

COASTAL QUATERNARY GEOLOGY MAPPING FOR NSW: EXAMPLES AND APPLICATIONS

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Abstract

Detailed geological mapping of the coastal plains of regional NSW was undertaken by the Geological Survey of NSW for the Comprehensive Coastal Assessment. Seamless GIS data sets were produced for the north and south coast of NSW that include 1:25,000-scale mapping of Quaternary geology deposits integrated with the best-available bedrock geology mapping. The mapping is available as GIS data files in a DVD data package with accompanying explanatory bulletin (Troedson & Hashimoto, 2008). More recently, the mapping has also been made available in the form of individual paper maps, with nine map sheets covering the north coast from Tweed to Port Stephens, and four just released for the south coast extending from Kiama to the Victorian border.

The Quaternary geology mapped encompasses coastal sand barrier (beach, dune, sand plains, etc.), estuarine and alluvial deposits. Classification was based on geological age (Holocene, Pleistocene, or undifferentiated Quaternary) and a combination of geomorphology, sediment character and depositional environment. Due to the effects of late Quaternary sea level changes there is significant complexity in these deposits, both laterally and vertically. Geological units occurring at the surface may differ markedly from those encountered in the shallow subsurface. The GIS data structure built into the digital mapping data takes account of this, enabling maps to be created of both surface and shallow subsurface deposits. Additionally the Quaternary geology GIS data is categorised to enable the user to create derivative maps based on such categories as dominant lithology, texture, pyrite content and carbonate content, facilitating the use of this data in a wide variety of applications.

This paper outlines the nature of the Quaternary geology map data and some potential applications, and provides examples of the mapping for the Port Macquarie area.

Introduction

The NSW coast, in particular the north coast, has extensive areas of Quaternary plains built from the sediments of alluvial, estuarine and coastal barrier depositional systems. From 2002-2004, a team of geologists from the Geological Survey of NSW undertook detailed geological mapping of these deposits across regional coastal NSW for the Comprehensive Coastal Assessment (CCA) - a key component of the NSW Government's \$11.7 million Coastal Protection Package, introduced in 2001 to improve coastal planning and management. The mapping was first released as a DVD data package in 2005, and a second edition with an accompanying bulletin was released in 2008 (Troedson & Hashimoto, 2008). Included in the data package along with the Quaternary mapping data sets and report are:

- Field and laboratory data for the Quaternary deposits;
- Generalised best-available bedrock mapping for the CCA area;
- Mineral resources data and report for the CCA area;

- Historic heavy mineral sand mining extents.

The CCA coastal Quaternary mapping has also been published as a series of double-sided paper maps, with nine maps for the north coast CCA area published in 2008 and four maps for the south coast CCA area published in 2013. Map areas are based broadly on local government areas. These maps display the mapping at 1:100,000-scale with key areas shown at 1:25,000-scale.

Nature of the mapping

The understanding of the nature and depositional history of NSW coastal Quaternary deposits that was developed through the pioneering work of coastal geologists Peter Roy, Bruce Thom and others (summarised in Roy, 1998) provided a basis for the coastal Quaternary geology mapping style and classification scheme. Figure 1 illustrates a generalised shore-normal geological cross-section based on the Hunter River but representative of many NSW Quaternary coastal depositional systems. This picture demonstrates the complexity in mapping Quaternary coastal deposits beyond their surface geomorphology in that at many locations the surface depositional units differ from those found in the shallow subsurface, reflecting the interplay of depositional and erosional processes, sediment supply and sea level changes through the Quaternary. For example, the development then infilling of estuaries as the sea rose to its present position after the last glacial lowstand of sea level has resulted in extensive areas where Holocene alluvial floodplain deposits overlie estuarine deposits within five metres of the ground surface.

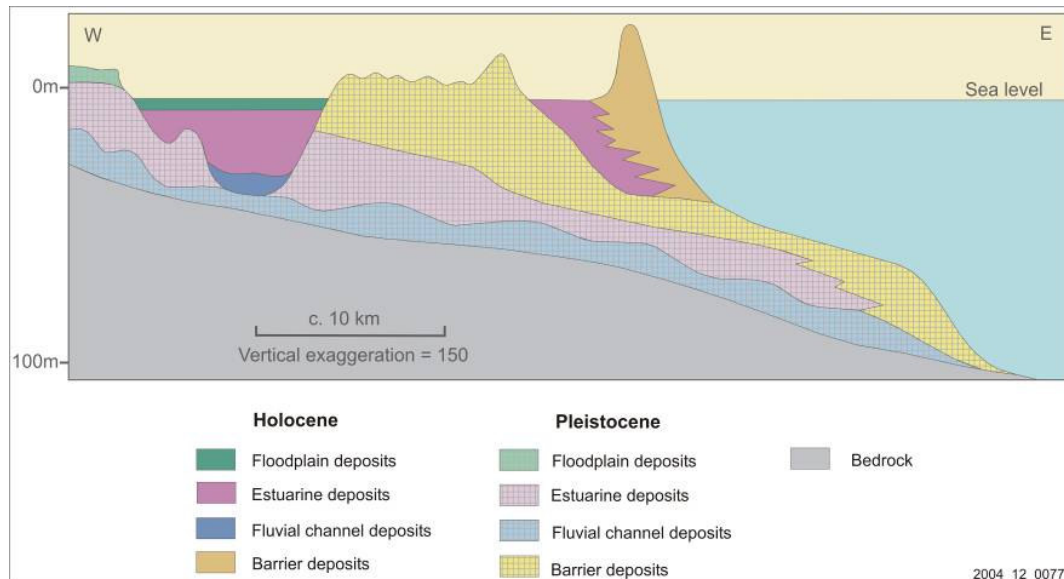


Figure 1. Generalised morphostratigraphic relationships for Quaternary coastal deposits in NSW (modified from Roy, 1998), based on the Hunter River delta.

The classification scheme used in the mapping includes fifty-six distinct unit types reflecting the detailed level of mapping. Units are defined by age (Holocene, Pleistocene or undifferentiated Quaternary), depositional system (alluvial plain, estuarine plain or coastal barrier) and morphostratigraphic unit. The latter are distinct in terms of geomorphology, depositional process, and/or sediment properties. Examples of classes used include Holocene alluvial floodplain (Qhas), Holocene estuarine mud basin (Qhem) and Pleistocene barrier flat (Qpbf).

Significant shallow subsurface units (within five metres of the surface), and thin, patchy veneer units were also mapped where they could be recognised or reasonably inferred. This 'stratigraphic' mapping was enabled by the flexibility inherent in digital mapping (GIS) systems. An example of the GIS data structure for the mapping is shown in Figure 2. Each row represents the data appended to a map polygon. Unit 1 is the primary surface unit and this field is always filled whereas the Veneer and Unit 2 fields are not. Other columns include Geol_Symb (the concatenation of Veneer//Unit 1/Unit 2, and useful for labelling), Surface (either Unit 1 or Veneer if defined), Near Surface (always Unit 1) and Subsurface (either Unit 1 or Unit 2 if defined). The latter three fields can be used to create fully attributed maps of surface, near-surface or shallow subsurface Quaternary geology, respectively.

ternary_polygons								
VENEER	REL_1	UNIT_1	REL_2	UNIT_2	GEOL_SYMB	SURFACE	NEAR_SURFA	SUB_SURFAC
		Qhap	/	Qhemd	Qhap/Qhemd	Qhap	Qhap	Qhemd
Qhs	//	Qhbw			Qhs//Qhbw	Qhs	Qhbw	Qhbw
		Qhea	/	Qhemd	Qhea/Qhemd	Qhea	Qhea	Qhemd
		Qhea	/	Qhemd	Qhea/Qhemd	Qhea	Qhea	Qhemd
		Qhea	/	Qhemd	Qhea/Qhemd	Qhea	Qhea	Qhemd
Qhas	//	Qhes	/	Qhbf	Qhas//Qhes/Qhbf	Qhas	Qhes	Qhbf
		Qhap	/	Qhemd	Qhap/Qhemd	Qhap	Qhap	Qhemd
		Qheb			Qheb	Qheb	Qheb	Qheb
Qhs	//	Qpbw			Qhs//Qpbw	Qhs	Qpbw	Qpbw
Qhs	//	Qpbw			Qhs//Qpbw	Qhs	Qpbw	Qpbw
Qhas	//	Qhes	/	Qpb	Qhas//Qhes/Qpb	Qhas	Qhes	Qpb
		Qheb	/	Qhbf	Qheb/Qhbf	Qheb	Qheb	Qhbf
Qhs	//	Qpbw			Qhs//Qpbw	Qhs	Qpbw	Qpbw
Qhs	//	Qheb	/	Qpb	Qhs//Qheb/Qpb	Qhs	Qheb	Qpb

Figure 2. Example of GIS data structure

An example of the information contained in the database of each map polygon is shown in Figure 3. A particular feature of the map data is the inclusion of fields that enable the construction of derivative maps including dominant lithology, dominant texture, predicted pyrite content and predicted organic carbon content.

Field	Value
FID	10173
Shape	Polygon
UNIT_1	Qhap
GEOL_SYMB	Qhap/Qhab
Data_Statu	Quaternary geological mapping produced by the Geological Survey of NSW for the Comprehensive Coastal Assessment 2004
Age	Holocene
Deposition	Alluvial Plain
Unit	Floodplain
Lithology	Silt, fluvial sand, clay
Dom_Lith	Fluvial sand to mud
Dom_Textur	Sand to mud
Provenance	Fluvial
Pyrite	Low
Carbonate	Low
Organic	Low
Full_Descr	Silt, clayey silt, sandy silt, silty sand, very fine to medium sand, silty clay, organic mud; usually fining upward and interbedded
Geomorph	Plain bounding active stream channel; lower elevation than levees; may consist of irregular, overlapping sediment lobes extending from levee toes into
Relations	Common transition unit between levee and backswamp; may unconformably onlap Pleistocene terraces or bedrock; overlies a variety of Holocene and
Depo_Proce	Aggradation through overbank fluvial deposition (suspension settling, crevasse splay); prone to episodic stripping in upstream and / or laterally confine
Comments	N/A
Potential_	Qhal, Qhas, Qhaa
Sed_Colour	Brown, greyish brown, brownish grey, dark grey, grey, dark brown, yellowish brown, dark yellowish brown, olive grey, olive brown; olive; mottled

Figure 3. Example of GIS database fields for a map polygon

Strengths and limitations of the mapping

The main strengths of the CCA coastal Quaternary mapping include:

- the accuracy and detail of Quaternary/bedrock boundary delineation and coastal Quaternary deposit mapping (at least 1:25,000-scale);
- datasets for north and south CCA areas are seamless and use the same Quaternary classification scheme throughout;
- the capacity to create derivative maps including dominant substrate sediment type (mud, sand, etc, relevant for factors such as erodibility and geotechnical properties) and predicted pyrite content (a proxy for acid sulphate soils risk);
- the capacity to create geological and derivative maps of both surface and shallow subsurface geological units.

Limitations include:

- Greater complexity of database structure compared to typical geological mapping products;
- Subsurface mapping is much broader scale and less precise than surface mapping.

Potential applications

There are a variety of purposes for which the coastal Quaternary geology mapping data could be used, some of which are listed in Table 1. Commonly the mapping would be used along with a variety of complimentary data sets which, depending on the task, might include topographic data (contours/digital elevation models), aerial imagery, and other map data such as acid sulphate soils risk and soils mapping. Different maps may be created from the Quaternary mapping data depending on the application and layers derived from the mapping could be used in GIS modelling tools.

Table 1. Potential applications for the Quaternary coastal mapping data

Application	Examples
Coastal hazard assessment	Coastal erosion risk, coastal recession risk, sea level rise impacts
Environmental and land use assessment and management	Habitat mapping; acid sulphate soils risk; soil types
Engineering studies	Geotechnical site assessment; infrastructure route selection; riverbank erosion risk
Resource assessment	Identification of construction material and silica sand resources; groundwater resource assessment
Scientific research	Geological/geomorphological history; geomorphic processes; habitat studies

Examples of mapping from the Port Macquarie area

Figures 4 and 5 show near-surface and shallow subsurface Quaternary geology maps for the Port Macquarie area. Legends are not shown for reasons of space, but in general yellow tones are coastal barrier units, pink tones are estuarine units, green tones are alluvial units and grey is anthropogenic (in this case man-made waterways). Textured grey areas are from an underlying hillshade image based on a LiDAR digital elevation model which shows through in bedrock areas. Note the more extensive areas

of estuarine deposits in the subsurface compared to the surface sediments around Fernbank Creek and Hibbard, with resulting implications for potential acid sulphate risk and geotechnical properties.

Figure 4. Near-surface Quaternary geology, Port Macquarie area

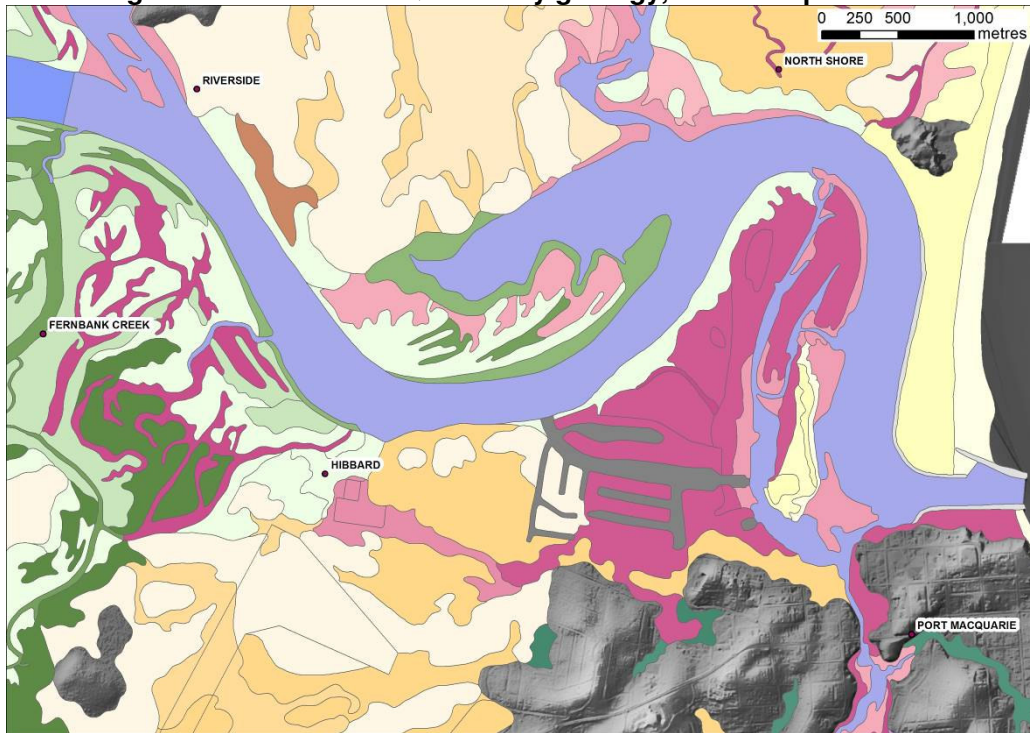
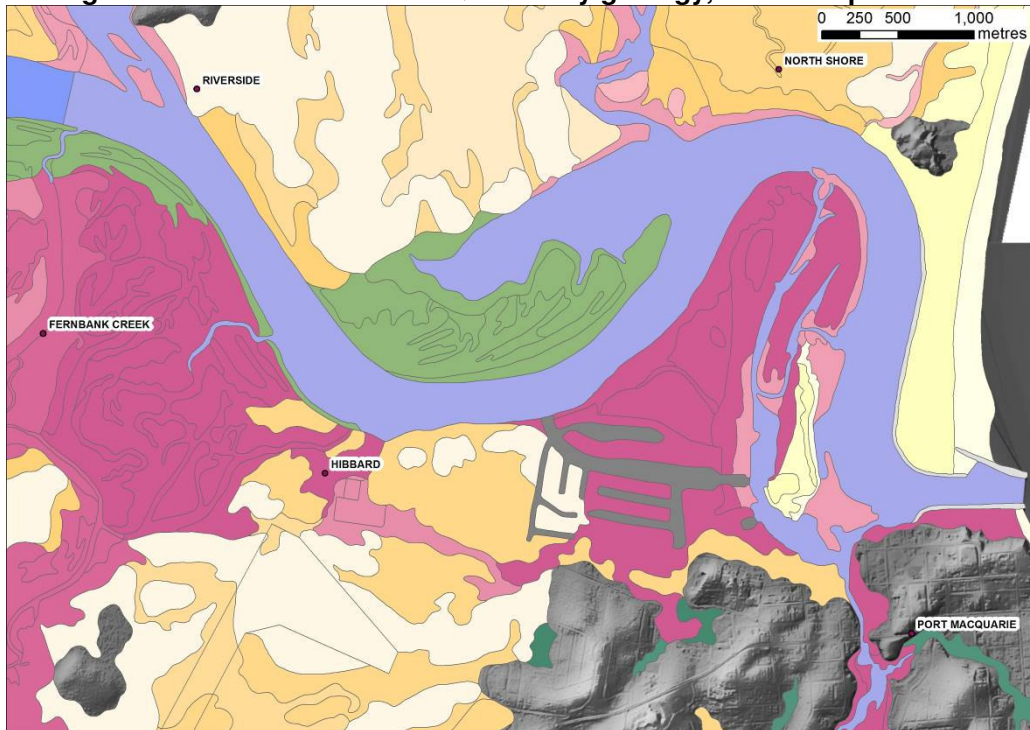


Figure 5. Shallow subsurface Quaternary geology, Port Macquarie area



Figures 6 and 7 show surface and shallow subsurface dominant sediment texture maps derived from the coastal Quaternary geology data. Note the more extensive sands in

the subsurface in the west of the map area. This information could be used in predictive modelling of coastal and riverbank erosion rates.

Figure 6. Surface dominant texture map, Port Macquarie area

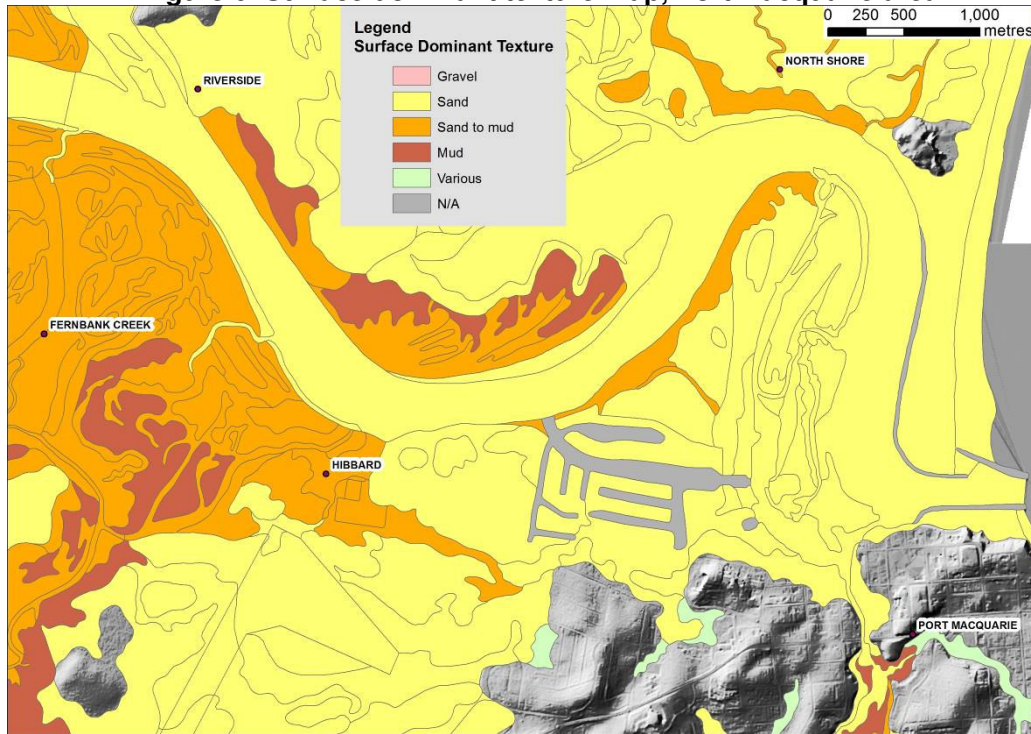
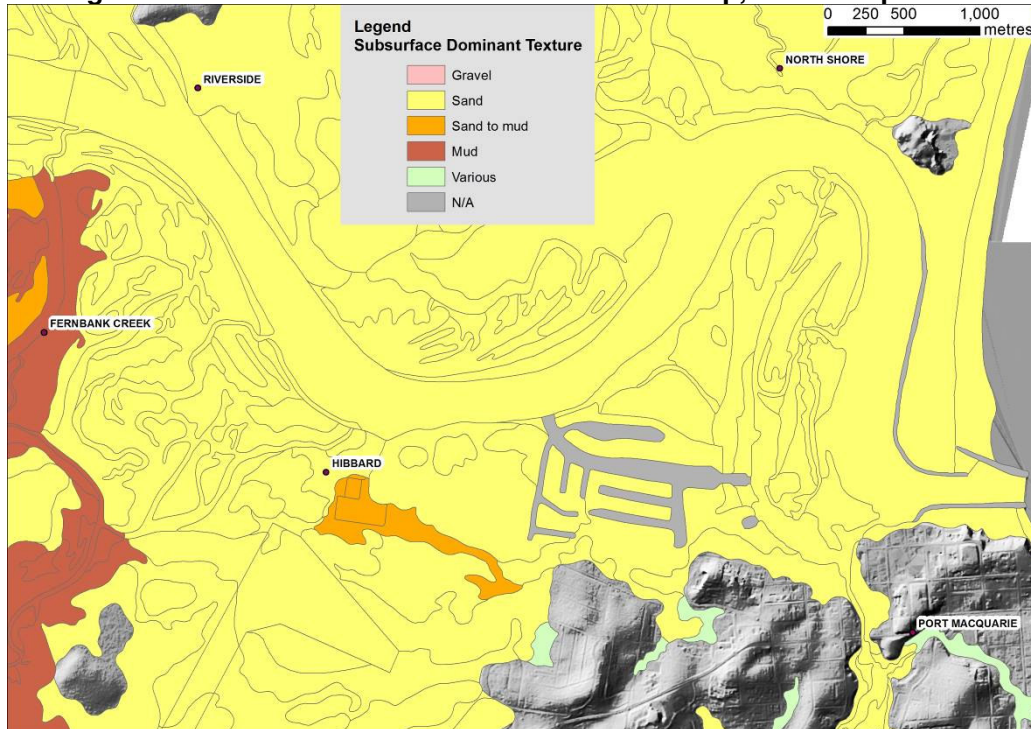


Figure 7. Shallow subsurface dominant texture map, Port Macquarie area



Figures 8 and 9 show maps of surface and shallow subsurface pyrite content derived from the coastal Quaternary geology dataset. Such maps enable users to gain an insight into the stratigraphy of potential acid sulphate soil materials.

Figure 8. Surface pyrite content map, Port Macquarie area

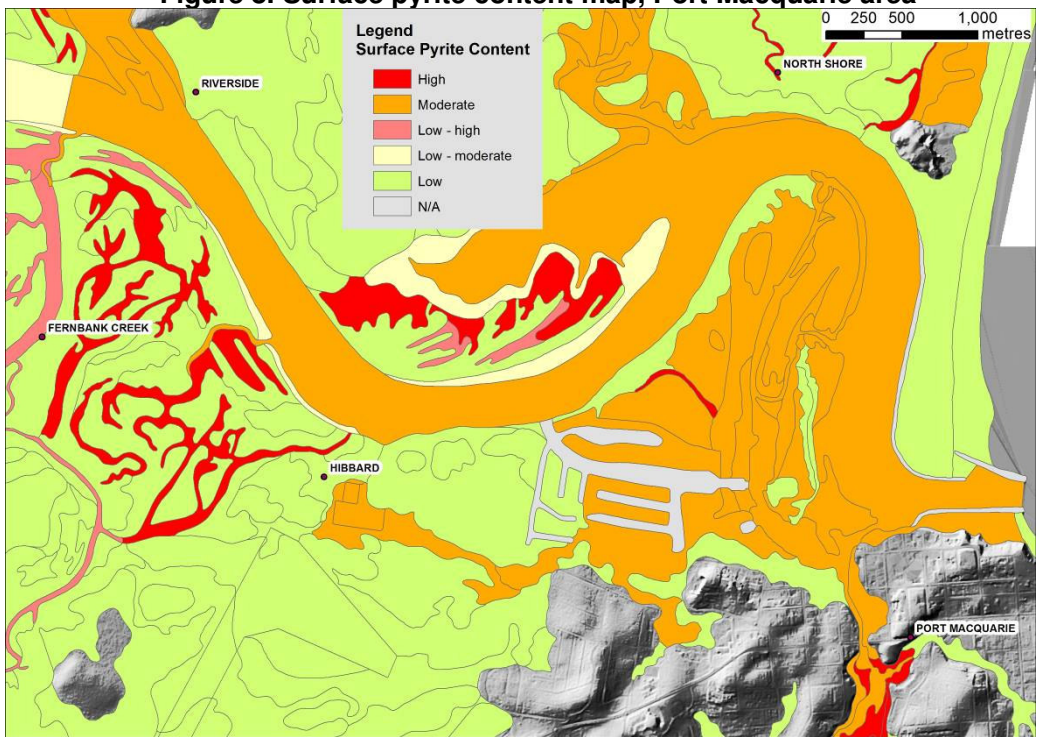
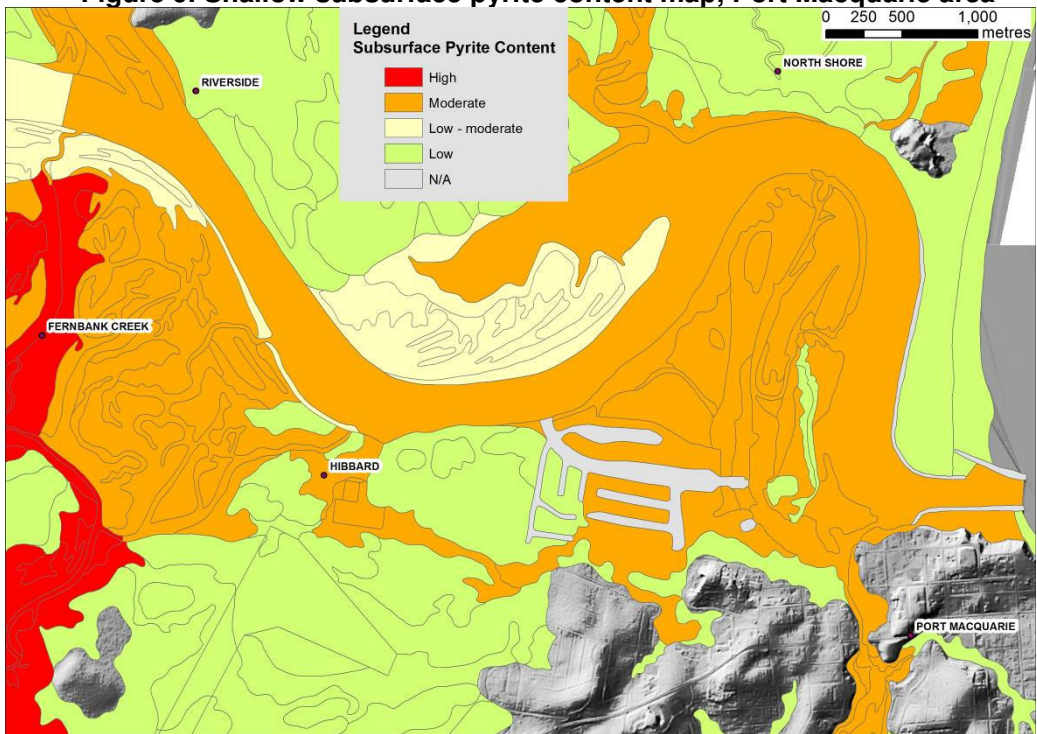


Figure 9. Shallow subsurface pyrite content map, Port Macquarie area



Summary and future work

The Quaternary geology mapping covers an area of 8052 square kilometres for the North Coast and 1123 square kilometres for the South Coast of NSW, a very small sample of which is illustrated in this paper. The CCA coastal Quaternary geology mapping data package, accompanying bulletin and associated paper maps are available for purchase from the Geological Survey of NSW. The bulletin contains extensive explanation of mapping methods, the geological framework, classification and description of units, regional variations and features, potential applications, and references.

Coastal Quaternary geological mapping of the Newcastle to Wollongong region was not undertaken previously and is currently underway. The mapping process has evolved to include datasets not readily available ten years ago in NSW including highly detailed LiDAR-derived digital elevation models (DEMs) and high resolution digital aerial imagery. This should increase mapping precision and enable mapping to be undertaken more rapidly and efficiently.

The coastal Quaternary surface mapping data is also being incorporated into the State-wide Geology Database currently being built by the Geological Survey of NSW.

References

Roy, P.S, 1998, 'Cainozoic geology of the coast and shelf', in E Scheibner & H Basden (eds), *Geology of New South Wales - Synthesis, Volume 2: Geological Evolution*, Memoir, vol. 13, no. 2, Geological Survey of New South Wales, Sydney, pp. 361-385.

Troedson A.L & Hashimoto, T.R, 2008, Coastal Quaternary Geology - North and South Coast of NSW, Geological Survey of NSW, Bulletin 34.