Analysis of Geophysical Datasets for Coastal Vulnerability and Asset Management

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SUMMARY

As part of Western Australia's State and Coastal Planning Policies, local councils are formulating Coastal Hazard Risk Management and Adaptation Plans (CHRMAP) with the aim of rating areas of concern with a risk level and to assist in future planning of land use and infrastructure.

To assist with geological modelling of future coastal erosion a suite of geophysical methods was utilised to model current sand thickness and depth and condition of underlying limestone bedrock. Seismic Refraction, Multichannel Analysis of Surface Waves (MASW) and Ground Penetrating Radar (GPR) were utilises and all proved to provide reliable data in suitable conditions. However, all methods showed limitations which were noted to improve productivity and planning of future coastal geophysical investigations. These limitations included dealing with loss of useable data due to interaction with saline, saturated sands, inaccessibility due to topography or local scrub, and data resolution.

A combination of Seismic Refraction and MASW proved to be the most robust and reliable combination of geophysical methods with GPR utilised only when well above mean sea level and where high resolution modelling of karst and pinnacles was required.
When combined with Cone Penetrometer Tests (CPT), selected methods showed to provide significant value to CHRMAP.

Key words: Coastal Erosion, Climate Change, MASW, GPR, Seismic Refraction.

INTRODUCTION

The effects of global climate change, coupled with urbanization of coastal areas, provides a great challenge for areas of sandy coastline as present in the South West of Western Australia. Sea level rise and a predicted increase in frequency and destructive force of storm events are expected to accelerate coastal erosion, increasing risk to urban and commercial properties as well as critical infrastructure.

By understanding the nature of underlying geology in critical coastal areas future planning and risk mitigation can be undertaken. Modelling of predicted sea level rise coupled with identified stable bedrock can be used to provide safe setback distances for current and future development.

Many local councils in Western Australia have taken the initiative to commission long term coastal erosion studies to help inform on future urban planning and risk mitigation including broad geotechnical studies. GBGMAPS have assisted in several geotechnical studies by undertaken geophysical investigations to define;

- thickness of sand cover
- depth and indicative hardness/stiffness of underlying limestone
- identification of karst

This presentation will outline number of case studies undertaken along the Western Australia Coastline between Geraldton and Binningup including the Greater Perth region. Case studies will detail how geophysical methods have been utilised to define existing geological strata, with particular focus on depth of sand cover, the level to limestone bedrock and identify karstic formations of potential risk.

METHOD AND RESULTS

Due to the variable nature of the Western Australia coastline a number of geophysical methods have been utilised to define subsurface composition and structure. Each method utilised proved helpful in increasing the subsurface modelling along the given coastlines, however limitations of each method had to be identified and understood to allow for complete and robust modelling of datasets.
Ground Penetrating Radar (GPR) proved to be a rapid and reliable method for simple definition of sand/limestone interface over sandy dunes. The low clay content in the upper sediments led to very low attenuation of signal giving penetration depths of greater than 10m utilising antennas in the 120-400 MHz range. The use of GPR was limited to accessible tracks where the antenna could slide over the surface and was not possible through coastal scrub. Furthermore GPR data quality was typically reduced on the beach foreshore due to the saline water infill of sands.

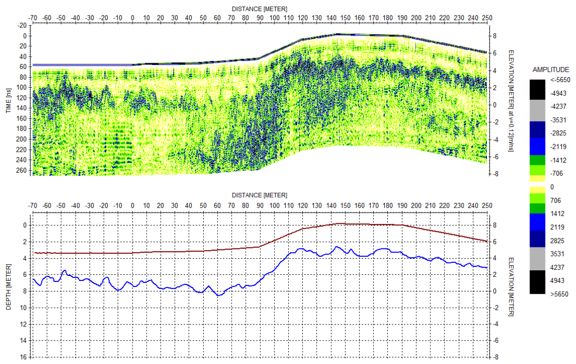

Figure 1. GPR radar-gram (top) and simplified layer model (bottom) with top of rock level in blue.

Seismic Refraction was utilised predominantly along transects perpendicular to the coastline over terrain that was unsuitable for either the GPR or MASW methods. The acquired data was generally of good quality, however low frequency noise was present on datasets acquired on days with strong wave activity. In addition, it was found that the definition of limestone near mean sea level (msl) was poor due to the interaction with saturated sands. As such the limestone interface determined via seismic refraction datasets was only interpreted above msl. Limestone encountered below msl were classified as ‘0m or below’.

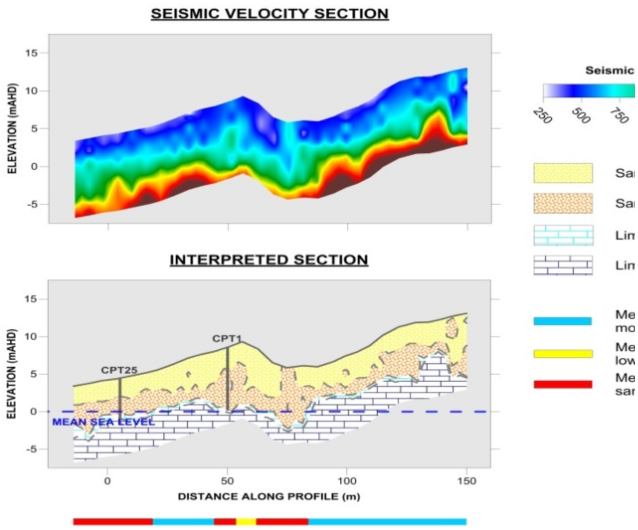

Figure 2. p-wave and interpreted models of dune structure perpendicular and adjacent to beach with CPT refusal depths overlaid.

Multichannel Analysis of Surface Waves (MASW) proved to be the most robust method for determination of sand/limestone interface as the measured Raleigh waves were not influenced by groundwater table or local saturated sands.

Data compilation was undertaken using all acquired methods and with close consultation with clients and end users to provide the most practical modelling of data.

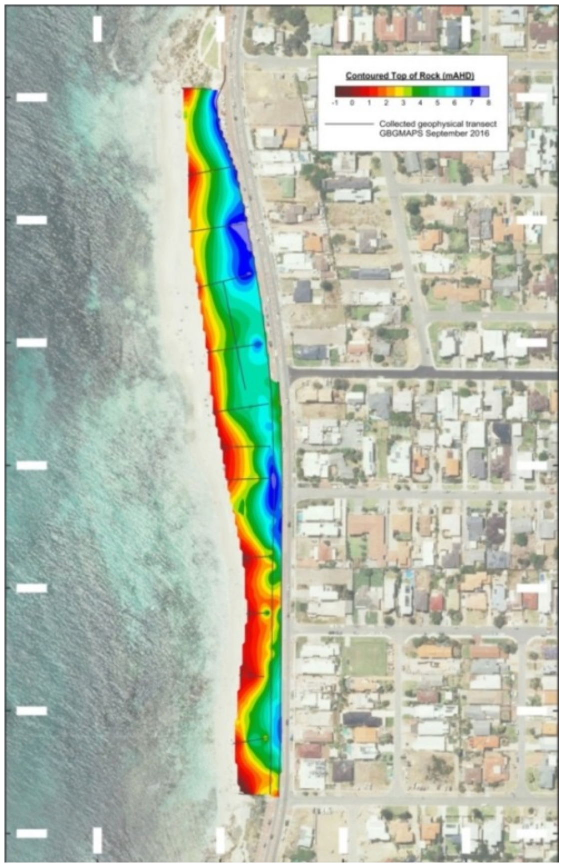

Figure 4. Contour map showing level (mAHD) to the top of rock along a 600m section of beach foreshore and coastal dune.

CONCLUSIONS

Geophysical test methods carried out with careful consideration to the often complex and dynamic coastal environment has proven to provide valuable information to coastal engineers and local government authorities along the Western Australian Coastline. Various geophysical methods including Ground Penetrating Radar, Seismic Refraction and Multi-channel Analysis of Surface Waves have been shown to image the coastal dune system including sand thickness, the level to underlying limestone, and karst features. Such information when measured relative to mean sea level can assist in determining areas of coastline most vulnerable to erosion and the subsequent risk to urban and commercial properties as well as critical infrastructure.

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REFERENCES

Baird Aust. Pty Ltd [2018] Geraldton Castal Hazard Risk Management and Adaptation Planning Project part 2 – Coastal Adaptation Report, 12-70

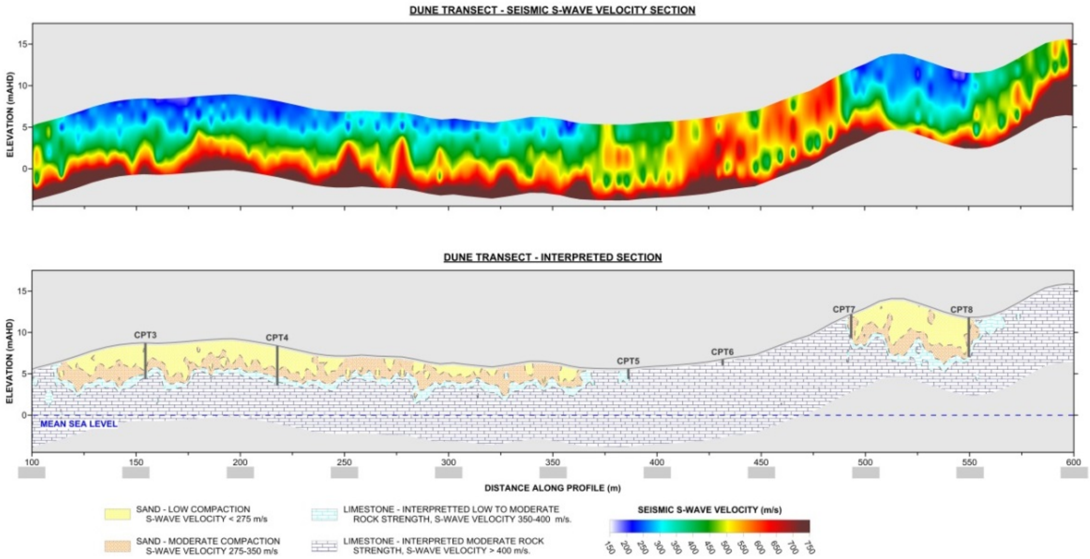

Figure 3. s-wave and interpreted models of dune structure parallel and adjacent to beach with CPT refusal depths overlaid.