WAMBERAL BEACH BASEMENT STRUCTURES: DEVELOPMENT OF A PROVISIONAL MODEL FOR ASSESSMENT OF ADDITIONAL COASTAL HAZARDS

Gary Blumberg Principal, Gary Blumberg and Associates *(GBA)*
P O Box 572, CAMMERAY NSW 2062, ph 9660 7663,
gba@tpg.com.au

Abstract

Gosford City Council *(GCC)* has developed a proposal for a terminal revetment at Wamberal Beach. In accordance with DCP 125, buildings at Wamberal are permitted seaward of the 2045 Erosion Hazard Line *(EHL)* but landward of the proposed revetment subject to various conditions, one of which is that the buildings not give rise to any increased hazard. GCC believes that this requirement is achieved with "a suspended structure assuming linear erosion progression of the sand dune".

Current proposals for shoreline residences at Wamberal include basement structures *(eg carparks)* that extend to the seaward side of the design EHL. Council is concerned that these structures may behave differently to suspended structures, potentially giving rise to increased coastal hazard at adjoining properties.

Gary Blumberg and Associates *(GBA),* Coastal, Estuary and River Engineers, have assisted GCC and residential proponents make an assessment of the additional coastal hazards attributed to basements. Various coastal assessment methodologies have been considered and applied, leading to a current approach. This paper summarises the development of ideas and procedures for assessment of the additional coastal hazards, and touches on related planning issues. The author invites critical comment and review.

Background

Wamberal Beach has a recent history of property and beach damage as a result of severe storms. Extensive beach erosion occurred in May 1974 and many houses were threatened. Four years later in June 1978, beach and dune erosion attributed to an intense rip cell undermined and destroyed two houses at Wamberal (**Plate 1**). Today the erosion escarpment left by these storms crosses some 90% of the seafront properties.

Coastline Management Plan

The Gosford City Open Coast Beaches Coastal Management Study and Coastal Management Plan *(CMP)* was adopted by GCC 1985 *(GCC, 1985).* The planning timeframe adopted in the CMP is 50 years, although potential implications beyond 50 years are also considered. Year 2045 is therefore adopted as the planning end date for which Erosion Hazard Lines *(EHLs)* are defined, and coastal hazard management options developed.

Plate 1 – Beachfront House Collapse – Wamberal 1978
(Photo courtesy: DNR)

The 2045 EHL is currently applied by GCC for assessment of coastal residential development. As an indication of the exposure to erosion of the shorefront properties at Wamberal, the 2045 EHL passes underneath, or even landward of, all but one of the existing 64 dwellings (**Figure 1**).

The adopted coastal hazard management measures for Wamberal include planning controls, sand nourishment and terminal protection *(or "revetment" as referred to in the DCP)*.

Development Control Plan

All land within the City of Gosford which is affected by the coastal processes of beach and/or cliff erosion, is covered by Development Control Plan *(DCP)* No 125 – Coastal Frontage. The DCP came into effect on 27 January 2000.

The objectives of DCP 125 are stated as follows:

(a) *minimise the risk to life and property associated with development and building on land which has a coastal beach and/or cliff frontage; and*

(b) *provide guidelines for the development of land within the coastal frontage area.*

All shorefront properties at Wamberal fall within the scope of the DCP, and Council must take its provisions into consideration in assessing any development proposals for these properties.

Clause 8.1.3 of the DCP stipulates that:

> *all structures constructed in the coastal frontage zone shall:*
>
> *(a) be compatible with the identified coastal hazards;*
> *(b) be setback as far landward as practicable;*
> *(c) not give rise to any increased hazard;*
> *(d) be designed not to be damaged by the designated hazard;*
> *(e) give consideration to the effects of larger events than the designated hazard;*
> *(f) be constructed in a manner or to a level which overcomes any problem from coastal hazards of runup and inundation.*

In line with this clause, the DCP does not permit buildings to be constructed on land identified as subject to "designated coastal hazards", where such land includes areas seaward of the 2045 EHL. Thus the full extent of the Wamberal shorefront is captured by this restriction.

However, the DCP incorporates development exemptions for Wamberal Beach, where Clause 8.1.4 states:

> *On Wamberal Beach building will be permitted seaward of the 2045 erosion line but landward of the proposed revetment subject to the following:*
>
> *(a) adequate foundation treatment designed to withstand the stormwave erosion;*
> *(b) that the building shall be set back from the alignment of the proposed revetment as required by Council;*
> *(c) an indemnity being provided.*

The Issue of Basement Structures

Thus according to the DCP, buildings at Wamberal are permitted seaward of the 2045 EHL but landward of the proposed revetment subject to various conditions, one of which is that the structure not give rise to "any increased hazard". GCC takes the position that in this zone no increased hazard is achieved with a suspended structure *(suitably elevated from the effects of wave runup)*, but for basement structures Council is concerned that these would behave differently, potentially giving rise to increased hazard at adjoining properties.

Gary Blumberg and Associates *(GBA)* was retained by GCC to examine this matter in late 2004. A "*Provisional Model*" to characterise the increased hazard was developed by GBA *(January 2005)*. Later, as part of a private property assessment at Wamberal, the methodology was subsequently refined *(September 2005)*. Other coastal engineers have made independent assessments and provided reviews to support separate development applications including basements *(Patterson Britton and Partners, and Water Research Laboratory)*. Within the last few months, at the request of GCC, the Department of Natural Resources has itself undertaken a review, incorporated refinements, and developed what it has called an "Alternate Empirical Model" *(Watson, 2006)*. The author gratefully acknowledges the various inputs by all these groups in developing and presenting this paper.

Design Coastal Processes for Wamberal Beach

WRL (1998) presents a detailed assessment of the various coastal processes operating at Wamberal Beach, prepared to enable the detailed design of the Terminal Protective Structure.

A summary of the design coastal processes relevant to this investigation, interpreted as applicable to a 50 year ARI event, is presented below in **Table 1**.

The Terminal Protection Structure *(TPS)* would be designed to withstand the coastal processes in **Table 1**. It follows that any buildings located in the lee of the TPS would be protected from these processes. However, the TPS is yet to be constructed. In the interim, any development proposals concerning these buildings should fully disregard the TPS and incorporate designs which account for the coastal processes in **Table 1**.

Table 1 - Design Coastal Processes for Wamberal Beach (1)

Still Water Level *(SWL)* including wave setup (2)	RL 2.7 m AHD
Wave height	
Breaking wave height H_b	3.4 m
Significant inshore wave height H_s	2.4 m
Wave period	
Mean wave period	10.6 s
Peak wave period	14.1 s
Back-beach scour level	
No structure	RL 0.0 to -1.0 m AHD
Toe of structure	RL -1.0 to -2.0 m AHD
Inshore wave length	62 m
Angle of repose of dune sand	33 degrees

Notes (1) Precincts III and IV, CMP, assuming 6 hr, 50 yr ARI storm
(2) "Average" SWL including wave setup equal to $0.1H_{so}$
Source WRL (1998), GCC (1995)

Coastal Hazards affecting Basement Structures

The NSW Coastline Management Manual outlines the range of hazards to be considered in a coastal hazard assessment *(NSW Government,1990)*. These comprise:

- beach erosion
- shoreline recession
- coastal entrance instability

- sand drift
- coastal inundation
- slope and cliff instability
- stormwater erosion
- climate change

Beach erosion, shoreline recession and coastal entrance instability can markedly alter the shape of the coastline. If not properly catered for, these hazards can imperil coastal developments and reduce amenity. Sand drift may contribute to a permanent loss of sand from the beach. It is at best a nuisance, although it too can overwhelm nearby developments. Low lying areas of the coast may be threatened by coastal inundation caused by storm surges and the action of large waves. Slope and cliff stability problems are a threat to the structural integrity of buildings constructed on coastal bluffs and steep sand dunes. Uncontrolled disposal of stormwater across a beach berm is unsightly and can exacerbate erosion. Climate change attributed to the Greenhouse Effect can exacerbate all of the above hazards.

The relevant coastal hazards in regard to basement impacts are beach erosion, shoreline recession, coastal inundation, slope instability and climate change. Coastal entrance instability is important for those properties adjoining the entrances to Wamberal and Terrigal Lagoon, however, apart from implications for increased beach erosion which would be accounted for in the EHLs, it is not specifically relevant to the matter of basement structures. Likewise sand drift and stormwater erosion may give rise to real, but non-related, coastal hazards. Cliff instability is of no consequence along Wamberal Beach.

For a basement impact to occur, it must be exposed to wave action, that is, it must:

(i) protrude seaward of the Line of Wave Impact *(LWI)*; and
(ii) be located below wave runup level.

[Note that at Wamberal Beach, given the range of dune heights and the manner in which the EHLs are defined, the 2045 LWI lies between approximately 3 and 5 m seaward of the 2045 EHL].

Thus severe beach erosion and shoreline recession at an affected basement could lead to elevated turbulence at the interface between the basement shell and the ground *(assumed to be dune sand)*, leading to additional scour or erosion. This additional erosion may be accounted for in the design of the dwelling at the site in question, but the extension of this additional erosion to neighbouring properties cannot be feasibly managed and may be unacceptable.

Coastal inundation is the flooding of coastal lands by ocean waters. Elevated coastal water levels during storms and wave runup and overtopping, both contribute to coastal inundation. Wave runup limits corresponding to 2% exceedence levels *(50 year ARI)* are estimated for Wamberal Beach in PWD (1984). These range between RL 6.4 and 8.2 m AHD, generally increasing from S to N. The runup levels may be compared with the dune crest level which also generally increases from S to N; from RL 6 in the vicinity of Terrigal Lagoon, to over RL 9 at the northern end of the beach *(WRL, 1998)*.

In the main the design wave runup levels do not exceed the dune crest level, and coastal inundation hazard is mostly contained at Wamberal Beach. It is assumed that any affected basements are structurally supported and contained, comprising suitable materials to withstand direct exposure to wave action. The deflection of runup by the basement would be unlikely to cause increased inundation hazard at neighbouring properties, but referred erosion may be a consequence.

Dunal slope instability is a second-order hazard, conceptually addressed in the same manner as currently applied by DNR for beach erosion *(Nielsen et al, 1992).* Climate change impacts are all embracing, affecting water levels, waves and erosion/recession. Once the baseline procedure is developed for assessing referred erosion impacts, then the implications of slope instability and any additional consequences of climate change may be considered.

In summary, the additional coastal hazards attributed to basement structures distil to the additional scour/erosion impacts, with second-order consequences for slope instability and elements of climate change.

Development of Analytical Approach for Basement Impacts on Referred Erosion Hazard

Provisional Model (GBA, 2006a)

A literature review undertaken by GBA as part of its original work for GCC encountered two empirically based techniques which provide some guidance as to the scale of additional scour which may be attributed to basements. These are included in:

(i) Rance (1980);
(ii) Komar and McDougall (1988)

Rance (1980) conducted laboratory experiments of local scour at different shaped vertical "piles" with diameters greater than 1/10th of the incident wave length (*this would require that the basement width exceeds approximately 6 m which seems reasonable, refer* **Table 1***).* The piles were exposed to coincident waves and currents. Rance provided estimates of maximum scour depths and scour extents as a function of equivalent pile diameter *(D_e)* for different orientations to the principal flow direction. A summary of the results obtained is shown in **Figure 2**. An interpretation of these results for this investigation would suggest a maximum horizontal *(alongshore)* extent of additional scour equal to say 85% of basement width.

Komar and McDougal (1988) report on excess back-beach erosion due to the presence of a coastal structure. Reviewing available laboratory and field data, they characterised the length of excess flanking erosion *(alongshore erosion s, extending from the end of the structure)* as a function of the structure length *(L_s,)*, reflecting the alongshore impact of the structure. A summary of the results obtained by Komar and McDougal is shown in **Figure 3**. These results suggest a maximum alongshore extent of additional scour equal to say 70% of basement width, a comparable magnitude to that established by Rance (1980). Komar and McDougal also provide guidance on the shore-normal extent of additional erosion *(r)* compared to that on the open coast away from the structure *(e).*

The physical reason for the direct dependence of the alongshore excess erosion on structure length *(basement width, B_B)* is uncertain, although an explanation attributed to Dean (1976) and McDougal et al (1987) is offered by Komar and McDougal. The natural response during a storm is the removal of sand from the beach face to form an offshore bar. The bar causes the waves to break further offshore, and the wider surf zone is able to dissipate more wave energy. With the effective exclusion of a section of the shoreline *(due to the basement protrusion)* that portion of the beach *(or dune)* can no longer contribute to bar development, and as a result the sand is obtained *(eroded)* from adjacent "unprotected" properties.

Komar and McDougal note that a number of other parameters in addition to structure length were examined for their effects on excess erosion, but no clear dependencies were observed. These included wave steepness, wave breaker type *(spilling, plunging and surging)* and water depth.

The author accepts that the similarities between a basement structure and a vertical pile *(ie Rance)* or coastal structure or revetment *(ie Komar and McDougal)* are somewhat tenuous, however in the absence of further more directly relevant data, the results do provide a level of guidance.

It developing the original *Provisional Model*, the author recognised that while the analysis assumed that the basement protruded into the Wave Impact Zone, no consideration was given as to the extent of the protrusion.

There could be situations where wide basement structures protrude only a small distance into the Wave Impact Zone. Alternatively, relatively narrow basement structures may protrude a relatively large distance into the Wave Impact Zone. When developing the *Provisional Model* it was the author's view that it would be overly conservative to have the Rance / Komar and McDougal estimates of alongshore extent of additional scour apply in respect of the former. To the contrary, it seemed plausible that for the latter case, with a basement of relatively large seaward protrusion *(ie groyne effect)*, additional scour could develop that extended beyond the 70% to 85% of the basement width.

With the empirical methodologies seemingly failing at the two boundary conditions, the author turned to a volumetric approach to characterise the referred erosion. In NSW, design erosion is commonly determined based on historical records of the volume of sand removal from the subaerial beach. Since the volume of sand denied from feeding storm erosion as a consequence of the basement could be readily determined, a proposal was developed which took the excluded volume of sand, applied to it a reduction factor in recognition that there would now be turbulent wave-current energy losses at the basement shell, and then sourced the sand shortfall from out to the sides and from below the basement protrusion.

The tenets of the *Provisional Model* may be summarised as follows:

(i) In principal, it seemed reasonable that a large proportion of the sand volume excluded by the basement shell was eroded from areas immediately adjacent.

(ii) In the absence of further analysis or modelling, it was suggested that say 80% of the full volume of the protrusion be sourced from around the basement shell *(the notional markdown from 100% making allowance for additional energy losses due to turbulence)*, sourced equally from both sides of the basement walls, and also from beneath the basement floor.

(iii) Having regard to findings on scour depth reported by Rance (1980) and Komar and McDougal (1988), the following conservative assumptions were then proposed:

- additional local scour into the face of the erosion escarpment is a maximum at the basement shell itself, reducing linearly with distance away from the basement;

- additional local scour adjacent to the basement walls and floor is equal to say 20% of the basement width, measured along the alignment of the face of the basement walls and floor respectively;

- directly below the basement shell, additional local scour is taken to terminate at Still Water Level *(SWL);* while below the basement shell but out to the sides, additional local scour is taken to terminate above SWL.

For further detail on the relevant formulae and application of the *Provisional Model*, please contact the author.

This *Provisional Model* was developed generically for Wamberal Beach. It was impressed upon Council that the model was based on "generic concepts of scour and beach erosion", and that its use was as "a baseline assessment measure subject to refinement and modification by more detailed coastal engineering assessment, in particular that including physical modelling."

Refined Provisional Model (GBA, 2006b)

It soon became clear that the *Provisional Model* was delivering an assessment that was overly conservative. Additional alongshore erosion impacts were being calculated for particular sites which extended numerous property widths, and this was queried by others. The main elements of the critique went to the choice of the 80% factor and the notion that the local additional scour below the basement terminated at the SWL*,* rather than extending to the depth of back-beach scour. Furthermore, it was suggested that Komar and McDougal (1988) offered more promise to the assessment methodology than the author may have initially conferred.

In September 2005, the author was involved in making an assessment of basement impacts for a particular development proposal at Wamberal Beach. The basis of the *Provisional Model* was reviewed and it was felt that Council give consideration to revising and further developing the *Provisional Model* methodology, as follows:

(i) continue to treat the basement as a "large" coastal structure subject to combined waves and currents *(ie plan dimension greater than 10% of inshore wavelength)*, but focus on the application of the findings of Rance (1980) and Komar and McDougall (1988) rather than the "sand volume balance" concept. The shortcoming in regard to "seaward extent of basement protrusion" perceived earlier by the author was felt to be suitably addressed by its incorporation in the equivalent diameter parameter *(D_e)* as defined by Rance (1980) – **Figure 2**;

(ii) D_e to be calculated as the equivalent diameter for the basement plan area protrusion, nominally given by the product of B_B and P_B, ie $D_e = (4B_BP_B/\pi)^{1/2}$;

(iii) the alongshore extent of additional scour protruding from the basement wall *(X_{AS})* to now accord with Rance (1980) as equal to 1.00 x D_e *(rather than 0.75 D_e given that storm waves [and currents] could be expected to impinge on the basement walls with some obliquity, refer* **Figure 2***).*

It was recognised that for basement structures suspended on piles this approach may be conservative in that, unlike Rance's coastal structures, they would not protrude below the depth of scour. For basement structures which may be contained within contiguous walls which penetrate to beneath the depth of scour, the findings of Rance were considered more directly applicable;

(iv) the additional scour adjacent to the basement walls and floor to now have regard to the "scour depth" S_m as defined by Rance (1980). Here it was suggested that this parameter be amended from $0.2B_B$ as proposed in the *Provisional Model*, to the maximum of $0.2B_B$ and S_m. This approach seemed reasonable in that:

- $0.2B_B$ was a maximum established by Komar and McDougal (1988) for coastal structures *(mainly seawalls –* **Figure 3***)*; and

- S_m was a measure of vertical scour below a horizontal sandy bed (**Figure 2**) – unlike vertical scour, lateral scour into the steep erosion escarpment would be assisted by gravity hence S_m could be interpreted as a lower bound value;

(v) X_{AS} to be measured radially from the plan intercept at ground level of the Line of Wave Impact *(LWI)* and the basement wall, out to the LWI. The plan shape *(at ground level)* of the zone of additional scour to be determined having regard to the local alignment of the LWI;

(vi) examine any incursion of the zone of additional scour to the foundations of neighbouring dwellings, and consider implications for stability impacts.

The procedure for applying the *Refined Provisional Model* was to initially establish the zone of additional scour for the Immediate LWI. If there was no incursion of this zone to the foundations of neighbouring dwellings, then to progressively check the 2015 and 2045 EHLs, and any intermediate lines as appropriate *(Note that Immediate, 2015 and 2045 EHLs are defined in the CMP)*. If there was no incursion of the zone of additional scour for all LWI's, then the basement could be taken to have no direct effect on the foundations. For the particular site for which the *Refined Provisional Model* was developed, it was suggested that a minor incursion *(< 5%)* to the footprint of the neighbouring dwelling be permitted, subject to appraisal by a Geotechnical Engineer.

It was GBA's contention that allowance should be made for slope adjustment and reduced foundation capacity associated with any additional scour, conforming with the principles adopted in Nielsen et al (1992). This too was felt to reside within the province of the Geotechnical Engineer.

An example of the application of the *Refined Provisional Model* is shown in **Figure 4**. For further detail on the relevant formulae and application of the *Refined Provisional Model*, please contact the author.

As with the *Provisional Model*, GBA impressed upon its client that the *Refined Provisional Model* should be treated as a "work in progress". Like its predecessor, it too was based on the same generic concepts, and should be subject to refinement and modification by more detailed coastal engineering assessment, in particular that including physical modelling.

Alternate Empirical Approach (Watson, 2006)

The *Refined Provisional Model* had the effect of substantially reducing the alongshore extent of additional erosion due to basements. As part of its review of the *Refined Provisional Model*, GCC referred the GBA investigation to the NSW Department of Natural Resources *(DNR)* for its consideration.

DNR has only in the last two months brought a separate review to this whole matter. They have assimilated the preceding work by GBA, Patterson Britton and Partners and WRL, and, in consultation with these parties, have developed their *Alternate Empirical Approach*.

DNR has prepared a simple procedure which should be suitable for application by technical personnel who do not necessarily have a background in coastal engineering. The procedure assumes that the coastal impacts at the seaward face of the basement closely ally to that of a seawall, and therefore defers exclusively to the work of Komar and McDougal (1988). DNR felt that Rance (1980) would be less applicable for an elevated suspended structure within the wave impact zone at the shoreline.

DNR's approach acknowledges directly that the impacts due to a basement will be less than that due to a seawall in that the basement is elevated in the dune profile, unlike a seawall which must protect to the depth of scour *(accepted as nominally RL -1.0 m AHD along the NSW coast)*. DNR accounts for this by reducing the extent of additional erosion in proportion to the relative occupation in the dune by the basement protrusion *(which is relatively elevated)*, compared to that of a seawall taken to the depth of scour.

DNR sets out eight assumptions on which the Alternative Empirical Approach is based:

- the basement or dwelling structure is elevated within a dunal structure composed of unconsolidated sand;
- the basement or dwelling structure is situated within the Zone of Wave Impact;
- negligible additional erosion impacts would be expected where the soffit level of the structure is elevated above 6m AHD;

- the elevated basement "shell" or dwelling is an enclosed structure of generally rectangular configuration designed to adequately withstand oceanic processes;
- the basement or dwelling structure will be sufficiently exposed on the active profile to realise the full extent of additional erosion impacts;
- the planform area above the basement structure will not contribute material to feed the storm demand;
- the basement or dwelling structure will not act like a groyne or similar shore-normal structure that inhibits alongshore sediment transport processes; and
- the depth to scour of the surrounding dunal system during a design event will be nominally -1m AHD.

The methodology used in the Alternative Empirical Approach is described in **Appendix A**.

As for the preceding model procedures, DNR impresses upon the user that unlike seawall structures, the impacts from elevated basement shell or dwelling structures have not been measured or model tested. DNR states that whilst the Alternative Empirical Approach provides an improved basis for the estimation of increased erosional impacts, it should be treated as an indicative guide only, and that more direct refinement would require the application of large scale physical model testing techniques.

Concluding Remarks

Like many aspects of shoreline sediment transport, the matter of additional erosion due to basements is enormously complex. Attempting to characterise this analytically would in the author's view would not be feasible, and an empirical approach guided by observation, experiment and experience must be used.

Whilst progress has been made in the development of a readily applicable technique for assessing the impact of basement structures on lateral erosion, there remains a degree of uncertainty as to how the results should be interpreted.

The question arises as to whether any incursion of additional erosion into a neighbouring property is acceptable. Furthermore, at Wamberal Beach, like any beach where a basement impact assessment may be made, the neighbouring property is likely to be substantially impacted itself before any referred effects from the basement are realised. Indeed, the neighbouring structure may itself have already failed. The progression of the erosion escarpment and location of the neighbouring dwelling on the site may therefore also be relevant considerations.

Acknowledgements

The author gratefully acknowledges inputs and discussions from various engineers in developing this work, in particular Mark Stables *(Gosford City Council)*, Phil Watson *(DNR)*, and Peter Horton *(Patterson Britton and Partners)*.

The author also acknowledges the support of its clients Gosford City Council and Slater Architects, for whom this work has been developed and applied.

References

Dean RG (1976)
Beach Erosion: Causes, Processes and Remedial Measures
CRC Critical Reviews in Environmental Control, 6 (3), 259-296

Gary Blumberg and Associates (2005a)
Wamberal Coastal Engineering Advice
Issue of Basement Structures and Potential for Additional Coastal Hazards
GBA J04-24/lr526 for GCC, 10 January 2005

Gary Blumberg and Associates (2005b)
25C Ocean View Drive, Wamberal
Coastal Engineering Assessment for Proposed Basement Structure
GBA J05-19/lr567 for Slater Architects, 6 September 2005

Gosford City Council (2000)
Development Control Plan 125 – Coastal Frontage
Adopted 18 January 2000

Gosford City Council (1995)
Gosford City Open Coast Beaches Coastline Management Study and Plan
WBM Oceanics and Planning Workshop, August 1995

Komar PD and McDougal WG (1988)
Coastal Erosion and Engineering Structures: The Oregon Experience
Journal of Coastal Research, Special Issue No 4, Coastal Engineering Research Foundation, Autumn 1988

McDougal WG, Sturtevant MA and Komar PD (1987)
Laboratory and Field Investigations of the Impact of Shoreline Stabilisation Structures on Adjacent Properties
Coastal Sediments '87, ASCE, 961-973

Nielsen AF, Lord DB and Poulos HG (1992)
Dune Stability Considerations for Building Foundations
Aust Civ Eng Trans, IEAust, Vol CE 34, 2

NSW Government (1990)
Coastline Management Manual
ISBN 0730575063, September 1990

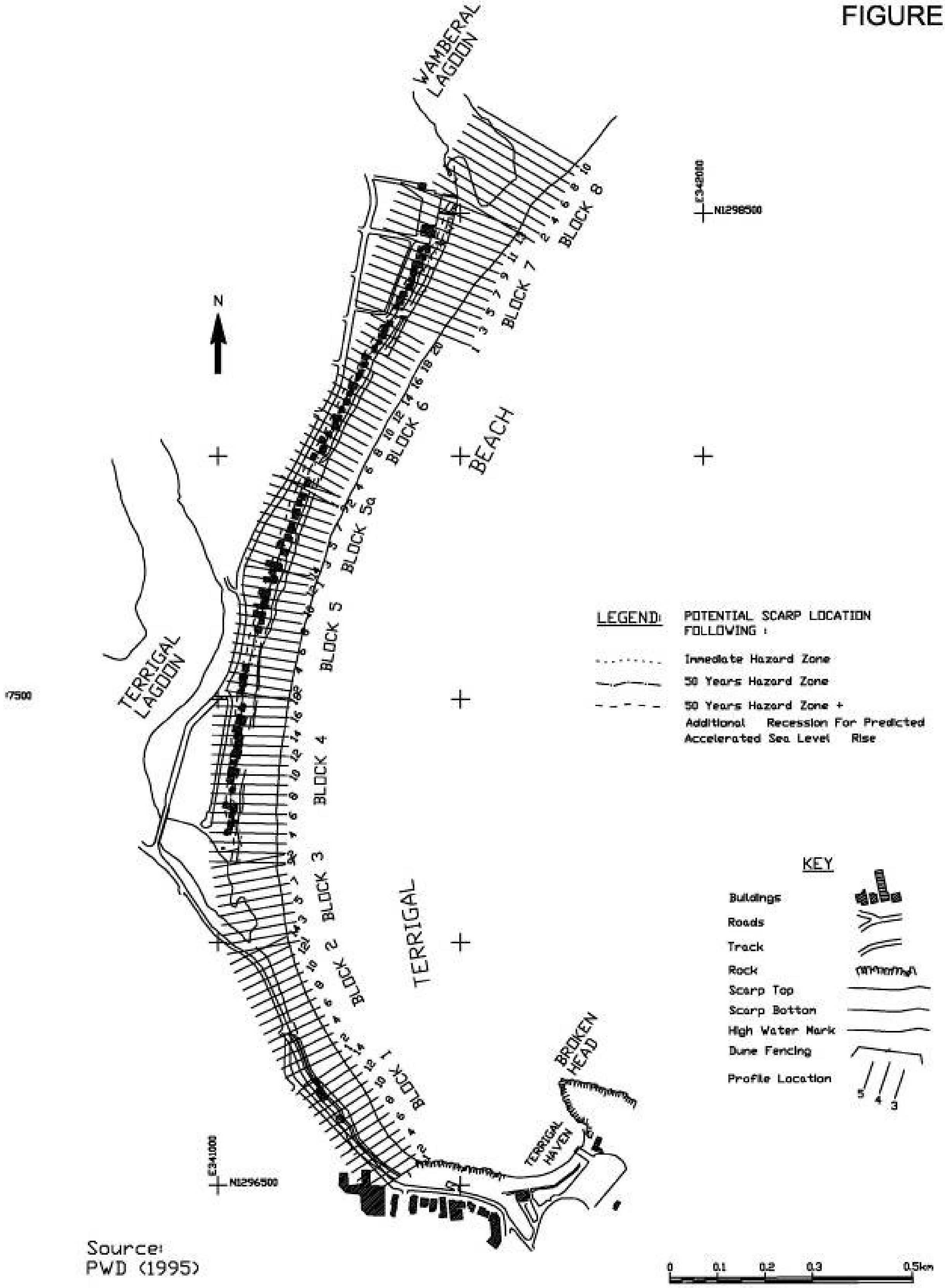
PWD (1984)
Gosford Coastal Process Investigation
NSW Public Works Department, Coast and Flood Branch
Draft for Public Exhibition, September 1984

Rance PJ (1980)
The Potential for Scour around Large Objects
Scour Prevention Techniques around Offshore Structures
London Seminar Society for Underwater Technology, pp 41-53

WRL (1998)
Design Study for Wamberal Beach, Terminal Protective Structure
Final Design Report
WRL Technical report 97/22, October 1998

Watson P (2006)
Review of Models to Assess the Extent of Impacts from Coastal Processes on Basement Structures (including Attachment A: Alternate Empirical Approach)
DNR Coastal and Floodplain Management Branch letter to GCC, 11 October 2006

FIGURE 1

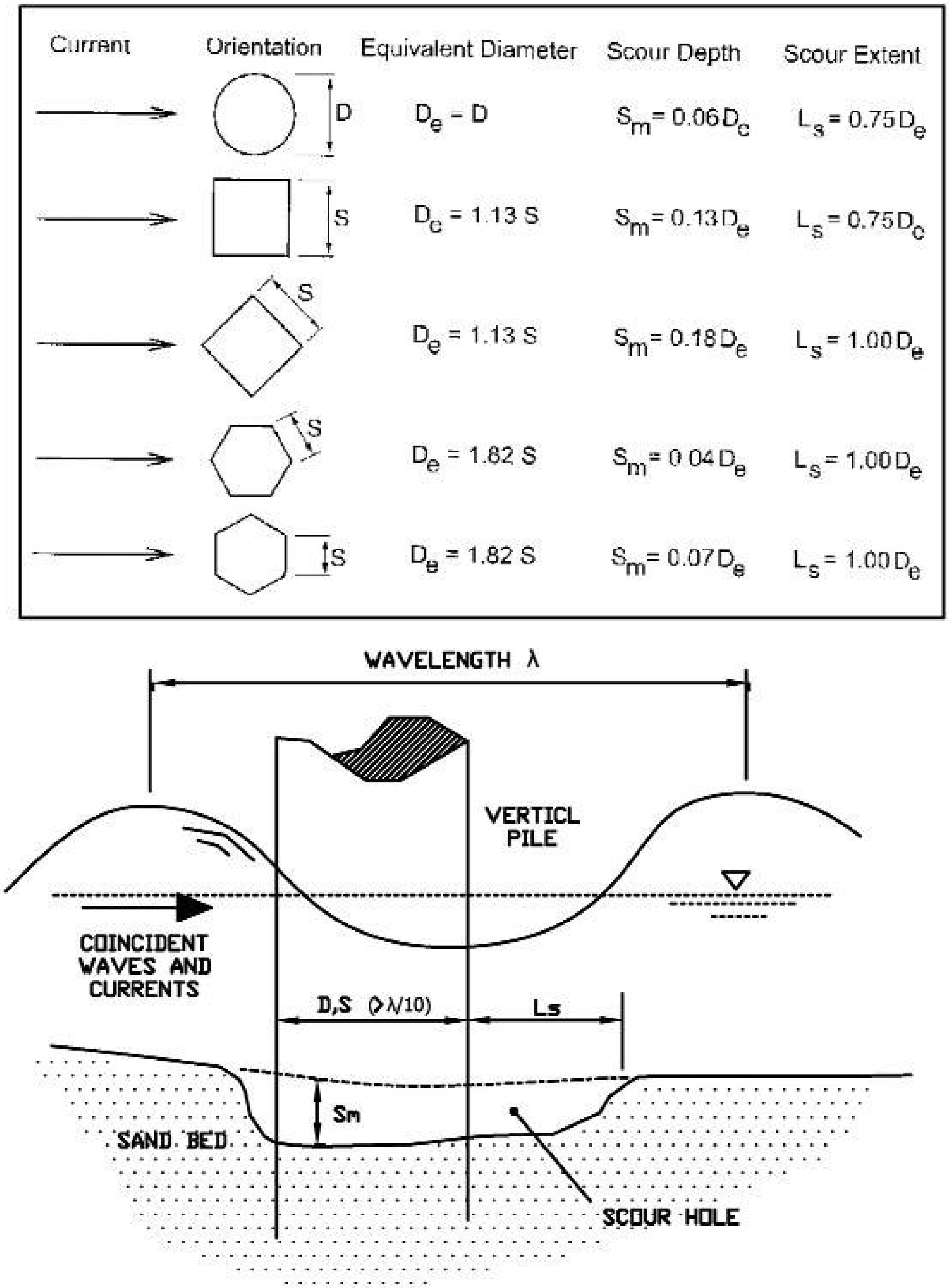


Source:
PWD (1995)

Gary Blumberg & Associates
15th NSW Coastal Conference
Plot date: 25/10/06

EROSION HARARD LINES

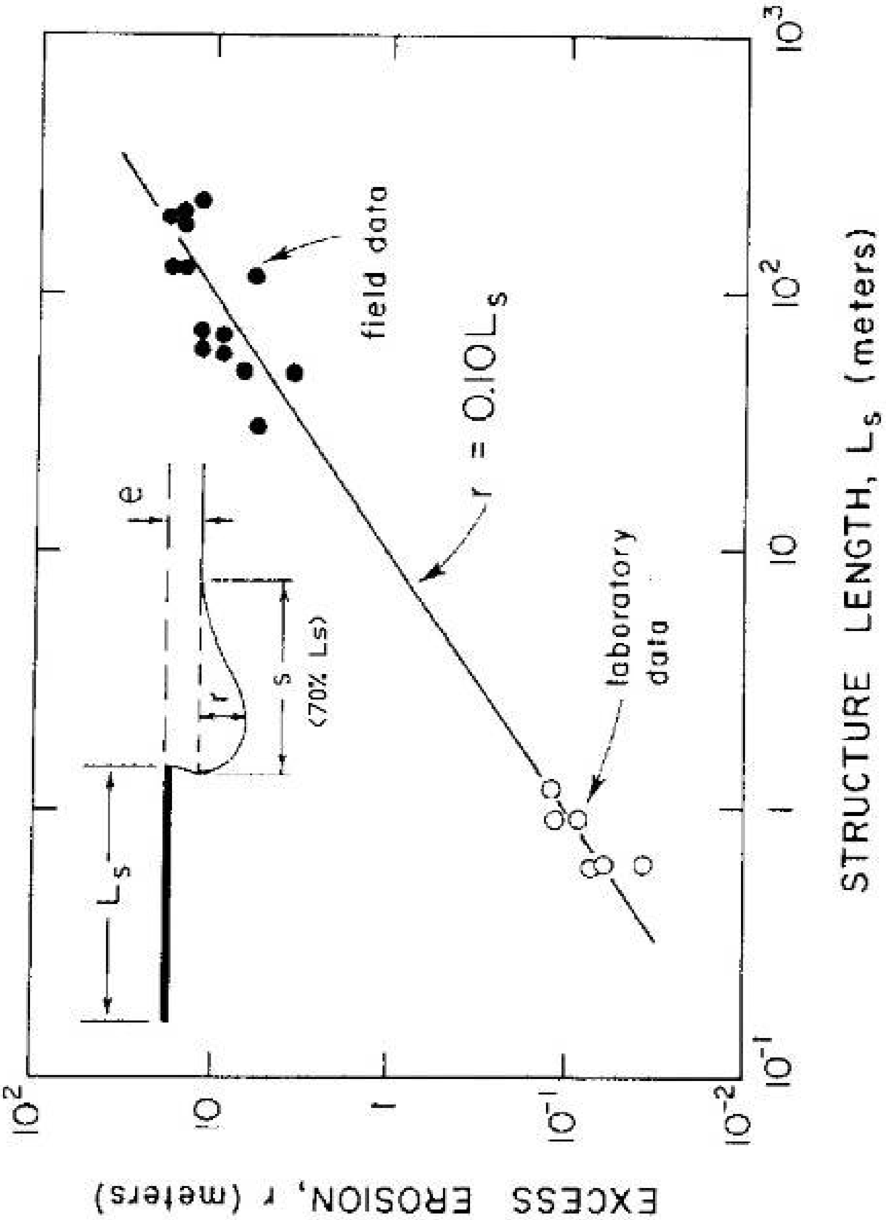
FIGURE 2



ESTIMATED MAXIMUM SCOUR AT SHORE STRUCTURES AFTER RANCE (1980)

Gary Blumberg & Associates
15th NSW Coastal Conference
Plot date: 25/10/06

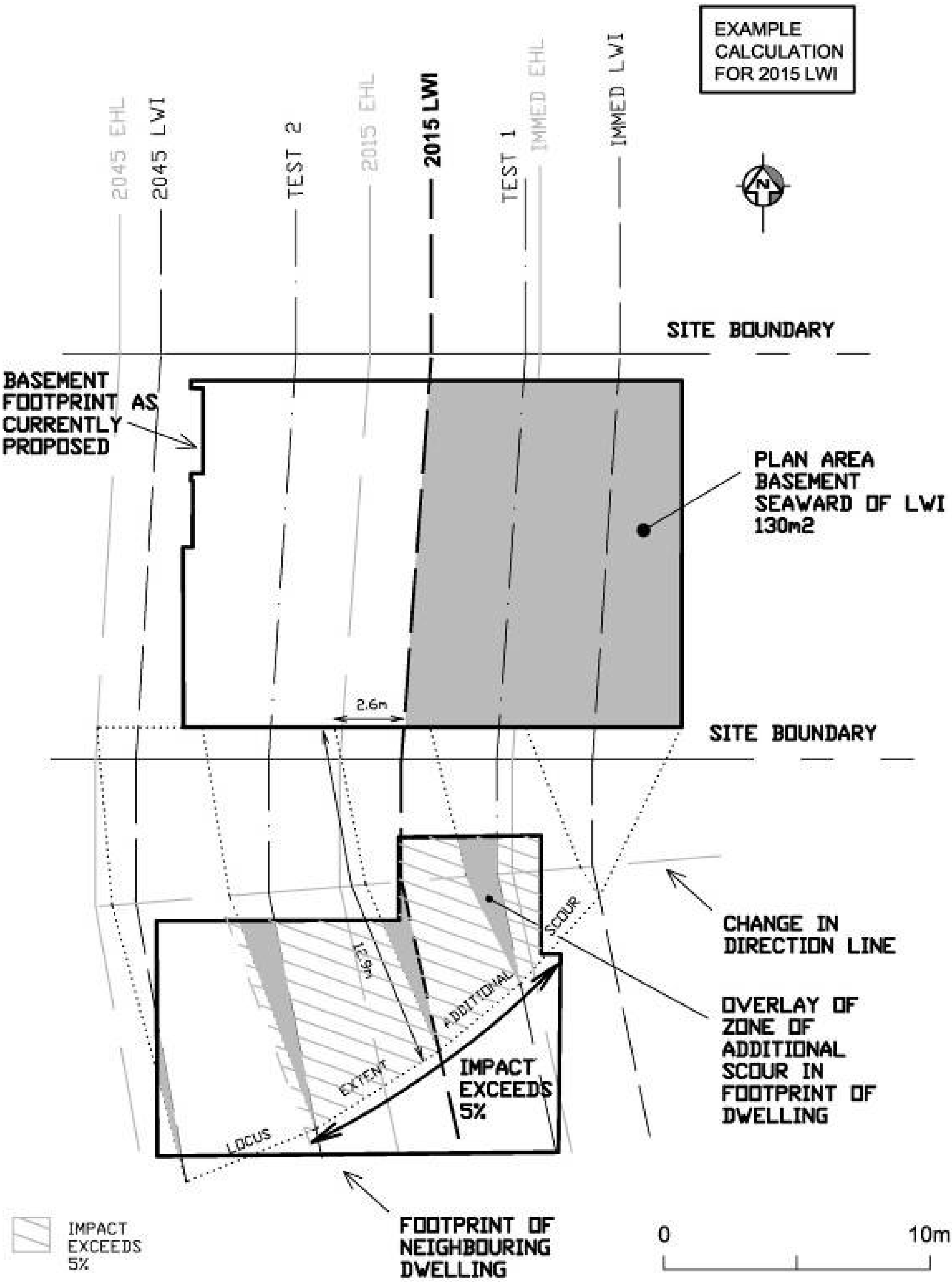
FIGURE 3



ESTIMATED BACK-BEACH EROSION DUE TO COASTAL STRUCTURES AFTER KOMAR AND McDOUGAL (1988)

Gary Blumberg & Associates
15th NSW Coastal Conference
Plot date: 25/10/06

FIGURE 4



EXAMPLE APPLICATION
OF REFINED
PROVISIONAL MODEL

Gary Blumberg & Associates
15th NSW Coastal Conference
Plot date: 26/10/06

APPENDIX A – *ALTERNATE EMPIRICAL APPROACH* AFTER WATSON (2006)

Alternate Empirical Approach (Watson, 2006)

This simple empirical approach has been developed to assist Gosford City Council to estimate the scale of increased erosion hazard from oceanic processes acting on basement "shell" and dwelling structures within the active dunal system along Wamberal Beach. The *Alternate Empirical Approach* advances work by Gary Blumberg & Associates (*Refined Provisional Model)* detailed in the coastal assessment report accompanying a DA at 25C Ocean View Drive, Wamberal.

The *Alternate Empirical Approach* proposed assumes that the coastal process impacts of the seaward face of the basement or dwelling structure will be closely allied to that of a seawall (based on the work of *Komar and McDougal (1988)). Komar and McDougal (1988)* determined that the maximum extent of additional alongshore and lateral erosion attributable to a seawall structure would be of the order of 70% and 10%, respectively, of the length of the seaward face of the structure.

Without modification, the direct adaptation of the increased erosion model for "seawalls" will overestimate the increased erosion attributable to a basement "shell" structure elevated within the active dunal system. The overestimation of the impacts is due to the fact that the more elevated a structure in the active dune, the less interaction with wave processes and subsequently reduced capacity to impede sediment transport processes.

In order to adapt the findings of *Komar and McDougal (1988)* to consider the extent of additional hazard attributable to elevated basement or dwelling structures, a reduction factor has been applied to accommodate that portion of the dunal system below the basement which is available to feed storm demand during a design erosion event.

It should be clearly understood that the *Alternate Empirical Approach* has been adapted from empirical approaches describing the impacts from quite different structures (seawalls). The adaptation of this approach inherently makes the predictions advised for elevated structures within dunal systems, less directly relevant.

Unlike seawall structures, the impacts from elevated basement "shell" or dwelling structures have not been measured or model tested. Whilst the *Alternate Empirical Approach* provides an improved basis for the estimation of increased erosional impacts, it should be treated as an indicative guide only. This approach could be more directly refined through the application of large scale physical model testing techniques.

The *Alternate Empirical Approach* is based on the assumption that:

- the basement or dwelling structure is elevated within a dunal structure composed of unconsolidated sand;
- the basement or dwelling structure is situated within the zone of wave impact;
- negligible additional erosion impacts would be expected where the soffit level of the structure is elevated above 6m AHD;
- the elevated basement "shell" or dwelling is an enclosed structure of generally rectangular configuration designed to adequately withstand oceanic processes;
- the basement or dwelling structure will be sufficiently exposed on the active profile to realise the full extent of additional erosion impacts;
- the planform area above the basement structure will not contribute material to feed the storm demand;
- the basement or dwelling structure will not act like a groyne or similar shore normal structure that inhibits alongshore sediment transport processes; and
- the depth to scour of the surrounding dunal system during a design event will be nominally -1m AHD.

Additional Alongshore Erosion (AAE) can be approximated from Figure 1 as follows:

AAE (metres) = **0.7** x $\mathbf{L_s}$ x **[1 – N]**

Where: $\mathbf{L_s}$ is the length of the seaward face of the basement shell (metres);

[1 – N] is a reduction factor based on the ratio (**N**) of the available portion of the active profile below the basement structure;

N is a volumetric ratio defined as $\mathbf{V_{Partial}/V_{Total}}$;

$\mathbf{V_{Partial}}$ is defined as the volume contained between the soffit level of the basement and -1m AHD over the plan area of the basement (less the volume of the pile or other foundation support system) (Refer Figure 2); and

$\mathbf{V_{Total}}$ is defined as the total volume contained above -1m AHD projected through the plan area of the basement to the equivalent surface of the dunal system (Refer Figure 3).

Additional Lateral Erosion (ALE) can be approximated from Figure 1 as follows:

ALE (metres) = **0.1** x $\mathbf{L_s}$ x **[1 – N]**

Where: $\mathbf{L_s}$ and **N** are defined as above.

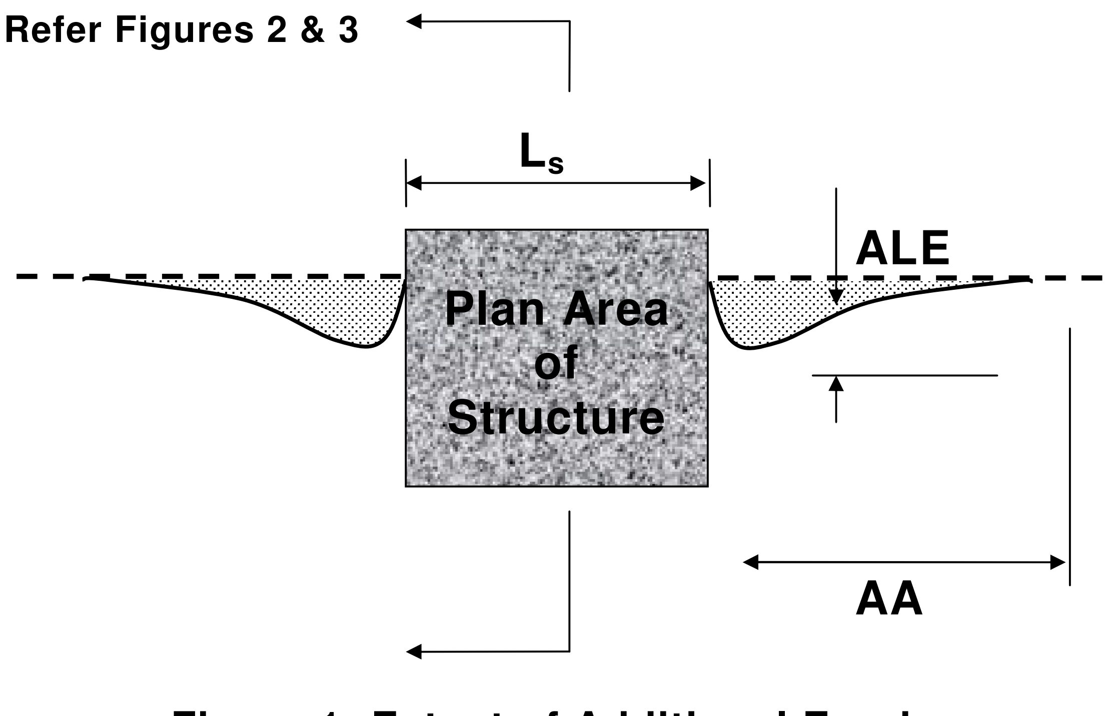


Figure 1: Extent of Additional Erosion adapted from *Komar and McDougal (1988)*

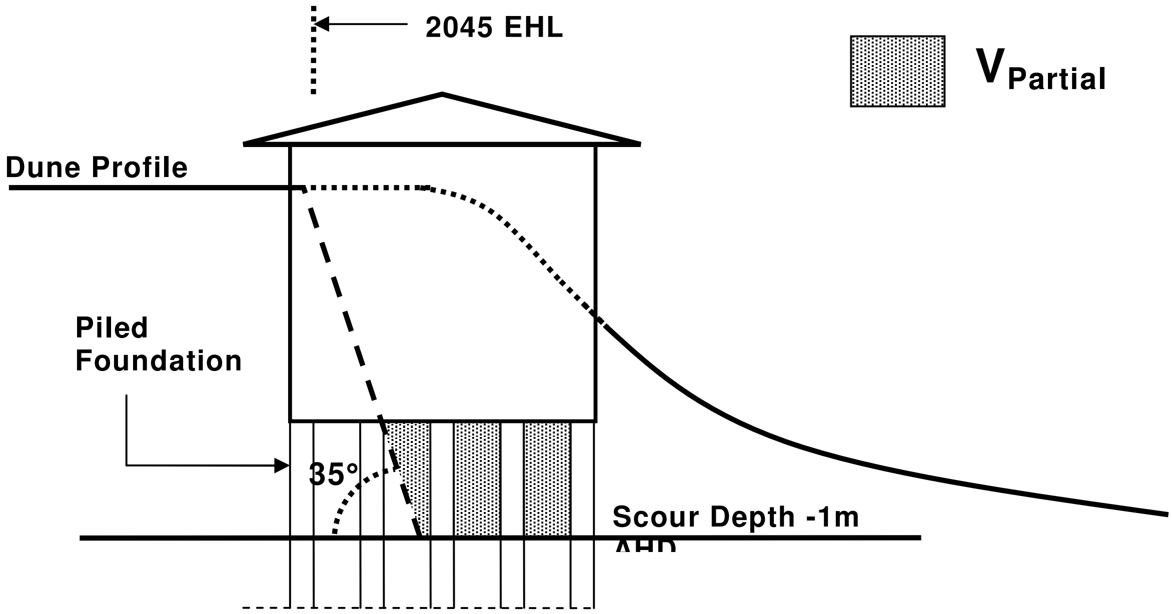


Figure 2: $V_{Partial}$

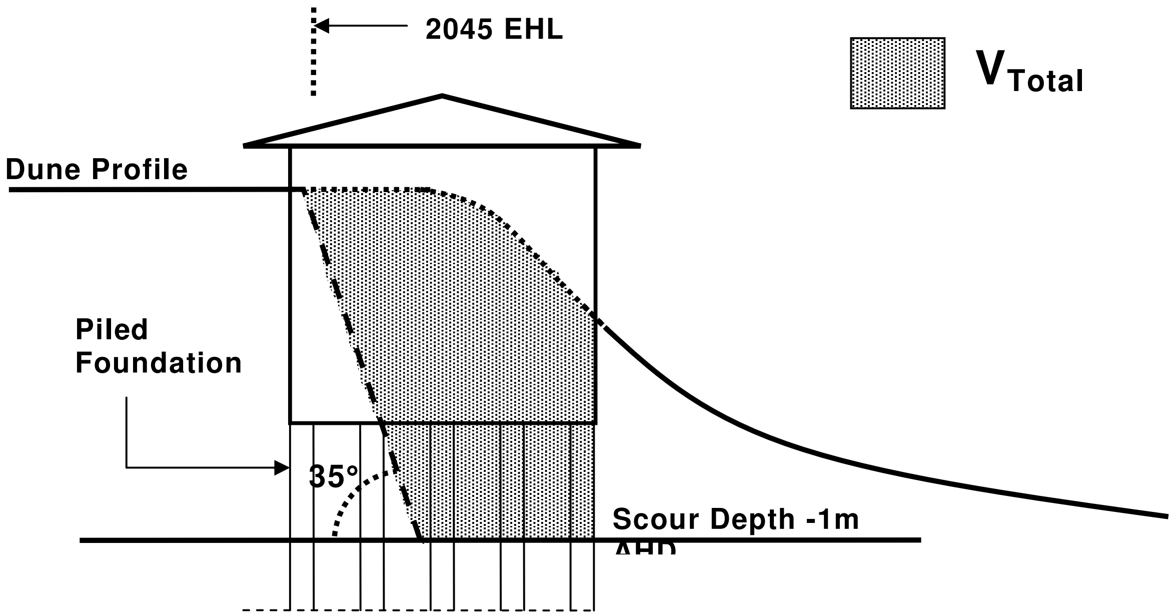
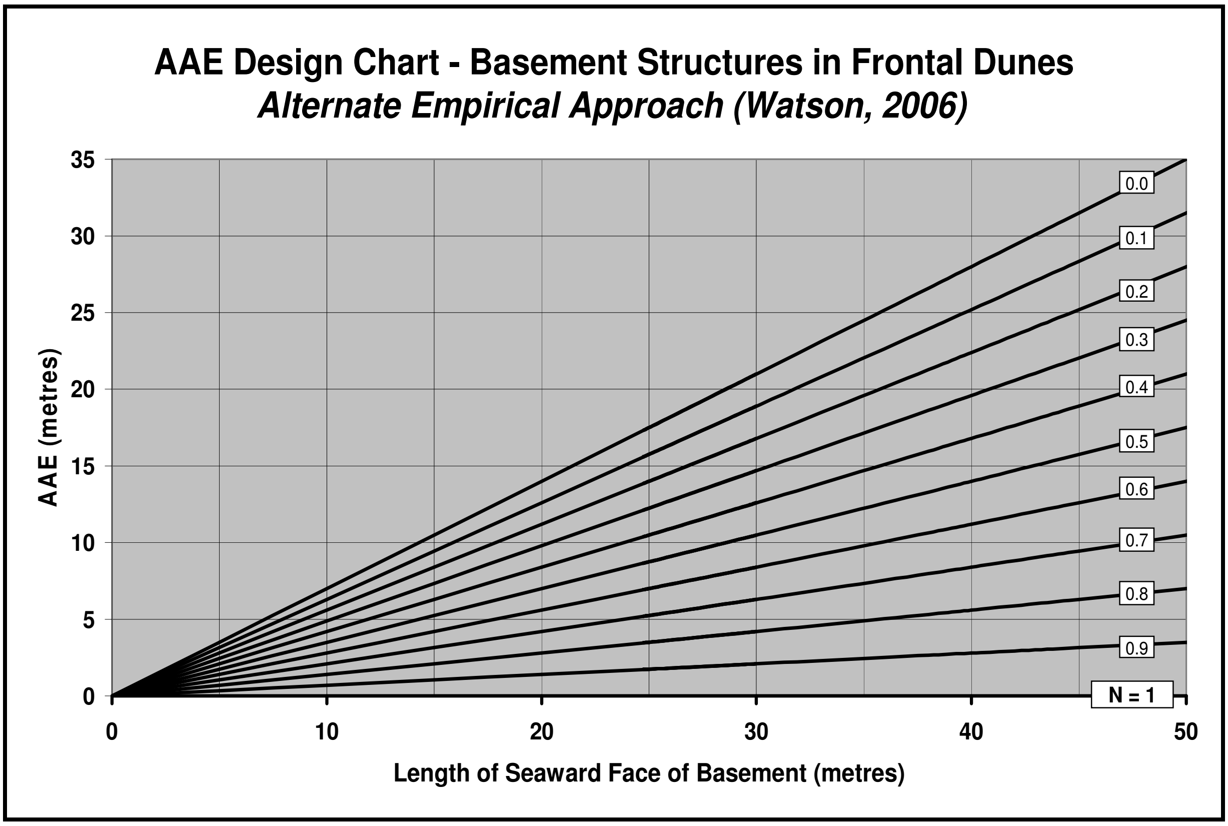
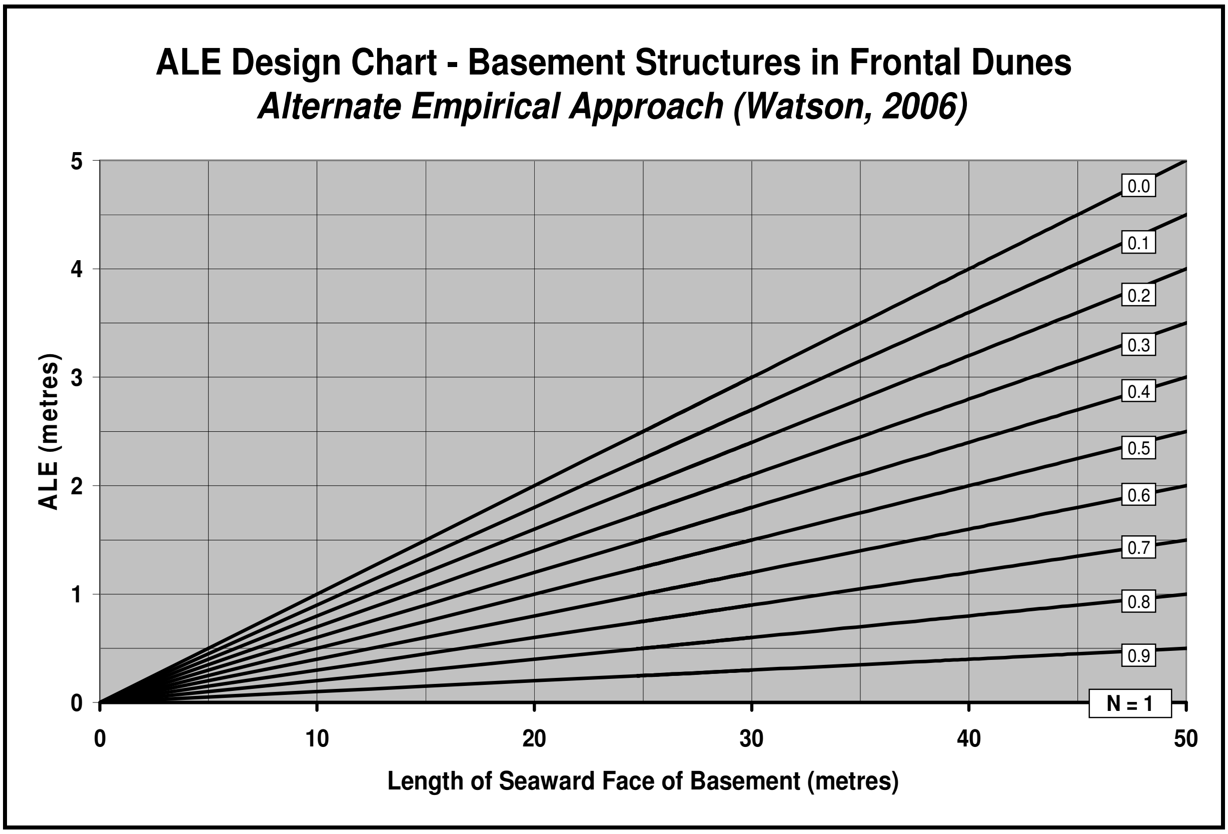


Figure 3: V_{Total}


AAE Design Chart - Basement Structures in Frontal Dunes
Alternate Empirical Approach (Watson, 2006)
35
30
25
20
15
10
5
0
AAE (metres)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
N = 1
0
10
20
30
40
50
Length of Seaward Face of Basement (metres)


ALE Design Chart - Basement Structures in Frontal Dunes
Alternate Empirical Approach (Watson, 2006)
5
4
3
2
1
0
ALE (metres)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
N = 1
0
10
20
30
40
50
Length of Seaward Face of Basement (metres)