cranbourne east
precinct structure plan

Hydrogeology Assessment - Groundwater and Salinity

CEUGP/SR18B

September 2007

TABLE OF CONTENTS

TABLE OF FIGURES

1 EXECUTIVE SUMMARY

1.1 Project Context

Environmental conditions in and around the Cranbourne East study area are being assessed as part of the development planning process. This report provides an initial assessment of groundwater systems and current and potential salinisation issues at the Cranbourne East site.

Effective groundwater management, together with appropriate land use development have the potential to provide environmental benefits and to improve the use of available water resources. This understanding provides an important context to the investigation of groundwater systems. Future investigations should consider potential sources of groundwater, options for augmenting groundwater supply and possible uses of a groundwater supply.

1.2 Existing Conditions

The objective of this project is to undertake a preliminary investigation of the hydrogeological conditions and land salinisation potential in the vicinity of the Cranbourne East Urban Growth Area.

The following conclusions are made from data sets that reflect the current conditions of catchment hydrology at Cranbourne East.

- The Cranbourne East study area spans across two major drainage basins, Port Phillip and Westernport. A northern subcatchment drains to Port Phillip, while three southern subcatchments drain to Westernport. The land surface slopes at a gradient of about 1:100 across the catchment study area.
- Small pockets of higher permeability geological units occur: Quaternary Dune sands and near-surface sands.
- In general the geological units are of low permeability (Silurian bedrock, Quaternary swamp deposits, Older Volcanics (weathered and fresh) and unweathered Baxter Sandstone).
- Junctions of sand units and low permeability units may provide conditions for shallow watertables to develop.
- Groundwater is expected to flow from the west to the east of the study area. Some higher permeability sand layers may provide pathways for groundwater flow but these layers have a limited spatial extent and terminate in less permeable basalt and sandstone.
- Areas prone to shallow watertable conditions (depth to watertable <= 2 m below surface) occur in a number of locations on the site.
- The majority of the study area falls within the Koo Wee Rup WSPA.
- Groundwater salinity is low over most of the study area. Slightly higher groundwater salinities to the eastern boundary do not appear to be associated with sites where shallow watertables occur.
- Groundwater bore hydrographs show a response to variations in rainfall.

1.3 Opportunities

Extraction and use of groundwater may be an opportunity for management to reduce the risk of shallow watertables in Cranbourne East. The nature of the groundwater system may be suited to this sort of management and it should be further investigated. It is expected that if groundwater use is feasible, only low volumes of groundwater would be expected to be available on a long term basis, as the site is part of the Koo Wee Rup WSPA.

Long term monitoring of groundwater conditions in critical locations would improve understanding of the groundwater system and provide warning of rising watertable conditions.

Additional pre-emptive management options to minimise the risks of increased net groundwater recharge include;

- non-residential land use;
- increased tree canopy cover;
- reticulation systems constructed to higher standard within these areas to minimise leakage
- install subsurface drainage systems
- use area as 'green space' with high tree canopy cover or other 'low net recharge' option (possibly an impervious surface with subsurface drains)

1.4 Constraints

The current catchment conditions do not appear to preclude any current land use within the Cranbourne East study area (e.g. residential dwellings and major roads are present). Furthermore, guidelines for appropriate construction of buildings, roads, and services exist for a range of different environments (including shallow saline watertables – for examples see Western Sydney and Wagga Wagga).

However, the catchment hydrology will change with development of Cranbourne East. In areas currently with a shallow watertable it is recommended that development aims to avoid land uses/management that could promote or create shallow watertable conditions

It should be noted that other parts of the Cranbourne East study area may be susceptible to shallow watertable conditions, in addition to the areas identified in this report. Further investigations may locate additional areas with requirements for particular land uses or land management.

2 INTRODUCTION

2.1 Project Context

Environmental conditions in and around the Cranbourne East study area are being assessed as part of the development planning process. There are many specialist reports contributing to this planning process including environmental site assessments, flood studies and water sensitive urban design.

This report provides an initial assessment of groundwater systems and current and potential salinisation issues at the Cranbourne East site. One of purposes of this study was to evaluate the outcomes of an investigation in 2005 that considered the potential constraints to urban development from shallow water tables in a wider urban growth area with Cranbourne East in its South Western area (SKM, 2005). In this earlier study the Cranbourne East study area was considered to be in a risk category of High Constrained to Constrained for urban development due to the likelihood of occurrence of shallow watertables (Figure 1). [Please note that Figure 1 comes directly from an earlier report and includes growth pocket boundaries and possibly other features that have been updated since it was drawn.] A more detailed and localised understanding of groundwater systems at Cranbourne East will assess the context of this risk and potential management options.

The City of Casey is also aware that effective groundwater management, together with appropriate land use development have the potential to provide environmental benefits and to improve the use of available water resources. This understanding provides an important context to the investigation of groundwater systems. Future investigations should consider potential sources of groundwater, options for augmenting groundwater supply and possible uses of a groundwater supply.

2.2 Project Objectives

The objective of this project is to undertake a preliminary investigation of the hydrogeological conditions and land salinisation potential in the vicinity of the Cranbourne East Urban Growth Area. Available data sets and literature sources are reviewed and a hydrogeological 'conceptual model' is developed. Interpretation of data sets in terms of catchment hydrology and options for site-scale water management are to be considered. This report provides recommendations for further investigation of site hydrogeology and pre-feasibility study of potential groundwater use schemes.

2.3 Relevant Investigations and Data Sets

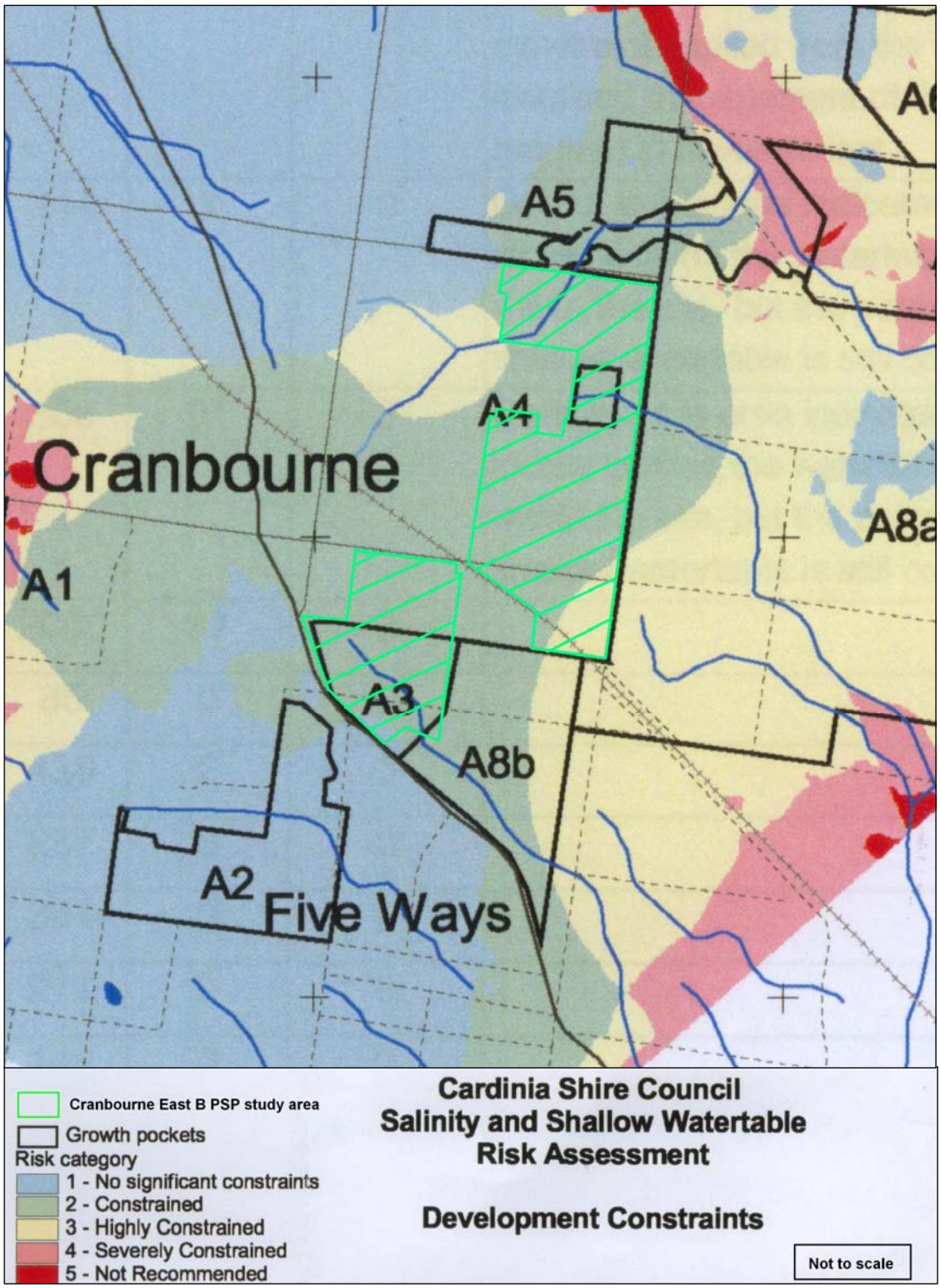
2.3.1 Data Sets and Geological Information Sources

The Victorian Groundwater Database (Groundwater Management System, GMS) is the primary source of groundwater data for this project. Geological maps released at various scales provide details of surface features of the local geology. The Port Phillip and Western Port Groundwater Flow Systems report (Dahlhaus et al., 2004) provides another perspective on geological interpretation.

2.3.2 Draft Reports for Cranbourne East

A number of draft reports for the Cranbourne East development have been made available through the website maintained by David Lock and Associates. Two reports have provided some context to this Stage 1 report: the Limited Contamination Assessment (Beveridge Williams, 2007); and the Preliminary Environmental Site Assessment (ATMA Environmental, 2006).

Figure 1 Groundwater constraints to urban development in area surrounding Cranbourne East (detail of figure from SKM, 2005).



3 CRANBOURNE EAST – CATCHMENT SETTING

3.1 Overview

The setting of the Cranbourne East Urban Growth Area within a larger catchment is fundamental to an understanding of the land, stream and groundwater hydrology. Cranbourne East is located east of Cranbourne township and between Port Phillip and Western Port Bays. The Cranbourne East site spreads across four relatively small catchments as shown in Figure 2 and Figure 3. These figures include topographic catchment boundaries evaluated using land surface elevation data supplied by City of Casey. The northern catchment drains to Port Phillip Bay and the three southern catchments drain to Westernport Bay. Surface runoff of rain water within these boundaries is expected to leave the catchments as a single stream or river.

The catchment boundary for groundwater flow is often not the same as the boundary for surface runoff. This is generally the case in low land surface areas with minimal elevation changes. As much of the Cranbourne East study area has low land surface elevations, the groundwater catchment boundaries are unlikely to correlate to the surface runoff boundaries.

3.2 Water Supply Protection Area

The Cranbourne East development area is located within the Koo Wee Rup Water Supply Protection Area (WSPA) boundary administered by Southern Rural Water. The WSPA covers aquifers at all depths as it is considered that there is some degree of hydraulic connection between aquifers in the area.

The beneficial use of groundwater in the study area includes beneficial use categories A2 and B. These categories span groundwater quality ranging from 500 - 3500 mg/L TDS (Total Dissolved Solids). There is significant variation in groundwater quality noted in and around the Cranbourne East site.

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SKM

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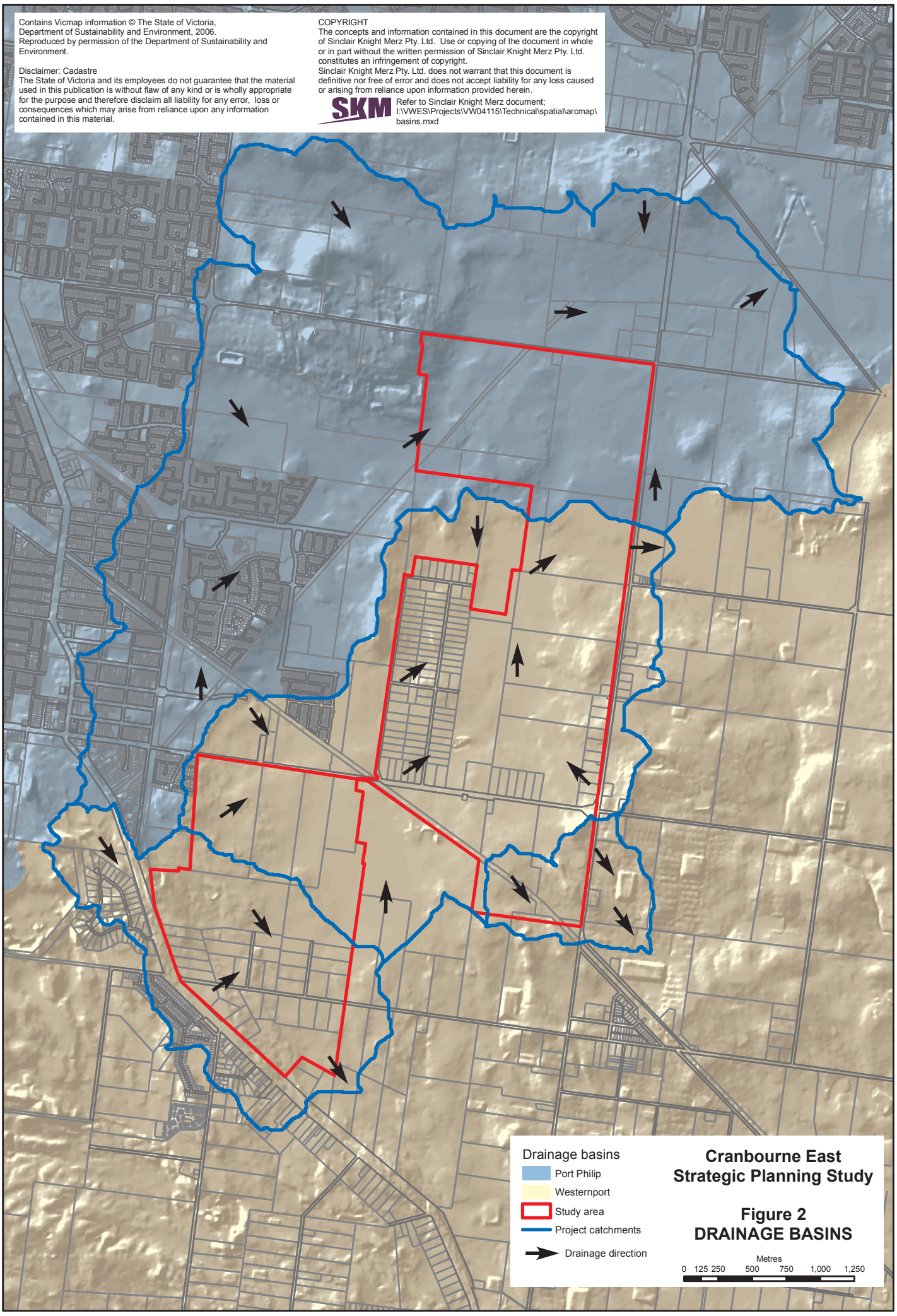
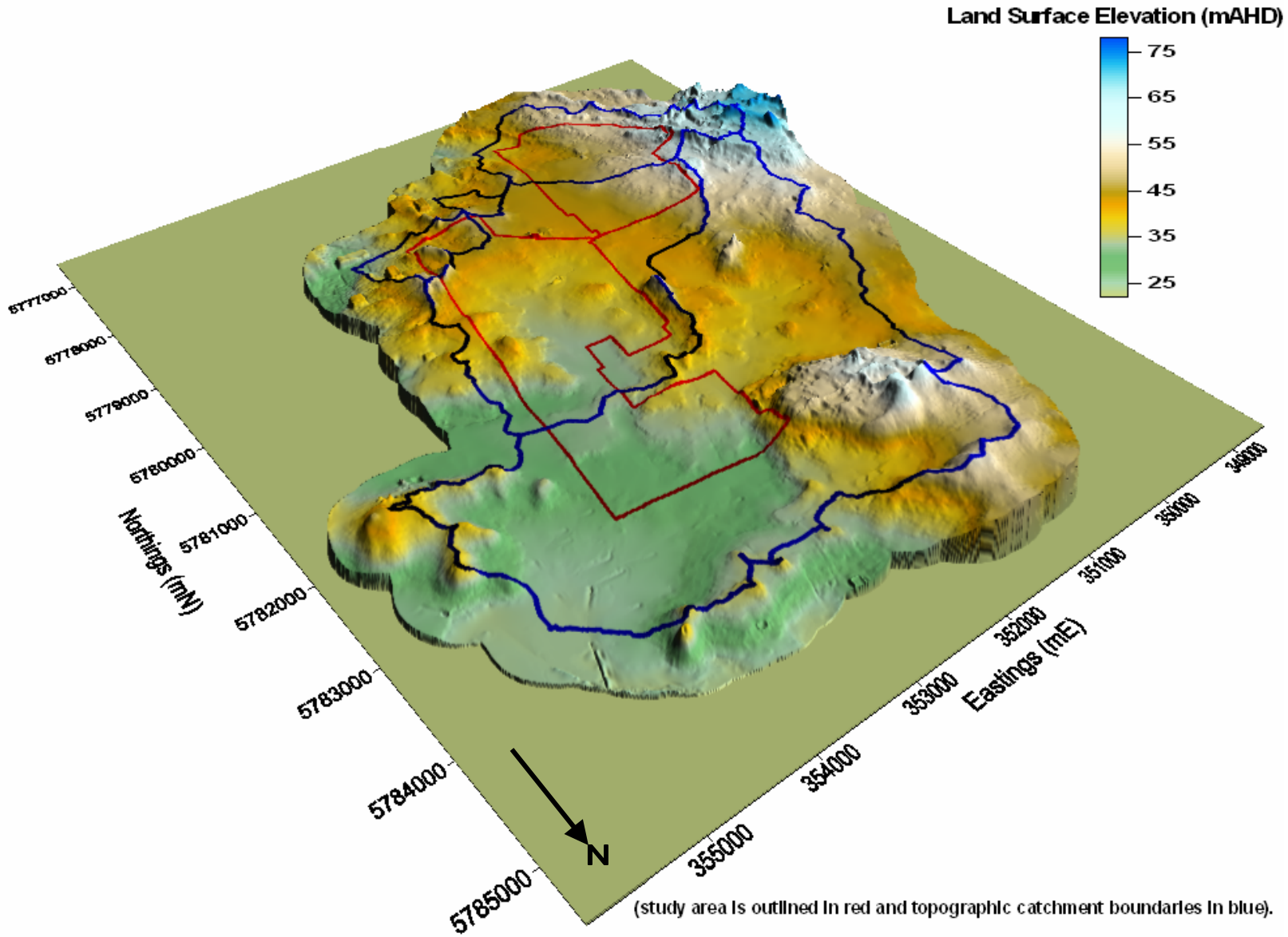


Figure 3 3D Surface Representation of Catchment



3.3 Summary of Geological Units

The near-surface geological units in the area surrounding the Cranbourne East site are shown in Figure 4. The main regional geological units are described below from most recent to oldest (see Queenscliff 1:250,000 Geological Map, Geological Survey of Victoria, 1971).

3.3.1 Quaternary Swamp Deposits

This geological type is labelled **Qm1** and includes swamp, lagoonal and marine deposits; mangrove swamp, salt marsh, clay, silt, peat and mud. This unit tends to include many clay layers and is relatively impermeable.

3.3.2 Quaternary Dunes

This unit is labelled **Qd2**, and comprises calcareous and siliceous sands, dune limestone and sand sheets (includes Cranbourne Sand). Sand units generally have high permeability.

3.3.3 Baxter Sandstone

The Baxter Sandstone is labelled **Nxx** and is described as ferruginous sandstone, sandy clay and ligneous clay. It is an upper Tertiary unit and is expected to be of low to medium permeability at Cranbourne East although this will need to be further investigated. Weathered sandstone can occasionally form sand lenses, porosity in unweathered sandstone is primarily due to fractures.

3.3.4 Older Volcanics

The older volcanics (labelled **Po**) are lower Tertiary basalt – igneous lava flow. Typically basalt weathers to a low permeability black clay and unweathered layers form low permeability fractured rock aquifers.

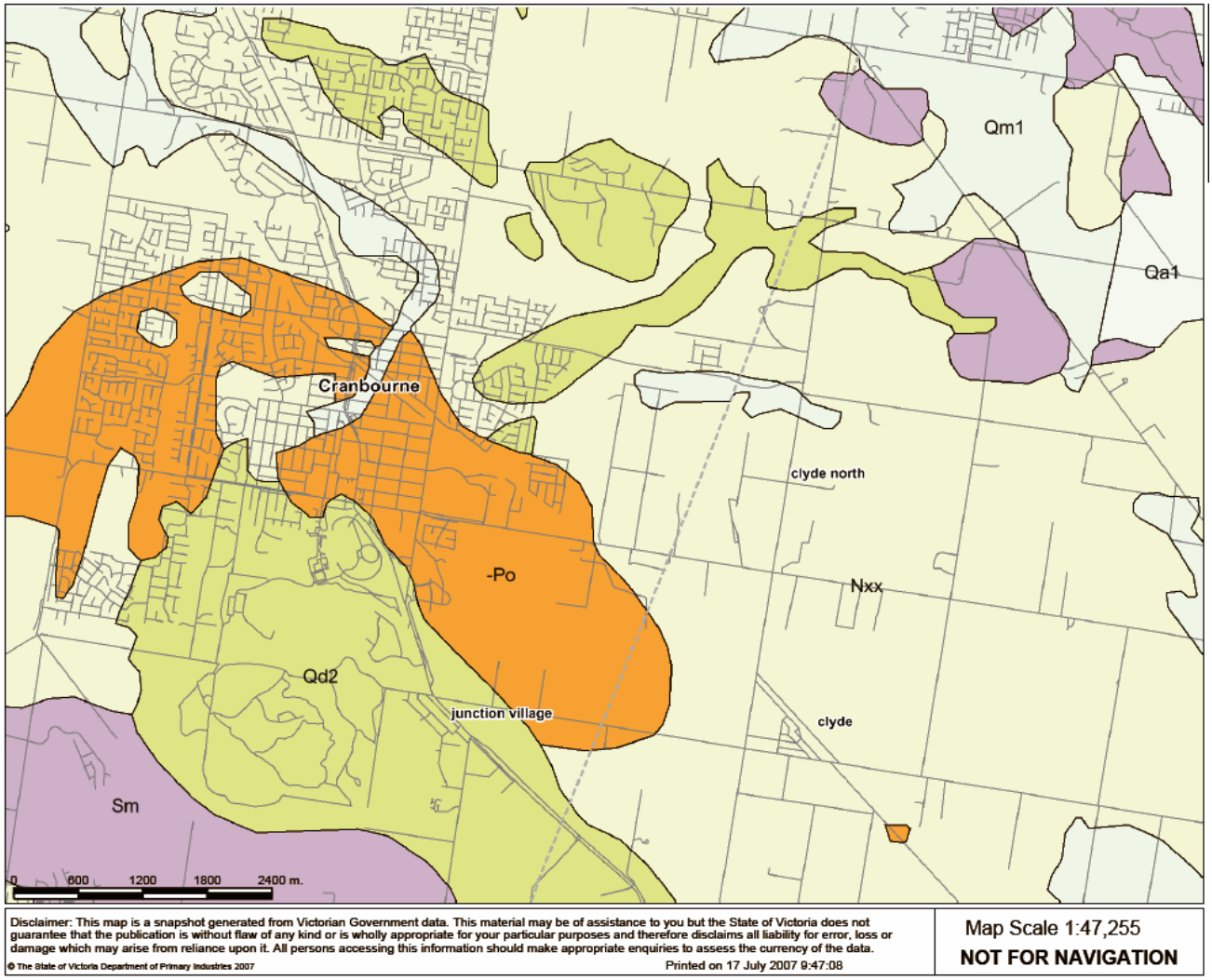
3.3.5 Lower Tertiary geological layers

The Lower Tertiary rock layers often include permeable sands and gravels. They do not occur near the land surface at Cranbourne East and therefore do not appear in Figure 4. If they have the right properties, these permeable rock layers are considered to be good targets for extracting groundwater and for using in aquifer storage and recovery (ASR) projects.

3.3.6 Silurian basement

The Silurian basement (labelled **Sm**), is comprised of mudstone, claystone and sandstone. Typically this unit has low hydraulic conductivity and groundwater flows through a series of fine fractures in a largely impermeable rock matrix.

Figure 4 Overview of land surface geology at the Cranbourne East site (derived from Queenscliff 1:250,000 Geological Map, Geological Survey of Victoria, 1971). Refer to the text in this report for a description of the five relevant geological units shown (Nxx, Po, Sm, Qd2 and Qm1).



4 HYDROGEOLOGY

4.1 Groundwater Flow Systems

The Cranbourne East site includes two groundwater flow systems identified in the report: Port Phillip and Westernport Groundwater Flow systems (Dahlhaus et al., 2004). These are:

- GFS 7: Local and intermediate flow systems in the fractured Older Volcanics
- GFS 10: Local and intermediate flow systems in the Brighton Group sediments (including Baxter Sandstone)

The groundwater flow systems report provides a useful but necessarily generalised context to catchment hydrology within areas of particular GFS types. For example, it is noted that GFS 10 is susceptible to salinity problems in some areas.

Ideally, the groundwater conditions that are local to Cranbourne East should be quantified including the thickness and hydraulic conductivity of all the significant geological layers on site. GFS 7 and GFS 10 are primarily local flow systems with short groundwater flow paths at the Cranbourne East site. This suggests that they would be responsive to management and that volumes of groundwater within the systems are not large.

The GFS approach supports the development of a conceptual hydrological model of the site below.

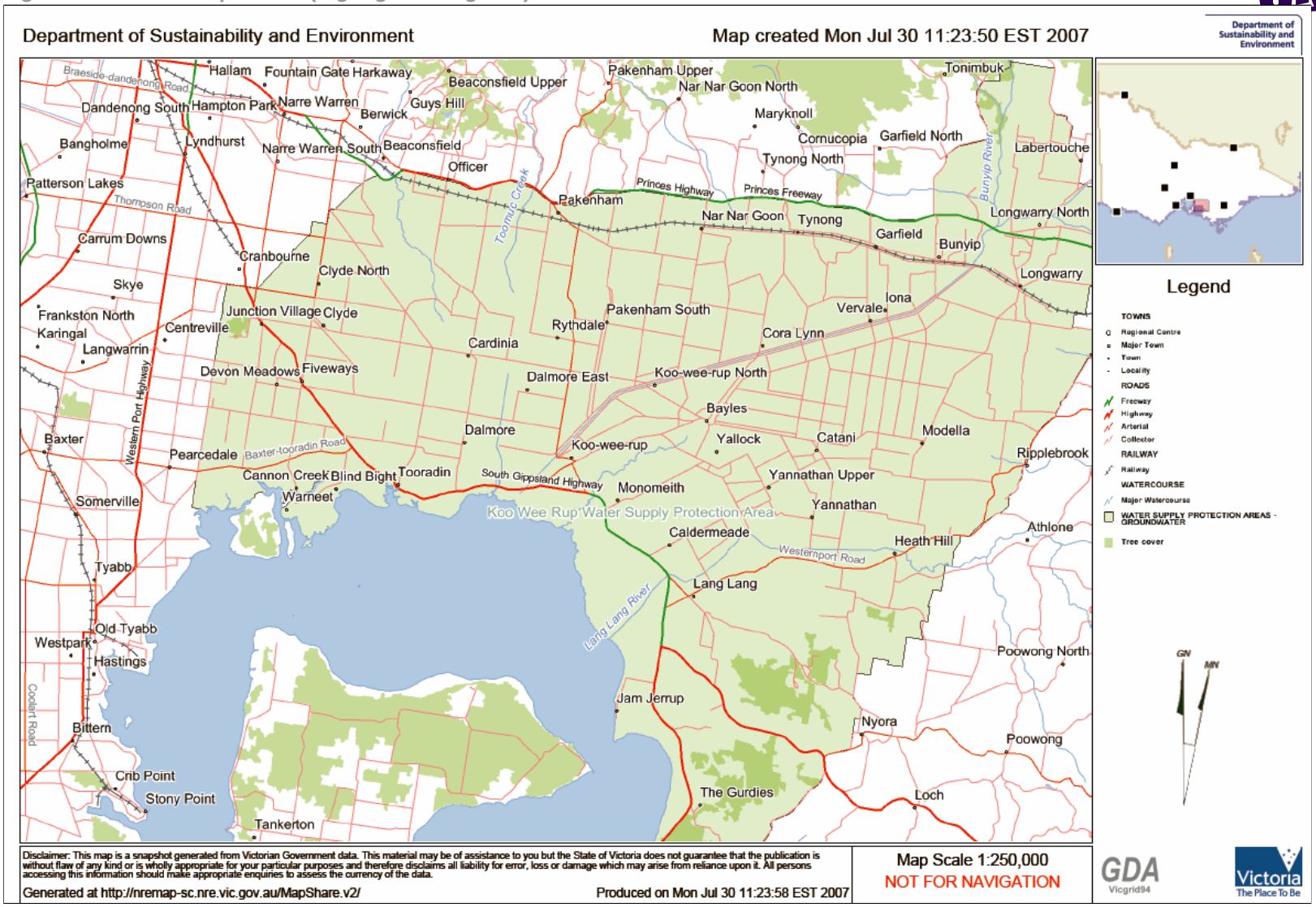
4.2 Koo Wee Rup Water Supply Protection Area

Groundwater is used throughout the region as a supplement or replacement to potable water from the reticulation system and diversions from waterways. It is used for a variety of domestic purposes, for stock watering, crop irrigation and limited industrial applications. Groundwater is a finite resource and as such it is important to ensure it is used sustainably. Extractions from groundwater reserves are managed within a framework called Permissible Annual Volumes (PAV). These are scientifically based estimates of the average volume of groundwater that can be extracted from an aquifer on a yearly basis without exhausting the groundwater resource.

A Water Supply Protection Area (WSPA) is declared when groundwater allocations exceed 70% of the PAV for an area, requiring a legally enforceable Groundwater Management Plan to be developed. The Cranbourne East study area falls within the Koo Wee Rup WSPA, shown in Figure 5. The aim of the plan is to manage the groundwater resources of the WSPA equitably and to ensure the long term sustainability of the resource. An extensive consultative process guarantees that groundwater users have a major input into the development of the Groundwater Management Plan for their area. A Ministerial appointed Consultative Committee which represents all relevant interests prepares the Plan. In an area where farming predominates, farmers who own or occupy farming land in the area must comprise at least half of the membership of the committee.

The Permissible Annual Volume (PAV) for the Koo Wee Rup WSPA is 13,550ML per year. Currently 95% of the 13,550ML is allocated to licensed users for purposes such as irrigation, commercial or industrial. Bores that are used solely for stock and domestic purposes are exempt from groundwater extraction licensing requirements but are required to be registered.

Figure 5 Koo Wee Rup WSPA (highlighted in green)



4.3 Observed Groundwater Levels

There are only three groundwater bores in the area surrounding Cranbourne East with recorded time series of groundwater levels. The bores locations are shown in Figure 6.

The time series groundwater levels recorded over the period 1987 to 2007 are shown in Figure 7. Bores 57176 and 91075 show a general rise in level up until 1996, then from 1996 - 2007 bores 91075 and 126975 show a general decline in groundwater level. These changes are likely to be a muted response to climatic variations over the period. Climatic variations represented in Figure 8 show the variation in cumulative residual rainfall over the period. Comparison by eye suggests the variation in groundwater level in the three bores (Figure 7) follows a similar temporal pattern to cumulative residual rainfall confirming the climatic response of groundwater levels in these bores.

The usual practice for preparation of a spatial map of depth to watertable or groundwater level data across a site is to select a short time period in which data must be recorded and a particular geological layer that all groundwater levels are recorded within. This approach is not strictly followed in this report as explained in the following.

Below, we have collated a composite data set including all available groundwater level measurements to increase the spatial coverage of data. As most bores are shallow the assumption is made that the groundwater levels indicate the depth to watertable. (This may not always be the case, as a clay-rich layer at or near the land surface can confine an underlying aquifer and reduce the correspondence between the measured groundwater potential in the aquifer and the depth to watertable as observed in a soil profile.)

The measurements include single measurements of depth to watertable made at the time of bore construction and measurements made at all depths. Where more than one measurement of depth to watertable has been made at a bore, the most recent recorded depth to watertable is used. The data set generated in this way has poor quality control and does not represent conditions on any particular date, but is useful in providing an overview of observed conditions across the site.

Figure 9 shows the measurement points and an interpolated depth to watertable surface. It shows that a significant area of the Cranbourne East study area has a watertable at a depth less than 2 metres. There is a low density of measurement points to the north of the study area and it has been noted in this area that one measurement point in particular may not be relevant to the watertable surface but was included anyway. It should be noted that there is no close correspondence between the implied depth to watertable in Figure 1 and Figure 9 – they represent outputs from investigations at completely different scales. Furthermore Figure 1 represents the risk of shallow watertables occurring over a period of 100 years or more whereas Figure 9 represents conditions at a single time.

Figure 10 illustrates the groundwater elevations across the study area. It suggests that the groundwater flows from a higher elevation in the west to a lower elevation in the east of the study area.

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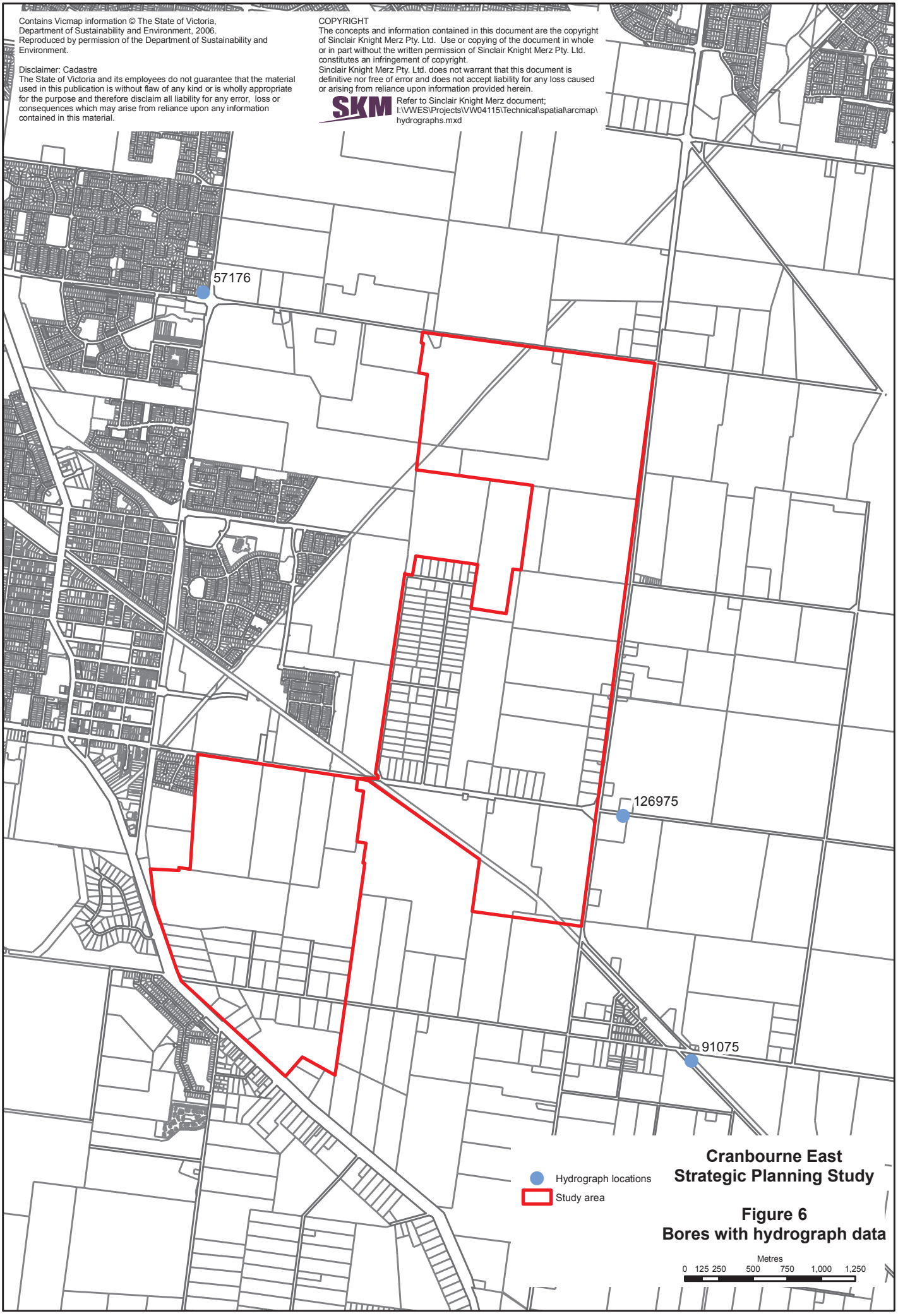


Figure 7 Groundwater bore hydrographs.

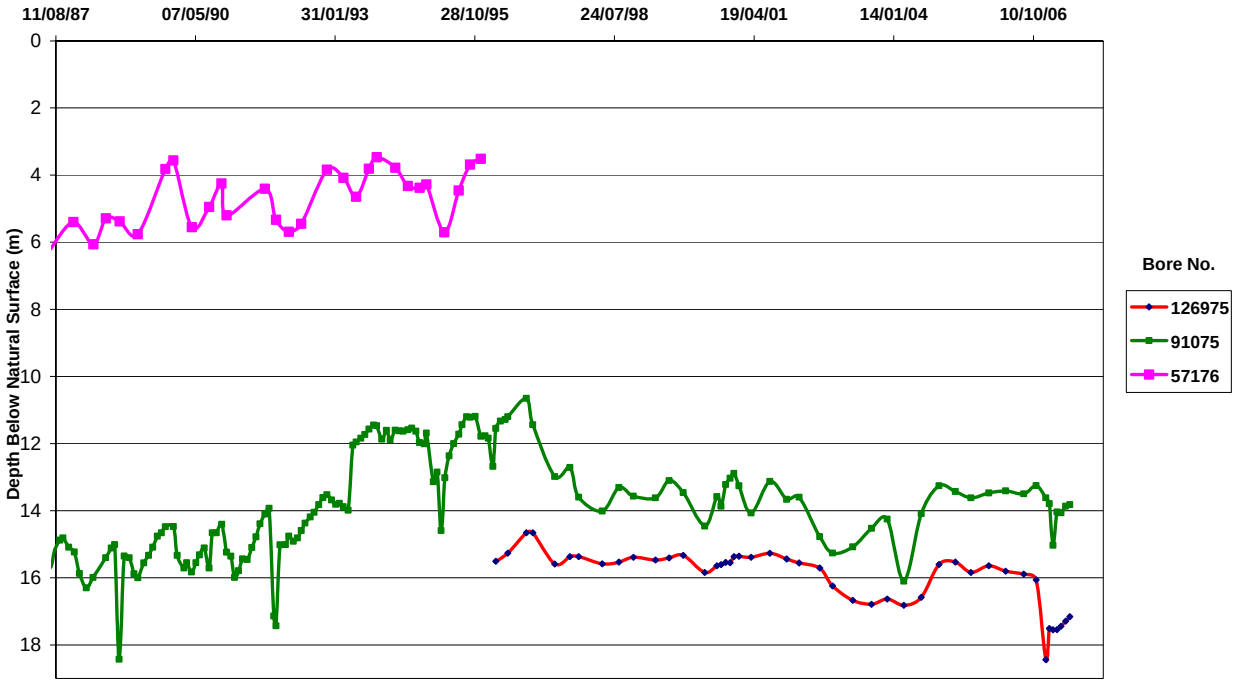
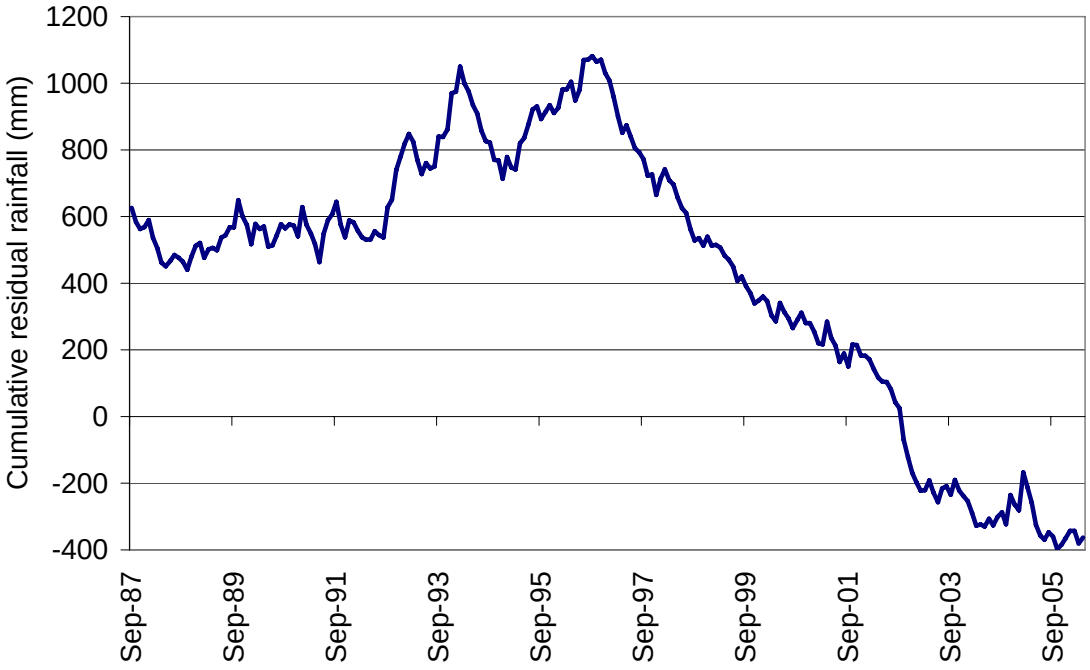


Figure 8 Cumulative residual rainfall at Narre Warren (station number 86085) over the period of the bore hydrograph record.



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Watertable depth (m)
- < 2
- 2 - 5
- 5 - 10
- 10 - 20
- > 20
- Subject to inundation

Bore location
Study area

Cranbourne East Strategic Planning Study

Figure 9
Watertable depth

Metres
0 125 250 500 750 1,000 1,250

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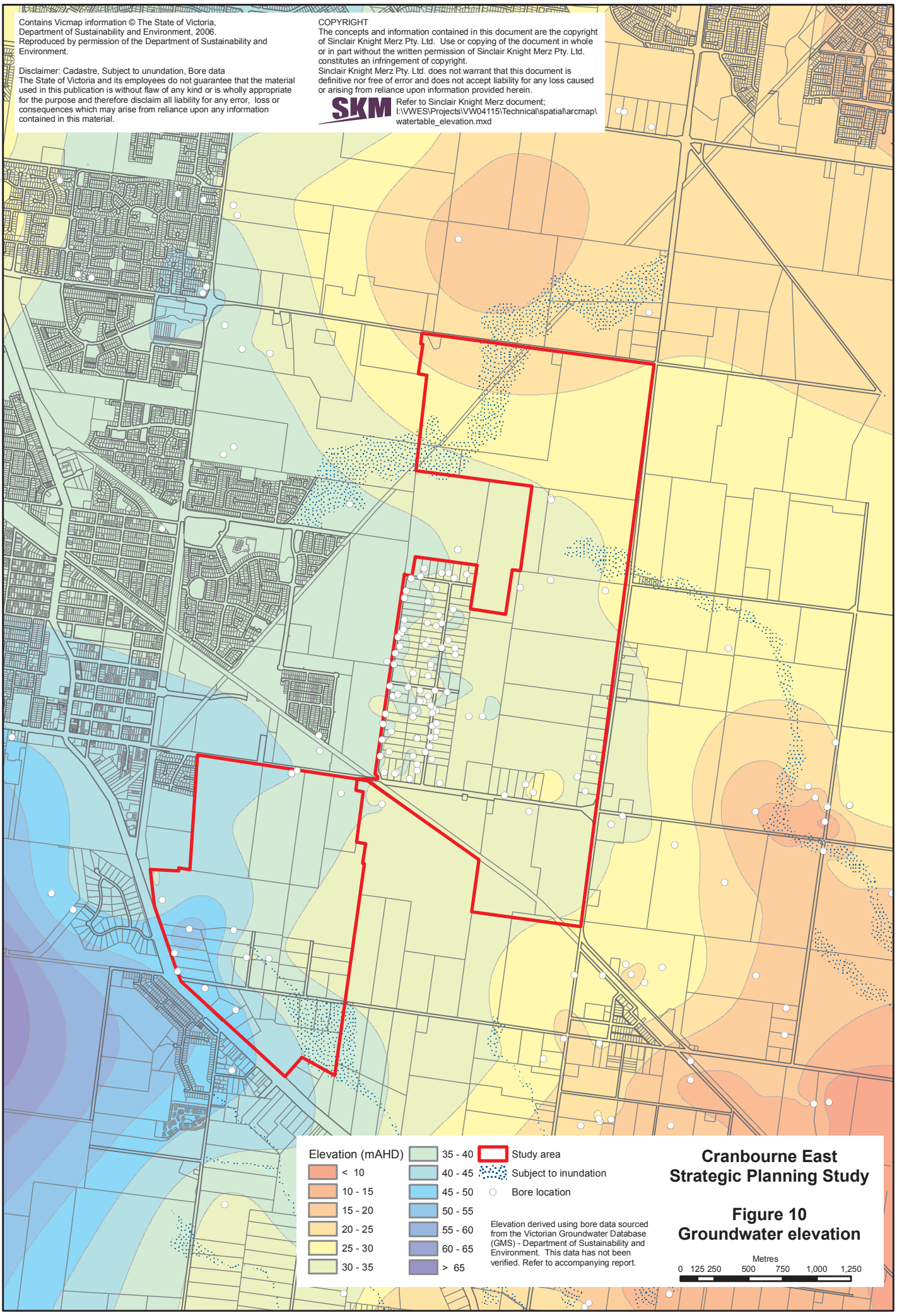


Cranbourne East Strategic Planning Study

Figure 10
Groundwater elevation

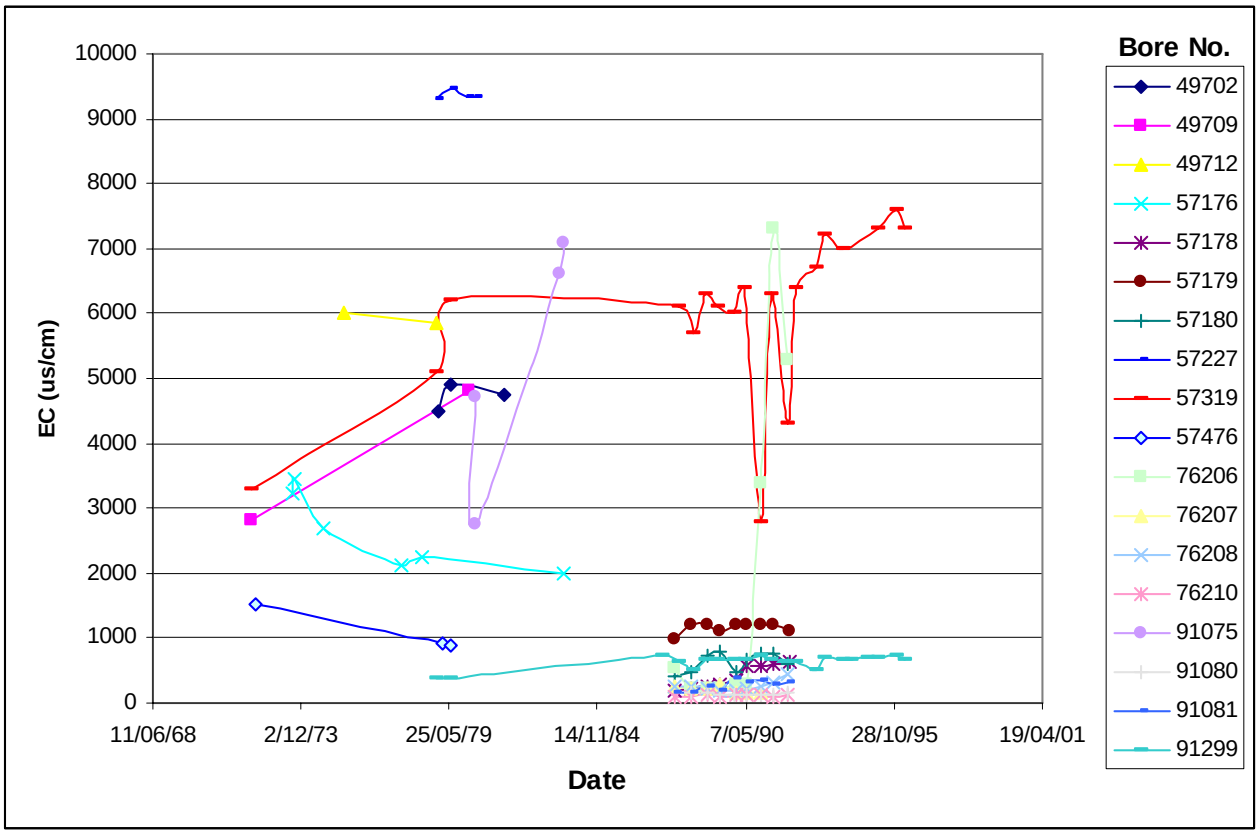
4.4 Groundwater Salinity

The State Groundwater Database (GMS) includes some time series for groundwater salinity in the area surrounding Cranbourne East (Figure 11). The available data at different bores are often recorded years apart and do not provide a consistent record.

There are a number of factors that should be considered when evaluating data for groundwater salinity. These include the date of measurement, the geological layer from which the groundwater is sampled and the regularity of measurements.

However, in order to increase the spatial coverage of groundwater salinity data in this report we have included all available salinity measurements. These include single measurements of salinity made at the time of bore construction, measurements made at any date since 1973 and measurements made at all depths. Where more than one measurement of groundwater salinity has been made at a bore, an average salinity value is calculated (i.e. for the bores shown in Figure 11). The data set generated in this way has poor quality control and does not represent conditions on any particular date, but is intended to be useful in providing an overview of the order of magnitude of groundwater salinity in the study area and may also highlight areas where high salinity values could be further investigated. The data set is presented in Figure 12.

Figure 11 Time series of groundwater salinity recorded around the Cranbourne East site.



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KOOWEERUP WATER SUPPLY PROTECTION AREA

Salinity derived using bore data sourced from the Victorian Groundwater Database (GMS) - Department of Sustainability and Environment. This data has not been verified. Refer to accompanying report.

Sailty divisions are from the State Environment Protection Policy (SEPP) - Groundwaters of Victoria

- Study area
- Koo Wee Rup WSPA
- Bore location

Salinity (TDS)

- < 500
- 500 - 1,000
- 1,000 - 3,500
- > 3,500

Cranbourne East Strategic Planning Study

Figure 11
Groundwater salinity

Metres
0 125 250 500 750 1,000 1,250

5 CONCLUSIONS

5.1 Context

The conclusions of the Groundwater and Salinity Assessment at Cranbourne East are summarised below. The preceding sections of this report provide important context to the following statements. Note that all conclusions are subject to further investigation, assessment and validation.

5.2 Conclusions

The following conclusions are made from data sets that reflect the current conditions of catchment hydrology at Cranbourne East.

- The Cranbourne East study area spans across two major drainage basins, Port Phillip and Westernport. A northern subcatchment drains to Port Phillip, while three southern subcatchments drain to Westernport. The land surface slopes at a gradient of about 1:100 across the catchment study area.
- Small pockets of higher permeability geological units occur (Figure 4): Quaternary Dune sands and near-surface sands.
- In general the geological units are of low permeability (Silurian bedrock, Quaternary swamp deposits, Older Volcanics (weathered and fresh) and unweathered Baxter Sandstone).
- Junctions of sand units and low permeability units may provide conditions for shallow watertables to develop.
- Groundwater is expected to flow from the west to the east of the study area. Some higher permeability sand layers may provide pathways for groundwater flow but these layers have a limited spatial extent and terminate in less permeable basalt and sandstone.
- Areas prone to shallow watertable conditions (depth to watertable <= 2 m below surface) occur in a number of locations on the site.
- The majority of the study area falls within the Koo Wee Rup WSPA.
- Groundwater salinity is low over most of the study area. Slightly higher groundwater salinities to the eastern boundary do not appear to be associated with sites where shallow watertables occur.
- Groundwater bore hydrographs show a response to variations in rainfall.

5.2.1 Groundwater Constraints to Urban Development

The groundwater constraints investigation (SKM, 2005) considered a large area extending from Cranbourne West at the western edge to Bunyip in the east. Most of this area lies within the Westernport Basin and has large upstream catchments that can affect the water balance and the watertable at any site. The method used by SKM (2005) was intended to be applied at a regional scale and necessarily made some generalisations about the nature of groundwater systems. In contrast to the larger region, the Cranbourne East site lies in four small catchments with small upstream areas. The groundwater systems are local and generally of low permeability. In light of the results of this report and subject to further investigation, it is considered that the risks to urban development may not be as severe as described by SKM (2005).

5.2.2 Implications for development at Cranbourne East

The current catchment conditions do not appear to preclude any current land use within the Cranbourne East study area (e.g. residential dwellings and major roads are present). Furthermore, guidelines for appropriate construction of buildings, roads, and services exist for a range of different environments (including shallow saline watertables – for examples see Western Sydney and Wagga Wagga).

However, the catchment hydrology will change with development of Cranbourne East. In areas currently with a shallow watertable it is recommended that development aims to avoid land uses/management that could promote or create shallow watertable conditions (see table below). Figure 13 is developed from Figure 9 and shows the areas in which planning should take account of shallow watertable conditions.

The table below presents the causes of shallow watertables and some recommendations for management options.

Threat:	Shallow watertables resulting in: waterlogging, land salinisation (in the long term), reduced life span of foundations/roads/services
Potential causes:	Shallow watertables occur where groundwater flow into an area exceeds groundwater flow out of the area. The Cranbourne East development should avoid increasing net groundwater flow into these areas. Factors to consider include the following: - irrigation of urban gardens, - runoff from impervious surfaces increasing infiltration in some areas, - leakage of reticulation system (the risks of leakage are likely to increase with the presence of an additional 'third pipe' system).
Pre-emptive management options	- minimise risks of increased net groundwater recharge * non-residential land use * increased tree canopy cover * reticulation systems constructed to higher standard within these areas to minimise leakage - install subsurface drainage system - use area as 'green space' with high tree canopy cover or other 'low net recharge' option (possibly an impervious surface with subsurface drains) - extraction and use of groundwater within development

Extraction and use of groundwater may be an opportunity for management to reduce the risk of shallow watertables in Cranbourne East. The nature of the groundwater system may be suited to this sort of management and it should be further investigated. It is expected that if groundwater use is feasible, only low volumes of groundwater would be expected to be available on a long term basis, as the site is part of the Koo Wee Rup WSPA.

It should be noted that other parts of the Cranbourne East study area may be susceptible to shallow watertable conditions, in addition to the areas shown in Figure 13. Further investigations may locate additional areas with requirements for particular land uses or land management.

Long term monitoring of groundwater conditions in critical locations would improve understanding of the groundwater system and provide warning of rising watertable conditions.

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SKM

Refer to Sinclair Knight Merz document;
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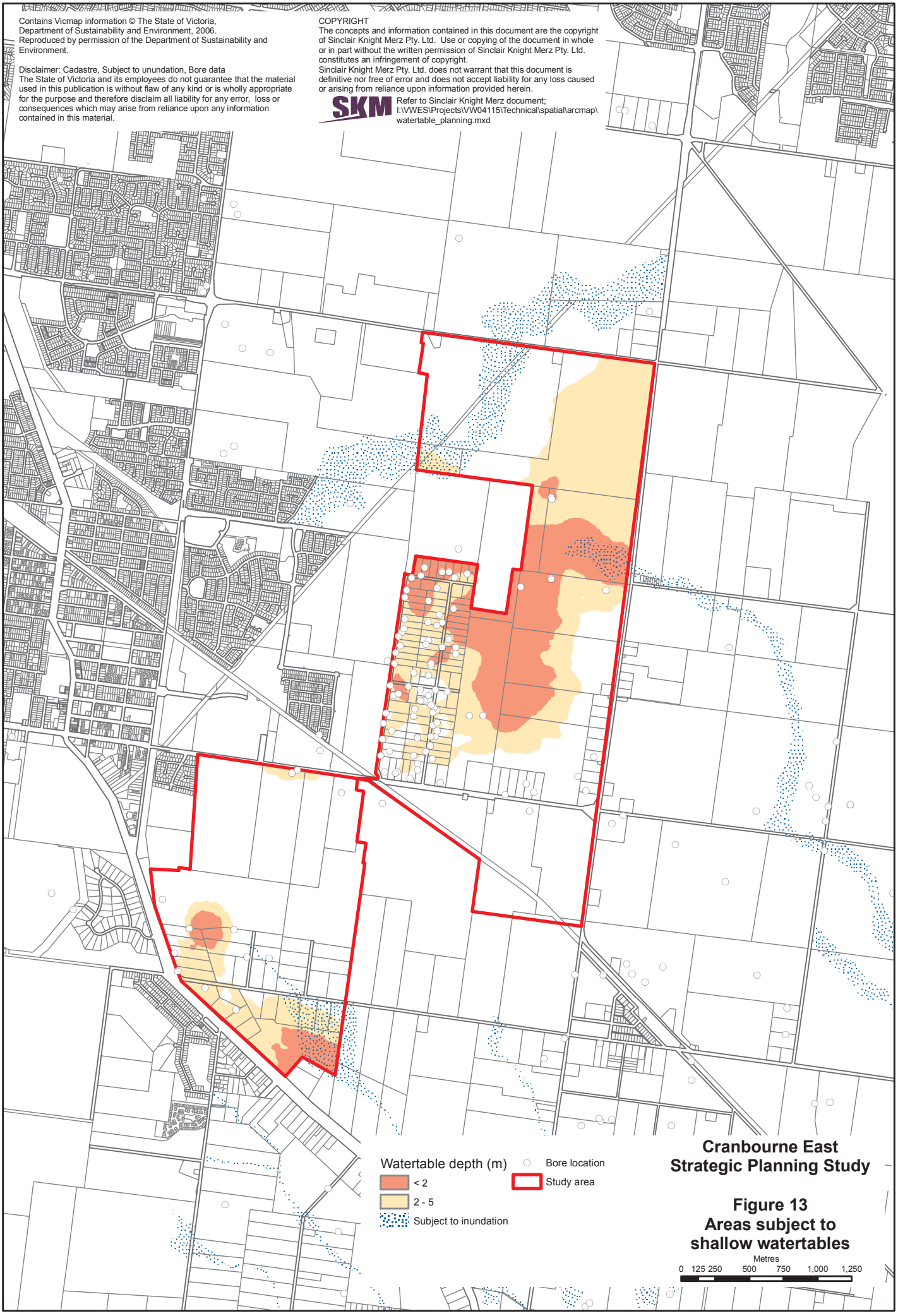

Cranbourne East Strategic Planning Study

Figure 13
Areas subject to shallow watertables

6 RECOMMENDATIONS

If more detailed and site specific information is required at Cranbourne East some possible future investigations are as follows.

- Development and testing of a hydrogeological “conceptual model” for example:
  - Monitor groundwater levels at multiple existing wells to validate the shallow watertable areas estimated by this report and illustrated in Figure 13.
  - drill groundwater bores to Silurian basement;
  - measure aquifer hydraulic parameters (‘slug’ tests) in sandstone, basalt and possibly other units
  - investigate groundwater flow paths with shallow observation bores
- Investigate the opportunities for stormwater management to enhance groundwater recharge (ASTR). Subsequent harvesting and use of an enhanced groundwater supply is likely to be beneficial to the environment and improve water use efficiency of the development.
- Investigate the potential effects of increased infiltration from water sensitive urban design on the water balance and groundwater conditions
- Further investigate areas of Cranbourne East that may be subject to shallow watertable problems and groundwater management options.

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