The Entrance Management Study (Patterson Britton and Partners 1999) specified that the dimensions of the channel should be 40 m wide at the base, 2 m deep with side slopes of approximately 1:3 (V:H). The layout of the channel is shown in Figure 1.6. Dredging would be carried out from approximately 200 m upstream of the southern boat launching ramp to approximately the alignment of the low water mark along the beach face, or as far as it is possible for the dredge to operate safely at the entrance. The volume of sand required to be dredged to provide a channel with the above dimensions will depend on the entrance bathymetry at the time of dredging, but is estimated to be of the order of 100,000 m^3.

An optional substantial sand/wave trap (as shown in Figure 1.6) could be dredged at the same time as the channel to increase the interval between dredging. The purpose of the wave trap would be to divert a significant proportion of the flood tide away from the main ebb channel and dissipate wave energy, capturing marine sand feeding in through the entrance. The wave trap would have dimensions of the order of 100 m x 200 m x 2-3 m deep but would require detailed design for the conditions at the time of dredging. The estimated volume of sand to be dredged to create the wave trap is 50,000 m^3. Patterson Britton and Partners (1999) estimated that the trap would be likely to infill at 10,000 m^3 per year and would require dredging approximately every five years. A further option would be the dredging of access to the northern boat ramp. This would require dredging a channel approximately 100 m long, 25 m wide to a depth of approximately 1.5 m. The volume to be dredged would depend on the conditions at the time but would be approximately 4,000 m^3.

The estimated time between maintenance dredging works was estimated by Patterson Britton and Partners (1999) as greater than ten years without a wave trap and between 10 and 15 years with a wave trap. The total present value cost of entrance works was estimated by Patterson Britton and Partners (1999) as $0.7 million without a wave trap and $1.9 million with a wave trap.

As dredging of the channel will yield sufficient sand for raising the sand spit and as adding the sand trap reduces the benefit cost ratio from 1.14 to 0.42 it is recommended that the sand trap not be constructed. The dredging of navigable access to the northern boat ramp would add comparatively little cost to the project. The dimensions of the new main channel were not based on rigorous modelling of entrance hydrodynamics. Significant savings would be realised if the dimensions of the channel were reduced. It is recommended that hydrographic surveys of the entrance channel be carried out at regular intervals and following significant changes caused by flood or storm events. This information, combined with records from the water level recorder and decision support system, will provide data for optimisation of the dredged channel design.

3.2 Dune Construction

The managed entrance policy requires the southern part of the entrance spit to be built up to a level of about RL 7.0 m AHD and stabilised so that it is not susceptible to storm washover. The northern part (approximately 200 m) of the spit should not be raised above RL 1.0–1.5 m AHD so that the entrance will be free to scour to its full width during major floods. The area to be built up and stabilised and the sacrificial fuse plug area are shown in Figure 1.6. The area on the southern bank scoured following the 1998 opening should be progressively reclaimed during the dredging operation.

Dredged sand should be discharged to the entrance spit in the area where the dune is to be constructed directly from the delivery line. Sand should be allowed to build up to the approximate required level (RL 7.0 m AHD) over the southern area of the spit. The dune should be subsequently shaped to the natural dune shapes of the area by a bulldozer. Sand fencing should be installed and natural vegetation planted according to guidelines from the Department of Land and Water Conservation. The approximate area covered by the raised dune will be 40,000 m^2.

3.3 Material Quantities and Indicative Costs

Estimated material quantities for the entrance works are summarised in Table 3.1. Actual quantities will depend on the conditions at the time and the final design of the works. Estimated unit costs are shown in Table 3.2.

Table 3.1 Entrance Works Estimated Quantities

Item	Quantity	Comments
Dredging	100,000 m^3	Design optimisation may reduce volume
Reclamation	5,000 m^3	Southern bank
Dune nourishment	95,000 m^3	Balance of spoil after reclamation
Dune stabilisation	40,000 m^2	Vegetation and wind protection
Dune fencing	700 m	

Table 3.2 Entrance Works Estimated Unit Costs

Item	Unit Cost (2002)	Comments
Dredging	\$6/ m^3	Includes placement, allow \$50,000 establishment/disestablishment cost
Dune stabilisation	\$3/m^2	Vegetation and wind protection
Dune fencing	\$5/ m	

4. Monitoring

4.1 Monitoring

Monitoring of the entrance is essential to manage a sustainable, long-term open managed entrance. Monitoring will allow identification of early signs of closure, allow evaluation of the health of the estuary and provide additional data to facilitate optimisation of the decision support system and the design of the dredging works.

MHL currently operates a water level monitoring station and rain gauge on behalf of Shoalhaven City Council in the entrance inlet, approximately 200 m upstream of the southern boat ramp. The water level data will provide the tidal input to the decision support system (see Chapter 5) to allow identification of increasing entrance constriction and trigger the entrance works. The rain gauge will provide data for estimating flood flows.

Shoalhaven City Council monitors water quality at four locations in Lake Conjola – the entrance boat ramp (Site 39), at the end of Milham Street (Site 49), Yoralla Bay (Site 479) and in the main body of the lake (Site 477). Annual results are presented in the SCC State of the Environment Report.

MHL monitors ocean wave conditions using seven Waverider buoys along the New South Wales coast. The closest Waverider sites to Lake Conjola are Port Kembla, Batemans Bay and Sydney. Both the Batemans Bay and Sydney buoys provide directional wave records. Waverider data will provide data for evaluating the effects of ocean storm waves.

Wave and rainfall records will be accessible on both the password-protected and public web sites to enable correlation with the measure of entrance constriction from the decision support system.

Analysis of aerial photos of the entrance was carried out by Patterson Britton and Partners (1999) for the years 1944, 1945, 1948, 1959, 1964, 1967, 1971, 1972, 1977, 1979, 1981, 1985, 1986, 1987, 1991, 1993 and 1997. These allowed identification and classification of the entrance condition at the time and correlation of the condition to preceding environmental events, particularly ocean storm events and rainfall.

A complete hydrographic survey of Lake Conjola was carried out by the Department of Public Works and Services in December 1992 and January 1993. The survey is reproduced at reduced scale as Appendix A. A survey of the southern part of the entrance area and part of the spit area was carried out by G A Goodman Surveys Pty Ltd for Shoalhaven City Council on 15 November 1999. The survey drawing shows details of the proposed interim entrance works.

4.2 Recommended Monitoring

It is recommended that measures be put in place to ensure the following environmental monitoring be continued or undertaken.

- continuous water level monitoring (currently undertaken)
- continuous rainfall monitoring (currently undertaken)
- regular water quality monitoring in the entrance inlet (currently undertaken) and specific monitoring following significant events
- regular monitoring of vegetation on the entrance spit
- regular wildlife survey on entrance spit
- annual hydrographic survey at key cross-sections across entrance channel and surveys after significant events
- annual survey of key sections across the entrance spit and after significant events
- annual small format aerial photography of entrance area and following significant events.

The estimated cost of monitoring additional to that currently undertaken is $20,000 p.a.

4.3 Database

Data collected by MHL is stored in a controlled, accessible database. It is recommended that Council establish a register of where relevant data collected by Council or other agencies is stored. Where it is not stored in a secure database that can be readily accessed in the future Council should acquire the data and place it in a secure database.

5. The Decision Support System

5.1 Description of the System

The decision support system is the key to maintaining a permanently open entrance. The aim of the system is to provide advance warning of entrance closure so that the essential activities that have to be carried out prior to the entrance works can be set in train to enable dredging to commence before closure. It is estimated that the pre-dredging activities will take a minimum of three months.

The identification of entrance constriction is based on work carried out and published by John Hinwood of Monash University and Errol McLean of the NSW Department of Land and Water Conservation (McLean and Hinwood 2000). The system will carry out a running harmonic analysis over a 30-day period of the Lake Conjola tidal data. The harmonic analysis will yield the principal lunar semi-diurnal tidal constituent M2 which has been shown to provide a good indicator of entrance constriction. The method overcomes the difficulty in identifying the slow decline in tidal range, due to shoaling, within tides that vary in range from tide to tide.

Manly Hydraulics Laboratory has maintained a water level recorder in the entrance channel since September 1992. The only closure event for which records are available is the closure at the beginning of November 1994. To test the method a harmonic analysis was conducted over the whole period of data and the constituents obtained and analysed. It was determined that the majority of the constituents were either unstable or insignificant over the period of analysis, however the M2 constituent showed a good correlation to the level of constriction of the entrance. During the period preceding the last closure in 1994 there was a reduction in the value of M2 which corresponded to the increasing constriction of the entrance and physical events (see Figure 5.1).

The process of entrance closure is a long-term process. The system needs to be flexible and evolving. In particular the trigger values need to be carefully monitored and compared to the physical conditions to allow the values to be refined with time. The water level data also requires quality control to correct missing or erroneous data as this has a major impact on the calculated M2 values. As the M2 values are determined from a rolling analysis of 30 days data the data errors affect a considerable period of data which can lead to a wrong interpretation of entrance constriction.

5.2 Trigger Conditions

The trigger conditions for the decision support system have been based on the 1994 entrance closure. The plot of the M2 constituent for this event and the proposed trigger levels are shown in Figure 5.1.

Four trigger levels have been set. The values of M2 and the conditions for each level are as follows:

Trigger Level A – Monitor Closely. M2 Values 0.15 – 0.08
Early signs of increasing entrance constriction.

Trigger Level B – Activate Plan. M2 Values 0.08 – 0.06
Constriction increasing, increasing risk of closure if major ocean storms occur but entrance may scour if there is a major flood. Commence pre-dredging activities. If a flood scours entrance during pre-dredging activities and M2 exceeds 0.15 put dredging on hold.

Trigger Level C – Possible Closure. M2 Values 0.06 – 0.03
Entrance constricted. Complete pre-dredging activities and commence dredging.

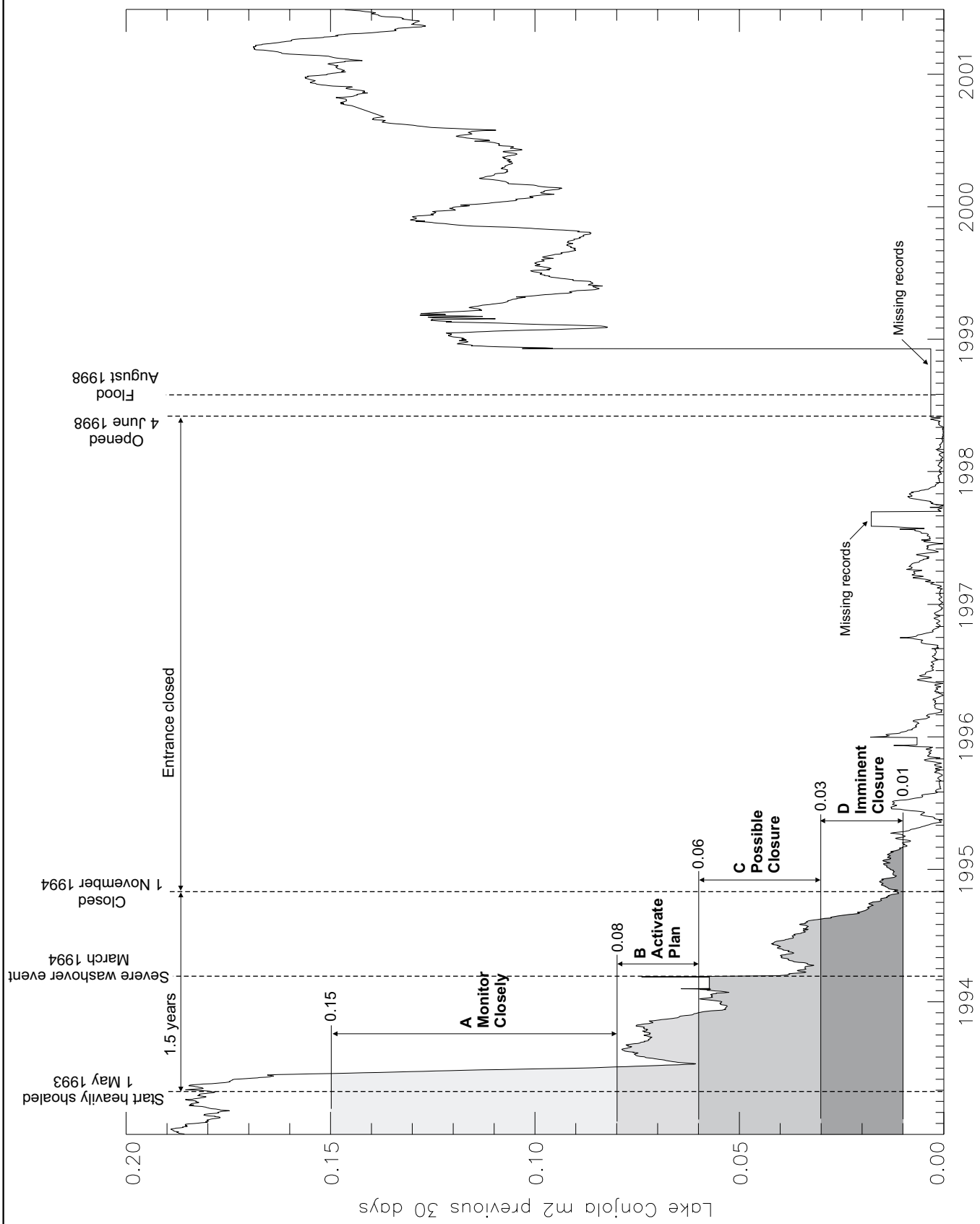
Trigger Level D – Imminent Closure. M2 Values 0.03 – 0.01
It is imperative that dredging commence as soon as possible.

It can be seen from Figure 5.1 that for the 1994 closure there was a period of almost 16 months from Trigger Level B – Activate Plan to closure.

5.3 Operation of the System

Manly Hydraulics Laboratory will operate the decision support system on behalf of Shoalhaven City Council for at least the first year. The system will be hosted on Shoalhaven City Council's web page on the MHL web site. This web page has password-protected access for Council officers. Information will also be available on an additional public access page. The system will provide a rolling assessment of M2 tidal constituent against time and access to offshore wave height, period and direction; and rainfall. Selected Council officers will be notified via e-mail, fax or SMS when M2 reaches key trigger levels.

Manly Hydraulics Laboratory will also produce the annual summary report for the commitment document on Council's behalf. The report will include a summary of the entrance performance over the year and an annual summary of the above environmental data. Hard and electronic copies of the report will be supplied for distribution by Council. The report will also be displayed on the public access web page.



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

LAKE CONJOLA ENTRANCE
TRIGGER CONDITIONS SUPERIMPOSED ON PLOT OF M2 VERSUS TIME FOR 1994 ENTRANCE CLOSURE

MHL Report 1159

Figure 5.1

DRAWING 1159-05-01.CDR

6. The Management Plan

6.1 Activities

The key activities within the Management Plan are shown below.

Table 6.1 Management Plan Activities

Activity	Responsibility
Monitoring water levels and rainfall	MHL while under contract to DLWC
Operation of decision support system	MHL while under contract to SCC
Environmental monitoring	SCC
Production of annual commitment report	MHL while under contract to SCC
Distribution of annual commitment report	SCC
Maintenance of commitment document	SCC
Initiation and management of plan activities	SCC
Sourcing funding	SCC to source from DLWC
Approvals from DLWC, Fisheries, NPWS	SCC
Surveys	SCC
Scheduling	SCC
REF update and submission	SCC
REF determination	SCC, NSW Fisheries, NPWS, DLWC
DA and SEE production submission	SCC
DA determination	SCC
Tender documentation	SCC
Tendering activities	SCC
Community liaison	SCC

6.2 Funding

The source of funding for entrance activities will be the Department of Land and Water Conservation. The cost of the works will be of the order of $800,000 (estimate in 2002, see Section 3.3). The final cost will depend on the final design and the tender process. As much lead time as possible will be required for allocation of funding. DLWC should be regularly kept informed of the state of entrance constriction and should receive the annual commitment document report.

6.3 Approvals

As outlined in the REF, approvals will be required from NSW Fisheries for dredging and NPWS for operations near the Little Tern nesting area and permission for beach access for the bulldozer to carry out grooming of the raised dune area.

Under the Crown Lands Act it is an offence to '*clear, dig up or cultivate public land*' or '*interfere with any substance, whether on or in, or forming part of, public land,*' without a licence or lease granted under the Act. At Lake Conjola the lake entrance bed and spit are defined as 'public land'. The Minister for Crown Lands may issue a licence or lease under the Act, but must consider an EIS or REF before granting a licence for entrance management works.

The Act provides for a program of land assessment that is to consist of preparation of an inventory of Crown land, an assessment of the capabilities of the land and identification of suitable uses for the land and, where practicable, the preferred uses. The Minister is to maintain an inventory of the physical characteristics of the land and other matters affecting the land, as are necessary to assess the capabilities of the land. These are to be used in identifying suitable or preferred uses.

As the bed of Lake Conjola and the spit are Crown land, the entrance works will require a lease or licence (Karen Stephens, DLWC pers. comm. 2002). Before this lease or licence is issued DLWC must be satisfied that the use is consistent with the land assessment. As there is not an existing land assessment for Lake Conjola, approval will require a waiver from the Minister for Land and Water Conservation (or someone with ministerial delegation, such as a Deputy Director General). Rob Michely (pers. comm. 2002) of DLWC Nowra suggested that this could be put together based on the information provided in the Review of Environmental Factors and the Entrance Management Plan. In order to avoid having to repeat this exercise, an ongoing licence should be sought, which would require payment of an annual fee (fees start at $70 pa).

6.4 Environmental Constraints

The dredging and dune operations will have to be timed to avoid the Little Tern nesting season from November to March. NPWS should be consulted regarding the timing. The works should also be timed to avoid the peak summer tourist period (which coincides with the Little Tern nesting). Consideration should also be given to the Easter holiday period. If possible dredging should be carried out in winter to minimise impacts on benthic invertebrates.

6.5 Review of Environmental Factors

The Review of Environmental Factors prepared to accompany this Entrance Management Plan may have to be revised to accommodate changes that have taken place since its preparation. Potential areas for revision would be the section on relevant environmental planning instruments, changes to the existing environment and the specific layout of the works. An updated eight part test may also have to be carried out.

The environmental monitoring outlined in Chapter 4 will facilitate updating the REF.

6.6 Surveys

Prior to dredging and building up the dunes a hydrographic survey of the entrance channel should be carried out to allow final design of the works and an estimate of dredge quantities. It would be advisable to include the same cross-sections surveyed in the 1992/93 survey to allow comparison. The Department of Land and Water Conservation operates a JetSki-based survey craft equipped with survey standard echo sounding and GPS equipment and comprehensive data logger. This craft would be ideal for surveying the shallow waters of the entrance channel and would provide a complete coverage at a competitive cost.

The dune area should also be surveyed prior to the works to allow the dune works to be designed and laid out.

It is also recommended that the regular hydrographic surveys and environmental monitoring in noted in Chapter 4 be carried out to provide information for optimising the decision support system and the environmental monitoring program.

6.7 Final Design

The final design of dredging, dune nourishment and reclamation of the eroded southern bank of the inlet channel should be carried out following the hydrographic survey. The process will need to balance the quantities to be dredged from the channel with the quantities for reclamation and dune nourishment. If there is enough hydrographic survey data available from monitoring the entrance channel configuration to allow correlation with the constriction indicated by M2 values and to calculate hydraulic parameters, there may be considerable scope to optimise the channel dimensions and reduce quantities.

6.8 Dredging Issues

The preliminary estimated quantity to be dredged is 100,000 m^3. This quantity should be refined following the pre-dredging hydro-survey and final design.

Based on experience from the 1999 dredging a 200 mm cutter suction dredge is recommended. In the opinion of the 1999 dredging contractor a 250 mm dredge would be too big. The equipment would be transported to site by low loader and assembled at the southern ramp. Two semi-trailer loads would be required for the dredge and one for pipes. The total number of truck loads would be approximately five. A mobile crane would be required for assembly. A week would be required for set up at the commencement of the project and a week for disestablishment at the end of the job. Production is estimated at approximately 500 m^3 per day. Depending on the final estimated quantity and the time available it may be necessary to utilise two dredges to complete the task in a reasonable time. It is not feasible to measure production by pre and post-dredge survey as the channel backfills rapidly during work. The preferred method is to dredge to the required depth, the superintendent to sign off and to survey the delivered volume on the spit to calculate quantities. The entrance channel is a difficult site for dredging due to the strong currents requiring anchors (rather than spuds) for location in the channel.

Based on experience from the 1999 dredging there is no dirty water runoff from the dredge spoil due to the well-washed nature of the sand.

6.9 Spit Issues

Following determination of the dredging quantity and survey of the spit the dune works should be laid out and the discharge point(s) identified. At the appropriate time a bulldozer will be required to distribute sand to the design shape. If possible the reclamation along the southern bank of the entrance should be carried out early in the dredging program to allow bulldozer access along the southern shore. Otherwise access to the beach (at the point shown in Figure 1.1) will have to be negotiated with NPWS. Measures for protection of the Little Tern nesting area and timing of works will also have to be negotiated with NPWS.

Control of public access to the spit and appropriate safety measures will have to be put in place during the works.

6.10 Contract Issues

A tender process will have to be undertaken prior to issuing a contract. Contract administration will then have to be carried out during the course of the contract. These will require the following activities.

- Prepare tender documents. Council will most likely have a standard form of contract. Specialist input may be required for technical specifications.
- Call tenders. This will require advertising and acceptance of tenders.
- Appoint contract superintendent to represent Council.
- Assess tenders received and award tender.
- Enter into contract.
- Monitor operations including environmental and OHS safeguards. Verify quantities and authorise payments.
- Sign off at completion of contract.

6.11 Community Issues

As part of management of the entrance it will be necessary to keep the Task Force and community informed of the ongoing monitoring of the entrance and the current level of constriction. This can be done through the regular committee meetings, by advertising the address of the website and distribution of the annual report.

When trigger level B is reached and the plan is activated it will be particularly important to inform the local community of the situation. The most effective means of doing this may be through a press release to the local paper. Similarly when a tender for works is let it will be particularly important to inform the community. This may best be achieved through a press release combined with a letter box drop providing information on starting dates for works and possible disruptions to access to the lake and spit.

During works it will be important to maintain access to launching ramps where this is compatible with public safety.

6.12 Actions and Timing Checklist After Trigger Level B

A draft action checklist is shown in Table 6.2 for actions after Trigger Level B is reached. The list should be used as a basis for developing an achievable checklist to ensure entrance works commence as soon as possible after the plan is triggered.

Table 6.2 Draft Action Checklist

Week	Action
1	Inform DLWC and formally apply for funding. Inform Task Force, other agencies and community. Determine possible time window for works to accommodate Little Tern nesting and tourist season. Initiate entrance hydrographic survey and spit survey. Initiate final design of works. Initiate REF update and generation of SEE for dune works. Initiate preparation of DA for dune works. Initiate approval applications to Fisheries, NPWS and DLWC.
4	Submit DA and SEE. Submit REF. Call tenders.
8	Close tenders. Assess tenders.
10	Gain funding approval. Gain all other approvals. Award tender.
12	Commence works.
30	Finish works.

6.13 Contact List

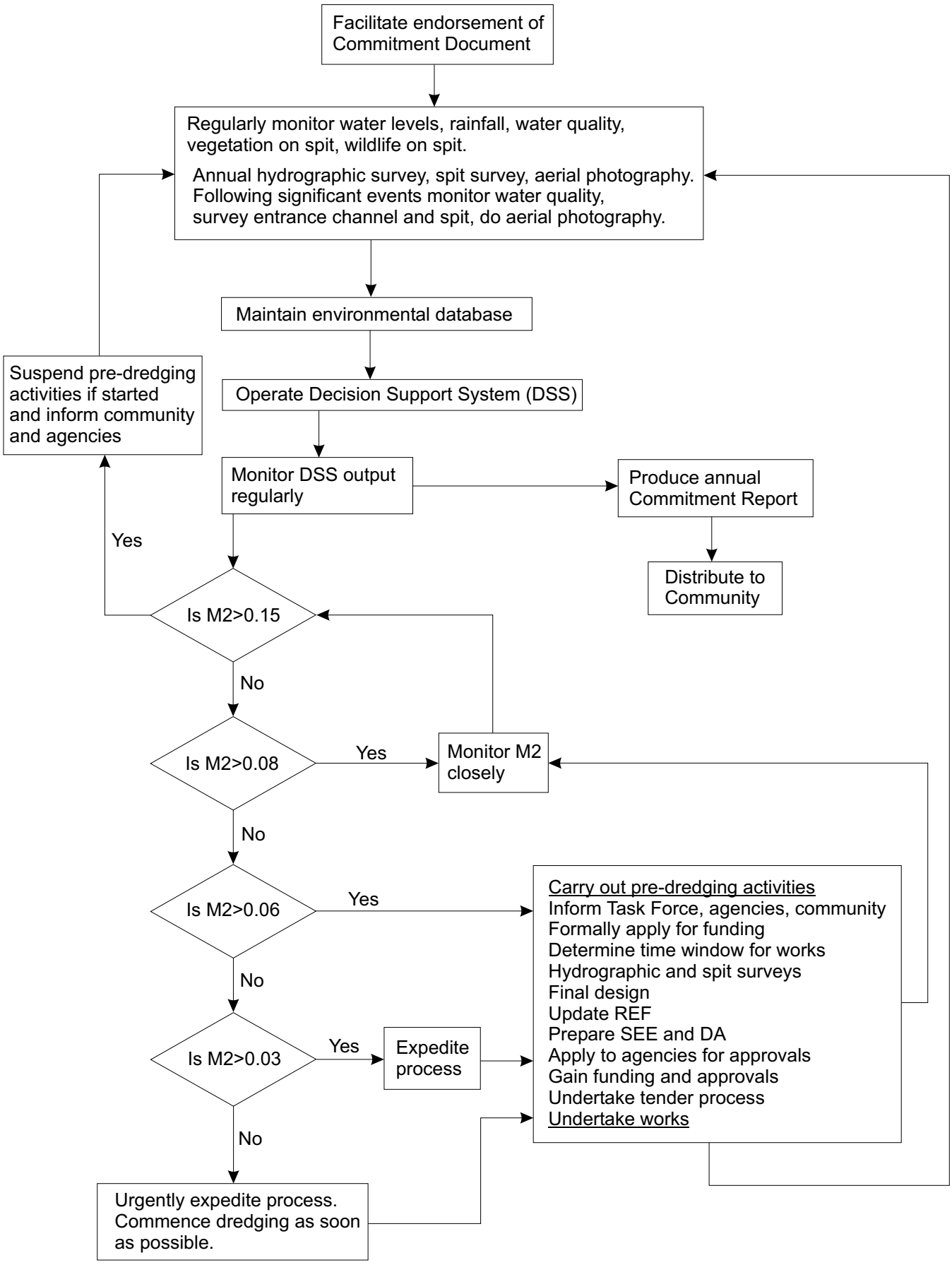
It is recommended that an up-to-date contact list for key stakeholders be maintained and distributed to expedite liaison between stakeholders.

Table 6.3 Key Stakeholders Contact List

Organisation	Contact	Phone	email
SCC	Martin Bergs	4429 3111	bergs@shoalhaven.nsw.gov.au
DLWC	Wollongong Office	4224 9600	
NSW Fisheries	Shoalhaven Office	4423 2200	
NPWS	Southern Directorate	6298 9700	
EPA	South Coast Office	4226 8100	
MHL - Management Plan	Bob Cook	9949 0200	rcook@mhl.nsw.gov.au
MHL - Decision support system	Bronson McPherson	99490200	bmcpherson@mhl.nsw.gov.au

6.14 Summary of Entrance Management Plan

The Entrance Management Plan is summarised in the flow chart shown in Figure 6.1.



NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
MANLY HYDRAULICS LABORATORY

FLOW CHART SUMMARY
OF THE ENTRANCE MANAGEMENT PLAN

MHL Report 1159

Figure 6.1

DRAWING 1159-06-01.CDR

7. The Commitment Document

The continued commitment document is an agreement with Council and Government agencies to undertake the activities required to ensure that the lake entrance will not close. The document is an agreement in principle to the plan by all parties and a clear description of the actions and funding required. The document summarises:

- the main requirements for maintaining an open entrance
- the main physical processes involved
- the implications for flooding, water quality and ecological processes
- the actions/strategy required, and by whom, to maintain the open entrance
- the areas of responsibility of Council and government agencies relevant to the Entrance Management Plan
- the required funding and funding sources to implement the plan
- implication for the operation of the plan if various elements of the strategy are not implemented.

This document will be submitted to Council and relevant government agencies for their comment, revision and ultimate endorsement. The document will be held by Council and will be made available to the Task Force and general public, as well as Council and relevant government agencies. To ensure the plan operation remains in the minds of stakeholders an annual report on the operation of the plan will be produced by Manly Hydraulics Laboratory. This annual report would be submitted to stakeholders by Council with a response form to be returned by stakeholders covering inter alia, any non-conformance with the endorsed actions/strategy set out in the document.

The commitment document is included as Appendix B.

8. Conclusions and Recommendations

The Entrance Management Plan contains an overview of the decision support system to identify when works should be implemented to maintain a permanently open entrance, and the actions required to implement the works.

Management of the entrance will be an ongoing activity and it may be many years before entrance works are implemented. It is therefore important that changing conditions are monitored and that the management plan is continually updated to accommodate these changes. Areas of change will include not only the entrance channel and environmental and ecological conditions, but the planning and legislative framework. These will affect the approval process at the time entrance works are implemented. Environmental monitoring will provide the data to optimise design of the works and to keep the information in the REF and SEE up to date, while keeping abreast of changes to the approval process will allow the required documentation to be prepared in good time.

The key to maintaining a permanently open entrance will be the decision support system which will allow early initiation of the actions to carry out the entrance works before closure. An obvious commitment to the decision support system and the overall entrance management plan by Council and Government agencies, and appropriate communication with the local community, will help ensure community support of the managed entrance concept.

9. References and Bibliography

Kevin Mills and Associates Pty Ltd 2000, *Ecological Assessment Proposed Stage 1 (Interim) Works Conjola Lake Entrance City of Shoalhaven*, Shoalhaven City Council, February 2000.

McLean E J and Hinwood J B 2000, *Modelling Entrance Resistance in Estuaries*, Coastal Engineering 2000.

McLean E J and Hinwood J B 1999, *The Impact of a Major Storm Event on Entrance Conditions of Four NSW Coast Estuaries*.

Narrabeen Lagoon Joint Estuary/Floodplain Management Committee 1996, *Management Policy for Narrabeen Lagoon Entrance*, Warringah and Pittwater Councils November 1996.

NSW Department of Public Works and Services 2003, *Lake Conjola Entrance Management Dredging Works Review of Environmental Factors*, Manly Hydraulics Laboratory Report No. 1161 (DPWS Report No. 01116).

Patterson Britton and Partners 1999, *Lake Conjola Entrance Study, Shoalhaven City Council*, Issue No. 2 May 1999.

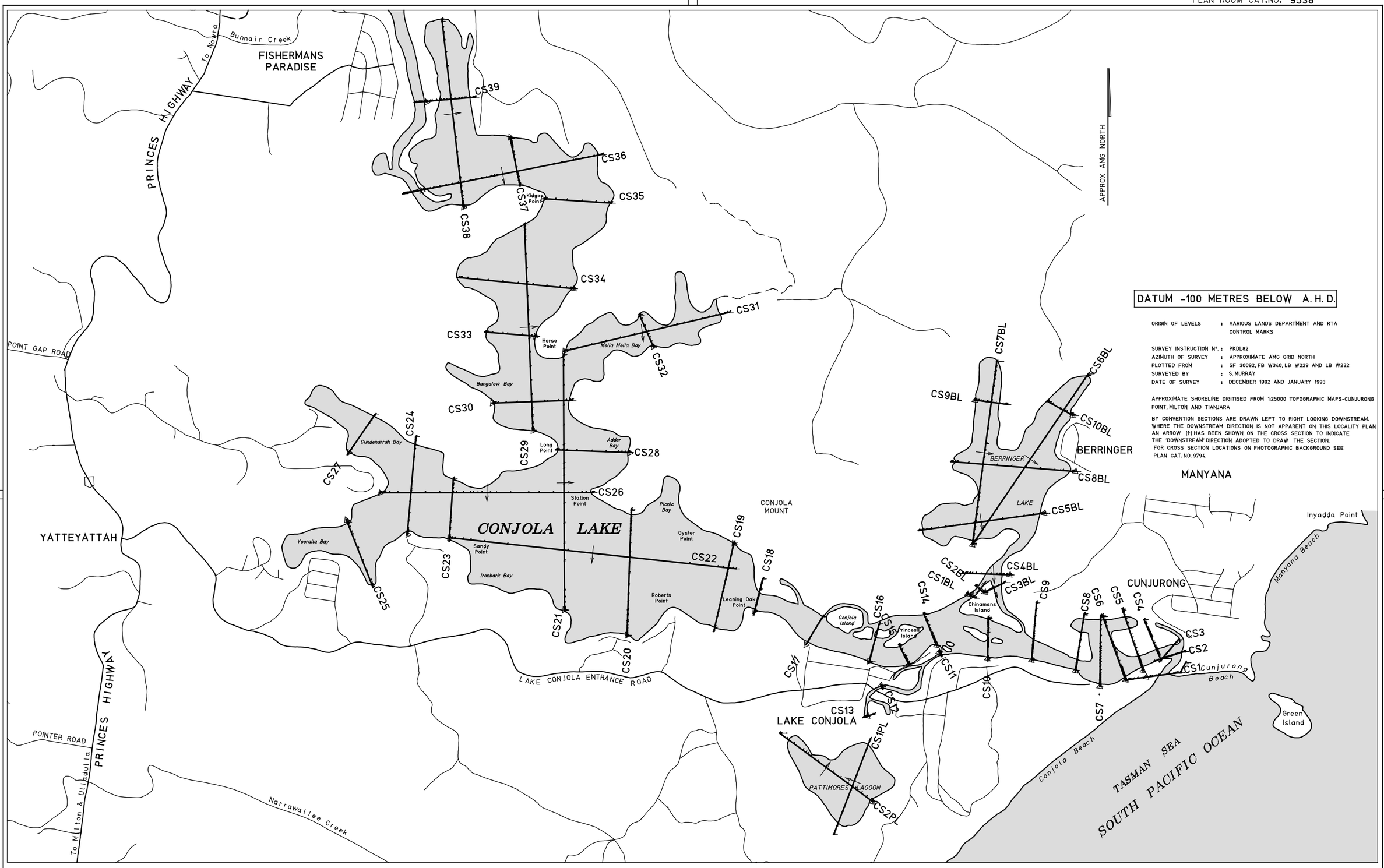
Shoalhaven City Council 1996, *Lake Conjola Stage 1 Estuary Processes Study Draft*, Shoalhaven City Council and NSW Department of Land and Water Conservation, August 1996.

Shoalhaven City Council 1999, *Lake Conjola Estuary Management Plan*, June 1999.

Shoalhaven City Council 1999, *Lake Conjola Entrance Stage 1 (Interim) Works, Review of Environmental Factors*, Issue No. 1 November 1999.

Appendix A

1992-1993 Hydrographic Survey



DATUM -100 METRES BELOW A.H.D.

ORIGIN OF LEVELS	:	VARIOUS LANDS DEPARTMENT AND RTA CONTROL MARKS
SURVEY INSTRUCTION N°.	:	PKDL82
AZIMUTH OF SURVEY	:	APPROXIMATE AMG GRID NORTH
PLOTTED FROM	:	SF 30092, FB W340, LB W229 AND LB W232
SURVEYED BY	:	S. MURRAY
DATE OF SURVEY	:	DECEMBER 1992 AND JANUARY 1993

APPROXIMATE SHORELINE DIGITISED FROM 1:25000 TOPOGRAPHIC MAPS-CUNJURONG POINT, MILTON AND TIANJARA

BY CONVENTION SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM. WHERE THE DOWNSTREAM DIRECTION IS NOT APPARENT ON THIS LOCALITY PLAN AN ARROW (↑) HAS BEEN SHOWN ON THE CROSS SECTION TO INDICATE THE 'DOWNSTREAM' DIRECTION ADOPTED TO DRAW THE SECTION.
FOR CROSS SECTION LOCATIONS ON PHOTOGRAPHIC BACKGROUND SEE PLAN CAT. NO. 9794.

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:10000 FOR THE PURPOSE OF A CROSS SECTION LOCALITY PLAN AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY
CROSS SECTION LOCALITY PLAN

SHEET 1 OF 19 SHEETS

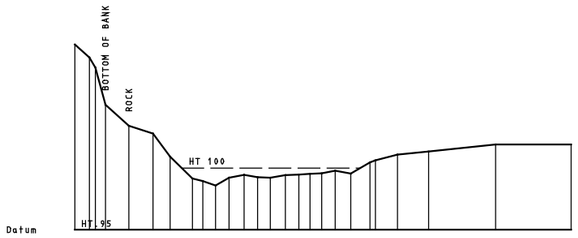
FILE F207

DRAWING NO.

B. 50789

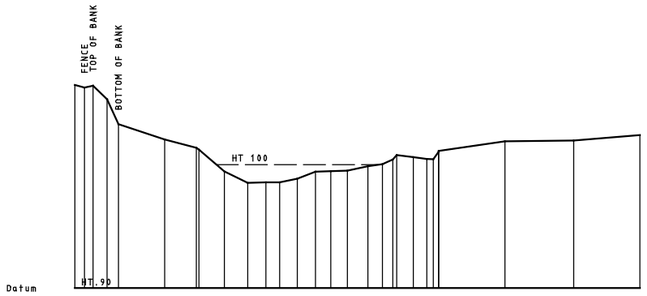
G:\IS\SAS\SVPRO\spf\CONJOLA\15285H1.DGN 24 JAN 2000 $(user) 09:38:16

679 0 100 200 300 960



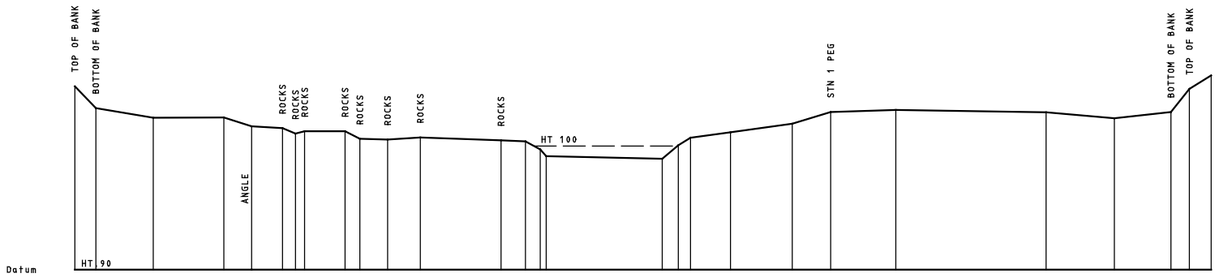
Chainage	Height
0.0	110.0
5.9	108.9
8.3	108.2
12.4	105.1
21.9	103.4
31.7	102.8
38.7	100.9
47.7	99.2
51.9	98.8
57.1	98.6
62.5	99.2
68.6	99.5
74.1	99.3
79.3	99.2
85.4	99.4
90.9	99.5
95.4	99.5
100.1	99.6
105.6	99.8
111.9	99.6
117.9	100.5
121.8	100.8
130.9	101.1
143.5	101.3
170.6	101.9
201.3	101.9

SECTION 3



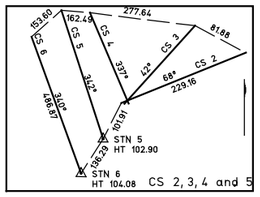
Chainage	Height
0.0	106.5
3.9	106.3
7.4	106.4
13.1	105.3
17.7	103.3
36.4	102.1
52.3	101.4
53.3	101.2
60.6	99.5
70.1	98.5
77.5	98.6
83.1	98.6
90.2	98.9
97.6	99.4
103.8	99.5
110.5	99.5
118.9	99.9
124.7	100.1
130.0	100.4
131.3	100.6
142.7	100.6
144.6	100.5
145.2	100.5
147.6	101.1
174.4	101.9
202.3	102.0
229.2	102.4

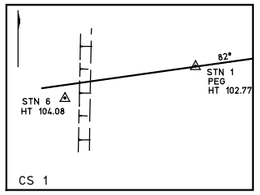
SECTION 2



Chainage	Height
0.0	104.8
8.5	103.1
31.8	102.3
60.4	102.3
71.7	101.6
84.2	101.5
89.5	101.0
93.2	101.2
109.6	101.2
115.6	100.6
126.8	100.5
140.1	100.7
172.8	100.5
182.7	100.4
187.7	99.7
189.2	99.2
238.2	99.0
244.7	100.1
249.7	100.7
265.9	101.1
290.9	101.8
306.5	102.8
332.9	102.9
393.9	102.8
421.6	102.3
444.5	102.8
452.0	104.6
469.8	105.7

SECTION 1





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF, ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
S. MURRAY
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 1,2&3

SHEET 2 OF 19 SHEETS

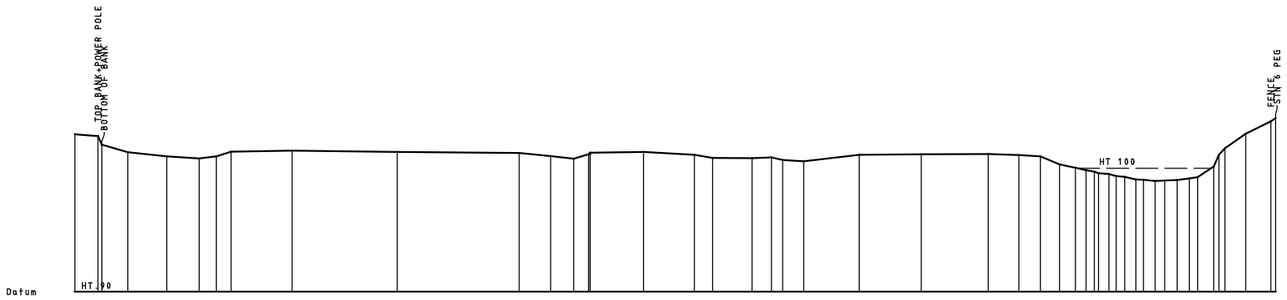
FILE F207

DRAWING NO.

B.50789

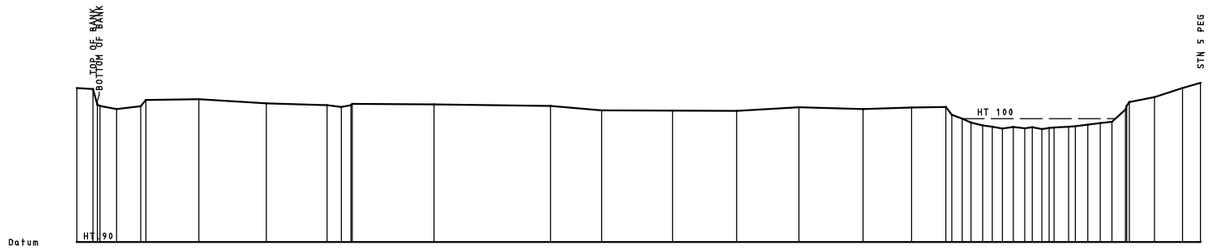
G:\IS\SASISVRO\yef\CONJOLA\9538S02.DGN
01:01:03 24 JAN 2000 $(user)

679
0 100 200 300
960



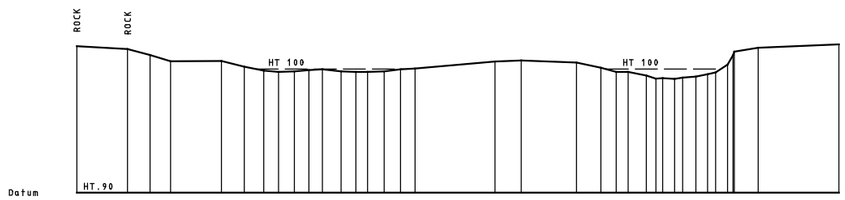
Chainage	Height
0.0	102.8
11.6	102.8
12.8	102.8
21.5	101.3
37.3	101.0
50.4	100.8
57.4	101.0
63.4	101.4
88.1	101.4
130.7	101.3
180.2	101.3
193.0	101.0
202.3	100.8
208.3	101.1
209.0	101.3
230.6	101.3
251.3	101.1
258.6	100.9
274.6	100.8
282.5	100.9
287.0	100.7
295.6	100.6
318.1	101.1
343.2	101.1
370.4	101.2
382.8	101.1
391.6	101.0
399.3	100.3
405.8	100.0
410.1	99.7
413.5	99.6
417.3	99.6
422.3	99.4
430.3	99.1
433.1	99.0
438.1	99.0
442.0	99.0
447.0	99.1
452.0	99.2
455.3	99.3
462.0	100.7
466.0	101.8
474.8	102.8
485.9	102.8

SECTION 6



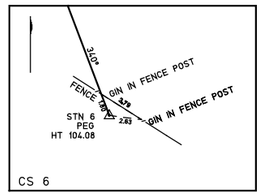
Chainage	Height
0.0	102.5
6.6	102.4
8.3	102.0
16.1	100.8
25.0	101.8
26.8	101.8
49.5	101.6
76.9	101.2
101.5	101.1
107.3	101.0
111.7	101.1
112.2	101.2
144.8	101.2
192.1	101.0
212.8	100.7
241.6	100.7
267.6	100.6
292.8	100.9
318.8	100.8
338.5	100.9
352.4	101.0
355.8	100.9
362.0	99.7
367.4	99.5
371.2	99.4
373.6	99.2
378.8	99.3
384.4	99.2
389.5	99.2
394.3	99.3
402.2	99.4
406.9	99.4
410.5	99.5
415.0	99.7
419.8	99.8
425.2	100.7
426.8	101.2
437.0	101.8
448.4	102.5
455.7	102.9

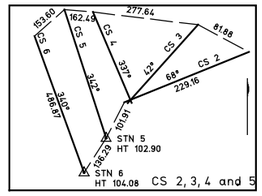
SECTION 5



Chainage	Height
0.0	101.9
20.6	101.6
29.7	101.1
38.0	100.6
58.7	100.7
67.9	100.2
75.8	99.9
81.8	99.8
88.2	99.8
94.1	99.9
99.6	100.0
107.2	99.8
113.2	99.8
117.9	99.8
124.6	99.8
131.3	100.0
137.2	100.1
169.6	100.6
180.2	100.7
202.6	100.5
212.5	100.1
218.7	99.8
223.6	99.8
230.9	99.5
237.8	99.3
241.8	99.3
242.4	99.2
245.7	99.3
251.0	99.4
255.8	99.6
259.1	99.7
263.3	100.1
264.9	100.4
266.6	101.2
276.3	101.7
309.0	102.0

SECTION 4





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF, ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 4,5&6

SHEET 3 OF 19 SHEETS

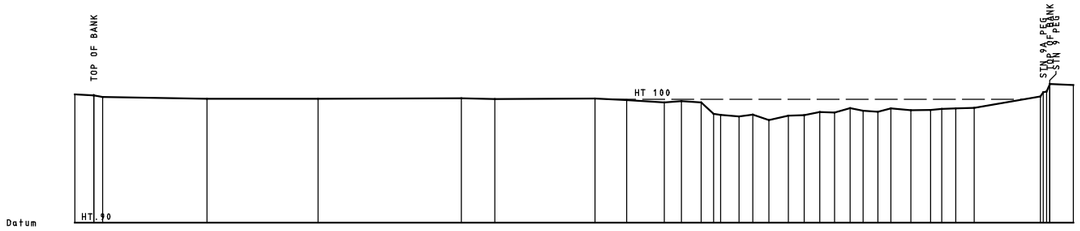
FILE F207

DRAWING NO.

B.50789

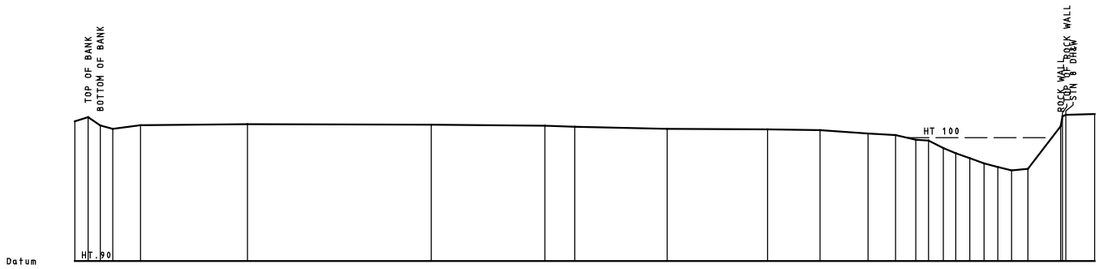
G:\IS\SESIS\PROJ\pdf\CONJOLA\95385H3.DGN 24 JAN 2000 $(User) 09:09:58

679 0 100 200 300 960



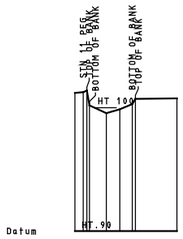
Height	100.4	100.3	100.2	100.1	100.0	100.1	100.0	100.1	99.9	99.7	99.9	99.8	98.8	98.6	98.8	98.3	98.7	98.7	99.0	98.9	99.3	99.1	99.0	99.3	99.1	99.2	99.2	99.3	100.2	100.2	100.1	101.2
Chainage	0.0	7.7	11.3	53.6	98.6	156.7	170.3	210.9	223.8	239.0	246.0	254.0	257.3	261.9	269.4	274.9	281.5	289.4	295.8	302.1	308.1	314.4	319.7	325.7	330.9	339.0	347.0	351.6	357.3	364.7	381.6	404.9

SECTION 9



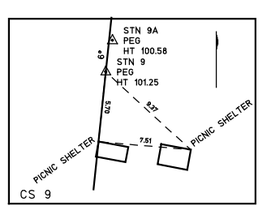
Height	101.3	101.7	101.0	100.7	101.0	101.1	101.1	101.0	100.9	100.7	100.7	100.6	100.3	100.2	99.8	99.8	99.2	98.7	98.3	97.9	97.6	97.4	97.5	100.2	101.9	101.9
Chainage	0.0	5.4	10.3	15.4	26.6	70.0	144.5	190.6	202.7	240.2	289.9	302.2	321.7	332.8	341.0	346.2	352.2	357.2	362.9	368.7	374.3	379.9	386.5	404.8	407.9	413.6

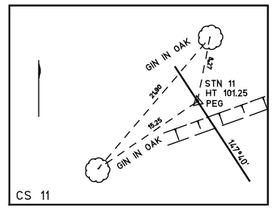
SECTION 8

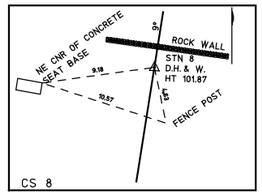


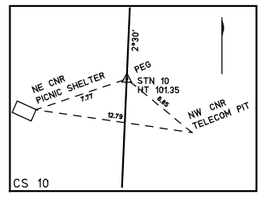
Height	101.2	101.3	101.2	101.2	99.5	99.9	100.7	100.8
Chainage	0.0	7.1	12.7	18.2	23.2	24.5	41.3	

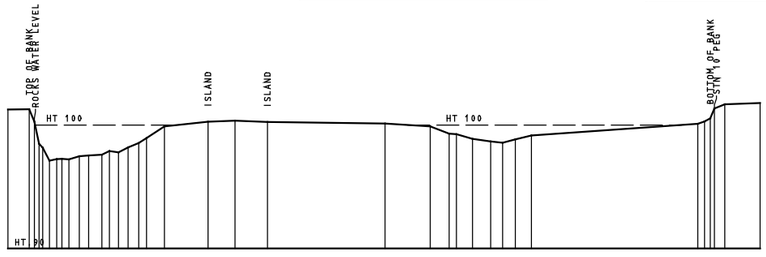
SECTION 11





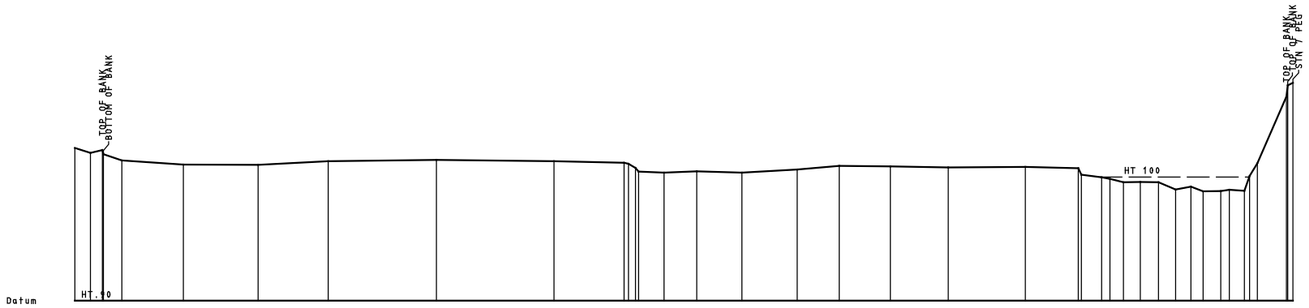






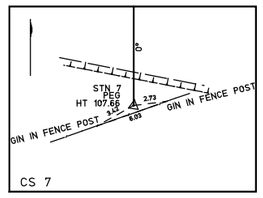
Height	101.3	100.3	100.3	100.2	100.2	100.1	99.9	99.9	99.8	99.7	99.6	99.5	99.4	99.3	99.2	99.1	99.0	98.9	98.8	98.7	98.6	98.6	98.8	99.2	100.1	101.2	101.8
Chainage	0.0	8.6	16.9	25.8	32.7	39.1	44.8	48.7	52.6	56.2	63.5	81.1	92.1	105.2	152.9	171.2	179.9	188.4	195.8	200.6	205.6	209.8	212.3	279.7	292.6	299.7	305.0

SECTION 10



Height	102.4	102.0	101.9	101.4	101.0	101.0	101.3	101.4	101.3	101.2	101.2	100.5	100.4	100.5	100.6	100.9	100.9	100.8	100.8	100.2	100.0	99.9	99.6	99.6	99.0	99.2	98.9	99.0	98.7	98.7	98.1	106.5	107.9
Chainage	0.0	6.3	11.2	19.1	44.0	74.3	102.7	146.6	194.3	232.7	236.5	238.6	238.9	252.2	270.5	292.9	310.0	330.7	354.2	385.5	408.2	416.6	419.4	425.2	432.1	439.5	446.4	452.6	457.6	464.7	468.2	476.3	479.6	481.3	484.0

SECTION 7



TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 7,8,9,10&11

SHEET 4 OF 19 SHEETS

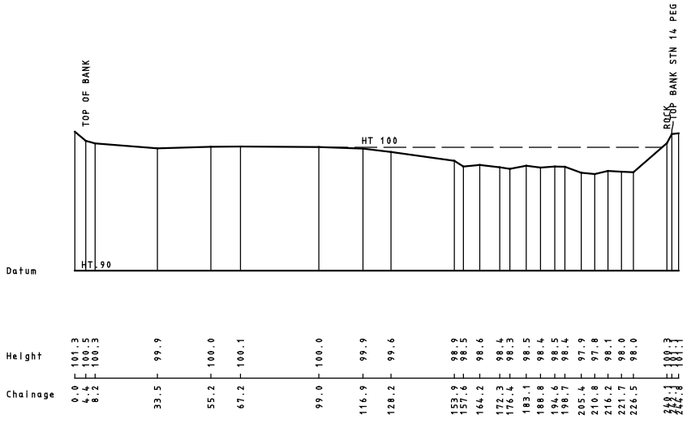
FILE F207

DRAWING NO.

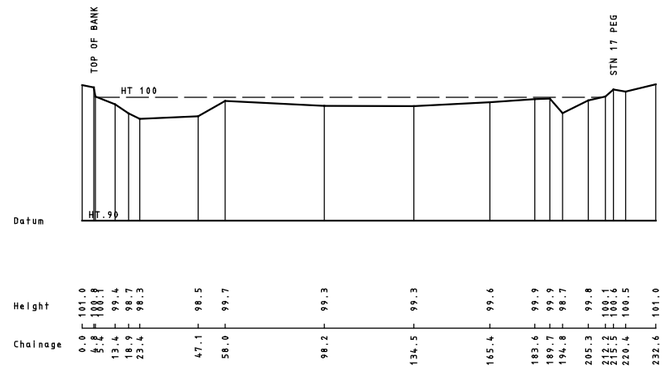
B.50789

G:\IS\SAS1\VRO\yef\CONJOLA\9538SH4.DGN
09:01:41 24 JUN 2000 $(user)

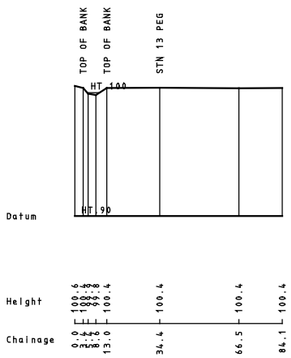
679 0 100 200 300 960



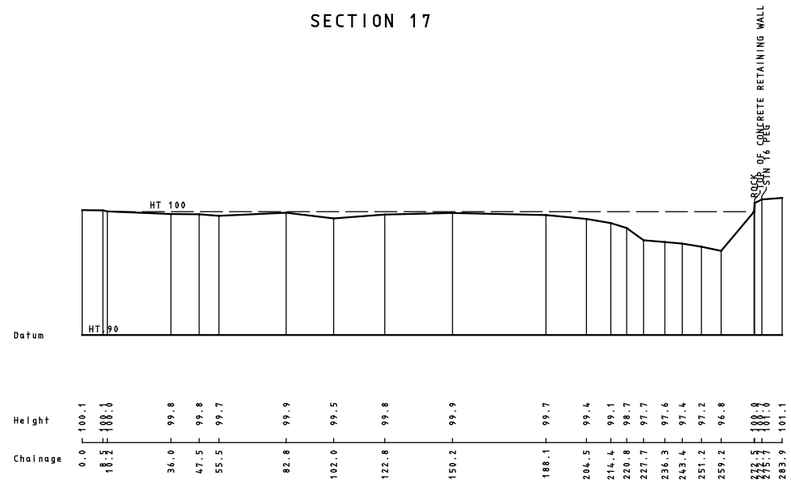
SECTION 14



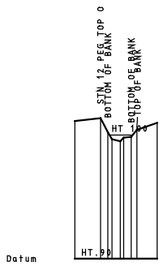
SECTION 17



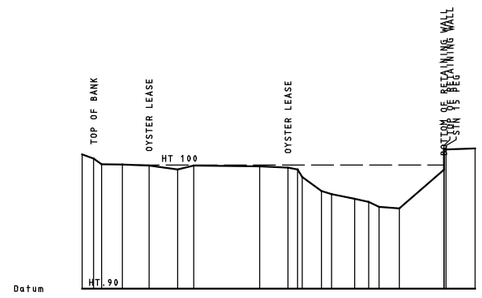
SECTION 13



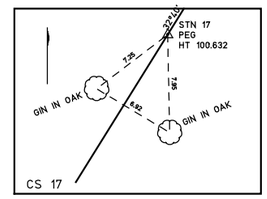
SECTION 16

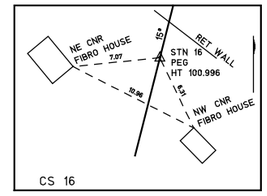


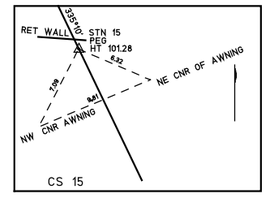
SECTION 12

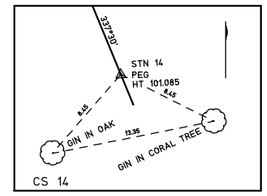


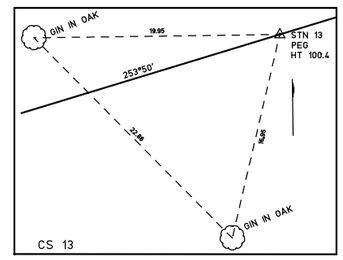
SECTION 15

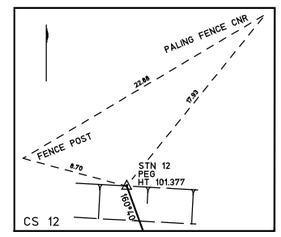












TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D

SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES
HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES
VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S. MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 12,13,14,15,16&17

SHEET 5 OF 19 SHEETS

FILE F207

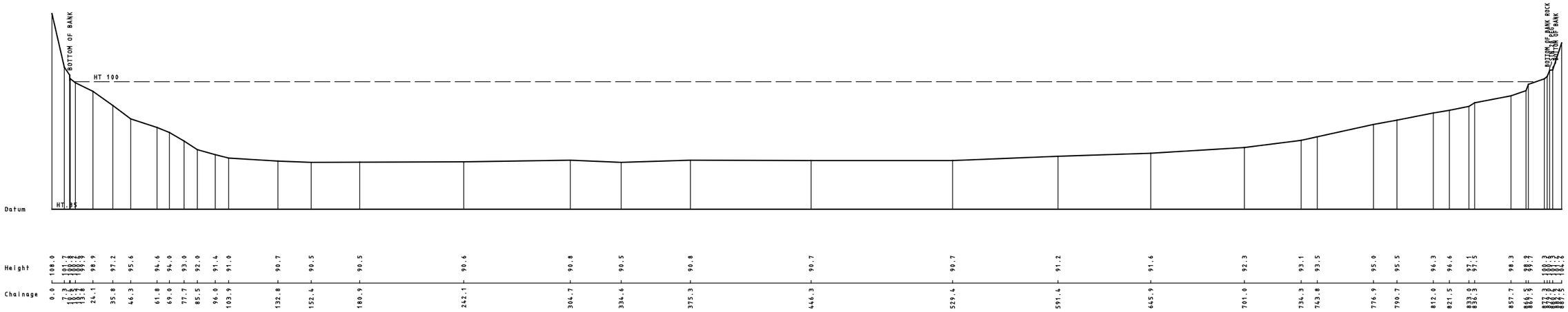
DRAWING NO.

B.50789

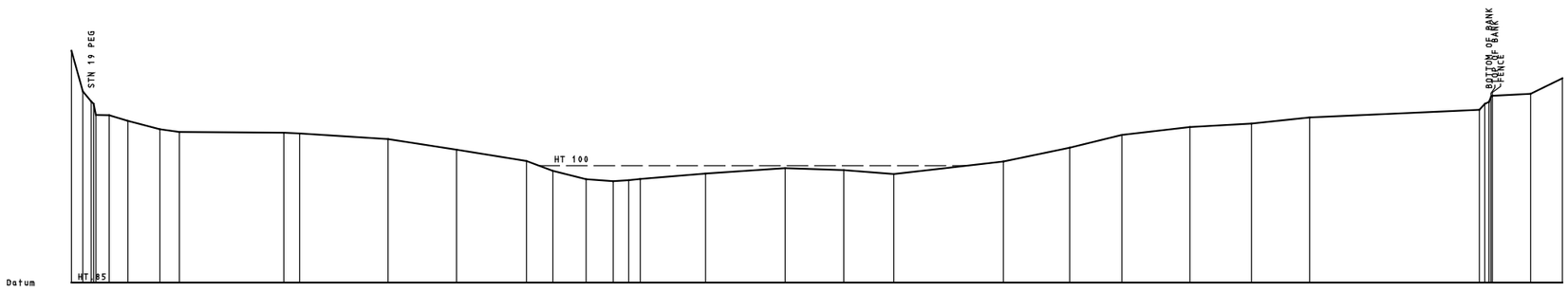
G:\IS\SAS\SVR0\yaf\CONJOLA\1538SH5.DGN

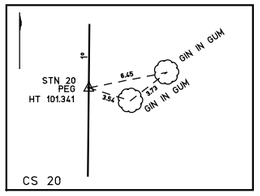
09:02:19 24 JAN 2000 $(user)

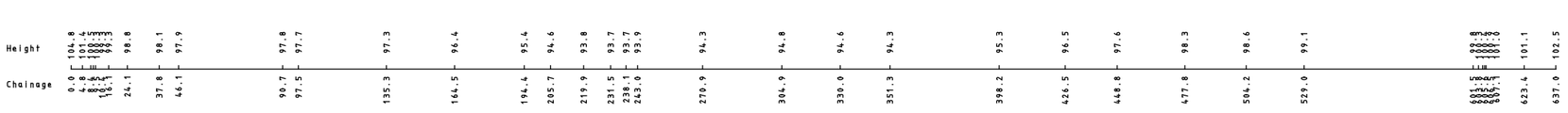
679 0 100 200 300 960



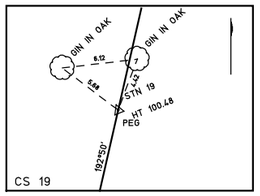
SECTION 20

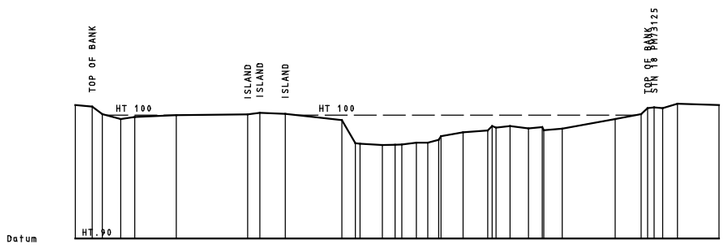


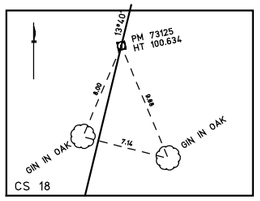




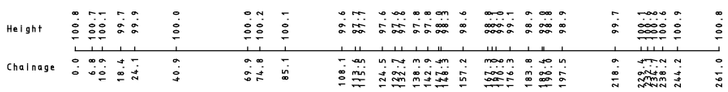
SECTION 19







TIE DIAGRAMS NOT TO SCALE



SECTION 18

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

SCALE 1:1000 METRES HORIZONTAL

SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 18,19&20

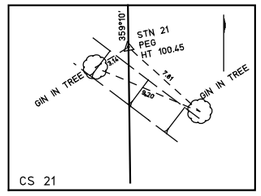
SHEET 6 OF 19 SHEETS

FILE F207

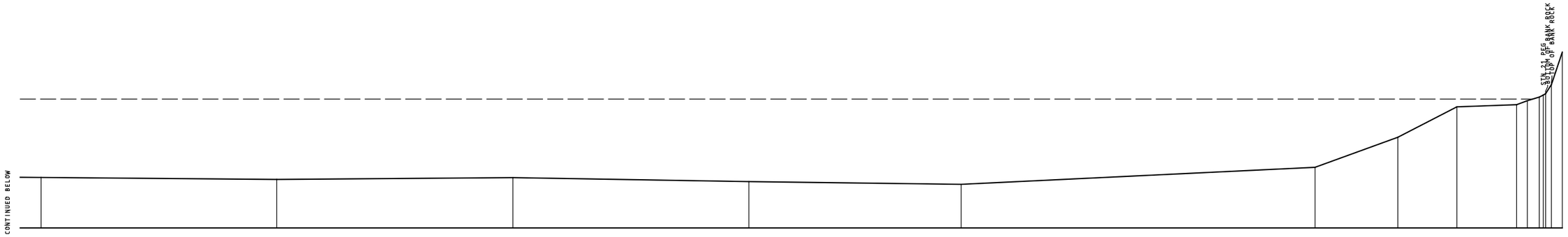
DRAWING NO.

B.50789

G:\IS\SAS1\VRO3\yef\CONJOLA\9538SH6.DGN 01:03:21 24 JAN 2000 $(user)

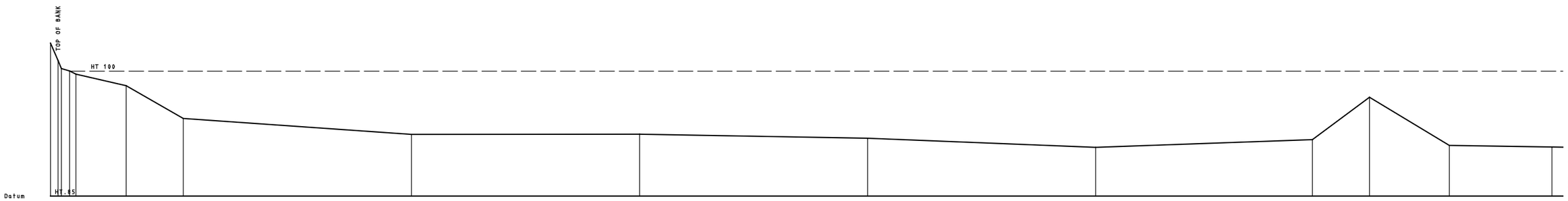


TIE DIAGRAM NOT TO SCALE



Chainage	Height
902.5	90.9
1039.5	90.7
1176.7	90.9
1313.8	90.4
1437.2	90.1
1642.9	92.1
1691.0	95.6
1725.3	99.1
1760.0	99.3
1764.2	99.8
1772.5	100.5
1777.5	101.4
1780.2	101.9
1786.5	105.5

SECTION 21



Chainage	Height
0.0	103.4
4.5	101.3
10.5	100.0
15.3	99.6
45.5	98.3
79.8	94.3
216.9	92.4
354.1	92.4
491.1	91.9
628.2	90.9
758.5	91.8
792.8	96.9
840.8	91.1
902.5	90.9

SECTION 21

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D

SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF, ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V.SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTION 21

SHEET 7 OF 19 SHEETS

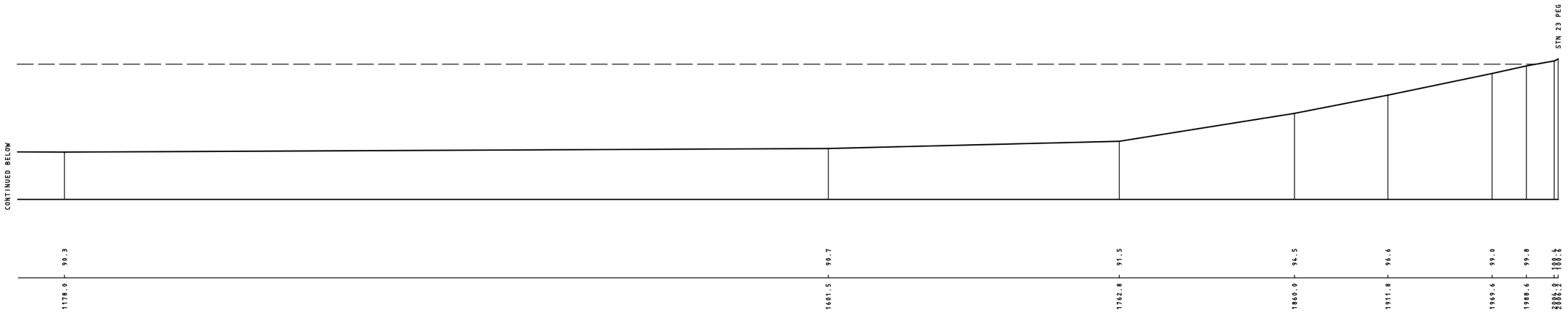
FILE F207

DRAWING NO.

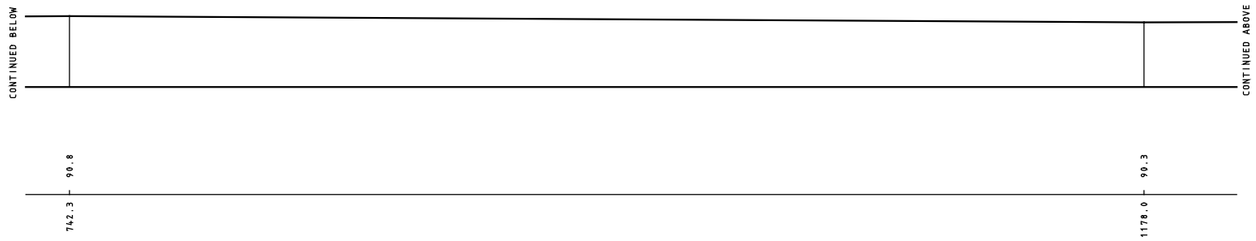
B.50789

G:\IS\SASISVR03\pdf\CONJOLA\9538SH7.DGN 24 JAN 2000 $(user) 09:04:15

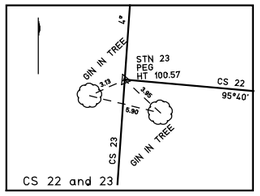
679 0 100 200 300 960



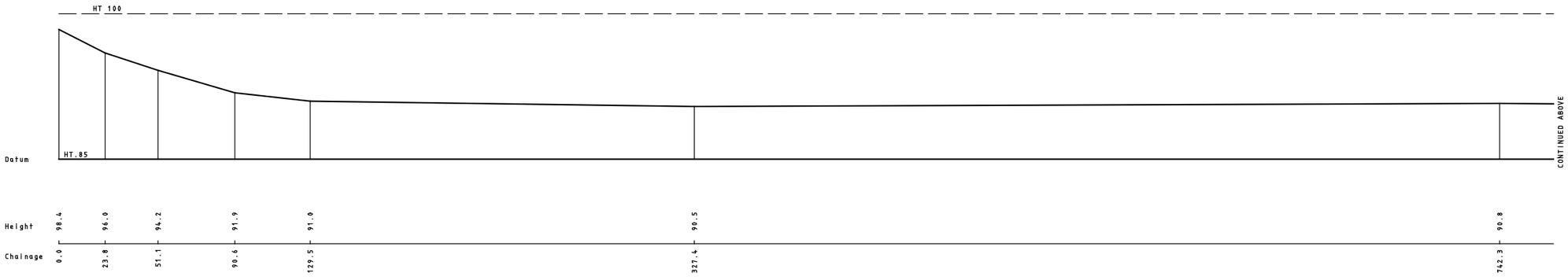
SECTION 22



SECTION 22



TIE DIAGRAM NOT TO SCALE



NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D.
SEE SHEET 1 FOR DETAILS

SCALE 1:1000 METRES HORIZONTAL (20 10 0 20 40 60 80 100)

SCALE 1:200 METRES VERTICAL (4 2 0 4 8 12 16 20)

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S. MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTION 22

SHEET 8 OF 19 SHEETS

FILE F207

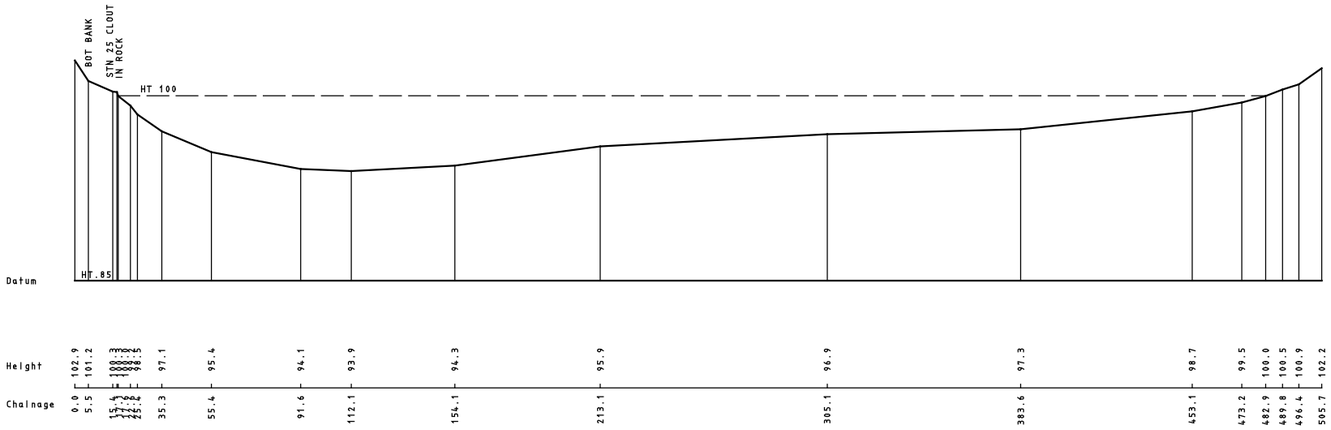
DRAWING NO.

B.50789

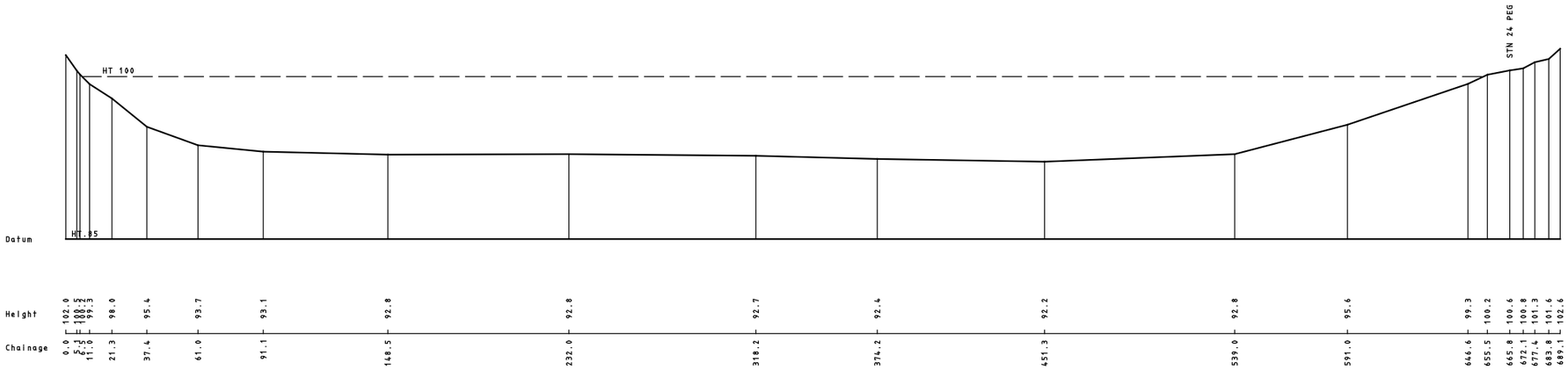
B.50789

G:\15\5515\PRO\ef\CON\RLA\15\5515H.DGN $(user) 24 JAN 2000 09:05:59

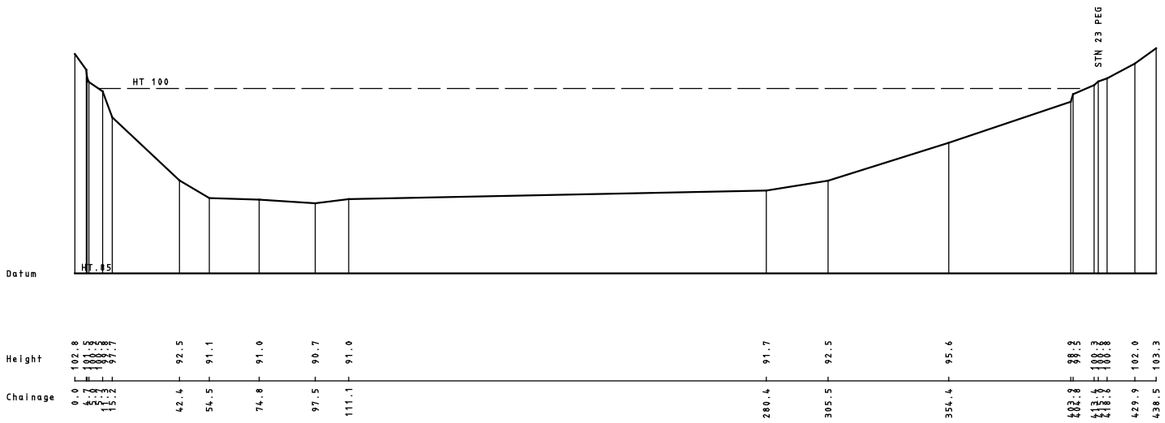
679 0 100 200 300 960



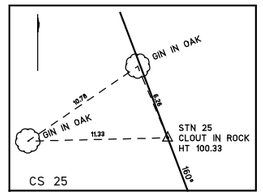
SECTION 25

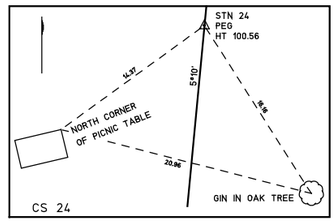


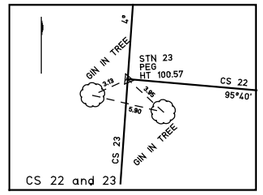
SECTION 24



SECTION 23







TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

SCALE 1:1000 METRES HORIZONTAL (20 10 0 20 40 60 80 100)

SCALE 1:200 METRES VERTICAL (4 2 0 4 8 12 16 20)

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 23,24&25

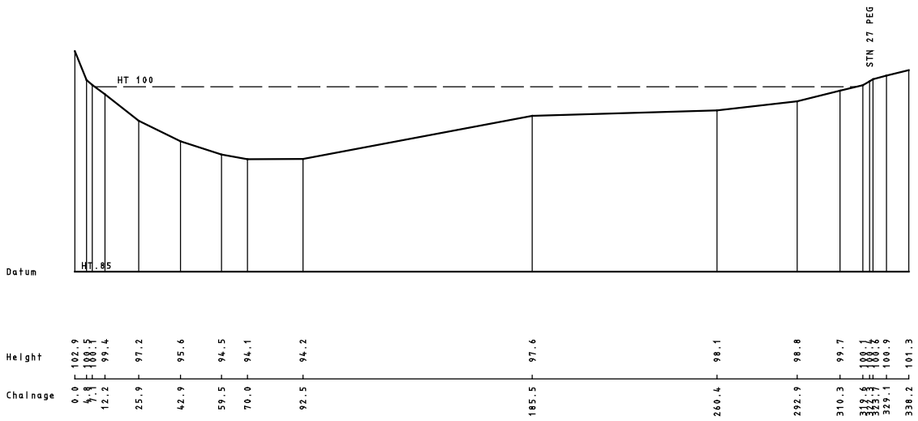
SHEET 9 OF 19 SHEETS

FILE F207

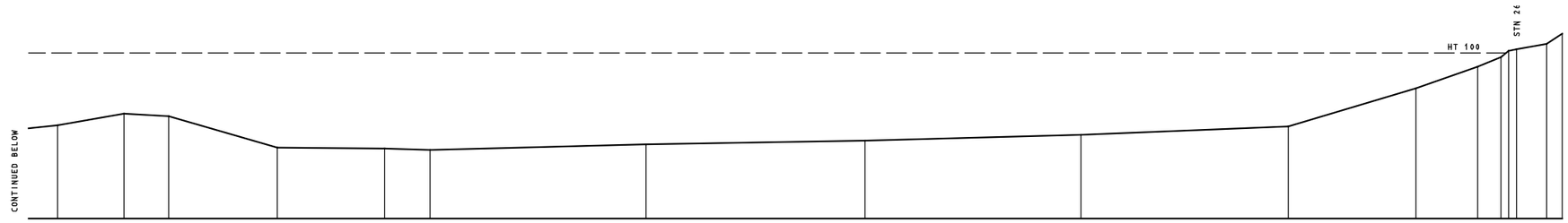
DRAWING NO.

B.50789

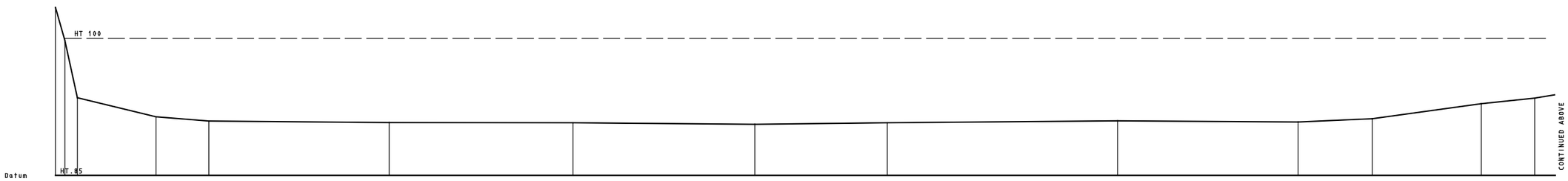
G:\IS\SAS\SVRO\yef\CONJOLA\9538SH9.DGN
09:04:59 24 JAN 2000 $(user)

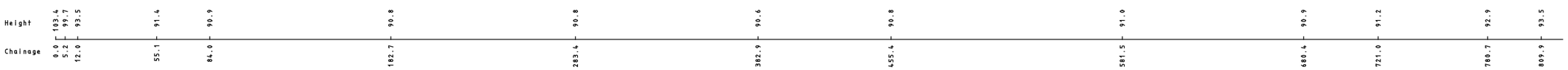


SECTION 27

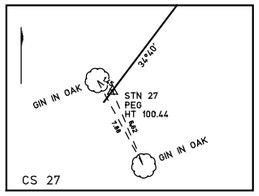


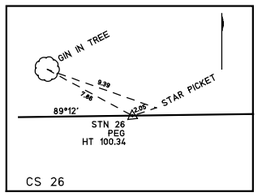
SECTION 26





SECTION 26





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

SCALE 1:1000 METRES HORIZONTAL (20 10 0 20 40 60 80 100)

SCALE 1:200 METRES VERTICAL (4 2 0 4 8 12 16 20)

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF, ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S. MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

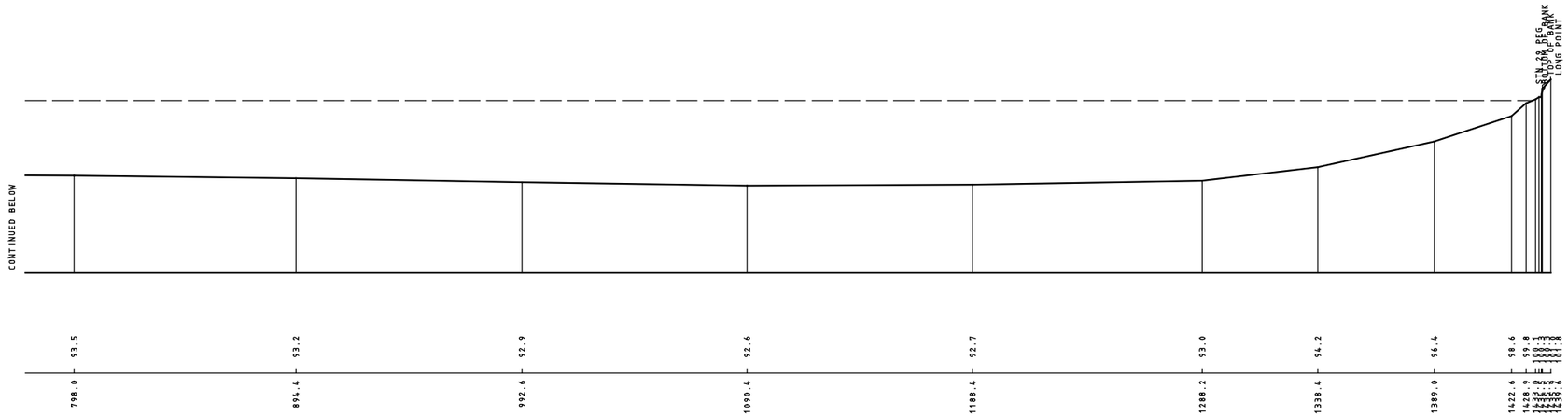
SECTIONS 26&27

SHEET 10 OF 19 SHEETS

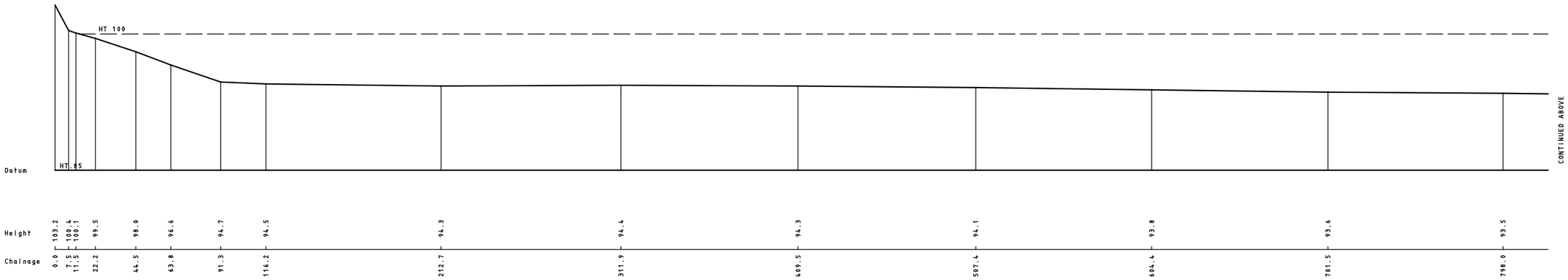
FILE F207

DRAWING NO.

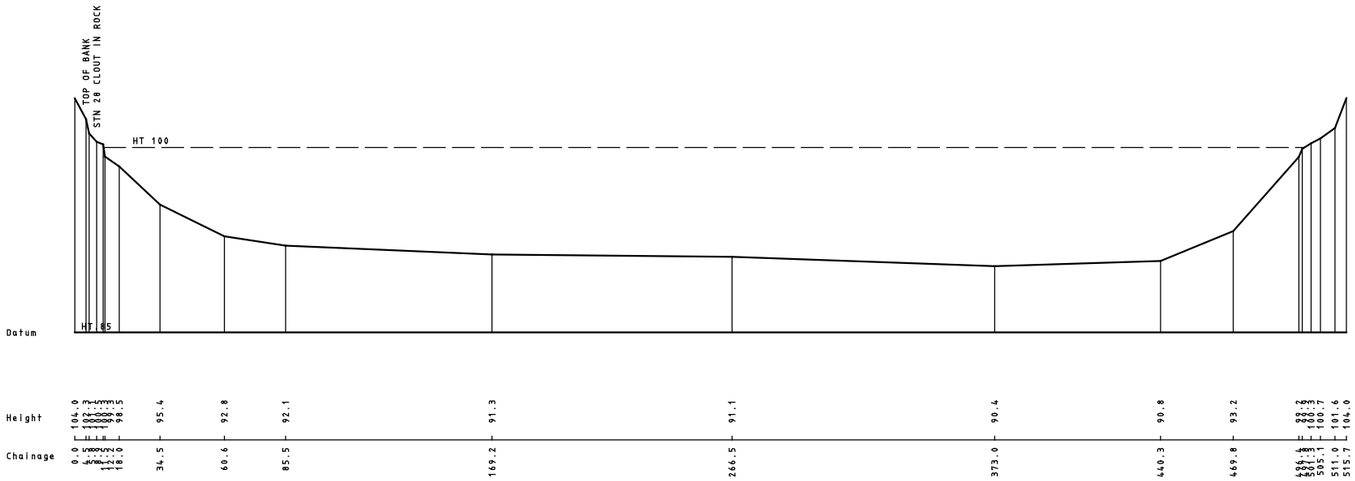
B.50789



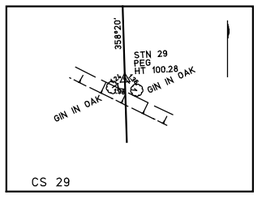
SECTION 29

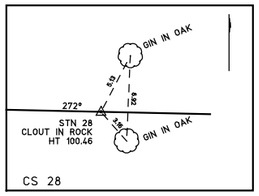


SECTION 29



SECTION 28





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 28&29

SHEET 11 OF 19 SHEETS

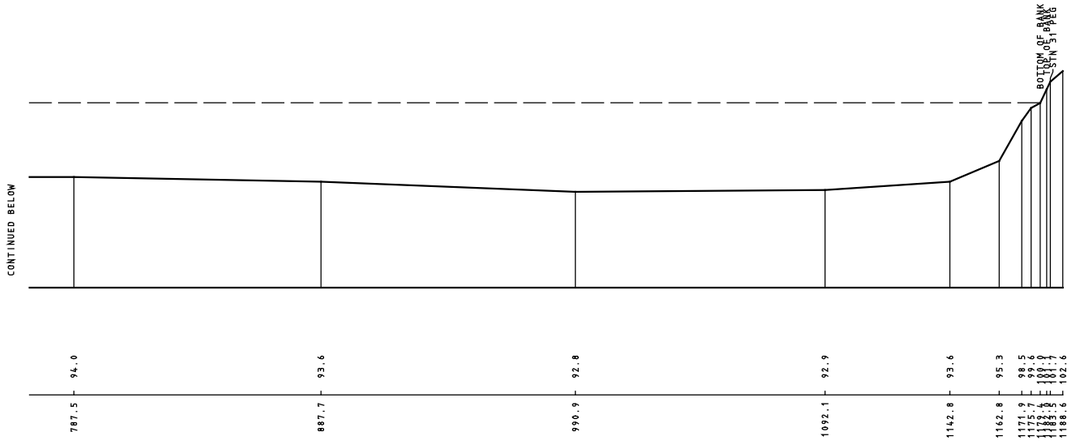
FILE F207

DRAWING NO.

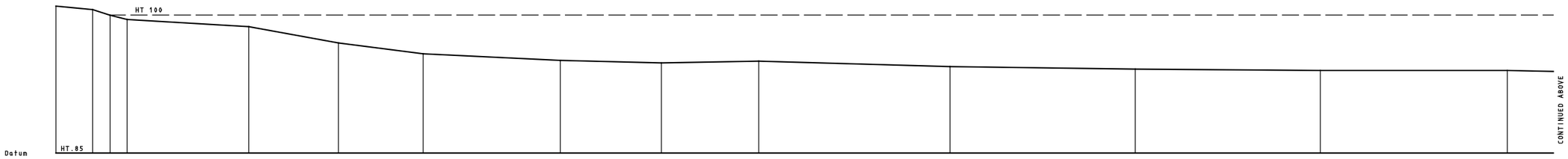
B.50789

G:\IS\SESIVRO\ydf\CONJOLA\V5385H11.DGN 01:01:37 24 JAN 2000 $(user)

679 0 100 200 300 960

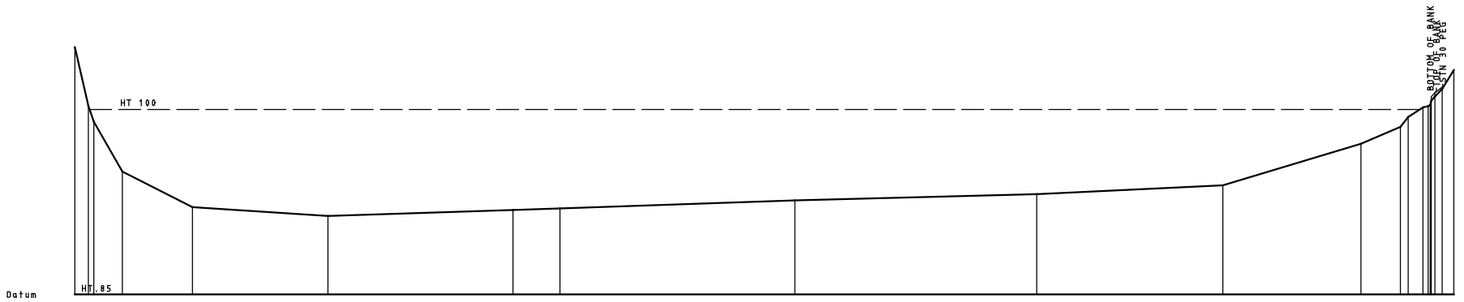


SECTION 31



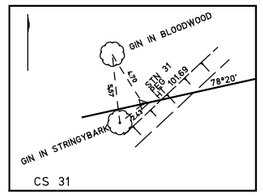
Height	101.0	100.6	100.0	99.5	98.7	97.0	95.8	95.1	94.8	95.0	94.4	94.1	94.0	94.0
Chainage	0.0	19.9	29.4	38.7	104.6	153.3	199.3	273.7	328.5	381.4	485.1	585.7	686.1	787.5

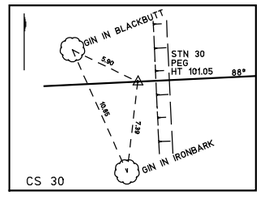
SECTION 31



Height	105.0	100.3	99.0	95.0	92.1	91.4	91.9	92.0	92.6	93.1	93.9	97.2	98.6	99.4	100.3	100.4	100.5	100.6	100.7	101.1	101.2	101.2
Chainage	0.0	5.5	7.7	19.3	47.7	102.6	177.7	196.7	292.0	390.1	465.6	521.6	537.5	548.7	557.5	564.5	570.5	576.5	582.5	588.5	592.5	596.2

SECTION 30





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 30&31

SHEET 12 OF 19 SHEETS

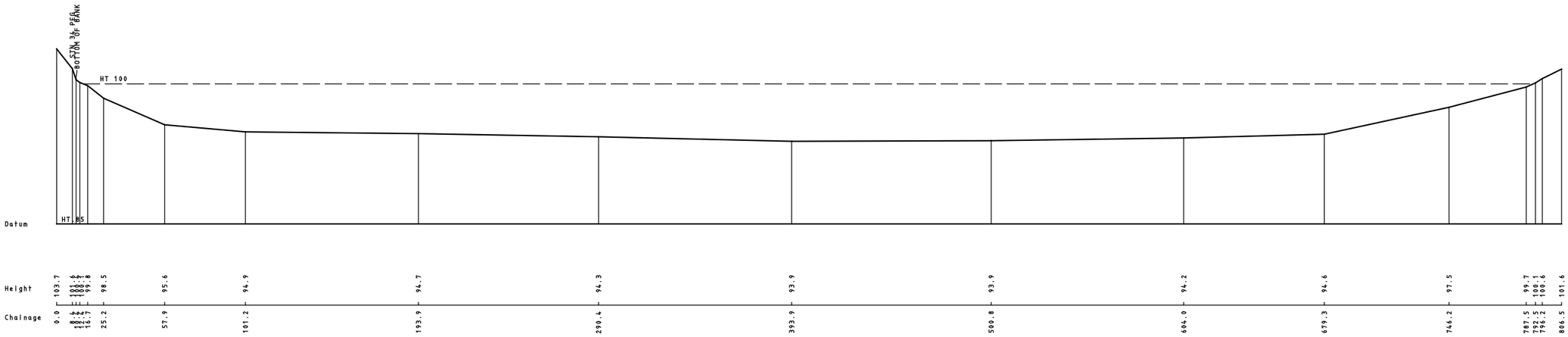
FILE F207

DRAWING NO.

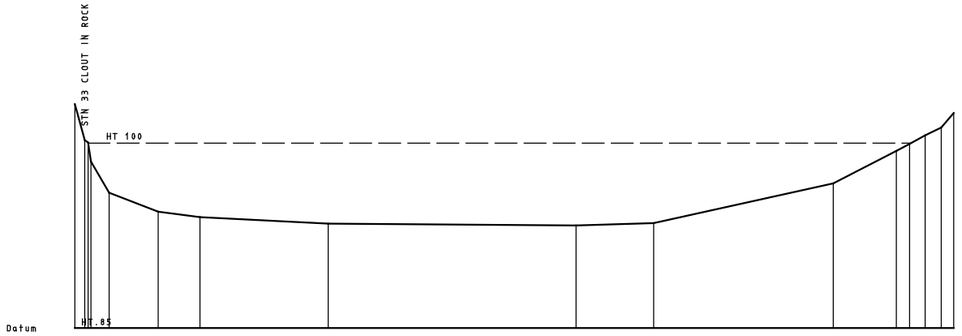
B.50789

G:\IS\SESIVRO\ydf\CONJOLA\V5385H12.DGN 24 JAN 2000 09:09:33

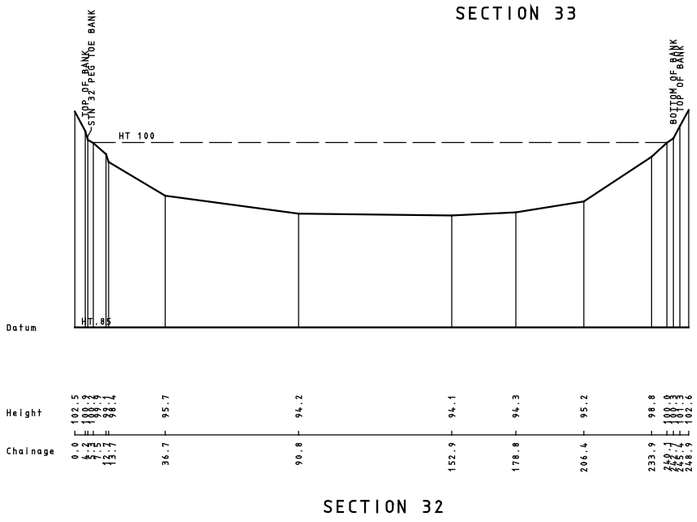
679 0 100 200 300 960



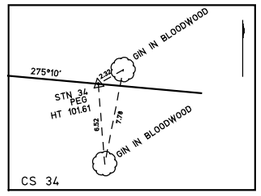
SECTION 34

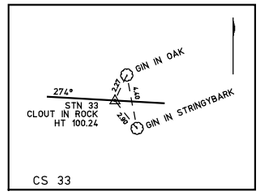


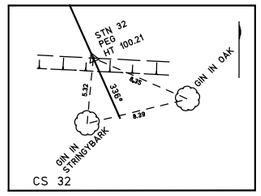
SECTION 33



SECTION 32







TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 32,33&34

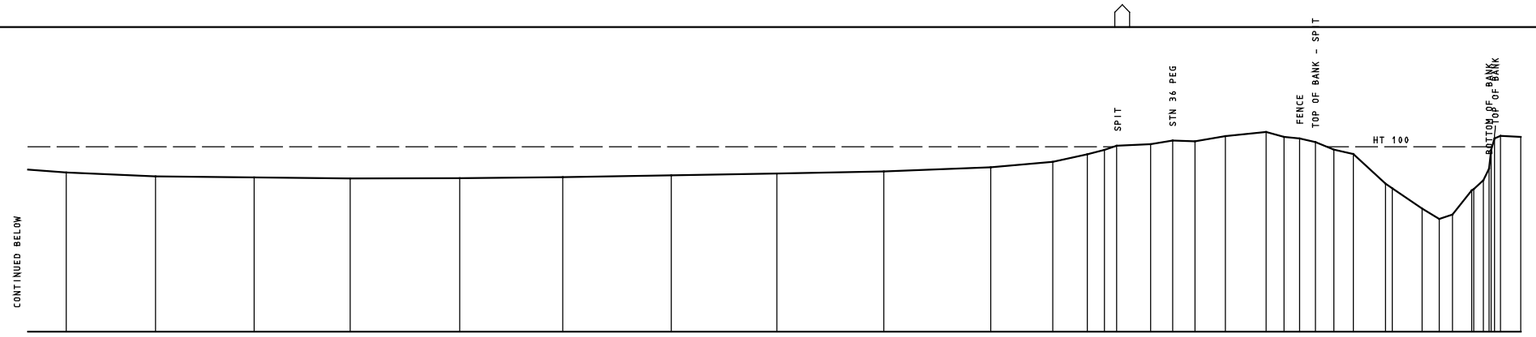
SHEET 13 OF 19 SHEETS

FILE F207

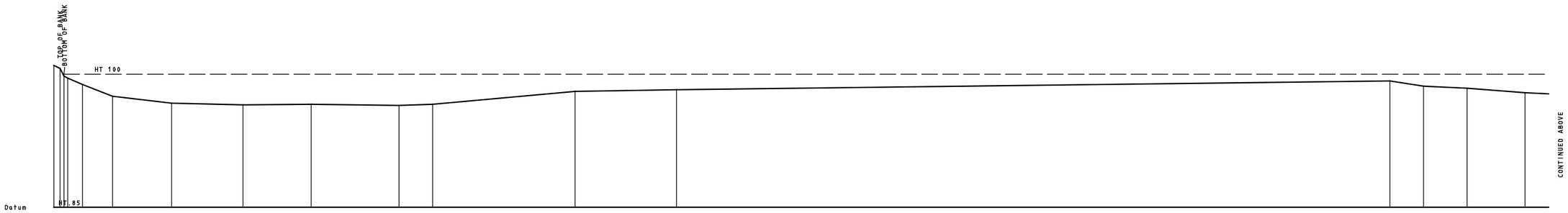
DRAWING NO.

B.50789

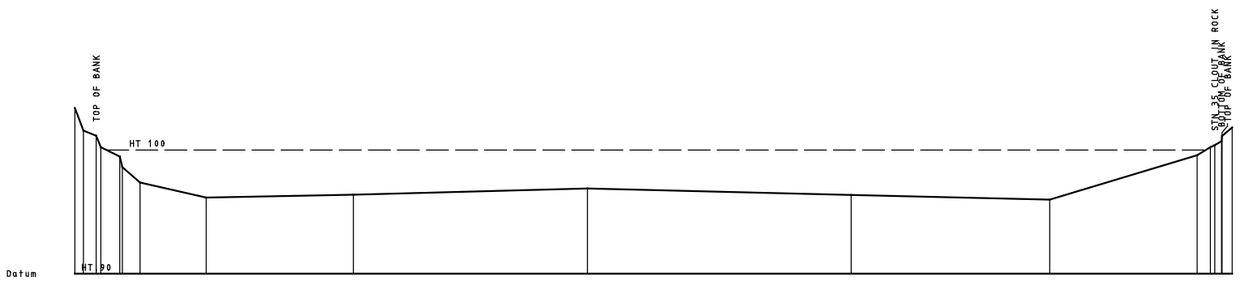
679 0 100 200 300 960

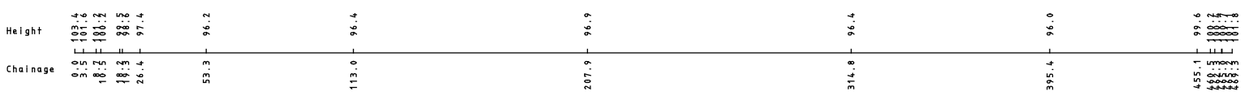


SECTION 36

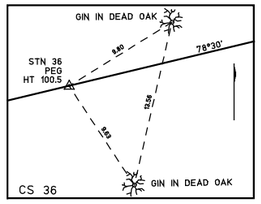


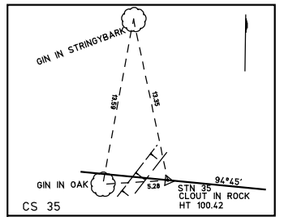
SECTION 36





SECTION 35





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

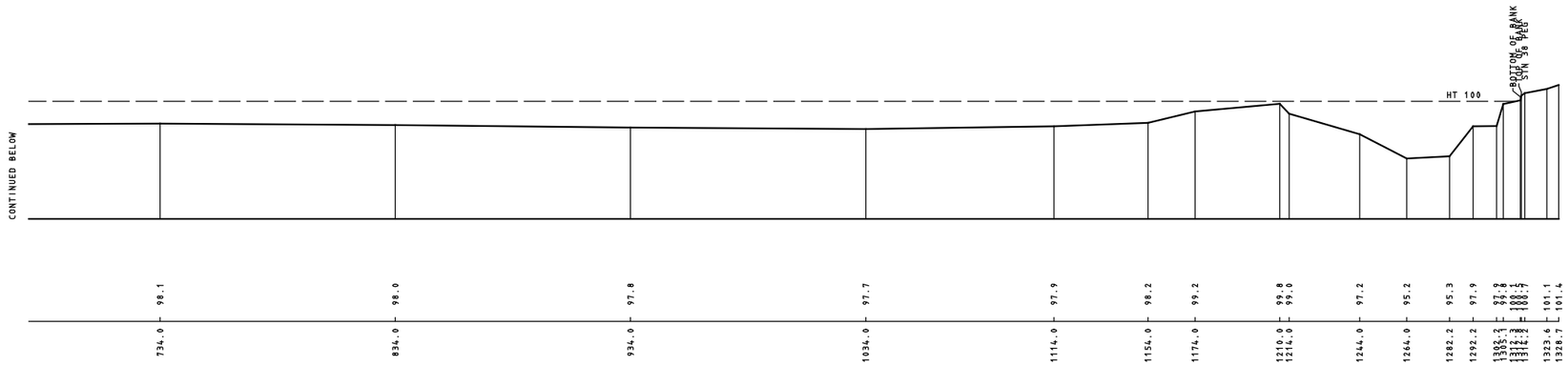
LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 35&36

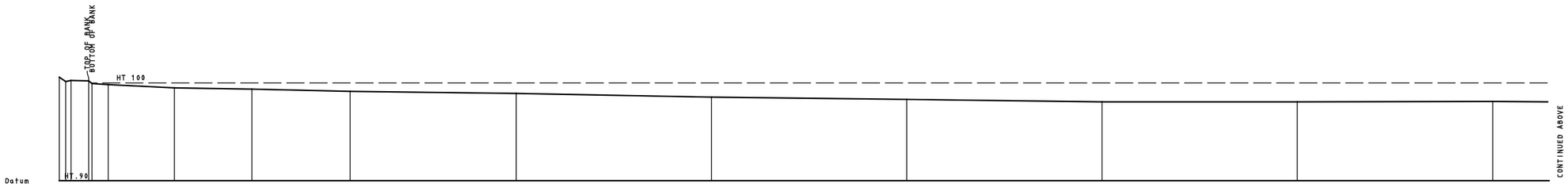
SHEET 14 OF 19 SHEETS

FILE F207

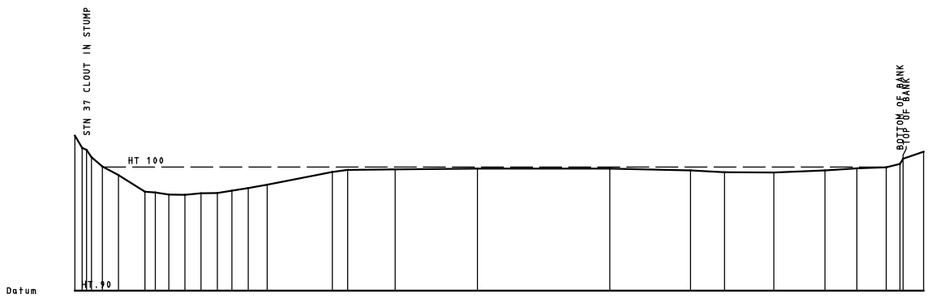
DRAWING NO.

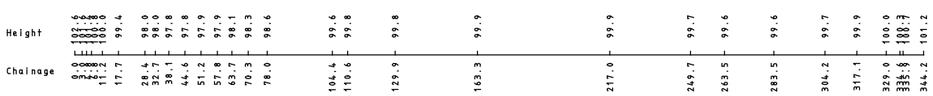


SECTION 38

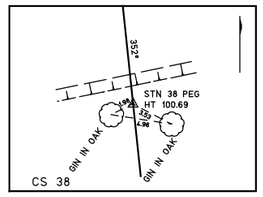


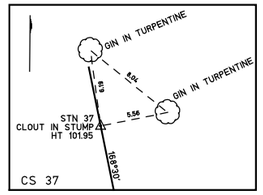
SECTION 38





SECTION 37





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM

100 METRES BELOW A.H.D

SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 37&38

SHEET 15 OF 19 SHEETS

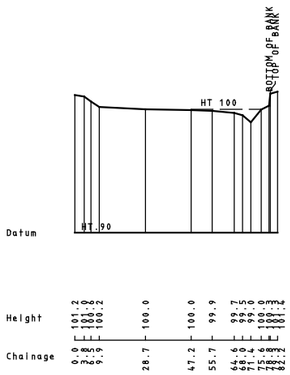
FILE F207

DRAWING NO.

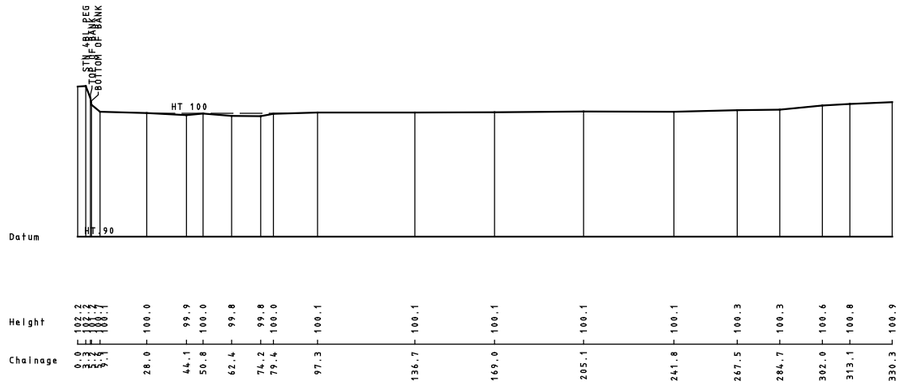
B.50789

G:\IS\SASIS\PROJ\pdf\CONJOLA\V5385H15.DGN 09:26:36 24 JAN 2000 $(user)

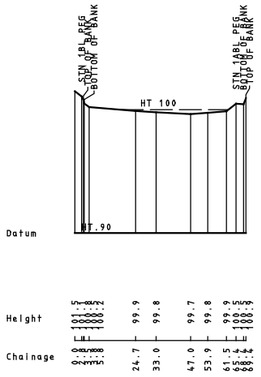
679 0 100 200 300 960



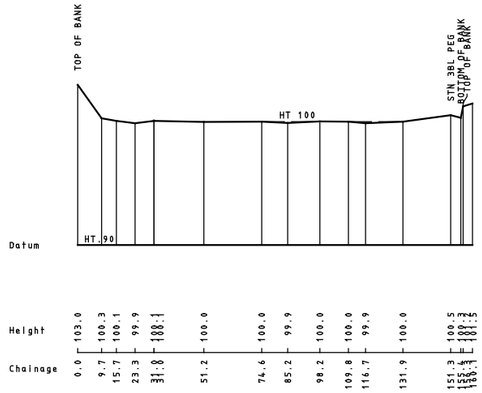
SECTION 2BL



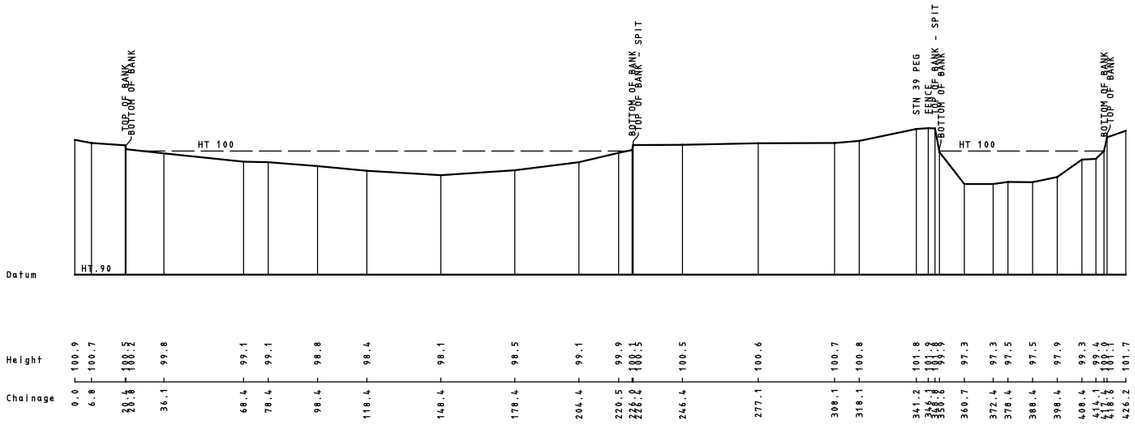
SECTION 4BL



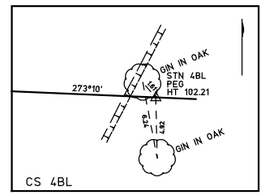
SECTION 1BL

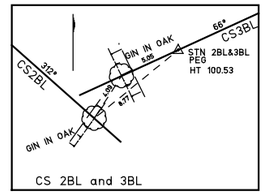


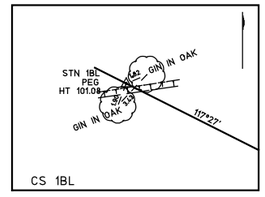
SECTION 3BL

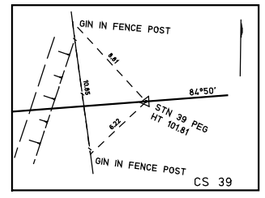


SECTION 39









TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM
BL INDICATES BERRINGER LAKE SECTIONS

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

SCALE 1:1000 METRES HORIZONTAL (20 10 0 20 40 60 80 100)

SCALE 1:200 METRES VERTICAL (4 2 0 4 8 12 16 20)

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S. MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 39,1BL,2BL,3BL&4BL

SHEET 16 OF 19 SHEETS

FILE F207

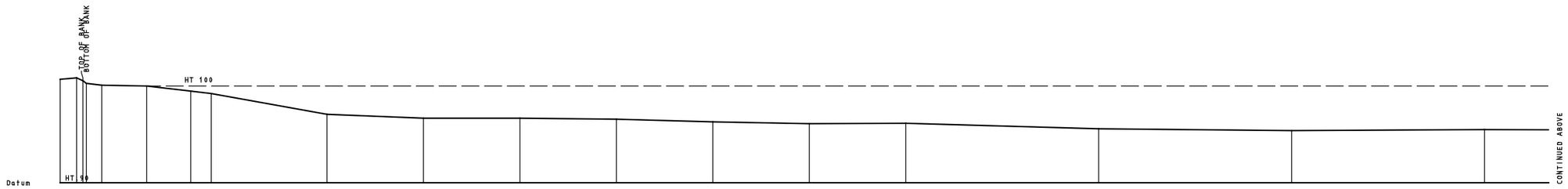
DRAWING NO.

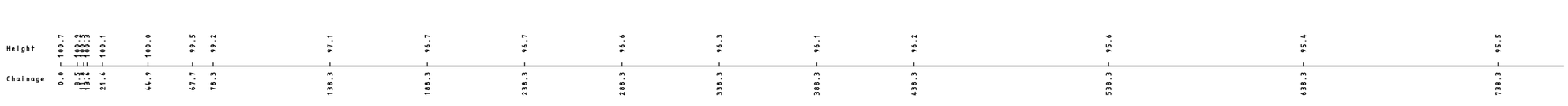
B.50789

G:\IS\SAS\SVR0\apf\CONJOLA\15385H16.DGN
09:27:14 24 JAN 2000 $(user)

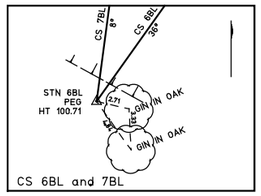
679
0 100 200 300
960

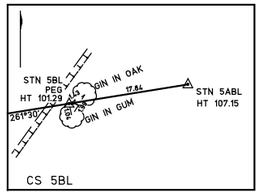
SECTION 6BL



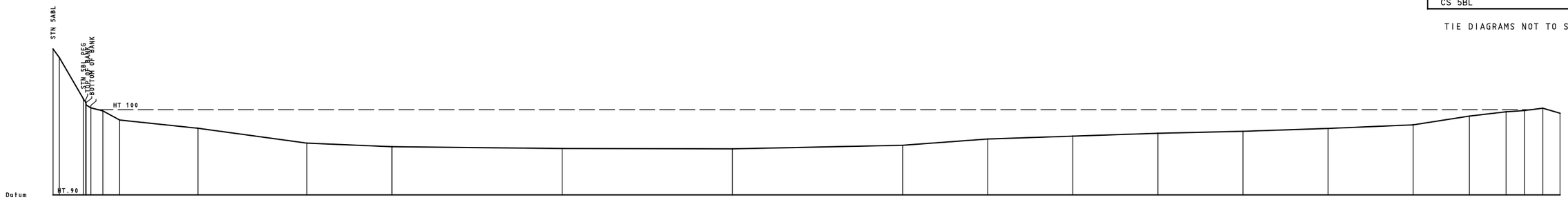


SECTION 6BL





TIE DIAGRAMS NOT TO SCALE



SECTION 5BL

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM
BL INDICATES BERRINGER LAKE SECTIONS

100 METRES BELOW A.H.D.
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES
HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES
VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS

GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 5BL&6BL

SHEET 17 OF 19 SHEETS

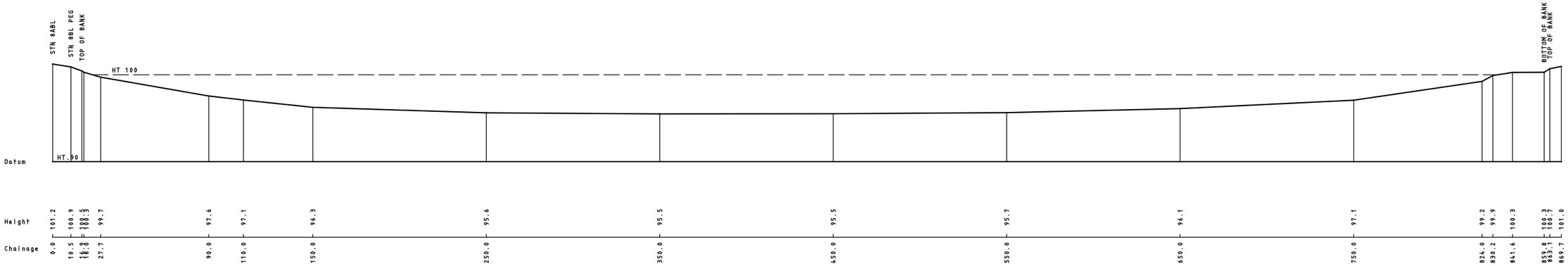
FILE F207

DRAWING NO.

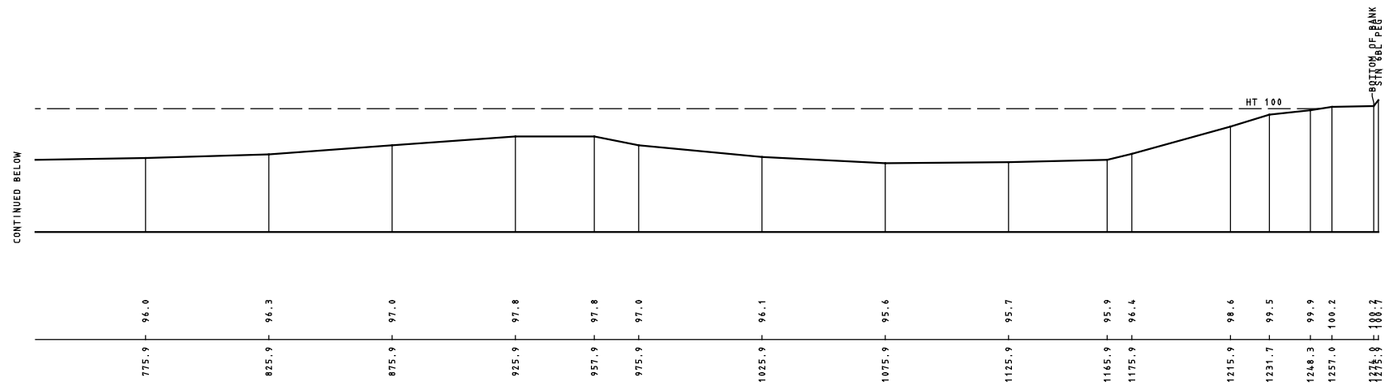
B.50789

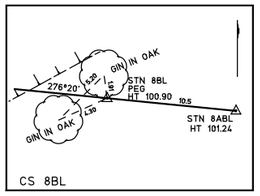
G:\IS\SAS15\PROJ\pdf\CONJOLA\95385H17.DGN
09:26:57 24 JAN 2000 $(User)

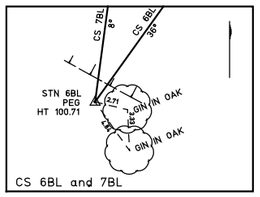
679
0 100 200 300
960



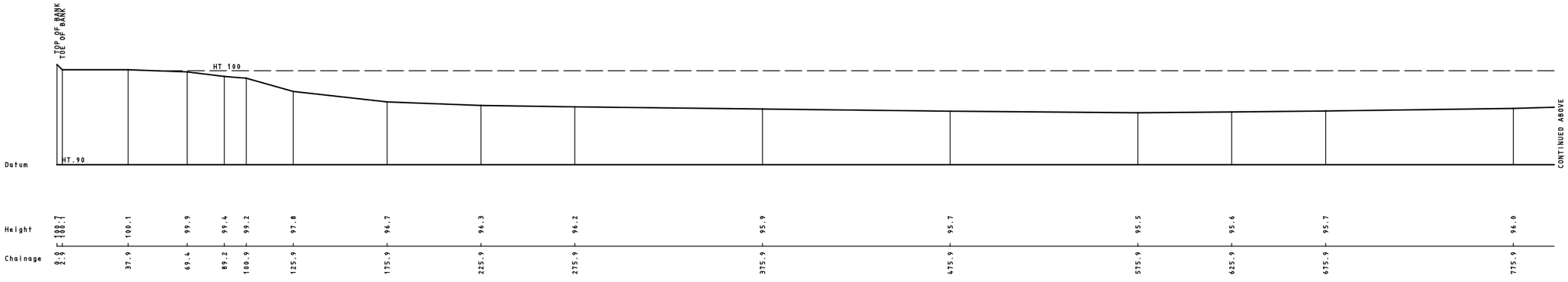
SECTION 8BL







TIE DIAGRAMS NOT TO SCALE



SECTION 7BL

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM
BL INDICATES BERRINGER LAKE SECTIONS

100 METRES BELOW A.H.D.
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S. MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES
DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS
GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY
SECTIONS 7BL&8BL

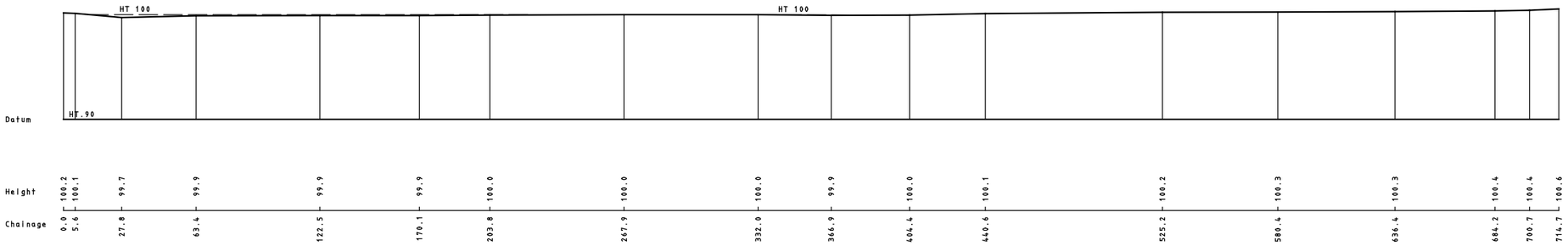
SHEET 18 OF 19 SHEETS

FILE F207
DRAWING NO.

B.50789

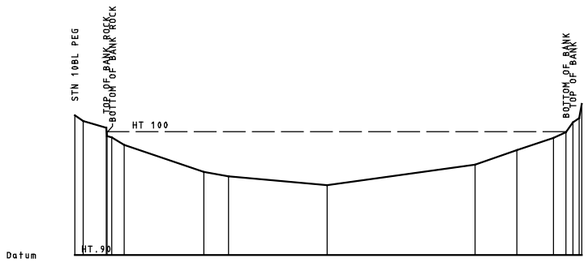
B.50789

G:\1\SAS\15\MAO\yafa\CONJOLA\NEW\LAYSESSIONS\NEW 8 (Layer) 24 JAN 2000 09:29:36

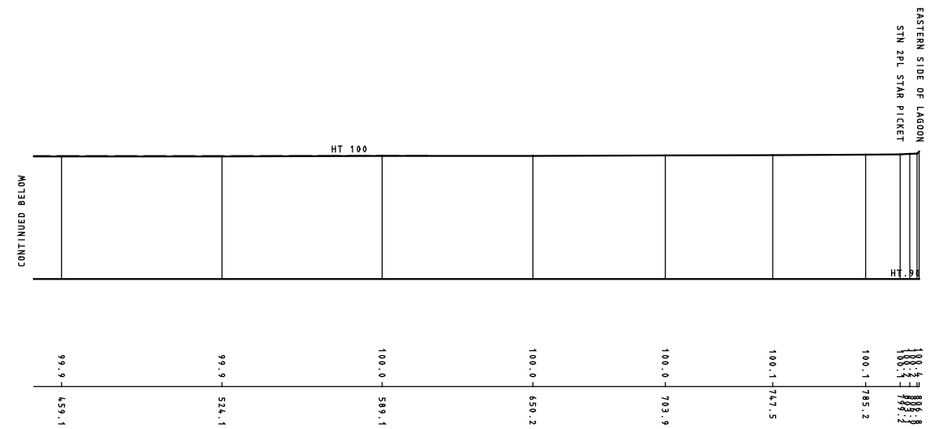


SECTION 1PL

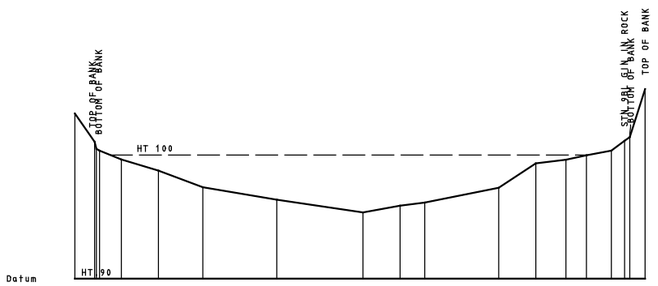
CS 1PL and 2PL - Not Available



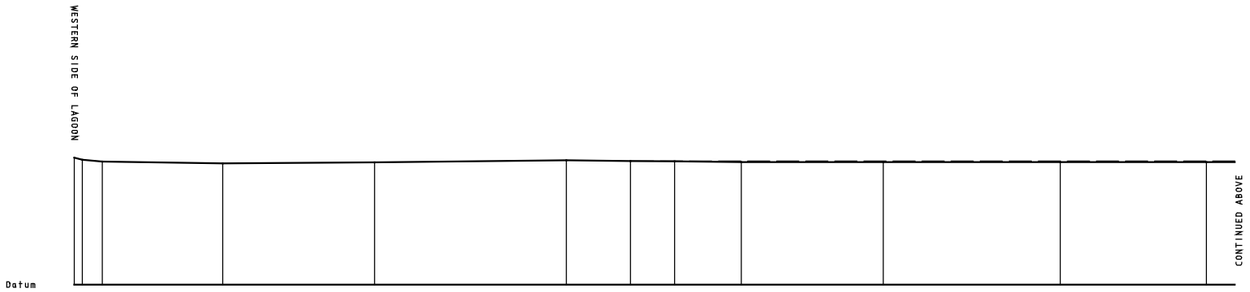
SECTION 10BL



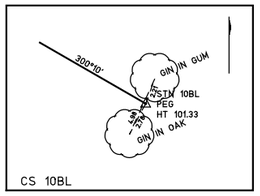
SECTION 2PL

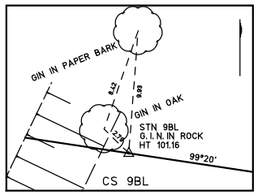


SECTION 9BL



SECTION 2PL





TIE DIAGRAMS NOT TO SCALE

NOTE: SECTIONS ARE DRAWN LEFT TO RIGHT LOOKING DOWNSTREAM
BL INDICATES BERRINGER LAKE SECTIONS
PL INDICATES PATTIMORES LAGOON SECTIONS

100 METRES BELOW A.H.D
SEE SHEET 1 FOR DETAILS

20 10 0 20 40 60 80 100
SCALE 1:1000 METRES HORIZONTAL

4 2 0 4 8 12 16 20
SCALE 1:200 METRES VERTICAL

CAUTION
THIS PLAN HAS BEEN PREPARED AT A SCALE OF 1:1000HOR. 1:200 VER. FOR THE PURPOSE OF RIVER MONITORING AND MAY NOT BE SATISFACTORY FOR OTHER PURPOSES. THE ACCURACY OF, ANY ENLARGEMENT OR OTHER REPRODUCTION MAY BE LESS THAN THAT OF THE ORIGINAL.

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

VERIFIED SIGNED BY S.MURRAY OCTOBER 1993
VALIDATED
APPROVED MANAGER G.V. SMITH OCTOBER 1993

DATUM
ORIGIN OF LEVELS
AZIMUTH
FOLDER LB FB
L.G.A.
SURVEYOR S.MURRAY
SURVEY DATE FILE
CADD ALAN ORCHARD

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

DICK PERSSON
DIRECTOR GENERAL OF PUBLIC WORKS
GEOMATICS, LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

LAKE CONJOLA HYDROGRAPHIC SURVEY

SECTIONS 9BL,10BL,1PL&2PL

SHEET 19 OF 19 SHEETS

FILE F207
DRAWING NO.

B.50789

679 0 100 200 300 960

Appendix B

Commitment Document

Lake Conjola Entrance Management
Continued Commitment Document

1. Purpose of Document

This 'Continued Commitment Document' (CCD) seeks to facilitate agreement in principle to the Lake Conjola Entrance Management Plan by all relevant parties and specifically to a continued commitment to the action and funding required to maintain an open entrance to the lake.

The CCD describes in summary form the benefits of and the processes involved in maintaining an open entrance. It outlines the necessary actions, funding and responsibilities.

The document is being submitted to you and other relevant groups for your comment, revision and ultimate endorsement.

It is intended that the document will be held by Shoalhaven Council or other suitable body to be agreed during review of this CCD. It will be made available to the general public, and relevant government agencies.

Shoalhaven Council, or other suitable body, will produce an annual report on the operation of the Plan, using the template attached to this CCD. The annual report will be sent to stakeholders with a response form to be returned covering conformance and non-conformance with the endorsed actions set out in this CCD.

Details of the Lake Conjola Entrance Management are presented in:
- Lake Conjola Entrance Management Plan – Report MHL 1159 December 2002.
- Lake Conjola Entrance Management Dredging Works – Review of Environmental Factors – Report MHL 1161 December 2002.

2. Implications of Maintaining an Open Entrance

The main community benefits of maintaining an open entrance to Lake Conjola are:

- Reduction in risk of flooding of low-lying areas adjacent to the lake including several villages and caravan parks.
- Maintenance of water quality – for public health, tourism activities, oyster production and fishing .

By maintaining an open entrance the existing lake regime will be changed resulting in a number of implications:
- the levels of bacteria, viruses and nutrients may be reduced with increased tidal flushing though they will still occur as the sources persist;

- the extent of seagrass decreases, though their health may improve;
- the abundance and diversity of habitats available for water birds changes and may advantage some species over others;
- there is increased accessibility for marine organisms to the lake, changing the abundance and diversity of fish and other species.

There are pros and cons related to maintaining an open entrance. In the case of Lake Conjola the Estuary Task Force has concluded that, presently, the benefits justify the maintenance of an open entrance.

3. Physical Processes Involved (in maintaining an open entrance)

- The entrance channel tidal shoals grow due to:
- Littoral drift along the coast resulting in marine sand infeed into the entrance.
- Windblown sand from Conjola Beach and the spit.
- Tidal scour of the high dunes inside the entrance on the southern side.
- As the entrance shoals grow, the tidal range inside the entrance and the tidal flows through the entrance decrease, and the ebb tide and fluvial flows are deflected against the high dune increasing scouring there and depositing more sand on the entrance shoals.
- This ongoing steady process is interrupted from time to time by severe coastal storms and by floods.
- The severe coastal storms trigger entrance closure by causing washover of sand from the spit into the entrance channel, consequently reducing channel size, restricting tidal flow which increases channel shoaling and can lead to channel closure, typically for several years.
- Floods scour the entrance shoals, resulting in a larger entrance channel, increasing tidal flows and tidal range and marine sand infeed.
- The key to improving entrance stability is to decrease the destabilising effects of the severe coastal storms.

4. Actions and Responsibilities to Maintain the Open Entrance

The actions required to maintain the open entrance are in broad terms:

- Continual long-term monitoring of entrance conditions.
- Implementation of works to achieve a long-term open entrance when shoaling reaches a point where closure is inevitable.
- The works comprise dredging a channel across the inner sand flats, to increase tidal flow and to use the dredged sand to build up the entrance spit to sufficient height, to restrict the amount of sand washed into the entrance by storm waves, and to reclaim the eroded southern bank of the inlet channel.

A decision support system will monitor the tidal range, and specifically the M2 tidal constituent, inside the entrance. Trigger levels have been set at ever-decreasing tidal ranges to initiate actions to maintain the open entrance.

The trigger levels are:

Trigger Level A – Monitor Closely. M2 Values 0.15 – 0.08

Early signs of increasing entrance constriction, monitor M2 carefully.

Trigger Level B – Activate Plan. M2 Values 0.08 – 0.06

Constriction increasing, increasing risk of closure if major ocean storms occur but entrance may scour if there is a major flood. Commence pre-dredging activities. If a flood scours entrance during pre-dredging activities and M2 exceeds 0.15 put dredging on hold.

Trigger Level C – Possible Closure. M2 Values 0.06 – 0.03

Entrance constricted. Complete pre-dredging activities and commence dredging.

Trigger Level D – Imminent Closure. M2 Values 0.03 – 0.01

It is imperative that dredging commence as soon as possible.

The key activities and responsibilities are:

Trigger Level	Activity	Responsibility
A and above	**Ongoing Activities**	
	Environmental monitoring program	SCC
	Monitoring water levels and rainfall	MHL under contract to DLWC
	• Operation of decision support system	MHL under contract to SCC
	• Production of annual commitment report	MHL under contract to SCC
	• Distribution of annual commitment report	SCC
	• Maintenance of commitment document	SCC
	• Community liaison by committee meetings, advertising website and annual report	SCC

Trigger Level	Activity	Responsibility
B	**Pre-works Activities**	
	• Scheduling of activities	SCC
	• Sourcing of funding	SCC
	• Gain approvals from DLWC, Fisheries and NPWS	SCC
	• Pre-works surveys of entrance channel and dune area	SCC
	• Update and submit REF for dredging	SCC
	• REF determination	SCC, Fisheries, NPWS, DLWC
	• Produce and submit DA and SEE for deposition of dredged sand	SCC
	• DA determination	SCC
	• Final design of dredging, dune nourishment and southern bank reclamation work	SCC
	• Community liaison by committee meetings and press release	SCC
	• Prepare tender documentation	SCC
C	**Pre-work Activities**	
	• Tendering activities and entering into contract	SCC
	• Community liaison by committee meetings, press release, letter box drop	SCC
D	**Work Activities**	
	• Dredging and sand deposition	Contractor
	• Monitoring operations, verifying quantities and authorising payments	SCC
	• Sign off at completion of contract	SCC

5. Funding

The estimated costs in 2002 are:

- Ongoing Activities $20,000 p.a. (for monitoring additional to that currently undertaken)
- Pre-work Activities $50,000
- Work Activities $800,000

The source of funding is the Department of Land and Water Conservation (DLWC). DLWC is to be kept informed via the annual commitment report.

6. Annual Report Template

- Results of ongoing environmental monitoring program.
- Results of water level, rainfall and tidal (M2) monitoring and analysis.
- Time series plot of trigger conditions, M2 and entrance (open/closed) condition.
- Status of implementation of pre-works activities.
- Status of implementation of works activities.
- Response form

  - Do you have any comments on the annual report?

  ……
  ……
  …….

  - Do you consider there are any items and issues not conforming with implementation of the plan?

  ……
  ……
  ……...

  - Are there any actions required and by whom?

  ……
  ……
  ……...