Arrawarra Beach Caravan Park Rock-Armoured Revetment

Response to Request for Information from NSW Coastal Panel

March 2016

DOCUMENT STATUS

Version	Doc type	Reviewed by	Approved by	Distributed to	Date issued
v01	Report	Christine Lauchlan Arrowsmith	Christine Lauchlan Arrowsmith	Client	22/03/2016

PROJECT DETAILS

Project Name	4362-01_R01v01
Client	Astoria Group
Client Project Manager	Kevin Shanahan
Water Technology Project Manager	Paul O'Brien
Report Authors	Paul O'Brien
Job Number	4362-01
Report Number	R01
Document Name	Response to Request for Information from NSW Coastal Panel

Cover Photo: Estuarine frontage to Arrawarra Creek Caravan Park. Photo 23rd March 2015.

Level 3, 43 Peel Street
South Brisbane QLD 4101

Telephone (07) 3105 1460
Fax (07) 3846 5144

ACN No. 093 377 283
ABN No. 60 093 377 283

TABLE OF CONTENTS

1. INTRODUCTION 1
2. DESIGN OCEAN WATER LEVELS & WAVE CONDITIONS 2
3. APPROACH / METHODOLOGY FOR STRUCTURAL DESIGN 3
4. MITIGATION OF TOE SCOUR 4
5. MITIGATION OF WAVE OVERTOPPING 5
6. MAINTENANCE REGIME 5
7. REFERENCES 6
Appendix A Information Request from the NSW Coastal Panel 7

LIST OF TABLES

Table 2-1 100 year ARI Ocean Water Levels & Wave Conditions - Offshore 2
Table 2-2 100 year ARI Ocean Water Levels & Wave Conditions - Inshore 3

1. INTRODUCTION

In September 2015, the engineering design and drawings for a new rock-armoured revetment along the estuarine foreshore of Arrawarra Beach Caravan Park were completed by Coastal Engineering Solutions Pty Ltd. The site is some 28kms north of Coffs Harbour - within the lower reaches of Arrawarra Creek at its confluence with Yarrawarra Creek.

Those drawings[1] were submitted in support of a Development Application made by Keiley Hunter Town Planning on behalf of Astoria Group Pty Ltd.

Following that submission, considerations by the NSW Coastal Panel have led to a request by the Panel for additional information concerning certain design parameters and structural arrangements proposed on the drawings. A copy of the information request from the NSW Coastal Panel is included as Appendix A.

This report provides the technical response to the specific queries raised by the NSW Coastal Panel with regard to the design and drawings prepared by Coastal Engineering Solutions. The document has been prepared by Mr. Paul O'Brien (formerly of Coastal Engineering Solutions) since he was the design engineer, and also approved the design drawings on behalf of Coastal Engineering Solutions. On 12th October 2015, Coastal Engineering Solutions Pty Ltd combined with Water Technology to provide specialised coastal engineering consulting services under the Water Technology name.

This response has been structured so as to address each of the five aspects raised by the NSW Coastal Panel, namely:

- Design Ocean Water Levels and Wave Conditions;
- Approach / Methodology for Structural Design;
- Mitigation of Toe Scour;
- Mitigation of Wave Overtopping; and
- Maintenance Regime

[1] Drawing Set titled "*Arrawarra Beach Caravan Park Revetment*" issued by Coastal Engineering Solutions Pty Ltd. Drawing numbers 15-849NSW-00 to 15-849NSW-18 inclusive.

2. DESIGN OCEAN WATER LEVELS & WAVE CONDITIONS

The structural design of the new revetment within the Arrawarra Creek estuary required the determination of the peak storm tide level as well as design wave parameters (of height, period, and duration) in order to determine the necessary physical characteristics of the armoured structure.

When designing the rock-armouring for the revetment fronting the Arrawarra Beach Caravan Park, Coastal Engineering Solutions used a 100 year ARI event.

The selection of specific characteristics of the 100 year ARI Design Event that were used in the design of the revetment was not a straight forward or simple process, as it consists of a combination of severe waves and extreme ocean water levels. Quite comprehensive and specialised studies are typically required to establish their joint probability.

The methodology applied to the design of the revetment by Coastal Engineering Solutions has been to adopt the Design Event having the 100 year ARI storm tide and associated wave characteristics defined by the comprehensive modelling undertaken for the *Coffs Harbour Coastal Processes and Hazards Definition Study* (BMT WBM, 2011). The relevant conditions are summarised in Table 2-1.

Table 2-1 100 year ARI Ocean Water Levels & Wave Conditions - Offshore

Climate Scenario	Storm Tide Level	Wave Height
Present-day	RL+3.0 m AHD	8.20 metres
Year 2050	RL+3.3m AHD	8.45 metres

It is important to appreciate that these wave conditions prevail in the ocean waters well offshore of Arrawarra Beach – not within the estuary itself. There will be significant attenuation of waves as they penetrate through the entrance of Arrawarra Creek. Large waves generated in deep offshore waters by the Design Event will shoal and break as they propagate shoreward towards the entrance to the Arrawarra Creek estuary. The amount of wave energy that then propagates into the estuary itself (and consequently impinge on the new revetment) is further limited by the depth of water over the entrance shoals and sandbars of the creek entrance.

Calculations of wave breaking phenomena within the Arrawarra Creek entrance area were undertaken by Coastal Engineering Solutions. The calculations consider the 100 year ARI storm tide and offshore wave characteristics; and then determine the changes in wave height distribution within the surf zone as a consequence of waves breaking within the random sea state at the creek entrance (using techniques of Goda, 2000). The calculations were undertaken for the various climate scenarios shown in Table 2-1.

When determining the possible condition of the ocean entrance to Arrawarra Creek at the time of the Design Event, the surveyed entrance bathymetry used for previous flood modelling for Arrawarra Creek (Umwelt, 2003) has been considered by Coastal Engineering Solutions. That study identified an entrance cross section being approximately 165 metre wide during the 100 year ARI flood; the crest of the entrance bar at approximately RL+1.3m AHD; with two smaller and much narrower flow channels cutting through the bar to a depth of around RL+0.25m AHD. When determining the penetration of waves through the entrance, the conservative assumption is made by Coastal Engineering Solutions that the entrance during the Design Event would be scoured to the lower channel level of RL+0.25m AHD across its entire 165 metre width – not just in the main ebb/flood channels.

The resulting design wave parameters for the revetment location behind the creek entrance shoals are presented overleaf in Table 2-2. These are the water level and wave characteristics used for the design of the rock-armoured revetment.

Table 2-2 100 year ARI Ocean Water Levels & Wave Conditions - Inshore

Climate Scenario	Storm Tide Level	Wave Height
Present-day	RL+3.0m AHD	2.0 metres
Year 2050	RL+3.3m AHD	2.25 metres

3. APPROACH / METHODOLOGY FOR STRUCTURAL DESIGN

Various methods for calculating the size of rock armour under wave attack have been proposed by the international coastal engineering profession in the past few decades. The decision as to which mathematical technique is the most appropriate has been the subject of much deliberation, however most practitioners are now generally agreed that the formulae originally developed by van der Meer (van der Meer, 1988) are the most appropriate. They are based upon an extensive series of physical model tests, which included a wide range of incident wave conditions, nearshore bathymetry, core / underlayer permeabilities, and rock characteristics. These algorithms form the basis of proprietary software packages now used by coastal engineers worldwide.

Consequently the design techniques attributed to van der Meer have been applied by Coastal Engineering Solutions for the engineering design of the rock-armoured revetment fronting the Arrawarra Beach Caravan Park.

In doing so, the extent of damage that is deemed to be acceptable under the 100 year ARI design criteria has been selected as 5%. This is in keeping with accepted worldwide practice when designing rock-armoured works within the marine environment.

The front slope of the armour layer has been selected by Coastal Engineering Solutions as 1 vertical to 1.5 horizontal. Previous experience shows that a flatter gradient is more difficult to build without specialised long-reach excavators. Flatter seawall slopes require a greater volume of rock product, and also have significantly greater impact on the visual amenity of the foreshore. A slope of 1 vertical to 1.5 horizontal was therefore deemed appropriate.

Accommodation of Future Climate Change – Design Philosophy

As well as possible sea level rise, the implications of potential changes to the climatology of eastern Australia need to be considered and incorporated into structural assessments and designs of foreshore protection works where appropriate.

In reality, any increase in offshore wave characteristics alone is not expected to result in significant practical changes to the size of armouring specified for rock-armouring. Of greater concern in design deliberations is the potential threat posed by a future rise in sea level.

Sea level rise as a consequence of future climate change will result in potentially greater depths of water over the entrance shoals of Arrawarra Creek - allowing greater wave energy to penetrate into the estuary and impinge on the rock-armoured revetment.

The higher ocean level also has the potential for inducing significant wave overtopping on a structure that was built to only accommodate present-day wave and ocean water conditions. Given that crest levels of the proposed revetment along the estuarine foreshore of Arrawarra Beach Caravan Park are likely to be vulnerable to wave overtopping during severe storms, the implications of future sea level has been included by Coastal Engineering Solutions in the design of the proposed rock-armouring works.

The methodology adopted by Coastal Engineering Solutions has been to design the rock armour to accommodate the expected increased wave energy as a consequence of climate change (sea level rise and changed storm climatology); and to construct the revetment to accommodate this possible future loading. To later increase rock armour characteristics on an existing seawall would be extremely difficult and costly - requiring substantial reconstruction.

This is not to suggest that all aspects of new armouring works need to be constructed to accommodate all aspects of future climate change. For example, the anticipated increase in wave overtopping can be included as subsequent upgrading works if/when actual climate change manifests itself. The design approach adopted by Coastal Engineering Solutions has been to structurally accommodate present-day overtopping rates by incorporating a crest scour blanket, but is cognisant of the possibility that future works (such as raising the crest level slightly higher by adding another layer of rocks) may be required in the later years of the seawall's design life. In this way the design and initial construction do not compromise options for dealing with any possible increased overtopping due to climate change at a later date.

In summary, the application of the design techniques of van der Meer (in conjunction with the approach of placing armour to accommodate future climate influences) has resulted in a structure having:

- Primary armour : two layers of 1.0 tonne rocks;
- Filter armour : two layers of 100kg rocks;
- To accommodate overtopping: extending the filter armour layers behind the crest of the revetment to create a scour blanket to mitigate any adverse effects of wave overtopping.

4. MITIGATION OF TOE SCOUR

During the Design Event it is expected that bed material in front of the rock-armoured revetment will scour as a consequence of incident waves and flood flows in the estuary. The extent of scour has been calculated by Coastal Engineering Solutions using standard numerical algorithms for scour of sandy material by waves and currents. The design then selects the founding level of the rock armouring layers so as to be at least one (D_{50}) rock diameter below the predicted scour level. This means that should the Design Event ever occur, there will nevertheless still be a firm foundation for the armoured-slope below any scoured estuary bed.

In retrospect, that arrangement for mitigating scour at the toe of the structure may not be evident in the conceptual arrangement shown in the *Type Cross Sections* shown on Coastal Engineering Solutions' Drawing 15-849NSW-02. The cross sections shown on Drawings 15-849NSW-12 to 15-849NSW-18 more accurately depict the relationships between the toe of the structure and the adjacent bed levels in the estuary.

In acknowledgement of the complexity of the processes associated with such scour (and potential inherent uncertainties in predicting their outcomes), a further precaution has been included as a design detail for the toe of the rock armouring. A row of *Type B Armour* (minimum 3 tonne rocks) is to be placed along the toe of the revetment to form a buttress for the armoured slope above. In the unexpected event of scour being greater than expected at a particular location on the revetment, it will be these large rocks that will first be "undermined". These large rocks then drop into the lower scoured bed, thereby armouring the edge of the scour hole that is immediately in front of the revetment. Whilst this can lead to some settlement or shifting of rocks within the matrix of the primary armour above, the structure will remain intact since the buttress rock is still able to serve its purpose.

This effective "self-armouring" of toe scour by large buttress rocks has been identified by Coastal Engineering Solutions in physical model tests undertaken when designing protection armouring for submarine pipelines on sandy seabeds.

5. MITIGATION OF WAVE OVERTOPPING

Typically the storm tide level in the ocean and the estuary will be either at or above the crest level of the armoured revetment during the 100 year ARI Design Event. Under such a scenario there will be significant green-water overtopping of the revetment. It is for this reason that the overtopping performance of the rock-armoured revetment has been carefully considered by Coastal Engineering Solutions during the structural design of the armouring arrangement.

The design techniques outlined in the "*Wave Overtopping of Sea Defences and Related Structures: Assessment Manual*" (EurOtop, 2007) have been applied by Coastal Engineering Solutions for conditions associated with the 100 year ARI Design Event.

Those investigations indicated that green-water overtopping along the estuarine revetment having a crest level of RL+3.00m AHD or above were at acceptable rates. However where the revetment crest is to be lower than RL+3.00m AHD there was potential for significant overtopping scour.

It is for this reason that a scour blanket consisting of 100kg rocks has been incorporated by Coastal Engineering Solutions into the revetment cross section where its crest level is below RL+3.0m AHD. The intent is that this scour blanket be covered with topsoil and grassed so as to be less visually intrusive. Should significant overtopping occur during a Design Event, then this soil and vegetation would be damaged and probably eroded away, but the overall structural integrity of the revetment and the scour blanket armour would be unaffected.

6. MAINTENANCE REGIME

The NSW Coastal Panel's request for information relating to the proposed implications to future maintenance of the rock-armoured revetment primarily concern the ability of the design to accommodate future climate change effects. The comments offered herein regarding the design philosophy (particularly in the preceding Section 3) offer some insight into how the design has considered and adopted measures to mitigate the adverse effects of future climate change.

Nevertheless the approach applied to the design by Coastal Engineering Solutions incorporate the following aspects to offset significant repairs and maintenance:

- The rock armour has been sized so as to accommodate the expected effects of future sea level rise, as well as changes to the regional wave climate. In other words, the rock armouring is more robust than it needs to be for present-day climate conditions, but will prove to be adequate during a more severe 100 year ARI storm tide and wave event occurring at some point in the future - when the predicted climate change effects may have manifested themselves.
- Nevertheless even during such a severe event, Coastal Engineering Solutions' design is such as to limit damage levels to 5%. In actual fact this may not necessarily require any significant repair works. The term "damage" nominated in such a way in coastal engineering designs accounts for the percentage of individual rocks which move from their initially placed position – which can be to a more stable position within the rock armour matrix. Often during severe storm events, the rock armour slope consolidates – resulting in a tightening of interlocking between individual rocks. So future 5% "damage" can also represent an improvement in structural stability at some locations within the revetment.

7. REFERENCES

BMT WBM, 2011. *Coffs Harbour Coastal Processes and Hazards Definition Study. Volume 1: Final Report.* Prepared for Coffs Harbour City Council. Revision 2, dated 15 February 2011. Document R.N1440.002.02.CoastalHazards_Final.doc.

EurOtop. 2007. *Wave Overtopping of Sea Defences and Related Structures: Assessment Manual.* Developed for EA/Defra, Rijkswaterstaat in the Netherlands and the German Coastal Engineering Research Council (KFKI). August 2007. Also published online URL http://www.overtopping-manual.com/calculation_tool.html.

Goda, Y., 2000. *Random Seas and Design of Maritime Structure.* Published by World Scientific Publishing Co. Pte. Ltd. Advanced Series on Ocean Engineering - Volume 15. ISBN 981-02-3256-X.

Umwelt Environmental Consultants, 2003. *1 in 100 year Flood Study. Lot 1 DP 789002, Lot 1 DP 26125 & Lot 12 DP 835612. Arrawarra Beach Caravan Park, Arrawarra.* Prepared for Astoria Developments Pty Ltd. Dated September 2003. Document 1698/R03/V1.

Van der Meer, J.W., 1988. *Rock slopes and gravel beaches under wave attack.* Published as PhD dissertation; also Delft Hydraulics Communication No. 396.

APPENDIX A INFORMATION REQUEST FROM THE NSW COASTAL PANEL

NSW GOVERNMENT | NSW Coastal Panel

Ms Keiley Hunter
Keiley Hunter Town Planning
PO Box 4481
COFFS HARBOUR NSW 2450

Our reference: DOC16/127342
Contact: Marc Daley, (02) 4927 3103

Dear Ms Hunter

I am writing to you concerning the Development Application lodged by you on behalf of Arrawarra Beach Pty Ltd for construction of a rock armoured revetment wall which forms the estuarine edge of Lots 1 and 2 DP 1209371 – 46 Arrawarra Beach Road, Arrawarra.

I wish to advise that a preliminary assessment of the documentation lodged with the DA, has identified some issues that will require further advice in order to consider the application. In particular, beyond the drawings in Appendix C, documentation that would support the selection of the design criteria advised appears absent along with any engineering appraisal that demonstrates the proposed structure can withstand the range of hydraulic loadings and wave impacts relevant at this location.

As you would appreciate the range of physical coastal and estuarine processes impacting upon this site are quite complex given its location at the confluence of Yarrawarra Creek, Arrawarra Creek and the Pacific Ocean, wrapping around the land margin to be protected. In order that the Coastal Panel can assess the suitability or structural adequacy of the proposed protection structure, it would be helpful for the Panel if you could provide further advice on the following aspects:

- how the relevant design wave and water level conditions advised have been determined for application at the proposed site;

- what design approach (or stability assessment) has been applied in order to propose the configuration of structure (slope, toe level, crest level, rock sizes, etc) to withstand the design coastal processes and hydraulic loadings envisaged;

- whether the scour levels at the toe of the proposed structure indicated are sufficient in this location. With a revetment structure in place to prevent channel or bank migration under flood outflows, there might be the potential for high velocities and associated sand losses from the near vicinity of the structure exceeding those considered relevant for normal beach scour levels on the open coast;

PO Box A290 Sydney South NSW 1232
59-61 Goulburn St Sydney NSW 2000
Tel: (02) 9995 5000 Fax: (02) 9995 5999
TTY (02) 9211 4723
ABN 30 841 387 271
www.environment.nsw.gov.au

- what consideration (if any) has been given to the likelihood of wave overtopping of the structure (given the crest level advised is particularly low in parts). If there is overtopping of the structure, how will this be managed? The crest levels advised might be sufficient to limit overtopping to acceptable levels but, there is no evidence this has been considered from the furnished information; and

- what maintenance regime (if any) is contemplated for such a structure (given what's proposed is a flexible rubble-mound structure) in order that it remain fit for purpose to meet desired level of protection following damage into the future. Further, how will it be adapted or maintained to accommodate projected sea level rise. Whilst sea level rise is acknowledged in the report there is no further information on how the structure has been designed to accommodate (or adapt to) such projections into the future.

Could you please provide the information requested to Marc Daley of the Office of Environment and Heritage. He can be contacted on (02) 4927 3103 or by email marc.daley@environment.nsw.gov.au. Please do not hesitate to call Marc Daley if you wish to discuss any matter concerning the development application further.

Yours sincerely

MARC DALEY
Secretariat
NSW Coastal Panel