THE AUSTRALIAN COASTAL SMARTLINE GEOMORPHIC AND STABILITY MAP VERSION 1: MANUAL AND DATA DICTIONARY

By:

Chris Sharples, Richard Mount & Tore Pedersen

School of Geography & Environmental Studies, University of Tasmania

8th October 2009

Manual version 1.1

Australian Government
Department of Climate Change

Australian Government
Geoscience Australia

UTAS

smartline
coastal data segmentation

Cover illustrations:

Top: A muddy (and in this case partly rocky) mangrove coast in the vicinity of Darwin, Northern Territory. Similar muddy mangrove coasts are characteristic of large parts of northern Australia, and with potentially increasing rainfall and fluvial run-off in northern Australia expected to result from climate change, there is potential for increasing sediment supply to cause progradation of some of these coasts (e.g., near river mouths), while other muddy shores with lesser sediment supplies may recede with sea-level rise (Photo: C. Sharples).

Middle: The calcarenite Zuytdorp Cliffs at Steep Point, Shark Bay area, Western Australia. Pleistocene to Holocene – age aeolian calcarenite (lithified calcareous dunes) is one of the most extensive coastal bedrock types along much of the western and southern coasts of the Australian continent. This cliff-line extends unbroken for about 190 kilometres from Steep Point southwards to near Kalbarri, making it one of the longest continuous sea-cliffs in the world. Steep Point is also the westernmost extremity of the contiguous Australian mainland (Photo: Ian Eliot).

Bottom: A long sandy beach backed by active transgressive dunes at Waterhouse Beach in north-eastern Tasmania. In part this coastal beach-dune system comprises sands reworked from terrestrial desert dunes that formerly covered much of the Bass Strait plain during arid Pleistocene low sea-level stands (Photo: C. Sharples).

Version History for this manual:

Version no.	**Date issued**	**Comment**
1.0	30th June 2009	Draft provided to Geoscience Australia for interim use on OzCoasts website.
1.1	8th October 2009	Finalised Manual and Data Dictionary to accompany Australian Coastal Smartline Geomorphic and Stability Map, version 1.

CONTENTS

This page intentionally blank

SUMMARY

This Manual and Data Dictionary provides information necessary to understand and use the 'Australian Coastal Smartline Geomorphic and Stability Map version 1', namely:

- Metadata, a Data Model and detailed attribute tables ("look-up tables") for the Australian Coastal Smartline Geomorphic and Stability Map version 1.
- Brief historical information on the creation of the dataset.
- Discussion and explanation of the "Smartline" format and the coastal landform classification principles and system used in this dataset.
- An introduction to and definitions of the coastal landform stability classes which have been derived from the coastal landform classification and also used in the Smartline map (greater detail is provided in a companion report: Sharples 2009).
- A table of the data sources used in compiling the Smartline map version 1.

The term 'Smartline' here refers to a GIS line map format which can allow rapid capture of diverse coastal data from both new mapping and pre-existing datasets, into a single consistently – classified map, which in turn can then be readily analysed for many purposes. This format has been used and refined during 2007 - 2009 to create a detailed nationally-consistent coastal geomorphic (landform) map of Australia, by combining data from over 200 prior mapped data sources. The 'Coastal Smartline Geomorphic and Stability Map of Australia' was compiled in the first instance for use in assessment of Australia's coastal vulnerability to sea-level rise and climate change by the Commonwealth Department of Climate Change and Geoscience Australia. However it is anticipated that the mapping created will be suited for many other coastal management and research purposes in future.

In the context of a need to conduct a comprehensive assessment of Australia's coastal geomorphology for the purpose of coastal vulnerability assessment, the ability of the Smartline format to readily combine data from numerous sources into a single consistent map provides a solution to the "information overload" that would otherwise result from attempting to assess Australia's coastal vulnerability using the several hundred geomorphology-relevant existing datasets that cover different parts of Australia's coast at different scales, using different classifications and styles of mapping.

This manual and data dictionary provides a detailed description of the Smartline in the form of ANZLIC-standard metadata, a data model and attributes tables. The manual also describes the principles and concepts underlying the Smartline mapping format.

The utility of the Smartline format results from application of a number of key principles:

- The use of a line-map format for coastal data mapping is practical because of the essentially linear (along-shore) nature of coasts.
- Multiple attributes describing a range of landform characteristics of the coastal area (to a nominal distance of 500 metres inland & offshore of Mean High Water Mark) are attached to a single GIS line representing the coastline.
- Because attributes attached to the Smartline describe a range of characteristics of a coastal area, and not simply the characteristics of the shore at the exact ground location of the mapped line itself, the precise location of the line in real space is not critical. However to be useful the

line should accurately represent the plan form of the coast, and in practice the mapped Mean High Water Mark line is generally the most appropriate available base map.

- The line is segmented where-ever any of the coastal attributes change in the along-shore direction. The Smartline map can be as spatially detailed in the along-shore direction as the available data sources allow (for example, in some cases the Smartline identifies individual pocket beaches only 20 or 30 metres long).

- Coastal land-forms are described in terms of 3 shore-parallel, tidally-defined zones (recorded as subtidal, intertidal and backshore landform-type attributes)

- Within each zone, landforms are described primarily in terms of their form and fabric (constituents), and only secondarily in terms of genetic or morpho-dynamic descriptors such as “beach”, “cliff”, “shore platform”, etc.

- Form and fabric characteristics are classified in broad categories which capture important landform distinctions but are also comparatively easy to classify out of source data of widely varying type, detail and quality.

- Hierarchical classification systems are used, so that coastal landforms can be classified into broader or more specific categories depending on the quality of available source data, and specific categories can be lumped back into broader categories if required.

Using these principles, the basic geomorphic attributes recorded for each mapped coastal segment include:

- Backshore landform types (as ‘Backshore proximal’ and ‘Backshore distal’ types);
- Intertidal landform types (dominant & sub-ordinate intertidal landform components);
- Subtidal landform types (dominant and sub-ordinate subtidal landform components);
- Backshore Profile (broadly classified coastal form or slope – e.g., plains, gentle or steep slopes, etc);
- Intertidal slope;
- Exposure (to swell waves); and
- Geology (exposed or underlying bedrock type, plus superficial types - e.g., calcarenites or laterites over exposed basement rocks - where present).

These attributes are recorded using both verbal and numerical (coded) attributes, the former being easier to read and construct map keys with, the latter being easier for use in many data analysis procedures including GIS queries. A comprehensive system of feature-level metadata is also used, providing references to the source and scale of the data used to populate each attribute cell of each coastal segment. Whilst the best available data has been incorporated into the Smartline, the quality and scale of the best available data varies considerably around the Australian coast, and commonly also for different attributes of the same stretches of coast. Hence the feature-level metadata provides a detailed record of the sources, quality and scale of data used in compiling the Smartline.

The design of the geomorphic attribute fields used in the Smartline Data Model reflects a deliberate (and hopefully successful) attempt to strike a balance between allowing the capture of a great deal of detailed information without the use of an overly complex data model or geomorphic classification system[1]. The result is that, whilst the information from individual Smartline geomorphic attribute

---

[1] That is, to capture detailed descriptive information using only a simple system of attribute fields requires a fairly complicated classification system, whereas using a very simple classification system to capture the same detailed information would require many more attribute fields. The Smartline attribute data model and classification attempts to strike a balance between these by using a moderate number of attribute fields and a

fields can be displayed in isolation, it is generally more useful to use queries to select and display combinations of information from several attribute fields (e.g., specific types of landforms or landform assemblages of interest will commonly correspond to line segments possessing a certain combination of attributes classes in more than one attribute field).

The Smartline format is not the most appropriate format for all coastal data purposes, and there are many applications for which polygon mapping and digital elevation models are more appropriate (e.g., inundation modelling). However the Smartline provides a highly practical format, both for compiling and for using or analysing data, for a wide range of purposes to which it is best “fit for purpose”.

Two broad types of application of the Smartline format in the coastal context are evident:

1. Assembly of diverse data into one consistent dataset, which can then be easily queried or reclassified to produce specified types of derivative information.

2. Provision of a coastal geomorphic map framework to which a wide variety of other coastal data sets can be attached.

In regard to the first application, the geomorphic attributes compiled into this Australian coastal Smartline geomorphic map (as described above) have been queried to select and map out coastlines falling into a range of specified “coastal landform stability classes”. These classify coastal landforms by their *style* of physical response (e.g., resilience, erosion, slumping, accretion) to coastal processes including sea-level rise and storm waves, based in the following inherent characteristics (or “*Fundamental Stability Factors*”) which are arguably the primary determinants of their intrinsic stability styles, and all of which can be derived from the Smartline geomorphic classification:

- *Fabric* (hard or soft constituents, implying differing erodibility or mobility)
- *Form* (flats, platforms, slopes, cliffs, etc, implying differing potential responses to coastal processes)
- *Coastal Setting* (located on open coast or in coastal re-entrants, implying exposure to different characteristic processes)
- *Geomorphic Setting* (shore backed by soft sediment or bedrock, implying differing potential for erosion and shoreline recession)

Note that whilst the differing stability classes defined by various combinations of these fundamental stability factors exhibit differing intrinsic *styles* of coastal landform stability or instability, these classes do not necessarily imply different *magnitudes* of response to coastal processes. The latter is also dependant on the degree to which a given landform of a given stability class (or style) is actually exposed to the varying processes driving its instability (e.g., sea-level rise, wave climate, sediment budget, etc).

In summary, the stability classes are defined at the highest level by fabric as follows, with each of these first-order classes further sub-divided into form, coastal setting and geomorphic setting sub-classes:

- *Muddy Shores*
- *Sandy Shores*
- *Sand Dune & Beach Ridge Coasts*
- *Coarse Sediment Shores* (incl. coarse – grade beaches and talus shores)
- *Undifferentiated Soft sediment Shores*
- *‘Soft Rock’ Shores*

---

mostly straightforward but hierarchically layered classification system to capture a great deal of landform type complexity.

- *Hard Rock Shores*
- *Undifferentiated Rock Shores*
- *Coral Coasts*
- *Unclassified*

The coastal landform stability classes are an example of distilling a simple but useful grouping of landform types out of the complex information previously captured by the primary Smartline geomorphic attributes. Although designed with assessment of coastal vulnerability in mind, the stability classification also serves as an intuitively useful grouping of coastal landform types for many other purposes.

As an example of the second application above (provision of a coastal map framework to which a wide variety of other coastal data sets can be attached.), the extensive Australian Beach Safety and Management Program (ABSAMP) database of geomorphic, environmental and public amenity and safety information on Australian beaches, separately compiled over many years by Professor A. Short and Surf Life Saving Australia, has been linked to the coastal geomorphic Smartline map by the simple addition of a common beach number attribute field (*ABSAMP_ID*).

1.0 INTRODUCTION

1.1 *A Nationally-Consistent Coastal Smartline Geomorphic and Stability Map for Australia*

A consequence of the widespread awareness of the potential coastal impacts of global climate change (IPCC 2001) has been recognition of the need for Australia-wide coastal geomorphic mapping using nationally-consistent landform classifications, in order to provide a national basis for identifying shores which are potentially susceptible to increased physical instability (e.g., erosion or accretion) in response to sea-level rise and climate change (Voice *et al.* 2006). Whilst a significant number of geomorphic (landform) maps of parts of the Australian coast existed prior to the development of the mapping described here (see Appendix One), they used a variety of different formats and geomorphic classifications.

The format and geomorphic classification of a useful nationally-consistent map needs to be capable of:

- allowing efficient extraction of data from a range of different existing geomorphic maps (in different formats and with different classifications) and translating these into a single nationally-consistent coastal landform classification and map;

- allowing rapid incorporation of new geomorphic mapping from fieldwork and remote sensing data, so as to allow future enhancement of the map; and

- allowing rapid identification of shores sensitive to increased physical change or instability resulting from climate change and sea-level rise, for example by the use of GIS queries to extract coastal types whose geomorphic characteristics' make them susceptible to particular styles of impact.

A segmented line-format (GIS polyline) coastal landform map had been successfully used in a similar way in Tasmania by Sharples (2006b, 2007), and was in turn similar to some formats that had previously been used for Oil Spill Response Atlas (OSRA) Shoreline Type mapping in other Australian states. The line (representing the Mean High Water Mark (MHWM) line) is tagged with multiple attribute fields describing multiple aspects of the geomorphology of each line segment. The line is segmented along the coast wherever a significant change in coastal landform types is located (i.e., wherever any one of the classified attributes changes). The essentially linear nature of coastlines and coastal areas makes line map formats well-suited to coastal mapping. The concept of using a segmented line to represent multiple coastal attributes is not new, having been used as long ago as 1958 (McGill) in a paper format; however the method is particularly well-suited to use in a Geographical Information System (GIS).

The successful use of a line-format coastal geomorphic map for coastal vulnerability assessment purposes in Tasmania led Geoscience Australia in association with the Department of Climate Change (DCC, formerly Australian Greenhouse Office) to let a contract during 2007 to a team at the University of Tasmania[2], to compile a coastal geomorphic and stability map for the entire Australian coast in the same format. The maps described in this manual were produced to a nationally consistent standard by both translating data from the available existing maps into a single format and classification, and by adding new information. In the course of compiling the national coastal geomorphic line map, the data model and mapping protocols have been refined, some principles for optimum application of the line-mapping method have been developed, and the term "Smartline" has been adopted to describe the 'matured' line-format mapping method.

[2] Team led by Richard Mount & Chris Sharples in the Spatial Science Group, School of Geography & Environmental Studies, University of Tasmania.

Section (2.0) of this manual outlines some basic principles of efficient Smartline application. Other sections describe the data model (data attribute fields and classification categories or attribute tables) used for the national coastal Smartline geomorphic map. This data model is not identical to that used for any existing Australian coastal geomorphic line mapping, although it is partly derived from the data model previously used by Sharples (2006a,b) in Tasmania, and that developed for Australia-wide usage in OSRA shoreline types mapping (Wardrop & Ball 2000). However, the data model used here builds on lessons learnt in over 6 years experience using a similar data model for Tasmanian coasts (Sharples 2000, 2006a,b), as well as incorporating modifications intended to encompass the broader range of coastal landforms found Australia-wide.

A national expert workshop was held in Hobart on 5th – 6th September 2007 to review a draft of this data model (Sharples *et al.* 2009, Appendix Two). The draft has been reviewed, modifying and added to in the light of the workshop outcomes. It is intended that the final outcome documented in this manual will prove a robust coastal Smartline geomorphic mapping system that will be useful on all shores, and which not only will enable identification of differing classes of physically unstable coastal landforms in the first instance, but will also be applicable to a range of other uses in the longer term. Given the enormous diversity of coastal landform types found around the Australian coast, it is expected that the data model provided here will be capable of describing most coastal landform types globally, and the classification system used is designed to be sufficiently flexible as to allow incorporation of further types (even including ice and permafrost coasts) where needed.

1.2 *Glossary of Terms and Acronyms*

The following glossary explains in broad terms the usage of a number of key terms for the purposes of this manual; users should note that in some cases the definitions used here may differ from those used elsewhere for the same terms. In particular, the meanings used during the Smartline compilation project for certain terms including "exposure" and "vulnerability" follow those of the Allen Consulting Group Report to the Australian Greenhouse Office (Allen 2005), however differing uses of these terms are also widespread, and some of these differing meaning are also noted here.

ABSAMP — Australian Beach Safety and Management Database. Database created by Surf Life Saving Australia (SLSA), which incorporates geomorphic data compiled by Prof. A. Short for all Australian beaches.

ACCRETION — Addition, deposition or accumulation of sediment. In effect, the opposite of erosion.

ACE CRC — Antarctic Climate & Ecosystems Co-operative Research Centre (based at the University of Tasmania)

AGGRADATION — Upwards accumulation and growth of a sediment deposit.

AHD — Australian Height Datum. Theoretically this datum is intended to lie at mean sea level, however ongoing sea-level rise means since AHD was defined means that AHD now lies a little below mean sea level in many areas.

AMSA — Australian Maritime Safety Authority. Agency responsible for the production of the Oil Spill Response Atlas (OSRA), from which significant amounts of coastal geomorphic mapping were incorporated into the Smartline.

ARENITE — Sand-grade lithified sedimentary rock (e.g., quartz sandstone, calcarenite, etc).

BEACH RIDGES — Generally multiple shore-parallel ridges inland of a shoreline, which formed during rapid progradation of a sandy shore. Beach ridges are not properly dunes, but rather stranded beach berms. However in some cases they may be composite features, where wind-blown dune sand has accumulated on a beach ridge after it has been isolated from ongoing wave action due to continued seawards growth of the beach in front of the ridge.

BERM A distinct change of slope on a beach, marking the landwards limit of recent wave action. On some beaches the berm is composed of coarser material (e.g., cobbles) deposited during storms.

CALCARENITE Sand-grade lithified sedimentary rock composed of cemented calcium carbonate grains (i.e., a type of limestone). On the Australian coast, many prominent calcarenite deposits are Holocene or Pleistocene coastal dunes of carbonate-dominated sand cemented by groundwater processes. Calcarenites vary from very hard tough rocks to soft friable sandy rocks. They are classified as 'hard rock' types by default in the Smartline geomorphic classification, unless specific occurrences are known to be soft.

CHENIER Ridge of relatively coarser sediment deposited over substrate of relatively finer sediment; multiple origins likely in different places, some may be storm deposits.

COLLUVIUM Slope deposits. Deposits of boulders, cobbles and finer material that have accumulated on slopes as a result of erosion and movement of material from higher levels. Many colluvial deposits in Tasmania formed under the more sparsely-vegetated conditions of the last glacial climatic phase.

DEM Digital Elevation Model. A widely used GIS format which represents surfaces (e.g., of land) as a grid, each cell of which has a defined location and elevation.

DEPARTMENT OF CLIMATE CHANGE (DCC) The Australian Commonwealth Government Agency concerned with mitigation of and adaptation to global climate change. Formerly the Australian Greenhouse Office.

DUNE A landform composed of unconsolidated sediment (generally sand) transported and deposited by wind. Dunes may form at inland sites but are a characteristic feature of sandy coasts (where dunes initially build above the high water mark from sand blown off a beach by onshore winds), but may occur in other rocky coastal situations such as cliff-top dunes, where the original source of sand is no longer apparent.

DUNEFIELD Multiple dunes that may extend hundreds of metres or even kilometres inland of a shoreline. Coastal dune fields commonly comprise multiple parabolic or transgressive dunes formed by erosion and re-mobilisation of sand initially deposited in foredunes, to form mobile sand bodies migrating inland away from the coast.

EROSION Removal of material (e.g., from a sediment body or landform) by natural processes (e.g., wave action). Coastal erosion typically results in landwards recession of the shoreline, but in theory need not do so; e.g., wind erosion of coastal dunes need not necessarily lead to shoreline recession (See also 'Recession').

EXPOSURE The term 'exposure' is used in two different contexts in this work:

1. In relation to Smartline geomorphic attributes, 'exposure' is used in a narrow sense as an indicator of the degree to which a shoreline segment receives whatever swell-wave energies impinge on the broader coastal region of which the segment is part.

2. In relation to risk assessment, and following the terminology of Allen (2005) 'exposure' here refers to the degree to which a hazard (a natural process with potential

to drive physical impacts on the coast, e.g., storm waves) actually impinges on a given coastal site.

It should be noted, however, that these usages differ from some other common usages of the term "exposure'. For example standard risk terminology used by Geoscience Australia treats the term 'exposure' as referring to the assets at risk such as infrastructure or ecosystems (John Schneider *pers. comm.*). That is, in this sense 'exposure' refers to the assets that may be potentially lost owing to a sites vulnerability to a certain hazard.

FABRIC For the purposes of the Smartline coastal landform map, 'fabric' refers to the constituents of a landform, or the types of material they are made of. Fabric types are classified by degree of lithification and grainsize; thus example fabric classes include: hard rock, soft rock, sand, mud, coarse sediment, etc.

FLOOD – TIDE DELTA A sediment deposit (usually sand) that has accumulated in a coastal lagoon or re-entrant, at the landwards end of a tidal channel or re-entrant mouth through which tidal currents transport sand.

FORM Shape or morphology.

GEOMORPHOLOGY The study of landforms, their forms, genesis, development and processes.

GEOMORPHIC Pertaining to geomorphology (see above).

GEOSCIENCE AUSTRALIA (GA) The Australian Commonwealth government agency concerned with the geo-sciences, including geological, geomorphic, geographic and topographic mapping and geohazard assessment functions. Formerly the Australian Geological Survey Organisation (AGSO) and the Bureau of Mineral Resources (BMR) prior to that.

GIS Geographical Information System. Digital mapping and analysis of mapped information, including point, line & polygon vector data, grid (e.g., DEM), raster & georeferenced image data formats.

GLACIAL PHASE A relatively cool period of Earth history during which significant expansion of glaciers and ice caps occurs, and sea level drops significantly. Multiple glacial phases have occurred during the last few million years. The Last Glaciation peaked about 22,000 to 17,000 years ago, and ended about 10,000 years ago.

GREENHOUSE OFFICE, THE (AGO) See 'Department of Climate Change'.

HAZARD In the context of coastal vulnerability, a 'hazard' is a process (e.g., sea-level rise or storms) which has the potential to impact on susceptible coasts to a degree which may place valued assets at risk.

HOLOCENE The stage of geological time between the end of the Last Glaciation (about 10,000 years ago) and the present. The Holocene effectively equates to the present interglacial climatic phase.

IMPACT In this context, the actual effects that a hazard (e.g., sea-level rise, storm waves) has on a coastal landform, ecosystem or other asset. In the case of coastal landforms, 'impacts' may be manifest as accelerated physical instability (erosion or accretion), as increased inundation, or in other ways such as saline groundwater intrusion. Used here in the sense of Allen (2005), the 'impact' of a 'hazard' on a coastal landform, ecosystem or other asset is a function of the assets inherent 'sensitivity' and its degree of 'exposure' to the 'hazard'. See also 'sensitivity' and 'exposure'.

INTERGLACIAL PHASE A relatively warm period of Earth History, between glacial phases, when glaciers and ice caps retreat and sea level rises significantly. The Earth is currently in an interglacial phase, and the last (previous) interglacial phase occurred around 125,000 years ago.

IPCC Intergovernmental Panel on Climate Change. An international organisation established in 1988 by the World Meteorological Organisation and the United Nations Environment Programme, for the purpose of reviewing and reporting on the current state of scientific understanding of and research into global climate change and its effects, including sea-level rise.

LATERITE A ferruginous regolith layer typically developed on the surface of a bedrock or sediment unit of which the laterite horizon is the highly weathered and altered product. Commonly exposed by coastal erosion in northern Australia; may also be exposed in southern Australia but more likely to be older 'fossil' laterites in that region.

LITHIC, LITHIFIED Indurated, consolidated, cemented or rocky materials (generally hard, albeit some may be relatively soft by reason of being weathered or only semi-lithified).

LITHIFICATION The geological processes whereby a soft sediment becomes a hard, tough rock over a period of time. Lithification processes include compaction of the sediment and the precipitation of chemical cements from groundwater.

LITTORAL DRIFT Movement of sediment (e.g., sand) along a shore in the near-shore zone, driven by along-shore currents generated by wave action.

LUTITE Very fine-grained (silt / mud / clay grade) lithified sedimentary rock (e.g., mudstone, siltstone, shale, etc).

MANGROVES These are an intertidal vegetation community common around much of the Australian coast. Because mangroves very commonly occupy broad muddy tidal flats (and contribute to the formation and maintenance of such flats by trapping sediment), the term 'mangroves' is commonly used to refer to the muddy tidal flat landform as well as the vegetation type. However this is incorrect usage because mangroves are a vegetation type not a landform type. Moreover, mangroves can and do also grow on sandy or rocky coasts, hence the Smartline geomorphic classification system classifies mangrove coasts by their landform type, leaving vegetation type mapping to be provided in purpose-designed vegetation maps.

MHWM Mean High Water Mark, i.e., the mean of high water over a long period of time.

MLWM Mean Low Water Mark, i.e., the mean of low water over a long period of time.

OSRA The Oil Spill Response Atlas, maintained by the Australian Maritime Safety Authority (AMSA). This dataset comprises digital mapping of a wide variety of coastal features and attributes, including shoreline type (landform) mapping which has been used in preparation of the Smartline coastal landform map.

PLEISTOCENE The stage of geological time spanning most of the last 2 million years up until the end of the Last Glaciation 10,000 years ago. The Pleistocene has been marked by a succession of glacial and interglacial climatic phases which have caused sea level to repeatedly rise and fall over a vertical range of about 130 metres, and have exerted a strong influence on coastal landform development globally.

POST-GLACIAL MARINE TRANSGRESSION In this report, the period of relatively rapid and continuous global sea-level rise following the maximum intensity of the last glacial climatic phase (circa 22,000 to 17,000 years ago), when sea level rose by about 130 metres before stabilising close to its present level about 6,500 years ago.

PROGRADATION Seawards growth or accretion of a shoreline by addition of sediment, usually where the sediment budget involves a predominance of sediment supply and accretion over erosion.

QUATERNARY The period of geological time spanning most of the last 2 million years up to and including the present. The Quaternary Period is sub-divided into the Pleistocene (older) and Holocene (recent) stages.

RECESSION Opposite to progradation: landwards movement of a shoreline due to removal of sediment or rock material by erosion.

RETURN PERIOD Average period of time between occurrences of a specified type of event. It is important to note that the return period is an average period only; i.e., a 50-year return period event does not necessarily occur regularly every 50 years. For example, two 50-year return period events could occur in one year, then not for another 100 years.

RISK As used in many coastal vulnerability assessments (e.g., Gornitz *et al.* 1994), *risk* is the product of both *hazard* and *vulnerability*, where the *hazard* is a physical process – such as sea-level rise or storm surge events – and *vulnerability* is the degree of exposure of things, such as geomorphic or ecological features, to the impacts of the hazards. The *risk* to valued assets at any location is then a combination of the *hazard* and the *vulnerability*[3]. This relationship is sometimes referred to as the "Varnes Risk Equation", where:

Risk = *Hazard* x *Vulnerability* x *Elements at Risk* (cited by Mazengarb 2005, p. 5)

Note however that the usage of 'vulnerability' cited above varies from some other usages in the literature, including the meaning of Allen (2005) which was used in the Smartline project (see "Vulnerability" below). Some usages of the term 'exposure' are closer in meaning to the intended meaning of 'vulnerability' in the Varnes Risk equation (see "Exposure" above).

RUDITE Coarse grained (pebble / cobble / boulder grade) lithified sedimentary rock (e.g., conglomerate, breccia, tillite).

SALINE FLATS
SALTPANS In coastal regions, low-profile areas with significant salt precipitates. Commonly occur on 'supratidal' flats which are occasionally (but not frequently) inundated by the sea (e.g., during storm surges).

[3] For example an asset on a coast vulnerable to the hazard of sea level rise (e.g., a low sandy shore) is at high *risk* if sea level rise is occurring (*hazard* high x *vulnerability* high), but would be at low *risk* if sea level rise were not occurring (*hazard* low x *vulnerability* high). Alternatively an asset on a coast not vulnerable to sea level rise (e.g., a moderately sloping bedrock coast) would be at low *risk* despite the occurrence of the hazard of sea level rise (*hazard* high x *vulnerability* low).

SALTMARSH A characteristic plant community inhabiting intertidal to supratidal shoreline zones. As with mangroves, the term 'saltmarsh' is sometimes used as a geomorphic mapping unit, however this can be misleading since saltmarsh may occupy a variety of different substrates including sandy, gravelly, muddy and peat substrates.

SEDIMENT BUDGET The balance between the supply of sediment (e.g., sand) to a shore and the erosion or removal of sediment from that shore.

SEMI-LITHIFIED Refers to sediments which are coherent and partly "turned to rock" (lithified) by processes of compaction and the precipitation of chemical cements by groundwater, yet remain softer and more erodible than a fully lithified rock.

SENSITIVITY In this context, the degree to which coastal landforms may potentially be impacted by coastal hazards such as sea-level rise and storm waves, given the inherent nature of the landforms (e.g., soft or hard, low-lying or steep). Such impacts may include physical instability (erosion, progradation) and/or inundation. Used in this way, the actual impacts that occur will depend on *both* the inherent 'sensitivity' of a landform, and also on its actual degree of 'exposure' to the 'hazard' itself (e.g., storm waves). See also the definitions of 'exposure' and 'hazard' used in this project.

This usage is based on that of Allen (2005), however note that Sharples (2006b) previously used "vulnerability" in the sense that 'sensitivity' is now used here; in contrast, "vulnerability' is now used here in a broader sense (see "vulnerability").

SLSA Surf Life Saving Australia; National organisation which funded geomorphic studies of all Australian beaches by Prof. Andy Short, and the compilation of this data into the ABSAMP database (see above).

SMARTLINE A coastal data mapping format based on attributing a GIS polyline representing the coastline with multiple attributes describing a range of coastal characteristics which describe not just the physical location of the line itself, but also features and processes characterising the coastal area to landwards, seawards and beneath the line, and segmenting (dividing) the line where-ever any one of the attributes change in the alongshore direction.

STABILITY The *susceptibility* or *sensitivity* of coastal landforms to physical change (erosion, progradation, etc); in this sense the term is used in a narrower sense than 'sensitivity', which encompasses both the susceptibility of coastal landforms to physical change and also to other impacts such as inundation. Thus, the stability of a landform depends primarily on its fabric (hard or soft constituents) and secondarily on its topography (steep, low-lying, etc), whereas its sensitivity to inundation may depend primarily on its topography.

STORM SURGE A temporary increase in sea level at the shore due to a combination of low barometric pressures and energetic onshore wind and waves. The magnitude of a storm surge is also strongly dependant on the tidal phase at the time of the peak surge.

SUPRATIDAL Areas above the High Water Mark which are (only) occasionally inundated by the sea (e.g., during storm surges). Classified as a sub-type of "Backshore" landform area for the purposes of the Smartline geomorphic classification.

SUSCEPTIBILITY Equivalent to the meaning of "sensitivity" as given above, more commonly used in this sense in the geomorphic literature than is "sensitivity" (because 'sensitivity' may also have political and social meanings), and sometimes used interchangeably with "sensitivity" in this report.

TALUS A variety of colluvium (slope deposits) typically comprising loose boulders and cobbles that have fallen, rolled or slid from an escarpment and accumulated below.

TIDES
TIDAL Variation in sea surface levels, typically on a daily cycle, owing to the gravitational influence of the moon and sun. Tidal levels may vary considerably owing to local barometric pressures, wind stress and other factors.

TRANSGRESSION In relation to the sea, a phase during which the sea rises or "transgresses" over formerly dry land.

TRANSLATION In coastal geomorphology: horizontal movement of a feature, for example of a coastal sand barrier as a result of erosion on one side and accretion on the other.

UNCONSOLIDATED,
UNLITHIFIED Refers to sediments that remain more-or-less loose or friable, not formed into hard rock by geological processes such as compaction and precipitation of cements from groundwater.

UNDIFF
UNDIFFERENTIATED Not divided into sub-types or sub-classes. For example, an 'undifferentiated sedimentary rock' is one which has only been identified as some type of sedimentary rock, but the specific type (e.g., sandstone, mudstone, conglomerate, etc) has not been determined.

VULNERABILITY The term 'vulnerability' is used in a confusing plethora of different ways by different authorities.

For the purposes of this Smartline project the term "Vulnerability" has been used in the sense of Allen (2005), where "Vulnerability" is the capacity of a system (human or natural) to adapt or cope with the impacts of a natural hazard to which it is exposed. That is, in the terminology of Allen (2005):

Vulnerability = Potential Impact (Sensitivity + Exposure) x Adaptive Capacity

However, alternative usages abound:

Sharples (2006b) previously used 'Vulnerability' in the sense of the Varnes Risk Equation (see 'Risk') above, where 'Vulnerability' is the degree to which a thing may potentially be impacted by a hazard. This sense of 'vulnerability' is similar to the meanings of 'Sensitivity' and 'Susceptibility' described above.

'Vulnerability' is also used in some risk management contexts to refer to the assets which may be at risk because of their 'exposure' to the 'impacts' of a 'hazard'.

WEATHERED,
WEATHERING The process by which hard lithified rock is broken down by mechanical, thermal and chemical processes into soft or friable materials susceptible to erosion. Note that materials that are chemically weathered (leached) and transported by groundwater may subsequently re-precipitate as laterites, 'duricrusts', hard-pans, 'coffee rock' or other products of weathering processes.

1.3 *Data Source Acknowledgements*

The Australian Coastal Smartline Geomorphic and Stability Map, version 1, was created using digital data provided by the following agencies and individuals (data suppliers and custodians):

Geoscience Australia.

Geological Survey of NSW (NSW Department of Primary Industries), NSW Department of Lands, NSW Maritime.

NT Department of Regional Development, Primary Industry, Fisheries and Resources (Formerly Department of Primary Industry, Fisheries and Mines), NT Department of Natural Resources, Environment, The Arts and Sport (Formerly Department of Natural Resources, Environment and The Arts).

Queensland Mines and Energy (QLD Department of Employment, Economic Development and Innovation - Formerly Department of Mines and Energy), Queensland Herbarium (QLD Department of Environment and Resource Management - Formerly Environmental Protection Agency), QLD Department of Environment and Resource Management (Formerly Environmental Protection Agency).

SA Department for Environment and Heritage, Department of Primary Industries and Resources SA.

TAS Department of Primary Industries, Parks, Water and Environment (Formerly Department of Primary Industries and Water).

GeoScience Victoria (VIC Department of Primary Industries), VIC Department of Primary Industries VIC Department of Sustainability and Environment.

WA Department of Environment and Conservation Geological Survey of Western Australia (WA Department of Mines and Petroleum – Formerly Department of Industry and Resources), Landgate (Western Australian Land Information Authority), WA Department of Transport (Formerly Department of Planning and Infrastructure).

Professor Andrew Short, University of Sydney.

A full list of the datasets used can be found in Appendix One. In some cases, datasets provided by the agencies listed above may themselves incorporate data previously derived from other sources. For example, the pre-existing Tasmanian Shoreline Geomorphic Types Digital Line Map Version 4.0 2006 (Source 183 in Appendix One, supplied by Tas Department of Primary Industries, Parks, Water and Environment) was itself constructed in part using some data from the Tasmanian Geological Survey (Mineral Resources Tasmania). Where-ever possible such original data sources have been cited in the attribute level metadata (see Data Model Section 6.2) as the data source for particular attributes and features.

2.0 THE 'SMARTLINE' COASTAL GEOMORPHIC MAPPING FORMAT

2.1 *The 'Smartline' Mapping Concept*

The 'Smartline' is a simple electronic (GIS) high resolution line map of the shoreline with a very large amount of information stored in a closely linked spatial database. The "smartness" of the line is in the types and volume of the stored information and in the way it can be transformed to display any required combination of that information.

The Smartline data model captures geographical data in a segmented GIS vector polyline with multiple attribute fields attached to each segment. The multiple attributes attached to each line segment not only record information about features which coincide with the line, but also about other features or processes which relate to the line segment in some simple way but are not necessarily spatially co-incident with it.

As Bartlett *et al*. (1997, p. 139) note, the essentially linear nature of coasts are their most obvious feature and are reflected in terms such as 'shoreline' and 'coastline'. Line format mapping is therefore an intuitively obvious method of mapping coastal attributes, and line format GIS has been previously used by a variety of coastal workers to represent coastal landforms (e.g., Bartlett *et al.* 1997, Sharples 2000, McFadden *et al.* 2007). Indeed, to the present writer's knowledge the earliest use of a line format map to record multiple coastal geomorphic attributes was a paper map of coastal landforms of the world prepared by McGill (1958), albeit this pre-GIS map had limited capacity to record multiple attributes of given coastal segments. Nonetheless, McGill (1958, p. 404) noted the innovative nature of the method, saying that "What is believed to be a cartographic innovation on a world map is the use of the coastal outline itself to indicate the distribution of the major classes of coastal landforms (plains, plateaus, hills, mountains)".

The line format GIS coastal geomorphic mapping developed during the Australian Coastal Geomorphic and Stability Mapping project has built on and refined some methods and classifications used in earlier line-format coastal mapping (e.g., Sharples 2000, 2006a,b), allowing the principles, constraints and appropriate applications for this mapping style to be more clearly defined than previously (as detailed below). To draw attention to what we consider to be the "conceptual maturing" of this mapping style, the trendy term "Smartline" was coined during the present project.

Although a Smartline coastal map has certain limitations compared to polygon mapping (e.g., it does not delineate the landwards planform and extent of geomorphic features), it compensates for this with the capacity to record arbitrarily detailed spatial data in the alongshore direction (through line segmentation or division), and by providing considerable efficiencies in both data capture (information from a diversity of data sources can be attributed to line segments more rapidly than the same information could be re-mapped into a consistent polygon format) and analysis (e.g., it is simple to extract a wide range of information from the multiple attributes attached to each line segment through GIS queries).

In the present case, the Smartline method is used to create a map of coastal landforms. Whilst the actual GIS line to which information is attached may simply represent the Mean High Water Mark (or some other convenient mapped coastal line), the attributes attached to the line may record information about landforms occurring both landwards and seawards of the line, as well as information about other environmental parameters directly relating to each segment of coast, such as the exposure of that coastal segment to wave energy. The GIS line is simply a repository for information about features and processes that need not necessarily coincide with the precise position of the line. Hence any existing mapped line which is located conveniently within the coastal area can be used (e.g., in many coastal environments a MHWM or MLWM line would serve the purpose equally well, albeit in macrotidal environments some decision may be needed as to which of these lines is most conveniently

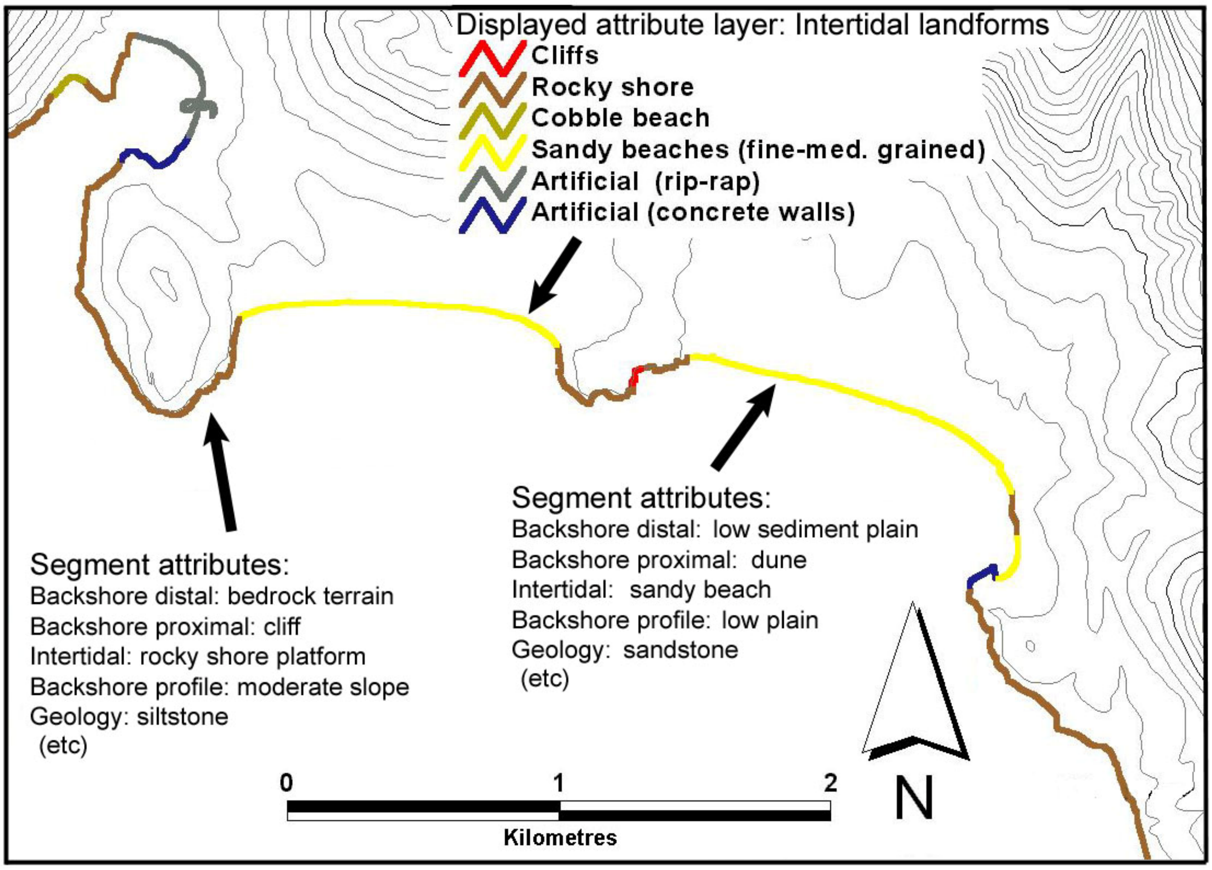


Figure 1: An example of a Smartline map used to map coastal landform attributes (contours are shown to provide context but are not part of the Smartline). This map displays one attribute field (Intertidal landform types) as a segmented colour-coded line, while some of the other attributes also tagged to each segment are listed for two example segments. These other attributes could also each be displayed separately as lines (see Figure 3), or any combination of attributes could be displayed by running queries to generate a new attribute field displaying that combined information (see Figure 4 & Figure 11).

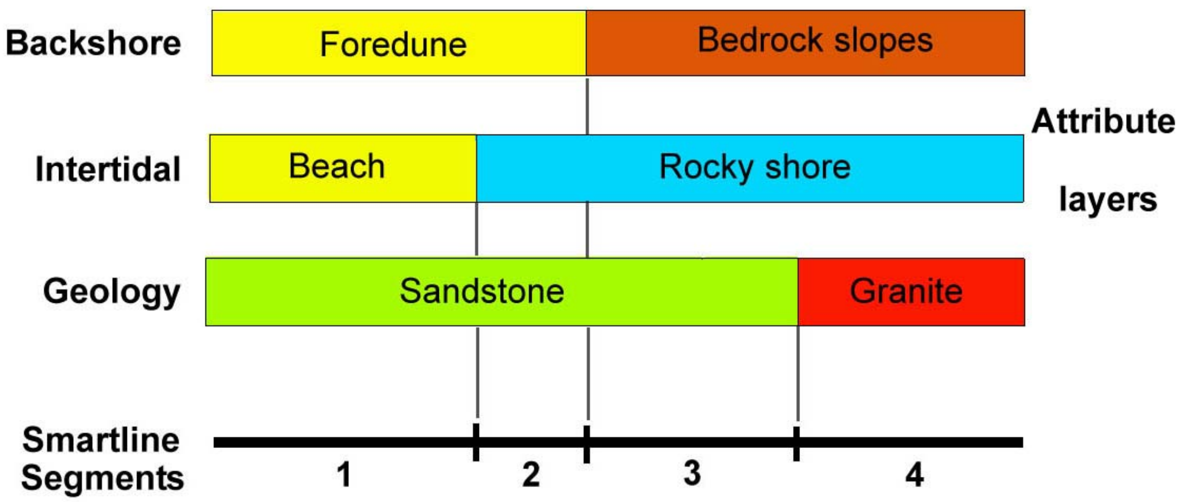


Figure 2: Diagrammatic illustration of Smartline segmentation: the Smartline (lower line) is segmented where-ever any one of its multiple attributes change, thereby preserving detailed information on the spatial extent of each attribute class in each attribute field.

positioned to capture the required data). The line is split into segments at every point along the line where any of the coastal attributes being recorded change. See Figure 1, Figure 2 & Figure 3.

The term "Smartline" is used for this mapping method for at least three reasons:

1. The method offers a "smart" means of capturing a very wide range of information about a coastal area, at arbitrarily detailed levels of classification, much more rapidly than the same information could be captured in a polygon or other mapping format.

2. Attaching multiple data fields to each line segment means that many types of data analysis can be undertaken very efficiently (or "smartly") using GIS queries. It is simple to generate a line map identifying all coastal segments having any required combination of the characteristics recorded in several attribute fields. So if one attribute records the type of landform present in the intertidal zone, and another records those found in the backshore zone, one can rapidly generate a map identifying the location of coastal segment having any desired combination of backshore and intertidal attributes (e.g., "rocky shores backed by dunes", or "mixed cobble and sand beaches backed by both lagoons and dunes").

3. However, a third reason for calling the map format a "Smartline" is that it is a method which is most effective if used in a *smart* fashion. A Smartline map is a very powerful format for certain types of data capture and analysis, but is not a particularly good format for certain other requirements (this issue is discussed further in Section (2.2) below). Thus, it is 'smart' to use the Smartline mapping method for purposes to which it is well-suited, and to use other formats such as vector polygons and rasters or grids for the purposes to which *they* are best suited[4].

The need to rapidly compile a coastal landform map for the entire Australian continent, in a format which will allow rapid identification of particular types of shores that are physically sensitive to sea-level rise and erosion, is a good example of the 'smart' use of a Smartline map.

Because of its evident advantages, the Smartline mapping method has previously been used for a variety of coastal mapping purposes in Australia and elsewhere, albeit without being referred to by that term. In particular, (geomorphic) Shoreline Types mapping for the Australian Maritime Safety Authority's (AMSA) Oil Spill Response Atlas (OSRA) – compiled to identify shores most sensitive to oil spills - has in most states been prepared in what could be referred to as a Smartline format. Given that the OSRA Shoreline Types mapping was one of the most important sources of coastal geomorphic data previously available in a GIS map format, the translation of that data into a new Smartline map was considerably simpler than would otherwise have been the case, essentially requiring only the running of simple queries to identify and reclassify each coastal type in the classification system described in this manual.

Smartline Advantages for Coastal Mapping

In addition to the potential for rapid data capture and analysis, the use of the Smartline format for coastal mapping in particular offers a number of additional advantages:

Comprehensiveness: The use of the Smartline format in coastal geomorphic mapping readily allows mapping of the presence of *all* types of coastal landforms, including not only broad features of the sort that are easily mapped in polygon format (e.g., dune fields, sediment plains), but also narrow linear features that are less frequently mapped in polygon geomorphic maps (e.g., rocky intertidal zones and sea cliffs). Most currently available coastal geomorphic polygon mapping for Australia is largely focussed on mapping Quaternary coastal sediment bodies and their landforms, and typically omit rocky parts of the coast, or else simply depict these as part of larger bedrock polygons without indicating the rocky shoreline landform types present. Although there are a few honourable

[4] Naturally, a further reason is that it is currently fashionable to use "Smart" as a prefix for lots of things. Let's hope this usage becomes established, otherwise it's going to look painfully dated in future…..

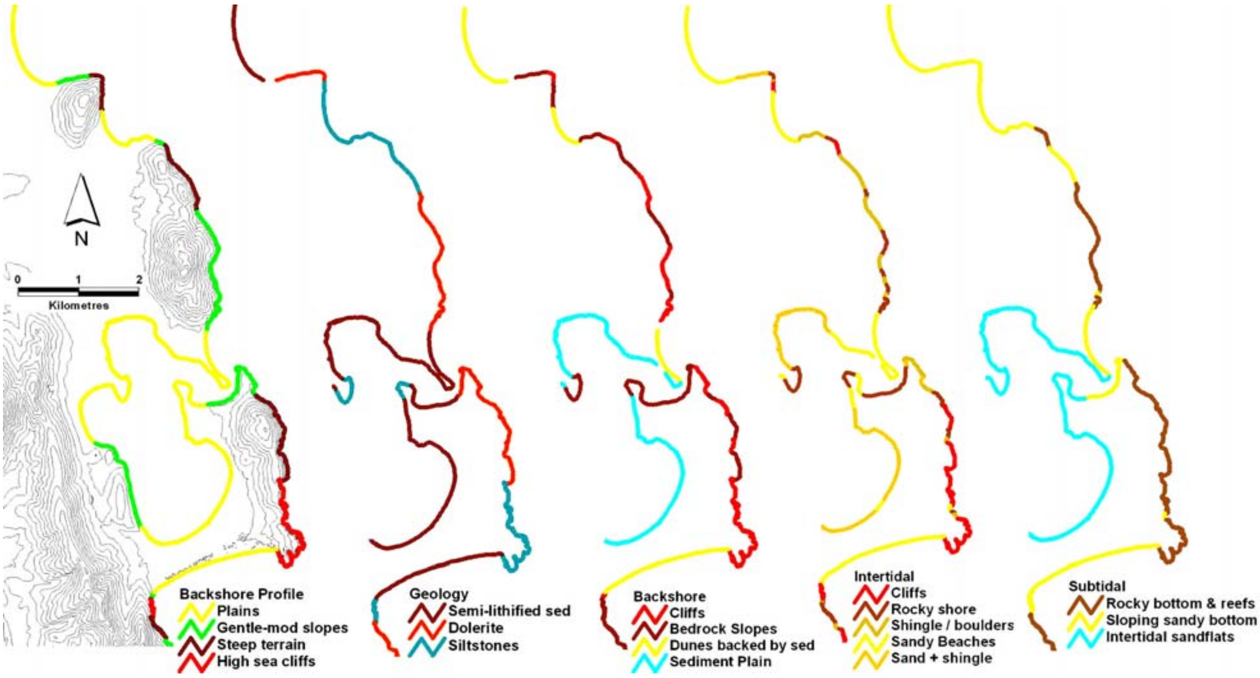


Figure 3: Example of the Smartline map format, using multiple colour-coded maps of the same coastal stretch to graphically illustrate some (but not all) of the geomorphic attribute fields tagged to each map segment. Each of these maps represents a different attribute layer tagged to a single GIS line map which in this case represents High Water Mark (MHWM). However the attribute layers describe not only shoreline attributes *at* the MHWM itself, but also attributes of the coastal area up to 500 metres landwards and seawards of the MHWM.

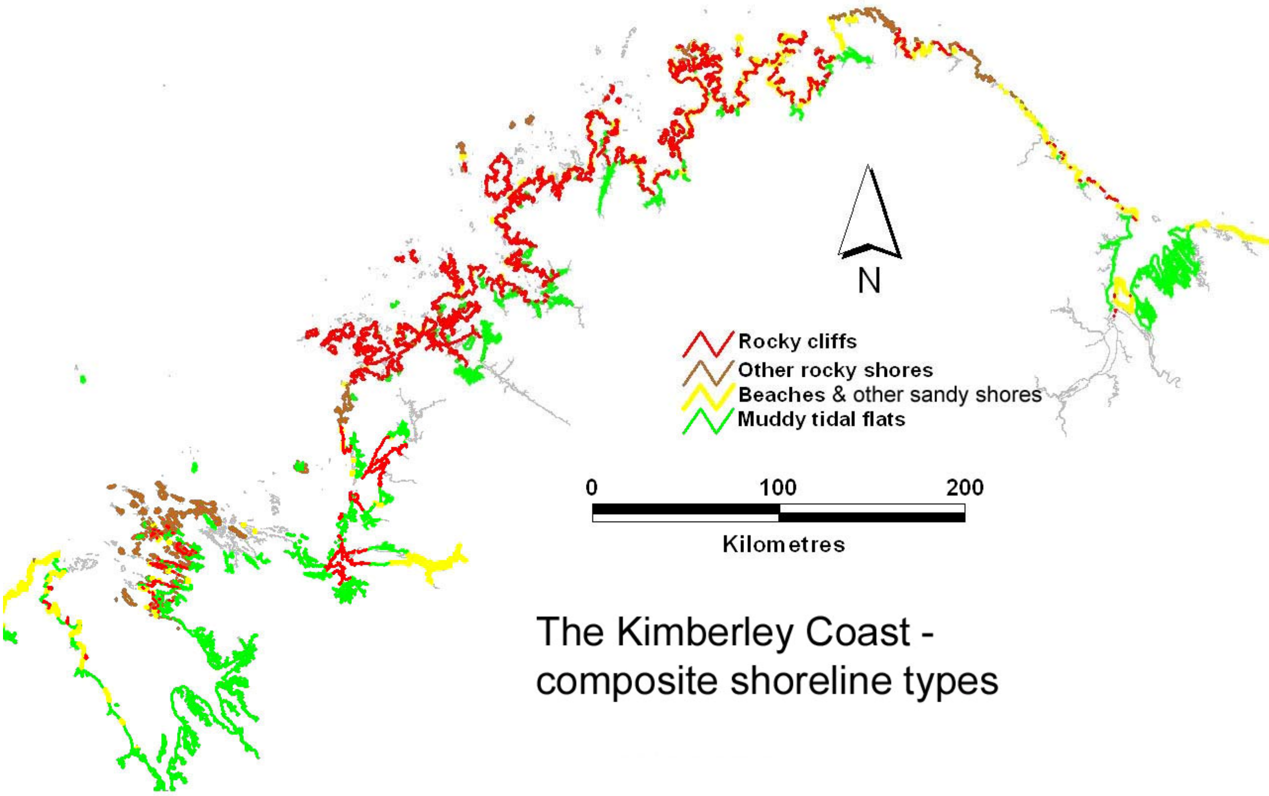


Figure 4: An example of using information from several Smartline attribute fields to produce a composite or 'generalised' shoreline type map. In the case of the Kimberley coast (WA), significant gaps exist in the Intertidal shoreline type attributes (due to limitations in the source datasets available for automated incorporation into the Coastal Smartline v.1). However, by combining information from the Intertidal and the Backshore Proximal attribute layers, it is possible to create a generalised 'shoreline types' map such as this, which provides a nearly-continuous characterisation of shoreline types along the Kimberley coast.

exceptions to this rule (e.g., Victorian Shoreline Types & Habitat polygon mapping – see Reference_ID 154 in Appendix One), these cover only limited stretches of coast, undoubtedly due to the large amounts of time involved in digitising polygons for narrow linear features such as cliffs and shore platforms (this requires zooming in to a very detailed scale in order to effectively digitise them, which in turn requires a lot of time). Hence it is likely that it will be a long time before comprehensive polygon geomorphic mapping of all coastal landforms – both soft-sediment and hard-rock types - will be available for the entire Australian coastline. In contrast, the Smartline coastal map project which this manual documents has compiled a comprehensive and considerably detailed geomorphic map of the Australian coast, including both hard and soft landform types, within a period of only two years (by rapidly importing data from a range of prior data sources and translating this into the Smartline format).

Visibility: In those few cases where narrow linear coastal landforms have indeed been mapped in a polygon format (e.g., Victorian Shoreline Types & Habitat polygon mapping – see Reference_ID 154 in Appendix One), the locations and distribution of these landforms on the maps are difficult to view unless the map is zoomed in to a very detailed scale, such that only short stretches of coast can be viewed at a time (small narrow polygons disappear as the map is zoomed out). In contrast, where the same landforms are represented as coded line segments in the Smartline format, their distribution can be readily viewed on maps zoomed out to much coarser scales, allowing their distribution along much larger stretches of coast to be viewed (since the line retains the same thickness no matter how far out it is zoomed).

The writers envisage that coastal Smartline geomorphic mapping - based on principles outlined below which aim to maximise the advantages of the format – will in future be useful for a broad range of management and research purposes beyond the coastal stability assessment purposes that are the present focus.

2.2 *Coastal Geomorphic Mapping Principles for the Smartline Format*

The Data Model and landform (geomorphic) classification system used in the Australian Coastal Smartline Geomorphic and Stability Map is based on the following principles. These principles are intended to ensure that the mapping process and final map capitalise on the advantages available from a Smartline format, and avoid wasting resources on attempting to (awkwardly) capture data which are better handled by other formats such as polygon mapping.

The key principles are:

- *The positioning of the base line-map in the shore-normal direction is not critical*. Since the line map attributes capture information about coastal landform features that are not necessarily located on the exact position of the line itself, the precise positioning of the base line in the onshore-offshore direction is not overly critical so long as it allows clear recognition of distinctive shoreline features such as bays and headlands. This allows a range of options for choosing base line maps, for example the line used can be a Mean High Water Mark (MHWM) line, a line which represents MHWM in some places but MLWM in others, or something else. However, in some coastal areas where several potential base line-maps are available but these are significantly different in form and/or widely separated (e.g., widely separated MHWM and MLWM lines along macro-tidal coasts with extensive intertidal flats), it will be necessary to select the line which is most conveniently positioned or shaped to capture the required attributes[5].

[5] For example, in a macrotidal environment with a reasonably straight MLWM line and a complex, convoluted MHWM line, it may be simpler to use the straighter MLWM line to indicate significant variations along the coast.

- *Base line-map scale and resolution is important in the alongshore direction*. Because the line map is segmented wherever any of the recorded geomorphic attributes change in the alongshore direction, it is important to locate segment ends as accurately as possible, hence the better the scale and resolution of the base-line map used, the greater the level of mapping detail that can be achieved in a Smartline.

- *The mapping of a small number of simple and broad but significant landform categories allows the optimum balance to be achieved between rapid mapping and a useful final map*. For example, the backshore, intertidal and subtidal zones are classified into only a few simple and broad slope classes in the Smartline classification detailed below. These classes are sufficiently broad that they can be quickly determined from visual estimation or automated gradient averaging across complex mapped terrains; however they usefully differentiate between significantly different coastal landform environments. For example, the few simple broad backshore profile classes defined in this manual are based on slope threshold angles which tend to correlate with transitions between low profile coastal sediment plains (typically soft erodible Quaternary sediment substrates), to gently or moderately sloping terrains (typically stable bedrock slopes), to steeper slopes over the landslide threshold angle for many materials (typically potentially unstable coastal slopes). These distinctions are very useful for a range of purposes including landform stability assessment, and are easily captured in a Smartline map. In contrast, where the intended use of a map requires measurement of gradients to within a degree, or indication of changes in gradients going inland from a shoreline, then such information would be awkward to capture and difficult to interpret in a Smartline. Such detailed topographic information is better represented by contours or digital elevation models, and the Smartline is not the appropriate map format to use for such purposes.

- *The use of hierarchical classification schemes allows geomorphic mapping at differing scales and levels of detail to be incorporated into a consistently-classified map without losing any information*. The geomorphic attribute classifications detailed in this manual (see Section 6.3) classify landforms into a small number of very broad "undifferentiated categories", but also sub-divide these into more detailed categories. This allows flexible use of available data sources – where only coarse information is available, landforms can be mapped as broad types, but where detailed information exists, that information can be captured as more detailed sub-categories. In this way a consistently-classified map can be completed for long stretches of coast despite variable-quality data being available, and the map classification will itself identify areas most in need of further more detailed mapping (i.e., those areas only mapped into the broadest categories are most in need of detailed mapping in future). On the other hand, if map data is required at a single broad level for data analysis reasons, the detailed sub-categories can easily be lumped back into the broader undifferentiated categories. An additional advantage of a hierarchical classification system is that it is generally simple to add new categories at the more detailed levels wherever new detailed mapping requires finer sub-divisions, and similarly new categories can be added at the broad level if entirely new coastal landform types are encountered[6].

- *Landform classification hierarchies used are based primarily on fabric (substrate / hardness categories) and secondarily on form (topography categories), rather than on genetic or morphodynamic classes.* The use of descriptive landform classes based primarily on broad fabric (e.g., bedrock, sand, cobbles, mud, etc) and form classes (e.g., cliff, slope, platform, lagoon, etc) provides a classification based on factual descriptive information which can usually be easily and quickly obtained from existing mapping, fieldwork and/or remote

[6] This gives the coastal Smartline geomorphic map classification described here the potential to be easily expanded to encompass [the few] coastal types not encountered in Australia, without restructuring the existing classification scheme. For example polar ice and permafrost shoreline types could be added as entirely new broad categories with whatever finer sub-divisions are needed.

sensing. Such a dataset nevertheless contains a wealth of information that can be used and interpreted in a wide variety of ways. Simply being able to map out the distribution of sandy shores as opposed to rocky or muddy shores provides information that is useful for many purposes, especially when such information is available for an entire continental shoreline.

In contrast, genetic or morphodynamic classifications – those based on determining the processes that have produced a landform - require considerably more time and effort to classify and then map. For example, it is a straightforward matter to rapidly classify a certain coastal landform as a sandy shore (or beach), but requires more collection of site-specific details for each beach to decide where that beach sits in a genetic or morphodynamic beach classification system such as that of Short (2006). Indeed, in some cases the origin of a coastal landform may be unknown or highly speculative, in which case it may be impossible or misleading to attempt to place it within a genesis-based classification system. Thus, and as previously noted by Soutberg (1990), for a landform classification system to be capable of encompassing all landform encountered (as is necessary in order to allow comprehensive mapping of all landform types encountered on long coastlines, for example), then it must be based primarily on factual descriptive criteria such as fabric and form, and can only secondarily incorporate genetic classifications since these may be unknown or uncertain for some of the features one wishes to map.

Of particular importance to the current project – that of creating a nationally-consistent landform classification and map from a diverse range of input mapping datasets – a map using a form/fabric landform classification with simple broad classes can be readily derived from a wide range of pre-existing mapped classifications, whereas a morpho-dynamic classification would require the availability of more specific information which much of the pre-existing mapping would not contain. That, the feasibility of using existing mapping to create a nationally-consistent coastal landform map for the whole Australia coastline, with as few 'unclassified' gaps as possible, is much greater if it is classified in a form/fabric system than if a morpho-dynamic or genetic classification were used.

It is a truism that any classification system for a given group of things (e.g., coastal landforms) is explicitly or implicitly designed to suit particular purposes, and that no one classification can serve all purposes. Whilst this is just as true of a fabric / form classification as of a morphodynamic one, it is also true that that the broader and simpler classifying principles used for a fabric & form classification as compared to a morphodynamic one mean that the former will be useful for a broader range of purposes than the latter.

However, and notwithstanding the above, it is in practice difficult to construct an easily-usable coastal landform classification intended for widespread use that is solely and rigorously based on fabric and form alone. Many common and widely used terms for coastal landforms are in fact genetic or morphodynamic classifications and it would potentially make a classification difficult to use and understand if such terms were avoided altogether. For example, while 'beach' is a simple and universally understood term, a beach is not merely a "sandy shoreline sediment body" but rather is generally defined as a *wave-deposited* sand body – which is a morphodynamic classification. Similarly, the term 'tidal flat' has genetic (tidal process) implications, and a rigorously fabric & form – based equivalent would be something like 'sediment flat'; however this is an unusual and not immediately recognisable term for such features, and could be confused with other non-tidal features. The solution adopted for the coastal Smartline geomorphic map is to use a landform classification which includes common and widely used genetic terms, but does so only at a lower level of classification than fabric and form. That is, the classification used here classifies coastal landforms firstly by their fabric, secondly by their form, and then subsequently by other widely-recognised categories including simple genetic or morphodynamic types such as "beach", "tidal flat", "chenier", and so forth (see Section 6.3). These lower-level classifiers may be considered as 'modifiers', and can allow the use of widely-recognised terms like "beach" within a rigorous higher-level fabric & form classification that would not otherwise allow the use of such terms. Note also that by favouring fabric over form, the classification differentiates between hard and soft coastal landform types at the primary level, which simplifies its use in identifying sensitive landform types.

- *A Smartline map can easily link to other classification databases*. Although the Smartline map format classifies landforms into primarily fabric- and form-based classes, a virtue of the format is that it is nevertheless a simple matter to link such mapping to other existing datasets which may classify or attribute coastal landforms in different or more complex ways. For example, a simple beach number attribute has been tagged to each beach line segment in the Australian coastal Smartline geomorphic map. This allows the Smartline attribute table to be directly linked to the extensive Australian Beach Safety and Management Program database (ABSAMP), which includes a morphodynamic classification of over 10,000 Australian beaches based on work by Short (2006), as well as providing other data such as access, facilities and swimming hazards. A similar linkage could be established for any other detailed classification work undertaken for various classes of Australian coastal landforms.

- *Significantly different types of things (e.g., landforms and vegetation communities) are not merged into a single hybrid classification, but rather are represented in different classifications*. It has been common practice in Australian coastal landform mapping to merge some coastal landform and vegetation classes within a single classification. For example, some coastal landform types are often described simply as “mangroves” or “salt marsh” or “sea grass beds”, while other coastal features in the same map may be classed as more properly geomorphic categories such as “rocky shore” or “sandy beach”. The problem is that mangroves, salt marshes and sea grass beds are not landforms at all – they are vegetation communities. Thus a map using both types of classification in a single layer is neither a purely geomorphic map nor a purely vegetation map, but rather a fragmented vegetation map combined with a fragmented geomorphic map.

  Whilst it may seem reasonable to use some vegetation communities as surrogates for certain landform types, such relationships may not hold true in all cases. For example, although mangroves are perhaps most characteristic of intertidal mud flats, they do also grow on relatively narrow (more sloping) shores, and on rocky and sandy coasts. So unless the physical substrate (fabric) and landform on which mangroves grow is specified, it is not strictly correct to regard “mangrove” as always indicating a certain type of coastal landform, and it can be misleading to do so. Nonetheless, it is recognised that one of the reasons for mapping certain coastal biological communities as “surrogate landforms” is because they do in fact exert strong controls on the types of landforms that develop in association with them. Thus mangroves may play a key role in trapping mud to form intertidal mudflats, and the removal of the mangroves could result in erosion of the mud and establishment of a different landform type. From many perspectives it therefore seems reasonable to regard, say, mangrove vegetation as inseparable from the landform upon which it grows, whose very existence and characteristics may be dependent on the presence of mangroves. However the problem remains that (1) such relationships may not hold true in all cases; and (2) a geomorphic classification logically should specify landform types (physical fabric and form), not vegetation types.

  One possible means of resolving the problem of whether coastal *landform* maps should depict communities such as mangrove, salt marsh or sea grass as “surrogate” landforms - or be more rigorous and only map the strictly sedimentary or geological physical substrate - would be to map both categories of information in separate attribute fields attached to each coastal landform segment. However, unless this were done in a comprehensive way – mapping all coastal vegetation communities as well as all landform classes identified – the result would be only a 'half-hearted' vegetation map attached to a more comprehensive geomorphic map. Recognising that separate mapping projects have and will continue to provide more comprehensive and focussed mapping of coastal vegetation and habitats, it is preferable to restrict the scope of a national coastal geomorphic exercise to landforms *per se*, and to utilise the vegetation and habitat maps that have been separately prepared as separate layers to be linked with or overlain on the geomorphic map as required.

Two apparent exceptions to this principle have been made in the Australian coastal Smartline geomorphic map, as follows:

- Where the only available mapping from which landform data can be extracted is mapping of "surrogate landforms" such as mangrove communities, the fact that (in this case) the presence of 'intertidal mudflats' has been inferred from maps depicting only 'mangroves' is indicated in the Smartline landform attributes.

- Coasts whose fabric comprises coralline materials (e.g., coral reef structures, etc) may be classified as 'coral' landforms; however this is done as a description of the physical material (fabric) making up the structure of the coast, and not primarily as a description of the coast as a (living) coral habitat.

- ***Smart Smartline Use:*** *The Smartline format should be used to map landform attributes which the format is well suited to capturing, but should not be used to map things that are better mapped in vector polygon or raster (grid) format*. Smartline and polygon or raster/grid map formats each have their own appropriate uses and advantages, which should be recognised and respected. Hence, rather than attempting to capture information in a Smartline format that really needs to be mapped in a polygon format, it is better to focus on using Smartline maps to capture the information types they are best suited to, and using polygon maps for data which really is best captured by that format. Trying to use the Smartline format to capture information that is better captured in polygon format merely results in complex and awkward attribute classifications which defeat the purpose of the Smartline format, namely to allow efficient capture and analysis of data.

  Figure 5 provides an example of coastal landform data that is best captured in a polygon format (namely that whereas a Smartline map can usefully record the *presence* of extensive dune fields behind a shore, actually mapping the types, extents and spatial relationships between different dune assemblages is best undertaken with polygon mapping). Similarly, whilst the Smartline format is well suited to capturing an attribute describing an averaged or generalised gradient (profile) of a coastal area, in cases where there is a need for mapping of topographic form details and variations in the coastal area, such information is much more usefully represented as contours or Digital Elevation Models (grids) than it could be represented in a Smartline format.

  The Smartline coastal geomorphic map described here is not intended to be a replacement for a longer term project of compiling polygon maps of Australian coastal landforms and Quaternary sediments, since such maps will be needed for purposes that a Smartline map cannot fulfil. The ongoing compilation of coastal landform polygon maps will remain an important need for many coastal research and management purposes. However, a Smartline map can be used for a range of *other* useful purposes, which include the urgent priority of identifying the location and extent of sensitive and potentially unstable coasts around the entire continent.

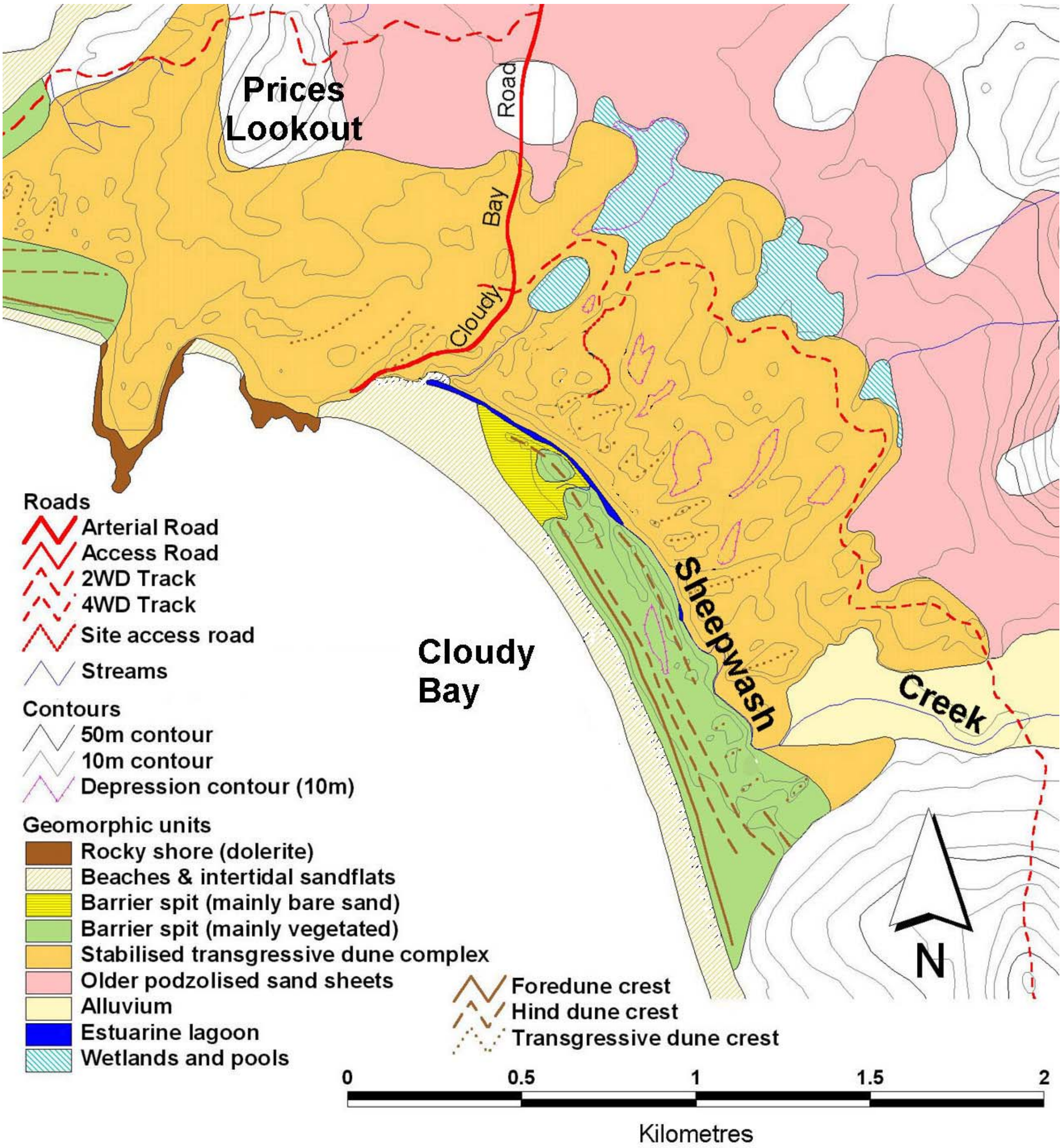


Figure 5: An example of coastal landform information which is *not* easily represented by a Smartline map. The beach at Cloudy Bay (southern Tasmania) is backed by a complex assemblage of residual hummock dunes, a foredune, parallel 'hind' dunes, a stabilised transgressive dune system, and older aeolian sand sheets still further inland. A Smartline map can easily represent the fact that (undifferentiated) dunes and sand sheets are present extending well inland behind this shore, using the *Backshore* attributes, and such information is useful for many purposes. However, using a Smartline map format to encode the details of the extents, planforms and spatial relationships between these differing dune types would be very awkward to say the least, and is best not attempted. That type of information is more appropriately represented using polygon or raster mapping.

3.0 COASTAL GEOMORPHIC CLASSIFICATION FOR THE AUSTRALIAN COASTAL SMARTLINE MAP

3.1 *Introduction*

This section provides an overview of the attribute field structure used for the Australian coastal Smartline geomorphic map. Section (6.3) following provides detailed tables of the attribute classes and codes used for each of the attribute fields.

3.1.1 Defining the Coastal Area for Smartline Mapping Purposes

The purpose of the coastal Smartline geomorphic map described by this manual is to map the landforms of the "coastal zone". However, the coastal zone is notoriously difficult to define, and a wide range of differing definitions have been used for various scientific, management and administrative purposes by a wide range of authorities (Kay & Alder 2005, p. 2). From a coastal geomorphic perspective, one possible definition of the coastal zone might be that it comprises the area in which marine wave, tidal and wind energies have significant or dominating effects on geomorphic (land-forming) processes. So defined, the "coastal zone" might extend from the effective wave base in the offshore direction, to the inland limits of wave or tidal action, of coastal aeolian sand deposition, or of tidal influences in the case of estuaries.

However, for a variety of reasons it may be difficult to locate the boundaries of the coastal zone in this fashion for mapping purposes, and for this and other practical reasons somewhat arbitrary boundaries are used for this mapping as described below. Indeed, the term 'coastal zone' itself is mostly eschewed in this manual, in order to avoid confusion with various specific (and differing) definitions of the 'Coastal Zone' that have elsewhere been enshrined in coastal planning legislation and policy instruments. In general, this manual uses the more general term 'coastal area' to refer generally to the region being mapped (see also Kay & Alder 2005, p.1).

The primary considerations used in defining the boundaries of the coastal area to be mapped using the Smartline format are the limitations of that format itself. The line format is suited to recording the attributes of features adjacent to and having a direct relationship to the (shore) line itself. However, the further one goes away from the line (onshore or offshore), the more difficult it is to say which (shore) line segment particular features relate to. Similarly, the further one looks from the line itself, the greater the diversity of the landforms encountered may become, making it progressively harder and more awkward to record these as attributes of the line using any simple classification scheme. The Smartline format is best suited to characterising a coastal area of relatively restricted width, and attempting to use it beyond that distance begins to defeat the advantages of the format. This is a situation where it becomes "smarter" to use a polygon map format to describe the extent, planform and diversity of coastal landforms extending large distances inland of the shoreline.

For the purposes of the Australian coastal Smartline geomorphic map, a distance of 500 metres offshore and inland of the shoreline represented by the Smartline (usually MHWM) has been adopted as a semi-arbitrary limit to the coastal area being mapped. While landforms of a distinctively coastal origin such as transgressive dunes or coastal wetlands may extend well over 500 metres inland in many parts of the Australian coast, incorporating information about such features into a Smartline map is likely to become more awkward with increasing distance and potentially greater diversity of landforms going inland. Whilst the adoption of a 500 metre inland "cut-off" to the coastal area as mapped by the Smartline will result in some distinctively coastal landforms being omitted from the Smartline map in some coastal regions, nevertheless a good characterisation of the landforms associated with the shoreline and broader coastal area will normally be achieved. The further mapping of wider coastal landform areas is a task better undertaken with polygon mapping.

3.2 *Overview of the Coastal Smartline Geomorphic Map Classification*

3.2.1 The Geomorphic Attribute Fields

This sub-section provides a brief outline of the purpose of each coastal geomorphic attribute used in the Australian coastal Smartline geomorphic and stability map. These attributes are based on an attribute system initially used by Sharples (2000, 2006a, b) for the Tasmanian Shoreline Geomorphic Types map, which has been modified in order both to encompass the broader range of coastal landforms found around the Australian continent, and also to implement a number of desirable improvements that have become apparent from over six years experience of using the original classification in Tasmania (Sharples 2006a, b). Elements of the OSRA Shoreline Types mapping system (Wardrop & Ball 2000) have also been incorporated.

The coastal geomorphic mapping system described here is based on the principle of describing and mapping coastal landforms in terms of the dominant landform types found in each of a series of shore-parallel tidally-defined zones (i.e., subtidal, intertidal, backshore). Landforms found in each zone are classified using a hierarchical system of simple descriptive categories based firstly on fabric (substrate, composition), secondly on form (broad topographic classes), and thirdly on modifiers which may include commonly used genetic or morphodynamic classes. The coast is digitally mapped as a single line (whose precise positioning is not critical but may typically be a Mean High Water Mark line). The line is segmented in the alongshore direction wherever a significant coastal landform change occurs, and each segment is attributed with fields describing the landforms in each of the shore-parallel tidally-defined zones adjacent (normal to) that particular segment.

The rationales behind much of this Smartline mapping system have been described in the preceding Section (2.0). As noted above a primary element of the system is the description of landforms in terms of a series of shore-parallel tidally-defined zones, namely the subtidal, intertidal and backshore zones. Since tidal zonation is a feature of virtually all coasts, this provides a logical basis for a nationally-consistent coastal landform classification. By their nature, the differing wave, wind and tidal processes affecting each tidal zone tend to produce distinctive and characteristic coastal landform types within each zone; hence description of the geomorphology of a stretch of coast requires characterisation of the landforms found in each tidal zone of any given coastal segment. The simple way to achieve this in a Smartline map format is to provide separate attribute fields to classify the landforms of each tidal zone for each coastal segment. The definitions used to delineate each tidal zone for the purposes of the Australian coastal Smartline geomorphic map are as follows (see also Figure 6):

Subtidal — Areas permanently inundated by the sea; i.e., areas below (seawards) of the Mean Low Water Mark.

Intertidal — Areas regularly but not permanently inundated and washed by waves; i.e., areas extending from Mean Low Water Mark to the upper limit of wave-wash sufficiently frequent as to prevent establishment of terrestrial vegetation (due to wave run-up and storm activity, this limit generally lies a little above the astronomical high tide line or MHWM).

Backshore — Areas never or only infrequently inundated or washed by waves; i.e., areas to landwards of or above the Intertidal Zone. This zone is taken to include Supratidal Zones where these are significant[7]. The backshore zone is defined to extend an arbitrary distance of 500 metres inland of MHWM for the purposes of the Smartline mapping described here.

[7] For the purposes of this mapping, Supratidal Zones are defined as areas only occasionally inundated or washed by waves. These are generally areas inundated during infrequent large storm surges, and may cover large areas on macro-tidal and/or low profile coasts, but may be of limited or negligible extent on moderately sloping and/or micro-tidal coasts.

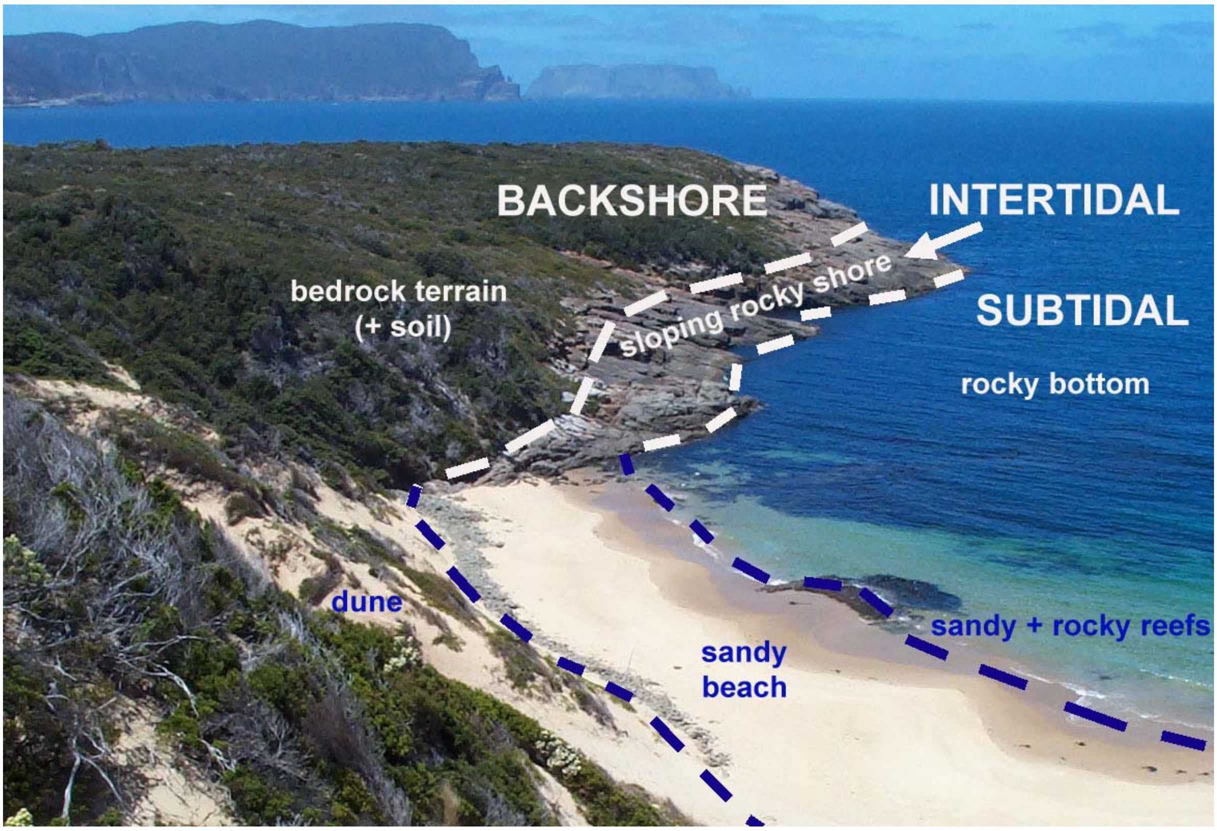


Figure 6: Example shoreline illustrating the division of the coastal area into tidally defined 'Subtidal', 'Intertidal' and 'Backshore' zones. Tidal zonation is a virtually universal coastal phenomenon which divides coasts into linear shore-parallel zones, each with distinctive landform types resulting from differing exposure to marine and terrestrial processes. These zones can easily be used as a basis for describing the complexities of a coastal landform assemblage by representing the landforms of each zone as multiple attribute layers tagged to a simple Smartline GIS polyline map format.

The landform types in each of these tidally-defined zones are described using two attribute fields or 'themes' to record both dominant and secondary or additional landform types or components in each zone, plus an additional attribute indicating the average slope or profile of each zone. The system of using two landform type attribute fields ('themes') to describe the landforms of each tidal zone acknowledges that coastal landforms are not always simple and homogeneous types, but may be assemblages of differing components (e.g., a rocky shore platform protruding from a sandy beach). The system described here allows an enormous range of possible landform types and assemblages to be defined using permutations of two classes from a relatively simple attribute table. This is simpler and more flexible than the alternative method of using a single landform attribute field for each zone; in which case a much longer and more complex classification of potential classes would be needed to capture the full range of coastal landform types and assemblages actually present on Australian coasts.

Several further attributes used in the Australian coastal Smartline geomorphic map describe other attributes relevant to the geomorphology of each coastal segment, including exposure (to swell wave energy) and geology (bedrock type).

The geomorphic attributes are of two fundamental types, namely *Geomorphic System Control Classifiers* and *Geomorphic Type Descriptors*. The distinctions between these are:

Geomorphic System Control Classifiers describe independent variables that have controlled the development of coastal landforms in each coastal segment, but are themselves determined by processes independent of the coastal processes currently operating in the segment. In the Smartline these are primarily the bedrock geology and in many cases the backshore profile (each produced by processes preceding the development of the present coastline). Other variables such as wave and wind climate, tidal range and vertical tectonic movement are also coastal geomorphic system controls which could in principle be incorporated as Smartline attributes, however these are not included in the current Australian coastal Smartline map and are probably better dealt with as independent datasets (see also Section 3.2.2 discussions). Other attributes such as biological character could also be considered as geomorphic system controls in part (since they can influence coastal landform development), albeit these are not entirely independent controls since they in turn may depend on certain geomorphic types being present on the coast, and more-over are also better dealt with as separate independently mapped datasets.

Geomorphic Type Descriptors describe the landforms that have actually been produced by coastal processes in each coastal segment, in response to the particular mix of geomorphic process controls exerted by the geomorphic system controls affecting each coastal segment. Such descriptors include the subtidal, intertidal, supratidal and backshore landform attributes described below.

A brief explanation of each coastal geomorphic attribute used in the mapping is outlined below; see also Section (6.0) for more detailed descriptions of these attributes including data models and attribute tables (lookup tables). Note that the somewhat cryptic field names used for each attribute field (given in italics below) are designed to be compatible with the limited field name lengths available in ESRI shapefiles.

Figure 7 and Figure 8 provide schematic illustrations of the application of these attributes to uniquely describing a variety of shoreline types.

Backshore Landforms (including Supratidal)
The backshore zone is broadly defined for the purposes of this mapping as the coastal area never or only infrequently inundated or washed by waves; i.e., areas to landwards of or above the intertidal zones. For the purposes of this mapping, the backshore zone includes supratidal zones, which are areas occasionally but only infrequently inundated or washed by waves (generally areas inundated during infrequent large storm surges). Supratidal zones may cover large areas on macro-tidal and/or low profile coasts, but may be of limited or negligible extent on moderately sloping and/or micro-tidal coasts.

For the purposes of this mapping, coastal backshore landforms may be described to a nominal distance of 500m inland of the Mean High Water Mark (MHWM). As such the “backshore” zone includes environments that could be characterised as “terrestrial” or “hinterland”. That is, the term “backshore zone” as used here includes both areas above MHWM that are influenced directly by coastal processes (e.g., coastal dune fields and supratidal saltmarsh or saltpans), and also areas whose landforms are primarily terrestrial in origin (e.g., bedrock ± soil slopes inland of the intertidal zone).

The original shoreline geomorphic types classification used in Tasmania provided only one attribute to describe the landform classes to landwards of the intertidal zone field (*Backshore*: Sharples 2000, 2006a, b), however this system has tended to require a complex attribute table where a sequence of several significant landform types is present in the backshore zone (for example, foredunes backed by a coastal lagoon or by an extensive prograded beach ridge plain). Experience with the Smartline mapping format has shown that this sort of backshore landform diversity can more easily be described using two backshore landform ‘themes’ (fields), to describe respectively the first significant landform type to landwards of the intertidal zone (*proximal* backshore landforms), and the dominant distinctive landform type(s) inland of that first landform (*distal* backshore landforms). This is a slightly different approach to that used for the intertidal and subtidal zones, where landform complexity is captured using a ‘dominant’ feature theme (*Intertd1* & *Subtid1*) and a ‘sub-ordinate’ feature theme (*Intertd2* & *Subtid2*) to describe multiple landform components within the intertidal and subtidal zones.

In contrast to intertidal and subtidal zones, it is a characteristic feature of backshore zones that the first (*proximal*) landform inland of the intertidal zone is commonly a feature distinctive of coastal processes (e.g., a cliff or foredune), whilst *distal* features further to landwards may or may not be of characteristically coastal origin (e.g., a bedrock terrain of dominantly terrestrial origin vs. a dune field of distinctively coastal origin). Hence in the case of backshore landforms it is more useful to have a system capable of identifying the distinctive *proximal* landforms, as well as characterising the dominant landform types in the backshore zone as a whole by using a *distal* landform type attribute for this purpose (which may or may not be the same as that found in the proximal part of the backshore zone).

Nonetheless it should be noted that whereas a distinctive *Backshore proximal* landform is a characteristic of many coasts, such a distinctive feature is not necessarily always present. For example some backshore zones may comprise simple bedrock terrain ± soil (of essentially terrestrial origin) in both the proximal and distal areas, in which case the *Backshore proximal* and *distal* attributes will be the same.

The backshore landform attribute fields used in the Australian Coastal Smartline Geomorphic and Stability Map are defined and described as follows:

Backshore landforms – Proximal (*Backprox*)
The first notable landform type or assemblage present immediately to landwards of or above the intertidal zone (may include supratidal landforms). On sandy shorelines this is typically a foredune, whereas on rocky shorelines it might be a sea cliff or simply a sloping bedrock slope with a soil mantle. The width of the proximal backshore zone is not defined – it depends on the scale of the proximal landform. See attribute table 6.3.3.

Backshore landforms – Distal (*Backdist*)
The dominant distinctive backshore landform type or assemblage inland of the proximal backshore landform (may include supratidal landforms). Backshore landforms may be classified for the purposes of this mapping to a distance of 500m inland. For example on a sandy shore where the proximal backshore landform is a foredune immediately behind the beach, then the distal backshore landform might be a lagoon[8], a field of further dunes or beach ridges behind the foredune, or simply a bedrock and soil slope where only a single foredune is present behind a beach. Where the proximal backshore landform type extends inland to over 500m (i.e., the backshore proximal and distal landforms are of the same type), the *Backdist* attribute may be the same as the *Backprox* attribute (e.g., on a rocky shoreline where the proximal backshore landform is a sloping bedrock and soil slope, the "distal backshore landform" will commonly be simply a continuation of the same thing). The distal backshore attribute may have an unclassified value in cases such as narrow tombolos or necks where only one backshore landform intervenes between two shorelines. See attribute table 6.3.3.

[8] In cases where supratidal saltmarsh is connected to the sea via channels cutting through dunes, the backshore proximal landform may be a dune, and the backshore distal may be a supratidal saltmarsh.

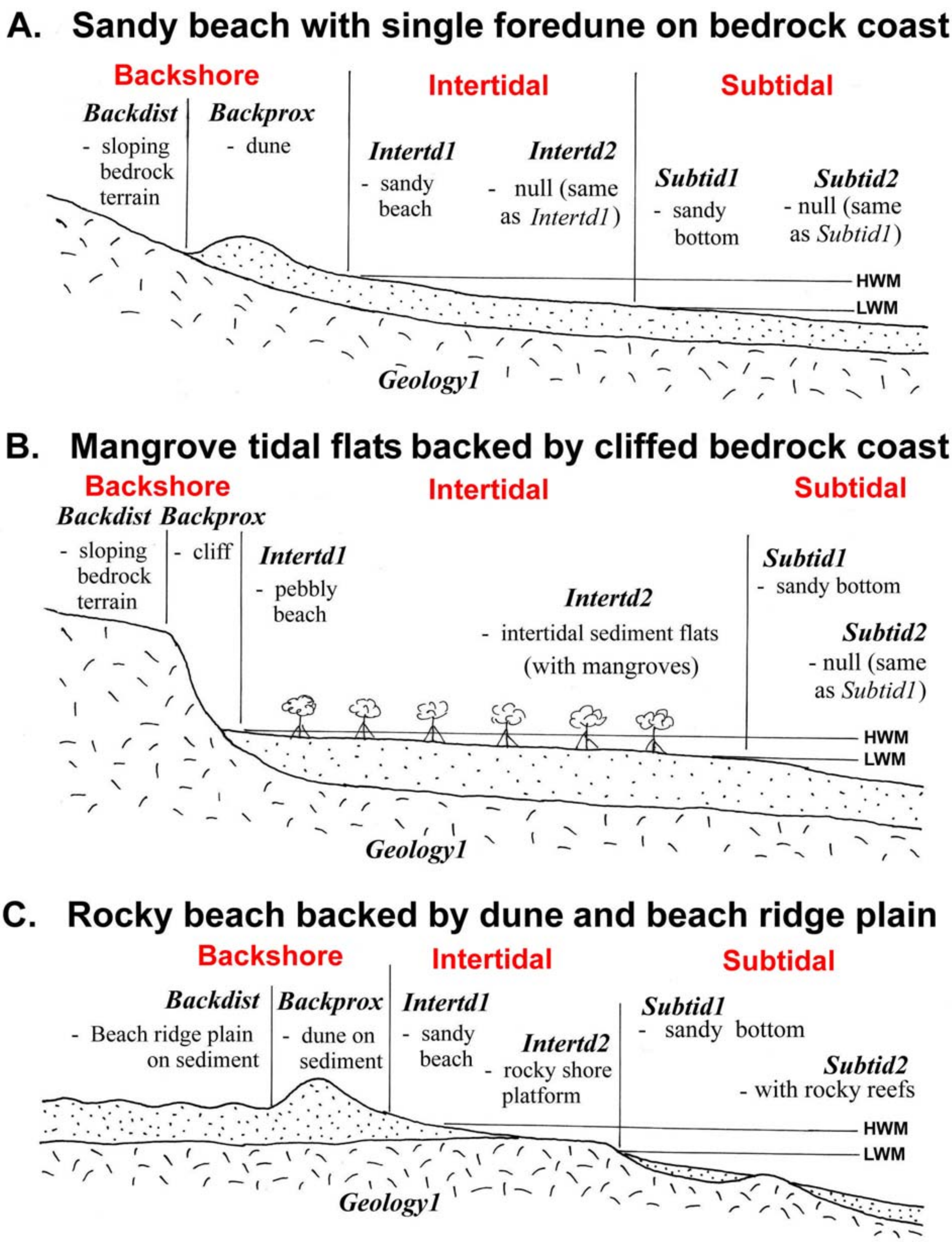


Figure 7: Example coastal profiles, illustrating how the coastal landform classification attribute fields described here, based on simple shore-parallel tidal zones, can describe a diversity of physical (geomorphic) coastal types (see also Figure 8 & Figure 9 & Figure 10). In the attribute table attached to the GIS line map, the line segments representing each of the above coastal types would be attributed with the indicated landform types (as numerical codes and brief verbal descriptions) for each of the indicated attribute fields (*Backdist*, *Backprox*, etc). For clarity, other attributes such as exposure and the profile or slope attributes for the Backshore and Intertidal Zones are not illustrated here.

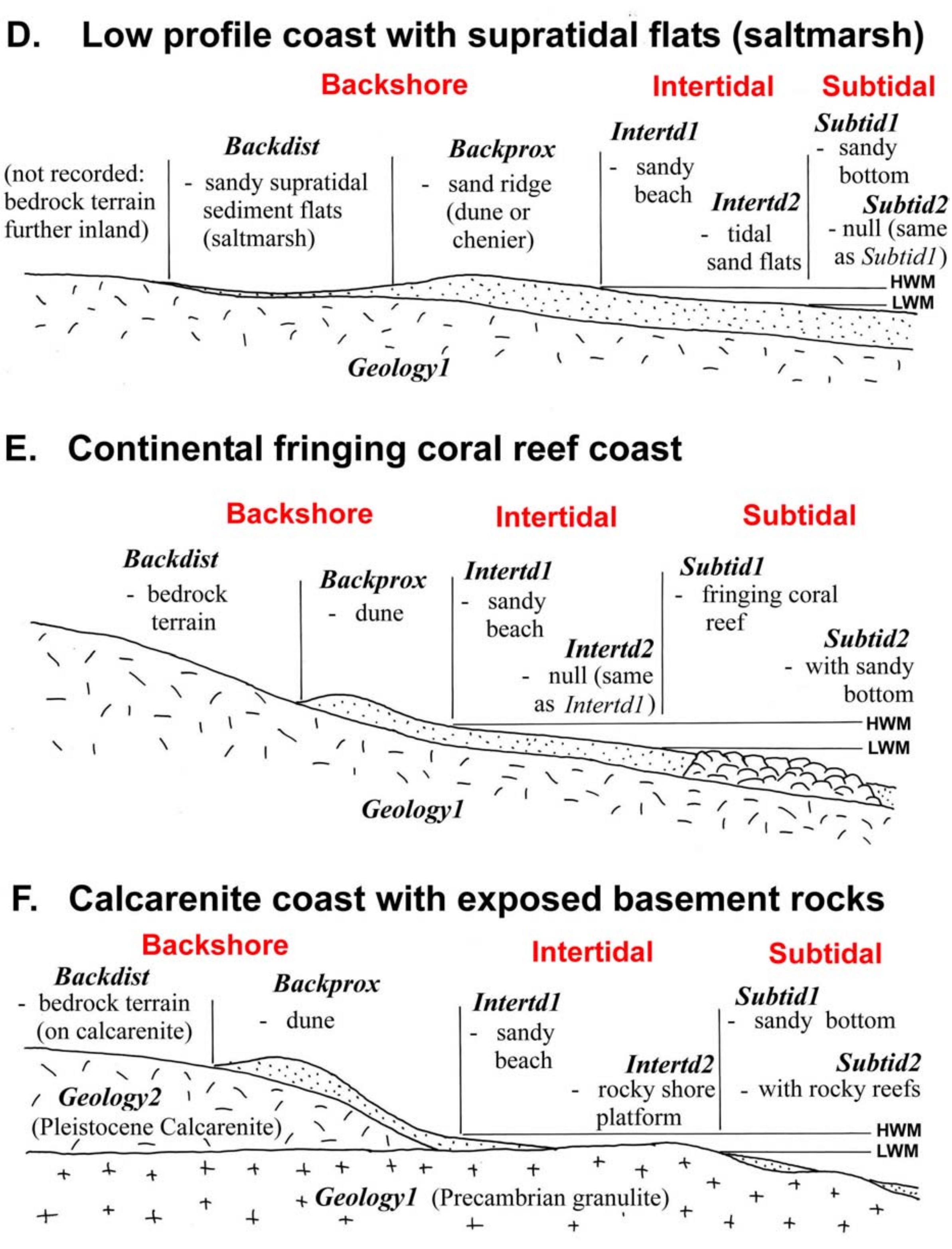


Figure 8: Example coastal profiles illustrating the use of the coastal Smartline geomorphic attribute fields, based on simple shore-parallel tidal zones, to descriptively classify a variety of physical shoreline types (see also Figure 7, Figure 9 & Figure 10).

Backshore profile ***(Backprof)***
This is the generalised topographic profile gradient of the coastal area extending landwards from the inland limit of the intertidal zone. By convention this is the averaged slope of the backshore terrain extending inland to the first major high point beyond which the terrain slopes significantly down going further inland, or the averaged slope to a point 500 metres inland, whichever is the lesser distance. Backshore profile is categorised into a small number of simple categories which broadly distinguish significantly different backshore geomorphic environments. This attribute usefully distinguishes low-lying coastal flats (typically shores backed by soft erodible and flood-prone low Holocene coastal deposits) from shores backed by moderately or steeply sloping bedrock terrain (typically terrain dominated by fluvial processes and with low exposure to marine erosion or flooding). The moderately-sloping backshore profiles commonly represent low-hazard terrain, whereas steeper backshore profile categories highlight terrain where slope instability is more likely to be a hazard.

Foredune heights are intended to be ignored by convention for the purposes of this attribute, such that a coast having a high foredune fronting an extensive low-lying beach ridge plain will be classed as having a low backshore profile.

This attribute theme includes one category which is defined differently to the others – namely high sea cliffs rising near-vertically to over 50 metres above the intertidal zone – on the grounds that such coasts have such a distinctive backshore profile that their specific identification is more useful for coastal mapping purposes than an averaged profile would be (e.g., the averaged profile of a 50m high sea cliff topped by flat ground could give a quite misleading indication of a quite moderate or even low-gradient overall backshore profile). The definition of high sea cliffs as being those over 50m high is based on the criterion for high cliffs adopted by Wardrop & Ball (2000, p. 22). See attribute table 6.3.4.

Intertidal Landforms
The intertidal zone is defined for the purposes of this mapping as areas regularly but not permanently inundated and washed by waves; i.e., areas extending from Mean Low Water Mark to the upper limit of wave-wash sufficiently frequent as to prevent establishment of terrestrial vegetation (due to wave run-up and storm activity, this limit generally lies a little above the astronomical high tide line).

A Smartline – precursor shoreline geomorphic mapping convention previously used by Sharples (2006a,b) provided two attributes to describe landform types of the upper and lower intertidal zone (*Upperint* and *Lowerint*). However in many cases this distinction between upper and lower intertidal zone landforms has proven somewhat arbitrary and misleading, with many intertidal landforms that were classified in one or the other of these zones (e.g., beaches and rocky shore platforms) actually spanning both zones. Nonetheless, many intertidal zones do exhibit several significantly different landform components within the same shoreline segment – for example, sandy beaches with rocky shore platforms protruding – and a useful descriptive classification should to be capable of encompassing this complexity. The approach adopted here is to retain two descriptive attribute theme fields for the intertidal zone which can each describe different significant elements of the intertidal zone of a given shoreline segment. These may describe upper and lower intertidal zone landforms or they may describe two landform components having a more complex spatial relationship. Where only one significant intertidal landform type or element is present in a particular shoreline segment, that class will be recorded as the primary intertidal landform element, and the other intertidal attribute field will be "unclassified". The two intertidal landform attribute fields or 'themes' are:

Intertidal zone landform element 1 (*Intertd1*)
The uppermost, dominant or only intertidal landform element. Must be either a landform type or "unclassified" (never a null record). See attribute table 6.3.5.

Intertidal zone landform element 2 (*Intertd2*)
The lower, secondary or additional intertidal landform elements. This may be an "unclassified" record if intertidal element 1 adequately describes the intertidal zone. See attribute table 6.3.5.

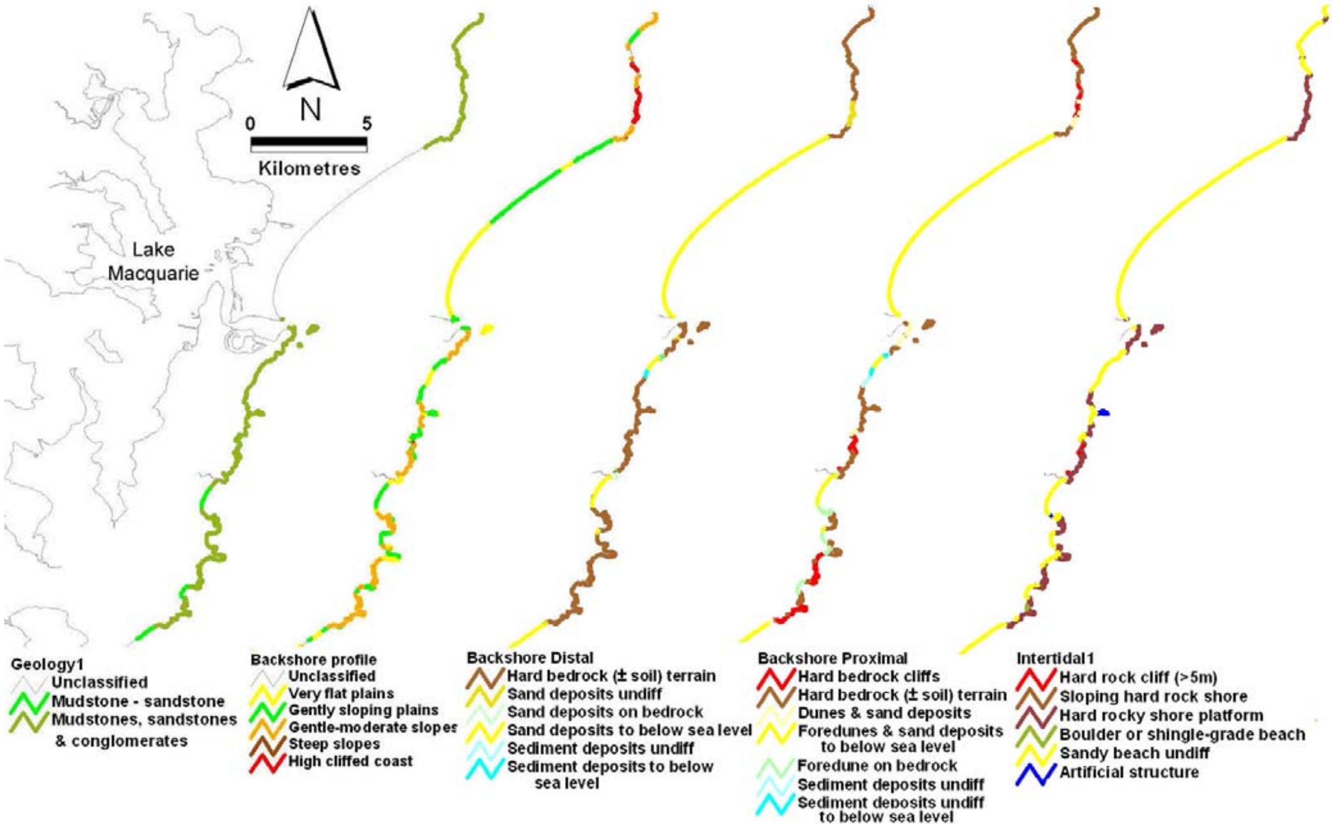


Figure 9: Example of the multiple layers of information captured in a coastal Smartline map for Lake Macquarie open coast (NSW), displaying some (but not all) of the attribute layers which permit a great deal of geomorphic information to be captured for each coastal segment. Compare with Figure 7 & Figure 8.

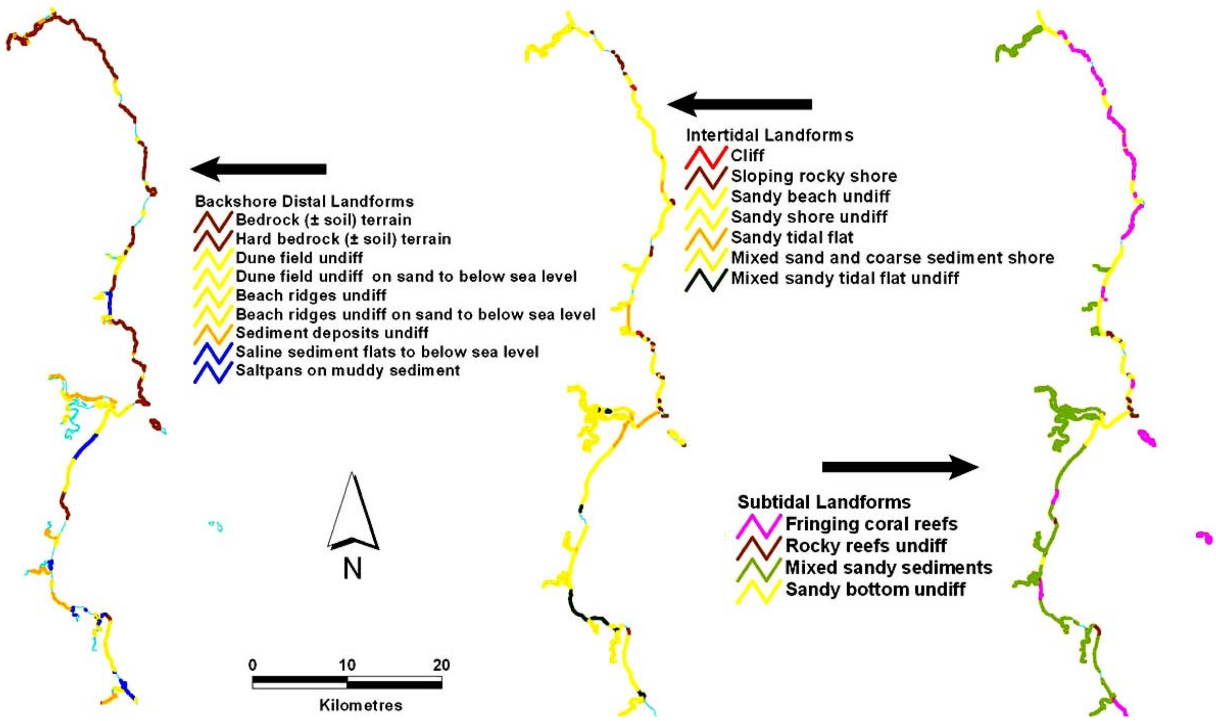


Figure 10: Example of a coastal Smartline map for Cape Tribulation area (Qld) showing some (but not all) of the attribute layers which permit a great deal of geomorphic information to be captured for each coastal segment. Compare with Figure 7 & Figure 8. Note that only one of the two attribute layers for each of the Backshore, Intertidal and subtidal layers is depicted here; additional information is also captured for this coastal stretch in the Backshore Proximal, Backshore Profile, Intertidal2 and other attribute layers not depicted here.

Intertidal Zone Slope (*Intslope*)
Slope of the intertidal zone, defined as the average broadly-categorised slope between the high and low water tide lines. This attribute is categorised into a small number of simple broad classes based on beach and rocky intertidal shore gradient classes previously proposed for oil spill response mapping purposes by Wardrop & Ball (2000, p. 22). Because many soft intertidal zones (e.g., beaches) may frequently change their profiles and slopes in response to storms and seasonal or longer changes in wave action, it would be meaningless to define precise intertidal slope angles for the purposes of this type of mapping. Instead, the purpose of this attribute is to draw broad (but useful) distinctions between very low angle intertidal zones (e.g., broad tidal flat coasts), narrower and moderately sloping shores, and steep or very steep shorelines. Ideally the intertidal zone classes should be determined by field inclinometer measurements or the use of a high resolution LiDAR - derived DEM. However where these methods are impractical, the simple slope classes are broad and distinctive enough to be usefully and quickly classified by simple visual estimation using air photos or other imagery. The purpose of these classes is to draw broad distinctions between very low angle intertidal zones (e.g., broad tidal-flat coasts), narrower and moderately sloping shores (e.g., many beaches, sloping rocky shores), and steep or very steep shorelines (e.g., cliffed or slumping shorelines). See attribute table 6.3.6.

Subtidal Landforms (substrates)
The landforms or substrate types dominating the near-shore subtidal zone. The subtidal zone is defined for the purposes of this mapping as areas permanently inundated by the sea; i.e., areas below (seawards) of the Mean Low Water Mark. The area considered relevant to this attribute may extend to a nominal 500 metres horizontally offshore, however the main intention is to record the substrate and landform types dominating the zone immediately below and seawards of the intertidal zone. No subtidal landform attribute was used in the precursor Tasmanian shoreline geomorphic mapping (Sharples 2006a, b); however in practice the landform types described by the lower intertidal attribute (*Lowerint*) actually included shallow subtidal landform types.

Subtidal landforms in this near-shore zone may include rocky substrates, rock or coral reefs, sandy or muddy bottom slopes, and complex mixtures of any of these or others. A useful descriptive classification ought to be capable of encompassing this complexity. The approach adopted here is to use two descriptive attribute theme fields for the subtidal zone which can each describe different significant landform or substrate elements of the zone for any shoreline segment. Where only one significant subtidal landform type or element is present in a particular shoreline segment, that class will be recorded as the primary subtidal landform element, and the other intertidal attribute field will be a null record. The two intertidal landform attribute theme fields are:

> **Subtidal zone landform element 1 (*Subtid1*)**
> *The dominant, co-equal or only subtidal landform element*. The map attribute must record either a landform type or “unclassified” (never a null record). See attribute table 6.3.7.
>
> **Subtidal zone landform element 2 (*Subtid2*)**
> *Secondary, co-equal or additional subtidal landform elements*. This field may be an “unclassified” record if the primary subtidal element (*Subtid1*) adequately describes the subtidal zone. See attribute table 6.3.7.

During the 2007-2009 Smartline project, subtidal landform (substrate) information was regarded as lower priority for the purposes of the project, and was only obtained for limited parts of the Australian coast. However, since much of the relevant data is available as physical habitat mapping, and since a parallel project has compiled a consistently-classified subtidal habitat map in polygon format for most of Australia (Mount *et al.* 2007), it will be relatively simple to derive the subtidal data needed for the Smartline from this habitat mapping, as a future exercise to upgrade the Smartline map.

Subtidal Zone Slope
No subtidal zone slope attribute was created during the 2007-2009 Smartline project, due to lack of suitable readily usable data, difficulties determining appropriate subtidal slope classes, and a perceived lower priority for this attribute. However, it is recommended that a Subtidal Zone Slope attribute be added to the Australian Coastal Smartline map in future (see Section 3.2.2 "Other Potential Attribute Fields" below).

Shoreline segment exposure (*Exposure*)
Degree of exposure of the shoreline segment to the oceanic swell and storm wave energies impinging on the broader coastal region as a whole. This attribute is categorised into only four broad categories (High, Moderate, Low & Very Low exposure), and is not a measure of the wave energy impinging on the shore, but rather of the degree to which the particular shoreline segment is exposed to whatever (oceanic) wave energies impinge on the broader coastal region as a whole. The actual wave energy reaching the shoreline segment is thus a function of both regional wave energy and of exposure to that wave energy (*Exposure*). Thus the wave energy reaching a "high" exposure shoreline on a high energy coast will be greater than the wave energy reaching a "high" exposure shoreline on a lower energy coast.

The exposure categories are classified in terms of the degree of exposure or sheltering of a coastal segment from the predominant oceanic swell and storm wave approach directions for that coast. See attribute table in section (6.3.8). By convention the shores of tidal re-entrants such as coastal lagoons and 'sheltered' estuaries are classed as 'Very Low' exposure where there is no significant penetration of swell or oceanic storm waves into the inlet, even where the interior width of the inlet provides sufficient fetch for large erosive wind-waves to be generated within the inlet during storms. In effect, the 'Low', 'Moderate' and 'High' exposure classes identify open-coast shores, while the 'Very Low' class identifies the shores of coastal re-entrants, tidal lagoons and many estuaries. Note that whilst not exposed to oceanic swells or oceanic storm waves, these shores may nevertheless be highly exposed to other energetic coastal processes such as tidal currents and locally-generated wind waves.

For the present purposes of this coastal Smartline geomorphic map, the exposure attributes used are mainly those that were previously mapped for the OSRA Shoreline Types mapping of Australian coasts. However, it is likely that different mappers in different states have used slightly different assumptions in defining their exposure categories. Hence, it would be preferable at some future time to re-map exposure categories by defining a consistent methodology for defining exposure categories for the whole Australian coast. Ideally, these categories should be defined with respect to not only a single dominant swell or storm wave direction for each coastal region, but rather with respect to all major swell and storm wave approach directions affecting each coastal region (noting that these directions are significantly different in different parts of the Australian coast). Thus, for any given coastal region, all shoreline segments directly exposed to any of (potentially several) significant wave approach directions would be classed as 'high' exposure, and only those shoreline segments that are sheltered from all significant wave directions would be classed as 'low' exposure (sheltered). It is likely that current CSIRO Marine Division modelling of wave climates for the entire Australian Coast (Hemer *et al.* 2008) will provide a useful basis for future remapping of exposure attributes to a nationally-consistent standard.

Note however, that since wave exposure datasets (based on swell wave modelling and fetch modelling) are indeed currently being developed, and are likely to undergo further improvement, it may in future be desirable not to include *Exposure* as a Smartline attribute at all, but rather to 'overlay' the Smartline geomorphic data on independent exposure datasets when and as required. See further comment in Section (3.2.2) below.

Geological Substrate Type(s)
The 'geological substrate' attributes identify the bedrock or geological substrate type(s) which were present prior to development of the present shoreline (even if only by a geologically-brief prior

interval, as may be the case with calcarenite coastal substrates in Australia), which are not actively being formed by ongoing coastal processes, and into which the present shoreline has been eroded, or over which coastal sediments have been deposited. That is, the geological substrate attribute identifies geological factors which have exerted a control on the type of shoreline landforms which have developed. As such, the geological substrate need not comprise only hard lithified rocks (although that is normally the case), but may also comprise soft, semi-consolidated or weathered materials, provided that these were present prior to development of the present shore, and that their characteristics have thus influenced the development of the shore rather than having been primarily produced *by* the development of the shore. Thus, substrates including semi-lithified Tertiary-age clays, thick lateritic regolith, some Pleistocene sediment deposits such as calcarenites, and even uplifted coral reefs, coralline breccias or phosphatic guano deposits may constitute the geological substrate on some coasts for the purposes of this mapping. Only the geological substrates exposed in the shoreline zone or those immediately underlying coastal sediments are recorded; any older bedrock types underlying these are not recorded.

On the other hand, for the purpose of this classification hard lithified rocks deposited on the coastline by ongoing or recent coastal processes (e.g., carbonate beachrock) are not considered to be the geological substrate or 'bedrock', since they are a *product* of ongoing coastal processes rather than an independent control on coastal development. These features are classified as coastal landforms, but not as geological substrates.

Geological substrate classes are categorised into a relatively small number of broadly-defined "litho-structural" types characterised by the constituents and fabric of the rock (lithology) and the structures of the rock (fracturing, bedding, folding, etc). It is these characteristics (rather than the ages or stratigraphical relationships of the bedrock units) which influence the coastal landforms that develop on the geological substrate. Note that it is the utility of a simple litho-structural geological classification for geomorphic and coastal stability mapping purposes which are the reason why this attribute is recorded in the Smartline geomorphic map, rather than simply expecting users to refer to separate existing geological mapping to obtain this information. Most available geological mapping utilises primarily litho-stratigraphic geological classifications; these have needed to be lumped together to produce litho-structural categories in the process of Smartline map compilation, and hence constitute a derived dataset designed to suit the purposes of the Smartline map, not simply a copy of the original geological mapping.

Geological substrate is an important control on coastal landform development, whether or not the bedrock is actually exposed on the present shoreline. For example, areas of relatively erodible bedrock are likely to develop low-profile coasts overlain by Quaternary deposits and soft sandy or muddy coasts, whereas less erodible bedrock types may develop rocky or cliffed coastal forms. Where bedrock is exposed at the coast, the character of the coastal landforms may be strongly determined by the bedrock type (e.g., granite rocky coasts typically exhibit very different forms to sandstone rocky coasts).

Because geological substrate type is significant as a geomorphic system control – and not only as a feature of the present-day shoreline – underlying geological substrate types are recorded even where not exposed (e.g., underlying sandy beaches), provided that they can be reasonably inferred from regional geological mapping, drilling or other data such as geophysics. However, this field may be left unclassified where no reasonable inferences can be made as to the underlying geological substrate.

Despite the convention adopted (above) of generally using the Smartline to map coastal landforms to 500 metres inland and offshore, the geological substrate is mapped as that substrate underlying the shoreline itself (i.e., the shallowest subtidal, intertidal and backshore proximal zones). Where different geological substrates underlie parts of the backshore distal zone further inland or the subtidal zone further offshore, these are ignored since it is the influence of geological substrate on shoreline development that is generally of most interest in coastal geomorphology[9].

Although the majority of shorelines will have only one type of geological substrate relevant to this classification, in some cases two distinctly different geological substrates may be present and exposed in the shoreline zone, both of which may have influenced coastal landform development and thus both of which ideally require mapping for the purposes of Smartline geomorphic mapping. A common example on Australian shores is the situation where an older bedrock type is exposed in the intertidal zone, but is immediately overlain by younger lithified aeolian calcarenites exposed in the backshore zone (see Figure 8F). In this case, both rock types are influencing coastal landform development and should both be identified as geological substrates. This complexity is dealt with in the Smartline classification through the use of two attribute theme fields for geological substrate (see below). In the example of calcarenite shores, both attribute fields would be used where calcarenite backshores overlie older bedrock exposed in the intertidal zone, however where calcarenite is the only geological substrate exposed in or immediately underlying the near subtidal, intertidal and backshore zones, then only calcarenite would be recorded as the primary geological substrate, with the secondary geological substrate theme field recording an "unclassified" value.

The two geological substrate theme fields are as follows:

> **Primary Geological Substrate (*Geology1*)**
> *The only or lowermost geological substrate (bedrock) type exposed on or underlying the shoreline zone*. The geological substrate (geological material present prior to development of the present-day shoreline) immediately underlying and/or exposed in the near-shore subtidal, intertidal or backshore zones. Where two significantly different geological substrates are present in a vertical sequence, the primary geological substrate is the lower or underlying geological substrate. Where the geological substrate is unknown, this field may have an "unclassified" value. See attribute table 6.3.9.
>
> **Secondary Geological Substrate (*Geology2*)**
> *Secondary or superficial geological substrate (bedrock) overlying a primary geological substrate (bedrock) type.* This attribute is used where two significant – and significantly different - geological substrates are exposed or immediately underlie soft superficial coastal sediments in a vertical sequence in the shoreline zone. Where no secondary type is present or known, this field may have an "unclassified" value. See attribute table 6.3.9.

Note that where two different geological substrates adjoin each other in the horizontal alongshore direction, then it is normally appropriate to split the Smartline into two differing segments on this basis. Where two distinctly different rock types are intermingled on scales too small to map (e.g., narrow igneous dykes intruding sedimentary rock), then either the dominant type only is mapped, or the geological substrate class is defined as being the mixture of the two types (e.g., 'igneous dykes intruding sedimentary rocks').

In Australia, two of the most common situations in which secondary geological substrate attributes are useful occur where either lithified aeolian calcarenite limestones (common on the western and southern shores of Australia) or eroding lateritic regolith profiles (common in northern Australia) outcrop in or underlie the backshore zone, but are themselves underlain by older bedrock types which are exposed in the intertidal and/or subtidal zones. However this attribute may also be useful in cases where two quite different older bedrock types are exposed in the shoreline zone (for example near Deep Glen Bay in Tasmania, where Permian-age siltstones (*Geology2*) form sea cliffs rising above underlying Devonian granites (*Geology1*) that are exposed at the high water line but only up to a few metres above sea level.

[9] Again, where information on more complex geological substrate relationships is required, a polygon map is a smarter way to provide this information than the Smartline.

Artificial Shorelines
Shorelines having artificial components (e.g., revetments), and shorelines which are wholly artificial (e.g., some port facilities) are described using appropriate descriptive attributes within the Backshore, Intertidal and Subtidal attributes fields, as for natural coastal landform features (see Sections 6.3.3, 6.3.5 & 6.3.7 for classification of artificial shore attributes within these fields, and Section 6.3.2 for relevant mapping conventions).

3.2.2 Other Potential Attribute fields

Other potential attribute fields for which meaningful data could theoretically be provided in a Smartline coastal map include *wave energy* (e.g., quantified as some index of wave height), *tidal range*, *wind regime*, *biological character*, *vertical tectonic movement*, and a range of other variables which relate to coastal geomorphic *processes*[10]. However, these have not been included in the Smartline Data Model for the following reasons:

- Most of these attributes are not so much descriptors of the landform types actually present on the coast, but rather are descriptors of the processes and energies that drive coastal geomorphic processes. The Smartline mapping project has been focussed simply on identifying shoreline geomorphic *types* that are potentially sensitive to physical impacts from climate change and sea-level rise, as a "First Pass" stage in coastal stability assessment. Consideration of the energies available to *drive* such impacts is logically a further distinct "Second Pass" stage of coastal stability assessment. As such, these variables will be very significant considerations in coastal stability studies beyond the "First Pass" level, but were not required for the immediate purposes of the Smartline project.

and:

- Data on most of these variables is available, or is being created, by other workers as separate models and datasets independent of this coastal Smartline map. These datasets can be overlain and intersected or linked with the Smartline map as required. Moreover, most of these datasets are undergoing frequent revision and updating, so that whenever they are required the latest versions should be obtained for use with this Smartline geomorphic map. It would be inefficient to incorporate the current versions of these datasets into the Smartline map, since their attributes in the Smartline would soon become out of date and need repetitive updating from the primary datasets[11]. In contrast, the Smartline geomorphic map is envisaged as a primary *descriptive geomorphic mapping* dataset for the Australian coast, which it is intended, will be a key repository for updated geomorphic information whenever this becomes available.

The most important attribute of a strictly descriptive geomorphic nature which has been omitted from the Smartline v1 - but ideally ought to be included - is *Subtidal Zone Slope* (see also Section 3.2.1 above). The definition envisaged for this attribute is: "the averaged slope of the subtidal zone from Mean Low Water Mark to a reference distance of 500m offshore" (this is a similar definition to that used for the backshore profile attribute). Because many soft shores may frequently change their shallow subtidal topography (e.g., as sand bars move and change in response to storms and seasonal or longer term changes in wave activity), it is not intended that precise subtidal slope angles be recorded

[10] Note also that the Smartline format can also record a wide range of non-geomorphic data that pertains to particular stretches of coast, including such things as information on coastal vegetation and wildlife communities, human population and other socio-economic statistics. This versatility opens the way for coastal Smartline data to be used for analyses extending well beyond purely geomorphic issues.

[11] Indeed, for this reason it may be better to in future delete the '*Exposure*' attribute from the Smartline, as it is likely that better measures of exposure will be or are available from other wave climate modelling sources.

for the purpose of this type of mapping; rather the purpose is to draw broad distinctions between gently and more steeply sloping near-shore bathymetries. As with the backshore profile, it is envisaged that subtidal slopes would be categorised into a small number of fairly broad, meaningful categories.

However, a key reason why this attribute was not included in the Smartline version 1.0 – apart from anticipated difficulties accessing and analysing appropriate data – was that more thinking remains to be thunk in order to define meaningful subtidal slope categories for use in the Smartline. This in turn requires clear identification of what purposes would most usefully be served by attributing the Smartline with subtidal slope categories.

One reason for classifying subtidal slope categories, from a coastal geomorphic stability perspective, is to give an indication of the potential effects of near-shore bathymetry on wave shoaling and run-up, sediment transport, and because of the significance of subtidal and shoreface gradients for coastal behaviour models such as the Bruun Rule (e.g., Bruun 1988) or the Shoreface Translation Model (e.g., Cowell *et al.*1995). The questions that remain to be answered are:

- whether simple averaged gradients, classified into a few broad categories, are actually useful for some applications such as (say) regional assessments of coastal sensitivity using these models, as opposed to using bathymetric maps or Digital Elevation Models giving more detail of variations in bathymetry over the 500m near-shore subtidal zone;

and:

- assuming an averaged and broadly classified subtidal gradient class would be a useful Smartline attribute, what are the significant subtidal slope class boundaries from the perspective of the Bruun Rule and other related coastal behaviour models?

4.0 OVERVIEW OF THE COASTAL SMARTLINE LANDFORM STABILITY MAP CLASSIFICATION

4.1 *Purpose of the Coastal Landform Stability Classification*

Coastal landforms vary widely in their potential inherent or "intrinsic" susceptibility to physical change or instability in response to a variety of coastal processes including sea-level rise. Styles of coastal landform instability (or stability) range from episodic or commonly cyclic erosion and deposition on muddy and sandy shores, through progressive & irreversible erosion and slumping on "soft rock" shores, to resilient stability (at least over human time scales) on many hard rock shores. An understanding of the varying styles of physical instability (or stability) exhibited by coastal landforms of differing types is fundamental to assessing coastal hazards and the vulnerability or otherwise of assets situated on those landforms.

This section briefly describes a coastal landform stability classification which has been designed to be used with the Smartline coastal landform classification described in the previous section. This classification has been derived by the extension and development of an earlier stability classification[12] developed by Sharples (2006b) for Tasmanian coasts. That precursor classification has been extended to encompass shoreline types not found in Tasmania (e.g., coral coasts), and the principles on which the classification system are based have been refined as a result of experience using the earlier Tasmanian system, together with input received from peers during a September 2007 workshop conducted for this project. This stability classification identifies coastal landform types that are *in principle* susceptible to various *styles* of instability (or stability) in response to coastal processes including but not limited to sea-level rise, in virtue of their fundamental geomorphic characteristics – primarily, their *fabric* (what they are made of), and their basic *form*. A more detailed discussion of the concepts underpinning this stability classification is provided in a separate companion report (Sharples 2009).

It is important to note that whilst the classification is intended to identify those coasts having potentially unstable landforms classified into basic types differentiated by distinctive *styles* of instability or stability (e.g., progressive erosion, potentially cyclic erosion & deposition, slumping, rock-falls, etc), the classification does not attempt to further rank the potential relative *magnitudes* of shoreline instability likely to be exhibited by the various landform stability classes. Since the magnitude of instability may vary widely for similar types of landforms depending on a complex interplay of regional and local processes and conditions, assessment of the potential magnitude of instability of any particular potentially unstable coastal landform requires additional assessment of regional variations in drivers such as wave climate, storm regime, tidal range, and the numerous other local physical and process conditions (e.g., sediment budget, topography, exposure, bathymetry, etc) which may strongly influence the actual physical response of particular shoreline types at particular locations to climate change and sea level rise. These levels of assessment are beyond the scope of the first pass stability assessment at which this classification is aimed.

In essence this is a "First Pass" coastal landform stability classification which categorises coastal landform types according to their potential or intrinsic *style* of susceptibility to physical instability in response to coastal processes including storms and sea-level rise. Further integration with information on those regionally-variable processes driving instability (such as wave and storm climates, tidal range, sea-level rise variation and vertical land movement), and local variables such as bathymetry, topography and sediment budget, is necessary in order to identify which particular coasts within any instability class are likely to exhibit a greater or lesser magnitude of instability compared to other coasts within the same or differing classes. See further discussion in Sharples (2009).

[12] Then called a "Vulnerability Classification" using a different meaning of "vulnerability" than that adopted here.

It is also important to note that this stability classification is neither a full vulnerability classification nor a full sensitivity classification, in the sense those terms are understood here. Whereas coastal landforms may be *sensitive* to either physical instability and/or to flooding, this *stability* classification refers only to coastal landforms susceptibility (or sensitivity) to physical instabilities such as erosion or accretion, but not to their susceptibility (or sensitivity) to flooding. Hence, the term landform "stability" is used here to refer to one type of landform "sensitivity" (or "susceptibility"), namely sensitivity to physical instability (erosion or accretion).

One advantage of a simple fabric/form system of stability classification is that it can be used very widely as a basis for classifying the potential stability of a wide diversity of shorelines globally. For example, the same type of shoreline stability classification (based on the earlier version provided by Sharples 2006b) has been used in a vulnerability assessment of the Venice region coastline in Italy (Torresan *et al*. 2008).

The landform stability class attributes of the Smartline (see data model and attribute tables) are populated by simply running a series of GIS queries on the basic landform classification attributes (described in Section 3.0 above) to identify coastal segments having the geomorphic characteristics corresponding to the various stability classes, as indicated in Figure 11 below (see attribute tables in Section 6.3.10 for definitions of each stability class).

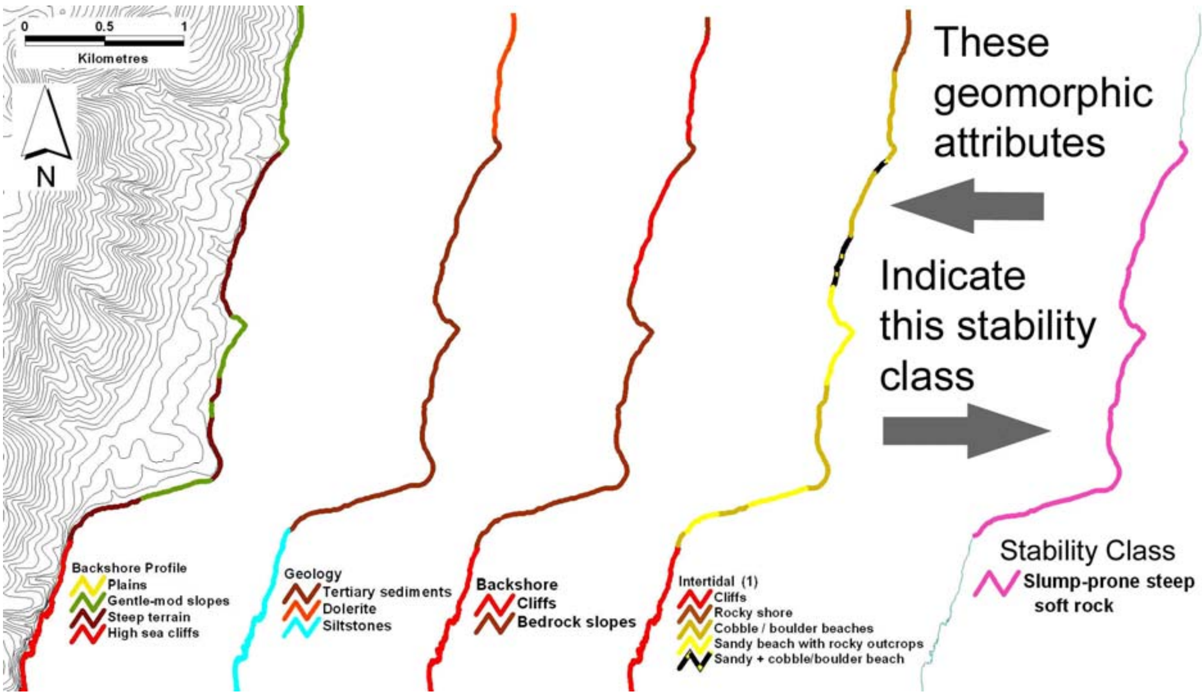


Figure 11: Example of the use of information from multiple Smartline attribute layers to identify a particular shoreline stability class. The geomorphic attribute layers were queried to identify those shoreline segments having the particular landform attributes (or "*Fundamental Stability Factors*") characteristic of a particular stability type. In this case, the selection of moderately to steeply sloping bedrock backshores, where the 'bedrock' is semi-lithified clayey sediments, identifies shores sensitive to progressive (irreversible) erosion and slumping (landslides) resulting from sea-level rise.

4.2 *Structure of the Coastal Landform Stability Classification*

The coastal landform stability classes are here defined using a hierarchy of "*Fundamental Stability Factors*"[13] based on the same fabric - form hierarchy that is the basis of the Smartline coastal geomorphic classification scheme (section 3.0). That is, the stability classes are defined *firstly* on the basis of their fabric (what they are made of), and *secondly* by their broadly-defined form[14], plus several other secondary fabric- and form-related factors, as shown in the following Table 1. The theoretical concepts underpinning both the Smartline Geomorphic Classification and this Stability Classification have been developed in tandem with a view to enabling a simple differentiation of (fabric-form based) stability classes from the (fabric-form based) Smartline geomorphic data.

The basis of this hierarchical ordering is the assumption that – as a very broad but useful generalisation – the *fabric* of coastal landforms (whether they are made of hard or soft constituents of differing erodibility and transportability) will ultimately be the single most important determinant of their potential stability, with their *form* (and other factors such as their degree of exposure to wave energy, currents and other geomorphic processes) being secondary to this over-riding influence. Thus for example, a granite shoreline will always be much more stable than a sand or mud shoreline, regardless of the forms of the shores or the wave climates (and other processes) to which they are exposed.

The use of ***fabric*** as the primary Fundamental Stability Factor is based on the assumption that as a broad generalisation, hard bedrock landforms (e.g., granite shores) will be *generally* more stable than unconsolidated sediment shores (e.g., muddy or sandy shores) or 'soft rock' shores (e.g., laterite or soft limestone shores). Fabric is the most fundamental determinant of how hard or soft (i.e., how susceptible in principle to erosion) a shoreline is. Similarly, within the broad category of soft sediment shores, a basic distinction is that unlithified sediments of finer grainsize will as a generalisation be more easily eroded and mobilised than coarser sediments.

Form is treated as being of generally secondary significance in determining coastal landform stability compared to fabric, but nonetheless is a fundamental factor. For the purposes of First Pass stability classification, form is categorised into very simple classes, e.g., platforms, gently to moderately sloping surfaces, steeply sloping faces, and vertical cliffs. These basic distinctions typically relate closely to potential instability, with steeper masses of a given coastal substrate (*fabric*) commonly having more potential for instability due their greater exposure to driving processes (e.g., wind or waves), and to the greater gravitational potential energy involved in higher, steeper landform features.

At the next-lower levels in the First Pass Stability Classification hierarchy, other form and fabric – related landform characteristics that are also of fundamental importance in determining coastal landform behaviour, and which are (importantly) also readily identifiable from information contained in the Smartline geomorphic attributes, are here regarded as additional secondary *Fundamental Stability Factors* which are used to allow further useful differentiation of stability classes where they are seen to be relevant. The two most important of these additional factors are here termed *Geomorphic Setting* and *Coastal Setting*. These are treated as being significant determinants of soft sediment shore behaviour, but are probably less significant determinants of soft rock and hard rock shore behaviour and thus are not used to sub-divide categories of the latter shoreline types. These described as follows:

---

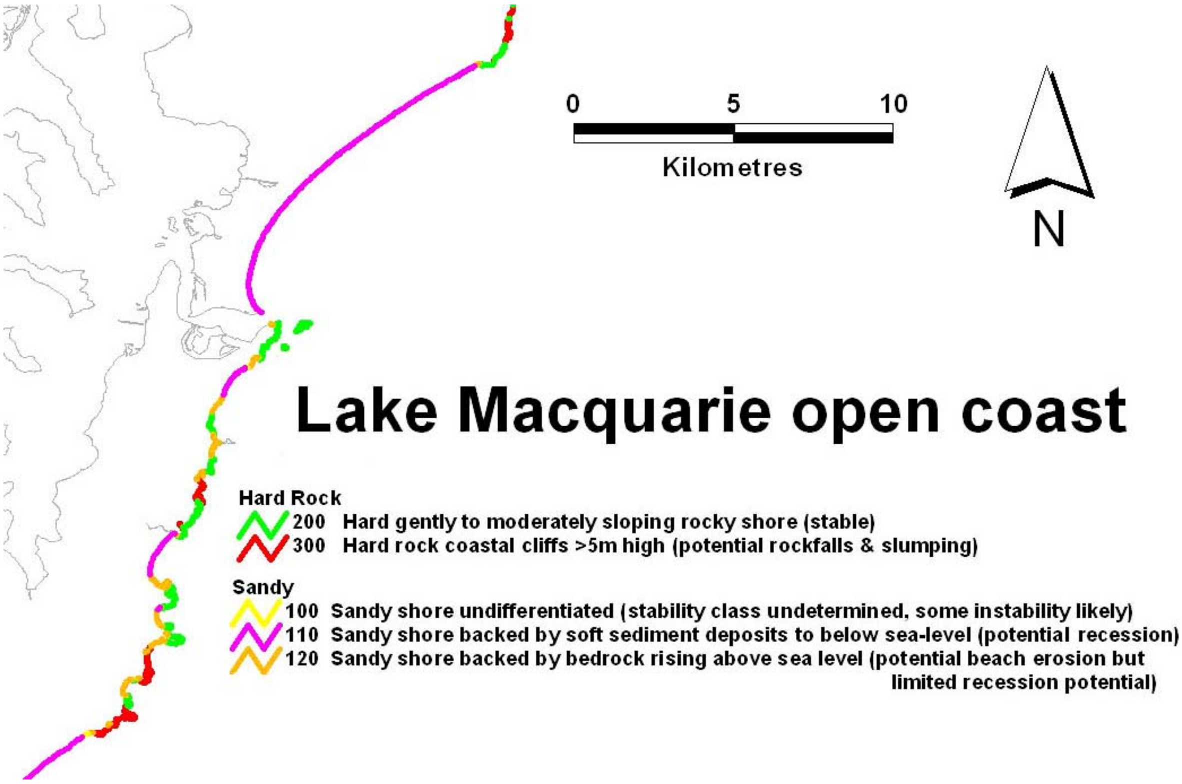
[13] Note these were called "Fundamental Vulnerability Factors" by Sharples (2006b), but are now here called "Fundamental Stability Factors".

[14] As an example of the implications of this hierarchy in practice, note that "Cliffs" (a form classification) do not constitute a single high-level stability class but rather occur twice, as sub-classes within both the "Hard Rock" and the "Soft Rock" landform categories. That is, the *fabric* classes "Hard Rock" and "Soft Rock" are the higher level stability classes, each of which is then sub-divided by the (lower-level) *form* categories such as 'Cliffs". Similarly, the stability class "Coarse Soft Sediments" includes both wave-deposited boulder beaches and coarse talus (colluvial) deposits; although the origins and to some extent the form of these deposits differ, they are grouped together by the high-level *fabric* criterion since they are both coarse unconsolidated sediments.

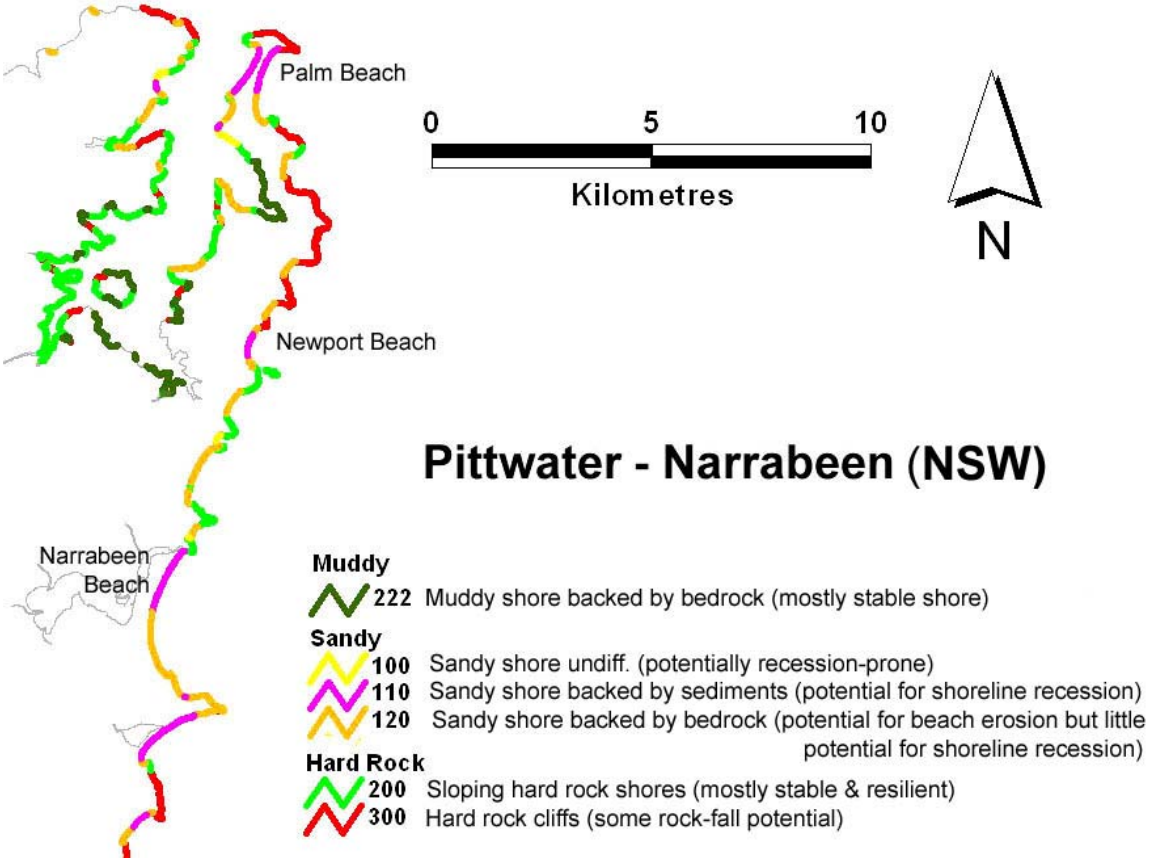
In the case of most of the soft-sediment stability classes, ***Geomorphic Setting*** here refers to the basic distinction between soft sediment shores that are immediately backed by rising bedrock surfaces (which may or may not be mantled by a veneer of soil or windblown sand) and those which are backed by low plains of soft (usually Quaternary-age) sediment whose depth extends to below present sea level for some distance inland of the shore. This basic distinction is highly relevant to the potential of soft sediment shorelines to recede significantly landwards in response to sea-level rise. Whereas on the one hand a shoreline backed by a soft sediment plain has the potential to recede as far inland as the soft sediment plain extends if it is exposed to the right erosional conditions, on the other hand a soft sediment shore backed immediately by a rising bedrock surface may be eroded in the intertidal zone but generally has little potential for significant landwards shoreline recession over typical planning timeframes of 50 – 100 years.

In the special case of the *Dunes* soft sediment stability class, *Geomorphic Setting* refers to whether or not dunes are exposed to wave action on their seawards margin. The *Dunes* stability class is unique amongst the soft sediment stability classes in that the primary agent of dune instability is wind, rather than waves. However, dune instability may be triggered by wave attack on foredunes, resulting in exposure of steep bare sand scarps to wind erosion. Hence the use of exposure to wave attack as a fundamental stability factor differentiates two basic dune stability sub-classes in respect of their exposure to instability-triggering process, namely those dunes where instability is triggered only by processes other than wave attack (e.g., cliff-top dunes), and those dunes where wave attack may be one of the processes triggering instability.

The ***Coastal Setting*** of soft sediment shorelines is also treated here as another important Fundamental Stability Factor in defining First Pass Coastal Landform Stability Classes. *Coastal Setting* here refers to whether a soft-sediment coastal landform is situated on an open coast shore, or within a tidal re-entrant (sheltered from but still connected to the open ocean via a tidal channel or opening). Shores in these two situations are subject to significantly different suites of coastal processes and driving forces. Open coasts are exposed to oceanic swells and storm waves, whereas in contrast tidal re-entrant shores are sheltered from swell and ocean storm waves, and exposed instead to local fetch-limited wind waves. Re-entrant shores also tend to be exposed to more significant tidal current processes than do open coast shores. As the term is used here, "tidal re-entrants" may include sheltered estuaries, barrier – barred coastal lagoons with a tidal channel connection to the open ocean, or other sheltered coastal waterways where ocean swell penetration is minimal. The differing processes to which shores in these differing coastal settings are exposed has resulted in recognition of the need to develop distinctive coastal behaviour models for re-entrant shores as opposed to open coast shores (e.g., Hennecke 2000, Hennecke & Cowell 2000, Travers 2007). Despite their sheltering from ocean swells and storms, the differing processes active in tidal re-entrants can result in shoreline erosion and recession processes that may exceed the scale of those on nearby open coast shores (compare Figure 13 & Figure 14). Hence the distinction between soft sediment shores on the open coast and those in tidal re-entrants is here considered to be a fundamental distinction for the purposes of coastal stability classification, and moreover is a distinction that can be readily identified from information provided by the Smartline geomorphic map.



(a)



(b)

Figure 12: Examples of coastal landform stability class maps for (a) the Lake Macquarie area open coast and (b) the Pittwater – Narrabeen areas of the NSW coast. These have been derived from a coastal Smartline geomorphic map by querying a range of landform attributes to generate maps of coastal landforms possessing specific combinations of the attributes ("*Fundamental Stability Factors*") corresponding to each stability class (see Figure 11).

In summary, the most important *Fundamental Stability Factors* used in differentiating First Pass coastal landform stability classes and sub-classes here are (see also Table 1):

Primary factor: Defines the stability classes:

Fabric (what the landform is made of, ranging from hard rock to soft rock to unlithified sediments of varying grainsize).

Secondary factors: Used as relevant to sub-divide particular stability classes:

Form: basic distinctions ranging from flat through sloping to vertical or cliffed landforms; or differing dune forms.

Geomorphic setting: for soft-sediment stability themes, this is a first-order fabric distinction determining potential susceptibility to coastal recession, namely whether *shoreline landform is backed by bedrock or soft – sediment.* However in the case of the '*Dunes*' stability theme, the geomorphic setting refers to *whether the dunes are exposed to wave action on the seawards side or not*.

Coastal setting: For soft-sediment stability themes for which this is thought to be a major factor controlling coastal stability, the 'coastal setting' refers to whether the *shoreline is located on the open coast or within a coastal re-entrant ('tidal inlet')*, and is important in defining a first-order distinction in the types (but not necessarily magnitudes) of processes to which a shoreline will be exposed.

Table 1 following provides summaries of the stability classes defined using this hierarchy of factors, and their styles of instability.

Table 1 (next page): A summary of First Pass Coastal Landform Stability Classes. These classes are defined on the fundamental stability factors of, firstly, the dominant *fabric*, and secondarily, the basic *form* plus a number of other form- & fabric-related factors as described in the text.

FABRIC (dominant constituents)		**FORM** (coastal profile)	**STABILITY CLASSES & SUB-CLASSES** (styles of instability likely in response to CC & SLR)	
Soft Sediments (unlithified, essentially unconsolidated sediments)	Dominantly Muddy	Flat to gently sloping shores	**Muddy intertidal flats** e.g., mangrove flats (complex, significant instability likely)	Backed by bedrock or soft sediment
				On open coast or in coastal re-entrants (inlets)
		Gently to moderately sloping shores	**Narrow muddy shores**, e.g., many estuarine shores (instability likely)	Backed by bedrock or soft sediment
				On open coast or in coastal re-entrants (inlets)
	Dominantly Sandy	Flat to moderately sloping shores	**Sandy shores or beaches ± tidal flats** (complex but prone to erosion & retreat)	Backed by bedrock or soft sediment
				On open coast or in coastal re-entrants (inlets)
		Dunes, windblown sheets, beach ridge backshores exposed to wind	**Sand dunes , ridges or sheets** (prone to increased mobility; some may stabilise)	Isolated from or exposed to wave attack
	Dominantly Coarse (pebble to boulder grade)	Gently to moderately sloping shores	**Shingle to boulder – grade beaches** - wave-deposited coarse sediment (instability likely, but response to SLR may be complex)	Backed by bedrock or soft sediment
		Moderately to steeply sloping shores & backshores	**Dominantly colluvial (talus) shores** where not significantly cliffed or dominated by protruding *in situ* bedrock. (unstable shores, ongoing slumping likely).	Backed by bedrock or soft sediment (generally backed by bedrock rather than extensive soft sediments)
	Undifferentiated soft sediment	Undiff	**Undifferentiated soft sediment shores** (instability likely but style unknown)	Backed by bedrock or soft sediment
				On open coast or in coastal re-entrants (inlets)
"Soft Rock" (inherently soft, semi-lithified or deeply weathered lithic substrates)	Various types sharing similar coastal stability styles, e.g. :- - Semi-lithified or inherently soft sedimentary rocks (e.g., clayey-gravelly semi-lithified sediments, soft limestones); *or* - Weathered bedrock & regolith (laterites, residual materials)	Flat to gently sloping backshore	**Low profile soft-rock shores** (potential progressive erosion and shoreline retreat)	
		Moderately to steeply sloping backshore (may include sub-ordinate colluvium)	**Moderate to steep profile soft-rock shores** (progressive erosion, slumping and shoreline retreat)	
		Very steep to cliffed backshore (may include sub-ordinate colluvium)	**Very steep to cliffed soft-rock shores** (comparatively rapid progressive erosion, slumping, rock-falls, slab collapses and shoreline retreat)	
Hard Rock (hard well-lithified substrates)	Hard lithified bedrock or coastal precipitates dominant, not deeply weathered	Gently to moderately sloping shore & backshore	**Low to moderate profile hard-rock** shores (robust physically stable shores, negligible likely retreat over human time-frames)	
		Steep to cliffed shore (may include sub-ordinate colluvium)	**Steep to cliffed hard-rock shores** (progressive erosion, slumping, rock-falls, slab collapses and shoreline retreat)	
Coral (biogenic hard structures and derived sediments; stability classes require further development)	Primary hard biogenic carbonate substrates	Flat to gently sloping structures	**Primary hard reefal structures** (potentially prone to break-up with coral death & wave action)	Fringing coral reefs (the only sub-class currently Smartline-mapped for the Australian continental coast)
				Other reefal sub-classes remain to be defined.
	Coral-derived sediments (e.g., coral-rubble beaches & beach-ridges)	Gently to moderately sloping shore & backshore	**Coralline sediments** (sub-classes of "coarse soft-sediment beaches" stability class above).	
	Secondary hard lithic substrates derived from coral (e.g., lithified coral breccias)	Mostly gently to moderately sloping shore & backshore	**Secondary hard lithic coral-derived substrates** (sub-classes of hard-rock or soft-rock stability classes above).	
Ice (ice-dominated shores; not relevant to continental Australia)	Pure ice (glacier and ice-sheet margins)	Undefined	**Ice shores** (potentially highly unstable, e.g. ice-berg calving)	
	Permafrost (ice-bound sediment)	Undefined	**Permafrost shores** (potentially highly unstable with warming, prone to summer melting releasing large quantities of sediment and causing rapid shoreline retreat).	

4.3 *Overview of the Coastal Landform Stability Classes*

This section provides a brief overview of the primary coastal landform stability classes defined for this work; more detailed description of these classes and their sub-classes can be found in Section (6.3.10) of this report (attribute tables), and in a separate companion report (Sharples 2009).

Muddy Shores (*Muddy*)

This class identifies shores having dominantly mud-grade (clay, silt) soft sediments in the intertidal zone, and may include sandy muds and pebbly muds where the mud fraction is considered dominant. This theme includes many estuarine, deltaic, saltmarsh- and mangrove-dominated shores, comprising both narrow muddy shores and broad muddy intertidal flats. This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions which are likely to be strongly related to potential stability in response to sea level rise, and which can be identified from information contained in the Smartline attributes. These distinctions are: generalised form (narrow muddy shores versus broad intertidal mudflats), and coastal and geomorphic settings as defined above.

In virtue of very fine sediment grainsizes (easily eroded & transported), muddy shores have the potential to be very unstable and mobile. In principle, many soft muddy shores are likely to recede with sea-level rise; however responses may be complex and widely variable depending on local conditions. For example, if climate change results in greater catchment runoff & erosion in northern Australia, muddy estuarine tidal flats in that region might potentially prograde if increased sediment supply exceeds the effects of sea-level rise (particularly where saltmarsh or mangroves can cause sediment-trapping).

Sandy Shores (*Sandy*)

This theme identifies shores dominated by sand-grade soft sediments in the intertidal zone. The transport (mobility) characteristics of sand-size particles not only make sandy beaches and shores the most abundant type of soft sediment shore on the Australian coast, but also cause them to exhibit distinctive erosion & accretion behaviour compared to other soft sediment shores. Because sandy shores are both easily eroded and also easily rebuilt by accretion processes, they can rapidly establish a dynamic equilibrium with changing coastal processes which may, for example, resulting in quickly alternating periods of erosion and accretion of the sandy shores where local conditions change cyclically, or alternatively may result in long periods of rapid progressive erosion if a major environmental variable such as sea level undergoes a long term change such as a progressive rise. This contrasts markedly with the behaviour of many other shoreline landform types, including finer or coarser sediment shores and erodible rock shores, many of which exhibit only uni-directional change (erosion) which merely varies in its rate as conditions change, or which respond in other distinctly different ways to sand shores.

'Sandy shores' may include mixed sand and shingle where sand is dominant. This theme includes sandy beaches, sandy tidal flats, and narrow sandy shores which may not be true "beaches" (e.g., sandy tidal channel shores which are not true wave-deposited sand bodies). This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions – namely location on open coast or coastal re-entrants & tidal inlets ('coastal setting'), and presence or absence of bedrock terrain backing the sandy shore above sea level ('geomorphic setting') - which strongly determine potential stability in response to sea level rise, and which can in many places be identified from information contained in the Smartline attributes. Open coast *vs.* re-entrant or inlet location is a first-order distinction which exposes sandy shores to quite different processes (e.g., dominantly swell waves *vs.* dominantly local wind waves & tidal currents). Significant erosion and recession may occur in both settings but the causes; styles and patterns of instability are likely to be very different. See Figure 13 & Figure 14. Bedrock *vs.* soft-sediment backing is another first-order control on sandy shore response since whilst bedrock limits potential shoreline recession, soft sediment backing may allow significant landwards shoreline recession to occur.

Figure 13: An example of an open coast sandy shore backed by a low-lying sediment plain. Although this shore has potential for significant erosion and landwards recession due to sea-level rise, at the present time (2009) this shore is experiencing accretion and incipient dune formation due to longshore drift processes and a dearth of recent major storm wave activity.

Figure 14: An example of a tidal re-entrant sandy shore backed by a low-lying sediment plain. This shore is located only a few kilometres from the open coast sandy shore depicted above, and is currently (2009) experiencing significant erosion and recession in response to the differing suite of processes affecting the tidal re-entrant in contrast to the nearby open coast.

This stability classification does not further differentiate sandy shores as being more or less stable in terms of beach morpho-dynamic types or other local geomorphic variables. For example, in the sensitive case of narrow sandy barriers backed by large lagoons, the *shores* of the sandy barriers are simply identified being potentially unstable sandy *shores*. This is partly because the inclusion of coastal lagoons in the Smartline map (version 1.0) has not been consistent around Australia, but more importantly because identifying (for example) a particular morpho-dynamic environment as a sandy barrier coast backed by a lagoon is arguably better undertaken at a more detailed level of stability assessment – involving additional site-specific local process variables – than the strictly first pass fabric-form characterisation of stability types that is intended here.

This theme classifies the stability of sandy shores in response to wave erosion, but does not identify potential associated dune instability. Although the latter may be triggered by sandy-shore wave erosion, unstable dune fields also occur behind some stable hard rocky coasts, and may be triggered by other factors such as artificial disturbance, reduced precipitation and/or increased wind speeds. Coasts potentially sensitive to increased (or decreased) dune mobility are therefore identified under the separate *Dunes* stability attribute (below).

Sand Dune & Beach Ridge Coasts (*Dunes*)

This class identifies coasts with significant soft sand deposits in the backshore having some potential for instability resulting from wind exposure and erosion (i.e., dune mobility). Such sandy backshores may be prone to sand mobility triggered by wave erosion of dune fronts (e.g., under conditions of rising sea-level) and/or by changing climatic conditions (reduced precipitation and increased wind speeds causing increased instability in some regions), as well as by artificial disturbances. Note however that there is also potential for increased precipitation and decreased wind speeds to cause dune stabilisation where these climatic trends occur. This theme includes aeolian sand-sheets, dunes, dune-fields or beach-ridges (soft sands either having some exposure to wind erosion and/or originally deposited by wind). Some sandy backshores (e.g., alluvial sand floodplain deposits) may not necessarily be included in this theme since in such cases in may not be clear that significant relief and exposure yielding a wind erosion susceptibility exists.

This *fabric*-defined stability theme is divided into a few major classes according to first-order distinctions which strongly influence potential stability in response to climate change and sea level rise specifically, and which can be identified from information contained in the Smartline attributes. However, this stability class emphatically provides only a 'First Pass' indication of coasts *potentially* prone to dune or windblown sand mobility. More confident assessment of the *likelihood* of mobility requires site-specific information on factors such as details of dune topography, vegetation cover, precipitation, wind climate and artificial disturbance, which are more appropriately captured in more detailed local-level mobility risk assessments.

This sensitivity is considered separately to sandy shore sensitivity to wave erosion and retreat, since whilst many dune fields occur behind sandy shores, some (stable or unstable) dune fields also occur behind stable hard rocky shores (e.g., cliff-top dunes). However since dune-fields isolated from the sea behind rocky or cliffed intertidal to proximal backshore zones are thereby protected from one potential trigger of dune mobility (wave attack), this distinction is also used as a classifier differentiating such less-exposed dunes from those which are exposed to wave attack in addition to other potential triggers of dune mobility (wind speed and precipitation changes, artificial disturbance, etc).

Coarse Sediment Shores (*Coarsed*)

This class identifies shores dominated by coarse-grade unconsolidated sediment in the intertidal zone. These may include (wave-deposited & wave-worked) shingle and boulder beaches, as well as dominantly talus (colluvial) shores (coarse mass movement-deposited material, generally little clast rounding from wave action). Note that only dominantly colluvial shores are classified here;

predominantly rocky or cliffed shores with sub-ordinate colluvium are classed as the appropriate 'Soft Rock' or 'Hard Rock' shore type.

Predominantly colluvial (talus) shores are characteristically prone to ongoing slumping of coarse material, which in many cases is likely to accelerate with sea-level rise. The behaviour of wave-deposited coarse (shingle to boulder) sediment shores is not as well understood as sandy shores; overall many coarse sediment shores (e.g., shingle beaches) show some cyclic cut-and-fill behaviour, and are likely to generally recede with sea-level rise, however in some circumstances it is likely that coarse sediment may also armour shores, hence reducing rates of erosion and recession.

This *fabric*-defined stability theme is divided into further major sub-classes, firstly by major fabric sub-types (colluvial vs. wave-deposited sediments), and then secondly by geomorphic settings (whether backed by bedrock or sediment). In contrast to other soft sediment stability themes, further sub-classes are not also defined on coastal setting (open or re-entrant coast), since the importance of coastal setting in controlling coarse sediment shore behaviour is unclear. The stability coding scheme would allow coastal setting factors to be easily incorporated as further sub-classes if required in future.

Undifferentiated Soft Sediment Shores (*Undifsed*)
This class identifies shores having soft sediment of unknown type in the intertidal zone. This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions - geomorphic and coastal settings as used for other sediment-based stability classes - which strongly determine potential stability in response to sea level rise, and which can be identified from information contained in the Smartline attributes.

The purpose of this classification is to allow identification of soft potentially unstable coasts in areas of poor geological and geomorphic mapping where the sediment type is unspecified. It is expected that any further stability assessment of such shores would include identification of the sediment type, resulting in these shores being reclassified under the appropriate specific stability theme.

"Soft Rock" Shores (*Softrock*)
This theme identifies shores having "soft" bedrock landforms in the backshore zone. See Figure 15 & Figure 16 for examples. "Soft" bedrock coasts often have sediment-mantled intertidal zones with little or no bedrock outcrop, since the soft bedrock itself is quite erodible. However, this stability class identifies coasts whose backshores are dominated by 'soft' bedrock types, as these will fundamentally determine the geomorphic behaviour of those coasts.

For the purposes of this 'First Pass' stability classification scheme, the category 'soft rock' is used as a broad and vaguely -defined contrast between tough well-lithified 'hard rock' on one hand, and 'soft sediment' on the other. However, this usage of 'soft rock' actually encompasses coastal materials of widely differing hardness and other characteristics. This admittedly simplistic usage of 'soft rock' has been employed here because no more useful and well-developed categories appropriate to the purpose appeared to the writer to be available. However it is hoped that in future a more sophisticated categorisation of 'soft rock' types will be developed that will be capable of more usefully differentiating variations in rock behaviour in response to processes such as sea-level rise.

'Soft' bedrock may be semi-lithified or inherently soft bedrock, strongly weathered bedrock or some other types of regolith. Examples include backshore "bedrock" landforms of clayey or gravelly semi-lithified Cainozoic-age sediment, soft limestone types, intensely fractured and deeply weathered volcanic rocks, lateritic duricrust profiles or coarse bouldery 'sediments' which are actually residual boulder and cobble - grade corestones remaining from weathering and winnowing of bedrock (all of these may be with or without humic soil mantles). This *fabric*-defined stability theme is divided into a few major classes according to first-order *form* (slope) distinctions which strongly determine potential stability or erosion style in response to sea level rise.

Figure 15: A “soft rock” shore (in this case, semi-lithified Tertiary-age clayey conglomerate and soft sandstone) exhibiting progressive erosion and recession. Although shores such as this typically exhibit ongoing progressive erosion even with stable sea-levels, rising sea levels can be expected to accelerate the rate of erosion evident here. The road immediately above this shore is imminently threatened by undercutting & collapse. Similar shores occur around many tidal re-entrants in Australia.

Figure 16: A coastal cliff in “soft rock” Tertiary-age semi-lithified sandstone. This is not hard bedrock, but a relatively soft and clayey rock type which has previously exhibited creep and slumping in the surrounding area. With sea-level rise, houses such as those along the rim of this cliff will be increasingly at risk of slumping resulting from more frequent higher wave attack on this shore, particularly where associated with water saturation during storm surges associated with low pressure systems and intense rainfall.

"Soft Rock" shores can in many situations erode quite rapidly enough to place infrastructure within metres or tens of metres of the shore at significant risk within the foreseeable future (see Figure 15 & Figure 16 for juicy examples). Moreover, unlike some soft sediment shores (especially sandy shores), most 'soft rock' shores exhibit only uni-directional change (progressive landwards erosion), which may vary in rate as coastal conditions change but cannot reverse and commence accreting as may happen on sandy and some muddy shores. Because of its progressive, irreversible and potentially rapid nature, the net erosion of 'soft-rock' shores can be just as rapid and of just as much concern as the better-known sandy coast erosion processes.

Hard Rock Shores (*Hardrock*)

This class identifies shores dominated by hard lithified bedrock landforms exposed in the intertidal zone and present with or without soil mantles or aeolian sand veneers in the backshore zone. See Figure 17 for an example. The intention of this theme is to identify hard rock coasts where bedrock is *exposed* at the shoreline (either in the intertidal zone and/or as backshore proximal cliffs). Shores immediately backed by hard bedrock, but with only soft sediments actually exposed in the intertidal zone, will be classified under other soft sediment stability themes as 'bedrock-backed' variants.

This *fabric*- and *form*-defined stability theme includes – as separate subclasses - both the mostly stable gently to moderately sloping hard rocky shores having minimal susceptibility to erosional retreat (or to storm surge flooding) within human time-scales, as well as steep to cliffed hard rocky shores which may be undergoing progressive erosional retreat, and may be susceptible to ongoing rock-falls, slumping, and collapses, albeit generally at slower rates than "soft-rock" slopes or cliffs.

Figure 17: A moderately sloping hard rock shore. Shores of well-lithified bedrock such as this are likely to exhibit negligible erosion related to sea-level rise over the next century or more, and given their moderate slopes are also minimally prone to inundation related to sea-level rise. In contrast to the houses on the low sandy spit in the background (which are at significant risk of erosion & flooding), infrastructure immediately above this sloping rocky shore will probably be at little risk from sea-level rise for some centuries, at least.

Note that hard sloping rocky intertidal zones with backshore dunes over gently to moderately sloping backshore bedrock terrain above sea level may exhibit some backshore instability in the form of dune mobility, and so are also identified as having potential backshore instability under the *Dunes* theme, but are nonetheless also identified in this *Hardrock* theme as shores which are stable in respect of marine erosion or inundation processes. This theme may also include rocky shores with minor soft-sediment beaches (with bedrock exposed) in the intertidal zone, in which case the same shores will also be included in the *Sandy*, *Coarsed* or *Undifsed* themes as bedrock-backed soft-sediment shore types. These shores have some potential for beach loss, but are not likely to be susceptible to erosional recession unless very steep to vertical in which case some cliff-line retreat is possible.

Undifferentiated Rock Shores (*Undfrock*)
This broad class identifies shores dominated by bedrock landforms in the intertidal and backshore zones, where the bedrock type (hardness) is unknown. The purpose of this classification is to allow identification of coasts known to be rocky but where poor geological and geomorphic mapping means the actual rock type is unspecified.

On a precautionary basis it is appropriate to treat these shores as potentially being less-stable “soft rock” landforms rather than more-stable hard rock landforms, however it is likely that in most cases any additional assessment of these shores will result in identification of the rock type and hence placement in either the “Soft Rock” or “Hard Rock” Shore stability themes (above).

Note that sloping rocky intertidal zones with backshore dunes over gently to moderately sloping backshore bedrock terrain above sea level may exhibit some backshore instability in the form of dune mobility, and so are also identified as having potential backshore instability under the *Dunes* theme. This theme may also include rocky shores with minor soft-sediment beaches in the intertidal zone, in which case the same shores will also be included in the *Sandy*, *Coarsed* or *Undifsed* themes as bedrock-backed types.

Coral Coasts (*Coral*)
This class identifies coasts characterised by hard actively growing biogenic carbonate structures (coralgal reefs) and associated derived sediments. Although coral coasts may also have (dead) coral reef structures and coral-derived sediments in the backshore zone as well as in the intertidal and sub-tidal zones, for the purposes of stability classification this theme is focussed on shores with actively forming (growing) sub-tidal to intertidal reefal structures and immediately associated structures and sediments. In contrast, other intertidal and backshore landforms of coralline origin – but not directly associated with actively growing coralline structures in the intertidal or subtidal zones - are generally classified under other stability themes. Thus, coral rubble and coral-derived sand beaches are simply classified as “Coral rubble coarse soft sediment shores” (coral rubble shingle beaches) and “Sandy Beaches”, whilst lithified coral breccia shores are considered as a type of “hard rock shore” where the rock type is a “coralline limestone breccia”. Similarly, intact uplifted coral reef structures which now form the backshore may be classified as “bedrock terrain” backshores where the bedrock type is “reefal coralline limestone”.

A key reason for placing “dead’ coralline deposits and landforms in different stability themes to “living” coral coast structures is that subtidal and intertidal living coral communities and their structures are uniquely sensitive to a range of impacts that may not impact so notably on other (non-living) carbonate rock and sediment coastal landforms, including relict (dead) coral reef structures and associated sediments. Thus, coral coasts may be subject to instabilities resulting from changes in ocean temperatures and pH causing coral death & physical breakdown, in addition to the wave climate factors which drive instability in other coastal types.

Because version 1 of the Australian Coastal Smartline Geomorphic and Stability Map was limited to the continental coast and major islands, but excluded the Great Barrier Reef and most atolls, this theme currently only includes undifferentiated coral communities and fringing coral reefs as distinctive classes, since these are the only classes within this theme that have actually been mapped in the current Smartline version 1. However it is envisaged that further definition of additional fabric and form classes within this fabric – defined theme will occur during future application of this mapping method to coral atolls and other coral coasts.

Ice Shores

A class for "Ice Shores" has been included in the coastal landform stability classification for completeness. Although no coasts falling into this category occur on mainland Australia or adjacent islands, these shore types occur extensively in some polar regions, hence inclusion of this category gives the classification sufficient flexibility to encompass most if not all natural shoreline types on Earth.

The classification "Ice Shores" is intended to encompass shores composed purely of ice (e.g., much of the Antarctic coast) and shores composed of ice-bound sediment, i.e., permafrost. Permafrost coasts are widespread along the arctic shores of Russia, Alaska, Canada and Scandinavia, and appear to be currently amongst the fastest-receding shores on Earth, as a result of rising ocean temperatures (Are *et al.* 2008). In this case, a key 'style' of erosion appears to be simple melting of the water ice binding the permafrost sediment, which releases large quantities of fine sediment into the Arctic Ocean each northern summer.

No Stability Classification (*Unclass*)

This category identifies shores not classified into any stability classes. The most common cause of a shore not being assigned a stability classification is that key attribute fields are unclassified due to unavailability of the required data.

Artificial Shores

For the purposes of this stability classification, shores are classified by their natural type. The intention is to identify what their stability class would be (or would have been) without artificial intervention. However where artificial shorelines are present, this descriptive information is nonetheless captured within the geomorphic attributes (see Section 3.2.1 & Section 6.3). Where insufficient information is available to determine the original (natural) shoreline type at the site, a heavily modified shore may be classified as having "No Stability Class" (see above).

5.0 METADATA FOR THE AUSTRALIAN COASTAL SMARTLINE GEOMORPHIC AND STABILITY MAP VERSION 1

This metadata record is a copy of the ANZLIC – standard metadata prepared in .xml format for the Smartline version 1 dataset by Tore Pedersen. This is a "parent" metadata record describing the entire dataset which is comprised of seven state (incl. NT) tiles; a "child" metadata record (in .xml format) has also been prepared for each state tile but these are not reproduced here.

General Properties	
File Identifier	CDBB1732-05D8-4D54-A4B1-FB7885B09B05
Hierarchy Level	series
Hierarchy Level Name	series
Standard Name	ANZLIC Metadata Profile: An Australian/New Zealand Profile of AS/NZS ISO 19115:2005, Geographic information - Metadata
Standard Version	1.1
Date Stamp	2009-09-08
Resource Title	Australian Coastal Smartline Geomorphic and Stability Map, version 1
Alternate Resource Titles	
	Australian Smartline, version 1
Other Resource Details	The recommended citation for this series is as follows: Sharples, C., Mount, R.E., Pedersen, T.K., Lacey, M.J., Newton, J.B., Jaskierniak, D. and Wallace, L.O. (2009) Australian Coastal Smartline Geomorphic and Stability Map, version 1. Canberra: Australian Government, Geoscience Australia. http://www.ozestuaries.org/
Key Dates and Languages	
Date of creation	2009-06-30
Date of publication	2009-06-30
Metadata Language	eng
Metadata Character Set	utf8
Dataset Languages	eng
Dataset Character Set	utf8
Abstract	The Australian Coastal Smartline Geomorphic and Stability Map, version 1 is a series of digital datasets that map the coastal landform types (geomorphology) of continental Australia and most adjacent islands (excluding the Great Barrier Reef). The series is comprised of seven individual datasets: one for each of Australia's coastal states and territories (New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria and Western Australia). These maps were compiled primarily using existing spatial data sets provided by a number of Commonwealth, State, Territory and other agencies from across Australia. The Smartline is a line map that represents the coastline (typically the High Water Mark, but see the attribute field "Basefeat" for details), and is split into segments wherever any of the coastal landform attributes change. Each individual coastline segment has a series of attributes which describe the landform types of that segment of the coast. The coastal characteristics recorded refer not only to those at the precise location of the coastline itself, but to a coastal area nominally extending up 500m inland and offshore of the coastline itself. Where such information is available, these attributes describe the landforms in the subtidal, intertidal and backshore zones; the backshore profile and intertidal zone slope; the shoreline segment exposure; and the

geological substrate.

The Smartline also contains attribute-level metadata: for each geomorphic attribute in each coastline segment, there are two additional attributes that identify the source dataset from which the attributes were derived, and defining the scale of the source dataset.

Finally, there are a series of attributes which classify each coastline segment according to a shoreline landform stability classification scheme.

The individual state maps are provided in ESRI shapefile format, in two versions: one using the GDA94 Geographic Coordinate System; the other using the GDA94 Geoscience Australia Lambert Conformal Conic Projected Coordinate System.

For further information about the Australian Coastal Smartline Geomorphic and Stability Map, version 1 and its component datasets, please refer to the individual metadata records for each state dataset, the Smartline Manual and Data Dictionary, and the Smartline Project Report.

Purpose	The series of digital datasets comprising the "Australian Coastal Smartline Geomorphic and Stability Map, version 1" were compiled for use in a first-pass assessment of Australia's coastal vulnerability to sea-level rise and climate change by the Commonwealth Department of Climate Change and Geoscience Australia. However it is anticipated that these datasets will be suited for many other coastal management and research purposes in future. For a more detailed discussion of the principles behind the Smartline mapping format, and the kinds of applications to which it is and is not suited, please refer to "The Australian Coastal Smartline Geomorphic and Stability Map Version 1: Manual and Data Dictionary".

Metadata Contact Information

Name of Individual	Name withheld
Organisation Name	University of Tasmania
Position Name	Data Coordinator, National Shoreline Geomorphic and Stability Mapping Project
Role	author
	Australia

Resource Contacts

Organisation Name	Geoscience Australia
Role	custodian
	Australia

Credit

The Australian Coastal Smartline Geomorphic and Stability Map, version 1 was derived from digital data provided by the following agencies and individuals:

Geoscience Australia

Geological Survey of NSW (NSW Department of Primary Industries)

NSW Department of Lands

NSW Maritime

NT Department of Regional Development, Primary Industry, Fisheries and Resources (Formerly Department of Primary Industry, Fisheries and Mines)

NT Department of Natural Resources, Environment, The Arts and

Sport (Formerly Department of Natural Resources, Environment and The Arts)

Queensland Mines and Energy (QLD Department of Employment, Economic Development and Innovation - Formerly Department of Mines and Energy)

Queensland Herbarium (QLD Department of Environment and Resource Management - Formerly Environmental Protection Agency)

QLD Department of Environment and Resource Management (Formerly Environmental Protection Agency)

SA Department for Environment and Heritage

Department of Primary Industries and Resources SA

TAS Department of Primary Industries, Parks, Water and Environment (Formerly Department of Primary Industries and Water)

GeoScience Victoria (VIC Department of Primary Industries)

VIC Department of Primary Industries

VIC Department of Sustainability and Environment

WA Department of Environment and Conservation

Geological Survey of Western Australia (WA Department of Mines and Petroleum – Formerly Department of Industry and Resources)

Landgate (Western Australian Land Information Authority)

WA Department of Transport (Formerly Department of Planning and Infrastructure)

Professor Andrew Short, University of Sydney

Lineage Statement

The series of digital datasets comprising the "Australian Coastal Smartline Geomorphic and Stability Map, version 1" were derived from a total of 240 individual datasets. A complete list of these source datasets with additional metadata is available both as a table in Appendix 1 of the Manual and Data Dictionary, and as a dbf file accompanying each of the State digital datasets.

Because of the wide variety of source datasets, a variety of different methods were used to extract and reclassify the source data. A generalised workflow is described below. Most of these steps were carried out using existing or newly-developed tools in ArcGIS 9.3:

1) For each coastal state, the best available coastline dataset was identified and obtained for use as a Smartline base map.

2) Attributes from each source dataset were transferred to a copy of the Smartline base map for the relevant state. For aspatial and non-georeferenced source datasets, the transfer process was manual; for georeferenced datasets, the transfer process was automated as much as possible.

3) The transferred attributes were reclassified and inserted into the appropriate Smartline field or fields using transfer tables and the Smartline Classification Scheme.

4) The individual Smartline base maps containing attribute data from different source datasets were merged into a single state Smartline.

5) Where conflicting or concordant attribute data were present for a single Smartline field, a resolution process was followed to choose a single attribute from those available. As a general rule, priority was given to the source datasets that contained the most relevant and detailed attribute information; if the available source datasets contained

similar attribute information, preference was given to the source dataset with the best spatial resolution.

6) A series of logical checks were carried out to ensure consistency between attributes in related Smartline attribute fields.

7) Coastal features less than 10m long were merged with the most similar adjacent feature (based on attributes) where possible. Some features which were less than 10m long (generally very small islands) could not be merged because there were no adjacent features to merge with.

8) A topology was developed and used to ensure that the Smartline geometry was identical to the original Smartline base map, and that the Smartline did not have any self-overlapping segments. All topological errors were repaired.

9) Incorrectly-spelled attribute data were detected and repaired using tables exported from an Access database containing the complete Smartline Classification Scheme.

10) The Smartline Stability fields were populated using queries based on particular combinations of geomorphic attributes.

Some of the steps outlined above are described in more detail in the Smartline Project Report (Sharples, C., Mount, R.E., Pedersen, T.K., Lacey, M.J., Newton, J.B., Jaskierniak, D. and Wallace, L.O. (2009) The Australian Coastal Smartline Geomorphic and Stability Map Version 1: Project Report. Canberra: Australian Government, Geoscience Australia), available from the OzCoasts website (http://www.ozcoasts.org.au/).

Jurisdictions

Australia
New South Wales
Northern Territory
Queensland
South Australia
Tasmania
Victoria
Western Australia

Search Words

GEOSCIENCES-Geology
GEOSCIENCES-Geomorphology
HERITAGE-Natural
MARINE-Coasts
MARINE-Geology-and-Geophysics

Themes and Categories

Topic Category	geoscientific Information

Status and Maintenance

Status	completed
Maintenance and Update Frequency	unknown
Date of Next Update	

Reference system

Reference System	GDA94
Reference System	GDA94 / Geoscience Australia Lambert

Data Scales/Resolutions

Scale	1:5000
Scale	1:1000000

Spatial Representation Type

Spatial Representation Type	vector

Extent - Geographic Bounding Box

North Bounding Latitude	-9.141329
South Bounding Latitude	-43.860374
West Bounding Longitude	111.140756
East Bounding Longitude	153.638727

Additional Extents - Geographic

Identifier	aus
Identifier	NSW
Identifier	NT
Identifier	QLD
Identifier	SA
Identifier	TAS
Identifier	VIC
Identifier	WA
Identifier	AUS

Distribution Information

Distributor 1

Distributor 1 Contact

Organisation Name	Geoscience Australia
Role	custodian
	Australia

6.0 DATA DICTIONARY FOR THE AUSTRALIAN COASTAL SMARTLINE GEOMORPHIC AND STABILITY MAP

6.1 *Introduction*

The data models and attributes used for the Australian Coastal Smartline Geomorphic and Stability Map have been modified from the precursor Tasmanian shoreline geomorphic classification (Sharples 2000, 2006a, b), variously in order to remedy problems found through experience using the Tasmanian classification, to respond to peer review comments on drafts of the classification system, and in order to encompass the broader range of coastal landform types found in other parts of Australia. The rationales for some of the major changes are described in Section (3.0) above. Elements of the OSRA Shoreline Types mapping system (Wardrop & Ball 2000) have also been incorporated.

Smartline map scales and coastal length statistics

The Australian Coastal Smartline Geomorphic and Stability Map uses the best scale of base coastline (generally MHWM) mapping available for each State. This varies from 1:100,000 (NT) to 1:25,000 or better (e.g., Vic. & Tas.), and in addition some state maps incorporate internal portions with differing scales. It was decided to use the best available map scales in each coastal region in order to enable the most detailed possible capture of coastal geomorphic data wherever sufficiently detailed data exists.

However one implication of this is that coastline length statistics derived from the Australian Coastal Smartline Geomorphic and Stability Map will not be directly comparable between all parts of the map (apparent coastal lengths increase with increasingly detailed map scale, since increasing lengths of line work are used to represent finer details of coastal plan forms). The best scale at which the entire Australian coastline can be represented at a single uniform scale is the Geoscience Australia Geodata 1:100,000 maps; however apart from the Northern Territory coast this provides significantly coarser detail than is actually available from the alternative coastline base maps that were used for the Smartline.

6.2 *Data Model*

This data model details the attribute fields used in the Australian Coastal Smartline Geomorphic and Stability Map. Attribute classifications, categories and codes used within each field are detailed in attribute tables ('lookup tables') provided in Section (6.3) below.

The somewhat cryptic field names used for each attribute field are designed to be compatible with some formats which allow only limited field name lengths. Each geomorphic attribute is recorded within the Smartline attribute table in two formats, as both a numerical (character string) code, and as an equivalent verbal descriptor. This allows greater flexibility in using the map and analysing map data.

Dataset name:

Australian Coastal Smartline Geomorphic and Stability Map, version 1
(File name *auscstgeo_v1*)

The dataset is supplied in state tiles; individual state tiles and their shapefiles have the same names with the state name added (see list below).

Co-ordinate Systems used:

Australia GDA 1994 Lambert Conformal Conic

This projected coordinate system is one of Geoscience Australia's standard coordinate systems for spatial data, and was created using information in Hill (2004). The parameters used in this projected coordinate system are defined below:

Projection	Lambert Conformal Conic
Datum	Geocentric Datum of Australia 1994

Spheroid	GRS 1980
Standard Parallels	18 and 36 degrees south
Central Meridian	134 degrees east
Latitude of Origin	0 degrees
Linear Unit	Metre

Geocentric Datum of Australia 1994
This geographic coordinate system is another of Geoscience Australia's standard coordinate systems for spatial data. ArcMap provides this geographic coordinate system by default. The parameters used are defined below:

Datum	Geocentric Datum of Australia 1994
Spheroid	GRS 1980
Prime Meridian	0 degrees
Angular Unit	Degree

List of Smartline file names:
The Smartline dataset comprises separate tiles for each state, supplied to Geoscience Australia in two versions as follows:

Coordinate System	Smartline file names
Australia GDA 1994 Lambert Conformal Conic (projected co-ordinate system; co-ordinates are eastings & northings)	*auscstgeo_nsw_v1_01_GDA94_LambertCC_EN.shp* *auscstgeo_nt_v1_GDA94_LambertCC_EN.shp* *auscstgeo_qld_v1_GDA94_LambertCC_EN.shp* *auscstgeo_sa_v1_GDA94_LambertCC_EN.shp* *auscstgeo_tas_v1_GDA94_LambertCC_EN.shp* *auscstgeo_vic_v1_GDA94_LambertCC_EN.shp* *auscstgeo_wa_v1_GDA94_LambertCC_EN.shp*
Geocentric Datum of Australia 1994 (un-projected geographic co-ordinate system – co-ordinates are latitude and longitude)	*auscstgeo_nsw_v1_01_GDA94_LL.shp* *auscstgeo_nt_v1_GDA94_LL.shp* *auscstgeo_qld_v1_GDA94_LL.shp* *auscstgeo_sa_v1_GDA94_LL.shp* *auscstgeo_tas_v1_GDA94_LL.shp* *auscstgeo_vic_v1_GDA94_LL.shp* *auscstgeo_wa_v1_GDA94_LL.shp*

Note that at the time of writing, one minor error correction (at a key site - Narrabeen Beach) has resulted in a slightly updated NSW map version (1.01) being supplied to the custodian, as indicated above.

Type: Vector polyline map, as ESRI shapefiles

Description: Line map (generally representing MHWM), divided into geomorphologically distinct segments. Attribute fields (as listed below) allow each segment to be tagged with unique geomorphic descriptions and data pertaining to the shoreline segment. Attribute field names have been restricted to 10 characters to comply with limitations in some formats. Each geomorphic descriptor (attribute field) is presented in two versions – a numerical code (_*n*) and a brief descriptive verbal label (_*v*) – in order to facilitate a variety of uses and analyses of the mapped data. The attributes for each field (geomorphic descriptor) are listed in detail at lookup tables in Section (6.3). All landform attribute fields (_*n* & _*v*) should either have a value or be "Unclassified", but not null. Thus, if a field has no value it is seen to be because of a lack of data, not potentially because of inadvertent omissions.

Attribute Fields:

Field	Type	Width	Attributes	Comments
Base Map Descriptors: Refers to base line map, which has been segmented and attributed to create this coastal geomorphic map.				
Baseline	string (text)	4	**Reference ID for source of base line map** (See Appendix One or separate *Smartline_v1_Data_Sources.xls* spreadsheet for listing of source details)	Reference ID code referring to a meta-database giving full details of base shoreline map used for Smartline
Basescale	string (text)	10	**Scale of base map** (which has been segmented and attributed with data from a variety of sources with differing source scales as indicated by *_s* attributes - see below) Format: 10K, 25K, 100K, etc, (where '10K' = '1:10,000 scale', etc) or indicate a range of scales where applicable, e.g., '250K-100K'	As quoted by source agency/custodian, else estimated. May vary along a coast.
Basefeat	string (text)	50	**Coastal feature upon which base line map is based** (e.g., MHWM)	May differ in different parts of coast.
Reference Data:				
Auscstfid	Long Integer (numeric)	-	**Unique Australian coastal segment identifier number (v.1.0).** Consecutive series of numbers for each state, commencing with a different numerical prefix for each state as follows: (1 - not used) 2 – NSW 3 – Vic 4 – Qld 5 – SA 6 – WA 7 – Tas 8 – NT (i.e., same numerical prefix as state postcodes)	Nationally-unique Feature ID numbers assigned to every feature (line segment); current for version 1.0 only (subsequent editing will require new FID sequence for each new map version).
Updated	Date	-	**Date of data currency or last update**, appearing as "YYYYMMDD" or "DD/MM/YYYY" depending on the GIS software used (e.g., in YYYYMMDD format, "20090626" means 26th June 2009)	Refers to last update of any of the *geomorphic* descriptors (only) for *this* line map segment (including date of importing data from older sources); does not necessarily refer to the age of the source data used, which is specified in *source* attributes (below).

ABSAMP_ID	string (text)	10	**Beach number** used by Dr Andrew Short & Surf Life Saving Australia, in ABSAMP database format. Number applied only to Smartline segments representing beaches.	Allows linking with ABSAMP database (& cross-referencing with Short beaches books).
Coastal Geomorphic Themes:				
Backprox_n *Backprox_v*	string (text)	6 50	**Backshore proximal landform** (numerical string code). (verbal label) The first notable landform feature immediately backing the intertidal zone. See attribute table 6.3.3.	The width of the proximal backshore zone is not defined – it depends on the scale of the proximal backshore landform type.
Backdist_n *Backdist_v*	string (text)	6 50	**Backshore distal landform** (numerical string code). (verbal label) Dominant distinctive backshore landform type inland of the first notable landform class backing the intertidal zone (i.e., inland of *Backprox* above). See attribute table 6.3.3.	Distal backshore coastal landforms are classified to a distance up to 500m inland of the MHWM for the purposes of this mapping. *Backdist* may be the same as *Backprox*, if *Backprox* landform type extends to over 500m inland of MHWM.
Backprof_n *Backprof_v*	string (text)	3 30	**Backshore profile class** (numerical string code). (verbal label) Generalised seawards slope gradient of backshore terrain, classified into only a few broad classes. See attribute table 6.3.4.	Averaged backshore terrain gradient from the intertidal zone to the first major inland high point or to 500 metres inland, whichever is the lesser distance (high foredunes are ignored, if present), except high cliffed coasts.
Intertd1_n *Intertd1_v*	string (text)	6 50	**Intertidal zone landform element 1** (numerical string code) (verbal label) Primary, upper or co-equal intertidal landform element. See attribute table 6.3.5.	
Intertd2_n *Intertd2_v*	string (text)	6 50	**Intertidal zone landform element 2** (numerical string code) (verbal label) Secondary, lower, co-equal or	Identifies additional intertidal landform features, may be an unclassified record if primary intertidal element

			additional intertidal landform element. See attribute table 6.3.5.	1 adequately describes intertidal zone.
Intslope_n *Intslope_v*	string (text)	3 20	**Intertidal zone slope** (numerical string code) (verbal label) Slope of the intertidal zone. See attribute table 6.3.6.	Defined as the slope of a line from MHWM to MLWM, categorised into only a few broad slope classes.
Subtid1_n *Subtid1_v*	string (text)	6 50	**Subtidal landform element 1** (numerical string code) (verbal label) Primary or co-equal landform element in near-shore subtidal zone. See attribute table 6.3.7.	Dominant substrate(s) & landform type(s) found immediately seawards of & below intertidal zone; area considered may nominally extend to 500 metres horizontally offshore, but the subtidal attributes are essentially intended to record the dominant substrates immediately below the intertidal zone.
Subtid2_n *Subtid2_v*	string (text)	6 50	**Subtidal landform element 2** (numerical string code) (verbal label) Secondary, co-equal or additional landform element in near-shore subtidal zone. See attribute table 6.3.7.	Identifies additional subtidal landform features, may be an unclassified record if primary subtidal element 1 adequately describes subtidal zone.
Exposure_n *Exposure_v*	string (text)	3 20	**Shoreline segment exposure** (numerical string code) (verbal label) Exposure of the individual coastal segment to whatever swell wave energy is received by the coastal region. See attribute table 6.3.8.	Classified into only 4 broad categories, one of which indicates the segment is not significantly exposed to swell waves. Not to be confused with *amount* of wave energy received by the coastal region (see Section 3.2.1)
Geology1_n *Geology1_v*	string (text)	6 50	**Primary Geological Substrate** (numerical string code) (verbal label) Only or lowermost litho-structural geological substrate (bedrock) type on or into which the present shoreline has developed. See attribute table 6.3.9.	Primary geological substrate present prior to development of present coastline. Includes inferred bedrock underlying soft sediment coasts where bedrock is not exposed.

Geology2_n *Geology2_v*	string (text)	6 50	**Secondary Geological Substrate** (numerical string code) (verbal label) Secondary or superficial litho-structural geological substrate (bedrock) type on or into which the present shoreline has developed. See attribute table 6.3.9.	Secondary geological substrate present prior to development of present coast. Generally refers to hard substrates in the backshore zone which overlie a 'Primary' bedrock type exposed in or underlying the intertidal zone.
Feature- Level Metadata: Geomorphic Data Sources and Scales Because of the multitude of data sources used in compiling this map, it is necessary to provide the following metadata fields (data source & scale) for each geomorphic attribute field of each feature (line segment). For a given attribute field, different records (coastline segments) may have differing data sources, and conversely the data in different geomorphic attributes (fields) for the same coastline segment (record) may be derived from different sources.				
A differently-named field for each geomorphic attribute: *Backprox_r* *Backdist_r* *Backprof_r* *Intertd1_r* *Intertd2_r* *Intslope_r* *Subtid1_r* *Subtid2_r* *Exposure_r* *Geology1_r* *Geology2_r*	string (text)	4	**Source (reference) from which the data in each record in each field was obtained**. Source ID or Reference_ID code number which refers to (and can be linked to) to a separate meta-database providing the full bibliographic details of each data source. (See Appendix One or separate *Smartline_v1_Data_Sources.xls* spreadsheet for listing of source details)	Refers to pre-existing map datasets or other references used to compile the mapped attribute field, or may include new fieldwork or remote sensed data acquisition by specified people where pre-existing data was not the primary source. May be a null record if corresponding *_n* & *_v* fields are "Unclassified".
A differently-named field for each geomorphic attribute: *Backprox_s* *Backdist_s* *Backprof_s* *Intertd1_s* *Intertd2_s* *Intslope_s* *Subtid1_s* *Subtid2_s* *Exposure_s* *Geology1_s* *Geology2_s*	string (text)	10	**Scale of geomorphic data capture in the source data for each record in each field** Format: 10K, 25K, 100K, etc, (where '10K' = 1:10,000 scale, etc) or indicate a range of scales where applicable, e.g., '250K-100K'	Different to base map scale. Refers to the scale of source data either as cited by the source, or estimated. May be a null record if corresponding *_n* & *_v* fields are "Unclassified".

Stability Themes:				
Muddy_n *Muddy_v* *Muddy_l*	string (text)	3 100 30	**Muddy Shores** Dominantly fine-grained soft-sediment intertidal zones. Includes some mangrove, tidal flat, estuarine and deltaic shores.	Potentially highly mobile, subject to erosion and/or accretion with varying conditions. See attribute table (Section 6.3.10).
Sandy_n *Sandy_v* *Sandy_l*	string (text)	3 100 30	**Sandy Shores** Dominantly sand – grade soft-sediment intertidal zones. Includes sandy beaches, tidal flats and other sandy shores.	Potentially highly mobile, cyclic erosion & accretion with coastal processes is normal & may mask underlying progressive changes due to long-term process or environment changes. See attribute table (Section 6.3.10).
Dunes_n *Dunes_v* *Dunes_l*	string (text)	3 100 30	**Sand Dune & Beach Ridge Coasts** Backshore dunes or beach ridges present; intertidal zone may be sandy, rocky or other types. Distinct from "Sandy" theme above, since dunes & dune fields may occur inland of rocky shores.	Potentially prone to dune mobility or stabilisation depending on wind and precipitation, vegetation and disturbance. See attribute table (Section 6.3.10).
Coarsed_n *Coarsed_v* *Coarsed_l*	string (text)	3 100 30	**Coarse Sediment Shores** Primarily dominantly boulder to pebble-grade shingle beaches, or dominantly coarse colluvial (talus) unconsolidated sediment shores.	Colluvial types generally prone to slumping, likely accelerated with sea-level rise; behaviour of coarse-grade beaches probably variable but many are likely prone to some cyclic cut-and-fill and progressive recession. See attribute table (Section 6.3.10).
Undifsed_n *Undifsed_v* *Undifsed_l*	string (text)	3 100 30	**Undifferentiated Sediment Shores** Shores dominated by soft sediment in the Intertidal zone, where sediment type is unknown.	Assumed potentially prone to erosion and recession. See attribute table (Section 6.3.10).
Softrock_n *Softrock_v* *Softrock_l*	string (text)	3 100 30	**"Soft Rock" Shores** Dominantly "soft rock" landforms in the backshore zone. May include landforms of semi-lithified or inherently soft bedrock, weathered bedrock or regolith including laterite profiles. May include gently to moderately sloping to cliffed profiles and sub-ordinate colluvium.	"Soft Rock" landforms are a distinctive category - much more erodible and slump-prone than hard rock shores, but less mobile than soft sediment shores. However erosion is mainly progressive and irreversible & long-term 'net' recession rates may be comparable to soft

				sediment shores. See attribute table (Section 6.3.10).
Hardrock_n *Hardrock_v* *Hardrock_l*	string (text)	3 100 30	**Hard Rock Shores** Gently to moderately sloping or steep to cliffed hard rocky intertidal and backshore landforms (steep to cliffed shores may include sub-ordinate colluvium).	Gently to moderately sloping shores are generally resilient, stable shores over foreseeable human time-frames. Steep to cliffed shores potentially prone to rock falls, slumps, collapse and shoreline retreat. See attribute table (Section 6.3.10).
Undfrock_n *Undfrock _v* *Undfrock _l*	string (text)	3 100 30	**Undifferentiated Rock Shores** Gently sloping to cliffed bedrock shores where bedrock 'hardness' unspecified in intertidal to backshore proximal zone.	On a Precautionary basis, susceptibility to instability may be assumed comparable to soft rock shore types. See attribute table (Section 6.3.10).
Coral_n *Coral_v* *Coral_l*	string (text)	3 100 30	**Coral Coasts** Shore dominated by biogenic reef structures of 'living' reefs, and derived coastal materials.	Complex responses to climate change & sea-level rise but may include death and physical break-up of reef structures. See attribute table (Section 6.3.10).
Unclass_n *Unclass_v* *Unclass_l*	string (text)	3 100 30	**No Stability classification** Coasts not classified into stability categories.	See attribute table (Section 6.3.10).
Other:				
Comments	string (text)	254	**General notes** and comments pertaining to the coastal segment.	Generally used to note special geomorphic issues or mapping issues pertaining to the segment.

6.3 *Smartline Classification – Structure and Attribute Tables ("Lookup Tables")*

6.3.1 Introduction – Attribute Formats & Hierarchical Organisation

This section provides attribute tables ("lookup tables") detailing the descriptive classes used for each geomorphic attribute field or "theme" in the Smartline coastal geomorphic classification, as outlined in the Data Model (Section 6.2 above). Attribute classes are defined using a system which endeavours to strike a balance between capturing as much detailed information as possible without requiring an overly complicated format.

Each attribute class or category is recorded in two equivalent forms, namely a numerical (string character) code as well as an equivalent brief descriptive verbal label. Whilst verbal descriptions are simpler for creating humanly-usable legends and the like, numerical codes are useful for certain types of data analysis including writing queries.

However, although only the attribute classes are used in the Smartline map itself, these are derived in a systematic fashion from three underlying tables of "Hierarchical Classifiers" (as described below). Hence, whilst the verbal labels provide an easily understood description of the attribute class, the equivalent 6-digit numerical codes not only label each type but also allow the derivation of the class from the underlying classifiers to be precisely specified (see further explanation below).

The attribute tables for the landform type theme fields *Backprox* & *Backdist*, *Intertd1* & *Intertd2* and *Subtid1* & *Subtid2* are organised in a hierarchical fashion, such that landforms can either be classified into only very broad categories (where limited information is available) or into more detailed categories where better information exists. The numerical codes for these fields are 6 - digit codes (3 digit pairs) structured thus:

- First digit pair = Fabric classifier
- Second digit pair = Form classifier
- Third digit pair = Genetic and/or other modifier classifiers as required.

The classification system used for these landform attributes is structured as a hierarchy of fabric over form over genetic and other 'modifier' criteria as required (see Section 2.2). Favouring fabric over other criteria means that the classification differentiates between harder and softer coastal landform types at the primary level, which makes it a simpler system to apply to landform stability classification (as described in Section 4.0).

Sub-classes within each of these three classifiers are also hierarchically ordered as indicated in
Table 2 following. Note that whilst the intention in constructing this classification scheme was to use the same hierarchy of sub-classes in the basic *Fabric* and *Form* classifiers for all landform themes, actual geomorphic differences between the three coastal landform zones (*backshore*, *intertidal* and *subtidal*) meant that some variations were needed in the hierarchical classifier tables for these three zones.

<table>
<tr><th rowspan="2">Hierarchy Level</th><th colspan="3">Landform Classifier</th></tr>
<tr><th>Fabric</th><th>Form</th><th>Genesis / other Modifiers</th></tr>
<tr><td>Top (1)</td><td>Fabric type by primary categories:

- Lithic (‘bedrock’);
- Unlithified sediment classes by broad grainsize category;
- Biological structures;
- Artificial structures;
- Unclassified.</td><td>Primary form categories:

- Flat (to gently sloping);
- Sloping (moderately to steeply);
- Vertical (to very steep);
- Complex forms;
- Sporadic or intermittent features;
- Unclassified.</td><td rowspan="3">Variable sub-class hierarchy (see attribute tables); sub-classes used generally define major process categories characteristic of each coastal landform zone (genesis), and widely used landform names and classes characteristic of the zone (e.g., ‘beach’, ‘talus’, ‘cliff’, etc).</td></tr>
<tr><td>2</td><td>- ‘Hardness’ & dominant mineralogy of lithification (for lithic substrates);
- Geomorphic setting (for unlithified sediment backshore substrates only) – i.e., whether intertidal landforms backed by bedrock above sea level or soft sediment to below sea-level in the backshore;
- Broad taxonomic groups (for biological structures);
- Broad groupings by material type (for artificial structures).</td><td>- Presence or absence of ridge (e.g., dune), terrace or complex forms super-imposed on primary form class;

or:

- Slope sub-classes.</td></tr>
<tr><td>3</td><td>Grainsize sub-classes within broad grainsize category (for unlithified sediment substrates).</td><td></td></tr>
</table>

Table 2: Ordering of sub-class criteria within the hierarchical classification schemes used to define landform classes for the Backshore, Intertidal and Subtidal landform themes. The same basic structure and ordering of the hierarchical *Fabric* and *Form* classifiers are used for all landform themes, although some variations and inconsistencies in these between the backshore, intertidal and subtidal classes have been necessitated by actual geomorphic differences between landforms in these three coastal zones. However the hierarchies of *Genesis / other Modifier* classifiers are significantly different between landform zones owing to the significant differences between geomorphic processes in these zones

The geological substrate (‘bedrock’) classes for the themes *Geology1* & *Geology2* are derived using a similar logic to produce a simple litho-structural classification of bedrock types (see Section 3.2.1). In this case, the three “Hierarchical Classifiers” used in the Geology Attribute table (Section 6.3.9) are:

- First digit pair = Lithology classifier
- Second digit pair = Structure classifier
- Third digit pair = Alteration processes and/or other modifier classifiers as required

The resulting geology classes are broad geological substrate classes primarily grouped by lithology and structure (which are directly relevant to coastal landform development), rather than by age or stratigraphic unit (which are traditionally used in most geological mapping, but are not necessarily directly relevant to the types of coastal landform development that may occur on the specific bedrock type).

Sub-classes within each of these three classifiers are also hierarchically ordered as follows:

Hierarchy Level	Geology Classifier		
	Lithology	**Structure**	**Alteration / other Modifiers**
Top (1)	Primary compositional groups by process of formation: - Siliceous sedimentary rocks; - Carbonate sedimentary rocks; - Volcanic igneous rocks; - Intrusive igneous rocks; - Bedrock weathering products (regolith); - Biogenic deposits; - Ice; - Special cases; - Unclassified.	Primary structural groups: - Undeformed; - Folded; - Fault-disrupted (intensely); - Jointed (notably); - Unclassified.	Degree of alteration (for all primary lithology classes except weathering products, biogenic deposits and ice): - Unconsolidated; - Semi-lithified; - Lithified; - Metamorphosed; - Altered (other alterations); - Unclassified. or: Primary “Modifier” categories characteristic of the particular primary lithology class (for weathering products, biogenic deposits and ice primary lithology classes).
2	- Major compositional sub-classes (for carbonate sedimentary rocks, igneous rocks and weathering products); - Broad taxonomic groups (for biogenic deposits).	- Secondary structural sub-classes.	- Major sub-classes characteristic of the primary lithology class and its degree of alteration (for all primary lithology classes except weathering products, biogenic deposits and ice):
3	- Broad grainsize classes (for sedimentary & igneous intrusive rocks).		

Table 3: Ordering of sub-class criteria within the hierarchical classification schemes used to define Geology classes for the *Geology1* and *Geology2* themes.

The numbering system used to derive the landform and geology class numerical codes is additionally based on the following principles:

- No leading zeros are used in the numerical codes, in order to avoid problems with some data processing procedures that automatically drop leading zeros.
- Each of the three hierarchical classifier numerical codes used to construct the landform or geology class codes uses 2 digits (rather than only one) so as to allow the potential for a large number of categories (up to 90, since leading zeros are not used) to be used for each classifier. Whilst the final 6 digit class code produced by the combination of three 2-digit hierarchical classifier codes is long and so potentially confusing, the consequence of the simpler alternative of using only 1-digit codes for each classifier is that the resulting availability of only 9 categories for each classifier would place onerous restrictions on the flexibility of the classification system.
- The hierarchical classifiers are indeed *hierarchical* – that is, in each table there are broad "undifferentiated" categories available for use where little information is available, however more specific sub-categories can also be used if sufficiently detailed mapping data is available. This provides an optimum balance between allowing capture of relatively simple or relatively detailed information depending on the data available without creating an unduly complex system. Moreover, the variety of simpler or more detailed classes created in this way can all be easily lumped back into "lowest common denominator" simple categories where it is necessary to display or analyse all map data at a uniform level of detail.
- As far as possible, the same numerical codes have been used for the same broad fabric and form classes (e.g., sand, coarse sediment, etc) in all landform attribute fields. "Unclassified" attributes or categories are specified using '9's. Where relevant and practical, numerical codes generally progress from lower numbers = 'lesser' categories (e.g., lower slopes, lesser exposure, etc) to higher numbers = higher categories (steeper slopes, greater exposure, etc).

Whilst an effort has been made to employ consistent classification rules and logic in creating the hierarchical classifier tables for each theme attribute field, it has been found to be difficult to entirely eliminate some exceptions and inconsistencies from the system adopted. Hence, for example, the fabric class "Lithic Substrate" as used in several landform attribute fields is essentially intended to encompass hard bedrock substrates; however it has proved simpler to include soft 'bedrock' types and hard beachrock (which is not bedrock) within this same class – as exceptions to the general rule – than to classify these types in any simpler alternative way within the adopted framework. This simply reflects the fact that any classification system is an attempt to impose artificial organisation on a group of natural phenomena that have not developed in any particular organised fashion. Such inconsistencies as exist in the Smartline coastal landform classification which follows do not seem to significantly diminish the practical utility of the mapping system.

How the landform & geology attribute tables work

The landform and geology attributes used in a precursor version (Sharples 2006a, b) of the current Australian Coastal Smartline Geomorphic and Stability Map were based on a single table of landform or geology types for each landform or geology attribute, with a numerical code for each class of landform or geology. In that earlier system, the landform and geology types were listed in an essentially *ad hoc* order, and their numerical codes functioned purely as arbitrary identifying codes for each type.

In the current system described here, the landform and geology classes (numerical codes and verbal labels) function in essentially the same way as the earlier system of Sharples (2006a,b), and remain the only classifiers actually used in the GIS files themselves (i.e., the hierarchical classifier tables can generally be ignored when actually using or editing the GIS data). However the classes are now derived in a systematic fashion from underlying tables of hierarchical classifiers, and hence the numerical codes are now constructed from the underlying hierarchical classifier codes so that the numerical code for a given landform or geology type is no longer simply an arbitrary label, but rather a code which specifically identifies the fabric, form and genesis / other modifier classifiers which have been used to generate the landform classes, or the lithology, structure and alteration / other modifier classifiers used to generate the geology classes.

The values of using underlying hierarchical classification tables to generate the final landform or geology classes, rather than simply listing classes in an *ad hoc* fashion, include:

- New classes can be derived in a systematic rather than *ad hoc* fashion when required;
- The system allows the precise derivation of each class to be specified by its numerical code, which allows simpler querying and data analysis procedures.

In the landform and geology attribute tables following, each of the three digit pairs making up the numerical codes refer to one of the three tables (or columns) of categories that are provided on the left hand side of each attribute table. These three column tables are the "Hierarchical Classifiers" and are used to systematically construct the 6-digit numerical codes, by a method similar to "keying out" taxonomic classifications (see Table 4); however the hierarchical classifiers themselves are not reproduced in full in the Smartline attribute tables (i.e., the shapefile .dbf files). Rather, the Smartline attribute tables use only the "Landform Classes" or "Geology Classes", which are the numerical codes and verbal labels provided on the right hand side of each attribute table.

Each landform or geology class records - as a 6-digit numerical code and a verbal label - a particular landform or geology type defined by a unique combination of the three hierarchical classifiers. In general, the classes actually provided in this Data Dictionary only list common landform or geology types that are actually used in the mapping; however the hierarchical classifiers can allow many more classes to be defined (by new combinations of hierarchical classifiers), and these can be added to the existing landform or geology classes as they are needed or become useful.

The following Table 4 (next page) illustrates how this system works, using an extract of the sandy landform portion of the intertidal landform attribute table (from Section 6.3.5).

Flexibility in classification and implications for searching the dataset:
In order to allow flexibility in the Smartline coastal landform classification system, the hierarchical classification tables have been structured in a way which allows some coastal landform and geology types to be classified in more than one way. This flexibility manifests in at least two ways, namely:

1.
Some landforms can be recorded equally correctly in either of two or more alternative fields; for example, beaches and tidal flats can each be recorded in either the *Intertd1_* field or the *Intertd2_* field; similarly coastal cliffs may be classified in the *Backprox_* field or in either *Intertd_* field. In general, the choice of which field to classify a feature in will depend on what other features of a particular shoreline segment also need to be recorded in the Smartline classification – allowing several different options for where to classify features in this system makes it easier to incorporate a complex range of features into the Smartline map. The downside of this flexibility is that one must be aware of it when searching the map for particular landform types (see below).

Hierarchical Classifiers (used to derive Landform classes)			**Landform Classes** (as used in Smartline attribute table)	
Fabric What the landform is made of (broad classes)	**Form** Broad form categories	**Modifier** Common descriptive terms, morphodynamic or genetic types, other useful classifiers.	**Code** *Intertd1_n* *Intertd2_n* (6 digits)	**Verbal Descriptive Label** *Intertd1_v* *Intertd2_v* (50 characters)
50 Sand undiff. 51 Coarse-grained sand dominant 52 Fine – medium grained sand dominant 53 Fine-grained sand dominant	10 **Flat** to gently sloping (<5°) 20 **Sloping** (moderately to steeply sloping 5° - 60°) 21 Moderately sloping (5°-15°) 22 Steeply sloping (15°-30°) 23 Very steeply sloping (>30°) 90 **Unclassified**	10 **Beach** (undiff) 11 Perched beach 20 **Tidal flat** 21 Tidal flat inferred from mapped mangroves 30 **Narrow sandy shore** 90 **Unclassified**	509090 509010 519010 512210 529010 509011 501020 531020 509030	Sandy shore undiff. Sandy beach undiff. Coarse sand beach Steep coarse sand beach Fine-medium sand beach Perched sandy beach (undiff.) Sandy tidal flat Sandy tidal flat (fine grained) Narrow sandy shore (e.g., non-beach sandy tidal channel shore)

New landform class to be added:
501021: sandy tidal flat inferred from mangroves

Table 4: An example of a portion of the Intertidal Landforms attribute table (Section 6.3.5) used to derive Landform Class codes and verbal labels (a similar system is used to derive Geology class codes). Each coloured line links three Hierarchical Classifier categories which yield particular numerical codes corresponding to particular landform types or classes. Far more landform classes could in principle be derived from this scheme than are actually listed in the Landform Classes columns (RHS); the intention is that only those Landform Classes actually used will be listed in these attribute tables, however when-ever new landform types are encountered in mapping, codes for these can be derived from the hierarchical classifiers and added to the Landform Classes lists with a suitable verbal label.

2\.
Some landform and geology types can also be defined in several alternative ways within this system; for example it is possible to specify the presence of protruding rocky outcrops on a tidal flat using either an appropriate *Form* classifier, or alternatively using an appropriate *Modifier* classifier. Again, this degree of flexibility was introduced to the system to make it possible to classify relatively complex mixtures of landform components in the coastal zone; however the downside is again that in searching the dataset for a particular landform or geology type, one must be aware of the possible alternative ways in which it may have been classified.

Because certain landform or geology types can be recorded in the Smartline map using more than one possible classification, and in more than one possible field, when searching the dataset for all occurrences of a particular type, it is necessary to ensure that all possibilities have been covered. However, because of the hierarchical nature of the classification it is also possible to narrow down the search for particular landform by searching first on the *Fabric* class (e.g., rather than searching first for "fine-medium sandy beaches" - which involves a *Modifier* class - it is likely to be more efficient to first search for simply "sandy shores" based on the *Fabric* classes alone). A similar logic can be used in searching for particular geology types where there is potential for these to have been classified in several alternative ways.

Note that in order to minimise potential confusion resulting from the flexibility of the classification, a number of classification conventions have been adopted as described in Section 6.3.2 following.

6.3.2 Smartline Landform Classification Conventions

Hierarchical Classification Terminology
The following standard terminology has been adopted for the purposes of the Smartline Landform classification:

Landform **ZONES**
A **Zone** refers to a specific (spatial) coastal zone (or area), as described in Section (3.2.1); see Figure 6. The landform zones used for the Smartline landform classification are the *Backshore*, *Intertidal*, and *Subtidal* zones.

THEMES
A **Theme** refers to a specific coastal attribute field which may be an attribute of a landform zone (e.g. the *Backshore Distal* landform theme or the *Backshore Profile* theme within the Backshore zone) or an attribute of the coast in general (e.g. shoreline segment *Exposure* or bedrock *Geology1*).

CLASSES
A **Class** refers to the individual categories within each theme. For example, the shoreline segment 'Exposure' theme has the classes "*Very Low*", "*Low*", "*Medium*" and "*High*", while the landform theme 'Backshore Distal' has a large number of actual or possible classes based on various combinations of the Fabric-Form-Modifier classifiers. Classes are defined both as numerical codes and as verbal descriptions.

Classification Flexibility & Conventions
Whilst the classification tables for each Smartline landform and geology theme are constructed in a consistent and hopefully logical fashion, as noted in Section 6.3.1 above the Smartline classification also allows some flexibility. There are advantages in being able to classify some landforms or geology types in alternative ways within the classification; however the downside of this is that it can create some inconsistencies and so greater complexity in extracting some types of information.

For this reason a number of conventions (listed below) have been adopted which, if adhered to consistently, can make the system simpler for recording and extracting certain types of coastal landform information.

Nonetheless, in complex situations some of these conventions cannot always be applied consistently. While it is intended that particular types of coastal landforms should generally recorded preferentially in a particular landform attribute field, this may need to be varied depending on complexities of the landform assemblages found at any particular site. For example, to search the map for all "coastal cliffs" it is important to be aware that while most coastal cliffs will be recorded as "*Backshore Proximal*" features (as per the convention described below), some may only be recorded as *Backshore Distal* features, and some may also be recorded as *Intertidal* or even *Subtidal* features, depending on complexities at particular coastal locations. Thus in order to search for all cliffs in the Smartline map, all these fields should be queried, not just the *Backshore Proximal* field.

Similarly for many other landform types; when searching for all examples of a particular landform type, it is important to query all attribute fields in which that landform type could possibly be recorded. Whilst this system makes queries a little more complex than could have been the case if specific landform types were always placed in only one field, it allows for much greater flexibility in recording data about complex coastal landform assemblages in the Smartline and thus ultimately allows the Smartline system to record much more information in a simple format than would otherwise be the case.

The following are key conventions adopted in assigning certain coastal landform types to Smartline attribute fields in cases were alternative usages are possible but may cause confusion:

Backshore Soft-Sediment Landforms
A first-order priority in classifying soft sediment landforms in the *Backshore Distal* and *Proximal* fields is to enhance the usefulness of their classification in coastal stability assessments by recording whether they are situated on a bedrock substrate which rises above sea level, or on a soft sediment substrate extending in depth to below present sea level. This distinction is of major importance in determining the potential for significant shoreline recession with sea-level rise (which may be the case where soft sediment substrates in the backshore extend below sea level, but is less likely where soft sediment features sit on a bedrock base which rises above present sea level). Thus, for example, wherever a dune is known or can reasonably be inferred to sit on a bedrock base above sea level, it should be classified as a "Dune on bedrock above Sea Level", but where it is known to sit on a soft coastal infill of unconsolidated sediment extending below present sea-level it should be classified as "Dune on soft sediment to below sea level". However, where the depth to bedrock is unknown and cannot be reasonably inferred, a soft landform such as a dune should be classified as "Dune undiff." where the "undiff" classification is a reference to the lack of distinction between dunes on bedrock or on soft sediment. By examining the backshore landform classes listed in Section (6.3.3), the user will note how the classification of many soft backshore landforms provides for three variants, namely "undiff", "on bedrock above sea-level" and "on soft sediment to below sea-level".

Supratidal Landforms
Supratidal environments (occasionally but not regularly inundated by the sea, e.g., during storm surges) are arguably distinctive from either backshore or intertidal environments. However, in order to minimise the complexity of the Smartline landform classification the convention adopted to classify supratidal landforms is that they are classified as special cases of *Backshore proximal* and/or *distal* landforms, rather than creating separate attribute fields specifically for supratidal landforms.

Dunes
Dunes are always Backshore features. If there is only one dune backing the shore, it is usually recorded in *Backshore Proximal* field only. Dune-fields are usually recorded as a *Backshore Proximal* dune plus a *Backshore Distal* dune-field. However a single cliff-top dune may be recorded as a *Backshore Distal* feature, with the cliff being a *Backshore Proximal* feature.

Coastal Cliffs
By convention, coastal cliffs are generally recorded as a *Backshore Proximal* landform, on the grounds that most such cliffs will predominantly rise above the intertidal zone, and are thus effectively the first landform to landwards of (& above) the Mean High Water Mark. Thus the associated *Intertidal* landforms can be recorded as "rocky shore", "rocky shore platform", "beach" or whatever is at the foot of the cliffs, and the *Backshore Distal* landforms (above & inland of the cliff) can be recorded as "bedrock terrain", "dunes on bedrock", or whatever the case may be.

However, this convention can be varied if necessary. For example, where the backshore comprises supratidal saltmarsh backed by a cliff, then the saltmarsh may be the *Backshore Proximal* landform and the cliff may be the *Backshore Distal* landform. Again, if the cliff plunges directly into the sea without a platform, talus cone or beach at its base, then the *Intertidal* (and sometimes even the *Subtidal*) landforms may also be recorded as "cliffs" or "plunging cliffs" in addition to the *Backshore Proximal* being classified as cliff.

Beaches
Beaches are generally recorded as the *Intertidal 1* landform in the intertidal zone, on the grounds that they are typically the uppermost (or only) landform feature in an intertidal zone, with rock platforms, tidal flats, etc, generally occurring below and to seawards of the beach proper. However, beaches can if necessary be recorded as the *Intertidal 2* landform in less common situations such as where a narrow

beach actually occurs below a dominantly rocky intertidal shore or an artificial seawall which lies at least partly within the intertidal zone (these would then be the *Intertidal 1* landform).

Tidal flats
Intertidal sediment flats are generally recorded as the *Intertidal 2* landform (i.e., the lowermost intertidal landform), on the grounds that the uppermost limit of the Intertidal Zone on such shores is commonly a narrow beach or a rocky or muddy shore, which would be recorded as the upper intertidal feature (*Intertidal 1*). However, Intertidal flats might be recorded as the *Intertidal 1* landform in cases where no other uppermost intertidal landform is identifiable (e.g., no clearly distinguishable beach is present); in this case the *Intertidal 2* attribute would be left unclassified.

Rocky Shore Platforms
Rocky shore platforms have typically been recorded as the *Intertidal 2* landform (with *Intertidal 1* being 'rocky shore', 'beach', or something else). However in some circumstances the rocky shore platform may be recorded as the *Intertidal 1* landform, for example where no other significant intertidal landform has been identified (in which case *Intertidal 2* is 'Unclassified'), or where the other major intertidal landform is a tidal sediment flat (in which case the rocky platform is generally the higher feature, and so is recorded as *Intertidal 1*, with the tidal flats recorded as *Intertidal 2*).

Saltmarsh substrates (e.g., sediment flats)
Saltmarsh has generally been classified as a supratidal community (and associated sediment flats landforms or substrates) in Smartline version 1.0 and as such has been recorded under the *Backshore distal* and / or *proximal* themes. However it is recognised that saltmarsh may arguably also occur in the intertidal zone, hence provision exists for saltmarsh substrates to be recorded as *Intertidal* classes with or without *Backshore* saltmarsh being also recorded.

Artificial Features
Artificial features present in any of the landform zones are recorded as a distinctive category within each landform theme in the same fashion as natural landform features (see attribute tables following), and may be recorded as appropriate in the Backshore, Intertidal and Subtidal zones. However, a convention adopted for the Backshore zone is that where an artificial shoreline is present extending into the backshore zone (e.g., a revetment immediately backing the intertidal zone, which may itself be backed by roads and buildings over a natural (e.g., sediment) substrate), then the artificial feature (in this case the revetment) is recorded as the *Backshore proximal* feature, but the natural substrate backing this (and underlying roads, buildings etc) is recorded as the *Backshore distal* substrate. The purpose of this convention is to allow both the recording of artificial shores, and also the recording of the natural backshore type over which artificial features have been constructed. This is of use for many purposes including assessing what the stability of the coast would be if artificial structures were not present or if they were to fail.

An exception to this rule could occur where a shoreline is reclaimed land in which the backshore zone is dominated by artificial fill to well inland of the artificial shoreline, in which case both the *Backshore proximal* and *Backshore distal* themes would be attributed as artificial types.

6.3.3 Backshore Landform Themes

Landforms of the Backshore Zone are described using two attribute theme fields (*Backprox* and *Backdist*), to allow capture of information describing complex backshore areas having more than one significant landform element (see also Section 3.2.1 for discussion). Both fields use descriptors drawn from the same attribute table (below). In this attribute table, the 'Hierarchical Classifiers' are used to systematically define each backshore landform type, while the 'Landform Classes' summarise each category using a numerical code combining the hierarchical classifiers, and a summary descriptive label. The Landform Classes listed are those categories actually used in attributing the Smartline v.1 map backshore landform type fields *Backprox* and *Backdist*, and can be added to (using new combinations of hierarchical classifiers) if additional backshore landform classes are required in future.

For the purposes of this classification, the 'backshore' zone includes 'supratidal' landforms (those found above normal MHWM, but which are occasionally inundated (e.g., during storm surges). See also Section (3.2.1).

Proximal Backshore Landforms

Field name: *Backprox*

***Explanation*:** The first notable landform type or assemblage present immediately to landwards of or above the intertidal zone. The width of the backshore proximal zone is not defined – it depends on the scale of the proximal landform. If the *Backprox* landform type dominates to 500m or more inland, then the Distal Backshore landform attribute (*Backdist*) may simply be the same.

Distal Backshore Landforms

Field name: *Backdist*

***Explanation*:** The dominant distinctive backshore landform type or assemblage inland of the proximal backshore landform. Backshore landforms may be classified for the purposes of this mapping to a distance of 500m inland. The distal backshore attribute may have an "Unclassified" value in cases such as narrow tombolos or necks where only one backshore landform intervenes between two shorelines. Where the proximal backshore landform type (*Backprox*) dominates inland to over 500m; the *Backdist* attribute may simply be the same.

Terminology notes:

In order to provide adequately descriptive verbal labels within a 50 character limit, it has sometimes been necessary to use cryptic terminology. Where the following phrases are used in verbal labels for backshore landforms, their meanings are specifically intended as indicated following:

"*…to below sea level*" or "*…to below SL*" refers specifically to the depth of soft sediments comprising the coastal landforms in question. For example, "alluvial sediment plain to below sea level" means that the *depth* of the alluvial sediments extends to below sea level.

"*…on bedrock*", "*…on bedrock above sea level*" or "*…on bedrock above SL*" indicates that the unconsolidated sediments forming the coastal landforms in question are resting on an underlying bedrock surface which is above present sea level.

The abbreviation "*sed*" is sometimes used for "sediment' or 'sediments" (in order to keep descriptions within field length limits).

Hierarchical Classifiers (used to derive Landform classes)			**Landform Classes** (As used in Smartline attribute table)	
Fabric What the landform is made of (broad classes)	**Form** (broad form categories) **Note:** same table applies to all fabric classes	**Genesis / other Modifiers** (morphodynamic or genetic types, common terms, other classifiers)	**Code** *Backprox_n* *Backdist_n* (6 digits)	**Verbal Label** *Backprox_v* *Backdist_v* (50 characters)
10 Lithic Substrate undiff. ± soil* ('Bedrock' (geological substrate pre-dating the current coast) or hard coastal deposits (e.g., tufas); essentially intended to refer to hard coastal substrates as opposed to soft sediments of coastal origin and biological or artificial structures of coastal provenance. However also includes soft (semi-lithified or weathered) 'bedrock' types as exceptions to the rule[15]) 11 Hard lithic material ± soil (e.g., hard bedrock, tufa) 12 Soft lithic material ± soil (e.g., semi-lithified clayey sediments, weathered bedrock, friable lateritic horizons)	10 **Flat** to gently sloping (<5°) 11 Plain without notable dune forms (absent or subdued) 12 Plain with shore parallel ridges 13 Plain with complex ridges 20 **Sloping** (moderately to steeply 5° - 60°) 21 Moderate slopes (5°-15°) 22 Steep slopes(15°-30°) 23 Very steep slopes (>30°) 30 **Vertical** (very steep to vertical >60°) 31 Low vertical face (<5m) 32 Cliff (>5m)	10 **Bedrock or 'geological substrate' undiff. terrain** (± soil) 11 Soil-mantled bedrock terrain 12 Bare-rock terrain 13 with patchy colluvium (undiff.) 14 with patchy soil-mantled colluvium 15 with patchy bare colluvium 20 **Hard bedrock ('geological substrate') terrain** (± soil) 21 Soil-mantled hard bedrock terrain 22 Bare hard bedrock terrain 23 with patchy colluvium (undiff.) 24 with patchy soil-mantled	 109010 103212 103213 103112 102010 101010 119020 113222 113223 113122 112020 111020	*Geological substrate, undiff:* Bedrock (± soil) terrain undiff Cliff (>5m) undiff Cliffs (>5m) with colluvium undiff Low cliff (<5m) undiff Sloping bedrock (undiff) terrain (± soil) Bedrock (undiff) platform (± soil) *Hard bedrock (geological substrate):* Hard bedrock (± soil) terrain Hard bedrock cliffs (>5m) Hard bedrock cliffs (>5m) with colluvium Low hard bedrock cliffs (<5m) Hard sloping bedrock terrain (± soil) Hard bedrock platform (± soil)

[15] Whereas deposits of coastal origin are only included in this fabric class if they are hard (lithified), bedrock (geological substrates pre-dating the current coast) are included even where they are soft (e.g., semi-lithified or weathered). This complexity in this one fabric class (which is fundamentally intended to identify hard coastal fabrics as opposed to the soft coastal sediment fabrics in most of the other fabric classes) has been adopted as a lesser complexity in preference to the greater complexity of having both coastal sediments and (soft) bedrock types as sub-categories of all primary fabric classes.

13 Ice-dominated substrate (Could include ice and permafrost where these constitute the coastal substrate in polar regions; not used in Australian Smartline map.) * <u>Note</u>: This fabric class covers both coastal bedrock and hard coastal deposits such as tufas because they have similar fabrics for the purpose of this fabric-form classification; their differing origins are distinguished using the 'modifier" classifiers. Where the lithic fabric is 'bedrock' (rather than precipitates of coastal origin), more details of substrate type are provided by the *Geology* attributes.	40 **Complex forms** 41 Shore-parallel ridge (foredune) 42 Complex ridge 43 Terraced slope 50 **Sporadic or intermittent features** 90 **Unclassified**	colluvium 25 with patchy bare colluvium 30 **Soft 'bedrock' ('geological substrate') terrain** (± soil) Semi-lithified or weathered bedrock, regolith substrate 31 Soil-mantled soft bedrock terrain 32 Bare soft bedrock terrain 33 with patchy colluvium (undiff.) 34 with patchy soil-mantled colluvium 35 with patchy bare colluvium 40 **Cemented coastal sediment terrain** (± soil) 41 Lime-cemented coastal sands undiff ('Legacy' terminology: may include undifferentiated calcarenites & beachrock.) 49 'Coffee rock' (humicrete or humates; exposed iron pans) 50 **Beachrock** (± soil) E.g., beachrock terraces; not used yet. 60 **Coastal Precipitates** (± soil) E.g., tufas. 70 **Ice** Would include glacier ice and permafrost; not used for Australia. 90 **Unclassified**	 129030 123232 123233 123132 122030 121030 109041	*Soft bedrock (geological substrate):* Soft 'bedrock' (± soil) terrain Soft 'bedrock' cliffs (>5m) Soft 'bedrock cliffs' (>5m) with colluvium Low soft 'bedrock' cliffs (<5m) Sloping soft 'bedrock' terrain (± soil) Soft 'bedrock' platform (± soil) *Other "lithic" substrates* Lime-cemented coastal sands undiff (<u>Note</u>: this term was used in some source datasets and may refer to calcarenites, calcrete or beach-rock; hence until this is resolved the original ambiguous term is used in the Smartline for cases where the actual nature of the material is still uncertain).

20 Sediment undiff. (depth unclassified) (Unconsolidated sediment of unknown grainsize or type, or interbedded sediments where no one type is known to greatly dominate, e.g., interbedded gravel, sand & mud, etc. Includes Quaternary alluvial sediments where present in the coastal area.) 21 Sediment undiff. over bedrock above sea level 22 Sediment deposits undiff. to below sea level		10 **Sediment undiff.** 11 Dominantly well-drained sediment undiff 12 Dominantly well drained sediment undiff with minor marshy areas 13 Dominantly well-drained sediment undiff with minor lagoons (and/or marsh) 14 Saltpans or saline flats (*supratidal* areas) on sediment undiff 15 Saltpans or saline flats on sediment undiff. with minor saltmarsh (*supratidal* areas) 16 Alluvial sediment undiff. 20 **Marshy sediment deposits undiff.** 21 Dominantly marshy sediment undiff deposits 22 Marshy and well-drained sediment undiff deposits (mixed) 23 Dominantly marshy sediment undiff deposits with minor lagoons 24 Marshy saline flats (dominantly samphire-vegetated *supratidal* areas) on sediment undiff deposits 25 Marshy supratidal	209090 219090 229090 201090 221090 209016 219016 229016 201016 221016 209026 229026 201026 221026 221010 221110 209020 229020 201020 221020	Sediment deposits undiff Sediment deposits undiff on bedrock above SL Sediment deposits undiff to below sea level Sediment plain undiff Sediment plain to below sea level Alluvial sediment undiff Alluvial sediment undiff over bedrock above SL Alluvial sediment undiff to below sea level Alluvial sediment (undiff) plain Alluvial sediment (undiff) plain to below SL Swampy alluvial sediment (undiff) Swampy alluvial sediment (undiff) to below SL Swampy alluvial sediment (undiff) plain Swampy alluvial sediment plain to below SL Sediment plain undiff to below sea level Sediment flats to below sea level (no dunes) Marshy sediment deposits undiff Marshy sediment deposits undiff to below sea level Marshy sediment flats undiff Marshy sediment flats undiff to below sea level

		saline flats on sediment undiff *inferred from mapped saltmarsh*. 26 Marshy alluvial sediments undiff. 30 **Lagoons on sediment deposits undiff**. (may or may not be connected to sea). 31 Dominantly lagoons on sediment undiff (no connection to sea) 32 Dominantly lagoons on sediment undiff (ephemeral or permanent connection to sea) 33 Dominantly estuarine channel or lagoon on sediment undiff (ephemeral or permanent connection to sea) 34 Saltpans or saline flats on lagoonal sediment undiff. deposits (evaporitic lagoonal environments). 35 Lagoons and *inferred* marshy saline sediment flats (inferred from saltmarsh) 90 **Unclassified**	201014 221014 201015 221015 201024 201025 221025 221024 221030 201034 201035 221034 221035	Saltpans or saline flats on sediment undiff Saline sediment flats to below sea level Saline sediment flats (minor saltmarsh) Saline sed flats (minor saltmarsh) to below SL Marshy saline sediment flats Marshy saline sediment flats inferred (saltmarsh) Marshy saline sed flats to below SL (saltmarsh) Marshy saline sediment flats to below sea level Lagoons on sediment plain to below sea level Saline evaporitic lagoonal sediment flats Lagoons & inferred marshy saline sediment flats Saline evaporitic lagoonal sed flats to below SL Lagoons & inf. marshy saline sed flats to below SL

30 Coarse sediments undiff. (depth unclassified) (boulders, cobbles and/or pebbles) 31 Boulders dominant (depth unclassified) 32 pebbles or cobbles dominant (depth unclassified) 33 Coarse sediments (undiff) over bedrock above sea level 34 Boulders dominant (over bedrock) 35 pebbles or cobbles dominant (over bedrock) 36 Coarse sediments (undiff) to below sea level. 37 Boulders dominant (to below sea level) 38 pebbles or cobbles dominant (to below sea level) <u>Note</u>: Fewer grainsize categories than for intertidal (less relevant inshore)		10 **High level boulder or shingle – grade beach deposits** (rounded clasts, wave-deposited) 11 Stony (rock clasts) 12 Coralline debris 13 Shelly debris 20 **Boulder or shingle – grade beach ridges or cheniers** (rounded clasts, wave deposited) 21 Stony (rock clasts) 22 Coralline debris 23 Shelly debris 30 **Talus, colluvium** ± soil (of bedrock material, mostly angular clasts) 31 Dominantly bare colluvium (little soil) 32 Colluvium with significant soil development 40 **Residual** (bedrock corestones, weathering debris) 50 **Coarse bedrock-derived material** undiff. 60 **Coarse coralline debris** undiff. (where not a wave-deposited coral debris beach) 90 **Unclassified**	319090 379090 329011 319020 379020 309021 329023 389023 329012 389012 309030 339030 369030 309031 309032 369032 349030 309040 369040	Boulder deposits undiff Boulder deposits undiff to below sea level Stony cobble deposits Boulder beach ridges Boulder beach ridge deposits to below sea level Cobble-boulder beach ridges Shelly beach ridges Shelly beach ridges on sediment to below sea level Coralline gravel deposits Coralline gravel deposits to below sea level Colluvium undiff (± soil) Colluvium undiff (± soil) on bedrock Colluvium undiff (± soil) to below sea level Colluvium (bare, little soil) Colluvium with significant soil development Colluvium with soil, to below sea level Bouldery colluvium on bedrock Residual rock debris deposits Residual rock debris deposits to below sea level

40 Mixed Sandy Sediments undiff. (depth unclassified) (sandy with boulders, cobbles or pebbles; note muddy sediments mixed with coarser material are classified as muddy sediment sub-types under fabric class 60) 41 Boulders & sand dominant (depth unclassified) 42 Pebbles or cobbles & sand dominant (depth unclassified) 43 Mixed sandy sediments over bedrock above sea level 44 Boulders & sand dominant (over bedrock) 45 Pebbles or cobbles & sand dominant (over bedrock) 46 Mixed sandy sediments to below sea level. 47 Boulders & sand dominant (to below sea level) 48 Pebbles or cobbles & sand dominant (to below sea level) <u>Note</u>: Fewer grainsize categories than for intertidal (less relevant inshore)		10 **Mixed sandy deposits undiff**. (no notable dunes, beach-ridges or cheniers) 11 Dominantly well-drained mixed sandy deposits 12 Dominantly well drained mixed sandy deposits with minor marshy areas 13 Dominantly well-drained mixed sandy deposits with minor lagoons (and/or marsh) 14 Saltpans or saline flats (*supratidal* areas) on mixed sandy deposits. 15 Saltpans or saline flats on mixed sandy deposits with minor saltmarsh (*supratidal* areas) 16 Mixed sandy alluvium undiff 20 **Marshy mixed sand deposits undiff**. (no notable dunes) 21 Dominantly marshy mixed sand deposits 22 Marshy and well-drained mixed sand deposits (mixed) 23 Dominantly marshy mixed sand deposits with minor lagoons 24 Marshy saline flats (dominantly samphire-vegetated *supratidal*	409090 439090 469090 409051 469051 429016	Mixed sandy sediments undiff Mixed sandy sediments undiff on bedrock Mixed sandy sediments undiff to below sea level Cheniers (gravelly sand) undiff Chenier (gravelly sand) deposits to below SL Alluvial sand and gravel deposits undiff

		areas) on mixed sand deposits 25 Marshy supratidal saline flats on mixed sand deposits *inferred from mapped saltmarsh*. 26 Marshy mixed sandy alluvium undiff. 30 **Lagoons on mixed sand deposits undiff.** (may or may not be connected to sea). 31 Dominantly lagoons on mixed sand deposits (no connection to sea) 32 Dominantly lagoons on mixed sand deposits (ephemeral or permanent connection to sea) 33 Dominantly estuarine channel or lagoon on mixed sand deposits (ephemeral or permanent connection to sea) 34 Saltpans or saline flats on lagoonal mixed sand deposits (evaporitic lagoonal environments). 40 **Windblown (aeolian) or wave-deposited (beach-ridge) mixed sand undiff** If used – subclasses as for sand (below).		

		50 **Cheniers of mixed sand undiff.** 51 Chenier 52 Possible chenier (unconfirmed) 90 **Unclassified**		
50 **Sand** undiff. (depth unclassified) 51 Coarse-grained sand dominant (depth unclassified) 52 Fine – medium grained sand dominant (depth unclassified) 53 Sand over bedrock above sea level 54 Coarse-grained sand dominant (over bedrock) 55 Fine – medium grained sand dominant (over bedrock) 56 Sand deposits to below sea level. 57 Coarse-grained sand dominant (to below sea level) 58 Fine – medium grained sand dominant (to below sea level)		10 **Sand deposits undiff.** (no notable dunes, beach-ridges or cheniers mapped) 11 Dominantly well-drained sand deposits 12 Dominantly well drained sand deposits with minor marshy areas 13 Dominantly well-drained sand deposits with minor lagoons (and/or marsh) 14 Saltpans or saline flats (*supratidal* areas) on sand deposits. 15 Saltpans or saline flats on sand with minor saltmarsh (*supratidal* areas) 16 Alluvial sand deposits. 17 Notably peaty sand deposits (generally lagoonal/lacustrine origin) 20 **Marshy sand deposits undiff**. (no notable dunes mapped)	509090 539090 569090 509017 569017 501090 561090 501111 561111 509020 569020 509027 569027 501120 561120	Sand deposits undiff Sand deposits undiff on bedrock above sea level Sand deposits undiff to below sea level Peaty sand deposits undiff Peaty sand deposits undiff to below sea level Sand plain undiff Sand plain undiff to below sea level Sand plain (no dunes, well drained) Sand plain to below SL (no dunes, well drained) Marshy sand deposits Marshy sand deposits to below sea level Marshy peaty sand deposits Marshy peaty sand deposits to below sea level Marshy sand plain (no dunes) Marshy sand plain to below SL (no dunes)

		21 Dominantly marshy sand deposits	509016	Sandy alluvium undiff
			539016	Sandy alluvium on bedrock above sea level
		22 Marshy and well-drained sand deposits (mixed)	569016	Sandy alluvium undiff to below sea level
			501016	Sandy alluvial plains
		23 Dominantly marshy sand deposits with minor lagoons	561016	Sandy alluvial plains to below sea level
			509040	Windblown sand, dunes or beach ridges undiff
		24 Marshy saline flats (dominantly samphire-vegetated *supratidal* areas) on sand deposits	569040	Windblown sand, dunes or beach ridges to below SL
		25 Marshy supratidal saline flats on sand deposits *inferred from mapped saltmarsh*.	509042	Dune undiff
			539042	Dune undiff on bedrock above sea level
			569042	Dune undiff on sand to below sea level
		26 Marshy alluvial sand deposits	504142	Foredune undiff
			534142	Foredune on bedrock above sea level
		27 Marshy & notably peaty sand deposits (generally lagoonal / lacustrine origin)	564142	Foredune on sand to below sea level
			509044	Dune field undiff
			539044	Dune field on bedrock above sea level
		30 **Lagoons on sand deposits undiff**. (may or may not be connected to sea).	569044	Dune field undiff on sand to below sea level
		31 Dominantly lagoons on sand deposits (no connection to sea)	501044	Dune field plain
			561044	Dune field plain on sand to below sea level
		32 Dominantly lagoons on sand deposits (ephemeral or permanent connection to sea)	509046	Parabolic dune field undiff
			539046	Parabolic dune field on bedrock above sea level
			569046	Parabolic dune field on sand to below SL
		33 Dominantly estuarine channel or lagoon on	509047	Dune field undiff with marshy swales

		sand deposits (ephemeral or permanent connection to sea) 34 Saltpans or saline flats on lagoonal sand deposits (evaporitic lagoonal environments). 40 **Windblown (aeolian) or wave-deposited (beach-ridge) sand undiff** 41 Aeolian sand-sheets (no distinct dune forms) 42 Single dune ridge 43 Dune field or beach ridges undiff 44 Dune field (multiple ridges). 45 Beach ridges 46 Parabolic dune field 47 Dune field with notable marshes in swales 48 Dune field with notable lagoons (± marshes) <u>Note</u>: stable (vegetated) vs. mobile (unvegetated) dunes have not been differentiated under this classification, partly because the stability of dunes may change rapidly and hence should be mapped on special-purpose maps rather than this broader – purpose Smartline map.	509043 539043 569043 561043 509045 539045 569045 501045 561045 509041 539041 569041 561030 501051 561051	Dune field or beach ridges undiff Dune field or beach ridges undiff on bedrock Dune field or beach ridges undiff to below SL Dune or beach ridge plain; sand to below sea level Beach ridges undiff Beach ridges on bedrock above sea level Beach ridges on sand to below sea level Beach ridge plain Beach ridge plain to below sea level Aeolian sand-sheets, depth uncertain Aeolian sand-sheets on bedrock above sea level Aeolian sand-sheets on sediment to below sea level Lagoon on sandy deposits to below sea level Chenier plain (sand) Chenier plain (sand) to below sea level

		50 **Cheniers of sand undiff** 51 Chenier 52 Possible chenier (unconfirmed) 90 **Unclassified**		
60 Mud undiff. (depth unclassified) (where "mud" is a broad term meaning wet silt &/or clay) Sandy mud classed as 'mud dominant' here. 61 Mud with pebbles or cobbles (depth unclassified) 62 Mud dominant (depth unclassified) 63 Mud over bedrock above sea level 64 Mud with pebbles or cobbles (over bedrock) 65 Mud dominant (over bedrock) 66 Mud deposits to below sea level. 67 Mud with pebbles or cobbles (to below sea level) 68 Mud dominant (to below sea level) <u>Note</u>: Fewer grainsize categories		10 **Mud deposits undiff.** 11 Dominantly well-drained mud deposits 12 Dominantly well drained mud deposits with minor marshy areas 13 Dominantly well-drained mud deposits with minor lagoons (and/or marsh) 14 Saltpans or saline flats (*supratidal* areas) on mud deposits. 15 Saltpans or saline flats on mud with minor saltmarsh (*supratidal* areas) 16 Alluvial mud deposits 17 Notably peaty mud (clay) deposits (generally lagoonal/lacustrine origin) 20 **Marshy mud deposits undiff.** 21 Dominantly marshy mud deposits 22 Marshy and well-drained mud deposits (mixed)	609090 669090 601090 661090 601020 661020 609016 669016 619016 601016 661016 601026 661026 609017 669017 609027 669027	Muddy sediments undiff Muddy sediments undiff to below sea level Muddy sediment flats undiff Muddy sediment flats to below sea level Marshy muddy sediment flats undiff Marshy muddy sediment flats to below sea level Muddy alluvium undiff Muddy alluvium undiff to below sea level Pebbly mud alluvium Muddy alluvial plain Muddy alluvial plain to below sea level Marshy alluvial mud flats Marshy alluvial mud flats to below sea level Peaty mud deposits undiff Peaty mud deposits undiff to below sea level Marshy peaty mud deposits Marshy peaty mud deposits to below SL

than for intertidal (less relevant inshore)		23 Dominantly marshy mud deposits with minor lagoons 24 Marshy saline flats (dominantly samphire-vegetated *supratidal* areas) on mud deposits 25 Marshy *supratidal* saline flats on mud *inferred from mapped saltmarsh*. 26 Marshy alluvial mud deposits 27 Marshy & notably peaty mud (clay) deposits (generally lagoonal / lacustrine origin) 30 **Lagoons on mud deposits undiff.** (may or may not be connected to sea, muds typically peaty). 31 Dominantly lagoons on mud deposits (no connection to sea) 32 Dominantly lagoons on mud deposits (ephemeral or permanent connection to sea) 33 Dominantly estuarine channel or lagoon on mud deposits (ephemeral or permanent connection to sea)	601027 661027 601014 631014 661014 601015 661015 601024 661024 601034 661034 609051 669051	Marshy peaty mud plain deposits Marshy peaty mud plain deposits to below SL Saltpans or saline mudflats Saltpans or saline mudflats on bedrock above SL Saltpans or saline mudflats to below sea level Saline mud flats (minor saltmarsh) undiff Saline mud flats (minor saltmarsh) to below SL Saltpans or saline mud flats with saltmarsh Saline mud flats with saltmarsh to below SL Saline flats on lagoonal muds Saline flats on lagoonal muds to below SL Muddy cheniers Muddy cheniers to below sea level

		34 Saltpans or saline flats on lagoonal mud deposits (evaporitic *supratidal* lagoonal environments). 40 Not used yet. 50 **Muddy cheniers undiff** 51 Chenier 52 Possible chenier (unconfirmed) 90 **Unclassified**		
70 Biological Structures undiff (Geomorphic structures directly formed by biological activity) 71 Coral structures 72 Stromatolite structures 73 Guano structures (phosphatic deposits)		10 **Coral reef structures undiff** 11 Emerged coral reef structure 90 **Unclassified**	719010	Coral reef structures undiff
80 Artificial Structures undiff (Artificially constructed features forming significant structural parts of the backshore proximal (& sometimes the distal) zone; Note that - except where reclaimed land extends well inland of the shore, or the natural substrate is unknown - artificial types are not used to describe the backshore distal zone, which preferably is characterised by its natural geomorphic or		10 **Landfill, reclamation** 20 **Coastal defence structures** (seawalls, revetments) 21 Rock (boulder) walls 22 Concrete walls 30 **Groynes & Breakwaters** 31 Boulder groynes 40 **Wharves & port structures** 50 **Jetties** 51 Jetty piles 60 **Other built coastal structures**	809090 809020 849010 819090 813020 813051 813063 819040	Artificial structure undiff Artificial seawall, type unspecified Reclaimed land (artificial fill) Impermeable artificial structure Vertical seawall Piles (Jetty) Vertical concrete structure Wharf (hard structure)

geological substrate, whether or not built over by artificial structures; this allows the *Backprox* attribute to indicate the presence of backshore artificial structures, while the *Backdist* indicates the underlying or backing natural substrate) 81 Impermeable artificial material undiff. (e.g., concrete, wooden structures) 82 Hard impermeable artificial material (e.g., concrete) 83 Other impermeable artificial material (e.g., wood) 84 Permeable artificial material (e.g., rip-rap, boulders, rubble fill, etc) 85 Natural geological substrate (bedrock or sediment, where artificially excavated) 86 Sediment (excavated & /or artificially laid down as anthropogenic deposits, e.g., dredging spoil piles).		61 Salt evaporation ponds 62 Boulder structures undiff 63 Concrete structures undiff 64 Wooden structures undiff 65 Boulder & concrete structures undiff 66 Boardwalk 70 **Excavation** 90 **Unclassified**	849090 849021 849031 859070 869010 861061	Permeable artificial structure (e.g., rip-rap) Boulder wall Boulder groyne Artificial excavations Artificial sediment deposits Salt evaporation ponds
90 Unclassified Fabric		30 **Lagoons on unclassified substrates** (may or may not be connected to sea). 90 **Unclassified**	909090 909030	Unclassified Lagoons undiff on unclassified substrate

6.3.4 Backshore Profile Theme

Field name: *Backprof*

***Explanation*:** High cliffed coastlines are identified as a distinctive profile category, and other coasts are broadly classed based on the generalised topographic profile (overall gradient) of the coastal backshore zone extending landwards from the inland edge of the intertidal zone to the first major high point or to 500m inland, whichever is the lesser distance. Foredune heights are intended to be ignored for the purposes of this attribute, such that a coast having a high foredune fronting an extensive low-lying beach ridge plain should be classed as having a low backshore profile. Backshore profile class boundaries are based in part on slope stability criteria, and thus differ from those used for intertidal zone slope classes (Section 6.3.6). See also Section (3.2.1) for discussion.

Profile Classes (as used in Smartline attribute table)		
Code *Backprof_n* (3 digits)	**Verbal label** *Backprof_v* (30 characters)	**Description**
100	**Plains**	Plains 0° - 6° Commonly coastal sediment plains; may be prone to erosion and flooding
110	Very flat plains	Very flat plains 0° - 3°;
120	Gently sloping plains	Gently sloping plains 3°- 6°
200	**Gentle-moderate slopes**	Gentle to moderate slope terrain 6° - 20°; Typically bedrock slopes, generally not flood-prone, slopes mostly stable.
300	**Steep slopes**	Steep slope terrain >20°; Slopes steeper than landslide threshold angles for many soils or colluvial materials, thus potentially unstable slopes (depending on slope materials)
400	**High cliffed coast**	High sea cliff coasts (>50m high cliffs); Identifies high cliffed bedrock coasts, irrespective of terrain profile inland of the cliff tops.
900	**Unclassified**	Unclassified, generally due to lack of data.

6.3.5 Intertidal Landform Themes

Landforms of the intertidal zone are described using two fields (*Intertd1* and *Intertd2*), to allow capture of information describing either simple (one landform element) intertidal zones, or complex intertidal zones having more than one significant landform element (see also Section 3.2.1 for discussion). Both fields use descriptors drawn from the same attribute table (below). In this attribute table, the 'Hierarchical Classifiers' are used to systematically define each intertidal landform type, while the 'Landform Classes' summarise each category using a numerical code combining the hierarchical classifiers, and a summary verbal descriptive label. The Landform Classes listed are those categories actually used in attributing the Smartline map Intertidal landform fields *Intertd1* and *Intertd2*, and can be added to (using new combinations of the hierarchical classifiers) if additional intertidal landform classes are required.

Intertidal Landform Element 1
Field name: *Intertd1*
***Explanation*:** The uppermost, dominant, co-equal or only intertidal landform element. The map attribute must record either a landform type or "Unclassified" (never a null record).

Intertidal Landform Element 2
Field name: *Intertd2*
***Explanation*:** Lower, secondary, co-equal or additional intertidal landform elements. This field may be "Unclassified" if the primary intertidal element (*Intertd1*) adequately describes the intertidal zone.

Hierarchical Classifiers (used to derive Landform Classes)			**Landform Classes** (as used in Smartline attribute table)	
Fabric What the landform is made of (broad classes)	**Form** Broad form categories **Note:** same table applies to all fabric classes	**Genesis / other Modifiers** Common descriptive terms, morphodynamic or genetic types, other useful classifiers.	**Code** *Intertd1_n* *Intertd2_n* (6 digits)	**Verbal Descriptive Label** *Intertd1_v* *Intertd2_v* (50 characters)
10 Lithic Substrate undiff* ('Bedrock' (geological substrate pre-dating the current coast) or hard coastal deposits (e.g., beach rock); essentially intended to refer to hard coastal substrates as opposed to soft sediments of coastal origin and biological or artificial structures of coastal provenance. However also includes soft (semi-lithified or weathered) 'bedrock' types as exceptions to the rule[16]) 11 Hard lithic material (hard bedrock, hard beachrock, hard precipitates, hard	10 **Flat** to gently sloping (<5°) 20 **Sloping** (moderately to steeply sloping 5° - 60°) 21 Moderately sloping (5°-15°) 22 Steeply sloping (15°-30°) 23 Very steeply sloping (>30°) 30 **Vertical** (cliff, very steeply sloping to vertical shoreface >60°) 31 Low vertical shoreface (<5m) 32 Cliff (>5m) 40 **Complex forms** 50 **Sporadic or intermittent features undiff.** (outcrops,	10 **Geological substrate ('bedrock')** undiff. (material deposited prior to present coast forming; may be hard (lithified) or soft (semi-lithified or weathered); may be 'basement' bedrock or regolith produced by former non-coastal processes (e.g., laterites); actual types are described by *Geology* attributes) 20 **Hard bedrock** (or geological substrate). 30 **Soft 'bedrock'** (or geological substrate) undiff. 31 Soft (*semi-lithified*) 'bedrock' or geological substrate	 109010 101010 102010 103210 105010 119091 119020 111020 112020 113220 115020 129091 129030	*Geological substrate, undiff:* Rocky shore (undiff) Rocky shore platform (undiff) Sloping rocky shore (undiff) Cliff (>5m) (undiff) Bedrock (undiff) outcrops protruding *Hard bedrock (geological substrate):* Hard bedrock shore inferred Hard bedrock shore Hard rocky shore platform Sloping hard rock shore Hard rock cliff (>5m) Hard bedrock outcrops protruding *Soft bedrock (geological substrate):* Soft 'bedrock' shore inferred Soft 'bedrock' shore

[16] Whereas deposits of coastal origin are only included in this fabric class if they are hard (lithified), bedrock (geological substrates pre-dating the current coast) are included even where they are soft (e.g., semi-lithified or weathered). This complexity in this one fabric class (which is fundamentally intended to identify hard coastal fabrics as opposed to the soft coastal sediment fabrics in most of the other fabric classes) has been adopted as a lesser complexity in preference to the greater complexity of having both coastal sediments and (soft) bedrock types as sub-categories of all primary fabric classes.

laterite horizons, etc). 12 Soft lithic material (semi-lithified clayey sediments, weathered bedrock, friable lateritic horizons, soft limestone, semi-lithified beachrock, etc). 13 Ice-dominated substrate (Could include ice and permafrost where these constitute the coastal substrate (in polar regions); not used in Australian Smartline map.) * Note: This fabric class covers both coastal bedrock and hard coastal deposits such as beachrock because they have similar fabrics for the purpose of this fabric-form classification; their differing origins are distinguished using the 'modifier' classifiers. Where the lithic fabric is 'bedrock' (rather than precipitates of coastal origin), more details of substrate type are provided by the *Geology1* attribute.	deposits, structures) 51 Minor or sub-ordinate component of intertidal zone 52 Moderately common 53 Intermittent but extensively present 54 Dominant intertidal component (although intermittent) 60 **Broken deposits** (still *in situ* and largely unweathered - i.e., not corestones) 90 **Unclassified** Note: "50: Sporadic features" and "60: Broken deposits" will mainly be used for sub-ordinate intertidal components (*Intertd2*).	(e.g., Tertiary clay deposits). 32 Soft (*weathered, regolith*) bedrock or geological substrate (regolith with soft weathered matrix present, not just residual corestone deposits; may include "rotten" bedrock, friable laterites, etc). 40 **Cemented coastal sediment** undiff. (other than identified true "beachrock" – e.g., beach shingle cemented by spring carbonate precipitates). 41 Dominantly coarse clastic types (breccias of rock boulders, cobbles or pebbles, ±sand) 42 Dominantly sandy (clastic) types 43 Dominantly fine- or very fine-grained clastic types 44 Dominantly coralline types (breccias ±sand) 45 Dominantly shelly (±sand) 49 'Coffee rock' (humicrete or humates; exposed iron pans)	121030 122030 123230 125030 122049 121049 109050 105450 105150	Soft 'bedrock' shore platform Sloping soft 'bedrock' shore Soft 'bedrock' cliff (>5m) Soft 'bedrock' outcrops protruding *Other "lithic" substrates* Sloping coffee rock deposit Coffee rock platform Beachrock undiff Beachrock undiff dominant Beachrock undiff patchy, subordinate

		50 **Beachrock** undiff. (cemented sediments) 51 Dominantly coarse clastic types (breccias of rock boulders, cobbles or pebbles, ±sand) 52 Dominantly sandy (clastic) types 53 Dominantly fine- or very fine-grained clastic types 54 Dominantly coralline types (breccias ±sand) 55 dominantly shelly (±sand) 60 **Coastal precipitates** (dominantly fine-grained) 61 carbonate precipitates (tufa, flowstone, etc). 62 ferruginous precipitates 70 **Ice** Would include glacier ice and permafrost (not used for Australia) 90 **Unclassified** 91 Inferred rocky shore only		
20 Sediment undifferentiated (Unconsolidated sediment of unknown grainsize or type, or		10 **Narrow-moderate width sediment shore** (may include beaches) 11 Beach (wave-deposited sediment,	209090 209011 201020 201021	Soft sediment shore (undiff) Beach (sediment type undiff) Tidal flats (sediment undiff) Tidal sediment flats (inferred from

interbedded sediments where no one type is known to greatly dominate, e.g., interbedded gravel, sand & mud, etc.)		type undiff) 20 **Tidal flats** 21 Tidal flats inferred from mapped mangroves 22 Tidal flats, no bedrock protruding 23 Tidal flats with bedrock protruding 90 **Unclassified**	 201023	mangroves) Tidal flats (sediment undiff), bedrock protruding
30 Coarse sediments undifferentiated (Boulders*, shingle, cobbles and/or pebbles. Note: 'shingle' = cobbles and/or pebbles) 31 Dominantly boulders undiff 32 Very large boulders (>5m dia.) 33 Boulders (<5m dia.) 34 Mixed boulders and cobbles 35 Boulders or cobbles undiff. 36 Dominantly cobbles 37 Mixed cobbles & pebbles 38 Cobbles or pebbles undiff. 39 Dominantly pebbles * Note that even very large boulders of bedrock are		10 **Boulder or shingle – grade beach** (rounded clasts, wave-deposited) 11 Stony beach (rock clasts) 12 Coralline debris beach 13 Shelly debris beach 20 **Boulder or shingle – grade berm** (rounded clasts, wave deposited, associated with sand beach) 21 Stony berm (rock clasts) 22 Coralline debris berm 23 Shelly debris berm 30 **Talus, colluvium** (of bedrock material, mostly angular clasts) 40 **Residual** (bedrock corestones, weathering debris) 41 Angular residual	309090 309010 312050 311050 381050 319011 359011 369011 389011 389012 399011 309013 309030 312230	Boulder or shingle-grade shore undiff Note: could be beach or talus or residual. Boulder or shingle-grade beach undiff Note: wave deposited (beach) Sloping boulder deposit (rock) undiff Flat boulder deposit (rock) undiff Flat pebble/cobble deposit (rock) undiff Boulder (rock) beach Boulder/cobble (rock) beach Cobble (rock) beach Pebble/cobble (rock shingle) beach Coral shingle beach Pebble beach Shelly beach undiff Colluvium (talus) undiff Steep boulder talus

regarded as simply large clasts of an unconsolidated coastal sediment (fabric class 32) for the purpose of this classification, unless they are fractured bedrock boulders which are still completely *in situ*, in which case they are regarded as bedrock masses (fabric class 10).		fragments 42 Rounded residual fragments 50 **Coarse bedrock-derived material** (beach, berm, colluvial or residual bedrock-derived material undiff) 90 **Unclassified**	319030 349042 356040	Boulder talus Cobble/boulder shore (rounded residual clasts) Bedrock breakdown debris (cobbles/boulders)
40 Mixed Sandy Sediments undiff. (mixed sandy sediments, i.e., boulders or cobbles or pebbles + sand; **note** that muddy sediments mixed with coarser material are classified as muddy sediment sub-types under fabric class 60) 41 Dominantly boulders undiff. and sand 42 Very large boulders (>5m dia) and sand 43 Boulders (<5m dia) and sand 44 Mixed boulders & cobbles and sand 45 Boulders or cobbles undiff. and sand 46 Dominantly cobbles and sand 47 Mixed cobbles & pebbles		10 **Notable coarse material with sandy beach or tidal flat** (rounded clasts, wave-deposited, may include undiff. distinct coarse berms) 11 Coarse stony material (rock clasts) with sand beach 12 Abundant coralline debris with sand beach 13 Abundant shelly debris with sandy beach 14 Coarse stony material (rock clasts) with sandy tidal flat 15 Abundant coralline debris with sandy tidal flat 16 Abundant shelly debris with sandy tidal flat 17 unused 18 Undifferentiated coarse	409090 409018 401019 401014 409013 419011 459011 469011 489011 499011 419030	Mixed sandy shore undiff Mixed sand beach Mixed sand tidal flats undiff Sandy tidal flats with coarse stony debris Mixed sand and shell beach Mixed sandy and boulder beach (rock) Sandy beach with cobbles/boulders (rock) Mixed sandy and cobble beach (rock) Sandy beach with cobbles/pebbles (rock) Sandy beach with pebbles (rock) Colluvial boulders on sandy beach

and sand 48 Cobbles or pebbles undiff. and sand 49 Dominantly pebbles and sand <u>Note:</u> 'boulders', 'cobbles' and 'pebbles' may be of rock, coral debris or shelly material; these can be differentiated using the modifier classifiers.		material with sand beach 19 Undifferentiated coarse material with sandy tidal flat 20 **Berm of coarse clasts on sandy beach***(rounded clasts, wave-deposited) 21 Coarse stony berm (rock clasts) on sandy beach 22 Coralline debris berm on sandy beach 23 Shelly debris berm on sandy beach 30 **Talus, colluvial material on sandy beach** (coarse clasts of bedrock material, mostly angular clasts) 40 **Residual *in situ* weathering stony debris on sandy beach** (bedrock corestones, weathering debris) 90 **Unclassified** * <u>Note</u>: A sandy beach with a coarse shingle berm could be mapped as <u>either</u> *Intertd1* = 409020 <u>or</u> as *Intertd1* = 509010 + *Intertd2* = 309021.		

50 Sand undiff. 51 Coarse-grained sand dominant 52 Fine – medium grained sand dominant 53 Fine-grained sand dominant		10 **Beach** (wave-dominated sandy shore) 11 Perched beach (sandy beach on bedrock slope or platform) 12 Beach with bedrock outcrops protruding 20 **Tidal flats** 21 Tidal flats inferred from mapped mangroves 22 Tidal flats, no bedrock protruding 23 Tidal flats inferred from 'shallow/emergent' seagrass. 24 Tidal flats with protruding bedrock 30 **Non-beach sandy shore** 31 Tidal channel shore (current-dominated) 90 **Unclassified sandy shore** 91 Unclassified sandy shore with protruding bedrock	509090 509091 509010 509012 505110 519010 519012 529010 529012 509011 501020 501022 501024 521020 501023	Sandy shore undiff Sandy shore with protruding bedrock Sandy beach undiff Sandy beach, bedrock protruding Subordinate sandy beach undiff (patchy) Coarse sand beach Coarse sand beach, bedrock protruding Fine-medium sand beach Fine-medium sand beach, bedrock protruding Perched sandy beach (undiff) Sandy tidal flats Sandy tidal flats, no bedrock protruding Sandy tidal flats with protruding bedrock Fine-medium sandy tidal flats Sandy tidal flats inferred from 'shallow' seagrass
60 Mud undiff (where "mud" is a broad term meaning wet silt &/or clay) 61 Mud (well sorted) 62 Mud with coarser material (undiff.) 63 Bouldery mud		10 **Narrow-moderate width muddy shore** 11 Narrow muddy (soil) shore (generally vegetation-bound organic-rich topsoil horizons at shoreline) 20 **Tidal flats**	609090 699090 609011 601020	Muddy shore undiff Sandy-mud shore undiff Narrow muddy shore (vegetation-bound soil) Muddy tidal flats

64 Bouldery & cobbly mud 65 Cobbly mud 66 Cobbly & pebbly mud 67 Pebbly mud 68 Pebbly & sandy mud 69 Sandy mud Note: For the purposes of this classification, silty or clayey shores are not differentiated, but are simply lumped as "mud".		21 Tidal flats inferred from mapped mangroves 22 Tidal flats, no bedrock protruding 23 Tidal flats with protruding bedrock 90 **Unclassified**	601023 691020 691023	Muddy tidal flats with protruding bedrock Sandy-mud tidal flats Sandy-mud tidal flats with protruding bedrock
70 Biological Structures undiff. (geomorphic structures directly formed by biological activity) 71 Coral structures 72 Stromatolite structures 73 Guano structures (phosphatic deposits) 74 Wrack (large quantities of kelp, seagrass, etc) permanently or frequently on shore		10 **Emerged structures** undiff. 11 Reef 20 **Ephemeral structures** 21 Rarely present 22 Intermittently present 23 Frequently or persistently present 90 **Unclassified**	745323	Wrack deposits (extensive and persistent)
80 Artificial Structures undiff. (artificially constructed features forming significant structural parts of the intertidal zone) 81 Impermeable artificial material undiff. (e.g., concrete, wooden		10 **Landfill, reclamation** 20 **Coastal defence structures** (seawalls, revetments) 21 Rock (boulder) walls 22 Concrete walls 30 **Groynes & Breakwaters** 31 Boulder groynes 32 Boulder & concrete groynes	809090 809030 819090 813020 813040 813062 813051 822032	Artificial shoreline undiff Groyne undiff Impermeable artificial shoreline Vertical seawall Wharf (hard vertical structure) Vertical concrete structure Piles (Jetty) Concrete & boulder groyne

structures) 82 Hard impermeable artificial material (e.g., concrete) 83 Other impermeable artificial material (e.g., wood) 84 Permeable artificial material (e.g., rip-rap, boulders, rubble fill, etc) 85 Natural geological substrate (bedrock, where artificially excavated) 86 Sediment (excavated & artificially laid down as anthropogenic deposits, e.g., dredging spoil piles).		33 Boulder breakwaters 34 Boulder & concrete breakwaters 36 Boulder groyne or breakwater undiff 37 Boulder & concrete groyne or breakwater undiff 40 **Wharves, port & marina structures** 41 Boulder structures 42 Concrete structures 43 Wooden structures 44 Boulder & concrete structures 50 **Jetties** 51 Jetty piles 60 **Other built coastal structures** 61 Boulder structures undiff 62 Concrete structures undiff 63 Wooden structures undiff 64 Boulder & concrete structures undiff 65 Boardwalk 70 **Excavation** 80 Not used 90 **Unclassified**	829022 823040 829044 822042 834065 849090 849061 849021 842021 849036	Concrete sea wall Concrete dock structures Concrete & boulder dock structures Concrete boat ramp Boardwalk Permeable artificial shoreline Artificial boulder structures undiff Boulder seawall Boulder revetment Boulder groyne or breakwater undiff
90 Unclassified Fabric		90 **Unclassified**	909090	Unclassified

6.3.6 Intertidal Slope Theme

Field name: *Intslope.*

***Explanation*:** Slope of the intertidal zone, defined as the average broadly-categorised slope between the high and low water tide lines (see also Section 3.2.1 for discussion). Intertidal Zone slope class boundaries are partly based on those proposed for intertidal zone mapping by Wardrop & Ball (2000, p.22), and differ from those used for Backshore Profiles (see Section 6.3.4) which are based on different criteria.

Slope Classes (as used in Smartline attribute table)		**Description**
Code *Intslope_n* (3 digits)	**Verbal label** *Intslope_v* (20 characters)	
100	**Flat**	Flat (<5°)
200	**Moderate**	Moderately sloping (5°- 30°)
210	**Gentle-moderate**	Gentle to moderate slope (5° - 15°)
220	**Moderate-steep**	Moderate to steep slope (15° - 30°)
300	**Steep**	Steeply sloping (>30°)
900	**Unclassified**	Unclassified, generally due to lack of data.

6.3.7 Subtidal Landform Themes

Landforms of the subtidal zone are described using two attribute fields (*Subtid1*and *Subtid2*), to allow capture of information describing either simple (one landform element) or complex subtidal zones having more than one significant landform element (see also Section 3.2.1 for discussion). Both fields use descriptors drawn from the same attribute table (below). In this attribute table, the ‘Hierarchical Classifiers’ are used to systematically define each subtidal landform type, while the ‘Landform Classes’ summarise each category using a numerical code combining the hierarchical classifiers, and a summary descriptive label. The Landform Classes listed are those categories actually used in attributing the Smartline map subtidal landform fields *Subtid1 & Subtid2*, and can be added to (using new combinations of hierarchical classifiers) if additional subtidal landform classes are encountered.

Subtidal Landform Element 1
Field name: *Subtid1*
***Explanation*:** The dominant, co-equal or only subtidal landform element. The map attribute must record either a landform type or “Unclassified” (never a null record).

Subtidal Landform Element 2
Field name: *Subtid2*
***Explanation*:** Secondary, co-equal or additional subtidal landform elements. This field may be “Unclassified” if the primary subtidal element (*Subtid1*) adequately describes the subtidal zone.

Hierarchical Classifiers (used to derive Landform Classes)			**Landform Classes** (as used in Smartline attribute table)	
Fabric What the landform is made of (broad classes)	**Form** (broad form categories) **Note:** same table applies to all fabric classes	**Genesis / other Modifiers** (morphodynamic or genetic types, common terms, other classifiers)	**Code** *Subtid1_n* *Subtid2_n* (6 digits)	**Verbal Label** *Subtid1_v* *Subtid2_v* (50 characters)
10 Lithic Substrate undiff. 11 Hard Lithic material 12 Soft lithic material 13 Ice dominated substrate	10 **Flat** to gently sloping (<5°) 20 **Sloping** (moderately to steeply sloping 5° - 60°) 21 Moderate slopes	10 **Geological substrate (bedrock) undiff.** 11 Extensive rocky bottom 12 Rocky reef s 13 Rocky reefs and	 109010 102010 101010 119020	 Rocky bottom undiff Sloping rocky bottom undiff Rocky platform undiff Hard rocky bottom

(Could include ice and permafrost where these constitute the coastal substrate (in polar regions); not used in Australian Smartline map.)	(5°-15°) 22 Steep slopes(15°-30°) 23 Very steep slopes (>30°) 30 **Vertical** (cliff, very steeply sloping to vertical >60°) 31 Low vertical face (<5m) 32 Cliff (>5m) 40 **Complex forms** 41 Lagoon (subtidal area protected by reefs to seawards) 50 **Sporadic or intermittent features** undiff. 90 **Unclassified** <u>Note:</u> "50: Sporadic features" will mainly be used for sub-ordinate sub-tidal components (*Subtid2*).	rocks exposed at low tide 20 **Hard bedrock (geological substrate)** 21 Extensive rocky bottom 22 Rocky reefs 23 Rocky reefs and rocks exposed at low tide 30 **Soft 'bedrock' (geological substrate)** 31 Extensive rocky bottom 32 Rocky reefs 33 Rocky reefs and rocks exposed at low tide 40 **Cemented coastal sediment undiff**. 49 'Coffee rock' (humicrete or humates; exposed iron pans) <u>Note:</u> other sub-types as for Intertidal, if used. 50 **Submerged beachrock undiff**. <u>Note:</u> sub-types as for Intertidal, if used. 60 **Coastal Precipitates** <u>Note:</u> sub-types as for Intertidal, if used. 70 **Ice**	129030 109012 101012 105013 119022 115023 103010 113020 123030 129049	Soft 'bedrock' bottom Rocky reefs undiff Rocky platform reefs undiff Patchy rocky reefs and exposed rocks Hard rocky reefs undiff Patchy hard rocky reefs and exposed rocks Plunging cliffs (undiff) Hard rock plunging cliff Soft 'bedrock' plunging cliff Coffee Rock

		Would include glacier ice and permafrost; not used in Australia. 90 **Unclassified**		
20 **Sediment** undiff.		10 **Sediment undiff bottom type undiff** 11 Extensive 12 Patchy 13 Protected (by reef to seawards) 90 **Unclassified**	209010	Sediment (undiff) bottom
30 **Coarse Sediments** undiff. 31 Dominantly boulders undiff 32 Very large boulders (>5m dia) 33 Boulders (<5m dia) 34 Mixed boulders and cobbles 35 Boulders or cobbles undiff. 36 Dominantly cobbles 37 Mixed cobbles & pebbles (shingle) 38 Cobbles or pebbles undiff (shingle) 39 Dominantly pebbles		10 **Boulders or shingle bottom** (rounded rock clasts) 11 Extensive 12 Patchy 13 Protected (by reef to seawards) 14 Subordinate component 20 **Coarse shelly debris bottom** 21 Extensive 22 Patchy 23 Protected (by reef to seawards) 24 Subordinate component 30 **Talus, colluvium** (mostly angular clasts) 31 Extensive	319090 309010 349010 369010 379010 379014 389010 309030	Boulder bottom undiff Boulder or shingle bottom undiff Boulder & cobble bottom Cobble bottom Cobble & pebble bottom Cobbles & pebbles (subordinate component) Shingle bottom (cobbles or pebbles) Subtidal talus (undiff)

		32 Patchy 33 Subordinate component 40 **Residual (bedrock corestones)** 50 **Coarse bedrock-derived material undiff.** 60 **Coarse coralline debris** 90 **Unclassified**		
40 **Mixed Sandy Sediments** undiff. (boulders or cobbles or pebbles + sand) 41 Dominantly boulders undiff. and sand 42 Very large boulders (>5m dia) and sand 43 Boulders (<5m dia) and sand 44 Mixed boulders & cobbles and sand 45 Boulders or cobbles undiff. and sand 46 Dominantly cobbles and sand 47 Mixed cobbles & pebbles and sand 48 Cobbles or pebbles undiff. and sand		10 **Boulders or shingle with sand** (rounded rock clasts) 11 Extensive 12 Patchy 13 Protected (by reef to seawards) 20 **Coarse shelly debris and sand** 21 Extensive 22 Patchy 23 Protected (by reef to seawards) 30 **Talus, colluvium with sand** (mostly angular clasts) 31 Extensive 32 Patchy 40 **Residual (bedrock corestones) with sand** 50 **Coarse bedrock-**	409090 449010 479010 419030	Mixed sandy sediments undiff Mixed cobbles, boulders and sand bottom Mixed cobbles, pebbles and sand bottom Talus boulders and sand bottom

49 Dominantly pebbles and sand Note: 'boulders', 'cobbles' and 'pebbles' may be of rock, coral debris or shelly material; these can be differentiated using the modifier classifiers.		**derived material undiff. with sand** 60 **Coarse coralline debris with sand** 90 **Unclassified**		
50 **Sand** undiff.		10 **Sandy bottom undiff** 11 Extensive sand 12 Patchy sand 13 Protected (by reef to seawards) 20 **Sandy bottom inferred from seagrass habitat mapping** 21 Extensive sand 22 Patchy sand 23 Protected (by reef to seawards) 90 **Unclassified**	 509010 502010 504113 509020	 Sandy bottom undiff Sloping sandy bottom undiff Sandy lagoon (protected) Sandy bottom inferred from seagrass
60 **Mud** undiff.		10 **Muddy bottom undiff** 11 Extensive 12 Patchy 13 Protected (by reef to seawards) 20 **Muddy bottom inferred from mangrove mapping** 21 Extensive 22 Patchy 23 Protected (by reef	 609010	 Muddy bottom undiff.

		to seawards) 90 **Unclassified**		
70 **Biological Structures** undiff. 71 Coral structures		10 **Fringing coral reefs** 11 Extensive 12 Patchy 13 Coral present (may not be reefs) Note: Classification intended to be extended to other coral structures & reef types, as needed. 90 **Unclassified**	 719010 719013	 Fringing coral reefs undiff Coral communities present
80 **Artificial Structures** undiff. (artificially constructed features forming significant structural parts of the subtidal zone) 81 Impermeable artificial material undiff. (e.g., concrete, wooden structures) 82 Hard impermeable artificial material (e.g., concrete) 83 Other impermeable artificial material (e.g., wood) 84 Permeable artificial material (e.g., rip-rap,		10 **Landfill, reclamation** 20 **Coastal defence structures** (seawalls, revetments) 21 Rock (boulder) walls 22 Concrete walls 30 **Groynes & Breakwaters** 31 Boulder groynes 40 **Wharves & port structures** 50 **Jetties** 51 Jetty piles 60 **Other built coastal structures** 70 **Excavation** 90 **Unclassified**	 809090 819090 813051 849090 849021	 Artificial subtidal structures undiff Impermeable artificial subtidal structures undiff. Piles (jetty) Permeable artificial subtidal structures undiff. Rock wall

boulders, rubble fill, etc) 85 Natural geological substrate (bedrock, where artificially excavated) 86 Sediment (excavated & artificially laid down as anthropogenic deposits, e.g., dredging spoil piles).				
90 **Unclassified** fabric		90 **Unclassified**	909090	Unclassified

6.3.8 Shoreline Exposure Theme

Field name: *Exposure*

***Explanation*:** Degree of exposure of the shoreline segment to the oceanic (swell & storm) wave energies reaching the broader coastal region as a whole (see also Section 3.2.1 for discussion). Differences in degree of exposure to locally generated wind-waves (e.g., across the fetch of semi-enclosed embayments) are not considered. This attribute is categorised into only four broad categories (high, moderate, low or very low exposure), and is not a measure of the 'absolute' wave energy reaching the shore, but rather of the degree to which the particular shoreline segment is exposed to whatever oceanic wave energies reach the broader coastal region as a whole. Thus the wave energy reaching a "high" exposure shoreline on a high energy coast will be greater than the wave energy reaching a "high" exposure shoreline on a lower energy coast. The exposure categories are classified in terms of the degree of exposure or sheltering of a coastal segment from the predominant oceanic swell and storm wave approach directions for that coast.

In effect, the 'Low', 'Moderate' and 'High' exposure classes identify swell-dominated open-coast shores, while the 'Very Low' class identifies the shores of fetch-dominated coastal re-entrants, tidal lagoons and many estuaries, which are sheltered from swell. Whereas the 'Very Low' exposure class identifies shores that are not significantly exposed to oceanic swells or oceanic storm waves, these fetch-dominated shores may nevertheless be highly exposed to other energetic coastal processes such as tidal currents and local wind waves.

Exposure Classes (as used in Smartline attribute table)		**Description**
Code *Exposure_n* (3 digits)	**Verbal label** *Exposure_v* (20 characters)	
100	**Very Low**	Mostly or entirely sheltered from oceanic swell or storm waves, mainly in coastal re-entrants such as estuaries or embayments with relatively narrow tidal channel connections to the ocean (but may be highly exposed to other energetic coastal processes such as tidal currents and locally-generated wind waves.)
200	**Low**	Sheltered, the aspect of the shoreline segment faces over 135° from, or is well sheltered from, dominant oceanic storm and swell wave directions.
300	**Moderate**	Moderately exposed, the aspect of the shoreline segment faces towards between 45° - 135° of dominant oceanic storm and swell wave directions.
400	**High**	Highly exposed, the aspect of the shoreline segment faces towards within 45° of dominant oceanic storm and swell wave directions.
900	**Unclassified**	Unclassified, generally due to lack of data.

6.3.9 Geological Substrate ('bedrock') Themes

The Geological Substrate is the bedrock or lithic substrate type(s) which were present prior to development of the present shoreline, and into which the shoreline has been eroded, or over which the coastal sediments have been deposited (see also Section 3.2.1 for discussion). The primary or only significant geological substrate exposed on or underlying a shoreline is recorded in the Smartline map using the *Geology1* attribute (see below). Bedrock classes are categorised into a relatively small number of broadly-defined "litho-structural" types categorised by the constituents and fabric of the rock (lithology) and the structures of the rock (fracturing, bedding, folding, etc). These characteristics (rather than the ages or stratigraphical relationships of the particular bedrock units) exert strong controls on the coastal landforms that develop on or in the bedrock.

For the purpose of this classification, some hard lithified rocks deposited on the coastline by coastal processes (e.g., carbonate tufas or beachrock) are not considered to be 'geological substrates' since they are a *product* of the coastal processes that formed the present coastline rather than an independent control on coastal development. These features are classified as coastal landforms (e.g., under *Backprox, Intertd1* or *Intertd2*). On the other hand some geologically-young materials – including some of coastal origin - may be classed as 'geological substrates' if they formed or were present prior to development of the present shore, even if only by a geologically-brief period. Thus, lateritic regolith, uplifted coral reefs or coralline breccias, phosphatic guano deposits and aeolian (dune barrier) calcarenites may all be classed as 'geological substrate' in those cases where they formed prior to development of the present shore, and are no longer actively being formed by ongoing coastal processes, but rather are being eroded into, reworked or buried by ongoing coastal processes.

Where two different geological substrates adjoin in the horizontal alongshore direction, it is normally appropriate to split the Smartline into two differing segments on this basis. Where two distinctly different rock types are intermingled on scales too small to map (e.g., narrow igneous dykes intruding sedimentary rock) then either the dominant type only is mapped, or the geological substrate class is defined as being the mixture of the two types (e.g., 'igneous dykes intruding sedimentary rocks').

However, where two significant – and significantly different - geological substrates are present in a vertical sequence in the shoreline zone, this complexity is dealt with in the Smartline mapping system through the use of two geological substrate fields, namely *Geology1* and *Geology2* as below (see also explanation in Section 3.2.1). Both fields use descriptors drawn from the same attribute table (below). In this attribute table, the 'Hierarchical Classifiers' are used to systematically define each geological substrate type, while the 'Geology Classes' summarise each category using a numerical code combining the hierarchical classifiers, and a summary descriptive label. The Geology Classes listed are those categories actually used in attributing the Smartline map geological substrate fields *Geology1* and *Geology2*, and can be added to (using new combinations of hierarchical classifiers) if additional geological classes are required.

Primary Geological Substrate
Field name: *Geology1*
***Explanation*:** The only or lowermost geological substrate (bedrock) type exposed on or underlying the shoreline zone. Where the geological substrate is unknown (e.g. due to extensive Quaternary sediment cover) and cannot be reasonably inferred from the known regional geological structure, this field may be "Unclassified".

Secondary Geological Substrate
Field name: *Geology2*
***Explanation*:** A secondary or superficial (overlying) geological substrate (bedrock) type overlying a primary geological substrate (bedrock) type in the shoreline zone. Where no secondary type is present, this field may be "Unclassified".

Hierarchical Litho-Structural Classifiers (used to derive Geology Classes)			**Geology Classes** (as used in Smartline attribute table)	
Lithology	**Structure** **Note:** same table applies to all lithology classes	**Alteration / other Modifiers** **Note**: same class structure applied to all lithology classes, with some differing sub-classes as required.	**Code** *Geology1_n* *Geology2_n* (6 digits)	**Verbal Label** *Geology1_v* *Geology2_v* (50 characters)
10 **Dominantly siliceous clastics** undiff. 11 Dominantly fine-grained (lutites – clays, silts) 12 Interbedded fine and medium-grained (lutite/arenite associations) 13 Dominantly medium-grained (arenites - sandstones) 14 Interbedded medium and coarse-grained (arenite/conglomerate	10 **Undeformed** (flat-lying or only gently tilted, may be normal-faulted) undiff. 11 Flat-lying, no significant faulting 12 Flat-lying, with notable normal faulting 20 **Folded** undiff. 21 Broad open folding 22 Intense disrupted folding 30 **Intensely fault-disrupted** (generally	10 **Unconsolidated** material (generally sediment) 20 **Semi-lithified** ('soft') material 25 with notable igneous intrusions 26 with notable carbonate interbeds 27 with calcareous clastics 28 with notable sponge spicules 29 with calcareous sediment and notable sponge spicules	109090 101020 109026 109030 109036 119020	Clastic sediments undiff Semi-lithified undeformed clastic sediments Semi-lithified clastics with some carbonates Lithified clastic rocks undiff <u>Note</u>: i.e., lutites ± arenites ± conglomerates. Lithified clastic undiff & some carbonate rocks <u>Note</u>: i.e., lutites ± arenites ± conglomerates + carbonates) Soft lutites (silts, clays) undiff

associations) 15 Dominantly coarse grained (rudites - conglomerates) 16 Interbedded lutites, arenites & rudites (each component common)	sheared, may be folded) 40 **Notable jointing** undiff (Mainly where jointing is dominant structural influence on rocky landforms) 41 Very wide joint spacing 42 Intensely (close-spaced) joint-fractured 43 Strong columnar jointing 90 **Unclassified**	30 **Lithified** undiff. 35 with notable igneous intrusions 36 with notable carbonate interbeds 37 with calcareous clastics 38 with notable sponge spicules 39 with calcareous sediment and notable sponge spicules 40 **Metamorphosed** undiff 41 contact metamorphosed ('baked', hornfelsic) 42 low grade regional metamorphism (e.g., slates, some quartzites) 43 high grade regional metamorphism (e.g., phyllites, schists, some quartzites) 44 very high grade regional metamorphism (gneiss, migmatite) 50 **Altered** undiff. 51 Hydrothermally altered 52 Deeply weathered (soft, clayey) 90 **Unclassified**	119030 111230 119036 119027 119029 119037 129020 129030 121230 129028 129037 139020 139030 131230 139036 149020 149030 159030 159052	Lutites (siltstones, mudstones) undiff Siltstones & mudstones (flat-lying, faulted) Lutites with subordinate carbonates Soft calcareous lutites Soft calcareous lutites and spongolites Calcareous lutites Soft sandstones & siltstones Lutite / arenite sequences undiff Siltstones & sandstones (flat-lying, faulted) Soft spongolite (in lutite/arenite sequences) Calcareous lutite/arenite sequences Soft sandstones Dominantly sandstones Note: may include quartzites – not always consistently differentiated in some source maps Dominantly sandstones (flat-lying, faulted) Sandstone with interbedded limestones Semi-lithified sandstones & conglomerates Sandstones & conglomerates Conglomerates (well lithified) Deeply weathered coarse sediments

			169020 169030 109040 109044 119042 112042 119043 129040 129041 122042 122043 129044 139040	Soft lutite/arenite/rudite associations Note: i.e., soft clays + sands + gravels Lutite/arenite/rudite associations Note: i.e., lithified lutites + arenites + conglomerates) Metasedimentary rocks undiff Gneisses, migmatites, high grade metamorphics Dominantly slates Folded dominantly lutite sequences (slates) Schists undiff Metamorphosed lutite/arenite sequences undiff Hornfelsic lutite/arenite sequences Folded arenites & lutites (slate/quartzite) Interbedded folded quartzites & schists Schists/quartzites/gneisses Quartzite undiff
20 Dominantly carbonates undiff (carbonate sediments and sedimentary rocks; limestones, dolomites) 21 Carbonates undiff – fine/medium grained 22 Carbonates undiff. - coarse (breccias) 23 **Limestones** undiff		10 **Unconsolidated** material (generally sediment) 20 **Semi-lithified** (‘soft’) material 21 Aeolian calcarenites 22 Coralline limestones 25 With notable igneous intrusions 26 With notable clastic	209030 239090 239020 239030 239036 241031	Carbonate rocks undiff Limestones undiff Soft limestone undiff Hard limestone undiff Hard limestone with clastic interbeds Aeolian calcarenite limestone

24 Limestones – fine/medium grained 25 Limestones – coarse (breccias) 26 **Dolomites** undiff 27 Dolomites – fine/medium grained 28 Dolomites – coarse (breccias)		interbeds 30 **Lithified** undiff. 31 Aeolian calcarenites 32 Coralline limestones* 35 With notable igneous intrusions 36 With notable clastic interbeds 40 **Metamorphosed** undiff 41 contact metamorphosed (‘baked’, hornfelsic) 42 Regionally metamorphosed (e.g., marble) 50 **Other altered carbonates** undiff. 51 Hydrothermally altered 52 Deeply weathered (soft, clayey) 55 Metasomatised (calcsilicates) 90 **Unclassified** * Note: intact reef structures classed under ‘biogenic’ below	251032 209040 269030 269040 209055	Coralline breccia (hard, lithified) Marble (undiff) Hard dolomite undiff Dolomite, metamorphosed Calcsilicates (metasomatised carbonates)
30 Volcanics & volcaniclastic rocks undiff 31 Lavas (undiff) dominant 32 Basic types (basalts) 33 Intermediate types 34 Acid types		10 **Unconsolidated** material (generally sediment) 20 **Semi-lithified** (‘soft’) material 25 With notable clastic interbeds 26 With notable carbonate interbeds	309030 319030 329030 329035 329036 321030 321052	Lithified volcanics undiff Lava rocks undiff Basalt undiff Basalt with clastic interbeds Basalt with carbonate interbeds Mostly undeformed basalts Deeply weathered undeformed

35 Pyroclastics (undiff) dominant 36 Volcaniclastic (volcanic lavas, pyroclastics + other interbedded sedimentary rock) sequences undiff. 37 Lavas & pyroclastics <u>Note:</u> pyroclastics are sediments of volcanic origin, whereas volcaniclastics are volcanic rocks with non-volcanic sedimentary rocks interbedded.		27 Scoria, unlithified matrix 30 **Lithified** undiff. 35 With notable clastic interbeds 36 With notable carbonate interbeds 37 Notably vesicular 40 **Metamorphosed** undiff 41 contact metamorphosed ('baked', hornfelsic) 42 low grade regional metamorphism (e.g., metavolcanics, slates, some quartzites) 43 high grade regional metamorphism (e.g., schists, quartzites, amphibolites) 44 very high grade regional metamorphism (e.g., gneiss/amphibolite/schist) 50 **Altered** undiff. 51 Hydrothermally altered 52 Deeply weathered (soft, clayey) 90 **Unclassified**	 329040 339030 349030 359027 359030 369030 363030 363052 369040 369043 369044 379030	basalts Metamorphosed basalts or 'greenstones' Dominantly intermediate lavas <u>Note</u>: e.g., andesites, trachytes, phonolites Dominantly acid lava rocks <u>Note</u>: e.g., dacites, rhyolites Scoria, unlithified matrix Dominantly pyroclastics undiff Volcaniclastic sequences undiff Structurally dismembered volcaniclastic sequences Deeply weathered volcaniclastic sequence Metamorphosed volcaniclastics Amphibolites, quartzites, schist Amphibolites, gneiss, schist Lava & pyroclastic rocks undiff
40 Intrusive igneous rocks undiff. (mainly crystalline medium to coarse-grained rocks)		10 **Unconsolidated** material 20 **Semi-lithified** ('soft') material 30 **Lithified** undiff. 40 **Metamorphosed** undiff	409030 419051 413051 419030	Coarse/medium igneous rocks undiff Serpentinite undiff Serpentinised ultramafic complexes Lamprophyres

41 Ultramafics undiff 42 Basic undiff. 43 medium grained (dolerites) 44 Coarse grained (e.g., gabbros) 45 Intermediate undiff 46 Coarse grained 47 Acid undiff 48 Coarse (granites, pegmatites)		41 contact metamorphosed 42 low grade regional metamorphism 43 high grade regional metamorphism (e.g., some amphibolites) 44 very high grade regional metamorphism (e.g., granulite) 50 **Altered** undiff. 51 Hydrothermally altered 52 Deeply weathered (soft, clayey) 90 **Unclassified**	429030 429043 429044 439030 431230 439040 449030 449040 459030 489030 489040 489044	Basic coarse/medium igneous rocks <u>Note</u>: e.g., dolerites, granophyres, gabbros Amphibolites Basic granulite Dolerite Dolerite (faulted) Dolerite, metamorphosed Gabbro Gabbro, metamorphosed Intermediate coarse/medium igneous rocks <u>Note</u>: e.g., diorites, monzonites, syenites Granitoids undiff <u>Note</u>: e.g., adamellites, granites, granodiorites Metamorphosed granitoids <u>Note</u>: may include granitic granulites or gneiss Granite gneiss
50 Weathering products (regolith) undiff 51 Dominantly ferruginous 52 Dominantly calcareous 53 Dominantly siliceous 54 Dominantly kaolinised 55 Dominantly aluminous		10 **Deeply weathered material undiff.** 11 Soft 12 Hard 13 Mixed 20 **Laterites/ferricretes** 21 Soft 22 Hard 23 Mixed 30 **Calcretes** 31 Soft	 549010 549011 519020 529030 559050	 Kaolinised deeply weathered rocks Kaolinised deeply weathered sediments Dominantly laterites/ferricretes Calcrete undiff Bauxite undiff

		32 Hard 33 Mixed 40 **Silcretes** 41 Soft 42 Hard 43 Mixed 50 **Bauxites** 51 Soft 52 Hard 53 Mixed 90 **Unclassified**		
60 Dominantly biogenic deposits undiff. (i.e., biological structures) Only minor use for continental Australia coasts to date, but this substrate category may be further developed for use on coral coasts (e.g., Pacific Islands). 61 Coral structures 62 Stromatolite structures 63 Guano structures (phosphatic deposits)		10 **Coral reef structures undiff** 11 Emerged coral reef structure Note: Other classes to be defined 90 **Unclassified**	619010	Coral reef structure undiff
70 Ice Ice-dominated coastal substrates (glacier ice, permafrost) Not used for continental Australia; but this category may be necessary for future extension of substrate classification scheme to polar coasts.		Note: classifiers to be defined (to include glacier ice, permafrost-bound sediment substrates)		Note: not used to date (not applicable to continental Australia)

80 Special cases 81 Banded Iron Formation (laminated iron and chert-rich sedimentary rocks) 82 Chert (siliceous precipitates) 88 Poorly specified rock types (but some information available) 89 Melange (intensely faulted / sheared mixed hard rocks, lithologies unspecified)		10 **Unconsolidated** material (generally sediment) 20 **Semi-lithified** ('soft') material 30 **Lithified** undiff. 40 **Metamorphosed** undiff 50 **Altered** undiff. 51 Hydrothermally altered 52 Deeply weathered (soft, clayey) 90 **Unclassified**	819040 829030 889030 893090	Banded Iron Formation rocks Dominantly chert rocks Lithified hard rocks undiff Melange (hard rocks) undiff
90 Unclassified	90 **Unclassified**	90 **Unclassified**	909090	Unclassified

6.3.10 Stability Themes

Stability themes and their sub-classes differentiate mapped coastal landforms according to their potential susceptibility to physical instability (erosion or accretion) in response to coastal processes including (but not limited to) sea-level rise. Differing stability themes are indicative of differing *styles* of physical response to coastal processes but are not necessarily indicative of differing *magnitudes* of response, which may vary considerably for a given stability class depending on a variety of local conditions and processes.

The stability themes are not primary geomorphic datasets in themselves, but rather have been derived from the Smartline geomorphic fields using GIS queries. The query scripts are based on the class definitions provided in the following tables (the query scripts are not reproduced here but have been archived by the UTas project team and are available for future use and modification if required). The basis for the definition of the various stability themes is discussed in a separate coastal stability classification report (Sharples 2009), and is summarised in Section (4.0) of this manual. The stability themes are primarily defined on the basis of landform *fabric* (i.e., what they are made of), which is here treated as the most fundamental factor determining coastal landform stability in response to coastal processes including sea-level rise.

Where appropriate, further sub-classes within some stability themes are differentiated on the basis of additional first-order landform *fabric* and *form* distinctions that are also identifiable from information contained in the Smartline attributes, but are not primarily differentiated according to the morpho-dynamic (geomorphic) *processes* acting on a coastal segment. Although in some cases the fabric and form distinctions relate strongly to the landforms exposure to differing coastal processes (e.g., location of a shore segment on the open coast or within a coastal re-entrant is important because it determines exposure to swell wave or tidal current processes), they are nonetheless treated here as primarily *form* or *fabric* properties (planform, sediment body or bedrock extent and form, topographic location, etc) which determine exposure to certain processes but do not provide a measure of the processes themselves. For example, location within a coastal re-entrant may typically expose a shore to tidal current processes, but the nature and magnitude of those processes will vary considerably depending on local conditions which can only be determined by a site-specific investigation at a "Third Pass" assessment level (as defined by Sharples 2009). In summary, the "*Fundamental Stability Factors*" used in differentiating coastal landform stability themes and sub-classes here are:

Primary factor: Defines the stability themes:
Fabric (what the landform is made of, ranging from hard rock to soft rock to unlithified sediments of varying grainsize).

Secondary factors: Used as relevant to sub-divide particular stability themes and classes:
Form: basic distinctions ranging from flat through sloping to vertical or cliffed landforms; or differing dune forms.
Geomorphic setting: for most soft sediment stability themes, this is a first-order fabric-related distinction determining potential susceptibility to coastal recession, namely whether *shoreline landform is backed by bedrock or by soft – sediment.* However in the case of the '*Dunes*' stability theme, the geomorphic setting refers to *whether the dunes are exposed to wave action on the seawards side or not*.
Coastal setting: For stability themes for which this is thought to be a major factor controlling coastal stability, the 'coastal setting' refers to whether the *shoreline is located on the open coast or within a coastal re-entrant ('inlet')* This can be pedantically considered a 'form' (topography) distinction, but is important in defining a first-order distinction in the types of processes to which a shoreline will be exposed.

Stability Theme: **Muddy Shores**
Field name: *Muddy*
***Explanation*:** Identifies shores having dominantly mud-grade (clay, silt) soft sediments in the intertidal zone. May include sandy muds and pebbly muds where mud fraction considered dominant. This theme includes many estuarine, deltaic and mangrove-dominated shores, comprising both narrow muddy shores and broad muddy intertidal flats. This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions which are likely to be strongly related to potential stability in response to sea level rise, and which can be identified from information contained in the Smartline attributes. These distinctions are: generalised form (narrow muddy shores versus broad intertidal mudflats), and coastal and geomorphic settings as defined above.

This fabric – defined Stability Theme has more sub-classes than any other, because it is the only theme in which all three Secondary Factors (form, coastal setting, and geomorphic setting as per previous page) were considered important enough to sub-divide the class on.

In virtue of very fine sediment grainsizes (easily eroded & transported), muddy shores have the potential to be very unstable and mobile. In general, soft muddy shores are likely to recede with sea-level rise; however responses may be complex and widely variable depending on local conditions. For example, if climate change results in greater catchment runoff & erosion, muddy estuarine tidal flats might potentially prograde if increased sediment supply exceeds the effects of sea-level rise (particularly where mangroves cause sediment-trapping).

It should also be noted that the intention of this classification is to ignore the presence or absence of artificial coastal protection structures, since the aim of this classification is to identify what the natural stability of the shoreline type would be (regardless of whether or not protection has in fact been constructed); however this is not always possible where artificial structures have entirely obscured or replaced evidence of the former natural character of a shore.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Muddy_n* (3 digits)	**Verbal label** *Muddy_v* (100 characters)	**Legend label** *Muddy_l* (30 characters)	
000	Not identified as a muddy shore	Not a known muddy shore	Unclassified shore, or (generally) classified as a non-muddy shore type.
100	Muddy shore undifferentiated	Muddy shore undifferentiated	Mud-dominated intertidal zones, whose forms, coastal settings and geomorphic settings are unknown or unspecified. *These shores are potentially unstable, but potential for significant landwards shoreline recession uncertain.*
101	Muddy shore backed by soft sediment deposits to below sea level	Muddy shore, sediment backed	Mud-dominated intertidal zones of unspecified form and coastal setting, but backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable, with potential for significant landwards shoreline recession.*
102	Muddy shore backed by bedrock rising above sea level	Muddy shore, bedrock backed	Mud-dominated intertidal zones of unspecified form and coastal setting, but backed by rising bedrock terrain above sea level. *These shores are potentially susceptible to some instability, however there is little potential for significant landwards shoreline recession.*
110	Open coast muddy shore undifferentiated	Open muddy shore undiff.	Mud-dominated intertidal zones of unspecified form dominated by open coast (oceanic) processes

			including swell wave climate and open coast tides, however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to open coast processes, but potential for significant landwards shoreline recession uncertain*
111	Open coast muddy shore backed by soft sediment deposits to below sea level	Open muddy shore, sed-backed	Mud-dominated intertidal zones of unspecified form dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to open coast processes, with potential for significant landwards shoreline recession.*
112	Open coast muddy shore backed by bedrock rising above sea level	Open muddy shore, rock-backed	Mud-dominated intertidal zones of unspecified form dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response to open coast processes, however there is little potential for significant landwards shoreline recession.*
120	Coastal re-entrant (inlet) muddy shore undifferentiated	Inlet muddy shore undiff	Mud-dominated intertidal zones of unspecified form dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to re-entrant processes, but potential for*

			significant landwards shoreline recession uncertain
121	Coastal re-entrant (inlet) muddy shore backed by soft sediment deposits to below sea level	Inlet muddy shore, sed-backed	Mud-dominated intertidal zones of unspecified form dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to re-entrant processes, with potential for significant landwards shoreline recession.*
122	Coastal re-entrant (inlet) muddy shore backed by bedrock rising above sea level	Inlet muddy shore, rock-backed	Mud-dominated intertidal zones of unspecified form dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response re-entrant processes, however there is little potential for significant landwards shoreline recession.*
200	Broad mudflat shore undifferentiated	Mudflat shore undiff	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, whose coastal and geomorphic settings are unknown or unspecified. *These shores are potentially unstable, but potential for significant recession uncertain.*
201	Broad mudflat shore backed by soft sediment deposits to below sea level	Mudflat shore, sediment backed	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats of unspecified coastal setting, but backed by soft sediments, typically low-lying Quaternary

			sediment plains, vertically extending below present sea level. *These shores are potentially unstable, with potential for significant landwards shoreline recession.*
202	Broad mudflat shore backed by bedrock rising above sea level	Mudflat shore, bedrock backed	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats of unspecified coastal setting, but backed by rising bedrock terrain above sea level. *These shores are potentially susceptible to some instability, however there is little potential for significant landwards shoreline recession.*
210	Open coast broad mudflat shore undifferentiated	Open mudflat shore undiff	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to open coast processes, but potential for significant landwards shoreline recession uncertain*
211	Open coast broad mudflat shore backed by soft sediment deposits to below sea level	Open mudflat shore, sed-back	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to open coast processes, with potential for significant landwards shoreline recession.*

212	Open coast broad mudflat shore backed by bedrock rising above sea level	Open mudflat shore, rock-back	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response to open coast processes, however there is little potential for significant landwards shoreline recession*
220	Coastal re-entrant (inlet) broad mudflat shore undifferentiated	Inlet mudflat shore undiff	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to re-entrant processes, but potential for significant landwards shoreline recession uncertain*
221	Coastal re-entrant (inlet) broad mudflat shore backed by soft sediment deposits to below sea level	Inlet mudflat shore, sed-back	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to re-entrant processes, with potential for significant landwards shoreline recession.*
222	Coastal re-entrant (inlet) broad mudflat shore backed by bedrock rising above sea level	Inlet mudflat shore, rock-back	Mud-dominated intertidal zones characterised by broad flat to gently sloping mudflats, dominated by local wind-waves, tidal currents and other

			coastal re-entrant (inlet) and/or estuarine processes; and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response to re-entrant processes, however there is little potential for significant landwards shoreline recession*
300	Narrow muddy shore undifferentiated	Narrow mud shore undiff	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, whose coastal and geomorphic settings are unknown or unspecified. *These shores are potentially unstable, but potential for significant recession uncertain.*
301	Narrow muddy shore backed by soft sediment deposits to below sea level	Narrow mud shore, sed-back	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores of unspecified coastal setting, but backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable, with potential for significant landwards shoreline recession.*
302	Narrow muddy shore backed by bedrock rising above sea level	Narrow mud shore, rock-back	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores of unspecified coastal setting, but backed by rising bedrock terrain above sea level. *These shores are potentially susceptible to some instability, however there is little potential for significant landwards shoreline recession.*

310	Open coast narrow muddy shore undifferentiated	Open narrow mud shore undiff	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to open coast processes, but potential for significant landwards shoreline recession uncertain*
311	Open coast narrow muddy shore backed by soft sediment deposits to below sea level	Open narrow mud shore,sed-back	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to open coast processes, with potential for significant landwards shoreline recession.*
312	Open coast narrow muddy shore backed by bedrock rising above sea level	Open narrow mud shr.,rock-back	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, dominated by open coast (oceanic) processes including swell wave climate and open coast tides, and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response to open coast processes, however there is little potential for significant landwards shoreline recession*
320	Coastal re-entrant (inlet) narrow muddy shore undifferentiated	Inlet narrow mud shore undiff	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores,

			dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to re-entrant processes, but potential for significant landwards shoreline recession uncertain*
321	Coastal re-entrant (inlet) narrow muddy shore backed by soft sediment deposits to below sea level	Inlet narrow mud shr.,sed-back	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; and backed by soft sediments, typically low-lying Quaternary sediment plains, vertically extending below present sea level. *These shores are potentially unstable in response to re-entrant processes, with potential for significant landwards shoreline recession.*
322	Coastal re-entrant (inlet) narrow muddy shore backed by bedrock rising above sea level	Inlet narrow mud shr.,rock-bak	Mud-dominated intertidal zones characterised by narrow gently to moderately sloping mud shores, dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; and backed by rising bedrock terrain above sea level. *These shores have some potential for instability in response to re-entrant processes, however there is little potential for significant landwards shoreline recession*

Stability Theme: **Sandy Shores**
Field name: *Sandy*
***Explanation*:** This theme identifies shores dominated by sand-grade soft sediments in the intertidal zone. The ideal transport (mobility) characteristics of sand-size particles not only make sandy beaches and shores the most abundant type of soft sediment shore on the Australian coast, but also cause them to exhibit distinctive erosion & accretion behaviour compared to other soft sediment shores. Because sandy shores are both easily eroded and also easily rebuilt by accretion processes, they can rapidly establish a dynamic equilibrium with changing coastal processes which may, for example, resulting in quickly alternating periods of erosion and progradation of the sandy shores where local conditions change cyclically, or alternatively may result in long periods of rapid progressive erosion if a major environmental variable such as sea level undergoes a long term change such as a progressive rise. This contrasts markedly with the behaviour of many other shoreline landform types, including finer or coarser sediment shores and erodible rock shores, many of which exhibit only uni-directional change (erosion) which merely varies in its rate as conditions change, or which respond in other distinctly different ways to sand shores. In the context of this coastal stability classification, it is important to note that the widely-used Bruun Rule of erosion with sea-level rise (e.g., Bruun 1988) was essentially formulated to describe sandy coast behaviour, and – since it describes a process which is heavily dependent on the characteristic sediment mobility characteristics of sand - is arguably not applicable to non-sandy eroding coasts unless substantially modified.

'Sandy shores' may include mixed sand and shingle where sand is dominant. This theme includes sandy beaches, sandy tidal flats, and narrow sandy shores which may not be true beaches (e.g., sandy tidal channel shores which are not true wave-deposited sand bodies). This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions – namely location on open coast or coastal re-entrants & tidal inlets ('coastal setting'), and presence or absence of bedrock terrain backing the sandy shore above sea level ('geomorphic setting') - which strongly determine potential stability in response to sea level rise, and which can in many places be identified from information contained in the Smartline attributes. Open coast *vs.* re-entrant or inlet location is a first-order distinction which exposes sandy shores to quite different processes (e.g., dominantly swell waves *vs.* dominantly local wind waves & tidal currents). Significant erosion and recession may occur in both settings but the causes, styles and patterns of instability are likely to be very different. Bedrock *vs.* soft-sediment backing is another first-order control on sandy shore response since while bedrock limits potential shoreline recession, soft sediment backing may allow significant relatively rapid recession to occur.

This stability classification does not further differentiate sandy shores as being more or less stable in terms of beach morpho-dynamic types or other local geomorphic variables. For example, in the sensitive case of narrow sandy barriers backed by large lagoons, the *shores* of the sandy barriers are simply identified being potentially unstable sandy *shores*. This is partly because the inclusion of coastal lagoons in the Smartline map has not been consistent around Australia, but more importantly because identifying (for example) a particular morpho-dynamic environment as a sandy barrier coast backed by a lagoon is arguably better undertaken at a more detailed level of stability assessment – involving additional site-specific local process variables – than the strictly First Pass fabric-form characterisation of stability types that is intended here. For a similar reason, sandy shores are not here differentiated according to the presence or absence of extensive intertidal flats, since these are an indicator of beach morpho-dynamic types and local geomorphic processes, and as such are more relevant at more detailed levels of assessment than are attempted here.

This theme classifies the stability of sandy shores in response to wave erosion, but does not identify potential associated dune instability. Although the latter may be triggered by sandy-shore wave erosion, unstable dune fields also occur behind some stable hard rocky coasts, and may be triggered by other factors such as artificial disturbance, reduced precipitation and/or increased wind speeds. Coasts potentially sensitive to increased (or decreased) dune mobility are therefore identified under the separate *Dunes* stability attribute (below).

It should also be noted that the intention of this classification is to ignore the presence or absence of artificial coastal protection structures, since the aim of this classification is to identify what the natural stability of the shoreline type would be (regardless of whether or not protection has in fact been constructed); however this is not always possible where artificial structures have entirely obscured or replaced evidence of the former natural character of a shore.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Sandy_n* (3 digits)	**Verbal label** *Sandy_v* (100 characters)	**Legend label** *Sandy_l* (30 characters)	
000	Not identified as a sandy shore	Not a known sandy shore	Unclassified shore, or (generally) classified as a non-sandy shore type.
100	Sandy shore undifferentiated	Sandy shore	Sandy shores whose coastal & geomorphic settings are unknown or unspecified. *These shores are potentially unstable, but potential for significant recession uncertain.*
110	Sandy shore backed by soft sediment deposits to below sea-level	Sandy shore, sediment backed	Sandy shore of unspecified coastal setting, but backed by soft sediments, typically low-lying Quaternary sediment plains. *These shores are potentially unstable, with potential for significant landwards recession of shoreline.*

120	Sandy shore backed by bedrock rising above sea level	Sandy shore, bedrock-backed	Sandy shore of unspecified coastal setting, but immediately backed by rising bedrock terrain (with or without superficial aeolian sand cover over bedrock above sea level). *These shores are potentially unstable, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.*
200	Open coast sandy shore undifferentiated	Open sandy shore	Sandy shores dominated by open coast (oceanic) processes including swell wave climate and open coast tides; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to open coast processes including (swell) wave climate, however potential for significant shoreline recession uncertain.*
210	Open coast sandy shore backed by soft sediment deposits to below sea-level	Open sandy shore, sed-backed	Sandy shores dominated by open coast processes and backed by soft sediments, typically low-lying Quaternary sediment plains. *These shores are potentially unstable in response to open coast processes, with potential for significant landwards recession of shoreline.*
220	Open coast sandy shore backed by bedrock rising above sea level	Open sandy shore, rock-backed	Sandy shores dominated by open coast processes and immediately backed by rising bedrock terrain (with or without superficial aeolian sand cover over bedrock above sea level). *These shores are potentially unstable in response to open coast processes, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.*

300	Coastal re-entrant (inlet) sandy shore undifferentiated	Inlet sandy shore	Sandy shores dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or estuarine processes; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to re-entrant processes including local wind-waves and tidal currents; however potential for significant shoreline recession uncertain.*
310	Coastal re-entrant (inlet) sandy shore backed by soft sediment deposits to below sea-level	Inlet sandy shore, sed-backed	Sandy shores dominated by coastal re-entrant (inlet) processes and backed by soft sediments, typically low-lying Quaternary sediment plains. *These shores are potentially unstable in response to re-entrant processes, with potential for significant landwards recession of shoreline.*
320	Coastal re-entrant (inlet) sandy shore backed by bedrock rising above sea level	Inlet sandy shore, rock-backed	Sandy shores dominated by coastal re-entrant (inlet) processes and immediately backed by rising bedrock terrain (with or without superficial aeolian sand cover over bedrock above sea level). *These shores are potentially unstable in response to re-entrant processes, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.*

Stability Theme: **Sand Dune & Beach Ridge Coasts**

Field name: *Dunes*

***Explanation*:** Identifies coasts with significant soft sand deposits in the backshore having some potential for instability resulting from wind exposure and erosion (i.e., dune mobility). Such sandy backshores may be prone to sand mobility triggered by wave erosion of dune fronts (e.g., under conditions of rising sea-level) and/or by changing climatic conditions (reduced precipitation and increased wind speeds causing increased instability in some regions), as well as by artificial disturbances. Note however that there is also potential for increased precipitation and decreased wind speeds to cause dune stabilisation where these climatic trends occur. This theme includes aeolian sand-sheets, dunes, dune-fields or beach-ridges (soft sands either having some exposure to wind erosion and/or originally deposited by wind). Some sandy backshores (e.g., alluvial sand floodplain deposits) may not necessarily be included in this theme since in such cases in may not be clear that significant relief and exposure yielding a wind erosion susceptibility exists.

This *fabric*-defined stability theme is divided into a few major classes according to first-order distinctions which strongly influence potential stability in response to climate change and sea level rise specifically, and which can be identified from information contained in the Smartline attributes. However, this stability class emphatically provides only a ‘First Pass’ indication of coasts *potentially* prone to dune or windblown sand mobility. More confident assessment of the *likelihood* of mobility requires site-specific information on factors such as details of dune topography, vegetation cover, precipitation, wind climate and artificial disturbance, which are more appropriately captured in more detailed local-level mobility risk assessments.

This sensitivity is considered separately to sandy shore sensitivity to wave erosion and retreat, since whilst many dune fields occur behind sandy shores, some (stable or unstable) dune fields also occur behind stable hard rocky shores (e.g., cliff-top dunes). However since dune-fields isolated from the sea behind rocky or cliffed intertidal to proximal backshore zones are thereby protected from one potential trigger of dune mobility (wave attack), this distinction is also used as a classifier differentiating such less-exposed dunes from those which are exposed to wave attack in addition to other potential triggers of dune mobility (wind speed and precipitation changes, artificial disturbance, etc).

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Dunes_n* (3 digits)	**Verbal label** *Dunes_v* (100 characters)	**Legend label** *Dunes_l* (30 characters)	
000	Not identified as a coast having significant dune, beach-ridge or aeolian sand backshores	Not a known dune coast	Unclassified backshore type, or (generally) classified as a non-dune, beach-ridge or aeolian sand-sheet backshore type.
100	Undiff dunes, aeolian sand sheets or beach-ridges exposure to wave attack unspecified	Dune coast undiff	Coasts whose backshores are characterised by dunes, aeolian sand-sheets or beach ridges whose exposure to wave attack are unknown or unspecified. *These backshores are potentially prone to sand mobility triggered by climatic changes, but exposure to direct impacts of sea-level rise and wave attack is unknown or unspecified.*
200	Undiff dunes, beach-ridges or aeolian sand-sheets exposed to wave attack at seaward side	Wave-exposed dunes	Coasts whose backshores are characterised by dunes, beach-ridges or aeolian sand-sheets (undifferentiated) extending inland from the high water mark (and thus exposed to wave-attack at their seawards margins). *These backshores are potentially prone to sand mobility triggered by climatic changes or directly by sea-level rise and wave attack.*
210	Single foredune exposed to wave attack at seaward side	Wave-exposed foredune	Coasts whose backshores are characterised by a single foredune immediately above high water mark (and thus exposed to wave-attack). *These backshores are potentially prone to limited sand mobility triggered by climatic changes or directly by sea-level rise and wave attack (limited*

			sand volume restricts potential sand mobility)
220	Dune-field undiff exposed to wave attack at seaward side	Wave-exposed dune-field	Coasts whose backshores are characterised by multiples dunes or a dune-field of undifferentiated type, extending inland from the high water mark (and thus exposed to wave-attack at the seawards margin). *These backshores are potentially prone to sand mobility triggered by climatic changes or directly by sea-level rise and wave attack*
230	Transgressive or parabolic dune-field (may have a foredune) exposed to wave attack at seaward side	Wave-exposed transgr. dunes	Coasts whose backshores are characterised by currently or formerly transgressive dune fields (with or without a foredune), which extend inland from the high water mark (and thus remain exposed to wave-attack at their seawards margins). *These backshores, with typically substantial dune relief and a history of dune mobility, are potentially prone to significant sand mobility triggered by climatic changes or directly by sea-level rise and wave attack.*
240	Aeolian sand sheets (with or without foredune) exposed to wave attack at seaward side	Wave-exposed aeol. sand sheets	Coasts whose backshores are characterised by aeolian sand-sheets (with or without a foredune, but dune forms otherwise subdued or absent) extending inland from the high water mark (and thus exposed to wave-attack at the seawards margin). *These (typically low-relief) backshores are potentially prone to moderate sand mobility triggered by climatic changes or directly by sea-level rise and wave attack.*

250	Beach-ridge plain (with or without foredune) exposed to wave attack at seaward side	Wave-exposed beach-ridge plain	Coasts whose backshores are dominated by low-relief sandy beach ridges (with or without a foredune), that are exposed to wave attack at the seawards margin. *These generally low-relief sandy backshores are potentially prone to moderate sand mobility triggered by climatic changes or directly by sea-level rise and wave attack.*
300	Undiff dunes, aeolian sand-sheets or beach-ridges disconnected from wave attack at seaward side	Disconnected dunes undiff	Coasts whose backshores are characterised by dunes, aeolian sand-sheets or putative beach-ridges* disconnected from wave attack behind non-sandy intertidal zones (e.g., cliff-top dunes). [****Note*** beach-ridges theoretically should not be present as these are progradational landforms which will only have formed in situations where the seawards margin will remain exposed to wave attack; however due to inconsistent mapping terminology some disconnected dunes may be incorrectly mapped as "beach-ridges", hence it is necessary to include such putative beach-ridges in this query. Note the implication that any 'beach-ridges captured by this class are probably not true beach-ridges, but rather are actually dunes.] *These backshores are potentially prone to sand mobility triggered by climatic changes, but not directly by sea-level rise and wave attack.*
310	Dunes, dune-field undiff or putative beach-ridges disconnected from wave attack at seawards side	Disconnected dunes	Coasts whose backshores are characterised by multiple dunes or a dune-field of undifferentiated type, or putative beach-ridges* disconnected from wave attack behind non-sandy intertidal zones (e.g., cliff-top dunes). [****Note*** beach-ridges theoretically should not be present as these are progradational landforms

			which will only have formed in situations where the seawards margin will remain exposed to wave attack; however due to inconsistent mapping terminology some disconnected dunes may be incorrectly mapped as "beach-ridges", hence it is necessary to include such putative beach-ridges in this query. Note the implication that any 'beach-ridges captured by this class are probably not true beach-ridges, but rather are actually dunes.] *These backshores are potentially prone to sand mobility triggered by climatic changes, but not directly by sea-level rise and wave attack.*
320	Transgressive or parabolic dune-field disconnected from wave attack at seawards side	Disconnected transgr. dunes	Coasts whose backshores are characterised by currently or formerly transgressive dune fields, disconnected from wave attack behind non-sandy intertidal zones (e.g., cliff-top dunes). *These backshores, with typically substantial dune relief and a history of dune mobility, are potentially prone to significant sand mobility triggered by climatic changes, but not directly by sea-level rise and wave attack*
330	Aeolian sand-sheets (dune forms subdued or absent) disconnected from wave attack at seawards side	Disconnected sand-sheets	Coasts whose backshores are characterised by aeolian sand-sheets (with dune forms subdued or absent), disconnected from wave attack behind non-sandy intertidal zones (e.g., cliff-top sand sheets). *These backshores are potentially prone to moderate sand mobility triggered by climatic changes, but not directly by sea-level rise and wave attack*

Stability Theme: **Coarse Sediment Shores**
Field name: *Coarsed*
***Explanation*:** Identifies shores dominated by coarse-grade unconsolidated sediment in the intertidal zone. These may include (wave-deposited & wave-worked) shingle and boulder beaches, as well as dominantly talus (colluvial) shores (coarse mass movement-deposited material, generally little clast rounding due to wave action). Note that only dominantly colluvial shores are classified here; predominantly rocky or cliffed shores with only sub-ordinate colluvium are classed as the appropriate 'Soft Rock' or 'Hard Rock' shore type. This *fabric*-defined stability theme is divided into further major sub-classes, firstly by major fabric sub-types, and then secondly by geomorphic settings (whether backed by bedrock or sediment). In contrast to other soft sediment stability themes, further sub-classes are not also defined on coastal setting (open or re-entrant coast), since the importance of coastal setting in controlling coarse sediment shore behaviour is unclear. The stability coding scheme would allow coastal setting factors to be easily incorporated as further sub-classes if required in future.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Coarsed_n* (3 digits)	**Verbal label** *Coarsed_v* (100 characters)	**Legend label** *Coarsed_l* (30 characters)	
000	Not identified as a coarse sediment shore	Not a known coarse sed shore	Unclassified shore, or (generally) classified as a non-coarse sediment shore type.
100	Coarse sediment shore, type & setting undifferentiated	Coarse sediment shore undiff	***Coarse sediment shores of unknown type*** Shores whose intertidal zones (and sometimes backshore zones) are dominated by coarse (pebble to boulder grade) unconsolidated and unlithified sediments of unspecified type, which may include wave-worked shingle or boulder beaches, or colluvial shores of mass movement origin (talus, landslide debris, etc); however geomorphic setting (bedrock or sediment backshore) is unspecified. *Potentially unstable shores, but style and magnitude of instability variable depending on sediment type and other factors, and potential for significant recession uncertain.*

110	Coarse sediment shore, type undifferentiated, backed by soft sediment deposits to below sea-level	Coarse sed shore, sed-backed	Shores whose intertidal zones (and sometimes backshore zones) are dominated by coarse (pebble to boulder grade) unconsolidated and unlithified sediments of unspecified type, which may include wave-worked shingle or boulder beaches, or colluvial shores of mass movement origin (talus, landslide debris, etc), and which are backed by soft sediments, typically low-lying Quaternary sediment plains. *Potentially unstable shores, style and magnitude of instability variable depending on sediment type and other factors, but with potential for significant landwards recession of shoreline.*
120	Coarse sediment shore, type undifferentiated, backed by bedrock rising above sea level	Coarse sed shore, rock-backed	Shores whose intertidal zones (and sometimes backshore zones) are dominated by coarse (pebble to boulder grade) unconsolidated and unlithified sediments of unspecified type, which may include wave-worked shingle or boulder beaches, or colluvial shores of mass movement origin (talus, landslide debris, etc), and which are immediately backed by rising bedrock terrain. *Potentially unstable shores, but style and magnitude of instability variable depending on sediment type and other factors, however there is little potential for significant landwards shoreline recession*
200	Coarse sediment beach, pebble to boulder grade undiff, setting undiff	Coarse sediment beach undiff	***Wave-worked coarse sediment, calibre undifferentiated (coarse-grade beaches)*** Shores whose intertidal zones are dominated by coarse (pebble to boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, where specific grainsize (pebble to boulder) is unspecified and geomorphic setting

			(bedrock or sediment backshore) is unspecified. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, and potential for significant recession is uncertain.*
210	Coarse sediment beach, pebble to boulder grade undiff, backed by soft sediments to below sea-level	Coarse sed beach, sed-backed	Shores whose intertidal zones are dominated by coarse (pebble to boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, where specific grainsize (pebble to boulder) is unspecified, and which are backed by soft sediments, typically low-lying Quaternary sediment plains. *Potentially unstable shores, response to sea-level rise poorly understood and may be complex, however there is potential for significant landwards recession of shoreline.*
220	Coarse sediment beach, pebble to boulder grade undiff, backed by bedrock rising above sea level	Coarse sed beach, rock-backed	Shores whose intertidal zones are dominated by coarse (pebble to boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, where specific grainsize (pebble to boulder) is unspecified, and which are immediately backed by rising bedrock terrain. *Potentially unstable shores, response to sea-level rise poorly understood and may be complex, however there is little potential for significant landwards shoreline recession.*
300	Boulder-dominated coarse-sediment beach, setting undiff	Boulder beach undiff	***Wave-worked boulder-dominated coarse sediment (boulder beaches)*** Shores whose intertidal zones are dominated by very coarse (boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and whose geomorphic settings (bedrock

			or sediment backshore) are unspecified. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, and potential for significant recession is uncertain.*
310	Boulder-dominated coarse-sediment beach, backed by soft sediments to below sea-level	Boulder beach, sed-backed	Shores whose intertidal zones are dominated by very coarse (boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and which are backed by soft sediments, typically low-lying Quaternary sediment plains. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, however there is potential for significant landwards recession of shoreline.*
320	Boulder-dominated coarse-sediment beach, backed by bedrock rising above sea level	Boulder beach, rock-backed	Shores whose intertidal zones are dominated by very coarse (boulder grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and which are immediately backed by rising bedrock terrain. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, however there is little potential for significant landwards shoreline recession.*
400	Cobble to pebble-dominated coarse sediment beach, setting undiff	Shingle/pebble beach undiff	***Wave-worked cobble to pebble-dominated coarse sediment (shingle beaches)*** Shores whose intertidal zones are dominated by coarse (pebble to cobble grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and whose geomorphic settings (bedrock or sediment backshore) are unspecified. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex,*

			and potential for significant recession is uncertain.
410	Cobble to pebble-dominated coarse sediment beach, backed by soft sediments to below sea-level	Shingle/pebble beach, sed-back	Shores whose intertidal zones are dominated by coarse (pebble to cobble grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and which are backed by soft sediments, typically low-lying Quaternary sediment plains. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, however there is potential for significant landwards recession of shoreline.*
420	Cobble to pebble-dominated coarse sediment beach, backed by bedrock rising above sea level	Shingle/pebble beach,rock-back	Shores whose intertidal zones are dominated by coarse (pebble to cobble grade) wave-worked (rounded) unconsolidated and unlithified beach deposits, and which are immediately backed by rising bedrock terrain. *Potentially unstable shores, but response to sea-level rise poorly understood and may be complex, however there is little potential for significant landwards shoreline recession.*
500	Colluvial (talus) coarse sediment shore, setting undiff	Colluvial (talus) shore undiff	***Dominantly colluvial coarse sediment shores (talus, mass movement shores):-*** Shores whose intertidal and/or backshore proximal zones are dominantly unlithified colluvial material (talus, landslide debris, etc), and whose geomorphic settings (bedrock or sediment backshore) are unspecified. Clasts may range from fine to boulder size, and are typically angular with little wave-rounding or reworking. *Already-unstable shores potentially prone to ongoing slumping and mass-movement, potentially accelerating with sea-level rise,*

			however potential for significant shoreline recession is uncertain. <u>Note</u> that predominantly bedrock-cliffed or sloping bedrock shores with only sub-ordinate colluvium are classified as hard- or soft-rock cliffs as appropriate, rather than as dominantly colluvial shores.
510	Colluvial (talus) coarse sediment shore, backed by soft sediment deposits to below sea-level	Colluvial shore, sed-backed	Shores whose intertidal and/or backshore proximal zones are dominantly unlithified colluvial material (talus, landslide debris, etc), and which are backed by extensive unlithified sediments. Clasts may range from fine to boulder size, and are typically angular with little wave-rounding or reworking. *Already-unstable shores potentially prone to ongoing slumping and mass-movement, potentially accelerating with sea-level rise, with potential for significant landwards recession of shoreline.* <u>Note</u> that colluvial shores are typically not backed by Quaternary sediment deposits such as fluvial or marine infills, however thick mantles of colluvial deposits backing the shore may warrant describing the shore as "sediment-backed".
520	Colluvial (talus) coarse sediment shore, backed by bedrock rising above sea level	Colluvial shore, rock-backed	Shores whose intertidal and/or backshore proximal zones are dominantly unlithified colluvial material (talus, landslide debris, etc), and which are immediately backed by rising bedrock terrain. Clasts may range from fine to boulder size, and are typically angular with little wave-rounding or reworking.

			Already-unstable shores potentially prone to ongoing slumping and mass-movement, potentially accelerating with sea-level rise, however there is little potential for significant landwards shoreline recession. Note that colluvial shores are typically best described as bedrock-backed, although in some cases where the bedrock may be intensely fractured and/or deeply weathered, and in the process of being mobilised to form the colluvial sediment mantle, it may be difficult to decide whether the shore should best be characterised as bedrock- or sediment-backed.

Stability Theme: **Undifferentiated Soft Sediment Shores**
Field name: *Undifsed*
***Explanation*:** Identifies shores having soft sediment of unknown type in the intertidal zone. This *fabric*-defined stability theme is divided into a few major classes according to first-order fabric and form distinctions which strongly determine potential stability in response to sea level rise, and which can be identified from information contained in the Smartline attributes.

This theme allows identification of soft potentially unstable coasts in areas of poor geological and geomorphic mapping where the sediment type is unspecified. It is expected that any further stability assessment of such shores would include identification of the sediment type, resulting in these shores being reclassified under the appropriate specific stability theme.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Undifsed_n* (3 digits)	**Verbal label** *Undifsed_v* (100 characters)	**Legend label** *Undifsed_l* (30 characters)	
000	Not identified as an undifferentiated soft sediment shore	Not a known undif soft sed shr	Unclassified shore, or (generally) classified as a non-"undifferentiated soft sediment" shore type.
100	Soft sediment (undiff) shore	Soft sediment shore	Soft sediment shores whose sediment type (grainsize), coastal & geomorphic settings are unknown or unspecified. *These shores are potentially unstable, but potential for significant recession uncertain.*
110	Soft sediment (undiff) shore backed by soft sediment deposits to below sea-level	Soft sed shore, sed-backed	Soft sediment shore of unspecified sediment type (grainsize) and coastal setting, but backed by soft sediments, typically low-lying Quaternary sediment plains. *Shore potentially unstable, with potential for significant landwards recession of shoreline.*
120	Soft sediment (undiff) shore backed by bedrock rising above sea level	Soft sed shore, rock-backed	Soft sediment shore of unspecified sediment type (grainsize) and coastal setting, but immediately backed by rising bedrock terrain.

			These shores are potentially unstable, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.
200	Open coast soft sediment (undiff) shore	Open soft sediment shore	Soft sediment shore of unspecified sediment type (grainsize) dominated by open coast (oceanic) processes including swell wave climate and open coast tides; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to open coast processes including (swell) wave climate, however potential for significant shoreline recession uncertain.*
210	Open coast soft sediment (undiff) shore backed by soft sediment deposits to below sea-level	Open soft sed shore, sed-back	Soft sediment shore of unspecified sediment type (grainsize) dominated by open coast processes and backed by soft sediments, typically low-lying Quaternary sediment plains. *These shores are potentially unstable in response to open coast processes, with potential for significant landwards recession of shoreline.*
220	Open coast soft sediment (undiff) shore backed by bedrock rising above sea level	Open soft sed shore, rock-back	Soft sediment shore of unspecified sediment type (grainsize) dominated by open coast processes and immediately backed by rising bedrock terrain. *These shores are potentially unstable in response to open coast processes, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.*
300	Coastal re-entrant (inlet) soft sediment (undiff) shore	Inlet soft sediment shore	Soft sediment shore of unspecified sediment type (grainsize) dominated by local wind-waves, tidal currents and other coastal re-entrant (inlet) and/or

			estuarine processes; however geomorphic setting (bedrock or sediment backshore) unspecified. *These shores are potentially unstable in response to re-entrant processes including local wind-waves and tidal currents; however potential for significant shoreline recession uncertain.*
310	Coastal inlet soft sediment (undiff) shore backed by soft sediment deposits to below sea-level	Inlet soft sed shore, sed-back	Soft sediment shore of unspecified sediment type (grainsize) dominated by coastal re-entrant (inlet) processes and backed by soft sediments, typically low-lying Quaternary sediment plains. *These shores are potentially unstable in response to re-entrant processes, with potential for significant landwards recession of shoreline.*
320	Coastal inlet soft sediment (undiff) shore backed by bedrock rising above sea level	Inlet soft sed shore,rock-back	Soft sediment shore of unspecified sediment type (grainsize) dominated by coastal re-entrant (inlet) processes and immediately backed by rising bedrock terrain. *These shores are potentially unstable in response to re-entrant processes, however although there is potential for beach lowering or other instability, there is little potential for significant landwards shoreline recession.*

Stability Theme: **“Soft Rock” Shores**
Field name: *Softrock*
***Explanation*:** This theme identifies shores having “soft” bedrock landforms in the backshore zone. “Soft” bedrock coasts often have sediment-mantled intertidal zones with little or no bedrock outcrop, since the soft bedrock itself is quite erodible. However, this stability class identifies coasts whose backshores are dominated by ‘soft’ bedrock types, as these will dominate the geomorphic behaviour of those coasts.

‘Soft’ bedrock may be semi-lithified or inherently soft bedrock, strongly weathered bedrock or some other types of regolith. Examples include backshore “bedrock” landforms of clayey-gravelly semi-lithified Cainozoic-age sediment, soft limestone, intensely fractured and deeply weathered volcanic rocks, lateritic duricrust profiles or coarse bouldery ‘sediments’ which are actually residual boulder and cobble - grade corestones remaining from weathering and winnowing of bedrock (all ± soil mantles). This *fabric*-defined stability theme is divided into a few major classes according to first-order *form* (slope) distinctions which strongly determine potential stability or erosion style in response to sea level rise, and which can be identified from information contained in the Smartline attributes.

“Soft Rock” shores can in many situations erode quite rapidly enough to place infrastructure within metres or tens of metres of the shore at significant risk within the foreseeable future. Moreover, unlike some soft sediment shores (especially sandy shores), ‘soft rock’ shores exhibit only uni-directional change (landwards erosion), which may vary in rate as coastal conditions change but can not reverse and commence accreting as may happen on sandy shores. Because of its progressive, irreversible and potentially rapid nature, the erosion of ‘soft-rock’ shores can be of just as much concern as the better-known sandy coast erosion processes.

For the purposes of this ‘First Pass’ stability classification scheme, the category ‘soft rock’ is used as a broad and vaguely -defined contrast between ‘hard rock’ on one hand, and ‘soft sediment’ on the other. However, this usage of ‘soft rock’ actually encompasses coastal materials of widely differing hardness and other characteristics. This admittedly simplistic usage of ‘soft rock’ has been employed here because no more useful and well-developed categories appropriate to the purpose appeared to the writer to be available. However it is hoped that in future a more sophisticated categorisation of ‘soft rock’ types will be developed that will be capable of more usefully differentiating variations in rock behaviour in response to processes such as sea-level rise.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Softrock_n* (3 digits)	**Verbal label** *Softrock_v* (100 characters)	**Legend label** *Softrock_l* (30 characters)	
000	Not identified as a soft rock shore	Not a known soft rock shore	Unclassified shore, or (generally) classified as a non-"soft-rock" shore type.
100	Undifferentiated profile soft-rock shore	Undif profile soft rock shore	Shores of soft bedrock in the intertidal and/or backshore proximal zone (unknown profile). *These shores are potentially susceptible to progressive erosional recession of unspecified style.*
200	Low profile soft-rock shore	Low profile soft rock shore	Shores with low profile (flat to gently sloping) backshores of soft bedrock. May include vertical faces <5m high and/or sub-ordinate colluvium, & may or may not be associated with a beach, rocky shore platform or sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). Includes some soft rock shores with artificial shoreline protection works intended to prevent erosion (and usually constructed in response to an existing erosion problem). *These shores are potentially susceptible to progressive erosional recession with generally only small-scale slumping and block falls.*

300	Moderately to steeply sloping soft-rock shore	Sloping soft rock shore	Moderately to steeply sloping soft rock terrain in the backshore proximal zone. May include vertical faces <5m high and/or sub-ordinate colluvium, & may or may not be associated with a basal rocky shore platform, beach, basal talus blocks or sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). Includes some soft rock shores with artificial shoreline protection works intended to prevent erosion (and usually constructed in response to an existing erosion problem). *These shores are potentially susceptible to progressive erosional recession with significant mass movement including slumping or landslides.*
400	Very steep to cliffed soft-rock shore	Soft rock coastal cliffs	Very steeply sloping to vertical cliffs (>5m high) of soft bedrock in the intertidal and/or backshore proximal zone. May include sub-ordinate colluvium, & may or may not be associated with a basal rocky shore platform, beach, basal talus blocks or sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). Includes some soft rock shores with artificial shoreline protection works intended to prevent erosion (and usually constructed in response to an existing erosion problem). *These shores are potentially susceptible to*

			progressive cliff-line retreat (comparatively rapid compared to hard rock shores) through rock fall, slab- collapse, slumping or other forms of erosion.

Stability Theme: **Hard Rock Shores**
Field name: *Hardrock*
***Explanation*:** Identifies shores dominated by hard lithified bedrock landforms in the intertidal and backshore zones (± soil mantles or aeolian sand veneers in the backshore zone). The intention of this theme is to identify hard rock coasts where bedrock is *exposed* at the shoreline (either in the intertidal zone and/or as backshore proximal cliffs). Shores immediately backed by hard bedrock, but with only soft sediments actually exposed in the intertidal zone, will be classified under other soft sediment stability themes as 'bedrock-backed' variants.

This *fabric*- and *form*-defined stability theme comprises both mostly stable gently to moderately sloping hard rocky shores having minimal susceptibility to erosional retreat (or to storm surge flooding) within human time-scales, and also steep to cliffed hard rocky shores which may be undergoing progressive erosional retreat, and may be susceptible to ongoing rock-falls, slumping, and collapses, albeit generally at slower rates than soft-rock cliffs.

Note that hard sloping rocky intertidal zones with backshore dunes over gently to moderately sloping backshore bedrock terrain above sea level may exhibit some backshore instability in the form of dune mobility, and so are also identified as having potential backshore instability under the *Dunes* theme, but are nonetheless also identified in this *Hardrock* theme as shores which are stable in respect of marine erosion or inundation processes. This theme may also include rocky shores with minor soft-sediment beaches (with bedrock exposed) in the intertidal zone, in which case the same shores will also be included in the *Sandy*, *Coarsed* or *Undifsed* themes as bedrock-backed types. These shores have some potential for beach loss, but are not likely to be susceptible to erosional recession unless very steep to vertical in which case some cliff-line retreat is possible.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Hardrock_n* (3 digits)	**Verbal label** *Hardrock_v* (100 characters)	**Legend label** *Hardrock_l* (30 characters)	
000	Not identified as a hard rock shoreline	Not a known hard rock shore	Unclassified shore, or (generally) classified as a non-"hard rock shore" type.
100	Undifferentiated profile hard rock shore	Undif profile hard rock shore	Shores dominated by hard rock landforms in the intertidal and backshore zones, but of unknown profile. *These shores are likely to have generally minimal susceptibility to coastal erosion, but some may be potentially susceptible to progressive cliff-line*

			retreat, rock falls or slumping.
200	Hard gently to moderately sloping rocky shore	Stable hard rocky shore	Gently to moderately sloping hard rock intertidal zone backed by gently to moderately sloping hard bedrock backshore terrain (± soil). May include shore platforms or vertical faces <5m high or minor sub-ordinate colluvium; may include soft sediment beaches in the intertidal zone (in which case the same shores are also included in the *Sandy*, *Coarsed* or *Undifsed* themes as bedrock-backed types); windblown sand may mantle backshore bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme – but not intertidal zone instability). *These mostly stable shores are likely to have minimal susceptibility to coastal erosion, slumping & rock fall, or to storm surge inundation*.
300	Hard rock coastal cliffs >5m high	Hard rock coastal cliffs	Steeply sloping to vertical cliffs (>5m high) of hard lithified bedrock in the intertidal and/or backshore proximal zone. May include sub-ordinate colluvium, & may or may not be associated with a basal rocky shore platform, beach, basal talus blocks or sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is also possible – see *Dunes* stability theme). *These shores are potentially susceptible to progressive cliff-line retreat (comparatively slow compared to soft rock shores) through rock fall, slab- collapse, slumping or other forms of erosion.*

Stability Theme: **Undifferentiated Rock Shores**
Field name: *Undfrock*
***Explanation*:** Identifies shores dominated by bedrock landforms in the intertidal and backshore zones, where the bedrock type (hardness) is unknown.

On a precautionary basis it is appropriate to treat these shores as potentially less-stable soft rock landforms than more-stable hard rock landforms, however it is likely that in most cases any additional assessment of these shores will result in identification of the rock type and hence placement in either the "Soft Rock" or "Hard Rock" Shore stability themes (above).

Note that sloping rocky intertidal zones with backshore dunes over gently to moderately sloping backshore bedrock terrain above sea level may exhibit some backshore instability in the form of dune mobility, and so are also identified as having potential backshore instability under the *Dunes* theme. This theme may also include rocky shores with minor soft-sediment beaches in the intertidal zone, in which case the same shores will also be included in the *Sandy*, *Coarsed* or *Undifsed* themes as bedrock-backed types.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Undfrock_n* (3 digits)	**Verbal label** *Undfrock_v* (100 characters)	**Legend label** *Undfrock_l* (30 characters)	
000	Not identified as an undifferentiated rock shore	Not a known undif rock shore	Unclassified shore, or (generally) classified as a non-"undifferentiated rock shore" type.
100	Undifferentiated profile undifferentiated rock shore	Undif rock shore	Shores of unspecified-type bedrock in the intertidal and/or backshore proximal zone (unknown profile). *These shores are potentially susceptible to some progressive erosional recession of unspecified style, but might be a robust stable shore.*
200	Low profile undifferentiated rock shore	Low profile undif rock shore	Shores with low profile (flat to gently sloping) backshores of unspecified-type bedrock. May include vertical faces <5m high and/or sub-ordinate colluvium, & may or may not be associated with a beach, rocky shore platform or

			sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). *These shores are potentially susceptible to some progressive erosional recession with generally only small-scale slumping and block falls, but might be robust stable shores.*
300	Moderately to steeply sloping undifferentiated rock shore	Sloping undif rock shore	Moderately to steeply sloping unspecified-type rock terrain in the backshore proximal zone. May include vertical faces <5m high and/or sub-ordinate colluvium, & may or may not be associated with a basal rocky shore platform, beach, basal talus blocks or sloping rocky shore in the intertidal zone. Windblown sand may mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). *These shores are potentially susceptible to some progressive erosional recession with potentially significant mass movement including slumping or landslides, but might be largely robust stable shores.*
400	Undifferentiated rock coastal cliffs >5m high	Undif rock coastal cliffs	Very steeply sloping to vertical cliffs (>5m high) of unspecified-type bedrock in the intertidal and/or backshore proximal zone. May include sub-ordinate colluvium, & may or may not be associated with a basal rocky shore platform, beach, basal talus blocks or sloping rocky shore in the intertidal zone. Windblown sand may

			mantle backshore distal bedrock surface above sea-level (in which case backshore dune instability is possible – see *Dunes* stability theme). *These shores are potentially susceptible to progressive cliff-line retreat (which may range from comparatively rapid to very slow depending on the rock type) through rock fall, slab- collapse, slumping or other forms of erosion.*

Stability Theme: **Coral Coasts**
Field name: *Coral*
***Explanation*:** This theme identifies coasts characterised by hard actively growing biogenic carbonate structures (coralgal reefs) and derived sediments. Although coral coasts may also have (dead) coral reef structures and coral-derived sediments in the backshore zone as well as in the intertidal and sub-tidal zones, for the purposes of stability classification this theme is focussed on shores with actively forming (growing) sub-tidal to intertidal reefal structures and immediately associated structures and sediments. In contrast, other intertidal and backshore landforms of coralline origin – but not directly associated with actively growing coralline structures in the intertidal or subtidal zones - are generally classified under other stability themes. Thus, coral rubble and coral-derived sand beaches are simply classified as "Coral rubble coarse soft sediment shores" (coral rubble shingle beaches) and "Sandy Beaches", whilst lithified coral breccia shores are considered as a type of "hard rock shore" where the rock type is a "coralline limestone breccia". Similarly, intact uplifted coral reef structures which now form the backshore may be classified as "bedrock terrain" backshores where the bedrock type is "reefal coralline limestone".

A key reason for placing "dead' coralline deposits and landforms in different stability themes to "living" coral coast structures is that subtidal and intertidal living coral communities and their structures are uniquely sensitive to a range of impacts that may not impact so notably on other (non-living) carbonate rock and sediment coastal landforms, including relict (dead) coral reef structures and associated sediments. Thus, coral coasts may be subject to instabilities resulting from changes in ocean temperatures and pH causing coral death & resulting physical breakdown, in addition to the wave climate factors which mostly drive instability in other coastal types.

Because version 1 of the Australian Coastal Smartline Geomorphic and Stability Map was limited to the continental coast and major islands, but excluded the Great Barrier Reef and most atolls, this theme currently only includes undifferentiated coral communities and fringing coral reefs as distinctive classes, since these are the only classes within this theme mapped by the current Smartline version 1. However it is envisaged that further definition of additional form and fabric – defined classes within this *fabric* – defined theme will occur during future application of this mapping method to coral atolls and other coral coasts.

Stability Classes (as used in Smartline attribute table)			Definition and Stability Style
Code *Coral_n* (3 digits)	**Verbal label** *Coral_v* (100 characters)	**Legend label** *Coral_l* (30 characters)	
000	Not identified as a coral coast	Not a known coral coast	Unclassified shore, or (generally) classified as a non-"coral coast" shore type.
100	Coral communities undifferentiated	Coral communities undiff	Coral communities, reefs or structures present in the sub-tidal to intertidal zones, but details unspecified or unknown. *Potential instability with sea-level rise and ocean temperature and pH changes: - prone to coral death and break-down, leading to some (unspecified) increased supply of sediment (wave-broken coral rubble) to the intertidal and backshore zones.*
110	Minor coral communities present (undiff)	Minor coral communities	Minor or sporadic coral communities present in the sub-tidal to intertidal zones, but no major or extensive reef structures. *Potential minor instability with sea-level rise and ocean temperature and pH changes: - prone to coral death and break-down, leading to minor supply of sediment (wave-broken coral rubble) to the intertidal and backshore zones.*
120	Major coral communities present (undiff)	Major coral communities	Major or extensive coral communities, reefs or structures present in the sub-tidal to intertidal zones, but other details unspecified or unknown. *Potential major instability with sea-level rise and ocean temperature and pH changes: - prone to coral death and break-down, leading to major*

			supply of sediment (wave-broken coral rubble) to the intertidal and backshore zones.
200	Fringing coral reefs undiff	Fringing coral reefs undiff	Fringing sub-tidal to intertidal coral reefs on continental coasts frequently associated with sand in the sub-tidal and intertidal zones. *Potential instability with sea-level rise and ocean temperature and pH changes: - prone to coral death and break-down, leading to significant increased supply of sediment (wave-broken coral rubble) to the intertidal and backshore zones.*
Further classification development anticipated for use with coral atolls and other coral environments			

Stability Theme: **No Stability Classification**
Field name: *Unclass*
***Explanation*:** Identifies shores not classified into any stability classes. The most common cause of a shore not being assigned a stability classification is that key attribute fields are unclassified due to lack of the required data.

Stability Classes (as used in Smartline attribute table)			**Definition and Stability Style**
Code *Unclass_n* (3 digits)	**Verbal label** *Unclass_v* (100 characters)	**Legend label** *Unclass_l* (30 characters)	
000	Shoreline stability classified	Stability classified	Classified as stable or unstable under a stability theme.
100	Stability unclassified	Stability unclassified	Not identified under any other stability theme.

REFERENCES

ALLEN, 2005: *Climate Change Risk and Vulnerability*; Final Report to the Australian Greenhouse Office by The Allen Consulting Group, March 2005, 159pp.

ARE, F., REIMNITZ, E., GRIGORIEV, M., HUBBERTEN, H.-W., & RACHOLD, V., 2008: The Influence of Cryogenic Processes on the Erosional Arctic Shoreface; *Journal of Coastal Research*, Vol. 24(1), p. 110-121.

BARTLETT, D., DEVOY, R., McCALL, S., & O'CONNOR, I., 1997: A Dynamically Segmented Linear Data Model of the Coast; *Marine Geodesy*, Vol. 20, p. 317-151.

BRUUN, P., 1988: The Bruun Rule of erosion by sea-level rise: A discussion of large-scale two- and three-dimensional usages; *Journal of Coastal Research*, Vol. 4(4), p. 627-648.

COWELL, P.J., ROY, P.S., & JONES, R.A., 1995: Simulation of large – scale coastal change using a morphological behaviour model; *Marine Geology*, Vol. 126, p. 45-61.

GORNITZ, V.M., DANIELS, R.C., WHITE, T.W., & BIRDWELL, K.R., 1994: The Development of a Coastal Risk Assessment Database: Vulnerability to Sea Level Rise in the US Southeast; in: Finkl, C.W. Jnr., (ed), Coastal Hazards – Perception, Susceptibility and Mitigation; *Journal of Coastal Research*, The Coastal Education and Research Foundation, Florida, USA, p. 327-338.

HEMER, M.A., CHURCH, J.A., O'GRADY, J., McINNES, K., HUNTER, J.R., 2008: *Variability and Trends in the Australian Wave Climate and Consequent Coastal Vulnerability*; Report to Department of Climate Change (Canberra) by CSIRO Marine and Atmospheric Research & Antarctic Climate and Ecosystems Co-operative Research Centre (Hobart), 92pp.

HENNECKE, W.G., 2000: *GIS-Based Modelling of Potential Sea Level Rise Impacts on Coastal Re-entrants and Adjacent Shorelines*; Ph.D. Thesis, School of Geosciences, University of Sydney, 223 pp.

HENNECKE, W.G., & COWELL, P.J., 2000: GIS modelling of impacts of an accelerated rate of sea-level rise on coastal inlets and deeply embayed shorelines; *American Association of Petroleum Geology*, Special Issue on Coastal Hazards.

HILL, R., 2004: *Projections and Datums used in GAV;* Unpublished Microsoft Word Document provided by Darren Skene, Geoscience Australia, on 14th Sept 2007.

IPCC, 2001: *Climate Change 2001: The Scientific Basis. Summary for Policymakers*; A Report of Working Group I of the Intergovernmental Panel on Climate Change (a United Nations committee).

JERIE, K., 2005: *Fluvial Geomorphology of Buttongrass Moorland Landscapes of Western Tasmania*; Nature Conservation Report no. 05/06, Earth Sciences section, Department of Primary Industries, water and Environment, December 2005, 51 pp.

KAY, R. & ALDER, J., 2005: *Coastal Planning and Management: Second Edition*; Taylor & Francis, London & New York, 380 pp.

MAZENGARB, C., 2005: *The Tasmanian Landslide Hazard Map Series: Methodology*; Record 2005/04, Tasmanian Geological Survey, Mineral Resources Tasmania, Department of Infrastructure, Energy & Resources, Hobart.

McFADDEN, L., NICHOLLS, R.J., VAFEIDIS, A., & TOL, R.S.J., 2007: A methodology for modeling coastal space for global assessment; *Journal of Coastal Research*, Vol. 23(4), p. 911-920.

McGILL, J.T., 1958: Map of Coastal Landforms of the World; *Geographical Review*, Vol. 48, p. 402-405.

MOUNT, R., BRICHER, P., & NEWTON, J., 2007: *National Intertidal/Subtidal Benthic (NISB) Habitat Classification Scheme Version 0.1 October 2007*; Australian Coastal Vulnerability Project, School of Geography and Environmental Studies, University of Tasmania.

SHARPLES, C., 2000: *Tasmanian Shoreline Geomorphic Types and Oil Spill Response Types: Data Dictionary*; Report to accompany digital data set, Department of Primary Industries, Water and Environment, Tasmania.

SHARPLES, C., 2006a: *Data Dictionary for the Tasmanian Shoreline Geomorphic Types Digital Line Map Version 4.0 (2006) (Tascoastgeo_v4gda)*; Report for Department of Primary Industries & Water (Tasmania), 45 pp.

SHARPLES, C., 2006b: *Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea-Level Rise: Explanatory Report, 2nd Edition*; Consultant Report to Department of Primary Industries & Water, Tasmania, 173 pp., plus accompanying electronic (GIS) maps.

SHARPLES, C., 2007: Indicative Mapping of Tasmanian Coastal Geomorphic Vulnerability to Sea-Level rise using a GIS line Map of Coastal Geomorphic Attributes; in: Woodroffe, C.D., Bruce, E., Puotinen, M. & Furness, R.A.,(eds), *GIS for the Coastal Zone: A Selection of Papers from CoastGIS 2006*; Wollongong Paper on Maritime Policy No. 16, University of Wollongong, p. 235 – 247.

SHARPLES, C., 2009: *A Coastal Landform Stability Classification for the Australian Coastal Smartline Geomorphic and Stability Map*; A report to Geoscience Australia and the Department of Climate Change, Canberra, by School of Geography & Environmental Studies, University of Tasmania.

SHARPLES, C., MOUNT, R.E., PEDERSEN, T.K., LACEY, M.J., NEWTON, J.B., JASKIERNIAK, D., & WALLACE, L.O., 2009: *The Australian Coastal Smartline Geomorphic and Stability Map Version 1: Project Report*; A report to Geoscience Australia and the Department of Climate Change, Canberra, by School of Geography & Environmental Studies, University of Tasmania.

SOUTBERG, T.L., 1990: *Towards a Descriptive Geomorphic Classification System for Nature Conservation Purposes*; Occasional Paper No. 23, Department of Parks, Wildlife and Heritage, Hobart, Tasmania, 30 pp. plus appendices.

SHORT, A.D., 2006: Australian Beach Systems – Nature and Distribution: *Journal of Coastal Research*, Vol. 22(1), p. 11-27.

TORRESAN, S., CRITTO, A., DALLA VALLE, M., HARVEY, N., & MARCOMINI, A., 2008: Assessing coastal vulnerability to climate change: comparing segmentation at global and regional scales; *Sustainability Science*, Vol. 3 (1), p. 45-65.

TRAVERS, A., 2007: Low-energy beach morphology with respect to physical setting: A case study from Cockburn Sound, southwestern Australia; *Journal of Coastal Research*, Vol. 23 (2), p. 429-444.

VOICE, M., HARVEY, N., & WALSH, K., (Eds), 2006: *Vulnerability to Climate Change of Australia's Coastal Zone: Analysis of gaps in methods, data and system thresholds*; Report to the Australian Greenhouse Office, Canberra, June 2006, 115 pp.

WARDROP, J.A., & BALL, D., 2000: *A Recommended System for the Classification of Shorelines for the Australian Oil Spill Response Atlas*; Wardrop Consulting & Marine and Freshwater Resources Institute, Victoria, March 2000, 27 pp. plus appendices.

This page intentionally blank.

APPENDIX ONE: TABLE OF DATA SOURCES USED IN SMARTLINE V.1

This Appendix provides details of all data sources used in the compilation of the Smartline version 1.0. The 'Reference_ID' number is the source Reference ID number (_r) used to identify each source in the Smartline attribute tables (see Data Model in Section 6.2). This information is also provided with Smartline shapefiles as an Excel spreadsheet capable of being linked directly to the Smartline attribute tables using 'Reference_ID' as the common field.

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
1	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7768_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Lakefield map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
2	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7868_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Jeannie River map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
3	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7869_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cape Melville map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
4	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7964_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Rumula map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
5	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7965_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Mossman map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
6	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7966_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Helenvale map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
7	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7967_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cooktown map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
8	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	7968_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cape Flattery map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
9	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8061_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Kirrama map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
10	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8062_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Tully map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
11	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8063_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Bartle Frere map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
12	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8064_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cairns map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
13	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8159_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Rollingstone map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
14	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8160_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Ingham map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
15	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8161_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cardwell map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
16	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8162_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Innisfail map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
17	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8163_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cooper Point map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
18	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8259_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Townsville map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
19	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8260_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Palm Islands map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
21	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8753_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Connors Range map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
22	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8754_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Carmila map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
23	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8755_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Mackay map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
24	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8852_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Marlborough map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
25	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8853_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Saint Lawrence map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
26	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8952_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Princhester map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
27	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	8953_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Shoalwater map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
28	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9050_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Bajool map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
29	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9051_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Rockhampton map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
30	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9052_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Bayfield map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
31	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9053_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Peninsula Range map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
32	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9149_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Calliope map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
33	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9150_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Gladstone map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
34	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9151_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cape Capricorn map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
35	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9249_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Miriam Vale map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
36	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9250_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Rodds Bay map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
37	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9347_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Childers map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
38	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9348_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Bundaberg map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
39	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9349_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Mitchell Creek map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
41	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9446_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Maryborough map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
42	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9447_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Pialba map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
43	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9541_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Murwillumbah map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
44	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9542_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Beenleigh map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
45	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9543_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Brisbane map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
46	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9544_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Caloundra map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
47	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9545_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Laguna Bay map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
48	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9546_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Wide Bay map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
49	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9547_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Happy Valley map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
50	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- 1:100 000 SHEET AREAS- MARCH 2007	1:100 000	Vector - Polygon	9548_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Waddy Point map sheet. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
51	Geology of the Ayr	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003168	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
52	Geology of the Burketown	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003154	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
53	Geology of the Galbraith	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003152	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
54	Geology of the Mornington	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003150	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
55	Geology of the Normanton	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003155	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
57	Geology of the Westmoreland	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003153	QLD	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
58	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	boba_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Bowen Basin. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
59	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	caka_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Carpenteria Karumba Basins. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
60	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	cype_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Cape York Peninsula. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
61	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	hopr_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Hodgkinson Province. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
63	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	quee_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Queensland Geology. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
64	QUEENSLAND GEOLOGICAL MAPPING (Polygonised vector) Data- REGIONAL - MARCH 2007	1:500 000	Vector - Polygon	tost_r.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Employment, Economic Development and Innovation - Queensland Mines and Energy	Torres Strait. Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
65	Geology of the Cambridge Gulf	1:250 000	Vector - Polygon	geolp.shp	ESRI shapefile	ANZCW0703003147	WA	Australian Government: Geoscience Australia	Bedrock and some landform data extracted.	Quaternary sediments plus bedrock mapping
67	1:50 000 environmental map - ALBANY (2427-I, 2428-II, 2527-IV, 2528-III)	1:50 000	Vector - Polygon	m24271gp.shp	ESRI shapefile	ANZWA1220000165	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes extracted.	Depicts Quaternary deposits plus exposed bedrock
68	1:50 000 environmental map - BROOME_ROEBUCK PLAINS (3362 II and PT 3362 III and 3361 IV)	1:50 000	Vector - Polygon	m33622gp.shp	ESRI shapefile	ANZWA1220000424	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
69	1:50 000 urban map - Bunbury - Burekup (2031-III, 2031-II)	1:50 000	Vector - Polygon	m20313gp.shp	ESRI shapefile	ANZWA1220000183	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
70	1:50 000 environmental map - BUSSELTON (1930-I)	1:50 000	Vector - Polygon	m19301gp.shp	ESRI shapefile	ANZWA1220000185	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
71	1:50 000 environmental map - FREMANTLE (2033-I, 2033-IV)	1:50 000	Vector - Polygon	m20334gp.shp	ESRI shapefile	ANZWA1220000171	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
72	1:50 000 environmental map - LAKE CLIFTON - HAMEL (2032-II, 2032-III)	1:50 000	Vector - Polygon	m20322gp.shp	ESRI shapefile	ANZWA1220000182	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
73	1:50 000 urban map - Harvey - Lake Preston (2031-I, 2031-IV)	1:50 000	Vector - Polygon	m20311gp.shp	ESRI shapefile	ANZWA1220000187	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
74	1:50 000 urban map - Mandurah (2032-IV)	1:50 000	Vector - Polygon	m20324gp.shp	ESRI shapefile	ANZWA1220000188	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
75	1:50 000 urban map - Moore River - Cape Leschenault (1935-II, 2035-III)	1:50 000	Vector - Polygon	m20353gp.shp	ESRI shapefile	ANZWA1220000189	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
77	1:50 000 environmental map - PERTH (2034-II, 2034-III, 2134-III)	1:50 000	Vector - Polygon	m20342gp.shp	ESRI shapefile	ANZWA1220000175	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
78	1:50 000 urban map - Pinjarra (2032-I)	1:50 000	Vector - Polygon	m20321gp.shp	ESRI shapefile	ANZWA1220000190	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
79	1:50 000 environmental map - ROCKINGHAM (2033-II, 2033-III)	1:50 000	Vector - Polygon	m20333gp.shp	ESRI shapefile	ANZWA1220000176	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
80	1:50 000 environmental map - ROTTNEST ISLAND (1934-II, 2034-III, 1933-I, 2033-IV)	1:50 000	Vector - Polygon	m19331gp.shp	ESRI shapefile	ANZWA1220000177	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
81	1:50 000 environmental map - TORBAY (2427-IV, 2428-III)	1:50 000	Vector - Polygon	m24274gp.shp	ESRI shapefile	ANZWA1220000179	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
82	1:50 000 environmental map - YALLINGUP (1930-IV, 1830-I)	1:50 000	Vector - Polygon	m19304gp.shp	ESRI shapefile	ANZWA1220000180	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
83	1:50 000 environmental map - YANCHEP (2034-IV)	1:50 000	Vector - Polygon	m20344gp.shp	ESRI shapefile	ANZWA1220000181	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
84	1:100 000 geological map - ARROWSMITH-BEAGLE ISLANDS (1938), first edition	1:100 000	Vector - Polygon	m1938_gp.shp	ESRI shapefile	ANZWA1220000003	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
85	1:100 000 geological map - COCANARUP (2830), first edition	1:100 000	Vector - Polygon	m2830_gp.shp	ESRI shapefile	ANZWA1220000015	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
86	1:100 000 geological map - DAMPIER (2256), first edition	1:100 000	Vector - Polygon	m2256_gp.shp	ESRI shapefile	ANZWA1220000005	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
87	1:100 000 geological map - DE GREY (2757), first edition - version 2	1:100 000	Vector - Polygon	m2757_gp.shp	ESRI shapefile	ANZWA1220000673	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
88	1:100 000 geological map - HILL RIVER-GREEN HEAD (1937 and 1938), first edition	1:100 000	Vector - Polygon	m1937_gp.shp	ESRI shapefile	ANZWA1220000002	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
89	1:100 000 geological map - MINGENEW-DONGARA (1939 and part 1839), first edition	1:100 000	Vector - Polygon	m1939_gp.shp	ESRI shapefile	ANZWA1220000004	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
90	1:100 000 geological map - PARDOO (2857), first edition - version 2	1:100 000	Vector - Polygon	m2857_gp.shp	ESRI shapefile	ANZWA1220000672	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
91	1:100 000 geological map - PRESTON (2156), first edition	1:100 000	Vector - Polygon	m2156_gp.shp	ESRI shapefile	ANZWA1220000110	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
92	1:100 000 geological map - RAVENSTHORPE (2930), first edition	1:100 000	Vector - Polygon	m2930_gp.shp	ESRI shapefile	ANZWA1220000020	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes extracted.	Depicts Quaternary deposits plus exposed bedrock
93	1:100 000 geological map - ROEBOURNE (2356), first edition	1:100 000	Vector - Polygon	m2356_gp.shp	ESRI shapefile	ANZWA1220000078	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
94	1:100 000 geological map - SHERLOCK (2456), first edition	1:100 000	Vector - Polygon	m2456_gp.shp	ESRI shapefile	ANZWA1220000008	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
95	1:100 000 geological map - WEDGE ISLAND (1936), first edition	1:100 000	Vector - Polygon	m1936_gp.shp	ESRI shapefile	ANZWA1220000001	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts Quaternary deposits plus exposed bedrock
96	1:250 000 geological map - BALLADONIA (SI51-03), first edition	1:250 000	Vector - Polygon	mi5103gp.shp	ESRI shapefile	ANZWA1220000126	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
97	1:250 000 geological map - BUSSELTON-AUGUSTA (part SI50-05 and part SI50-09), first edition	1:250 000	Vector - Polygon	mi5005gp.shp	ESRI shapefile	ANZWA1220000131	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
98	1:250 000 geological map - DAMPIER_BARROW ISLAND (SF50-02 & PT SF50-01), second edition	1:250 000	Vector - Polygon	mf5002gp.shp	ESRI shapefile	ANZWA1220000453	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
99	1:250 000 geological map - PERTH (SH50-14 and part SH50-13), first edition	1:250 000	Vector - Polygon	mh5014gp.shp	ESRI shapefile	ANZWA1220000130	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
100	1:250 000 geological map - ROEBOURNE (SF50-03), second edition	1:250 000	Vector - Polygon	mf5003gp.shp	ESRI shapefile	ANZWA1220000096	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
101	1:250 000 geological map - WINNING POOL - MINILYA (SF50-13 and part SF49-16), second edition	1:250 000	Vector - Polygon	mf5013gp.shp	ESRI shapefile	ANZWA1220000129	WA	Government of Western Australia: Department of Mines and Petroleum	Landform attributes and some bedrock data extracted.	Depicts (some) Quaternary deposits plus bedrock
102	1:500 000 Interpreted bedrock geology of Western Australia	1:500 000	Vector - Polygon	Geology_500K.shp	ESRI shapefile	ANZWA1220000374	WA	Government of Western Australia: Department of Mines and Petroleum	Used for automated extraction of bedrock data in areas covered by Quaternary sediments or not available as better scale vector GIS geology maps; parts of bedrock data originally extracted in this way were subsequently manually replaced by attributes indicating hard surface Quaternary calcarenite as bedrock where this covers the basement bedrock.	Depicts pre-Quaternary bedrock only; omits overlying Quaternary calcarenites which are regarded as hard bedrock for the purposes of this mapping project. Manual interpretation of calcarenite extent (from other Quaternary mapping) has in places been used to 'over-ride' bedrock interpretation from this dataset where appropriate.

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
103	Extractive Geology of the Outer Darwin Area 1:100K Geological Dataset in MapInfo Format	1:100 000	Vector - Polygon	DwnExtract_GeolUnitPoly_R_100	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources		
104	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	C5215GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Bathurst Island 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
105	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5203GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Fog Bay 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
106	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5207GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Cape Scott 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
107	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5211GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Port Keats 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
108	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	C5216GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Melville Island 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
109	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	C5313GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Cobourg Peninsula 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
110	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5301GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Alligator River 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
111	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	C5315GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Wessel Islands 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
112	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5311GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Roper River 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
113	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	C5316GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Truant Island 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
114	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5304GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Gove 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
115	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5308GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Port Langdon 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
116	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5312GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Cape Beatrice 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
117	NTData (Digital Geology of the Northern Territory)	1:250 000	Vector - Polygon	D5316GEO.E00	ESRI Arc interchange format	ANZNT0001000070	NT	Australian Government: Geoscience Australia	Pellew 250K Map Sheet. Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
119	Arnhem Bay 250K Geology	1:250 000	Vector - Polygon	AB_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
120	Auvergne 250K Geology	1:250 000	Vector - Polygon	AU_LithOutcrop_250K	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
121	Blue Mud Bay 250K Geology	1:250 000	Vector - Polygon	BM_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
122	Darwin 250K Geology	1:250 000	Vector - Polygon	DW_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
123	Milingimbi 250K Geology	1:250 000	Vector - Polygon	Milin_Geology_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
124	Mount Young 250K Geology	1:250 000	Vector - Polygon	MY_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
125	Urapunga and Roper River 250K Geology	1:250 000	Vector - Polygon	UR_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
126	Robinson River 250K Geology	1:250 000	Vector - Polygon	RR_GeolUnitPolygon_R_250	MapInfo	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	Depicts (some) Quaternary deposits plus bedrock
127	Metallogenic Series - Gosford-Lake Macquarie 1:100 000 9131 & 9231 Provisional	1:100 000	Vector - Polygon	Provisional_Gosford_Lake_Macquarie_100K_MGAz56.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used for landform mapping in central coast gap not covered by CCA Quaternary & landform mapping (Reference_ID's 166 & 167)	Quaternary sediments plus bedrock mapping
128	Newcastle Coalfield Regional Geology 1:100,000 geological map	1:100 000	Vector - Polygon	NewcastleCF100rockunit_MGAz56.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used for landform mapping in central coast gap not covered by CCA Quaternary & landform mapping (Reference_ID's 166 & 167)	Quaternary sediments plus bedrock mapping

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
129	Port Hacking 1:100,000 geological map	1:100 000	Vector - Polygon	PortHacking100RockUnit_MGAz56.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used for landform mapping in central coast gap not covered by CCA Quaternary & landform mapping (Reference_ID's 166 & 167)	Quaternary sediments plus bedrock mapping
130	Sydney 1:100 000 Geological Series Sheet 9130 (Edition 1) 1983	1:100 000	Vector - Polygon	Sydney100Surficial_MGAz56.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used for landform mapping in central coast gap not covered by CCA Quaternary & landform mapping (Reference_ID's 166 & 167)	Quaternary sediments plus bedrock mapping
131	Wollongong 1:100,000 geological map	1:100 000	Vector - Polygon	Wollongong100RockUnit_MGAz56.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used for landform mapping in central coast gap not covered by CCA Quaternary & landform mapping (Reference_ID's 166 & 167)	Quaternary sediments plus bedrock mapping
133	NSW Statewide Geological Database - NSW Attribute Data Set contains Southern CRA, Upper NE, Lower NE, Bohena, Sydney, Central & standard geological mapping datasets	1:250 000	Vector - Polygon	Bedrock_250K_Geology_GCS94.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used to attribute Geology (bedrock) attributes for NSW	Bedrock units only (Quaternary omitted, bedrock beneath Quaternary inferred or left blank)
136	Botany Bay Foreshores	Unknown	Vector - Polygon	botanybayshoreline.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Maritime	OSRA Shoreline Types dataset	Intertidal landform types (including artificial shore types) for Botany Bay shoreline.
137	Sydney Harbour Boulderfields	1:5 000	Vector - Polygon	BoulderFields.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Maritime	OSRA Shoreline Types dataset; metadata was of limited assistance for differentiating artificial and natural shoreline 'boulder fields', hence some mis-interpretation may have occurred.	Intertidal, subtidal and backshore "boulder" landforms in Sydney Harbour estuary only, apparently includes artificial revetments or 'rip-rap', some natural rocky shores, some residual boulders associated with sandy and muddy shores. Mapped for primarily habitat rather than landform classification purposes.
138	Shoreline Type (Extreme)	1:100 000	Vector - Polygon	shoreline-coast-extreme-geo.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Maritime	OSRA Shoreline Types dataset	Intertidal landform types (including artificial shore types) for open coast shore from Botany Bay north to Arakoon (60 km north of Port Macquarie) ; minor backshore and subtidal landform information.
139	Shoreline Type (Extreme) (Estuary)	1:100 000	Vector - Polygon	shoreline-estuary-extreme-geo.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Maritime	OSRA Shoreline Types dataset	Intertidal landform types (including artificial shore types) for parts of several estuaries north of Sydney Harbour; minor backshore and subtidal landform information.
140	Sydney Harbour Foreshores	1:5 000	Vector - Polygon	sydneyshoreline.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Maritime	OSRA Shoreline Types dataset	Intertidal landform types (including artificial shore types) for Sydney Harbour estuary; minor backshore and subtidal landform information.
141	Junction Bay, Northern Territory (1:250 000 Geological Series Sheet SC 53-14)	1:250 000	Raster - Image (non-georeferenced)	junction.ecw	ERMapper Enhanced Compression Wavelet	N/A	NT	Northern Territory Government: Department of Regional Development, Primary Industry, Fisheries and Resources	Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping
142	Regolith–landform resources of the Cowaramup–Mentelle 1:50 000 sheet	1:50 000	Vector - Polygon	regolith.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Mines and Petroleum	Detailed bedrock & backshore, intertidal and subtidal landform attributes extracted.	Detailed landforms, Quaternary sediment and exposed bedrock mapping, terrestrial and subtidal areas.
143	Regolith–landform resources of the Geraldton 1:50 000 sheet	1:50 000	Vector - Polygon	regolith.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Mines and Petroleum	Detailed bedrock & backshore, intertidal and subtidal landform attributes extracted.	Detailed landforms, Quaternary sediment and exposed bedrock mapping, terrestrial and subtidal areas.
144	Record 2002/10 - Regolith-Landform Resources of the Karridale-Tooker and Leeuwin 1:50 000 Data Package	1:50 000	Vector - Polygon	regolith.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Mines and Petroleum	Detailed bedrock & backshore, intertidal and subtidal landform attributes extracted.	Detailed landforms, Quaternary sediment and exposed bedrock mapping, terrestrial and subtidal areas.
145	Geological rock types and rock type lines (1:100,000) (GEOL100)	1:100 000	Vector - Polygon	geol100_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002487	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Bairnsdale_(SJ55-07)_and_Sale_(SJ55-11). Bedrock & some landform attributes extracted.	Quaternary sediments plus bedrock mapping
146	Geological rock types and rock type lines (1:100,000) (GEOL100)	1:100 000	Vector - Polygon	geol100_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002487	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Mallacoota_(SJ55-08). Bedrock & some landform attributes extracted.	Quaternary sediments plus bedrock mapping
147	Geological rock types and rock type lines (1:100,000) (GEOL100)	1:100 000	Vector - Polygon	geol100_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002487	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Portland_(SJ54-11)_and_Colac_(SJ54-12). Bedrock & some landform attributes extracted.	Quaternary sediments plus bedrock mapping
148	Geological polygons and lines (1:250,000) (GEOL250)	1:250 000	Vector - Polygon	geol250_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002488	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Bairnsdale_(SJ55-07)_and_Sale_(SJ55-11). Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping
149	Geological polygons and lines (1:250,000) (GEOL250)	1:250 000	Vector - Polygon	geol250_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002488	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Mallacoota_(SJ55-08). Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping
150	Geological polygons and lines (1:250,000) (GEOL250)	1:250 000	Vector - Polygon	geol250_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002488	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Portland_(SJ54-11)_and_Colac_(SJ54-12). Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping
151	Geological polygons and lines (1:250,000) (GEOL250)	1:250 000	Vector - Polygon	geol250_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002488	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Melbourne_(SJ55-05)_and_Queenscliff_(SJ55-09). Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping
152	Geological polygons and lines (1:250,000) (GEOL250)	1:250 000	Vector - Polygon	geol250_polygon_geo_gda94.shp	ESRI shapefile	ANZVI0803002488	VIC	Victorian Government: Department of Primary Industries - GeoScience Victoria	Warragul_(SJ55-10). Bedrock & some landform attributes extracted.	(Some) Quaternary sediments plus bedrock mapping

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
153	Coastal shoreline types and habitats for the Victoria coast	1:25 000 to 1:100 000	Vector - Polygon	V_BUFF_CST.SHP	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline Types dataset; used to extract some Backshore landform, Intertidal landform, Subtidal landform, exposure and geology attributes.	Coarse coastal polygons delineating Backshore, Intertidal and Subtidal landforms, with some information on exposure and geology (where calcarenite present). Cover whole of Victorian coast including some inlets and estuaries.
154	Coastal shoreline types and habitats mapped as part of the Coastal Resource Atlas program for Victoria (1990-98)	1:25 000 to 1:50 000	Vector - Polygon	V_SHORE12_G.shp	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline Types dataset; used to extract Backshore, Intertidal and Subtidal landform information for the area covered, also Intertidal slope and exposure information.	Detailed polygons interpreted from aerial photography, delineating Backshore, Intertidal and Subtidal landforms, intertidal slope, exposure to wave energy, shoreline substrate type and shoreline form categories. Covers Cape Otway to Cape Liptrap including Port Phillip and Westernport Bays, and Corner Inlet / Nooramunga coastal sections. Some positional inaccuracies may be present due to transfer of information from non-orthorectified aerial photography.
155	Coastal Classification	1:25 000	Vector - Line	coast25_dd94.shp	ESRI shapefile	ANZVI0803002019	VIC	Victorian Government: Department of Primary Industries	Base map for westernmost 3km of Victorian Smartline (see also Reference_ID 205). Also used to extract data on Intertidal landform types where no better data available.	Line represents Mean High Water Mark. Attributed with simple intertidal landform classification (rocky vs sandy shores). Covers whole of Victorian open coast, excluding inlets and estuaries.
156	Marine Substrata Classifications (SUBSTRATA100/)	Scale uncertain, likely 1:100 000	Vector - Polygon	substrata4g.shp	ESRI shapefile	ANZVI0803002001	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline Types dataset; used to extract subtidal landform and some geology attribute data.	Moderately detailed polygons delineating marine (i.e., subtidal) substrates & habitat types (bedrock, coarse or fine sediment, reefs). Data derived from interpretation of LANDSAT 5 satellite imagery. Dataset covers whole open coast of Victoria but not inlets and estuaries.
157	Geology 100k - Detailed Surface Geology (polygon features)	1:100 000	Vector - Polygon	gl100k_poly.shp	ESRI shapefile	ANZSA1002000004	SA	Government of South Australia: Primary Industries and Resources SA	Some bedrock & landform attributes extracted.	Quaternary sediments plus bedrock mapping
165	Andy Short's Google Earth beach locations	N/A	Vector - Point	Western Australia.kmz	Google Earth KMZ	N/A	National	Professor Andy Short, University of Sydney	Used as a guide for manual attribution of ABSAMP_ID attribute field.	Beach centre point locations
166	Comprehensive Coastal Assessment Coastal Quaternary Geology	1:25 000	Vector - Polygon	NCCA_quaternary_unit1_polygons.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used to map intertidal & backshore Quaternary sediment landforms; absence of mapped Quaternary sediment in this dataset inferred to indicate bedrock terrain ± soil (such inferences cited as Source_ID 237 – see below)	Detailed mapping of Quaternary sediments, from south of Wollongong to Vic border.
167	Comprehensive Coastal Assessment Coastal Quaternary Geology	1:25 000	Vector - Polygon	SCCA_quaternary_unit1_polygons.shp	ESRI shapefile	N/A	NSW	New South Wales Government: NSW Department of Primary Industries	Used to map intertidal & backshore Quaternary sediment landforms; absence of mapped Quaternary sediment in this dataset inferred to indicate bedrock terrain ± soil (such inferences cited as Source_ID 237 – see below)	Detailed mapping of Quaternary sediments, from south of Wollongong to Vic border.
169	Geomorphology Landform of Darwin Harbour	1:25 000	Vector - Polygon	darland_g94.shp	ESRI shapefile	ANZNT0001000157	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	OSRA Shoreline Types dataset	Delineates Backshore, intertidal & some subtidal landforms in Darwin Harbour region.
171	OSRA Shoreline Types, NT	1:250 000	Vector - Line	cliffs_g94.shp	ESRI shapefile	ANZNT0001000264	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	OSRA Shoreline Types dataset; Large gaps in dataset.	Delineates some Intertidal and backshore landform types, exposure and intertidal slope data, for Darwin regional coast, Bathurst & Melville Islands, NE Arnhem Land – Wessel Islands – Gove Peninsula, Bickerton Island, Groote Eylandt & Sir Edward Pellew Group islands – McArthur river mouth region.
172	OSRA Shoreline Types, NT	1:250 000	Vector - Polygon	shore_type_g94	ESRI shapefile	ANZNT0001000264	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	OSRA Shoreline Types dataset; Large gaps in dataset.	Delineates some Intertidal and backshore landform types, exposure and intertidal slope data, for Darwin regional coast, Bathurst & Melville Islands, NE Arnhem Land – Wessel Islands – Gove Peninsula, Bickerton Island, Groote Eylandt & Sir Edward Pellew Group islands – McArthur river mouth region.
173	Northern Territory Land Units Surveys Dataset	1:250 000	Vector - Polygon	North_NT_94.shp	ESRI shapefile	ANZNT0903000054	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
174	Northern Territory Land Units Surveys Dataset	1:1 000 000	Vector - Polygon	South_NT_94.shp	ESRI shapefile	ANZNT0903000054	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Received a clipped version of this dataset, called "LS_Sth_Clip.shp". Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
175	Land Resources of the Lower Finnis, Northern Territory	1:25 000	Vector - Polygon	dunde_25.shp	ESRI shapefile	ANZNT0782000010	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
176	Land Resources of the Greater Darwin Area, Northern Territory	1:25 000	Vector - Polygon	gtrdw_25.shp	ESRI shapefile	ANZNT0001000223	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
177	Land Resources of the Adelaide - Mary River Floodplain, Northern Territory	1:50 000	Vector - Polygon	plain_50.shp	ESRI shapefile	ANZNT0903000029	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
178	Land Resources of Point Stuart Station, Northern Territory	1:50 000	Vector - Polygon	ptstu_50.shp	ESRI shapefile	ANZNT0782000104	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
179	Land Resources of Tiwi Islands Land Capability Study, Northern Territory	1:100 000	Vector - Polygon	tilcs_100.shp	ESRI shapefile	ANZNT0782000098	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
180	Land Resources of Wagait Aboriginal Reserve, Northern Territory	1:50 000	Vector - Polygon	war_50.shp	ESRI shapefile	ANZNT0903000030	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Landform types information extracted for Smartline	Maps units based on landform, vegetation and other attributes.
182	Coastal Shoreline Classification	1:10 000, 1:20 000, 1:40 000, 1:50 000	Vector - Line	SA_ShorelineClassificationRealigned_Nov2007.mdb	ESRI Personal Geodatabase	N/A	SA	Government of South Australia: Department for Environment and Heritage	Smartline base map for SA. OSRA Shoreline types mapping with additional data.	Detailed line-format mapping of coastal landform types and bedrock geology for whole SA coast plus Kangaroo Island & other major islands.
183	Tasmanian Shoreline Geomorphic Types Digital Line Map Version 4.0 (2006)	1:25 000	Vector - Line	tascoastgeo_v4gda.shp	ESRI shapefile	ANZTA0015000054	TAS	Tasmanian Government: Department of Primary Industries, Parks, Water and Environment - Land Conservation Branch	OSRA Shoreline types mapping with additional data. However note that much of the data compiled in this map is referenced according to original data sources rather than to this compilation.	Detailed line-format mapping of coastal landforms and other attributes including bedrock geology. This map and its Data Model was the immediate precursor of the national Australian Smartline map.
184	LIST Hydline Digital Topographic Series	1:5 000 to 1:25 000	Vector - Line	coastline.shp	ESRI shapefile	ANZTA0005000138	TAS	Tasmanian Government: Department of Primary Industries, Parks, Water and Environment - Information and Land Services Division	Smartline base map for TAS	Line representing Mean High Water Mark.
192	1.2.5 Flood Tide WA	1:100 000 to 1:250 000	Vector - Line	tidalflat.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping	Line delineating occurrence of WA tidal channels & flats (sediment grainsize unspecified) from Shark Bay northwards. Not a comprehensive representation of all tidal flats in that region.
193	2.1.23 Breakwater WA	1:100 000 to 1:250 000	Vector - Line	bwater.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping	Delineates several artificial breakwater structures from Garden island north to Jurien only. Not a complete representation of all breakwaters in that coastal region.
194	2.1.01 Cliffs of WA	1:100 000 to 1:250 000	Vector - Line	cliffs.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping	Delineates several major coastal cliff complexes, including the Kimberley, Zuytdorp and Baxter Cliffs. Not a complete representation of cliffs on WA coast, however (e.g., omits sea cliffs in Albany region)
195	2.1.03 Sand Beach of WA (Linear representation)	1:100 000 to 1:250 000	Vector - Line	sandy.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping	Delineates some but not all WA intertidal sandy shores including beaches, from SA to NT borders. Several major gaps in the coverage include Busselton to Perth region & Geraldton region. Note that some "sand beaches" mapped in this dataset do not correspond with ABSAMP Database beaches and also some are in locations likely to be only mudflats (e.g., a long stretch of the Derby area coast at the head of King Sound). These have been incorporated into the Smartline but require future checking.
196	TOPO101: Coasttyp- WA coastline beach type large scale	1:100 000 to 1:250 000	Vector - Line	shorelin.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping; Two attributes found only in this dataset ("headland/sandy beach" & "waterways") were not used in the Smartline. "Headland / sandy beach" was not used because it simply merges beaches and rocky shores into a single attribute. However these have very different sensitivities to wave erosion and hence need to be depicted separately by the Smartline. For some of the coasts concerned, equivalent data has been obtained from other sources, however in some regions such as parts of the Kimberley, the affected shores unfortunately remain unclassified.	Delineates intertidal and some backshore landform types along much of the WA coast apart from large gaps around Geraldton and Perth – Busselton. Partly a combination of the rock.shp (Source 199), cliffs.shp (194), sandy.shp (195), tidalflat.shp (192), bwater.shp (193) & saltm.shp (202) OSRA layers for WA, but includes additional data (esp. "waterways" and the merged shoreline type "headland / sandy beach") in a number of areas (e.g., south coast, Kimberley).

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
198	2.1.10 (0.5m) Resolution Shoreline classification (Linear representation)	1:100 000, 1:250 000	Vector - Line	washoreline.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping; Some attributes partly duplicate information in Source 196 (shoreline.shp) - for example some 'cliffs' are depicted in both datasets - however washoreline.shp includes significant landform information additional to that in shoreline.shp and its constituent files.	Delineates mainly intertidal landform types along much of the WA coast between Port Hedland and Esperance, plus a small area near Broome. However, does not include Great Australian Bight, Eighty Mile Beach or the Kimberley shores.
199	2.2.1 Exposed rocky shores WA	1:100 000 to 1:250 000	Vector - Line	rock.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping; All rocky shores delineated in this dataset are attributed as "Beachrock", however this appears misleading. Many are certainly hard bedrock, including calcarenite. Some may be true beachrock, but this is unclear given the above. The metadata does not assist with this issue, hence in compiling the Smartline all "Beachrock" shores delineated in this dataset were assumed to be simply bedrock shores.	Delineates many rocky (non-cliffed) shores throughout WA coastline, but includes many gaps in the data coverage. Although the dataset name describes it as "exposed" rocky shores, some are actually sheltered (e.g., in Shark Bay), hence this dataset has not been used to attribute the Smartline "Exposure" attribute.
201	2.1.18 Mudflats WA	1:100 000, 1:250 000	Vector - Polygon	mudflats.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping	Identifies significant supratidal mudflats (saline flats) and intertidal mudflats between Shark Bay and the Kimberley to Bonaparte Gulf, interpreted from satellite imagery.
202	2.1.17 Saltmarshes WA	1:100 000	Vector - Polygon	saltm.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Transport	OSRA Shoreline types mapping; Used to infer backshore (supratidal) marshy saline sediment flats in the Smartline.	Very restricted data-set, delineates 3 salt-marshes on Northwest Cape (Ningaloo region) only.
204	Mosaic of SRTM DEM Version 2	3 Arc Second grid	Raster - DEM	aust_srtm_geodetic.ers	ERMapper Raster Dataset	N/A	National	Australian Government: Geoscience Australia - Australian Centre for Remote Sensing	Best resolution elevation mapping available for entire Australian coast at a single uniform scale, used to derive Backshore Profile attribute consistently for entire coast (coarse scale suited the need to 'generalise' the backshore topography for this attribute).	Space Shuttle Radar Mission Digital Elevation Model, covering entire Australian continent. Mosaic of Australian tiles at 3 arc second resolution produced by Australian Centre for Remote Sensing (ACRES).
205	Victorian coastline and borders at 1:25:000 scale (VIC25_ARC/VIC25ARC)	1:25 000	Vector - Line	vcst25g_a.shp	ESRI shapefile	ANZVI0803002866	VIC	Victorian Government: Department of Sustainability and Environment	Smartline base map for Victoria, except westernmost 3 km (see Reference_ID 155)	Inferred to represent Mean High Water Mark
206	Coastal shoreline types in Shallow Inlet	1:25 000	Vector - Polygon	shal_inlet_g.shp	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline types mapping; Used to extract Backshore, Intertidal and Subtidal landform information for the area covered, also Intertidal slope and exposure information.	Detailed polygons interpreted from aerial photography, delineating Backshore, Intertidal and Subtidal landforms, intertidal slope, exposure to wave energy, shoreline substrate type and shoreline form categories. Covers estuarine shores plus a few km of open coast at Shallow Inlet, west of Wilsons Promontory, Victoria. Some positional inaccuracies may be present due to transfer of information from non-orthorectified aerial photography.
207	Coastal shoreline types in Lakes Entrance region and eastern Gippsland Lakes	1:25 000	Vector - Polygon	gl_shore_g.shp	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline types mapping; Used to extract Backshore, Intertidal and Subtidal landform information for the open coast area covered, also Intertidal slope and exposure information. Data for Gippsland Lakes could not be used in the Smartline, which did not have a base map for Gippsland Lakes. This data is intended to be added in future.	Detailed polygons interpreted from aerial photography, delineating Backshore, Intertidal and Subtidal landforms, intertidal slope, exposure to wave energy, shoreline substrate type and shoreline form categories. Covers approx 20 km of open coast around Lakes Entrance (eastern Victoria), plus parts of the Gippsland Lakes tidal lagoon shores. Some positional inaccuracies may be present due to transfer of information from non-orthorectified aerial photography.
208	Coastal shoreline types in Mallacoota Inlet	1:25 000	Vector - Polygon	mal_inlet_g.shp	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline types mapping; Used to extract Backshore, Intertidal and Subtidal landform information for the area covered, also Intertidal slope and exposure information.	Detailed polygons interpreted from aerial photography, delineating Backshore, Intertidal and Subtidal landforms, intertidal slope, exposure to wave energy, shoreline substrate type and shoreline form categories. Covers approx. 5km of open coast, plus estuarine shores, at Mallacoota Inlet, eastern Victoria. Some positional inaccuracies may be present due to transfer of information from non-orthorectified aerial photography.

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
209	Coastal shoreline types in Portland Harbour and its surrounds	1:25 000	Vector - Polygon	portland2_g.shp	ESRI shapefile	N/A	VIC	Victorian Government: Department of Primary Industries	OSRA Shoreline types mapping; Used to extract Backshore, Intertidal and Subtidal landform information for the area covered, also Intertidal slope and exposure information	Detailed polygons interpreted from aerial photography, delineating Backshore, Intertidal and Subtidal landforms, intertidal slope, exposure to wave energy, shoreline substrate type and shoreline form categories. Covers Portland Harbour (western Victoria) and the coast for a few km to either side. Some positional inaccuracies may be present due to transfer of information from non-orthorectified aerial photography
212	Survey and Mapping of 2003 Remnant Vegetation Communities and Regional Ecosystems of Queensland, Version 5.0 (December 2005)	1:50 000, 1:100 000	Vector - Polygon	re05_54.e00	ESRI Arc interchange format	N/A	QLD	Queensland Government: Department of Environment and Resource Management - Queensland Herbarium	Landform types used in Smartline compilation.	Regional ecosystem mapping, comprising vegetation community plus landform type mapping.
213	Survey and Mapping of 2003 Remnant Vegetation Communities and Regional Ecosystems of Queensland, Version 5.0 (December 2005)	1:50 000, 1:100 000	Vector - Polygon	re05_55.e00	ESRI Arc interchange format	N/A	QLD	Queensland Government: Department of Environment and Resource Management - Queensland Herbarium	Landform types used in Smartline compilation.	Regional ecosystem mapping, comprising vegetation community plus landform type mapping.
214	Survey and Mapping of 2003 Remnant Vegetation Communities and Regional Ecosystems of Queensland, Version 5.0 (December 2005)	1:50 000, 1:100 000	Vector - Polygon	re05_56.e00	ESRI Arc interchange format	N/A	QLD	Queensland Government: Department of Environment and Resource Management - Queensland Herbarium	Landform types used in Smartline compilation.	Regional ecosystem mapping, comprising vegetation community plus landform type mapping.
215	Survey and Mapping of 2003 Remnant Vegetation Communities and Regional Ecosystems of Queensland, Version 5.0 (December 2005)	1:100 000	Vector - Polygon	re05_extra54.e00	ESRI Arc interchange format	N/A	QLD	Queensland Government: Department of Environment and Resource Management - Queensland Herbarium	Landform types used in Smartline compilation.	Regional ecosystem mapping, comprising vegetation community plus landform type mapping.
216	Physical Shoreline Classification of Queensland	1:100 000	Vector - Line	shoreline_class.shp	ESRI shapefile	N/A	QLD	Queensland Government: Department of Environment and Resource Management	OSRA Shoreline types mapping	Detailed line-format mapping of subtidal, intertidal and backshore coastal landforms, however data model was unclear, not explained by metadata.
217	Revel Munro 1:50,000 Airphoto interpretation (1978)	1:50 000	Printed maps	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Primary Industries, Parks, Water and Environment - Land Conservation Branch	Original ink & paper maps prepared for Tasmanian Conservation Trust "Coastal Tasmania" project but never published by that project.	Coastal landform information digitised in 1999 – 2000 by C. Sharples and incorporated into original Tasmanian coastal line map (see dataset 183).
218	Chris Sharples 1:10,000 - 1:40,000 scale air photo interpretation (2000)	1:10 000 to 1:40 000	Printed air photos	N/A	N/A	N/A	TAS	N/A	Interpretation of Scamander to Dover portion of SE Tas coast, for which original interpretation maps by Munro (dataset 217) had disappeared	Coastal landform information digitised in 1999 – 2000 by C. Sharples and incorporated into original Tasmanian coastal line map (see dataset 183).
219	Chris Sharples field inspections 2000-2008	1:10 000, 1:25 000, 1:50 000, 1:100 000, 1:250 000	N/A	N/A	N/A	N/A	National	N/A	Field work done by Chris Sharples	Mainly information incorporated into Tasmanian OSRA shoreline types map (dataset 183), but also some more recent observations incorporated into Smartline mapping of other states during production of Smartline (auscstgeo_v1).
220	Frances Mowling field inspections 2005-2006	1:10 000	N/A	N/A	N/A	N/A	TAS	N/A	Field observations reported by Frances Mowling to Chris Sharples	Information incorporated into Tasmanian OSRA shoreline types map (dataset 183).
221	Short, Andrew D. (2006) Beaches of the Tasmanian Coast and Islands: A guide to their nature, characteristics, surf and safety. Sydney University Press: Sydney, 283pp. ISBN 1-920898-12-3	1:10 000	Printed book	N/A	N/A	N/A	TAS	N/A	Used to assist manual attribution of ABSAMP_ID field, and some beach landform attribute data extracted.	Book providing geomorphic descriptions of all Tasmanian beaches
222	Geological Survey of Tasmania: Published maps, unspecified (scales variously 1:25,000, 1:50,000 & 1:250,000)	1:25 000, 1:50 000, 1:250 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Various geological maps used in compiling original Tasmanian OSRA Shoreline Types map (dataset 183) but not individually recorded at that time. Generally the best available geological map sheet at the time (circa 2000) was used for each coastal region.
223	Burnie 1967 1 mile Geological Map (Geological Survey)	1:63 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
224	Dover 1:50,000 Geological Map (Farmer & Forsyth 1993)	1:50 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
225	St Helens 1:50,000 Geological Map (McClenaghan et al. 1987)	1:50 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
226	Calder Geological Map 1:25,000 2006 (Calver)	1:25 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
227	Devonport Geological Map 1:25,000 2006 (Calver)	1:25 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
228	Ulverstone Geological Map 1:25,000 2006 (Calver)	1:25 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
229	Wynyard Geological Map 1:25,000 2006 (Calver)	1:25 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
230	Sorell 1:50,000 Geological Map (Gulline 1982)	1:50 000	Printed map	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Infrastructure, Energy and Resources - Mineral Resources Tasmania	Mainly used to attribute coastal bedrock types and indentify backshore sediment plains	Depicts (some) Quaternary deposits plus bedrock
231	Western Australia- South Coast Coastal Landform Mapping	1:10 000 to 1:24 000	Vector - Line	SmartlineCoast_sthcst_20080107.shp	ESRI shapefile	N/A	WA	Government of Western Australia: Department of Environment and Conservation	Mapping done by Ewan Buckley, Ian Eliot and Michael Higgins of the Marine Policy and Planning Branch, WA Department of Environment and Conservation	Air photo interpretation and digitising of subtidal, intertidal and backshore landform types undertaken for the Smartline (version 1) project.
233	GEODATA COAST 100K 2004	1:100 000	Vector - Line	cstntcd_l.shp	ESRI shapefile	ANZCW0703006621	National	Australian Government: Geoscience Australia	Smartline base map for NT	Line representing Mean High Water Mark
234	WA MHWM Coastline (extract from Landgate Topographic data set)	1:100 000	Vector - Line	Topo_Coastline.mdb	ESRI Personal Geodatabase	N/A	WA	Government of Western Australia: Landgate	Smartline base map for WA	Line representing Mean High Water Mark
235	NEW SOUTH WALES DTDB HYDROGRAPHY THEME MEDIUM SCALE DRAINAGE	1:25 000	Vector - Line	NSW25K_MeanHighWaterMark	ESRI shapefile	ANZNS0404000872	NSW	New South Wales Government: Department of Lands	Smartline base map for NSW (open coast)	Line representing Mean High Water Mark.
236	NEW SOUTH WALES DTDB HYDROGRAPHY THEME MEDIUM SCALE DRAINAGE	1:25 000	Vector - Polygon	NSW25K_HydroArea	ESRI shapefile	ANZNS0404000872	NSW	New South Wales Government: Department of Lands	Smartline base map for NSW (estuaries and coastal lagoons)	Line representing water line, but precise definition of waterline unclear.
237	Data added or edited by C. Sharples during version 1 production, by extrapolation or inference from related attribute data.	Various - see individual attributes for scale	N/A	N/A	N/A	N/A	National	N/A	Identifies reasonable inferences (‘professional judgement and interpretation’) by C. Sharples in cases where available data does not explicitly map the attribute in question.	Refers to a variety of inferences made by C. Sharples, but generally based on reasonable inferences from other data sources used in the same coastal region. For example, some “Bedrock Terrain ± soil” backshores on northern and southern NSW coasts have been inferred from an absence of Quaternary polygons on (very detailed) CCA Quaternary mapping (Reference_ID’s 166 & 167 above).
238	Jones, T., Middelmann, M. And Corby, N. (2005) Natural Hazard Risk in Perth, Western Australia. Department of Industry, Tourism and Resources and Geoscience Australia.	1:50 000	Printed report	N/A	N/A	N/A	WA	Australian Government: Geoscience Australia	Coastal recession hazard mapping based on depth of calcarenite bedrock surface wrt sea level	Report containing borehole information collated to map stretches of coast backed by hard calcarenite bedrock above or below sea level.
239	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 153 and 154	See datasets 153 and 154	Information from files 153 and 154 were combined to derive this attribute. See individual files for details.	See 153, 154	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 153 and 154
240	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 154 and 155	See datasets 154 and 155	Information from files 154 and 155 were combined to derive this attribute. See individual files for details.	See 154, 155	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 154 and 155
241	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 155 and 209	See datasets 155 and 209	Information from files 155 and 209 were combined to derive this attribute. See individual files for details.	See 155, 209	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 155 and 209
242	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 146 and 153	See datasets 146 and 153	Information from files 146 and 153 were combined to derive this attribute. See individual files for details.	See 146, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 146 and 153
243	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 147 and 153	See datasets 147 and 153	Information from files 147 and 153 were combined to derive this attribute. See individual files for details.	See 147, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 147 and 153
244	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 149 and 153	See datasets 149 and 153	Information from files 149 and 153 were combined to derive this attribute. See individual files for details.	See 149, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 149 and 153
245	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 150 and 153	See datasets 150 and 153	Information from files 150 and 153 were combined to derive this attribute. See individual files for details.	See 150, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 150 and 153
246	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 151 and 153	See datasets 151 and 153	Information from files 151 and 153 were combined to derive this attribute. See individual files for details.	See 151, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 151 and 153

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
247	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 152 and 153	See datasets 152 and 153	Information from files 152 and 153 were combined to derive this attribute. See individual files for details.	See 152, 153	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 152 and 153
248	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 150 and 154	See datasets 150 and 154	Information from files 150 and 154 were combined to derive this attribute. See individual files for details.	See 150, 154	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 150 and 154
249	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 151 and 154	See datasets 151 and 154	Information from files 151 and 154 were combined to derive this attribute. See individual files for details.	See 151, 154	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 151 and 154
250	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 152 and 154	See datasets 152 and 154	Information from files 152 and 154 were combined to derive this attribute. See individual files for details.	See 152, 154	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 152 and 154
251	Combined datasets used to create Victorian Smartline v1.0	See scale information for datasets 150 and 209	See datasets 150 and 209	Information from files 150 and 209 were combined to derive this attribute. See individual files for details.	See 150, 209	N/A	VIC	N/A	Interpretation of attributes using multiple data sources by C. Sharples & T. Pedersen, Smartline Project team.	See descriptions for datasets 150 and 209
252	NSW landform attributes mapped using visual interpretation of Google Earth imagery by M. Lacey, Smartline Project team	1:25 000	Raster - Image (georeferenced)	N/A	N/A	N/A	NSW	N/A		Imagery referred to during manual attribution of Smartline. Scale estimated from zoom and resolution of imagery used for particular sites.
253	MANGROVE MAPPING BYNOE HARBOUR	1:25 000	Vector - Polygon	mangb_25.shp	ESRI shapefile	ANZNT0001000221	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Used to infer muddy tidal flats where no better landform data available.	Mangrove vegetation community mapping.
254	MANGROVE MAPPING DARWIN HARBOUR	1:25 000	Vector - Polygon	mangd_25.shp	ESRI shapefile	ANZNT0001000082	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Used to infer muddy tidal flats where no better landform data available.	Mangrove vegetation community mapping.
255	Regionalisation of Mangrove Communities along the Northern Territory Coast	1:250 000	Vector - Polygon	ntman_250.shp	ESRI shapefile	N/A	NT	Northern Territory Government: Department of Natural Resources, Environment, The Arts and Sport	Used to infer muddy tidal flats where no better landform data available.	Mangrove vegetation community mapping.
256	Tyler, I.M., Griffin, T.J. & Playford, P.E. (1992) Yampi. Australia 1:250,000 Geological Series, Sheet SE 51-3, Second Edition. Geological Survey of Western Australia, Department of Minerals and Energy	1:250 000	Raster - Image (non-georeferenced)	se5103.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
257	Resource Management and Conservation Division (2007) Arthur-Pieman Conservation Area Vehicle Tracks Assessment: Geoconservation and Biological Values. Report to Parks and Wildlife Service, Tasmania. Department of Primary Industries and Water, Hobart	1:10 000	Printed report	N/A	N/A	N/A	TAS	Tasmanian Government: Department of Primary Industries, Parks, Water and Environment - Land Conservation Branch	Used info in Appendix 3: "Sites of Geoconservation Significance", p.198-199	Identifies distinctive high level (backshore) cobble berms or 'beaches' (likely storm deposits) in part of western Tasmania (Arthur-Pieman River's coast).
258	Landform attributes mapped using visual interpretation of Google Earth imagery by C. Sharples, Smartline Project team	Various - see individual attributes for scale	Raster - Image (georeferenced)	N/A	N/A	N/A	National	N/A	Imagery referred to during manual attribution of Smartline. Scale estimated from zoom and resolution of imagery used for particular sites.	Interpretation of coastal landforms from visual inspection of imagery by Chris Sharples.
259	Wilde, S.A. & Walker, I.W. (1984) "Pemberton-Irwin Inlet". Australia 1:250,000 Geological Series, Sheet SI50-10 and part of Sheet SI50-14. Geological Survey of Western Australia (un-georeferenced raster)	1:250 000	Raster - Image (non-georeferenced)	si5010.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
260	Van de Graff, W.J.E., Butcher, B.P. & Hocking, R.M. (1983) "Shark Bay - Edel". Australia 1:250,000 Geological Series, parts of Sheets SG 49-8 and part of Sheet SG 49-12. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sg4908.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
261	Hocking, R.M., Van de Graff, W.J.E., Butcher, B.P. & Blockley, J.G. (1982) "Ajana". Australia 1:250,000 Geological Series, Sheet SG 50-13. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sg5013.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock

Reference ID	Dataset Title	Scale	Data Type	File Name	File Type	ANZLIC ID	Region or Jurisdiction	Supplier or Custodian	Notes	Description
262	Playford, P.E., Willmott, S.P., Johnstone, D., Horwitz, R.C. & Baxter, J.L. (1971) "Geraldton - Houtman Abrolhos". Australia 1:250,000 Geological Series, Sheet SH 50-1 and part of Sheet SH 49-4. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sh5001.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
263	Van de Graff, Hocking, R.M., Butcher, B.P. & Walker, I.W. (1982) "Yaringa". Australia 1:250,000 Geological Series, Sheet SG 50-9. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sg5009.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
264	Denman, P.D. & Van de Graff, W.J.E. (1981) "Quobba". Australia 1:250,000 Geological Series, Sheet SG 49-4. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sg4904.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
265	Hocking, R.M., Denman, P.D., Van de Graff, W.J.E., Butcher, B.P., & Moore, P.S. (1985) "Wooramel". Australia 1:250,000 Geological Series, Sheet SG 50-5. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sg5005.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
266	Towner, R.R., Gibson, D.L. & Crowe, R.W.A. (1981) "Mandora". Australia 1:250,000 Geological Series, Sheet SE 51-13. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	se5113.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
267	Towner, R.R., Gibson, D.L. & Crowe, R.W.A. (1981) "Munro". Australia 1:250,000 Geological Series, Sheet SE 51-14. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	se5114.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
268	Gibson, D.L., Towner, R.R. & Crowe R.W.A. (1983) "LaGrange". Australia 1:250,000 Geological Series, Sheet SE 51-10. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	se5110.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
269	Guppy, D.J., Lindner, A.W., Brunnschweiler, R.O., Gibson, D.L., Towner, R.R., & Crowe, R.W.A. (1982) "Broome". Australia 1:250,000 Geological Series, Sheet SE 51-6. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	se5106.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
270	Hickman, A.H. & Gibson, D.L. (1981) "Port Hedland - Bedout Island". Australia 1:250,000 Geological Series, Sheet SF 50-4 and part of Sheet SE 50-16. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	se5016.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
271	Van de Graaff, W.J.E., Denman, P.D., Hocking, R.M., Baxter, J.L. (1980) "Yanrey - Ningaloo". Australia 1:250,000 Geological Series, Sheet SF 50-9 and part of Sheet SF 49-12. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sf5009.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
272	Van de Graaff, W.J.E., Denman, P.D., Hocking, R.M. (1981) "Onslow". Australia 1:250,000 Geological Series, Sheet SF 50-5 and part of Sheet SF 49-8. Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sf5005.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock
273	Williams, I.R., Ryan, G.R. & Halligan, R. (1968) "Yarraloola". Australia 1:250,000 Geological Series, Sheet SF 50-6. Bureau of Mineral Resources & Geological Survey of Western Australia	1:250 000	Raster - Image (non-georeferenced)	sf5006.jpg	JPEG Image	N/A	WA	Australian Government: Geoscience Australia	Paper / raster versions only available at time of Smartline compilation; used by C. Sharples to manually interpret and digitise some coastal landforms.	Depicts (some) Quaternary deposits plus bedrock

smartline

coastal data segmentation