Wyong Shire Council

Review of Environmental Factors Maintenance Dredging at the Mouth of Tumbi Creek, Killarney Vale

April 2002

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Maintenance Dredging at the Mouth of Tumbi Creek, Killarney Vale

Appendices

A. Photographs

B. Survey Plans

C. Report on Acid Sulphate Soil Assessment November 2001. Douglas Partners

D. Letter Report on Proposed Dredging, Tumbi Creek, Berkeley Vale
March 2002. Douglas Partners

E. Report on Effect of Wave Action from Dredging.
March 2002. Patterson Britton and Partners

1.0 EXECUTIVE SUMMARY

Siltation has blocked the main navigation channel connecting Tumbi Creek to Tuggerah Lake. This blockage has increased the flooding effects on properties close to the Creek, and is potentially having negative impacts on water quality and on marine life that frequents the creek. It is also preventing the use of the channel and lake by small boats that have used this channel for many years for recreational purposes.

This Review describes Council's proposal to cut a new navigation channel between the Lake and the boatramp in Tumbi Creek using a 10/8-cutter suction dredge, with discharge of the spoil under controlled conditions across part of the bed of Tuggerah Lake. The Review assesses the potential positive and negative impacts of the proposal, and concludes that the proposed dredging can be undertaken with all environmental issues able to be satisfactorily addressed and monitored. It will provide benefits that justify the undertaking of the work.

This proposal is being submitted under the provisions of State Environmental Planning Policy No. 35: Maintenance Dredging of Tidal Waterways, and is also being proposed as part of the Tuggerah Lakes Estuary Management Plan.

2.0 INTRODUCTION

2.1 History of Channel

Tumbi Creek has a boat ramp close to its mouth where it empties into Tuggerah Lake. The siltation of the channel from the boatramp to the Lake has caused concern about flooding issues and water quality in the creek, as well as raising community concern at the loss of boat access to the lake. Figures 1 and 2 show the location of the creek and proximity of the boatramp to Tuggerah Lake.

Mainly recreational boat owners gain access to Tuggerah Lake by using the boatramp and channel. The channel also allows the free movement of marine life between the Lake and the creek, and assists in the flushing of the creek that carries stormwater from a large developed catchment.

The channel in Tumbi Creek has a history of closures due to siltation at its mouth. The channel was last re-opened by dredging in 1995. Prior to that date it was dredged in approximately 1986 and earlier in the 1970's.

2.2 Siltation

An examination of the Tumbi Creek catchment for possible sources of sediment has concluded that the principal sediment source appears to be from the creek itself, with the worst areas being upstream from Wyong Road. It appears that the level of development in the catchment has increased both the volume and velocity of stormwater flows in the creek, leading to areas of bank erosion and instability of sections of the creek banks. Further minor sources of erosion were noted on some individual private allotments.

In addition, it is also believed that there has been some sediment contribution from lake-borne materials such as dead seagrass (wrack) and sediments moved into the channel mouth from the lake and along the foreshore.

Council has investigated the creek bank erosion sites and prepared design plans for remedial works. Many of the erosion sites are located at the tail outs from stormwater drains serving developed areas. Where these drains empty into Tumbi Creek, turbulence appears to have eroded back along the drainage lines and undercut the drains and the creek banks.

These areas will be stabilised with soil, geofabric and rock armouring as appropriate. Replanting will also be undertaken to restore these sites and prevent further erosion.

It will also be necessary to remove fallen trees in the creek where they are diverting flows and causing further bank erosion and undercutting.

Action commenced in March 2002 to stabilise these areas. Due to the estimated cost of these works (approximately $250,000) these works will continue into 2002/2003.

2.3 Proposed New Channel

For reasons detailed in this Review it is proposed to leave the existing channel in its current blocked condition, and dredge a new channel from Tumbi Creek to Tuggerah Lake.

The site of the proposed new channel is situated near the eastern end of The Peninsula, a cul-de-sac at Killarney Vale at the southern end of Tuggerah Lake. The site location is shown in Figure 1. The proposed orientation of the channel is shown in Figure 2. Also included in the Appendices are survey plans of the proposed new channel.

Council's proposal will involve cutting a new channel to the west of the old channel, with the channel facing a more northerly direction than the north-easterly orientation of the old channel. This is considered to be closer to the position of the original creek and should assist in maintaining the channel in an operational condition. The new channel will also have a larger volume, which is expected to provide a longer operational life.

This proposal is being submitted under the provisions of State Environmental Planning Policy No. 35: Maintenance Dredging of Tidal Waterways, and is also being proposed as a management study component of the Tuggerah Lakes Estuary Management Plan.

2.4 Spoil Disposal Options

The very early dredging campaigns at the mouth of Tumbi Creek generally disposed of dredge spoil by depositing it on the adjacent lake foreshore, particularly on the eastern side of the creek mouth. As the surrounding residential areas have developed this practice has become unacceptable and other disposal options are required.

The dredging campaign in 1995 utilised a very small holding pond constructed at the northern end of the Adelaide Street Oval to provide a temporary storage site. This pond was located approximately 500 metres upstream of the creek mouth, and was constructed on the only available open space of any size in reasonable proximity to the work site. It was found in practice that this operation was extremely difficult and expensive due to the relatively small area of the pond and the difficulties experienced in excavating and removing the spoil. In 1995 the cost of the work was in excess of $250,000 and involved removal of approximately 4,000 cu. metres of material. This site is no longer considered to be suitable as a disposal or holding area due to its small size and disruption to the use of the adjoining Council sportsground.

Of all the alternatives considered for re-dredging the channel (refer Section 6.0), cutting a slightly re-aligned new channel is now considered to be the most appropriate. However, this will require the discharge of the dredge spoil evenly across the bed of Tuggerah Lake where it would become incorporated into the existing bottom mud. This Review examines the potential impacts of this proposal in more detail.

3.0 DETAILED DESCRIPTION OF THE PROPOSAL

3.1 Extent of Blockage

Soundings and surveys carried out by Council have confirmed that the existing navigation channel at the mouth of Tumbi Creek has accreted to the point where it is no longer passable by any watercraft. When Tuggerah Lake is at a level of 0.0 m to 0.1 m Australian Height Datum (AHD) there is practically no interchange of water between the Lake and Tumbi Creek. There is a land bridge above water level across the mouth of the creek at these average lake levels. The extent of this siltation is obvious from the photographs in the Appendices.

3.2 Siltation Sources

The deposition of material at the mouth appears to be mainly due to erosion along the stream bank of Tumbi Creek in its upper reaches. There is also an accumulation of dead seagrass on the lake-side of the channel due to the blockage that has occurred. Together, this material has totally filled the old channel in the vicinity of the creek mouth in such a way, and to such an extent, that it is not possible to carry out any effective work to remove the blockage from the land.

The original proposal put forward by Council at the beginning of 2001 was to use a long reach excavator to provide a minimal channel along the eastern side of the old creek channel for boat movements between the creek and the lake. Delays in receiving approvals to using land-based equipment meant that the most feasible method now available will require floating plant such as Council's cutter-suction dredge to clear this material.

Action to address siltation sources is discussed in Section 2.2.

3.3 Dredge Pond

Due to the restricted nature of the site and built-up surrounding areas, there is no practical option available to establish a dredge pond of any appreciable size within a reasonable pumping distance of the blocked channel. A large pond size is important because of the very high volumes of water that are required to be pumped in any dredging operation, and the need to allow sediments to settle and clear water to be decanted.

Alternative techniques to using a large settling pond were considered and are discussed in Section 6.0. The option now proposed to spread dredged material across the bed of the lake is discussed in the remainder of this Review.

3.4 Proposed Disposal of Dredge Spoil

It has been calculated from the survey plans in the Appendices that approximately 30,000 cubic metres of material will have to be dredged for the new channel. The channel will be approximately 50 m wide, 1.5 to 2 metres deep and 460 metres long. It is proposed to relocate the dredged material to an offshore discharge site that will spread the spoil across the adjacent bed of the lake. This will be achieved through a 250 mm dredge discharge line, which will have its discharge end supported and moved by boat over the bed of Tuggerah Lake over the area shown in Figure 3.

The proposal will distribute the spoil across an area of approximately 300,000 square metres. This will result in an initial increase in bed height of approximately 100 mm over this area, although it is expected that the bottom muds will slowly move to spread this material over a greater area at a reduced increase in bed height. The average water depths in the proposed disposal area when the lake is at an average height of 0.1 m AHD are approximately 1.5 m to 2.0 m.

The material to be dredged will be predominantly clay, with an overlying stratum of fine muds and organic matter. From previous dredging experience it is known that the clay will generally discharge in small spheroids, and these are expected to slowly settle into the deep stratum of organic mud overlying the bottom of the lake in the proposed disposal area. The finer materials are of similar composition to the muds on the lake bed. They will settle within the silt curtain screen and become part of the lake bed.

Exploratory boreholes drilled in the southern section of Tuggerah Lake in the last three years by Coal Operations Australia Limited (C.O.A.L.) have shown that the depth of organic muds on the bed of the lake in this area varies between about 8 m and 38 m. The other organic materials already overlying the clay in the area of the proposed new channel will also settle to the lakebed in the discharge area. They will be discharged within a floating silt curtain to ensure that the area of highest turbidity is confined within the target area during the dredging period.

During dredging operations a floating silt curtain will also be maintained around the working dredge, and the dredge discharge line will be either sunk or marked such that it does not present a hazard to any other watercraft.

Before and after bottom surveys will be undertaken of the disposal area to check that the increase in level of the lakebed does not exceed an average depth of 100 mm. To mitigate the possibility of "mounding" of the discharged materials on the lakebed, the dredge pipe will be regularly relocated across the discharge area. This will be achieved by attaching it to a workboat and slowly moving the discharge pipe across the discharge area while keeping the pipe end under water.

In addition, the density of the discharged material will be adjusted by the dredge operator to ensure as even a spread of dredged material as possible within the floating silt curtain. This can be achieved by reducing the depth of each cut by the dredge, slowing the speed of movement of the cutting head or allowing more water to be pumped with the dredge spoil. Together, these actions should assist in spreading the dredged material down as a layer on the lake bed.

In terms of total water volume in Tuggerah Lake and effects on flood levels, the proposed relocation of material from the dredged channel to the centre of the lake will not affect flood levels around the Tuggerah Lake.

4.0 JUSTIFICATION FOR THE PROPOSAL

4.1 General Impacts

Dredging operations have been periodically carried out to maintain a navigable channel at the mouth of Tumbi Creek over the past thirty years. Council has received a large number of complaints as well as a signed petition requesting that Council again dredge and re-open the channel to the lake. The siltation has now effectively closed the mouth of the creek to boat users and at low lake levels access for marine life is all but denied.

More significantly, investigations have shown that the blocked channel mouth will worsen flooding of properties in the low-lying areas along the lower reaches. This is a major concern for Council and the most compelling reason to undertake dredging works.

Dredging by cutter suction dredge is necessary to allow safe continued access between Tumbi Creek and Tuggerah Lake for boat owners who use the public boat ramp near the mouth of the Creek. There are also a number of residents living along Tumbi Creek who directly access the creek from their properties. They use the creek to gain access by boat to Tuggerah Lake and this access is currently denied to them.

Entry to Tuggerah Lake for boats requiring deeper water than shallow draught canoes and similar vessels is very limited along the southern shore of Tuggerah Lake. Given the population living in the nearby areas the maintenance of boat access to the lake at Tumbi Creek is considered to be a priority.

The proposed work will also allow the free passage of marine life between the creek and the lake and improve the water quality in the creek. The creek channel is currently greatly restricted when the Lake is at its lower range of normal water levels.

4.2 Flooding Impacts

Investigations of the effect on flood levels of the channel blockage have shown that in a 1% creek flood there will be an extra 490 mm depth of water at a point 100-200 metres upstream of the boatramp and footbridge in Tumbi Creek. This extra water depth will affect sixteen properties in the area of The Peninsula, Lakedge Avenue and Gregory Street. The effect will be small but will result in greater depths of water in surrounding yards, downstairs laundries and similar low-lying areas in this flood event.

The proposed new channel will ensure that these properties do not experience the additional water depths caused by the channel blockage.

4.3 Ecological Impacts

The impacts on the ecology of the estuarine section of Tumbi Creek behind the sediment barrier are quite severe. Measurements of water quality variables immediately upstream of the sediment barrier indicate conditions that are deleterious for invertebrates and fish that live within the creek. Twelve months ago, water quality variables (eg. Dissolved oxygen (DO), Salinity, Turbidity and Total Nitrogen) within the estuarine section of Tumbi Creek were similar to those measured in other creeks entering the Tuggerah Lakes. Since the mouth of the creek has "silted up" there has been a decline in the quality of water within the creek. As an example, the concentration of DO within the water immediately upstream of the sediment barrier was recently measured at 2.2 ± 0.4 mg/L and 2.6 ± 0.4 mg/L. At these concentrations fish kills are inevitable and assemblages of macroinvertebrates have probably also been significantly altered. DO concentrations at similar sites within Wyong River and Ourimbah Creek measured at the same time ranged between 5.7-7.4 mg/L.

4.4 Economic Justification

The estimated cost of dredging the proposed new channel is $350,000 including necessary studies. This cost is significantly less expensive than any of the alternatives examined in Section 6.0 of this Review.

5.0 IMPACTS OF THE PROPOSAL

5.1 General

When the Tumbi Creek channel was last dredged in 1995 there were no adverse environmental impacts observed or recorded. However, it must be said that at that time there were no specified requirements for monitoring general environmental effects in a holistic sense, and a strict scientific assessment of all aspects of the work was not made.

Public complaints during the dredging campaign were minimal, and controls were in place to prevent escape of the sediments collected in the small spoils pond constructed at the end of the Adelaide Street Oval. The dredged material was taken in trucks with sealed bodies for ultimate disposal at the (then) Council tip at North Entrance.

The significant difference between the 1995 dredging and that currently proposed is that this proposal will relocate dredged material into Tuggerah Lake, where the material will be allowed to spread across the lake bed in a controlled manner.

The proposed dredging operations are expected to have minimal adverse environmental impacts but provide significant benefits to the community. The following details describe the main considerations relating to this proposal.

5.2 Sediment Transport and Water Quality

Floating silt curtains will be placed in Tumbi Creek to prevent sediments being transported up Tumbi Creek or out into Tuggerah Lake. These curtains will contain sediment movements as a result of disturbance by the dredging operation. Floating screens will also be placed around the discharge point of the dredge pipe into Tuggerah Lake to contain the finer materials to the immediate area of discharge. The curtains will not be relocated to new disposal sites until the increased turbidity caused by the discharged material has reduced to less than that of the surrounding lake waters.

The dredge discharge pipe will be attached to a workboat or suitable craft to allow it to be moved around the discharge area. This will ensure that the spoil is evenly distributed over the proposed discharge area.

It should be noted that being a naturally shallow coastal lagoon (average depth less than two metres), Tuggerah Lake is significantly affected by storms and strong winds. These frequently cause greatly increased turbidity in the Lake. It is not expected that the proposed works will cause increased turbidity of the Lake waters.

5.3 Flora and Fauna

5.3.1 General

The proposed dredged channel and the disposal area do not contain any known habitat for Threatened or Endangered Species, nor is the area known for such species.

5.3.2 Seagrass Meadows

The seagrass meadows adjacent to the mouth of Tumbi Creek in Chittaway Bay are dominated by beds of eelgrass (*Zostera capricorni*) and paddle weed (*Halophila ovalis*). At the mouth of Tumbi Creek, the seagrass beds are patchily distributed and generally in very poor condition. Healthy beds of *Zostera* occur away from the creek running parallel to the shoreline out to a depth of approximately 1.5m. To quantify the spatial extent of the seagrass meadows, their seaward extent on either side of the entrance to Tumbi Creek were mapped by the Centre for Research on Ecological Impacts of

Coastal Cities, University of Sydney (EICC). *Zostera capricorni* was mapped by recording the presence or absence of the plant along a 2km front running parallel to the shore. The edge of the bed of *Zostera* was located initially by swimming one transect out from the shore along the middle of the proposed channel. This position was then marked with a buoy. To ensure that it was the edge of the *Zostera* bed, the substratum was searched for a further 5-10 m seaward by SCUBA divers. The boundary of the *Zostera* bed was followed and a point was recorded every 25 m for 1 km in an easterly and westerly direction of the proposed channel. The positions of the edge were recorded with a Garmen II GPS data logger and the depth was also recorded. Once the edge of the *Zostera* bed was determined within the designated area, random points were chosen either side of the boundary of this bed. These points were also recorded by the GPS and the cover of the substratum was identified to verify the boundary of the *Zostera.* The GPS coordinates and the points were overlayed on a digital bathymetric map of Chittaway Bay identifying the boundary of the seagrass bed near Tumbi Creek (Figure 4).

There are no significant seagrass beds within the proposed excavation channel as shown on the survey plans. The removal of material from the proposed channel will potentially increase turbidity levels in the immediate vicinity during dredging operations but these effects will be short-term and localised. Floating silt curtains will be used to contain the turbidity and prevent sediments moving further away to the seagrass beds along the foreshore of the lake. A monitoring program has been implemented to quantify the effects, if any, on the adjacent seagrass meadows. This monitoring is being done by EICC.

There are no seagrass beds in the disposal area as the water depth is generally too great and the water turbidity is too high. Seagrass beds are located in the shallow foreshore areas around the lakes. There is no reason to believe that they will be impacted by the proposed disposal of dredge spoils further out into Tuggerah Lake.

5.3.3 Macrobenthic Assemblages

The proposed disposal area offshore from Tumbi Creek has been evaluated using information provided from core drillings taken by C.O.A.L. Pty Ltd when undertaking exploratory drilling for coal deposits under the lake. It has been confirmed that the large area of lakebed from Chittaway Bay in the west to Saltwater Creek in the east largely comprises organic muds to a depth of between 8 m and 38 m. The structure and dynamics of these sediments were also evaluated in the Tuggerah Lakes estuary process study as were those within the shallow fringing seagrass habitats. Generally the deeper open water sediments were comprised of a soft mud, whilst the shallow sediments were comprised of sandy mud.

Benthic assemblages within the shallow seagrass areas adjacent to the proposed channel are comprised of a range of macrobenthic organisms. The most abundant macroinvertebrate taxa found in the shallow seagrass sediments around Chittaway Bay are polychaete worms (Capitellidae and Opheliidae), molluscs (*Nassarias burchardi* and *Battalaria australis*) and amphipods.

In the deep-water sediments (at the location of the proposed disposal of spoil), the dominant macroinvertebrate taxa are from the polychaete families Opheliidae and Magelonidae. In general the number of species and the abundance of macrobenthic fauna is significantly smaller in the open-water habitats compared with the seagrass habitats.

A study has been commissioned (EICC) to examine the effects of both the dredging and disposal of spoil on macrobenthic assemblages in shallow seagrass and open water habitats. The relatively small area to be affected (300,000 sq. m) compared to the area of the Tuggerah Lakes (75 sq km) and previous work in this area suggests that the overall impact will be very small, however this will be quantified through the monitoring program. Previous studies on the effects of spoil disposal and dredging are few. A study by the Australian Museum in the Hawkesbury estuary found that some macrobenthic organisms were killed by dredging operations and spoil disposal however their re-colonisation back into the sediments was relatively fast (few months) once the dredging operation was completed.

5.3.4 Fish and Crustaceans

The sediment barrier at the mouth of Tumbi Creek is potentially impeding the passage of fish and crustaceans into and out of the creek, especially when the lake is at lower levels. The proposed dredging should reinstate this passage for marine animals. A study is currently being done by NSW Fisheries to assess the impact of the dredging on fish and other nektonic assemblages. Previous studies by Wyong Shire Council and NSW Fisheries have identified that there are abundant fish assemblages in the seagrass meadows adjacent to Tumbi Creek. As part of this assessment, a recent survey by NSW Fisheries identified up to 23 species of fish and 8 species of crustacean at the mouth of the creek and in the adjacent seagrass meadows. Of these species, many were considered to be economically important (NSW Fisheries data).

5.3.5 Saltmarsh and Wetland Vegetation

A survey of the saltmarsh and wetland vegetation along the foreshore adjacent to Tumbi Creek was done to assess the potential habitat that may be affected by any onshore operations. Saltmarsh communities are considered to be threatened communities within NSW, and within Tuggerah Lakes approximately 85% of these habitats have been lost or severely degraded. The foreshore in this area has been elevated through dredging during the Lakes Restoration program. The edge of the lake has a rich assemblage of salt tolerant plants with very few weeds. The saltmarsh along these foreshores is considered healthy with up to 24 species identified along the edge. An elevated zone, landward of the saltmarsh is poorly vegetated however behind this zone there is a swamp forest dominated by *Casuarina glauca*. This small forest provides harbour for animals and despite the presence of many weeds warrants conservation and should not be destroyed (Sainty 2002). If large amounts of sediments or settlement ponds were to be built then much of this fringing saltmarsh and wetland vegetation would be destroyed.

5.4 Soils

5.4.1 General

The impact from the dredge working to cut a new channel on the water quality of Tumbi Creek and Tuggerah Lake will be short term only, and will be contained by the use of floating silt curtains.

The nature and size of the dredging activities are not expected to cause any long-term erosion or sediment control problems to adjacent creek banks or the lake foreshore. A wave study has been undertaken as discussed in Section 5.10 to asses possible future impacts from waves.

5.4.2 Acid Sulphate Soils

Samples taken from the area to be dredged show that the material is likely to be acid sulphate or potential acid sulphate in nature. However, the material to be relocated will remain in or under water at all times. It is proposed that during dredging, the end of the pipe will be kept under water. As a result, the material will not be given the opportunity to cause acidity-related problems. The natural alkalinity of the waters of Tuggerah Lake will be a further buffer to any acidity.

A study has been undertaken of the acid sulphate potential of soils to be dredged. A copy of this geotechnical report is included in Appendix C. This report identified that all but one of the nine soil samples tested were potential acid sulphate soils.

A further study of the potential for these soils to create acidity problems when dredged and immediately placed under water was undertaken. A copy of the report by Douglas Partners is included in Appendix D. The report concludes that as "the sediments are currently near neutral and are in and will be replaced into seawater, the potential for any acid generation would be negligible."

Although no acidity problems are expected with the proposed method of dredging and disposal, pH testing in the surrounding waters will be undertaken as part of the water quality testing programme (see Section 7.2.3).

5.4.3 Heavy Metals and Pesticides

Heavy metals and organochlorines pesticides can accumulate within sediments and have the potential to cycle through the food chain. Trace metals and pesticides within the sediments have been examined in both the shallow seagrass and deeper open water habitats of Chittaway Bay (Tuggerah Lakes Estuary Process Study). These compounds can be toxic to aquatic organisms and have the potential to bioaccumulate in fish, shellfish and humans.

The concentration of pesticides within the sediments in both seagrass habitats and deeper sediments were below detection limits. The sediments within the deeper open water had greater concentrations of trace metals compared with the shallow sediments. The concentration of trace metals in the sediments were below levels that are known to cause adverse environmental effects.

5.5 Air Quality

Within the Tumbi Creek area emissions into the surrounding atmosphere will only occur from the power plants of the dredge and associated workboats.

Emissions from this equipment will comply with the relevant Australian Standards. Over the expected time of the work (less than twelve weeks) there will be no significant effect on air quality.

The material removed may generate some odour when exposed to the air. However, this should not be of concern as all dredged material will be relocated under water at the discharge point. The disposal area will also be located between 300 m and 800 m from the nearest house on the foreshore and this will ensure that odours are not discernible on the lake foreshore.

5.6 Noise

There will be some short-term noise effects generated by the operation of the dredge and workboats for a period of approximately twelve weeks during excavation of the channel.

All working machines will be required to comply with the relevant Australian Design and Operational Codes. The working hours will be limited to the hours of 7.00 AM to 7.00 PM between Monday and Saturday.

Any splashing noise generated by the dredge or workboats will also be inaudible on the shore.

While there will be a minimal rise in ambient noise levels for the period of the project, this will have little adverse effect on the local community.

5.7 Socio-Economic Effects

The removal of deposited materials will restore access for recreational boat owners to Tuggerah Lake from Tumbi Creek. This will have beneficial effects financially and socially by allowing recreational boating to continue at this site.

5.8 Fuelling and Hydraulic Oil Spillages

A potential source of pollution is fuel spillage from the dredge or the workboats. Fuel spillage is most likely to occur during refuelling operations.

The only fuel on the site will be in the fuel tanks of the workboats and dredge. Any refuelling of the workboats and dredge will be via a fuel truck. Any spillages will be immediately contained to prevent

fuel entering the lake. Any soil contaminated with fuel due to a spillage will be collected and disposed of at Buttonderry Tip in accordance with legislative requirements.

It is noted that there have been no cases of significant fuel spills from Council's aquatic equipment in over ten years of operation on the Tuggerah Lakes.

It is possible that during the course of the work an hydraulic hose may fail on the dredge or associated vessels. Council has in place an emergency response procedure for such an event, and absorbent materials and booms are carried to minimise the impact of such an event. This procedure is also used in the event of a fuel spill, and involves containment of the spilled liquid, control of the cause of the spill and collection and removal of the contaminated materials.

Due to the low risk of a fuel or hydraulic oil spill, the containment procedures already in place and the absence of any significant incidents experienced in over ten years of aquatic operations the potential risk to the environment from spillages is considered to be extremely small and acceptable.

5.9 Flooding

As in many areas around the Tuggerah Lakes, early development of residential properties in the vicinity of Tumbi Creek occurred without detailed consideration of flooding issues. During periods of high rainfall flooding of land adjacent to Tumbi Creek will occur, as the creek channel cannot contain the flows. Further development in the catchment has also lead to increased stormflows. Backwater effects from lake floods are also possible in the areas close to the creek mouth.

The current blockage in the channel at the mouth of the creek has been analysed to assess the potential impact on flood levels at surrounding residential areas. It has been determined that the blockage will cause an additional increase in flood levels of 0.49 metres at a point 100-200 metres upstream of the creek mouth during a 1% flood event with the lake at a relatively low level of 0.5 metres AHD. This extra depth of water will have an effect on some sixteen properties that are located along The Peninsular and surrounding streets.

To remove these effects a minimum channel width of 15 metres is required, with a channel bed at a level of -0.8 metres AHD. This equates to a water depth of around one metre under normal lake levels.

The new channel to be dredged is proposed to be approximately fifty metres wide and up to two metres deep for the full distance out to the drop over into deeper water. This extra channel size is proposed to provide some longevity to the channel by providing additional storage for sediments.

The proposed dredging work is intended to reduce the impacts of flooding on surrounding properties as well as provide a better channel for small boats to gain access to Tuggerah Lake from Tumbi Creek.

5.10 Wave Action

A study was undertaken of the likely impact of waves moving up the new channel. These waves could be wind - or boat-generated. The results of the study are included in Appendix E.

The study concluded that the new channel was not expected to result in significant modification of the shoreline. Any increase in shoreline erosion was also not expected to be significant, and should be monitored. If required, some minor rock protection could be installed. Keeping the channel away from the shoreline was also suggested, and this will be implemented as far as practicable.

6.0 ALTERNATIVES TO DREDGING NEW CHANNEL

6.1 General

A number of options were considered to provide an acceptable channel to the Lake in addition to the proposed option to dredge a new channel as described in this Review. The proposed option is estimated to cost approximately $350,000 including necessary studies. These alternative options are described briefly below.

Every option that involved removal of material from the site by truck for disposal at the nearest approved landfill site will also incur transport costs plus landfill fees. It has been estimated that transport costs will be $10.00/cu.m for loading and transport of material for the 40km round trip from Tumbi Creek to the Buttonderry Landfill site on Hue Hue Road at Kiar.

Also assuming that the dredged material can be accepted into the tip as clean fill (cheapest option), a further charge of $11/cu.m will be incurred.

For loading, transporting and disposing of 30,000 cu.m of material the minimum cost would therefore be 30,000 x $21 = $630,000. Additional costs for treating the material with lime to control acidity may also be required but have not been costed.

6.2 Excavator on Shore

This option was based on using a long-reach excavator working from the eastern shore to open up a channel suitable for boats to access the Lake. The option always had limited viability as the channel extends well past the shoreline into the Lake, and hence is unreachable if the channel becomes significantly blocked.

The option was considered viable early in 2001, but delays in receiving necessary approvals meant that when approvals were received in August 2001 the siltation had increased to the extent that use of a shore-based excavator was no longer feasible.

Due to the extent of the siltation and its location this is no longer a viable option.

6.3 Use of a Small Dredge

A very small dredge (100 mm) pumping material into a small separation plant and cyclone on the shore has been considered. Although this system is available and is well suited to removing small silt fans from in front of stormwater outlets, it would not be an economically viable option for Tumbi Creek and would be extremely slow.

A small dredge similar to that used on Lake Macquarie can dredge and process approximately 100cu.m of material per day. A rate of approximately $40/cu.m (exclusive of GST) was obtained to excavate, process and transport material to the Buttonderry Tip. With an additional $11/cu.m for tip fees, the use of this small dredge is estimated to cost 30,000 x $51 = $1,530,000.

At a production rate of 100cu.m per day this system would require 300 days to remove the material in the proposed channel.

6.4 Re-Dredge Previous Channel

It has been calculated that the volume of material to be removed to re-establish the previous channel is approximately 17,500 cubic metres. The problem of spoil disposal still exists with this option, as locating a reasonable size open space area to allow construction of the temporary storage pond(s) required is difficult.

With this small quantity of material to be dredged and temporarily stored, one option examined was the construction of a long narrow pond on the foreshore on the eastern side of Tumbi Creek. Such a pond would present a number of a difficulties:-

- The existing foreshore was built up using mud and ooze pushed out of the lake under the Tuggerah Lakes Restoration Project. This material was highly unstable and capped with sand. Any pond built here would have to be constructed above ground using imported material to build bund walls, adding significantly to the costs.

- Assuming a pond was to be built on the foreshore the established trees and vegetation would have to be removed and a haul road constructed to import material. A pond width of 20 metres might be achievable. With theoretical wall heights of say three metres, the pond would need to be 290 metres long just to hold the full amount of material to be dredged. This is an impractical size. Even if the pond was to be built to hold half the quantity of material to be dredged, the pond would still be of an unrealistic scale due to the need to allow for batter slopes on the walls and sufficient depth to allow the fines to settle out in the pond in a reasonable time. From previous experience a very large pond is required if very fine particulate matter is to settle out each day.

- There are significant areas of existing saltmarsh along this foreshore. Saltmarshes are considered an ecologically threatened community in NSW and since Tuggerah Lakes has already lost 85% of its saltmarsh, then this option would cause further degradation to this community.

- A pond on the foreshore would be close to houses, and odours would be a problem.

- Public safety would be a major concern due to the nature and depth of material to be held in the pond, the steep side slopes of the pond walls and the closeness to a public shared pathway. A security fence would need to be built and maintained around the pond at all times.

- Removal of material from such a pond would also present some difficulties as the long, narrow pond would fill from the western end but access would be from the eastern end of the pond.

This option is not preferred over the proposal to dredge a new larger channel slightly to the west of this original channel and disperse the dredged material over the bed of the lake.

6.5 Floating Excavator and Barges

This option would involve floating an excavator on a barge and using it to excavate the channel and empty the spoil into barges which would carry skips or similar. These barges would be towed to shore and then loaded into trucks for disposal at Buttonderry Tip.

This option would involve a number of different plant items, including an excavator and barge, a transporter barge and skips and some method of unloading the skips on to trucks to be taken to the Buttonderry Landfill site.

Based on a number of assumptions regarding cycle times and volumes of material moved per hour, an estimated rate of $16/cu.m was calculated to excavate, transfer and deposit the material into trucks at the boatramp ready for transport to the landfill site. This cost will thus be 30,000 x $16 = $480,000.

To this cost must be added the cost of transport to the landfill site and disposal charges of $630,000.

The total estimated cost of this option is thus $1,110,000.

This option was discounted on the basis of higher costs and the difficulty of handling the semi-fluidised materials surrounding the stiffer materials that would be excavated.

6.6 Temporary Road Over Channel

This option would involve using ballast to construct a temporary road over the location of the required channel (either for the old channel or the proposed new channel location). Excavators and trucks would

then be used to excavate the required channel, and transport the material to the Buttonderry Landfill site along another temporary road that would have to be built along the foreshore from the channel to Adelaide Street. The foreshore in this area is reclaimed material and would not withstand the repeated running of laden trucks without reinforcement. The ballast in the creek/lake would be progressively removed once the channel had been excavated.

This option would require the construction and later removal of approximately 300m of temporary foreshore haul road; the importing and later removal of suitable ballast to construct a haul road over the site of the required channel which would be up to 500m long; and the excavation of material from within the creek/lake to form a new channel.

It is noted that the existing channel that has now been closed due to siltation was previously dredged to a depth of approximately 1.3m. It can be expected that the material in this channel will require extensive ballast to provide a workable haul road.

The estimated cost of loading, transporting and disposing of 30,000 cubic metres of material will be $630,000 as identified in section 6.1. The construction and later removal of the foreshore haul road has been estimated to cost approximately $270,000. The cost of providing, and later removing, ballast rock to construct a haul road over the channel itself is difficult to estimate due to the unknown quantity of rock that may be required. However, it is not unreasonable to expect that this element of the work could cost in excess of $200,000. The total estimated cost of this option is therefore likely to being in excess of $1.1M.

This option would be very expensive and relatively slow and is not a preferred option due to the amount of material that would need to be handled and damage caused to the foreshore.

6.7 Do Nothing

This option would appear to incur no costs in the short term, but does not address any of the problems identified in this Review. This is not considered to be a viable option for this project.

6.8 Cost/Benefit Considerations

From the above analyses it can be seen that the least expensive dredging option involves disposing of the dredge spoils across the lake bed. The estimated cost of this option is approximately $350,000. The nearest alternative option is four times as expensive.

While costs are fairly readily calculated, it is much more difficult to quantify benefits. Three main areas of benefit can be identified.

The reduction in flooding of sixteen properties in the vicinity of the creek during a 1% flood will have some economic value. This monetary value is expected to be very small however, given the house floor levels of these properties.

The improvements to water quality and environmental benefits from a re-opened creek are also important, but an economic value cannot be easily placed on this benefit.

The final benefit results from the increased recreational value from re-opening the channel from the boatramp in the creek to Tuggerah Lake. This benefit is also very difficult to quantify in a meaningful way.

Whilst allocating monetary values to these benefits is difficult, the costs of not doing the work are considered to be very high in terms of loss of environmental, recreational and amenity values.

The re-opening of the channel by dredging is considered to be necessary for the reasons detailed in this Review. It is further considered that the benefits to be accrued justify the cost of the proposed work.

7.0 ASSESSMENT OF IMPACTS

7.1 General

The proposal to dredge accumulated sediments at the mouth of Tumbi Creek and discharge them across the bed of Tuggerah Lake has been assessed for both positive and negative impacts. These are summarised in this section.

There will be some short-term, negative impacts during the removal of accumulated sediment in the Tumbi Creek channel from the boatramp to Tuggerah Lake. These impacts will be controlled so that any effects are localised, of short duration and will cause minimal inconvenience to nearby residents.

The removal of sediment from the channel will have positive benefits by reducing the impacts of additional depths of floodwaters from large flood events on nearby residential properties. A new channel will allow boat users to travel safely between Tuggerah Lake and Tumbi Creek. In addition, the free passage of marine life will be possible.

Appropriate monitoring programmes will be put in place to ensure that the works do not create further problems in terms of the local environment and flora and fauna.

It is considered that any potential negative impacts of the proposal are minimal and are outweighed by the positive benefits of reinstating a navigable channel between Tumbi Creek and Tuggerah Lake. Furthermore, the opening of the channel will allow estuarine water back into the creek, which will alleviate the adverse ecological conditions, bought on by the reduced quality of water in the creek.

7.2 Environmental Monitoring Programmes

A scientifically rigorous environmental monitoring program has been designed to assess the potential impact of dredging on shallow-water seagrass beds, benthic invertebrates, fishes and water quality. Furthermore the effects of disposing the dredge-spoil on benthic assemblages and water quality will also be done in the deeper water habitats (1.5-2m) using a similarly robust experimental design. The temporal component of each of the studies has a minimum of 2 times before and 2 times after dredging. The water quality sampling will require more intense temporal sampling with at least 2 times before, 2 times during and 2 times after the dredging. Details of these programmes are presented below, and summarised in Table 1 at the end of this Section.

7.2.1 Seagrasses and Macrobenthic Assemblages

The hypothesis, that dredging a new channel will have an environmental impact on seagrass beds and macrobenthic assemblages adjacent to Tumbi Creek, will be tested using a scientifically rigorous experimental design (EICC). For the shallow water habitats, estimates of seagrass cover will be made from five replicate quadrats in each of a range of sites at appropriate distances from the dredged channel. Furthermore, five benthic cores will also be collected at each site and the biomass of seagrass and the abundance and diversity of macrobenthic invertebrates evaluated. At the deeper water spoil disposal location, five replicate benthic cores will be collected by SCUBA divers from each of two random sites. Two reference locations will also be sampled at Saltwater Creek and Ourimbah Creek using the same spatial and temporal scales (Figure 5). These variables will be analysed using appropriate univariate and multivariate statistical techniques and will be reported as part of the environmental impact assessment for this programme

As well as examining the biological structure, subsamples of the benthic cores will be collected and analysed for sediment particle size distribution, both before and after dredging. This will be done to analyse any potential change in the structure of the sediments in the spoil disposal site.

7.2.2 Fishes

The juveniles of many fish and prawn species are dependent on seagrass beds for both food and shelter. Disturbance to seagrass beds has the potential to adversely affect these organisms. Because the dredging associated with the proposed reopening of the entrance channel to Tumbi Creek may effect seagrass, the juvenile fish and prawns in the area are to be quantified to assess the scale of likely impacts on these organisms.

NSW Fisheries is currently doing a Biodiversity Survey of juvenile fish and prawns in estuaries throughout NSW. Methods developed during this NHT funded project will be used to do an assessment of these organisms in Tuggerah Lakes. This will take the form of replicated surveys before and after the dredging, and at appropriate reference sites as well as in the vicinity of Tumbi Creek. Samples collected during the field surveys will be sorted in the field wherever possible, but some may need to be returned to the laboratory at Port Stephens Fisheries Centre for further sorting and/or positive identification of specimens. All fish sampling in Tuggerah Lake will be covered under ACEC permit no. 98/10.

Once samples have been identified and enumerated, the data will be subjected to statistical analysis and a report prepared as part of the environmental impact assessment. Fisheries hoped that the information gained from the fish study would be useful in evaluating not only the proposed dredging at Tumbi Creek but also future activities in Tuggerah Lake which may impact on seagrasses. The effects of dredging Tumbi Creek will be examined by sampling fish and decapods using a seine net (20m headline x 2m drop x 12mm stretched mesh). Samples will be collected from sites either side of the channels into Tumbi, Saltwater and Ourimbah Creeks as well as along the proposed dredge line in Tumbi Creek. At each site, 5 samples will be collected over beds of *Zostera*. All taxa collected will be identified to the lowest practicable taxonomic level with verifications provided by the Fish Section of the Australian Museum. It is anticipated that four sampling events will be undertaken, two before the dredging and two after dredging. The location of sampling sites is generally the same as the seagrass sampling sites.

7.2.3 Water Quality

Wyong Shire Council has been monitoring water quality in the estuary and the tributary creeks (including Tumbi Creek) since 1997. These data have been published in the Tuggerah Lakes Estuary Process Study Report. The most recent data were collected in March 2002 from within Tumbi Creek and from within the lake close to the spoil disposal site. The variables that are usually measured in water quality surveys can undergo significant temporal variation. It is therefore proposed that water quality sampling will be done at appropriate spatial and temporal scales, before, during and after the dredging operation. Once the dredge begins its work, 3 replicate measurements of water quality variables will be collected from 2 random sites within a distance of 20m from where the dredge is working and outside the silt curtain at the spoil site. At each of the sites, the following variables will be measured, dissolved oxygen, temperature, pH, salinity and turbidity using a YEOKAL 311 submersible data logger. Three replicate water samples will also be collected at each of the sites and the total nitrogen and phosphorus concentrations in the water determined back in the laboratory. This sampling schedule will be replicated at each of the reference sites identified in the seagrass and benthos monitoring programmes.

7.3 Outcomes

At the conclusion of the dredging campaign, the results of all studies will be collated and presented in a final report. This report will be used for the Tuggerah Lakes Estuary Management Study and Plan, and the various scientific components will be published in the scientific literature. The technical report will be made available to State Government agencies and Local Government authorities for use in their estuary management plans in NSW.

Table 1 Summary of Environmental Monitoring Programmes

Monitoring Task	Responsibility	Sampling Frequency		
		Pre-Dredging	During Dredging	Post-Dredging
• Seagrass	EICC	2x		2x
• Benthos	EICC	2x		2x
• Fish/Crustaceans	NSW Fisheries	2x		2x
• Water Quality	Council (Environmental Systems)	2x	2x	2x
• Sediment Particle Size	Council (Environmental Systems)	2x		2x

Key: *2x = two sampling periods at appropriate spatial scales identified in REF.*

8.0 CONCLUSION

Access to Tuggerah Lake from Tumbi Creek is via a channel that is periodically blocked with sediment carried down to the Lake in the Creek, and by material washed into the Creek from the Lake. The re-opening of this channel by dredging is required to reduce adverse flooding impacts on nearby residential properties. In addition, it will reinstate a navigable channel for boat users and maximise the potential for marine life to move freely between the Creek and the Lake. Water quality will also be improved in the creek itself.

Examination of the potential environmental impacts from the proposed removal of sediment in the channel has shown that any negative impacts are expected to be minimal and can be controlled. In contrast, the positive impacts from this work have been demonstrated in the past following previous dredging operations with no observed adverse effects. Reduced effects on local flood heights, better access to the lake and free passage of marine life have been the positive results of the work.

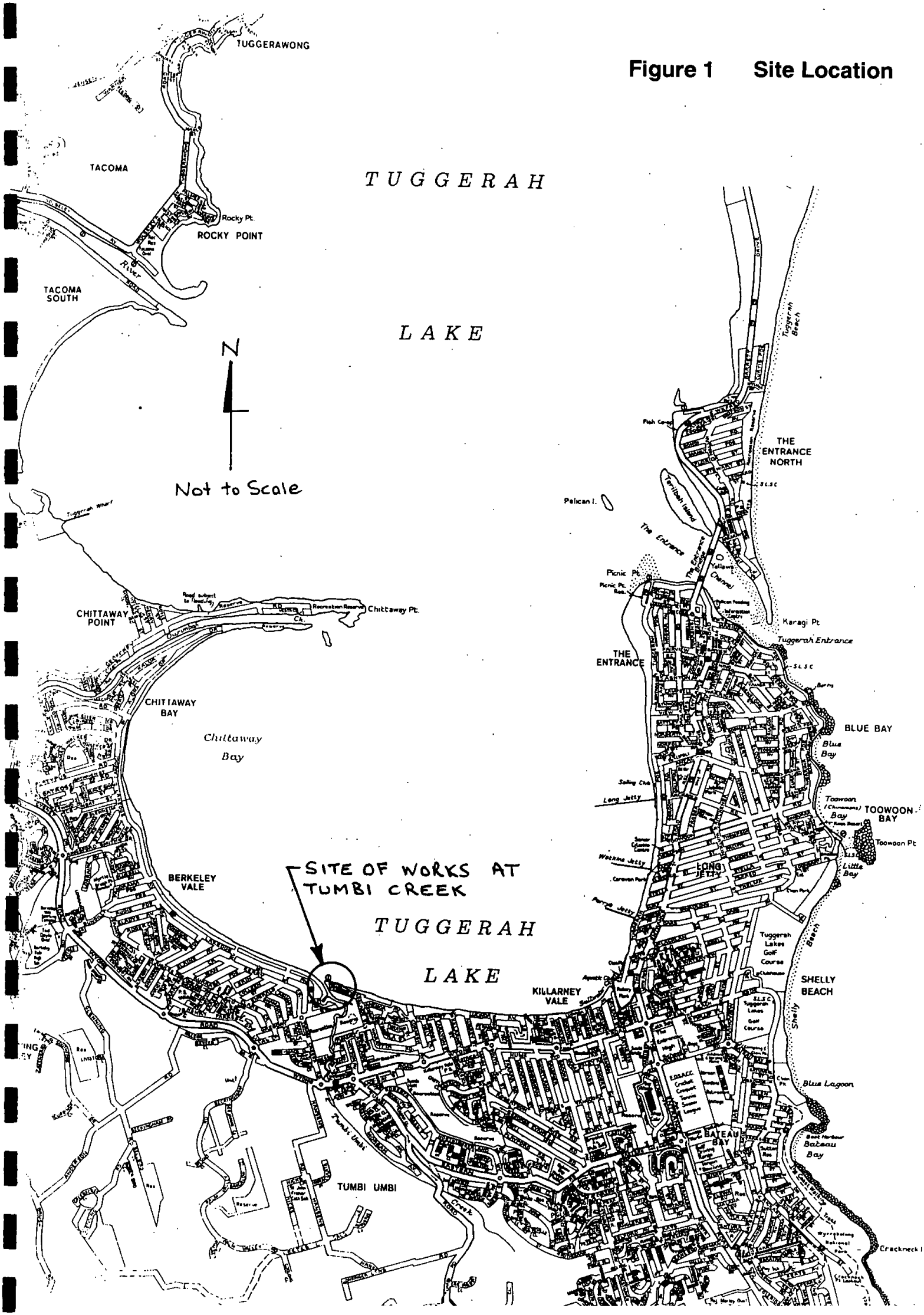
Long term local residents and waterway users are also in favour of re-opening the channel.

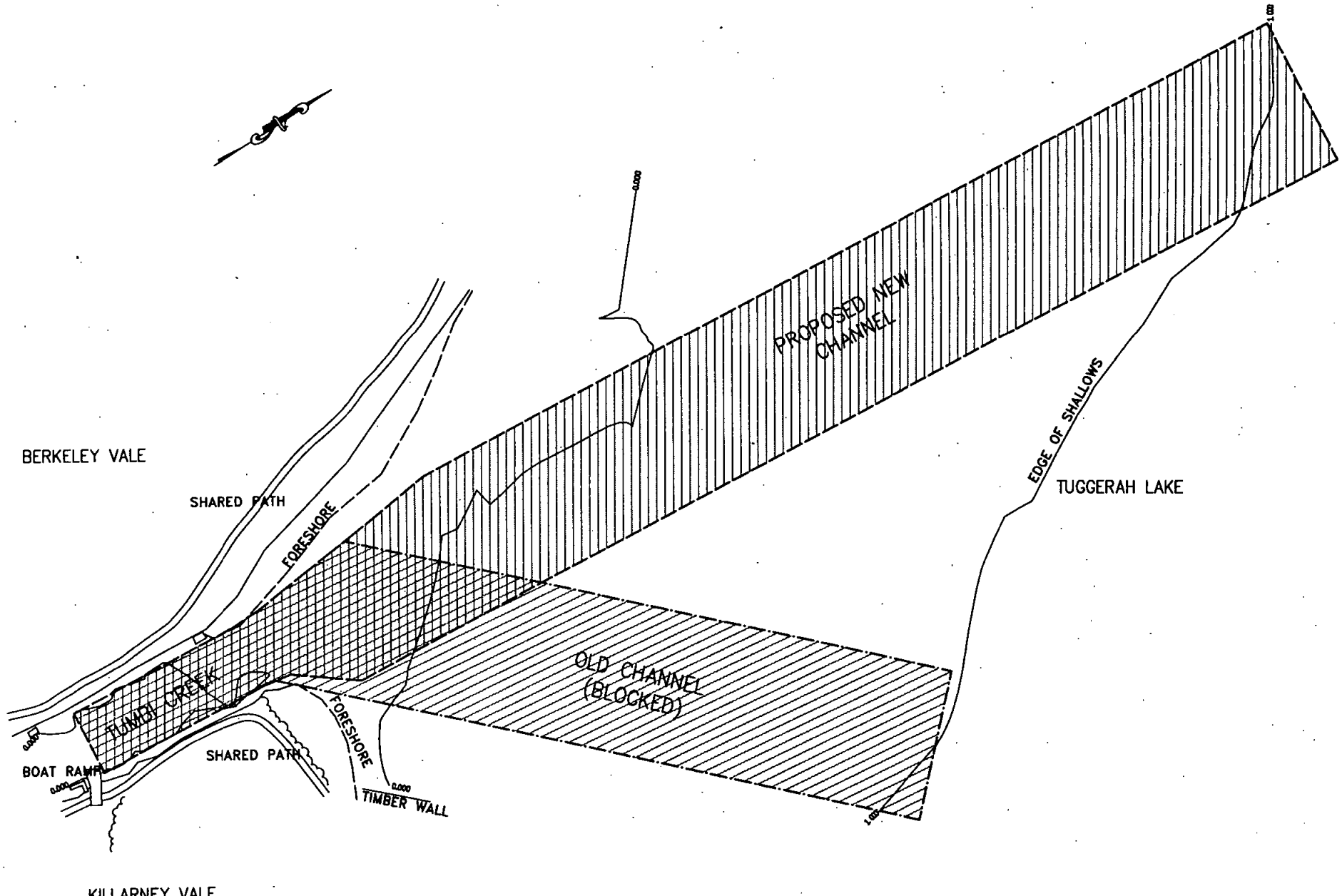
The proposed work as described in this Review will provide a positive benefit to the community and will minimise the problems that occur when the channel is blocked at the mouth of Tumbi Creek. The results from this management experiment will also be used in the Tuggerah Lakes Estuary Management Study, and will provide valuable data for State Government agencies and managers of all estuaries in NSW.

Figures

Appendices

Figure 1 Site Location

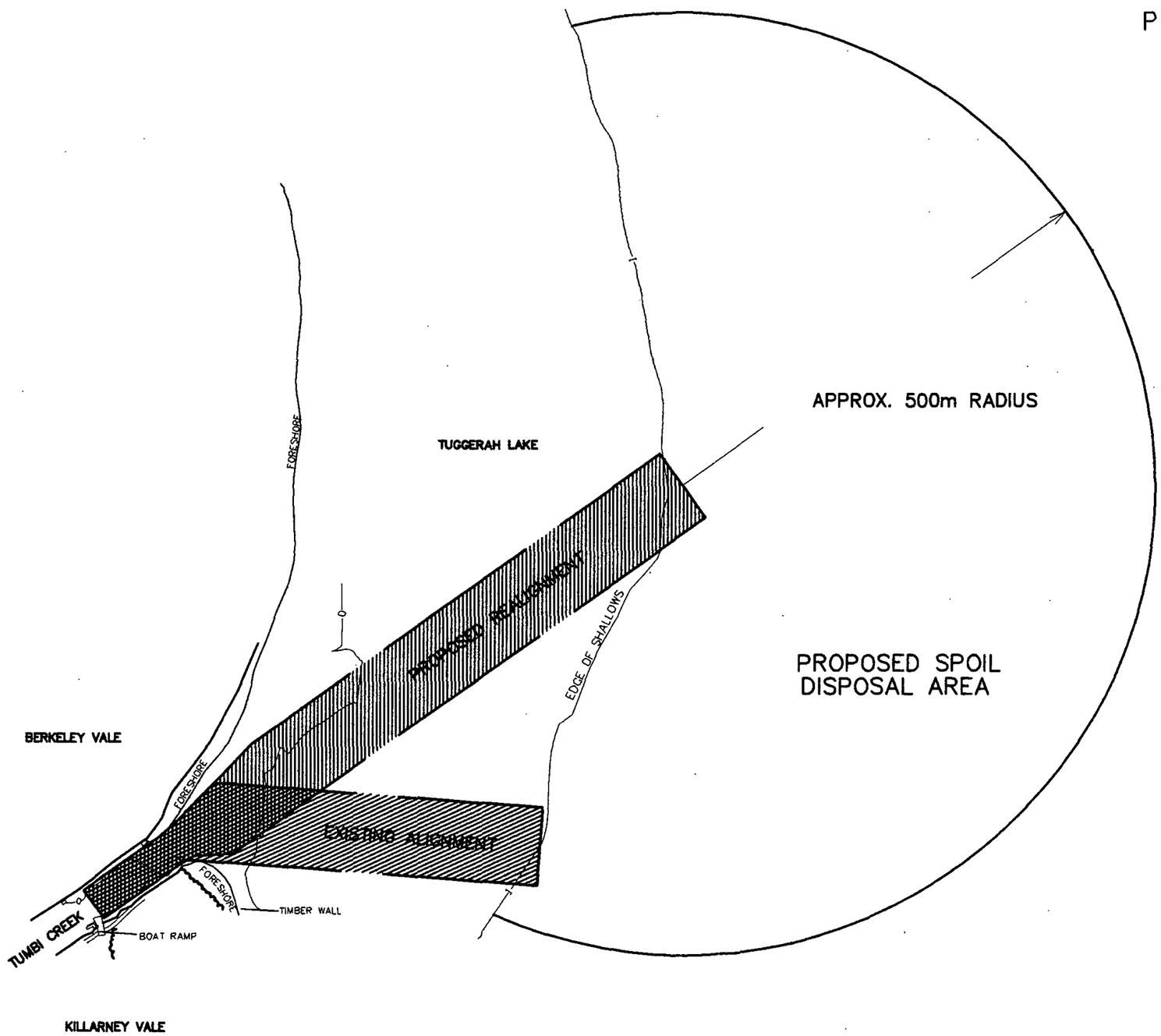




SCALE	PROPOSED DREDGING OF TUMBI CREEK CHANNEL ENTERING TUGGERAH LAKE					
WYONG SHIRE COUNCIL	APPROVED BY DIRECTOR OF STRATEGIC PLANNING	DATE 9/01	DATUM	SHEET NO. 1	NO. OF SHEETS 1	PLAN NO. 12321

Figure 2 Channel Alignment

Figure 3
Proposed Spoil Disposal Area



No.	DESCRIPTION AMENDMENT BLOCK	INT.	DATE

SCALE
N.T.S.

Drawn.....
Checked.....
Manager.....
Director of Engineering Services.....

WYONG SHIRE COUNCIL

PROPOSED SPOIL DISPOSAL AREA

JOB / DISK	No. SHEETS	DATE
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REGISTERED PLAN No.		SHEET No. 1

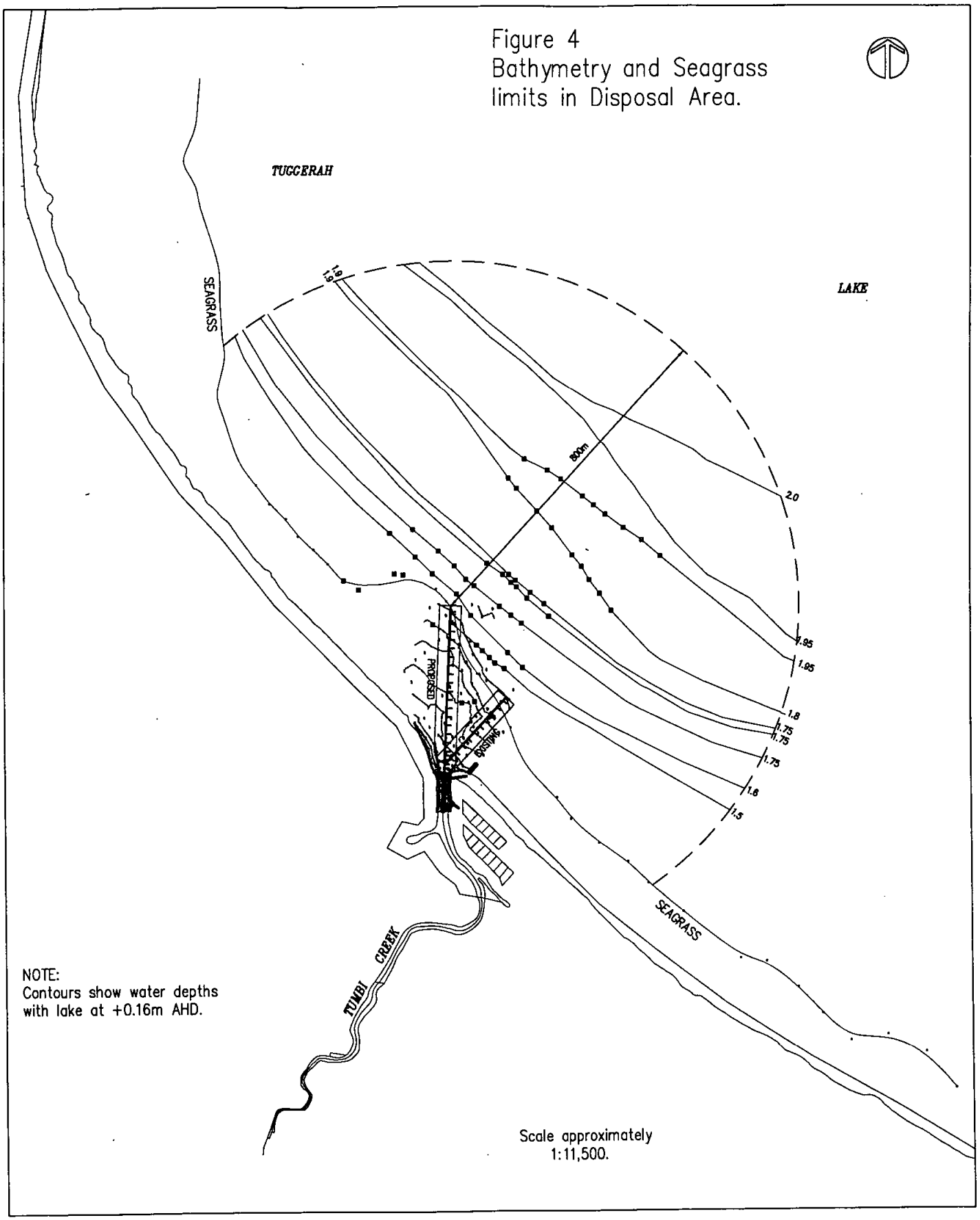


Figure 4
Bathymetry and Seagrass limits in Disposal Area.

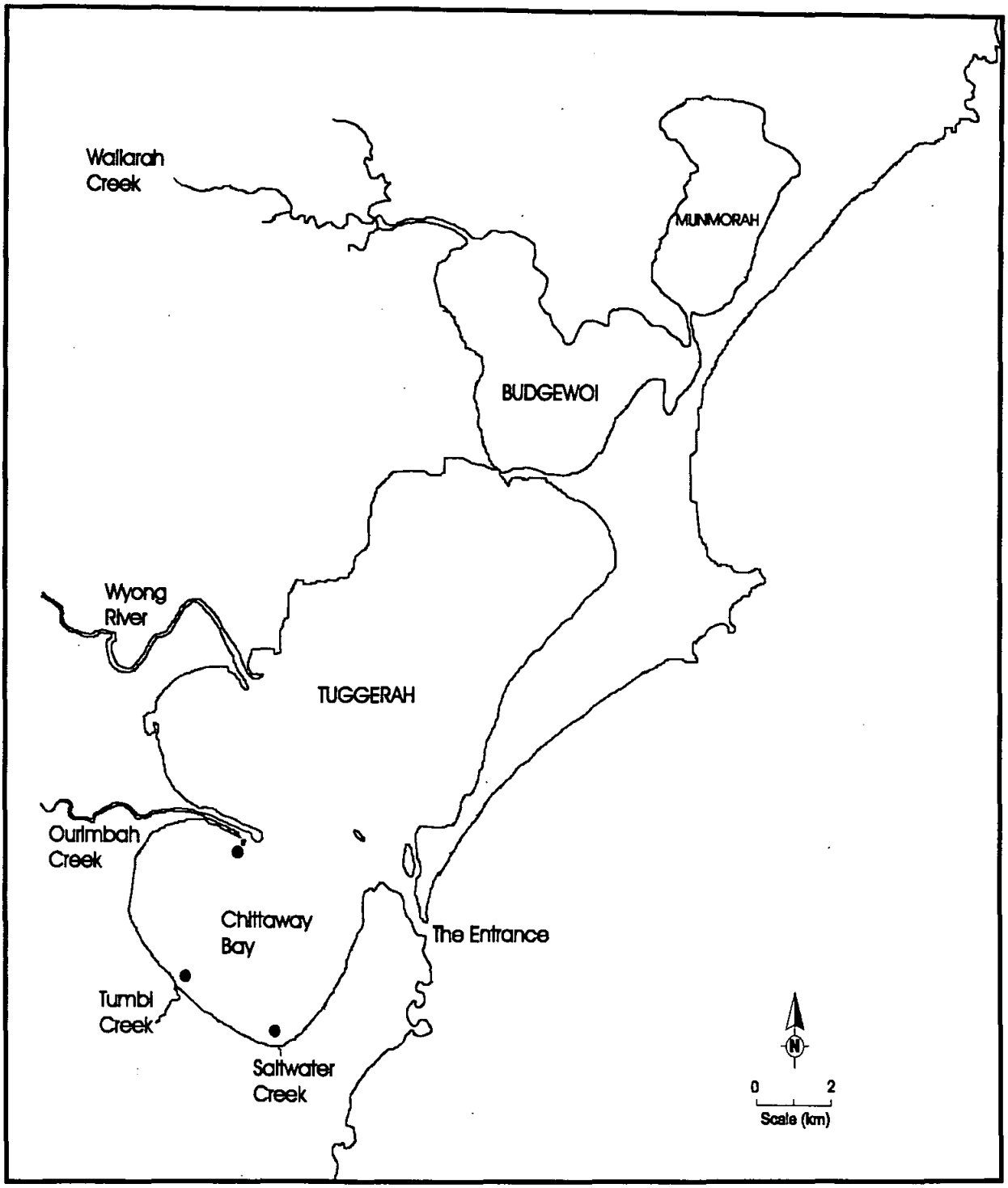


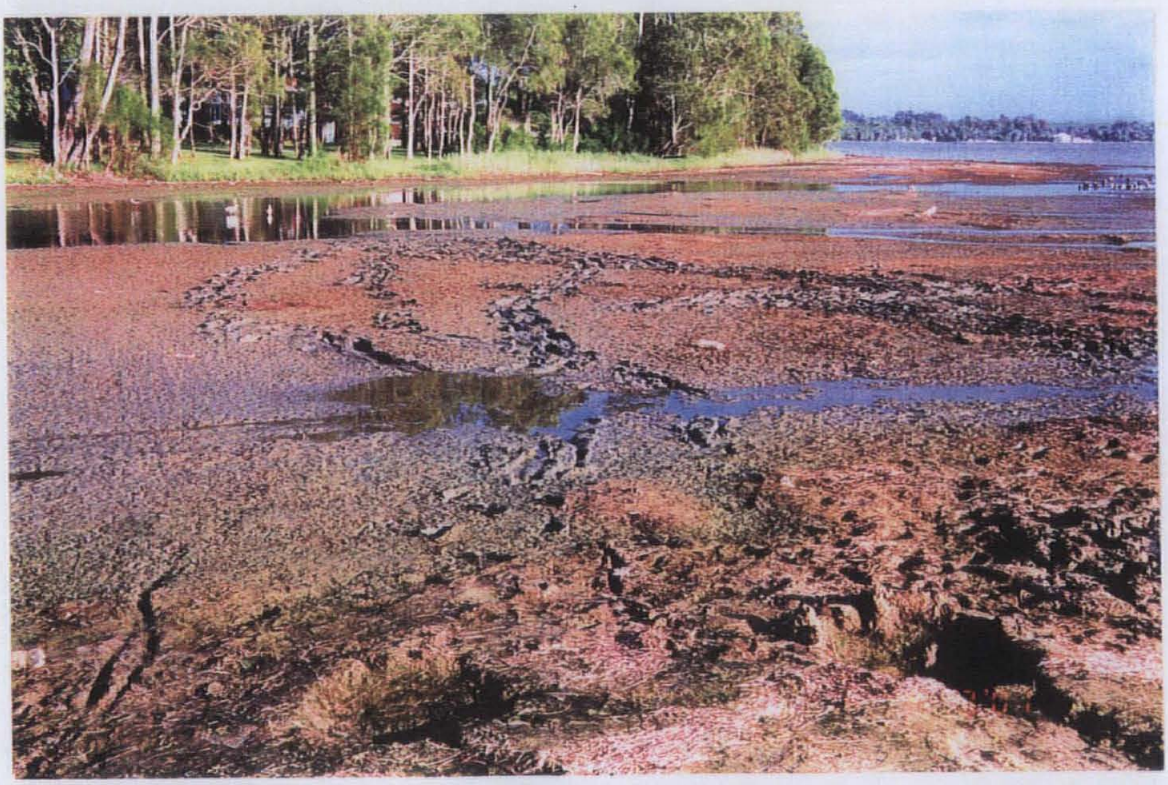
Figure 5. Location of the sampling sites at Tumbi, Saltwater and Ourimbah Creeks.

APPENDIX A

Photographs

Above: Aerial photograph showing mouth of Tumbi Creek, previous channel and proposed channel

Below: Extent of Siltation at mouth of Tumbi Creek



APPENDIX B

Survey Plans

PROPOSED DREDGING OF TUMBI CREEK NAVIGATIONAL CHANNEL ENTERING TUGGERAH LAKE

SCHEDULE

1–2 PLAN

PROPOSED NEW ALIGNMENT

3 LONG SECTION

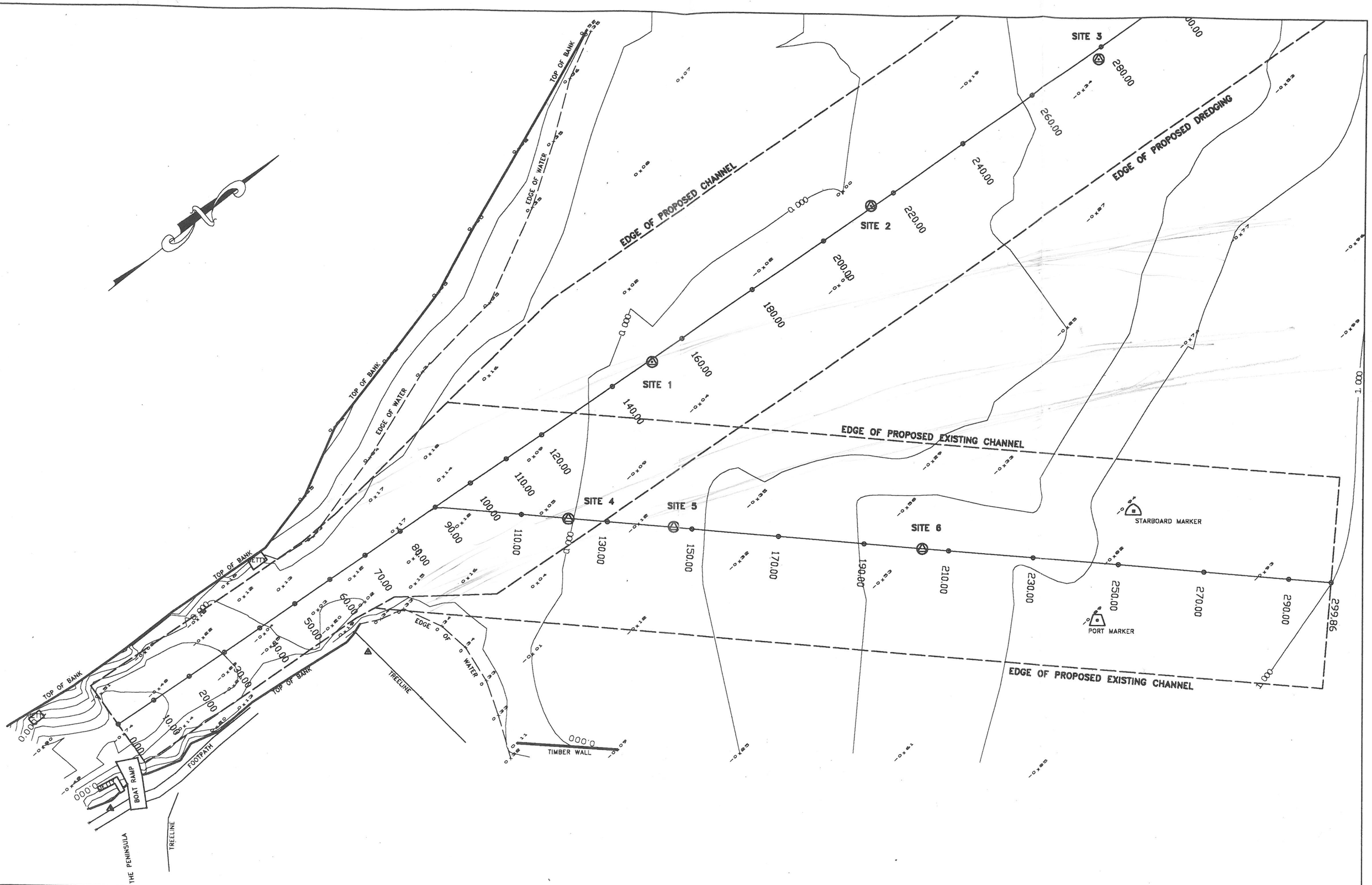
4–7 CROSS SECTIONS

EXISTING ALIGNMENT

8 LONG SECTION

9–11 CROSS SECTIONS

WYONG SHIRE *building a better tomorrow!*



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Drawn By S.Murray
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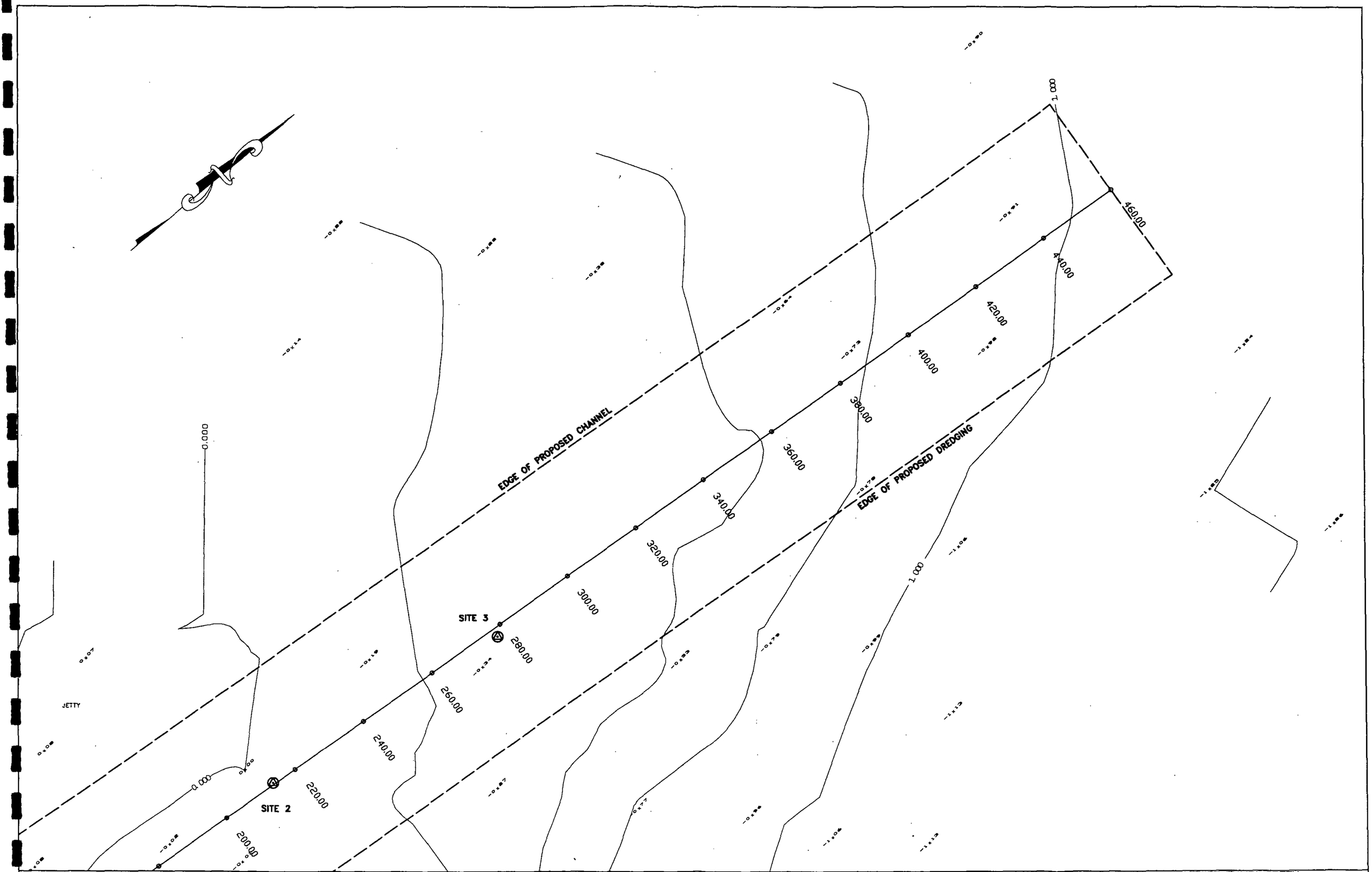
WYONG COUNCIL

PROPOSED DREDGING OF TUMBI CREEK
NAVIGATIONAL CHANNEL ENTERING TUGGERAH LAKE

APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	1	11	12266



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PROPOSED DREDGING OF TUMBI CREEK
NAVIGATIONAL CHANNEL ENTERING TUGGERAH LAKE

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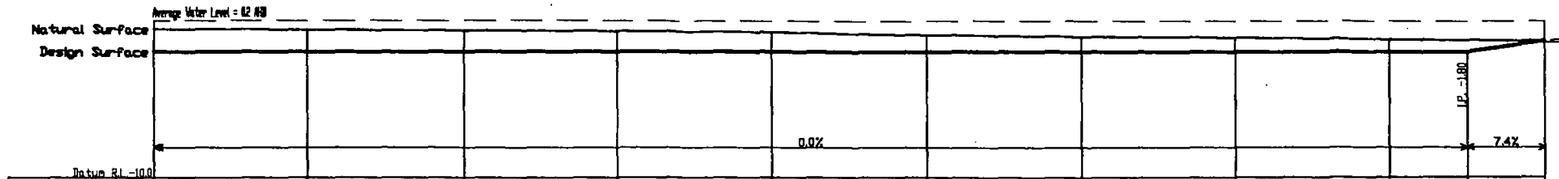

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280.00	-1.459	-1.800	-0.341
300.00	-1.431	-1.800	-0.369
320.00	-1.387	-1.800	-0.413
340.00	-1.319	-1.800	-0.481
360.00	-1.278	-1.800	-0.522
380.00	-1.101	-1.800	-0.699
400.00	-0.999	-1.800	-0.801
420.00	-0.918	-1.800	-0.882
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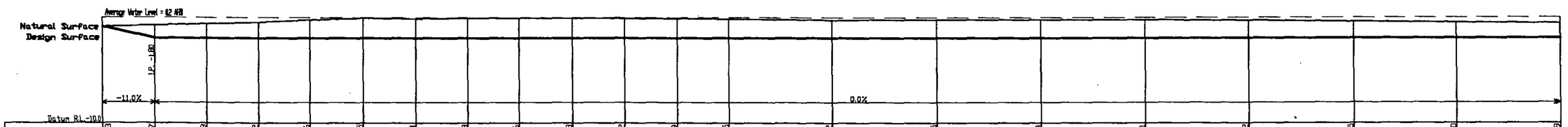
450.00		-1.800	
460.00	+0.000	-1.060	-1.060



CHAINAGE	CUT/FILL	Design Surface	Natural Surface
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20.00	-1.419	-1.800	-0.381
30.00	-1.562	-1.800	-0.238
40.00	-1.776	-1.800	-0.024
50.00	-1.945	-1.800	0.145
60.00	-1.894	-1.800	0.094
70.00	-1.943	-1.800	0.143
80.00	-1.966	-1.800	0.166
90.00	-1.943	-1.800	0.142
100.00	-1.922	-1.800	0.122
110.00	-1.909	-1.800	0.109
120.00	-1.875	-1.800	0.075
140.00	-1.762	-1.800	-0.038
160.00	-1.785	-1.800	-0.015
180.00	-1.774	-1.800	-0.026
200.00	-1.791	-1.800	-0.009
220.00	-1.742	-1.800	-0.059
240.00	-1.625	-1.800	-0.175
260.00	-1.530	-1.800	-0.270
280.00	-1.459	-1.800	-0.341

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WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
PROPOSED REALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

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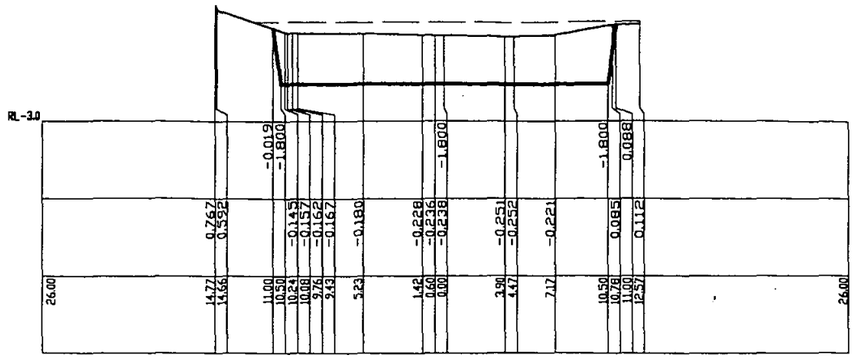

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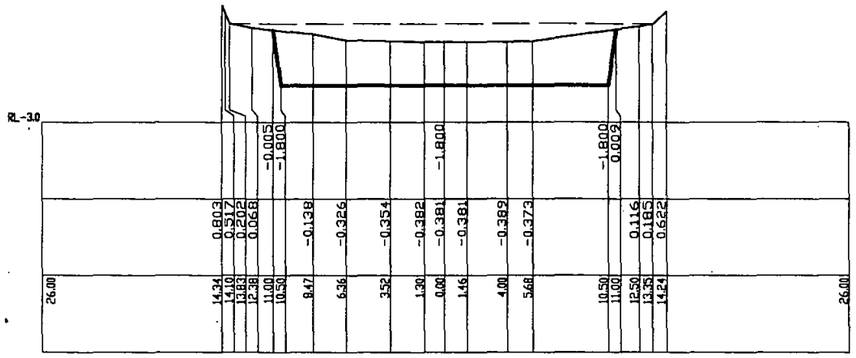

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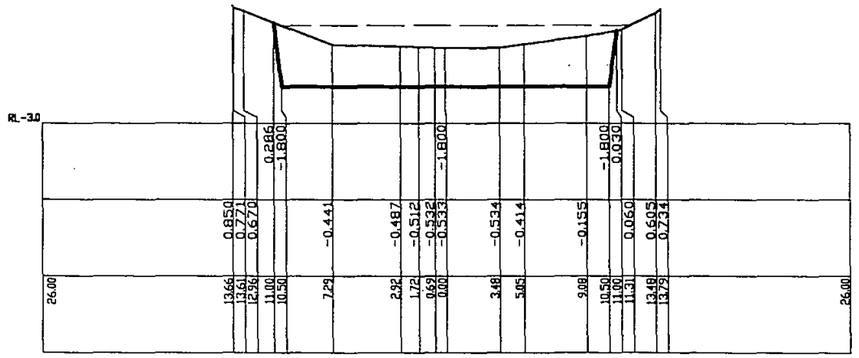

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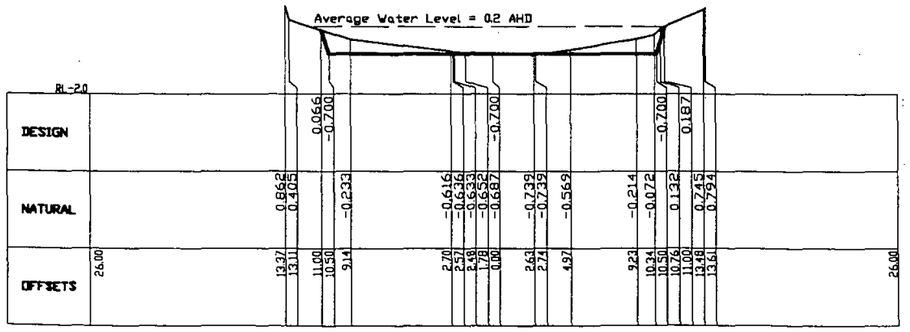

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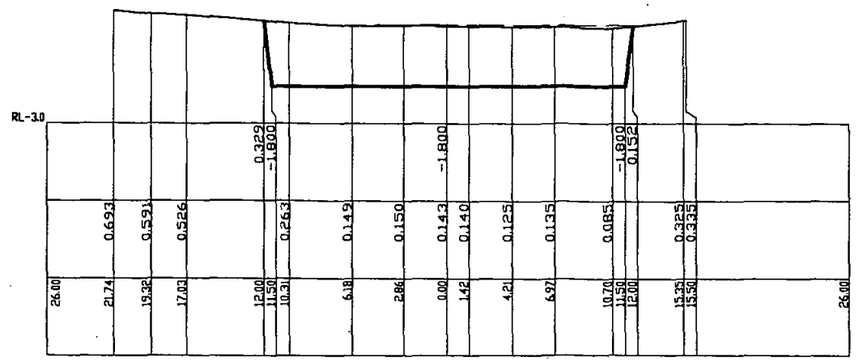

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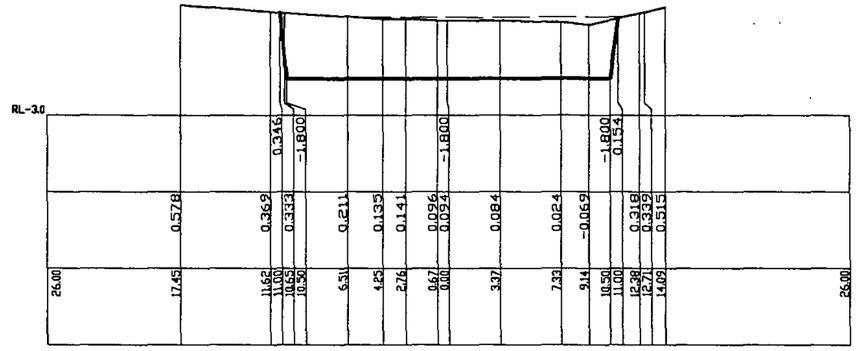

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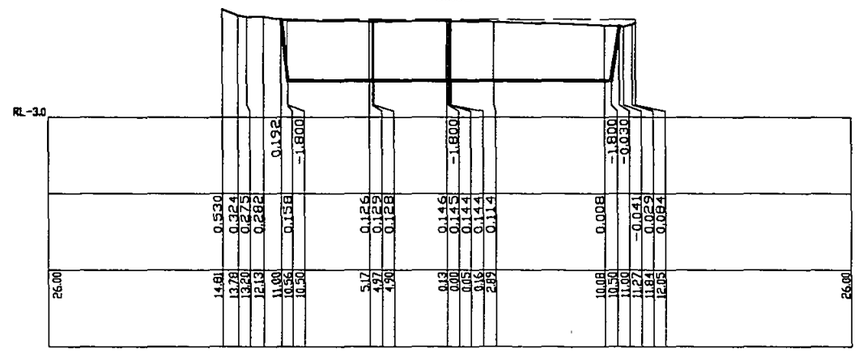

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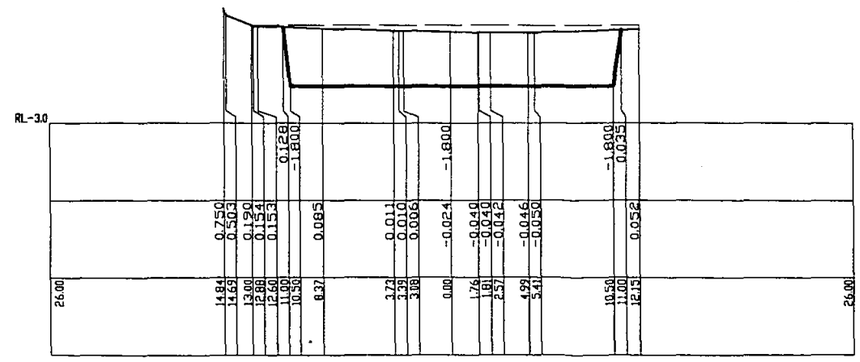

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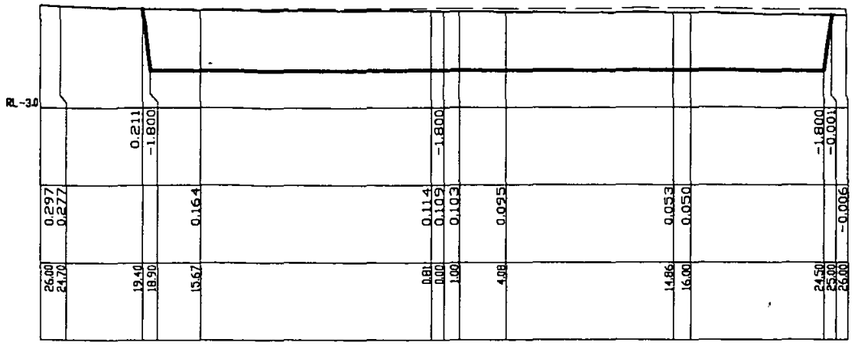
Designed By . . . S.Murray . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES
Scale Horizontal 1:400 Vertical 1:200

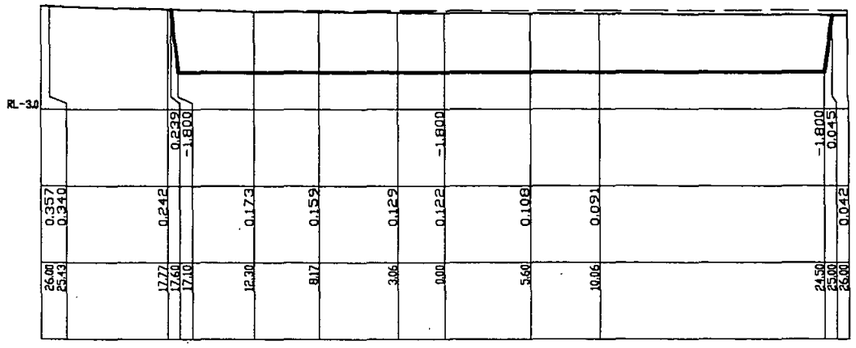
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
PROPOSED REALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

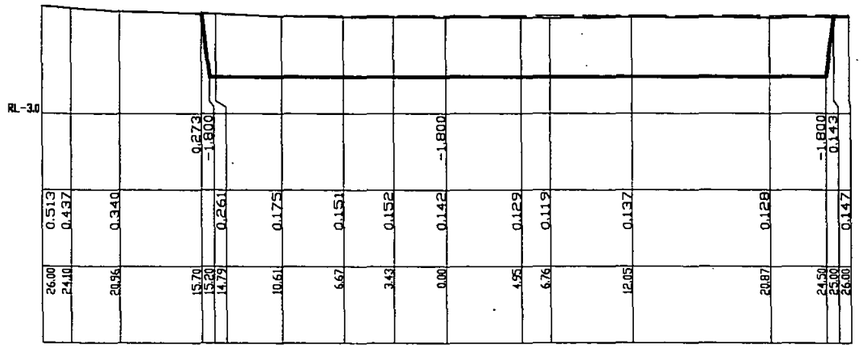
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	4	11	12266



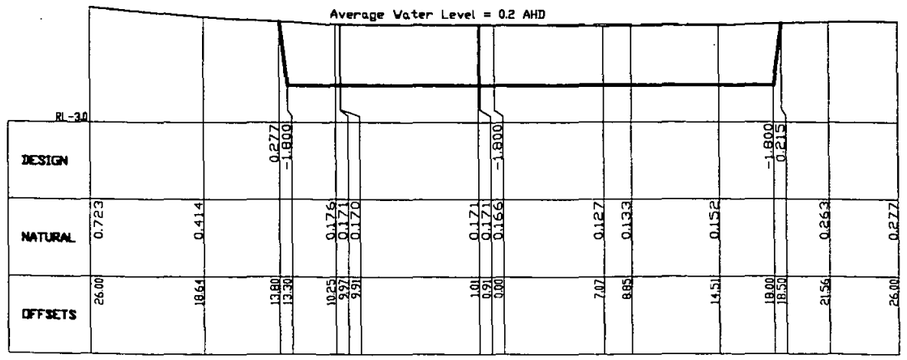
110.00



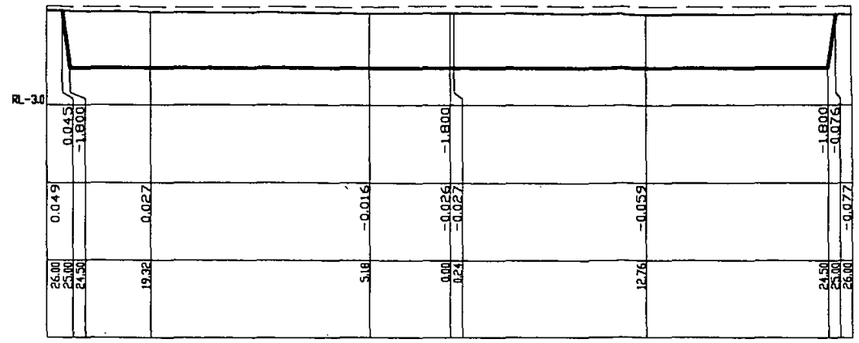
100.00



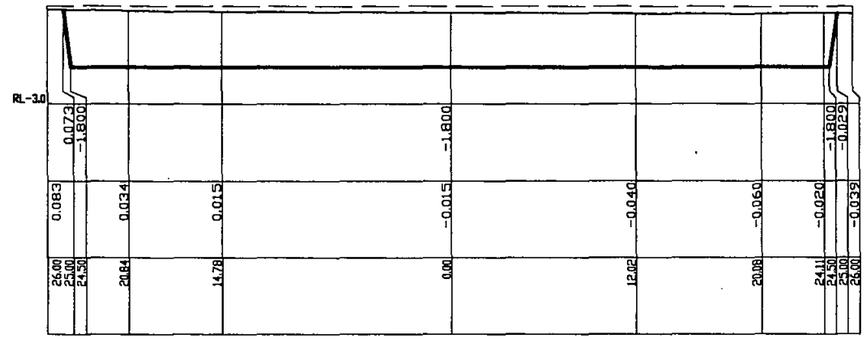
90.00



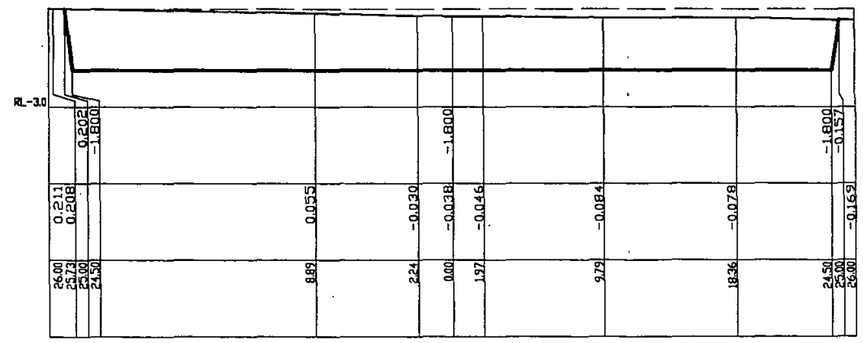
80.00



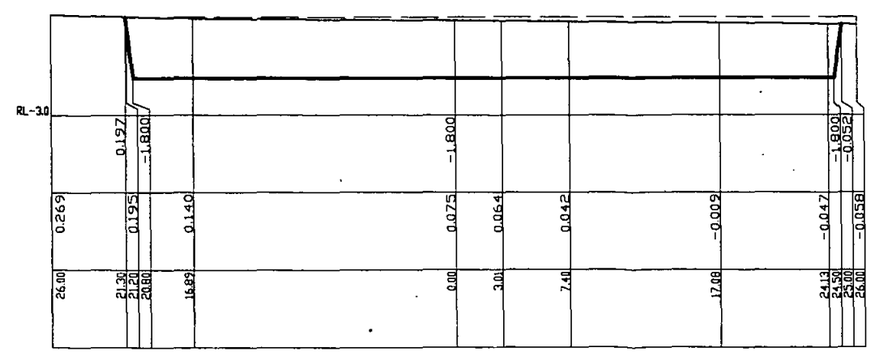
180.00



160.00



140.00



120.00

LOT	D.P.	DATE SENT	DATE RECVD
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DESIGNED DETAILS	DESIGN CHK DETAILS

MICROFILM
YES NO X
APPROVED
DATE

JOB NO. 2505
DISK NO.

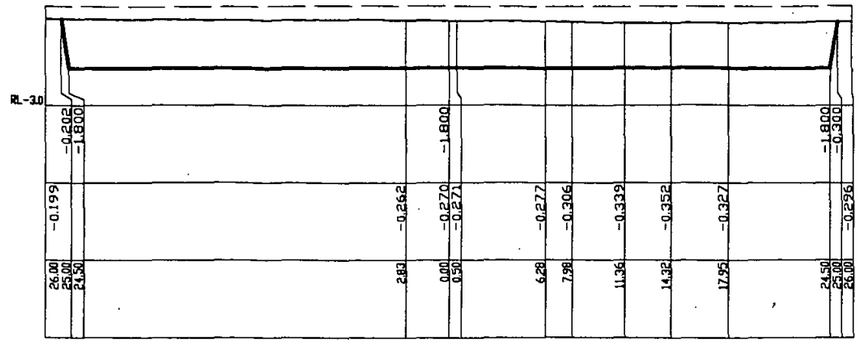
Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . S.Murray . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES
Scale Horizontal 1:400 Vertical 1:200

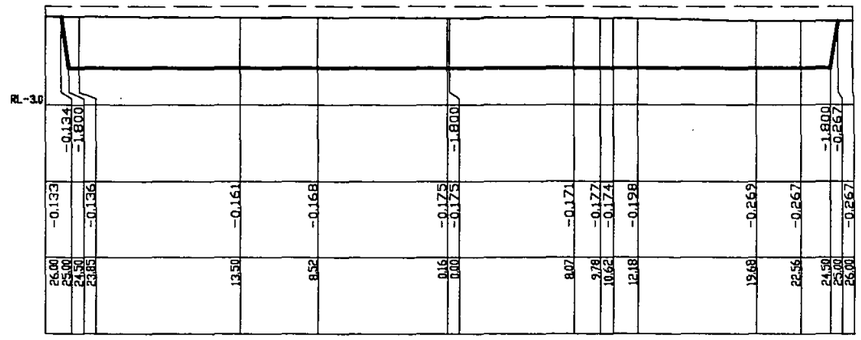
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
PROPOSED REALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

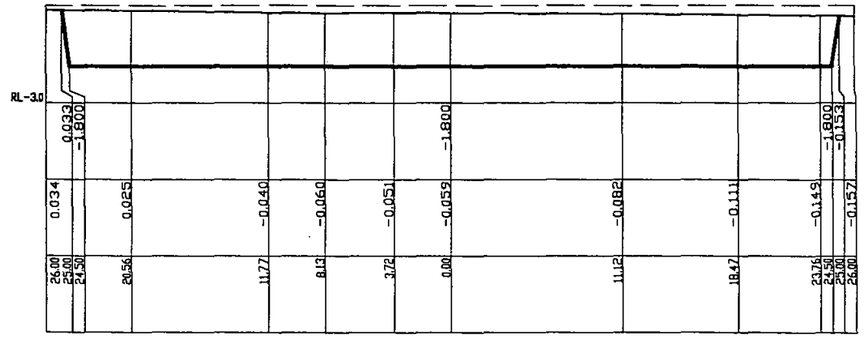
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	5	11	12266



260.00

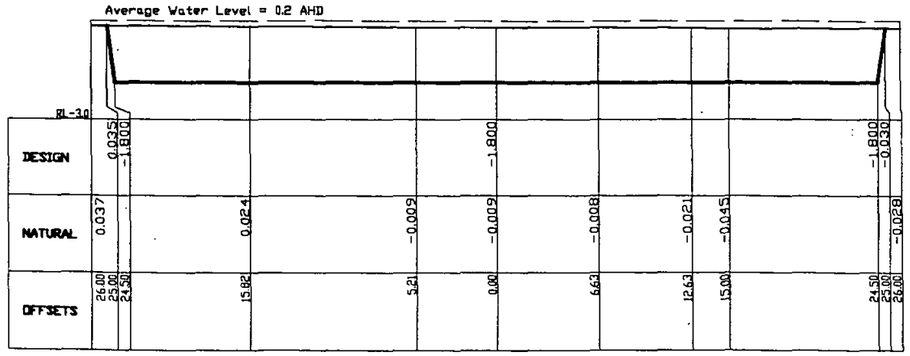


240.00

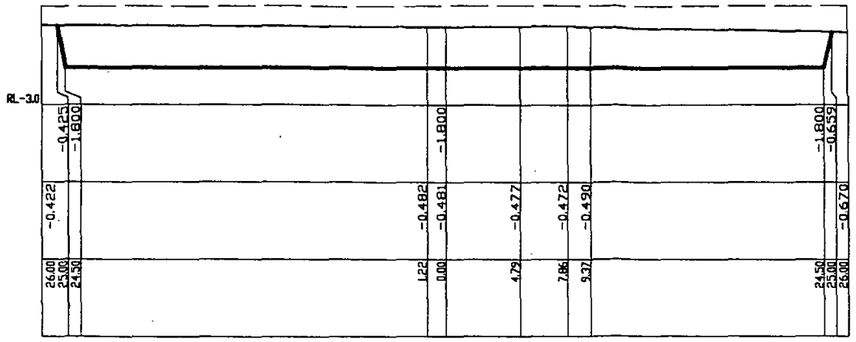


220.00

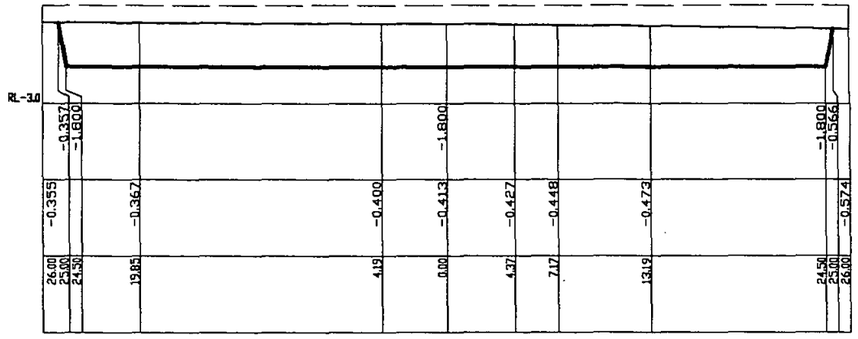
Average Water Level = 0.2 AHD



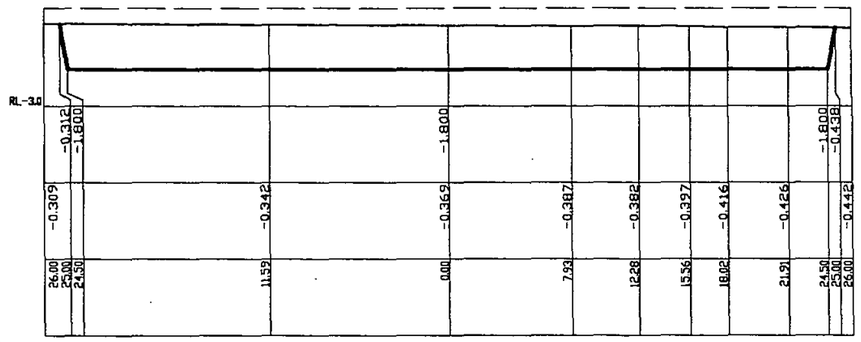
200.00



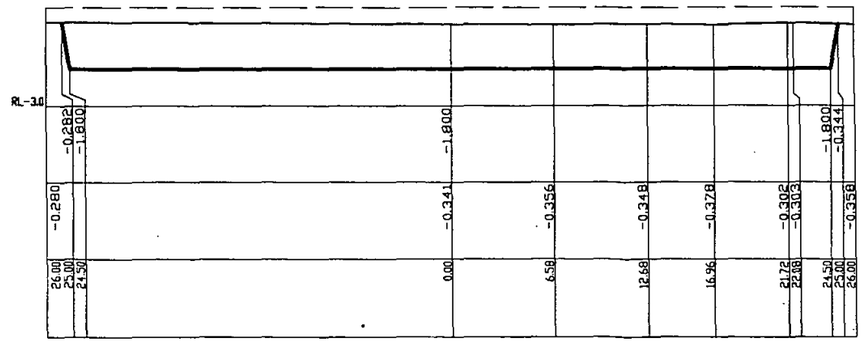
340.00



320.00



300.00



280.00

LOT	D.P.	DATE SENT	DATE RECV'D
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DRAWING DETAILS	DRAWING TITLE DETAILS

MICROFILM: YES / NO X

APPROVED

DATE

JOB NO. 2505

DISK NO.

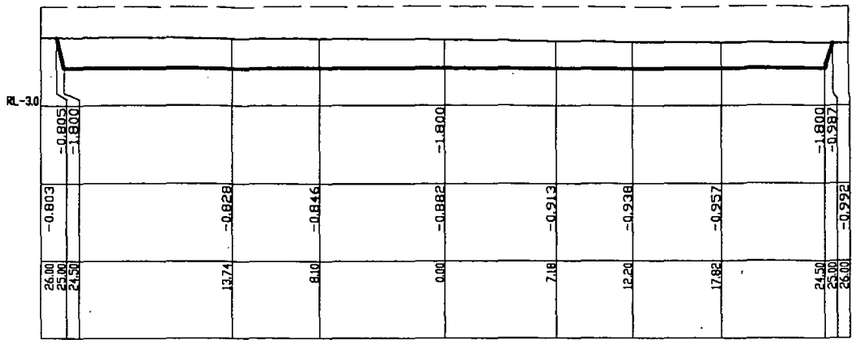
Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . S.Murray . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES
Scale Horizontal 1:400 Vertical 1:200

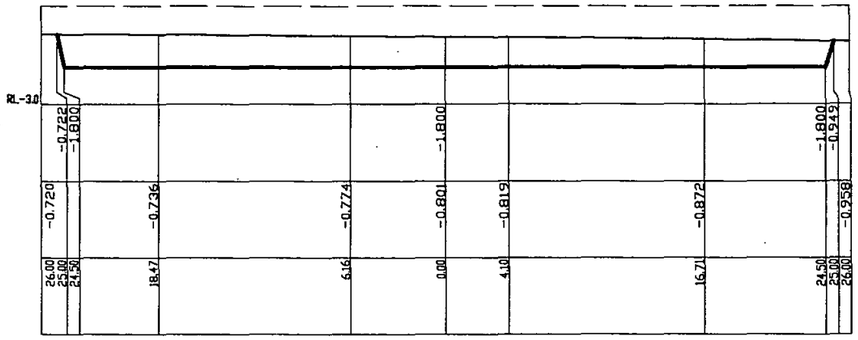
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
PROPOSED REALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

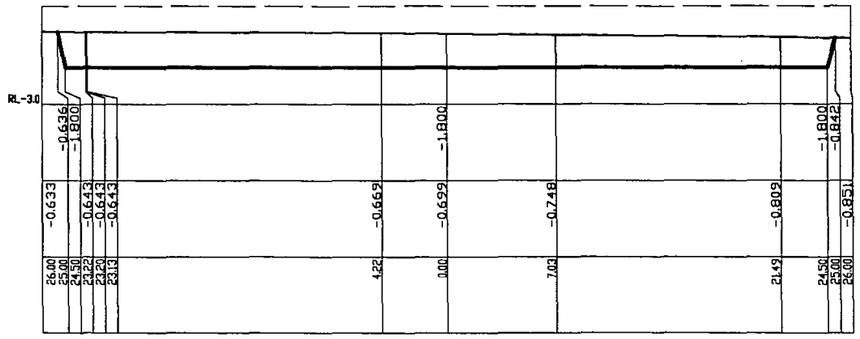
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	6	11	12266



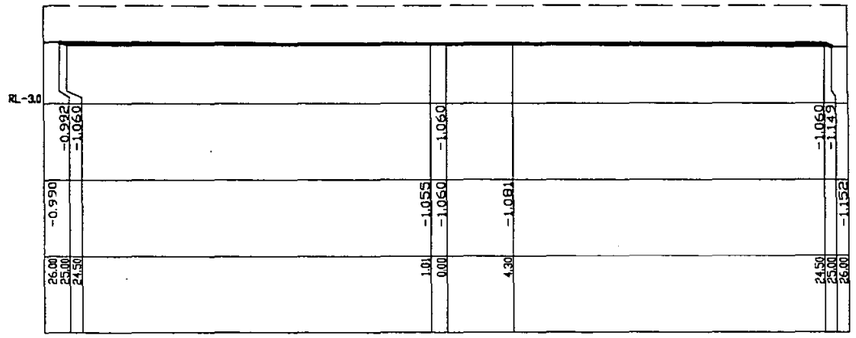
420.00



400.00

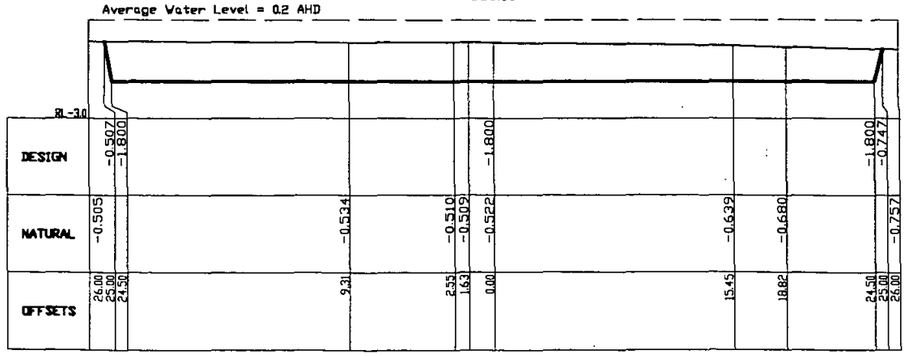


380.00

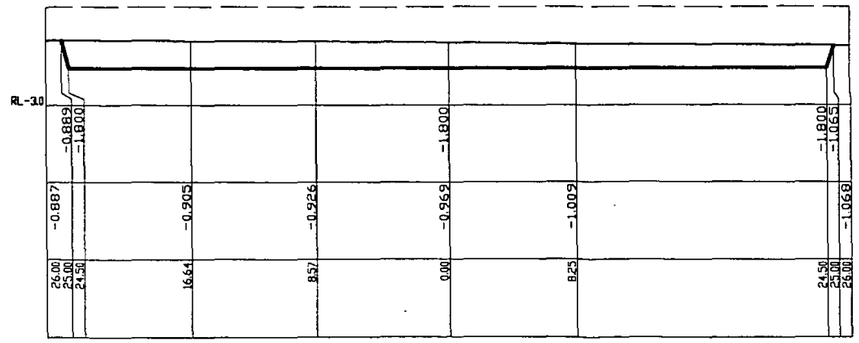


460.00

Average Water Level = 0.2 AHD



360.00



440.00

LOT	D.P.	DATE SENT	DATE RECV'D
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DRAWING DETAILS	DRAWN BY DETAILS

MICROFILM YES NO X

APPROVED

DATE

JOB NO. 2505

DISK NO.

Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . . S.Murray . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

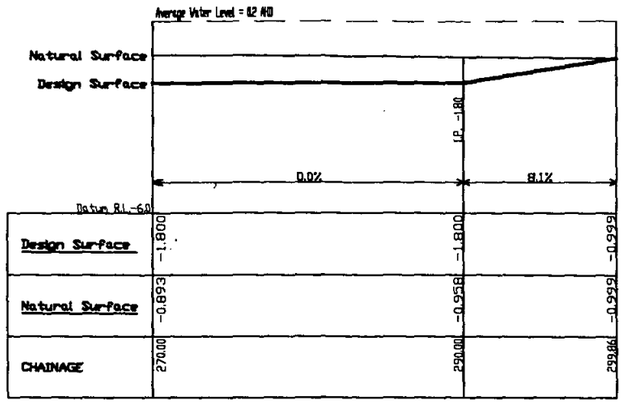
SCALES

Scale Horizontal 1:400 Vertical 1:200

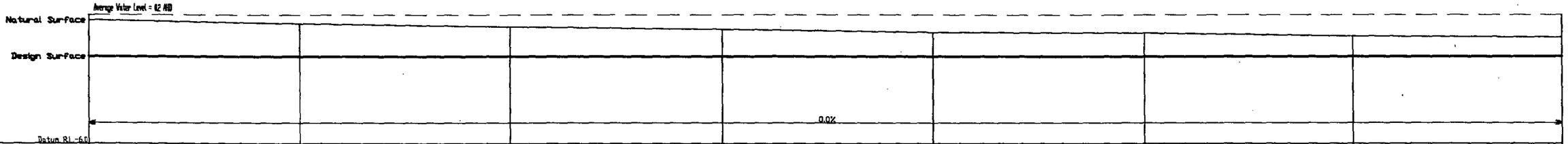
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
PROPOSED REALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

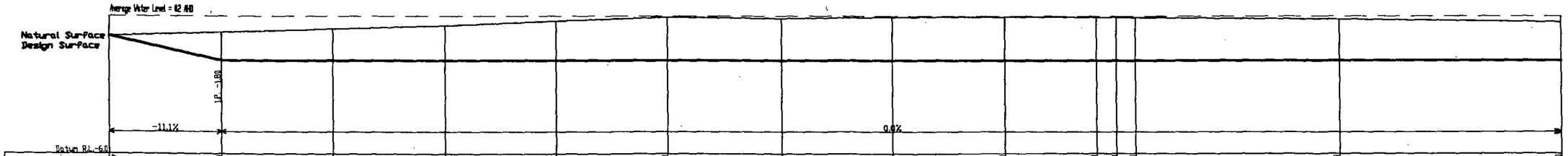
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	7	11	12266



Design Surface	-1.800	-1.800	-0.999
Natural Surface	-0.893	-0.958	-0.999
CHAINAGE	270.00	290.00	299.86



Design Surface	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800
Natural Surface	-0.060	-0.226	-0.382	-0.509	-0.645	-0.675	-0.833	-0.893
CHAINAGE	130.00	150.00	170.00	190.00	210.00	230.00	250.00	270.00



Design Surface	-0.687	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800	-1.800
Natural Surface	-0.687	-0.533	-0.381	-0.238	-0.024	0.145	0.094	0.143	0.166	0.147	0.142	0.136	0.070	-0.060
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	88.20	90.00	91.66	110.00	130.00

LOT	D.P.	DATE SENT	DATE RECV'D
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	[redacted]	[redacted]

MICROFILM
YES NO X
APPROVED
DATE

JOB NO. 2505
DISK NO.

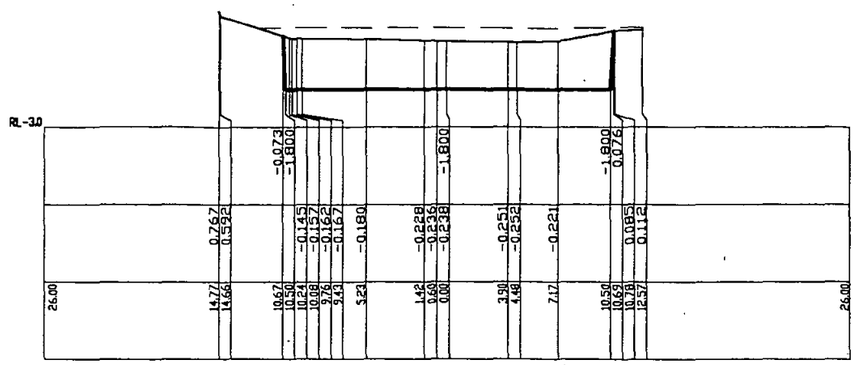
Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . S.Murray . . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

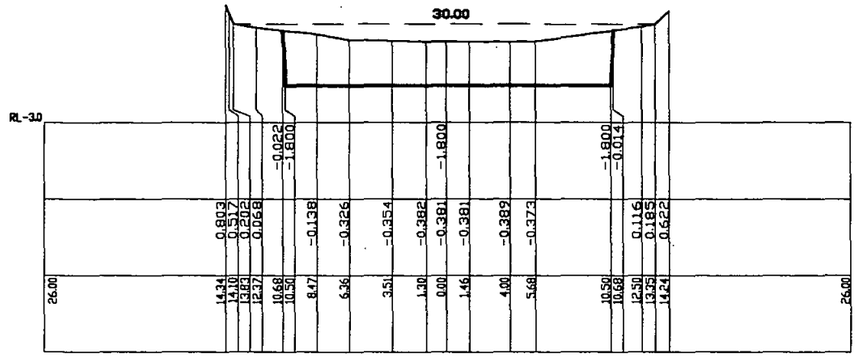
SCALES
Scale Horizontal 1:400 Vertical 1:200

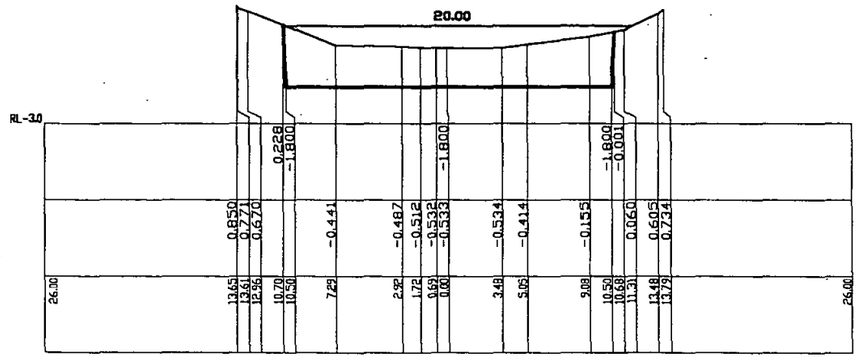
WYONG COUNCIL

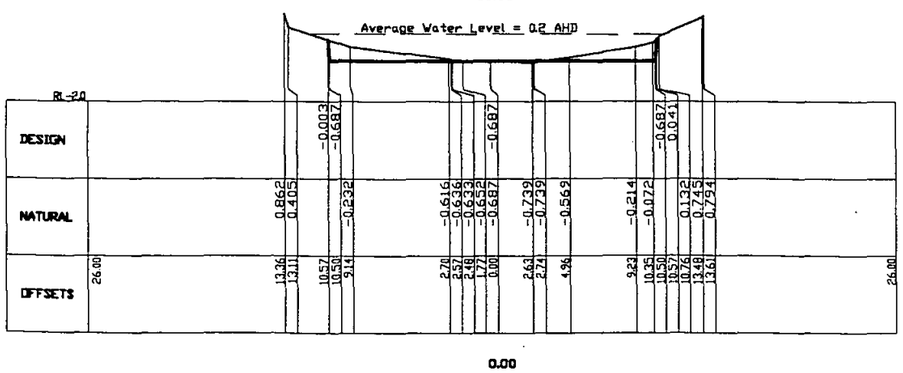
HYDROGRAPHIC SURVEY – TUMBI CREEK
EXISTING ALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

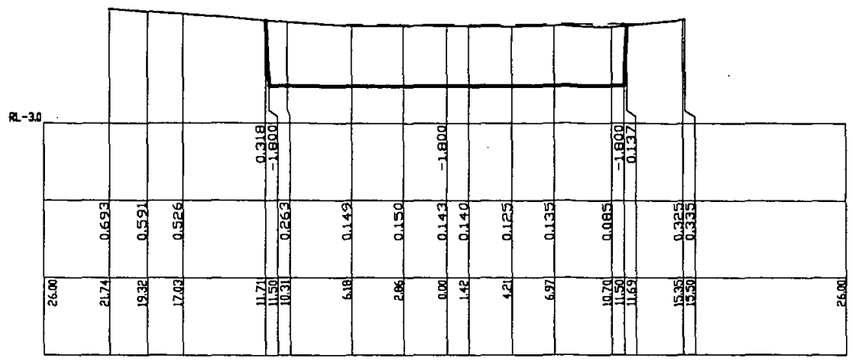
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	8	11	12266

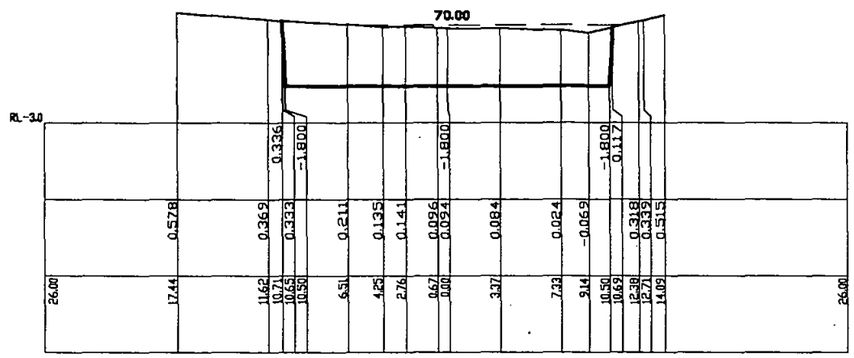


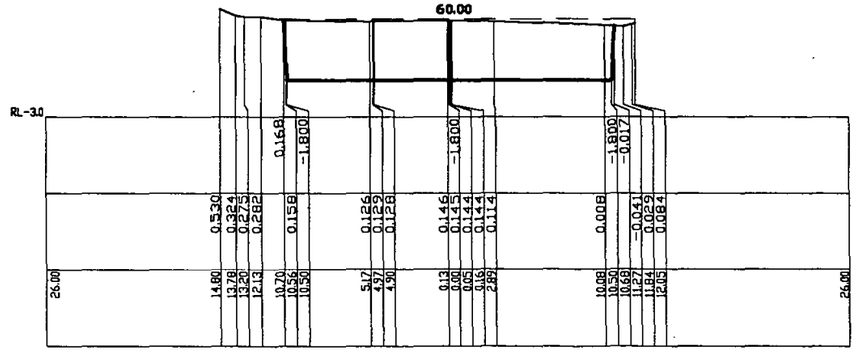


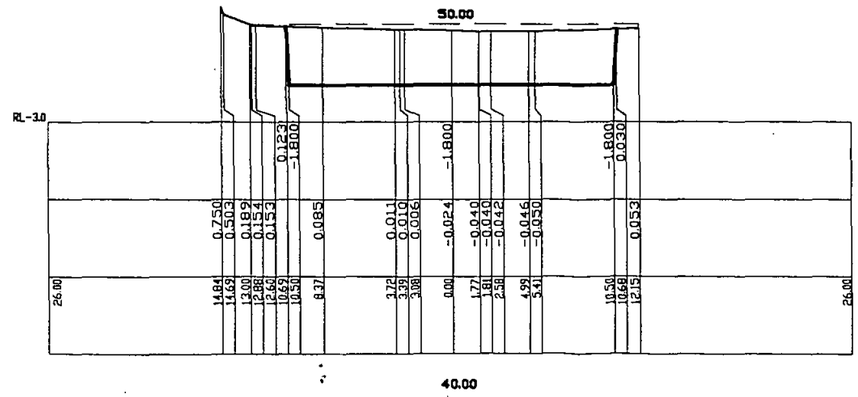












LOT	D.P.	DATE SENT	DATE RECVD
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DRAWING DETAILS	DESIGN DWG DETAILS

MICROFILM
YES NO X
APPROVED
DATE

JOB NO. 2505
DISK NO.

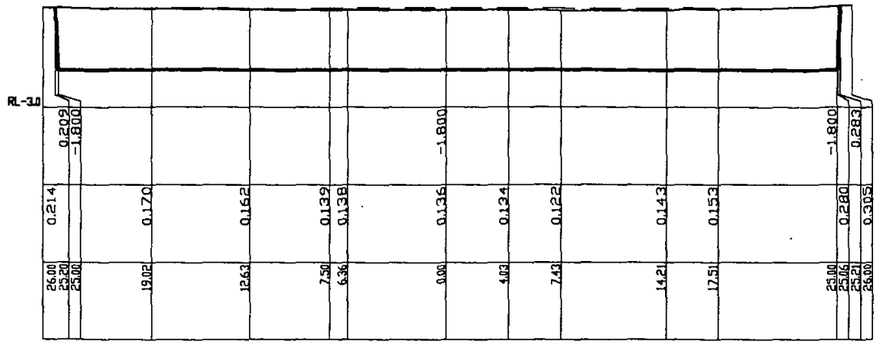
Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . S.Murray . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES
Scale Horizontal 1:400 Vertical 1:200

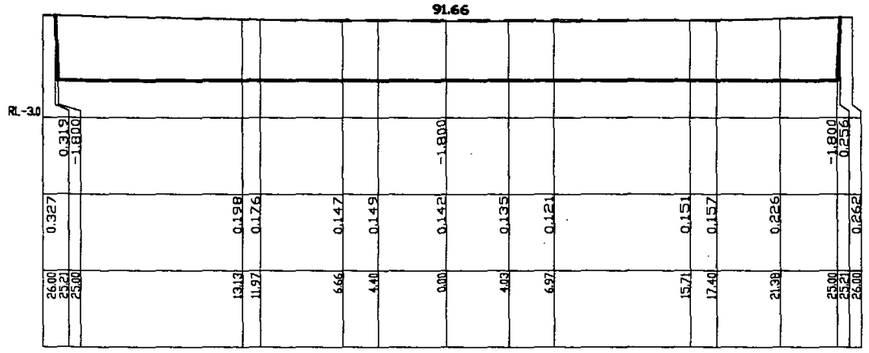
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
EXISTING ALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

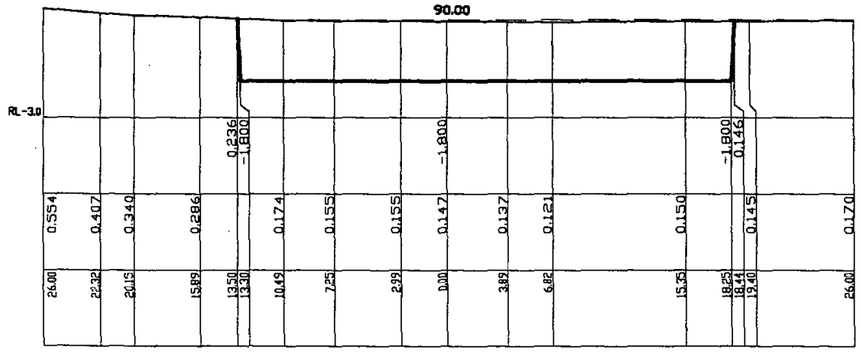
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	9	11	12266



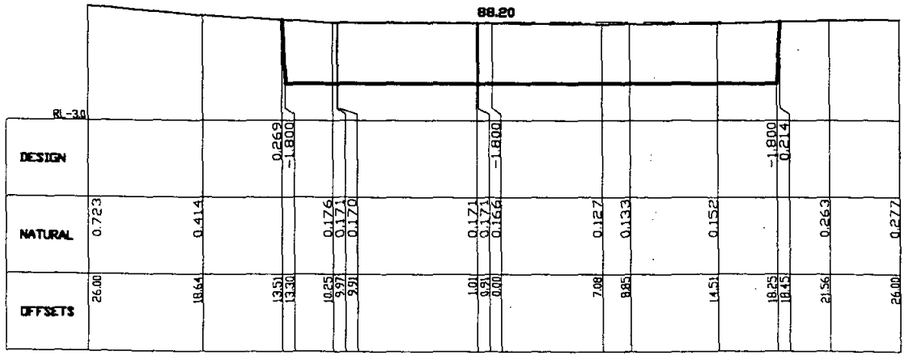
91.66



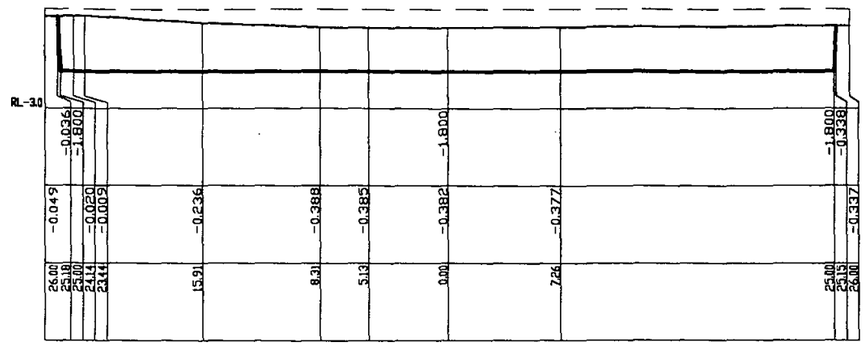
90.00



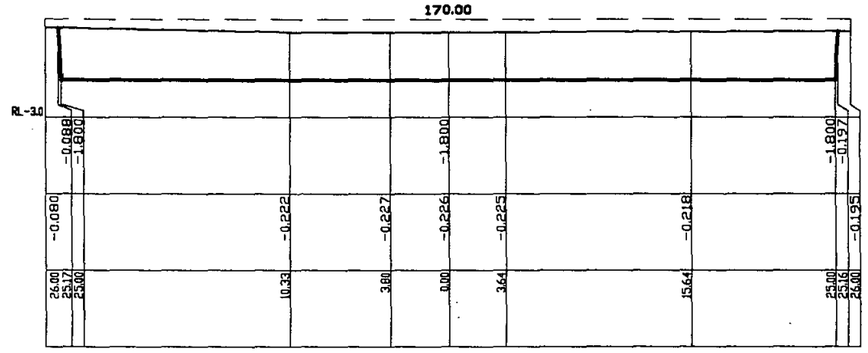
88.20



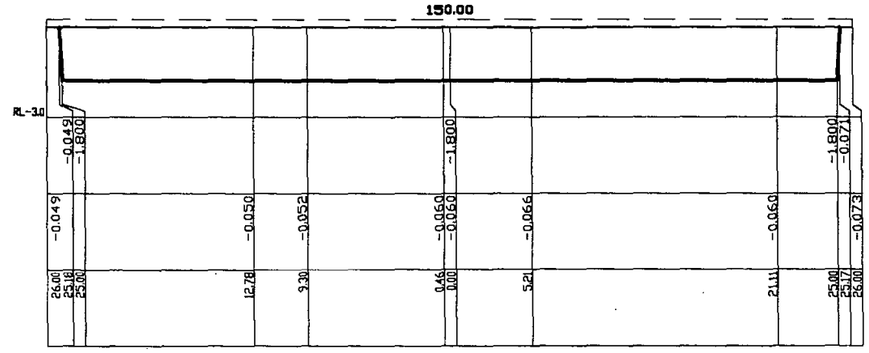
80.00



170.00

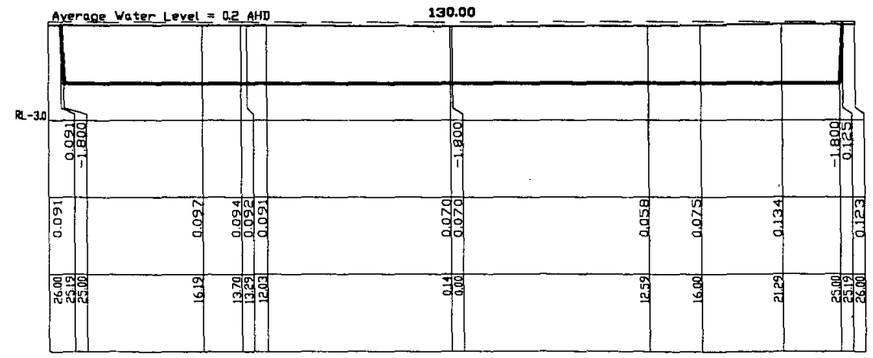


150.00



Average Water Level = 0.2 AHD

130.00



110.00

LOT	D.P.	DATE SENT	DATE RECVD
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DESIGNER DETAILS	DESIGN SRV DETAILS

MICROFILM
YES NO X
APPROVED
DATE

JOB NO. 2505
DISK NO.

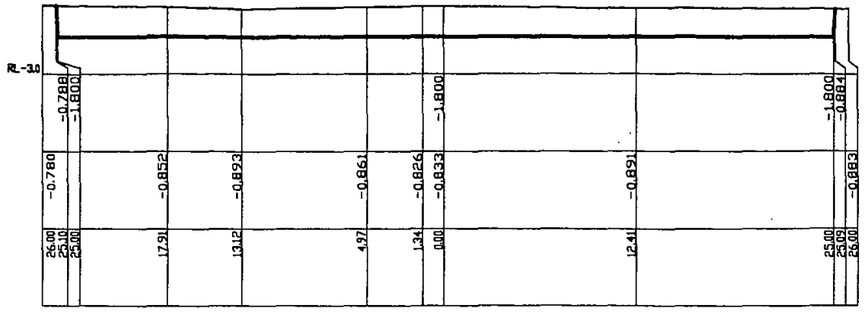
Surveyed By . . S.Murray 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . S.Murray . . .
Drawn By . . . . . S.Murray . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES
Scale Horizontal 1:400 Vertical 1:200

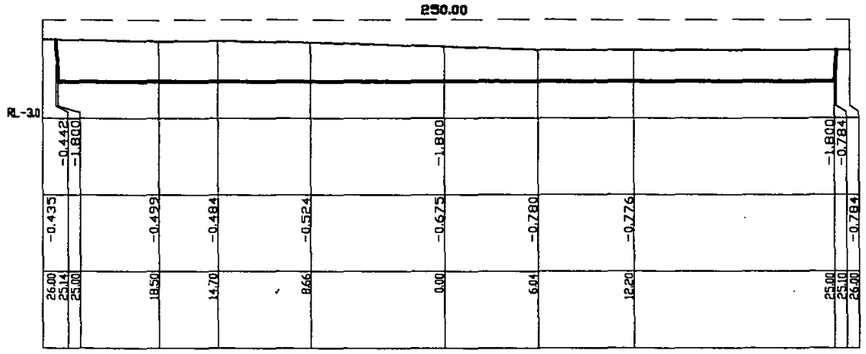
WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
EXISTING ALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

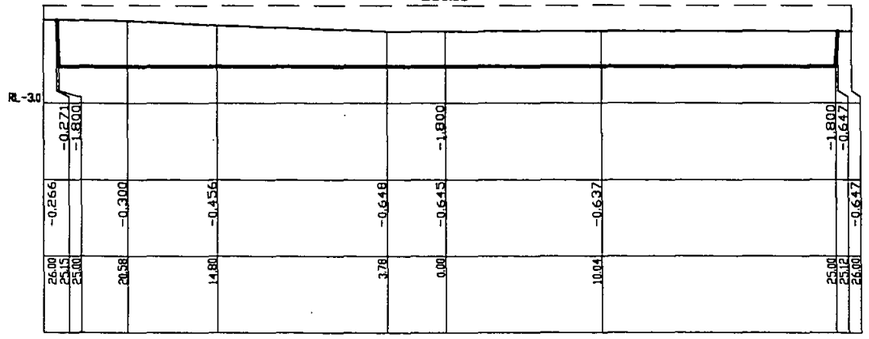
APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	10	11	12266



250.00

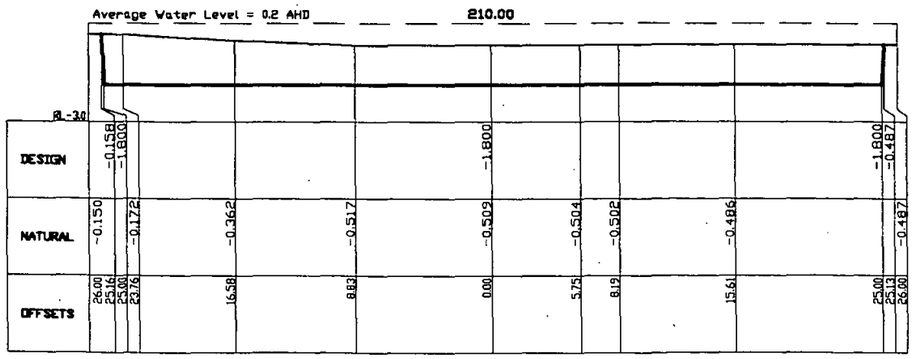


230.00



Average Water Level = 0.2 AHD

210.00



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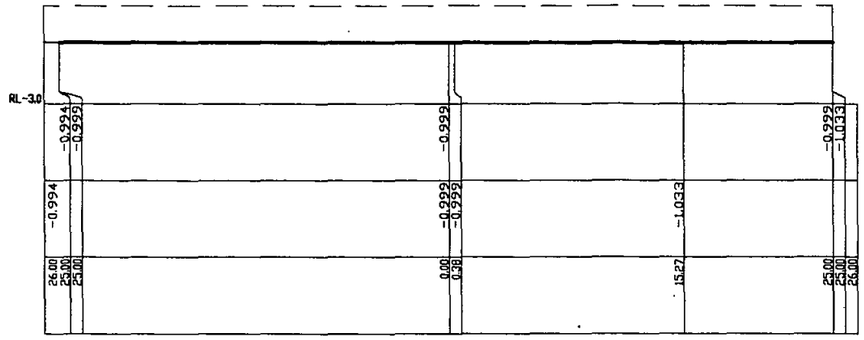

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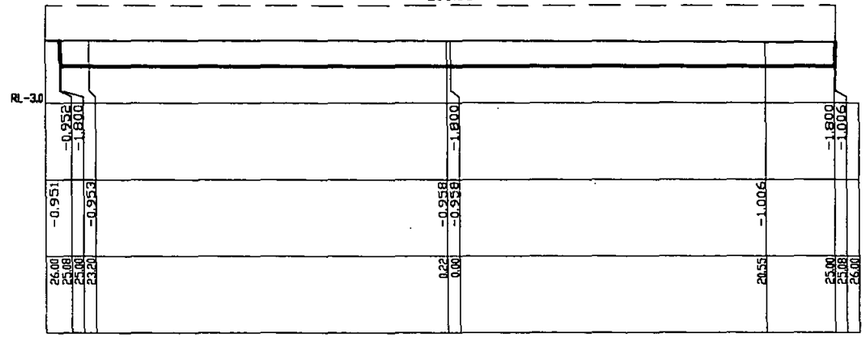

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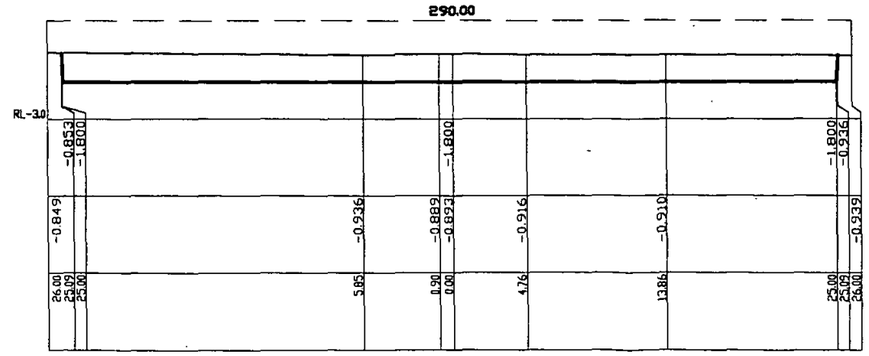

270.00

LOT	D.P.	DATE SENT	DATE RECV'D
NOTICE OF ENTRY			

DATE	No.	AMENDMENT	DESIGNER INITIALS	DRAWN AND INITIALS

MICROFILM: YES / NO X

APPROVED

DATE

JOB NO. 2505

DISK NO.

Surveyed By . . S.Murray . 5/6/01
Surveyor's Ref . . . . . .
Designed By . . . . S.Murray . . . .
Drawn By . . . . . S.Murray . . . .
Checked By . . . . . .
Passed By . . . . . .

SCALES

Scale Horizontal 1:400 Vertical 1:200

WYONG COUNCIL

HYDROGRAPHIC SURVEY – TUMBI CREEK
EXISTING ALIGNMENT OF NAVIGATIONAL CHANNEL
KILLARNEY VALE

APPROVED BY	DATE	DATUM	SHEET NO.	NO. OF SHEETS	PLAN NO.
DIRECTOR OF STRATEGIC PLANNING	20/7/01	AHD	11	11	12266

APPENDIX C

Report on Acid Sulphate Soil Assessment
November 2001
Douglas Partners

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Geotechnics • Environment • Groundwater

REPORT
on
ACID SULPHATE SOIL ASSESSMENT

TUMBI CREEK,
BERKELEY VALE

Prepared For:
WYONG SHIRE COUNCIL

Project 34427
November 2001

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Douglas Partners
Geotechnics · Environment · Groundwater

PH:sd
Project 34427
19 November 2001

REPORT ON
ACID SULPHATE SOIL ASSESSMENT
TUMBI CREEK, BERKELEY VALE

1. INTRODUCTION

This factual report presents the results of an acid sulphate soil (ASS) assessment of the Tuggerah Lakes sediment near the mouth of Tumbi Creek at Berkeley Vale. The work was commissioned by Mr. S. Murray of Wyong Shire Council.

It is understood that it is proposed to dredge a channel to provide a consistent depth of 2 m leading into Tumbi Creek and the work was required for planning purposes.

Three test bores were drilled at locations nominated by Wyong Shire Council and samples were collected and tested for potential ASS. Details of the field work and the test results are contained herein.

2. SITE DESCRIPTION

The site is located in the Tuggerah Lake near the mouth of Tumbi Creek at Berkeley Vale and is accessed via a public reserve and a concrete cycle/walkway.

3. REGIONAL GEOLOGY

Reference to the Geological Survey of New South Wales 1:250 000 Series Sheet for Sydney indicates that the site is underlain by Quaternary Alluvium which generally comprises gravel, sand, silt and clay. Further to the above, reference to the Department of Land and Water Conservation Acid Sulphate Soil Risk Map for Wyong indicates that there is a high probability that potential ASS will occur in the lake bottom sediments.

4. FIELD WORK

4.1 Methods

The field work for the assessment comprised three test bores drilled by hand methods to depths ranging from 1.8 m to 1.9 m from a modified boat. Samples of the soil profiles were collected at the depth intervals requested by Wyong Shire Council and returned to the laboratory for strata identification and testing purposes.

The test bore report sheets are attached and should be read in conjunction with the notes defining classification methods and descriptive terms.

4.2 Results

The depth of water at the test bore locations varied from 0.3 m to 0.55 m and the encountered subsurface conditions are broadly summarised below:

Bottom Sediment

SANDY CLAYEY SILT	Dark grey black sandy clayey silt in all test bores to depths ranging from 0.9 m to 1.0 m, overlying
SANDY CLAY	Very soft to stiff grey and grey orange mottled sandy clay in all test bores to the termination depths ranging from 1.8 m to 1.9 m

It should be noted that the datum for the depth measurements was the surface of the water in the lake as requested by Wyong Shire Council.

5. LABORATORY TESTING

As requested by Wyong Shire Council nine samples (three from each test bore) were screened in the laboratory for potential PASS. The samples were tested for pH and results below pH 4 are considered to indicate PASS. If the results indicated pH levels in excess of pH 4 the samples were oxidised by the addition of hydrogen peroxide generally in accordance with the acid sulphate screening procedure detailed in the ASSMAC Manual (Ref.1) and retested for pH. Ref.1 indicates that the pH is an indication of the potential for a soil to generate acid upon oxidation.

The results of the screening tests are indicated in Table 1

Table 1 – Results of Acid Sulphate Soil Screening

Test Bore No.	Depth (m)	pH in Distilled Water	pH in H_2O_2	Result
TB1	0.6	7.53	2.28	Potential ASS
TB1	1.2	7.61	2.64	Potential ASS
TB1	1.8	7.20	5.38	Not likely to be ASS
TB2	0.4	7.27	2.47	Potential ASS
TB2	1.0	7.66	2.38	Potential ASS
TB2	1.8	7.47	2.80	Potential ASS
TB3	0.7	7.61	2.86	Potential ASS
TB3	1.1	7.71	2.78	Potential ASS
TB3	1.85	7.70	2.75	Potential ASS

Following the initial screening the samples were submitted to a specialised testing laboratory for the determination of Peroxide Oxidisable Combined Acidity and Sulphate (POCAS). The results of this testing are presented in Table 2

Table 2 – Results of POCAS Testing

Sample ID	Depth (m)	TAA (mol/t)	TPA (mol/t)	Spos (%)	TSA (mol/t)	Comments
TB1	0.6	<2	210	0.669	211	Potential ASS
TB1	1.2	<2	3	0.054	4	Potential ASS
TB1	1.8	<2	<2	0.009	<2	Not ASS
TB2	0.4	<2	232	0.894	233	Potential ASS
TB2	1.0	<2	187	0.371	189	Potential ASS
TB2	1.8	<2	34	0.115	35	Potential ASS
TB3	0.7	<2	<2	0.343	<2	Potential ASS
TB3	1.1	<2	16	0.139	17	Potential ASS
TB3	1.85	<2	<2	0.082	<2	Potential ASS

TAA = Total Actual Acidity
TPA = Total Potential Acidity
Spos = Potential Oxidisable Sulphur
TSA = Total Sulphuric Acidity

Tables 1 and 2 give some results which appear to be conflicting but this is simply due to the limitations of using hydrogen peroxide oxidisation as an indicator of acid sulphate potential. The results from Table 2 are more useful for assessing acid sulphate potential as they measure the oxidisable sulphur and not simply the total oxidisable material.

6. COMMENTS

On the basis of the initial screening using pH as an indicator more detailed analysis has been undertaken in the form of POCAS testing. The results indicated that all but one of the nine samples tested were potential acid sulphate soil. The levels of oxidisable sulphur are above the threshold levels detailed in Ref.1 for the implementation of an acid sulphate management plan. Further to the above and based on an assumed soil bulk density of 2 t/m^3, Table 4.6 of Ref.1 indicates that some of the site soils have the potential to produce up to 55 kg of sulphuric acid (H_2SO_4) per tonne of disturbed soil.

It is understood that it is proposed to provide a 2 m deep navigable channel at the mouth of Tumbi Creek by dredging the lake sediments. It is further understood that the dredged material is to be redeposited away from the site below the permanent water level in Tuggerah Lakes.

Given the above, the management strategies detailed in Ref.1 indicate that burial of potential acid sulphate soil below the permanent water table is appropriate for mitigating the impacts from these soils.

DOUGLAS PARTNERS PTY LTD

Paul Herring
Senior Technical Officer

Reviewed by:

Michael J Thom
Principal

Attachments

General Notes
Test Bore Report Sheets
Laboratory Test Results

References:

1. NSW Acid Sulphate Soil Management Advisory Committee - *Acid Sulphate Soil Manual* – August 1998

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Geotechnics • Environment • Groundwater

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in

clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18)\ c_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section

is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL

- BITUMINOUS CONCRETE
- CONCRETE
- TOPSOIL
- FILLING
- PEAT
- CLAY
- SILTY CLAY
- SANDY CLAY
- GRAVELLY CLAY
- SHALY CLAY
- SILT
- CLAYEY SILT
- SANDY SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GRAVEL
- SANDY GRAVEL
- COBBLES/BOULDERS
- TALUS

SEDIMENTARY ROCK

- BOULDER CONGLOMERATE
- CONGLOMERATE
- CONGLOMERATIC SANDSTONE
- SANDSTONE FINE GRAINED
- SANDSTONE COARSE GRAINED
- SILTSTONE
- LAMINITE
- MUDSTONE, CLAYSTONE, SHALE
- COAL
- LIMESTONE

METAMORPHIC ROCK

- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

IGNEOUS ROCK

- GRANITE
- DOLERITE, BASALT
- TUFF
- PORPHYRY

SEAMS

- SEAM > 10 mm
- SEAM < 10 mm

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TEST BORE REPORT

CLIENT: Wyong Shire Council
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Tumbi Creek, Berkeley Vale

DATE: 1 November 2001
PROJECT No.: 34427
SURFACE LEVEL: Not Measured

BORE No. 1
SHEET 1 OF 1

Depth m	Description of Strata	Sampling & In Situ Testing: Type	Depth (m)	Test Results	Core Recovery %
0	WATER				
0.3	SANDY CLAYEY SILT: Dark grey/black sandy clayey silt, saturated	D	0.6		
1 1.0	SANDY CLAY: Firm to stiff grey orange mottled sandy clay, M>>Wp	D&pp	1.2	100 kPa	
	- grey and soft to firm from 1.5m	pp	1.5	50 kPa	
		D	1.8		
1.85	Test Bore terminated at 1.85m. Limit of investigation				
2					

RIG: Hand Tools DRILLER: MVH LOGGED: PHFH CASING: PVC to 1.2m
TYPE OF BORING: 50mm dia. hand auger
GROUND WATER OBSERVATIONS: N/A Test Bore located in Tuggerah Lake
REMARKS: Depths recorded from water level

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	Wp Plasitc limit (%)

CHECKED:
Initials:
Date: 21/11/01

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TEST BORE REPORT

CLIENT: Wyong Shire Council
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Tumbi Creek, Berkeley Vale

DATE: 1 November 2001
PROJECT No.: 34427
SURFACE LEVEL: Not Measured

BORE No. 2
SHEET 1 OF 1

Depth m	Description of Strata	Sampling & In Situ Testing: Type	Depth (m)	Test Results	Core Recovery
0	WATER				
0.3	SANDY CLAYEY SILT: Dark grey/black sandy clayey silt, saturated	D	0.4		
	- becoming more sandy and dark grey from 0.5m				
0.9	SANDY CLAY: Soft grey sandy clay, M>>Wp				
1		D&pp	1.0	40 kPa	
	- some orange mottling from 1.5m	pp	1.5	60 kPa	
		pp	1.7	50 kPa	
1.8	Test Bore terminated at 1.8m. Limit of investigation	D	1.8		
2					

RIG: Hand Tools DRILLER: MVH LOGGED: PHFH CASING: PVC to 1.2m
TYPE OF BORING: 50mm dia. hand auger
GROUND WATER OBSERVATIONS: N/A Test Bore located in Tuggerah Lake
REMARKS: Depths recorded from water level

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	Wp Plasitc limit (%)

CHECKED:
Initials:
Date: 21/11/01

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TEST BORE REPORT

CLIENT: Wyong Shire Council
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Tumbi Creek, Berkeley Vale

DATE: 1 November 2001
PROJECT No.: 34427
SURFACE LEVEL: Not Measured

BORE No. 3
SHEET 1 OF 1

Depth m	Description of Strata	Sampling & In Situ Testing: Type	Depth (m)	Test Results	Core Recovery %
0	WATER				
0.55	SANDY CLAYEY SILT: Dark grey sandy clayey silt, some small shells, saturated	D	0.7		
1 1.0	SANDY CLAY: Very soft to soft grey orange mottled sandy clay, virtually saturated	D&pp	1.1	30 kPa	
		pp	1.65	50 kPa	
		D	1.85		
1.9	Test Bore terminated at 1.9m. Limit of investigation				
2					

RIG: Hand Tools DRILLER: MVH LOGGED: PHFH CASING: PVC to 1.2m
TYPE OF BORING: 50mm dia. hand auger
GROUND WATER OBSERVATIONS: N/A Test Bore located in Tuggerah Lake
REMARKS: Depths recorded from water level

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	Wp Plastic limit (%)

CHECKED:
Initials:
Date: 21/11/01

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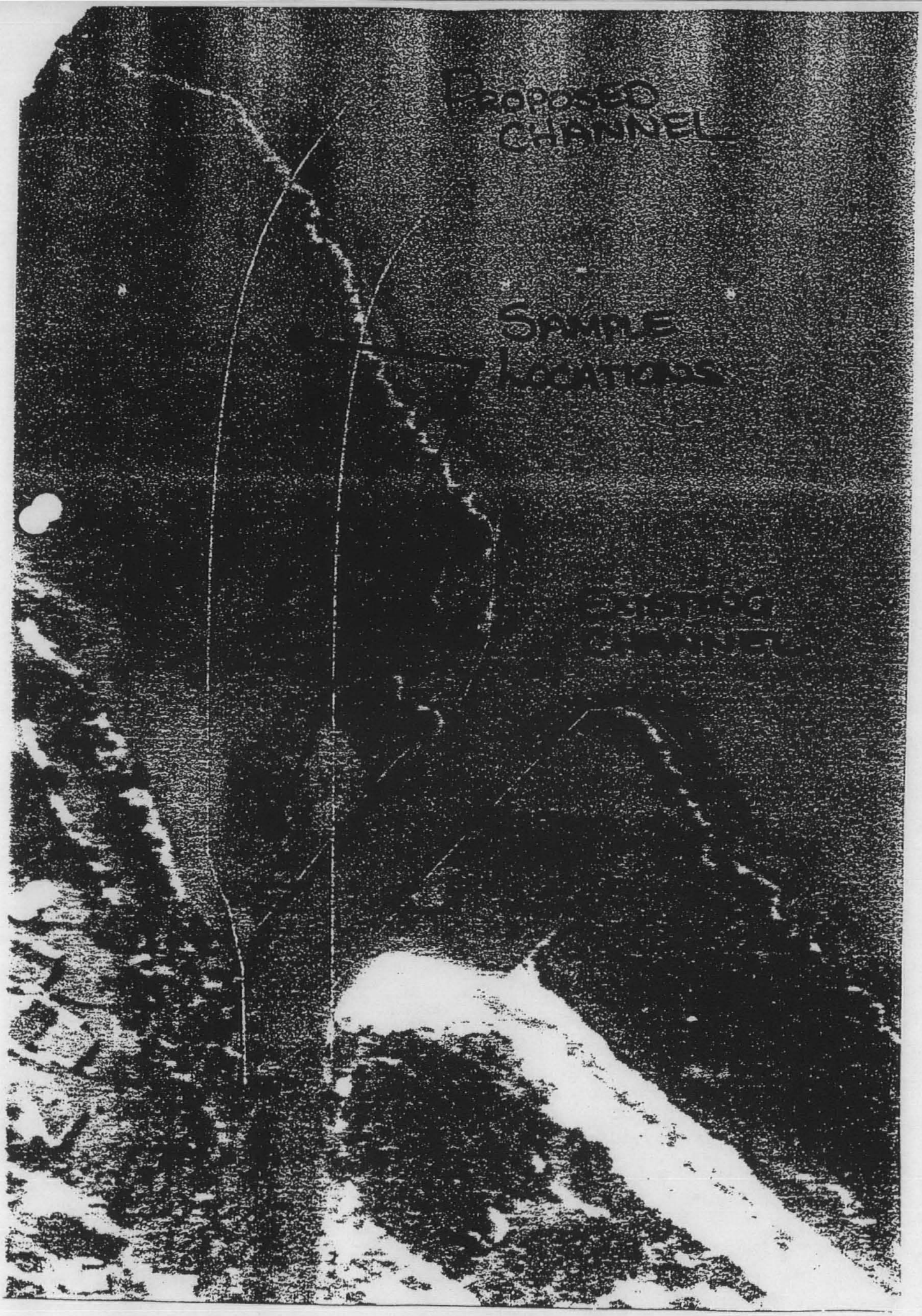
PROPOSED
CHANNEL
SAMPLE
LOCATIONS

APPENDIX D

Letter Report on Proposed Dredging
Tumbi Creek, Berkeley Vale
March 2002
Douglas Partners

Douglas Partners
Geotechnics • Environment • Groundwater

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IGP:BDS:bds
Project 34427A
4 April 2002

WYONG SHIRE COUNCIL
Doc. No. 513541
REC'D - 8 APR 2002

ACT	INFO	DEPT	FILE No.
	✓	MDY	L030/31800

Wyong Shire Council
PO Box 20
WYONG NSW 2259

Attention: Mr Mike Long

Facsimile: 4351 1096

Dear Mike

PROPOSED DREDGING
TUMBI CREEK, BERKELEY VALE

Further to a meeting at Wyong Shire Council Chambers on 13 December 2001, and subsequent e-mail of 20 December 2001 from your Mr. Shane Murray, we are pleased to provide herewith comments relating to proposed dredging of Potential Acid Sulphate Soil (PASS) at the above site.

It is understood that the proposed development at the site comprises realignment of the existing creek channel, with an estimated 30 000 m^3 of soil to be dredged from the creek mouth and deposited back on to the lake floor.

Previous investigation has been carried out by this company with the results presented in our Report No 34427 dated November 2001. The field investigation comprised three bores drilled using hand tools to depths in the range 1.8 – 1.9 from a boat within Tuggerah Lake near the Tumbi Creek mouth at locations nominated by WSC. The fieldwork indicated the subsoil comprised a sandy clayey silt layer approximately 0.5 – 0.7 m thick, overlying sandy clay. The soils were generally very soft to soft.

Laboratory testing indicated the soils were near neutral in pH, although the soils contained significant quantities of oxidisable sulfur and as such would be classified as PASS.

The results of the laboratory testing are reproduced in Table 1 below.

Table 1: Results of POCAS Testing

Sample ID	Depth (m)	TAA (mol/t)	TPA (mol/t)	S_{pos} (%)	TSA (mol/t)	Comments
TB1	0.6	<2	210	0.669	211	Potential ASS
TB1	1.2	<2	3	0.054	4	Potential ASS
TB1	1.8	<2	<2	0.009	<2	Not ASS
TB2	0.4	<2	232	0.894	233	Potential ASS
TB2	1.0	<2	187	0.371	189	Potential ASS
TB2	1.8	<2	34	0.115	35	Potential ASS
TB3	0.7	<2	<2	0.343	<2	Potential ASS
TB3	1.1	<2	16	0.139	17	Potential ASS
TB3	1.85	<2	<2	0.082	<2	Potential ASS

Notes: TAA = Total Actual Acidity
TPA = Total Potential Acidity
S_{pos} = Potential Oxidisable Sulfur
TSA = Total Sulphuric Acidity

It is understood that comment is required on the potential for the PASS material to oxidise underwater due to the presence of dissolved oxygen.

Using the methods outlined in Table 6.1 of the Acid Sulphate Soil Manual (Ref 1), it is estimated that soils with the highest potential for acid generation could generate up to 27 kg of sulphuric acid (H_2SO_4) per tonne of soil dredged. Assuming a bulk density of 1.5 tonnes/m^3 for the very soft to soft soils at the site, this equates to approximately 41 kg H_2SO_4/m^3, or 1230 tonnes H_2SO_4 for the project. This is an upper bound estimate based on an S_{pos} of 0.894%, the highest recorded for the samples tested. Where an average S_{pos} for the PASS of 0.333% is used, quantity of acid generated drops to approximately 15 kg H_2SO_4/m^3, or 450 tonnes H_2SO_4.

The above estimates are based on the assumption that complete oxidation of sulphides within the pyrite (Fe_2S), with 2 mol of sulphuric acid generated per mol of pyrite and no soil buffering occurring. Following the initial generation of acid continued acidification can occur as Ferrous ion further oxidise. However the continued oxidisation is predicated on the initial oxidisation process forming an acidic regime and the presence of bacteria in the soil which act as catalysts.

Full oxidisation of the iron pyrite will require exposure to air, whereas the dredged sediments will be deposited immediately under seawater. At neutral pH, haematite in sediment is stable and ferrolysis does not occur. Recent studies on several aspects of acid sulphate soil formation and interaction have been undertaken at Wollongong University. One of these studies has identified that the presence of a certain bacteria will continue and accelerate the oxidisation process, however the bacteria can only survive in a low pH environment. Another of the current studies addresses the acid generation from the flood mitigation system in the Shoalhaven River area, with the funding of Department of Fisheries. This study has found that the regular injection of seawater has been able to reverse the pH environment in these canals which have measured pH levels below 4.

Seawater has a pH of approximately 8.2, which is controlled by a dissolved carbonate and bicarbonate system, with alkalinity of approximately 120 mg/L due to the presence of calcium carbonate (Ref 2). This carbonate and bicarbonate content can effectively neutralise significant quantities of acidity (up to 2 moles of acidity per m^3 seawater). Although it should be appreciated that the use of carbonate resources may have an impact on nutrient levels and chemical balance for aquatic fauna in closed systems.

At the time of publishing Ref 1, the Acid Sulphate Soils Management Advisory Committee – Technical Committee was undertaking a review of this acid mitigation method, however the results of this work are not available to our knowledge.

Notwithstanding the above a review of available data on acid sulphate remediation treatments still indicates that placement of dredged sediment is an appropriate method of treatment of estuarine sediments. Several papers such as the "Case Studies of Acid Sulphate Soil Management" by Dr GM. Bowman have presented data on the above treatment.

While it must be acknowledged that some oxidisation is theoretically possible the probability is low. When we consider that the sediments are currently near neutral and are in and will be replaced into seawater, the potential for any acid generation would be minimal provided significant turbulence is prevented as this can result in oxygen enrichment in the seawater.

We trust that the above comments are sufficient to your present requirements.

Yours faithfully
DOUGLAS PARTNERS PTY LTD

Ian G. Piper
Associate

Reviewed by

Michael J Thom
Principal

References:

1. NSW Acid Sulphate Soils Advisory Committee, "*Acid Sulphate Soil Manual*", August 1998

2. National Water Quality Management Strategy – Australia and New Zealand Environment and Conservation Council, "*Australian Water Quality Guidelines for Fresh and Marine Waters*", (2000)

APPENDIX E

Report on Effect of Wave Action from Dredging
March 2002
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WYONG SHIRE COUNCIL
Doc. No. 513569
REC'D - 5 APR 2002

ACT	INFO	DEPT	FILE No.
	✓	MDL	W30/31800

Manager Open Space and Recreation
Wyong Shire Council
PO Box 20
WYONG NSW 2259

4 April, 2002

Attention: Mr Mike Long

Dear Sir

TUMBI CREEK DREDGING – WAVE IMPACT ASSESSMENT

The following sets out the findings of an assessment of the impact on wave climate and foreshore erosion of the proposed dredging of a navigation channel at the mouth of Tumbi Creek, Tuggerah Lake.

1. INTRODUCTION

Extensive sedimentation at the mouth of Tumbi Creek has implications for flood levels at local properties and has adversely affected navigation for recreational craft that use the boat launching ramp facility. It is proposed to create a navigation channel through this shoal, which follows the northerly alignment of the creek. The channel would be created to a design level of between 1.5 and 2.0 m below Australian Height Datum *(AHD)* over a width of up to 50 m and a length of approximately 460 m. The proposal involves the removal of around 30,000 m^3 of predominantly silts and clays and the placement of this material as a thin veneer on the surface of the lake bed over an area of around 300,000 m^2.

The Department of Land & Water Conservation *(DLWC)* has identified a number of issues that need to be addressed in the Review of Environmental Factors *(REF)* document which is currently under preparation by Council. One of these issues is the potential adverse effect(s) that the dredging and disposal activities may have on the wave energy reaching the shoreline and its potential to exacerbate foreshore erosion.

The following discussion sets out the existing wave climate at the site, the likely changes to the wave climate that will result from the dredging and disposal activities and subsequent impacts on foreshore erosion and sediment transport regimes.

2. EXISTING WAVE CLIMATE

The existing wave climate at the site is comprised of locally generated wind waves and boat wake *(when the channel is navigable)*.

2.1 Locally Generated Wind Waves

Locally generated wind waves at the site are the result of wind blowing across the water surface of Tuggerah Lake. Wave height is dependent on the speed, duration and direction of the wind, the length of water over which the wind blows *(known as fetch)* and the water depth.

An in-house mathematical model was used to predict the height and period of wind generated waves at the site for particular directions and average return intervals *(ARI's)*. The model uses the recognised algorithms set out in the Shore Protection Manual ***(Reference 1)*** with directional wind information established for Sydney.

A comparison of wind data supplied by the Bureau of Meteorology for the Sydney Airport and Norah Head weather stations showed that the wind climates at these two sites were similar. The approximation of the wind climate at Tuggerah Lake to that of Sydney is therefore considered to be appropriate.

The site is exposed to wind waves emanating from the north through to the east-north-east sectors. A summary of the wind wave climate established at the site for 22.5 degree directional intervals is presented below in **Table 2.1**. This table shows the significant wave height and the corresponding wave period estimated for the site for the 1 and 50-year ARI events.

Table 2.1: Existing Wind Wave Climate at the Site

Wind/Wave Direction	Fetch (km)	Average Depth[3] (m)	1-Year ARI Event		50-Year ARI Event	
			H_s[1] (m)	T_s[2] (s)	H_s[1] (m)	T_s[2] (s)
N	3.1	1.2	0.35	2.0	0.50	2.4
NNE	11.8	2.2	0.60	3.0	0.80	3.5
NE	7.7	1.7	0.55	2.8	0.70	3.1
ENE	3.9	1.7	0.45	2.3	0.65	2.7

Notes: 1. H_s is the significant wave height which is equivalent to the average height of the largest one third of waves in the wave train.
2. T_s is the spectral wave period corresponding to H_s.
3. Average water depth is based on an average lake level of 0.2 m above AHD *(data supplied by Manly Hydraulics Laboratory for Long Jetty site)*

Table 2.1 shows that the largest waves are generated from a north-north-easterly direction with the 1-year and 50-year ARI significant wave heights estimated at around 0.6 and 0.8 m respectively.

2.2 Boat Wake

An assessment of boat wake at the site has been made based on experience with similar sites and discussions held with the local Waterways Authority Boating Officer *(Ms Sue Lynch)*. It is understood that boat usage of the boat launching ramp is currently negligible due to the unnavigable state of the creek entrance. Prior to the sedimentation of the existing channel it is estimated that the maximum wave height of boat wake generated at the site would have been 0.3 m *(refer to **Section 4.2**)*.

3. GEOTECHNICAL CONDITIONS

Three boreholes were drilled along the alignment of the proposed channel by Douglas Partners in November 2001 *(refer to **Reference 2**)* as part of an investigation to characterise the physical and chemical nature of the material to be dredged. The locations of these boreholes are shown on **Figure 1**. It has been established that a layer of soft sediment *(sandy clayey silts)* typically overlies stiffer sandy clays. Of the three boreholes, Borehole 1 is most interest to this current study as it is located close to the shoreline where potential wave impacts are likely to be more noticeable. The approximate location of this borehole is shown on **Figure 1** with the borehole log being shown on **Figure 2**.

This borehole log shows that a layer of firm to stiff sandy clay is overlain by some 700 mm of sandy clayey silt. The distinction between these two sediment types is important as the layer of firm to stiff sandy clay is likely to be resistant to erosion by waves while the overlying layer of sandy clayey silt is likely to be subject to reworking under wave action until a stable bed slope is achieved.

Based on an examination of the existing bathymetry shown on Council Plan 12266 and discussions with Douglas Partners, it is considered that a stable bed slope for the overlying soft sediment is likely to be of the order of 1 in 10 *(vertical to horizontal)*.

4. MODIFICATION OF EXISTING WAVE CLIMATE

4.1 Locally Generated Wind Waves

The locally generated wind waves propagating to the site are short period and short crested. As such, any refraction/diffraction of these waves as a result of the proposed dredging works would be minor.

The significant shoals located within the nearshore area of the lake through which the proposed navigation channel would be created would still serve to reduce wave energy propagating to the shoreline by inducing wave-breaking of the larger waves emanating from all directions except the north, which corresponds roughly to the proposed channel alignment. These waves would tend to propagate further upstream along the channel and could possible now break on the shoreline at the creek entrance.

In addition, some focussing of waves approaching from the north-east and north-north east sectors may result in the vicinity of the creek entrance from minor refraction of waves along the proposed channel towards the shore. As such, it is possible that some increase in wave energy around the entrance to Tumbi Creek would result from the proposed dredging works.

Modification of the existing wave climate from the proposed disposal activities are likely to be insignificant provided that the material is disposed of in a thin veneer as proposed. However, large mounds created on the lakebed may interfere with approaching waves.

Because wave heights around the entrance to Tumbi Creek will be limited by water depth *(due to the breaking of the larger waves on the nearshore shoals)* the worst-case scenario as far as wave heights at the site are concerned would result at times of high lake level.

4.2 Boat Wake

As discussed previously in **Section 2.2**, boat usage at the site is currently restricted by extensive sedimentation of the existing channel. However, following dredging of the proposed channel the site is likely to be popular, although usage would be limited by lack of carparking and other facilities. It would be used by small trailerable craft *(including jet skis)* associated with activities such as sailing, fishing and water skiing. The craft using the facility would have a maximum length of approximately 4.5 m (Sue Lynch, Waterways Authority, *pers comm*).

Although there are no gazetted navigational speed restrictions at the site it is likely that due to the restricted nature of the waterway *(even allowing for the proposed dredging works)* speeds would be limited to approximately 5 knots.

On this basis it is estimated that the boat wake wave generated at the site following the completion of the dredging works is unlikely to exceed a maximum wave height of around 0.3 m.

5. IMPACT OF PROPOSED DREDGING WORKS ON SHORELINE EROSION

As outlined above in **Section 4**, some minor modification of the existing wave climate is expected as a result of the proposed dredging and disposal activities. In particular, some increase in wave energy could be expected around the entrance to the creek. This increase in wave energy could have a subsequent impact on shoreline erosion. **Figure 1** shows where the possible impact of modification of the wave climate could be expected and conversely where no impact of the shoreline would be expected.

In addition to impacts on the stability of the foreshore as a result of modification of the existing wave climate, it is considered that the proposed dredging works may have a direct impact on the stability of the foreshore. This situation would arise where a near-vertical cut *(as indicated on Council Plan No. 12266)* was made into the overlying soft sediment *(sandy clayey silt)*. It would be expected the side slope would slump and readjust to a stable slope under wave action, which as discussed in **Section 3** is likely to be around 1 in 10 *(vertical to horizontal)*. Depending on the distance from the proposed channel edge to the shoreline, and the depth of the overlying soft sediment, some readjustment of the shoreline may result. An indication of the extent of readjustment is shown on **Figure 3**.

6. IMPACT OF PROPOSED WORKS ON SEDIMENT TRANSPORT REGIMES

The sediment transport at the site is controlled by significant freshwater events in Tumbi Creek and the local wave climate.

The flooding of Tumbi Creek supplies sediment to the lake, which is evidenced by the sedimentation of the existing navigation channel and the significant nearshore shoals that have formed at the entrance to the creek. The proposed navigation channel would not effect this process, however because the proposed channel is better aligned with Tumbi Creek, the proposed channel may have greater longevity than the existing channel.

Wind waves on the lake act to stir and subsequently transport/rework lakebed sediments onshore/offshore and alongshore. Given that the site is predominantly exposed to waves emanating from the north to the east-north-east, net sediment transport along the shoreline of the lake in the vicinity of the site would be expected to be from the east towards the west *(away*

from the site). In comparison to the existing navigation channel, the proposed navigation channel would not be expected to have any additional impact on this sediment transport.

7. SUMMARY AND RECOMMENDATIONS

It is not expected that the proposed works would result in significant modification of the shoreline with an increase in wave energy around the entrance to Tumbi Creek the only likely impact. This increase in wave energy could act to exacerbate shoreline erosion, which although difficult to quantify, is not likely to be significant. It is considered that an appropriate approach would be to monitor any impact on shoreline erosion and if required mitigate against such erosion with, for example, rock-work. No impact on sediment transport regimes at the site are anticipated from the proposed works.

The potential for instability of the foreshore to result from the dredging of near-vertical channel batters too close to the shoreline could be mitigated against through the dredging of flatter batters or the provision of a greater distance between the edge of the proposed channel and the shoreline. Based on a stable bed slope of 1 in 10 *(and a depth of sandy clayey silt of approximately 700 mm)*, a buffer distance of around 7 m between the channel and the shoreline is considered to be appropriate.

In addition, it is suggested that a sediment trap could be incorporated into the proposed dredging works upstream of the boat launching ramp facility. This would serve to trap sediment which is worked downstream before it had the potential to affect the navigability around the facility, thereby increasing the longevity of the proposed improvement works.

We trust that the above advice meets your requirements. Should you seek clarification of or have any questions regarding the above please do not hesitate to contact either the undersigned or Mr Matt McDonald on 9957-1519.

Yours faithfully
PATTERSON BRITTON

Michael Wright

Michael Wright
Principal

Review / Verification by Date

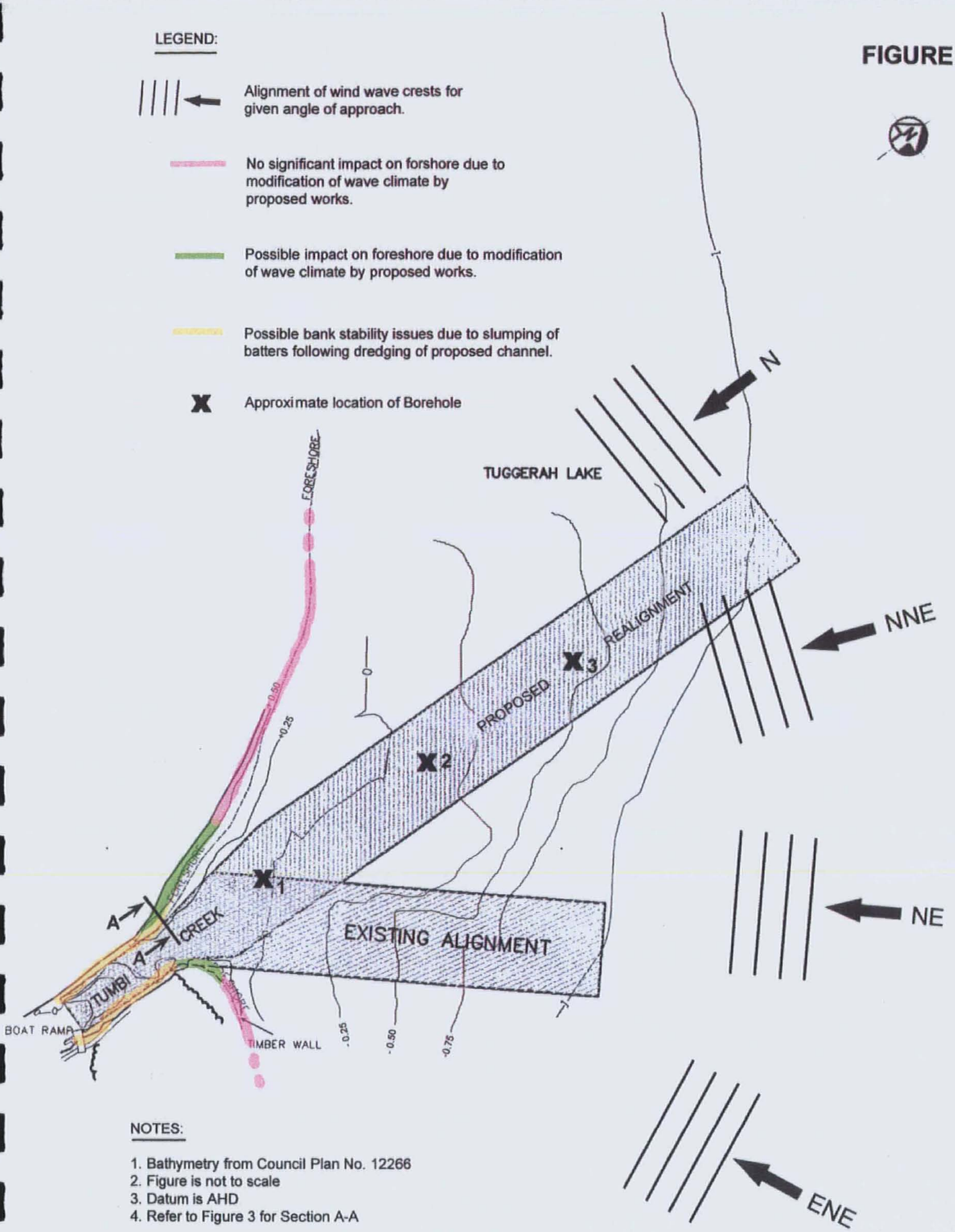
4/4/02

REFERENCES

Reference 1 US Army Corps of Engineers
Shore Protection Manual, Volume 2,
1984.

Reference 2 Douglas Partners
Report on Acid Sulphate Soil Assessment – Tumbi Creek, Berkeley Vale
Prepared for Wyong Shire Council, November 2001.

FIGURE 1



NOTES:

1. Bathymetry from Council Plan No. 12266
2. Figure is not to scale
3. Datum is AHD
4. Refer to Figure 3 for Section A-A

J4504 / Fig1foreshore_erosion.jpg
SOURCE: Wyong Shire Council

IMPACT OF PROPOSED WORKS ON FORESHORE EROSION

CLIENT: Wyong Shire Council
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Tumbi Creek, Berkeley Vale

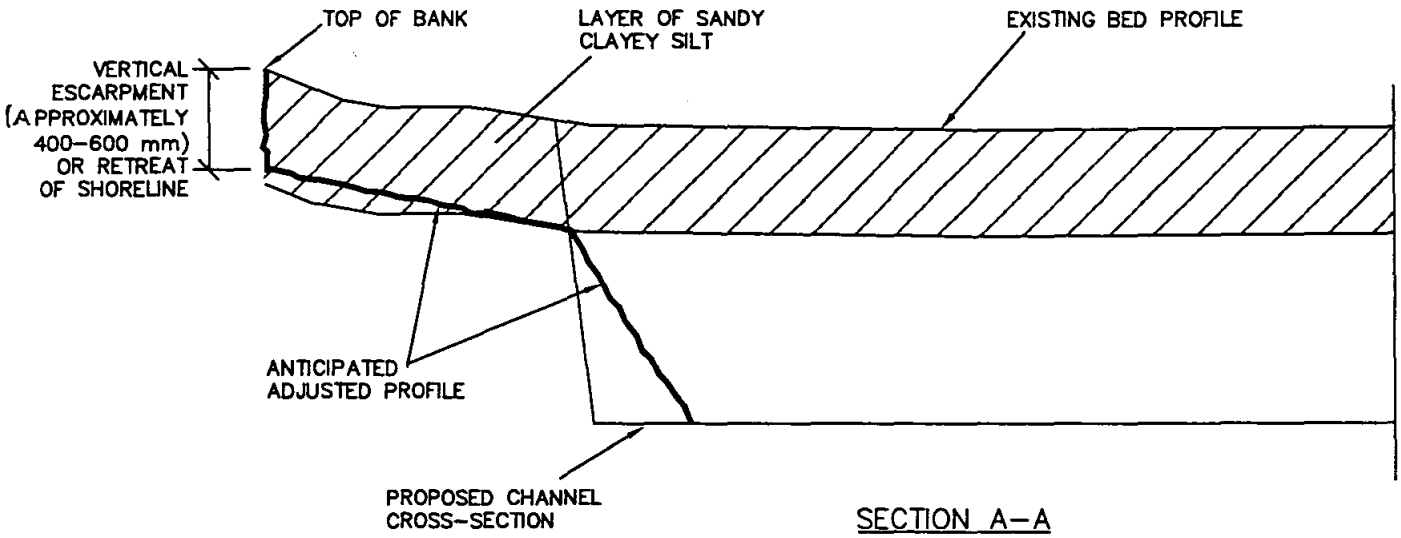
DATE: 1 November 2001 BORE No. 1
PROJECT No.: 34427 SHEET 1 OF 1
SURFACE LEVEL: Not Measured

Depth m	Description of Strata	Sampling & In Situ Testing: Type	Depth (m)	Test Results	Core Recovery %
0	WATER				
0.3	SANDY CLAYEY SILT: Dark grey/black sandy clayey silt, saturated	D	0.6		
1 1.0	SANDY CLAY: Firm to stiff grey orange mottled sandy clay, M>>Wp	D&pp	1.2	100 kPa	
	- grey and soft to firm from 1.5m	pp	1.5	50 kPa	
		D	1.8		
1.85	Test Bore terminated at 1.85m. Limit of investigation				
2					

J4504 / FIG3.1_BOREHOLE.jpg
SOURCE: Reference 1

BOREHOLE LOG FOR BOREHOLE No.1, DOUGLAS PARTNERS (2001)

FIGURE 3



NOTES:

1. REFER TO FIGURE 1 FOR LOCATION OF SECTION A-A.
2. FIGURE NOT TO SCALE (2x VERTICAL EXAGERATION).

CROSS-SECTION SHOWING ANTICIPATED ADJUSTMENT OF BATTERS FOLLOWING DREDGING OF PROPOSED CHANNEL

J4504/ FIG3_CROSS_SECTION.dwg