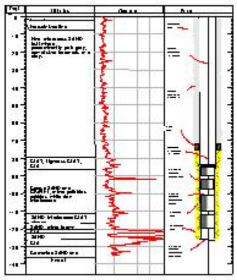
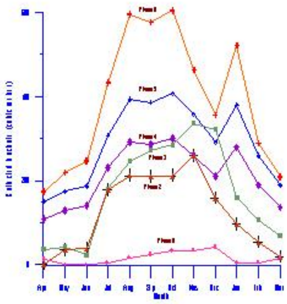
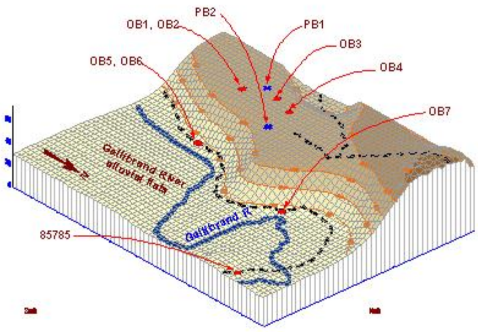
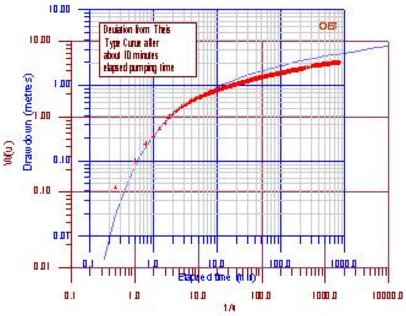
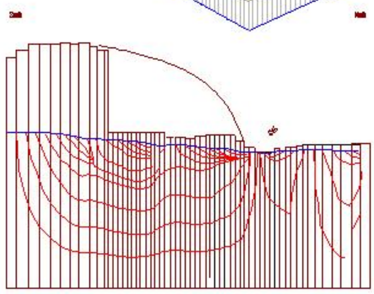
URBAN DEVELOPMENT INVESTMENTS AUSTRALIA

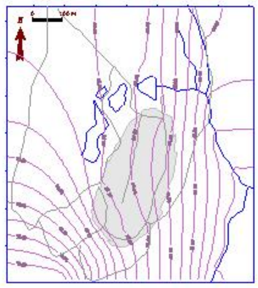












HYDROGEOLOGICAL ASSESSMENT BROMPTON LODGE ESTATE, 980-1050 WESTERN PORT HIGHWAY, CRANBOURNE SOUTH

May 2013 Ref. No.: GW-13/017

JOHN LEONARD CONSULTING SERVICES

Groundwater and Environmental Consultants

JOHN LEONARD CONSULTING SERVICES Pty Ltd
ACN082316890

28 Mernda Avenue
Carnegie VIC 3163
Tel/Fax: (03) 9569 2625
e-mail: jleonard@bigpond.net.au

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1.0 INTRODUCTION

JOHN LEONARD CONSULTING SERVICES (JLCS) was engaged by Watsons Pty Ltd (Watsons) on behalf of Urban Development Investments Australia Pty Ltd to prepare a Hydrogeological Assessment of the proposed Brompton Lodge residential development at 980-1050 Western Port Highway, Cranbourne South.

1.1 BACKGROUND

The Hydrogeological Assessment was undertaken to 1) ascertain groundwater conditions, 2) identify groundwater related hazards or potential hazards and possible impacts on the proposed development, 3) to assess potential impacts of the development on groundwater, and 4) to assess the sustainability of maintaining dwarf galaxias populations after the site is subdivided.

Urban Development Investments propose to develop land at 980-1050 Western Port Highway, Cranbourne South as a residential subdivision. The proposed development site is located about 45 km south-southeast (SSE) of the Melbourne Central Business District (Figures 1.1 and 1.2). The site is trapezoidal shaped and is bounded by Cranbourne-Frankston Road (east) and Dandenong-Hastings Road (west). The site's northern boundary trends along the proposed extension of Bullarto Road (Figure 1.2). The proposed development site includes land described as PS331597, TP133266, TP329796, TP371251, TP375573 and TP529244 (Figure 1.3).

The majority of the proposed Brompton Lodge development site is used for cattle grazing and fodder crop production. Parts of the site are used for poultry farming, and agistment and pre-training of thoroughbred race horses (Figure 1.4). A large part of the site was used for sand extraction under Works Authority WA121 issued by the Department of Primary Industry. A number of former pits and spoil heaps are present on the property. [Some pits appear to be outside of the boundary of WA 121; this could be because the boundary plotted on DPI GeoVic Explore Victoria online interactive website was incorrect or extraction actually occurred beyond the Work Authority boundary.]

1.1.1 Hydrogeological Assessment and Salinity Management

Groundwater can contribute to water logging and salinity problems which may require modification to development plans and/or require engineering works to mitigate potential groundwater related problems. In addition residential developments have the potential if not properly designed to adversely impact on the beneficial uses of local groundwater resources. Groundwater is now recognised as a crucial component of Water Sensitive Urban Designs. Knowledge of near surface geology, depth to the water table and local groundwater quality is important for designing waterways and wetland features including wetland treatment systems.

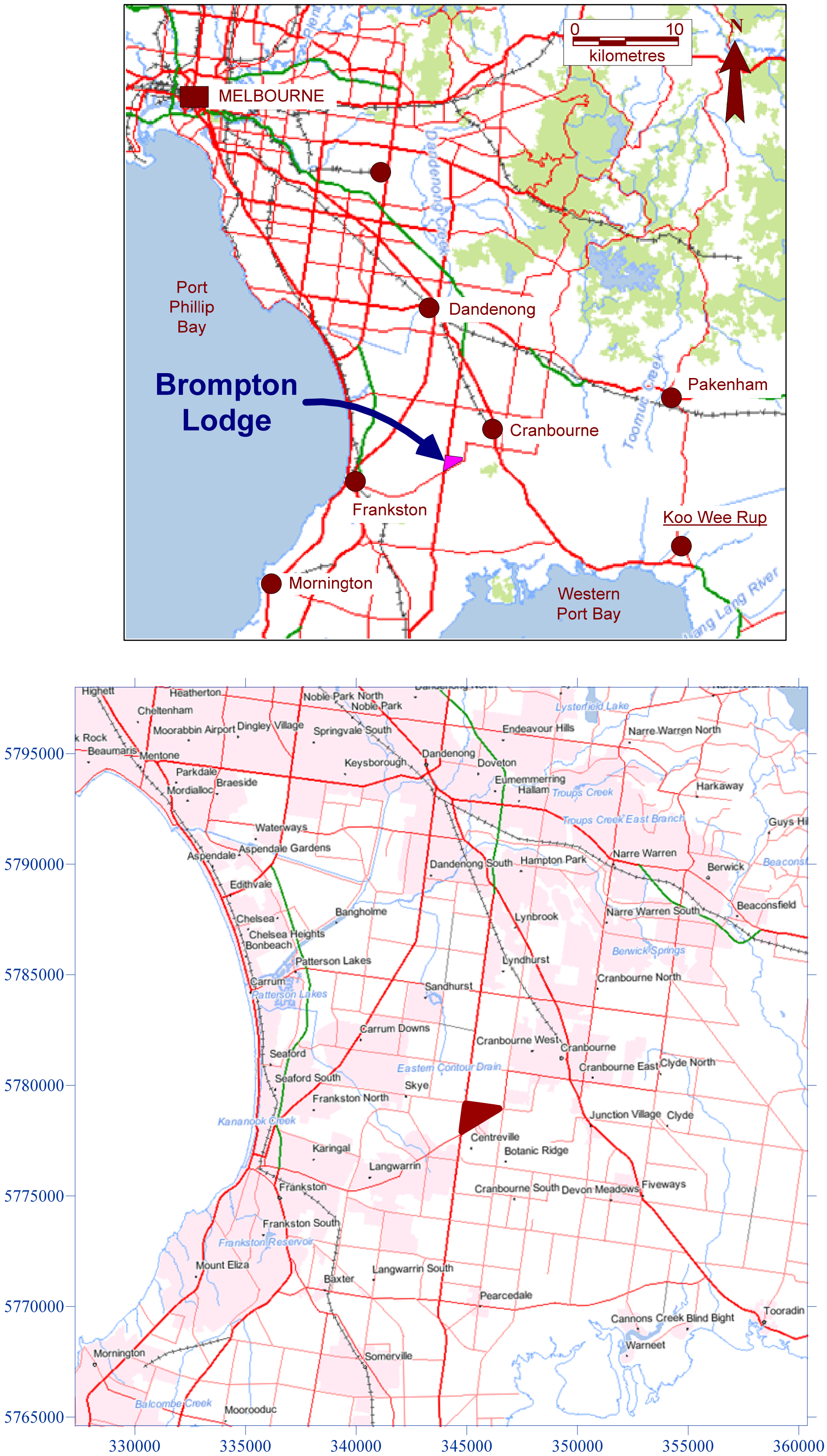


FIGURE 1.1 Brompton Lodge General Location

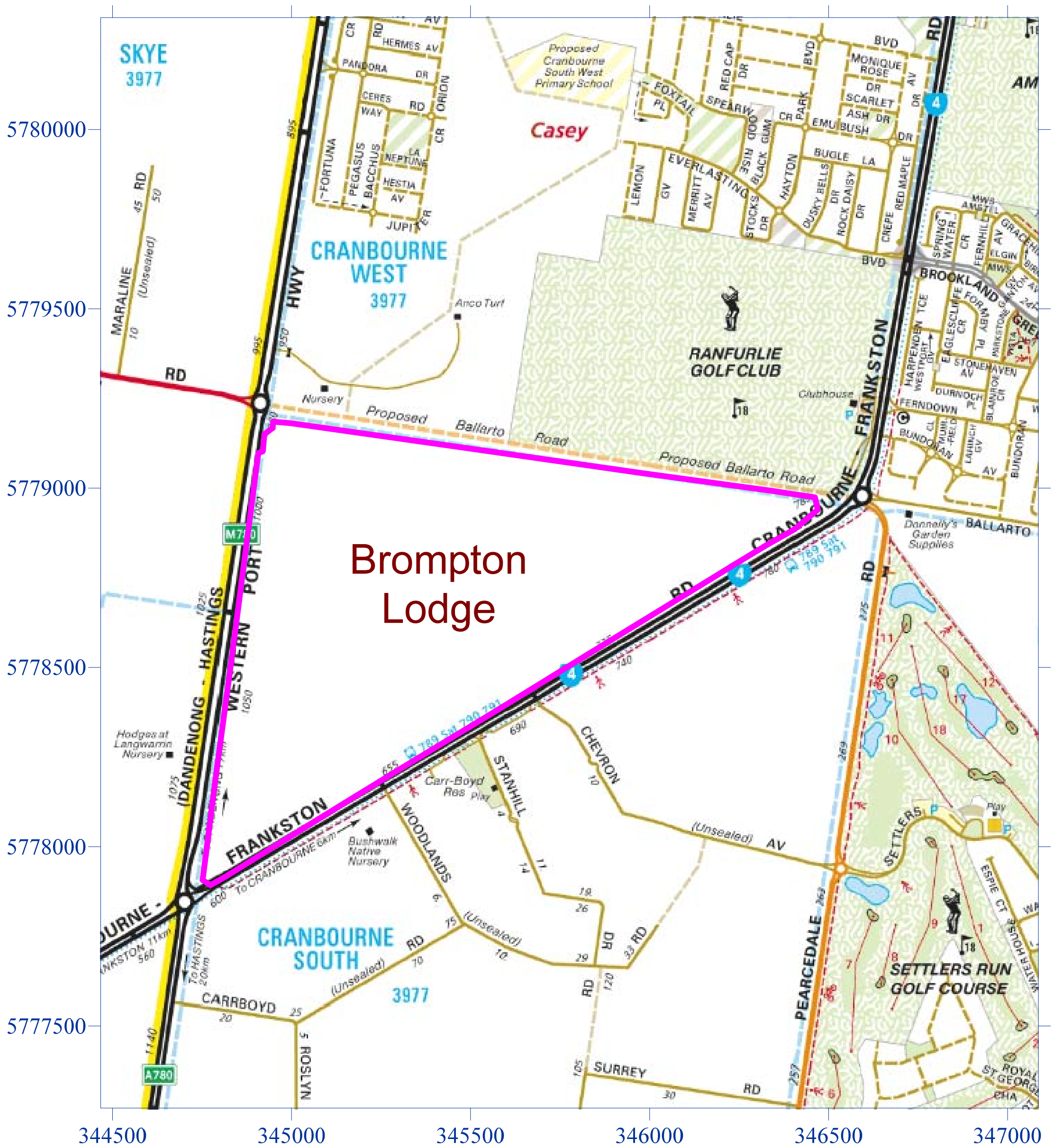


FIGURE 1.2 Brompton Lodge Site Location

1.1.2 Dwarf Galaxias Habitat

A population of dwarf galaxias, a nationally threaten fish species, were identified in two interconnected ponds in former sand pits at Brompton Lodge during a field surveys by J McGuckin, Streamline Research Pty Ltd (McGuckin, 2008, 2011). The locations of the ponds are shown in Figure 1.6. The dwarf galaxias is considered of national significance and is listed as vulnerable under the Environment Protection and Biodiversity Conservation (EPBC) Act, 1999. In Victoria, the dwarf galaxias is considered a threatened species by the Department of Sustainability and Environment (DSE, 2007) and is listed for protection under the Flora and Fauna Guarantee Act, 1988 (McGuckin, 2011).

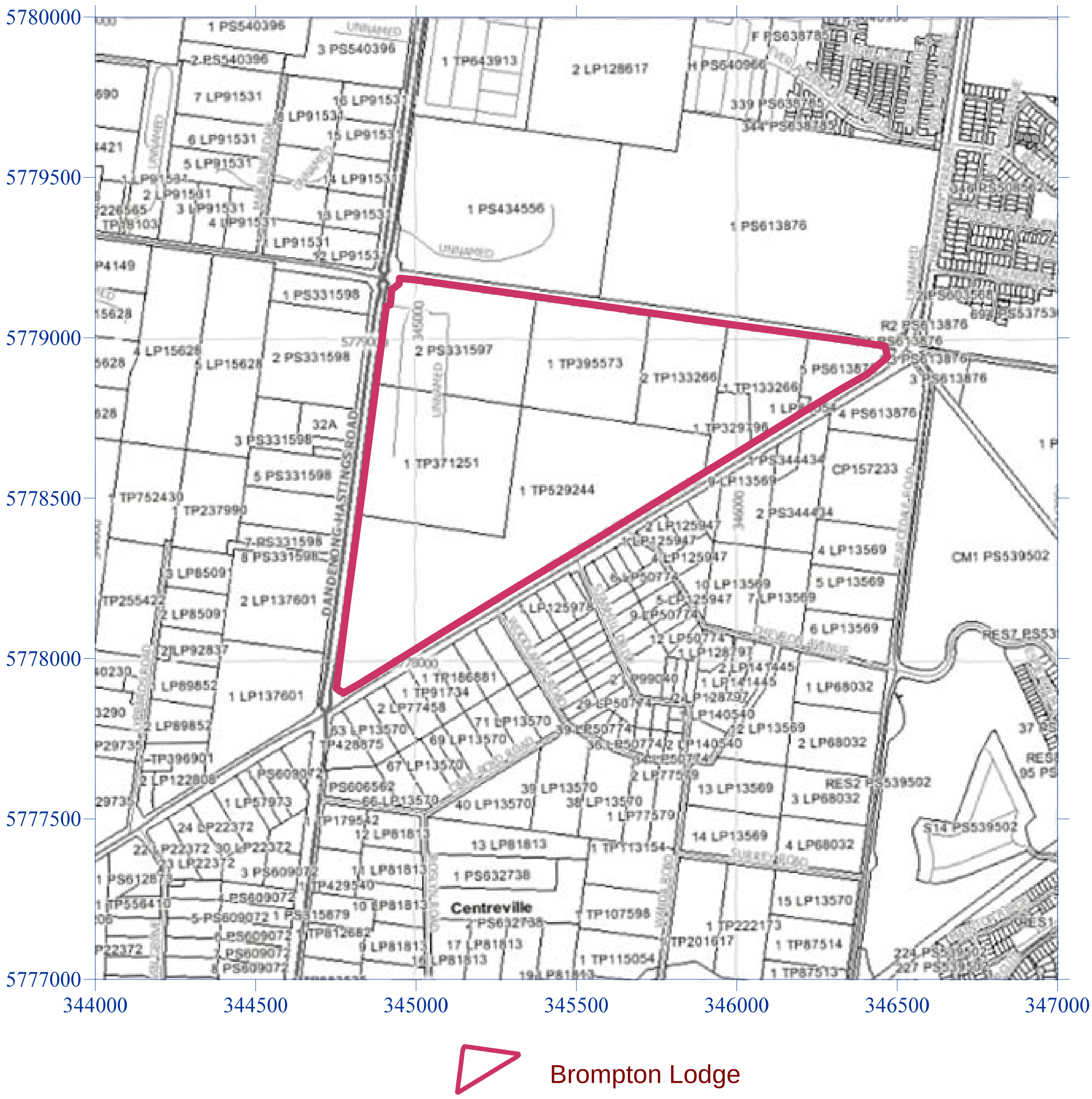


FIGURE 1.3 Brompton Lodge Land Parcels

The dwarf galaxias habitat ponds are located in former sand extraction pits which are not natural habitats but are man-made water storages. McGuckin (2011) considered that the dwarf galaxias were introduced into the ponds during flooding events.

Provision of a sustainable habitat for the dwarf galaxias is a requirement for the proposed Brompton Lodge development. A Conservation Management Plan for dwarf galaxias has been prepared by John McGuckin, Streamline Research (McGuckin, 2013). The plan includes development on a new habitat pond. The relationship of the surface water in the proposed habitat pond to local groundwater is assessed as part of the Hydrogeological Assessment report.

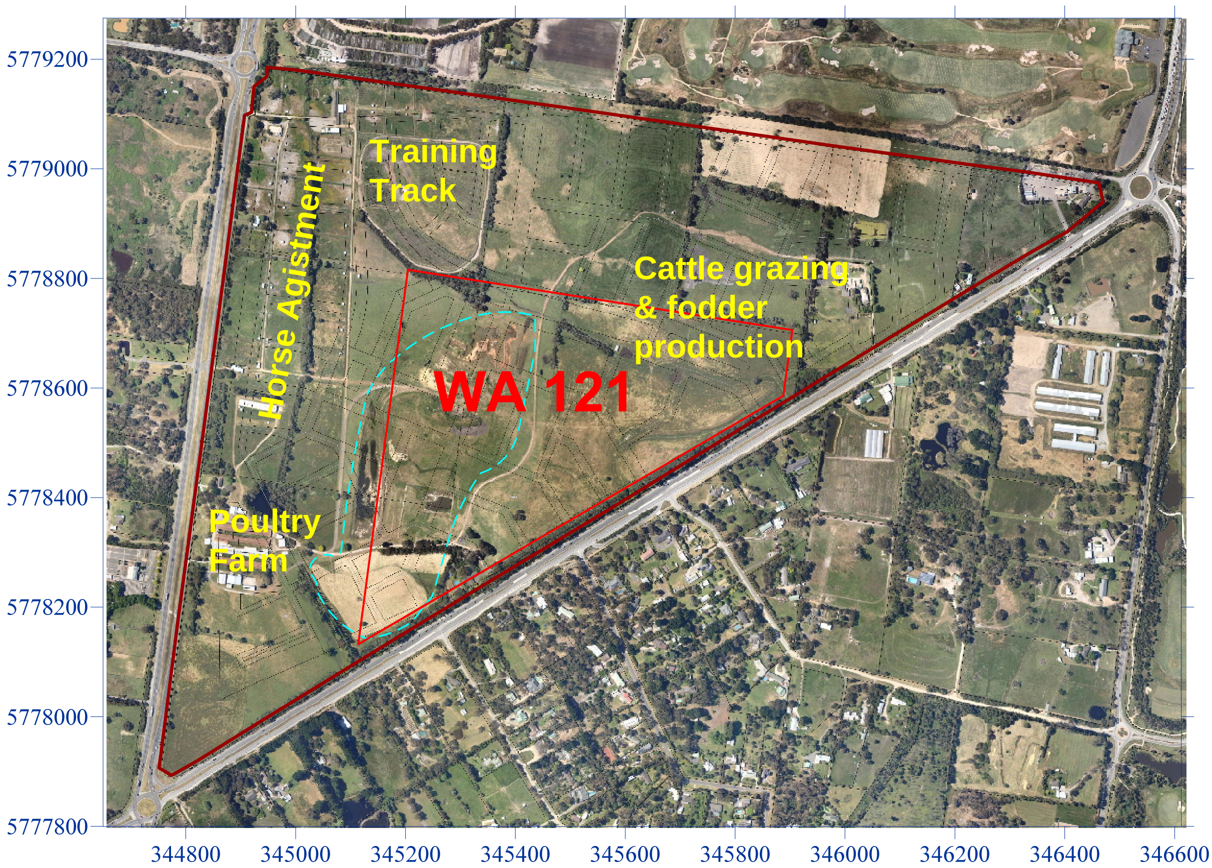


FIGURE 1.4 Brompton Lodge Land Uses

FIGURE 1.5 WA 121 Area Boundary (GeoVic Explore Victoria website)

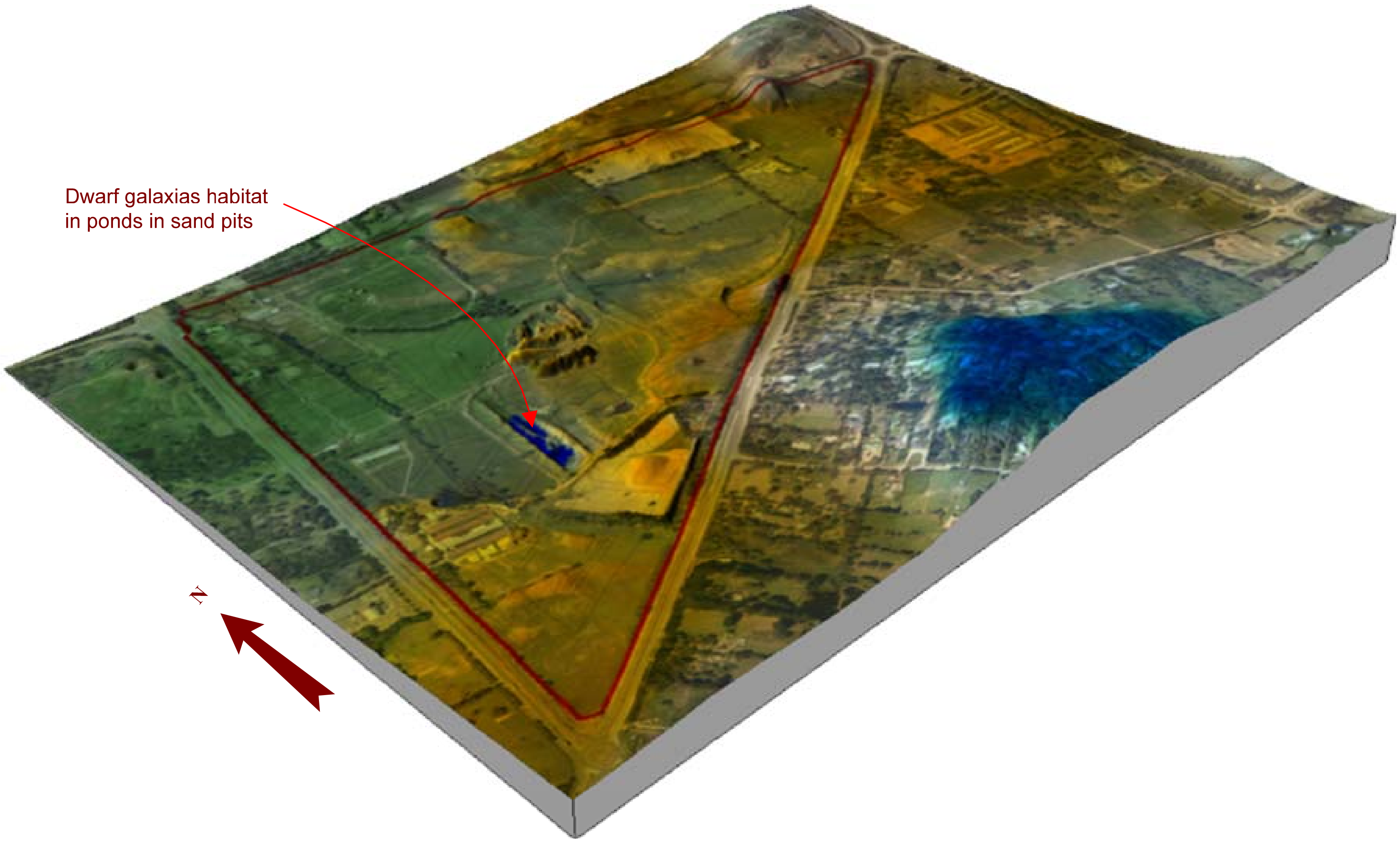


FIGURE 1.6 Brompton Lodge Satellite Image Draped Over Digital Elevation Model

1.3 GROUNDWATER INVESTIGATIONS

Extensive groundwater investigations have been undertaken at Brompton Lodge to ascertain the hydraulic relationship between water in the ponds and local groundwater, and to identify any groundwater relation measure that could be implemented to protect the dwarf galaxias habitat. The field investigation included installation of a network of monitoring bores, measuring groundwater levels and chemistry, and surveying the elevation of the base of the identified dwarf galaxias habitat ponds.

A total of 25 bores have been installed on the property. Seventeen bores were installed during December 2007 by URS (URS, 2008); bores were installed during July 2011 by JLCS to enable more accurate mapping of groundwater around the dwarf galaxias habitat ponds. Coffey installed an additional five monitoring bores during January 2013 as part of a Phase 2 Environmental Site Assessment.

The base of the habitat ponds was also surveyed by Watsons to enable determination of the depth of the standing water in the ponds and comparison of the elevation of the free water surface in ponds with surrounding groundwater to ascertain whether the ponds are feed by groundwater inflow (hydraulic gaining ponds) or whether water escapes through the floor of the ponds (hydraulic losing ponds).

1.4 INFORMATION SOURCES

This report documents the hydrogeology of the Brompton Lodge site and surrounding area with emphasis on groundwater occurrence, potential for urban salinity to develop, and designing site features including wetlands (by Neil Craigie & Associates) and ponds for relocated dwarf galaxias habitat.

Information used in preparing the Hydrogeological Assessment report was obtained from a number of sources including site-specific investigations. Key data sources include:

- State groundwater data bases.
- GEDIS geological data base (managed by the DPI).
- GSV Victoria seamless geological maps.
- Published hydrogeological reports and papers (Hancock and Kenley, 1967; Thompson and Harris, 1972; Hancock, 1992; Leonard, 1979, 1982, 1988, 1992; 2003, 2006).
- Preliminary site groundwater investigations by URS. [Groundwater Assessment Proposed Brompton Lodge Residential Development. Draft report prepared for Watsons Pty Ltd by URS, February 2008.
- Site feature survey data provided by Watsons.
- Phase 2 Environmental Site Assessment Brompton Lodge Redevelopment 980-1050 Dandenong-Hastings Road, Cranbourne South, Vic. Draft report prepared for Watsons Pty Ltd by Coffey Environments, March 2013.
- Monitoring data from purpose installed on-site monitoring bores.
- Fish survey of Brompton Lodge Precinct Cranbourne South. Report prepared for Watsons Pty Ltd John McGuckin, Streamline Research Pty. Ltd, April 2011.

- Hydrogeological Assessment Dwarf Galaxias Habitat, Brompton Lodge, 955 Cranbourne-Frankston Road, Cranbourne West. Report prepared for Watsons Pty Ltd by John Leonard Consulting Services, September 2011.
- Groundwater and Salinity Hydrogeological Assessment, Brompton Lodge, 955 Cranbourne-Frankston Road, Cranbourne West. Draft Report prepared by John Leonard Consulting Services for Watsons. 2011.
- Conservation Management Plan for dwarf galaxias (Galaxiella pusilla) for the development of Brompton Lodge, Cranbourne South. Report prepared for Watsons Pty Ltd John McGuckin, Streamline Research Pty. Ltd, March 2013.
- Brompton Lodge Estate, 980-1050 Western Port Highway Cranbourne South, Surface Water Management Strategy. Neil M Craigie Pty Ltd, May 2013.

Extensive groundwater investigations have been undertaken at Brompton Lodge to ascertain the general groundwater occurrence, chemistry and the hydraulic relationship between local groundwater and surface water. The field investigation included installation of a network of monitoring bores, bore surveying, sand pit pond surveying and measuring groundwater levels and chemistry.

The various maps produced for this report have been georegistered to the UTM MGA94 coordinate system, and elevations referenced to the Australian Height Datum (AHD).

2.0 DEVELOPMENT CONCEPT AND WORKS

2.1 CONCEPT PLAN

The proposed subdivision development concept plan for Brompton Lodge showing the proposed lay out of the site including housing lots, roads and parks/reserves, drainage corridors, wetlands, and the (relocated) dwarf galaxias habitat pond is shown in Figure 2.1. (Wolfdene Drawing No UD 2100 dated 22.04.13). The development concept plan is draped over a digital elevation model in Figure 2.2.

Brompton Lodge has area of about 105 ha with a gross developable area of about 86 ha. Permit 1 application area is located in the northwest section of the property covers about 35.1 ha. The Permit 1 area is proposed to include a major wetland/retarding basin and associated sediment basins and a dwarf galaxia habitat pond to replace the lesser quality habitat in old sand pits on the site (Craigie, 2013).

The residences will be provided with reticulated water supply and a sewerage collection system. Each lot within the estate will also be serviced with a “third pipe system” that will provide treated water from Melbourne Water’s Eastern Treatment Plant. The third pipe water will be plumbed to buildings for toilet flushing, outdoor car washing and garden watering.

2.2 SURFACE WATER MANAGEMENT

A surface water management strategy was prepared for Brompton Lodge by Neil Craigie and Associates (Craigie, 2013). The main components of the surface water management works are described below (from Craigie, 2013). The various components are shown in Figure 2.1 and plotted on a site digital elevation model in Figure 2.2. The main waterways and assets are shown at larger detail in Figure 2.3.

- Two constructed open waterways (East Waterway and West Waterway; Figure 2.2) to convey external catchment inflows from Cranbourne-Frankston Road frontage through to the common existing outfall point in the NRCL land (currently used as the Anco Turf Farm) on the north side of Ballarto Road.

- The western waterway will be generally located within a 30 m reserve along the Western Port Highway frontage. It will convey external catchment flows plus some portion of overland flows from the development for events greater than 5 years ARI. No pipe discharges from the development will enter this waterway.

- The eastern open waterway will be located within a reserve of varying width from 40 m minimum to 70 m. It will be separate from the western waterway until Ballarto Road.

- 5 year Average Recurrence Interval (ARI) pipeline systems to convey urban stormwater from all parts of Brompton Lodge (and the abutting property to the east), into water quality treatment systems and on to the eastern waterway.

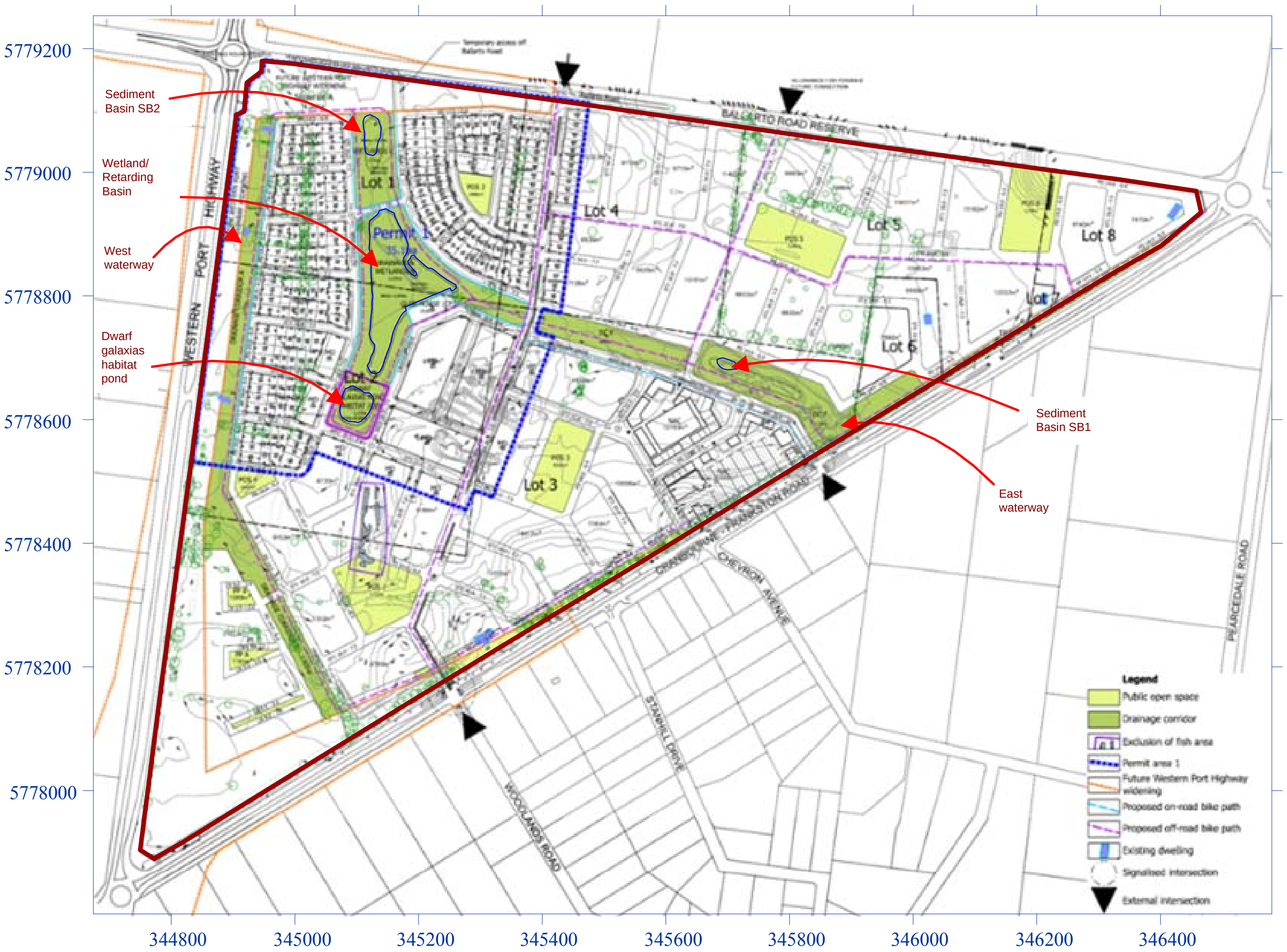


FIGURE 2.1 Development Concept Plan (Wolfdene Drawing No UD 2100 dated 22.04.13) Plus Surface Water Management Works

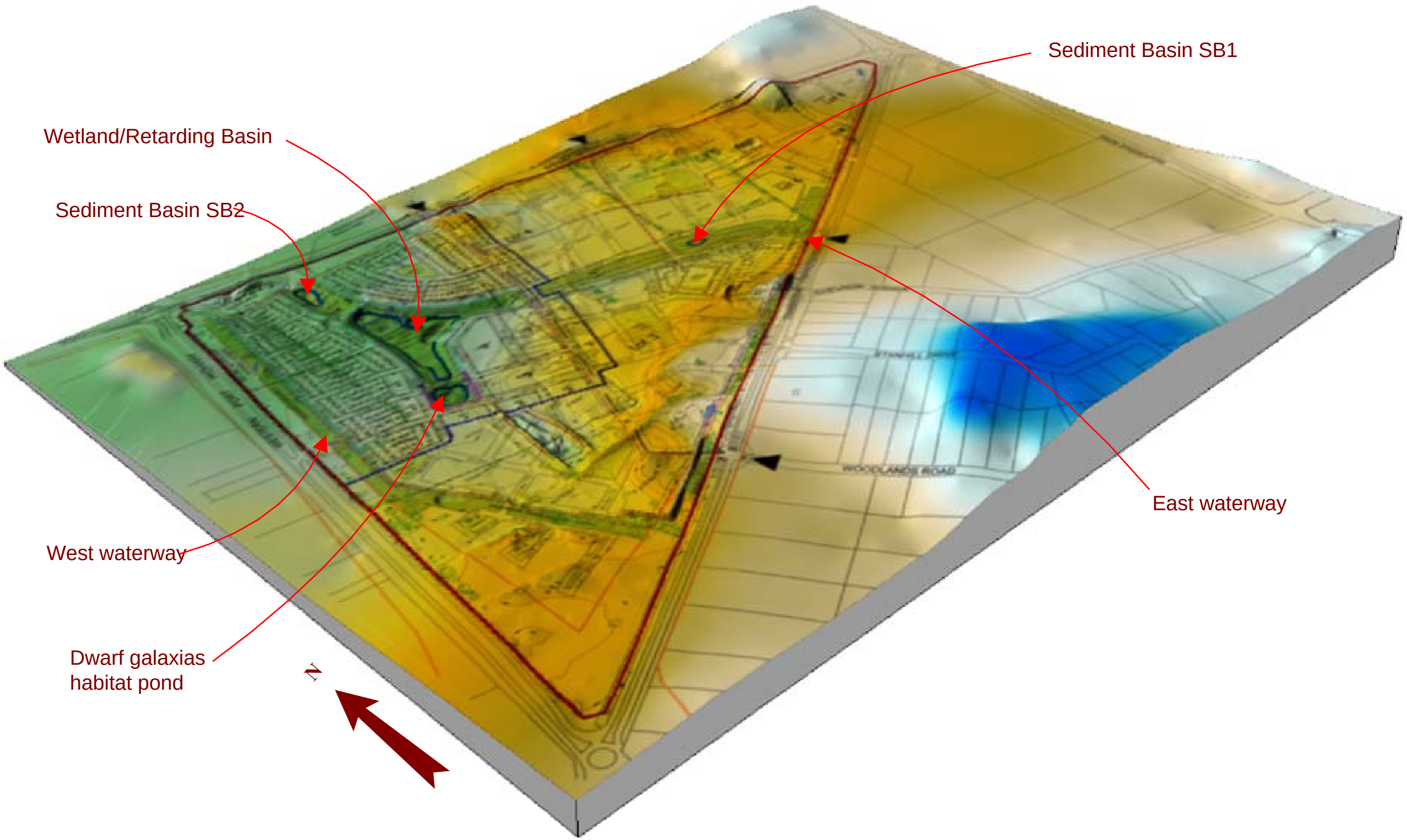


FIGURE 2.2 Brompton Lodge Development Concept Plan Draped Over Digital Elevation Model

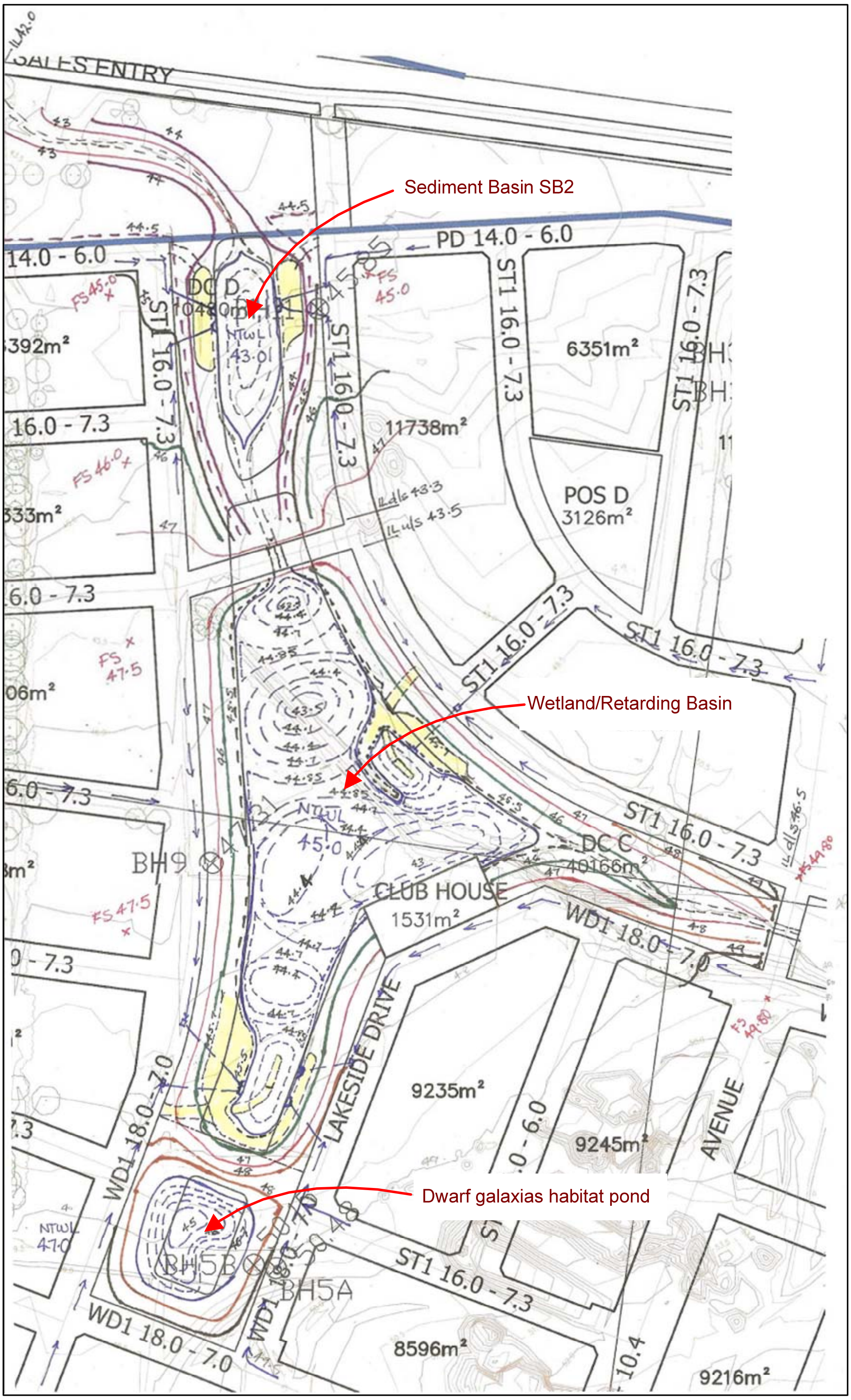


FIGURE 2.3 Design Surface Levels Dwarf Galaxias Habitat Pond, Wetland/Retarding Basin and Sediment Basin SB2 (After Craigie, 2013)

- One offline sediment basin of 700 m2 water surface area at the upstream end of the site discharging to the east waterway opposite the NAC (SB1). This basin will pretreat urban discharges from 13.6 ha of urban development on the north side catchment of Brompton Lodge including the urban land to the east.

- A constructed online major wetland/retarding basin (WLRB) totalling 1.53 ha water surface area including inlet sediment basins forming the estate landscape and recreational centrepiece on the east waterway at the Clubhouse. The bulk of the Brompton Lodge development drainage (65.3 ha) is directed into the sediment basin inlets.

- An online sediment basin of 2,000 m^2 water surface area on the eastern waterway at the north boundary of the development (SB2), to deal with the residual 9.6 ha development catchment.

- A dwarf galaxia habitat pond located just upstream of the major wetland/retarding basin, to replace existing artificial habitat that has developed in some former sand pits in the development area. This pond is to be separated from the surface water drainage system up to the 100 year ARI event but provided with freshwater supply from the wetland as needed.

2.3 SITE DEVELOPMENT WORKS

Development works at Brompton Lodge will include but not limited to:

- Demolition of buildings including poultry sheds, horse shelters/stables as well as a number of old houses.

- Stripping vegetation and site grading which will remove the many small depressions across the site.

- Excavating the waterways, wetland retarding basin and sediment basins.

- Excavating a new purpose-designed habitat pond for dwarf galaxias.

- Emplacing clean fill over low-lying land adjacent to the wetland retarding basin and dwarf galaxias habitat pond to a minimum of 600 mm above the 1 in 100 year flood level. This work will require about 1-2 m of fill in the area to the west of the wetlands and about 1 m of fill to the northwest of the west lands (D Muscillo, Watsons, pers. comm., May 2013).

- Removing the soil overburden stock piles; the stockpiled soil will be used as on-site fill material.

- Infilling farm dam and water filled sand pits except for the main sand pit ponds which will be maintained initially until dwarf galaxias population is successfully established in the new purpose constructed habitat pond.

- Constructing large areas of impervious cover (roofs, pavements, driveways, road surface, etc.) associated with residential subdivision development.
- Constructing of sewerage collection system.
- Constructing reticulated water supply third pipe system
- Constructing treated waste water supply (third pipe) system.

3.0 URBAN SALINITY

3.1 CAUSES OF SALINITY

The term 'salinity' is used to describe the accumulation of dissolved salts in the soil zone (soil salinisation) and surface water systems (stream salinity). Salinisation can emerge where the water table intersects the ground surface or is within capillary rise of the ground surface. [Capillary rises depends on soil pore size. In sandy and gravelly soil with larger pores, the head will be less than in clay soils with very small pores (Figure 3.1: Table 3.1)]. Salinity is generally the result of changes in land use that cause increased recharged to unconfined aquifers. Where the increase in recharge cannot be matched by a commensurate increase in groundwater discharge, the water tables can rise to near the land surface, where discharge occurs by evapotranspiration. Evaporation from the shallow watertable concentrates the naturally occurring salts in the groundwater and soils, leading to salinisation. As the near surface groundwater evaporates, salts are concentrated in the groundwater and can crystallise in the soil and on or within building materials, and can causing physical stress on metal and concrete structures and vegetation. Shallow groundwater and salt lead to increased rising damp, failure of damp courses and deterioration of building materials in foundations and walls (ABCB, 2007). Salt damage from wick effects is usually confined to older buildings where footings were porous brick and damp courses either non existent or inadequate in comparison with modem materials. Where more modern structures suffer damage this is most often the result of poor building practices (Leake, undated).

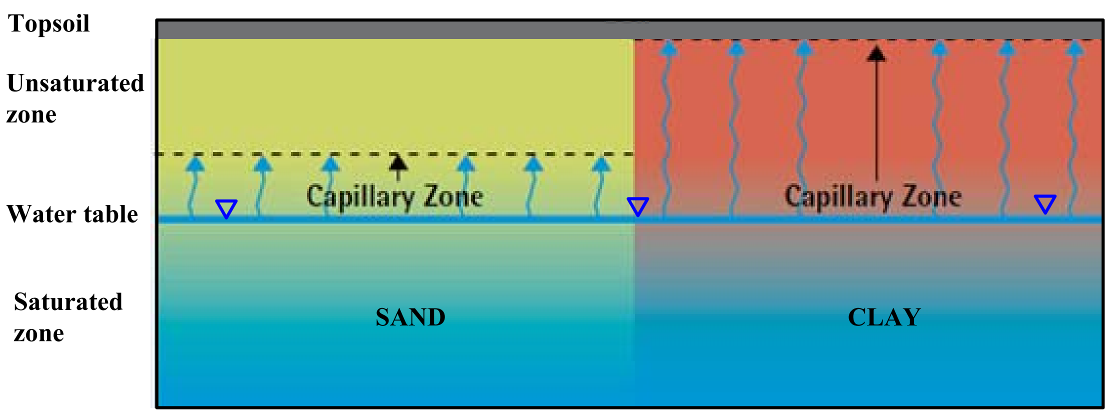


FIGURE 3.1 Schematic Illustrating Capillary Rise in Sand Compared to Clay

TABLE 3.1 Typical Capillary Rise Heights

Lithology	Capillary Rise (mm)	Lithology	Capillary Rise (mm)
Clay	360 - 600	Medium sand	25
Silt	360 - 560	Coarse sand	15
Very fine sand	100	Very coarse sand	4
Fine sand	50	Fine gravel	1.5

Source: Durkay, M (2004).

3.2 SALINITY HAZARD AND SALINITY RISK

Although "risk" and "hazard" are often used as equivalent terms in common language, they were defined differently in the Australian/New Zealand Standard on Risk Management (AS/NZS 4360:1999): [These definitions were used in the collaborative program between the National Land and Water Resources Audit and State and Territory agencies (http://www.anra.gov.au/topics/salinity/pubs/national/salinity_aus.html).
]

Hazard: anything that can cause harm to an asset (e.g. salt loads in lands where groundwater has potential to rise);

and

Risk: estimation of the expected amount of harm that will occur to the asset when a condition occurs (e.g. shallow saline groundwater under cropland).

Risk has to be calculated and depends on the development feature at "risk" (e.g. house foundations, roads, gardens) and the consequence. For example the consequences of a salinity hazard at a garden site would be minor whereas the consequence could be more serious for salinity damage to house or road foundations. Proposed subdivision sites can therefore be categorised according to whether or not a salinity hazard exists or could occur in the future at a specific site and the consequences of any identified hazard (salinity risk).

3.3 URBAN SALINITY MANAGEMENT LEGISLATIVE FRAMEWORK

3.3.1 Planning Provisions

Where urban salinity is considered to be a risk in Victoria, power is transferred to local councils to manage land use planning. The Victoria Planning Provisions (VPPs) are Statewide planning controls which are the basis of all municipal planning schemes. The VPP include the State Planning Policy Framework (SPPF) which covers strategic planning issues of State importance. Clause 15.03 of the SPPF includes objectives and implementation measures to minimize salinity. A Salinity Management Overlay (SMO) is an overlay which can be applied by councils in areas affected by salinity. The purposes of SMOs include encouraging development to be undertaken in a manner which minimizes salinity impacts (ABCB, 2010a).

3.3.2 Building Protection

The Building Code of Australia (BCA) contains the required technical standards for building construction in Australia. The goal of the BCA is to achieve the minimum necessary standards that are nationally consistent to ensure health, safety (including structural safety and safety from fire), amenity and sustainability objectives are met. Where building and construction regulations are the authority of the State and Territory governments in Australia, the BCA is given power to cover technical aspects of building construction through individual State and Territory enacting legislation.

As a performance based code, the BCA requires that the construction industry is able to provide practical, safe and enduring buildings that are fit for their desired purposes. Within this framework, the BCA has performance requirements ensuring that buildings are not unduly susceptible to environmental elements, such as soil moisture and salinity. It is through these performance requirements that the BCA ensures there are adequate means to maintain structural protection against soil moisture and salinity damage.

Provisions to protect buildings from the effects of saline intrusion and saline soils in the BCA are incorporated in the provisions for 'Damp and Weatherproofing' in Volume One and 'Concrete and Reinforcing' and 'Weatherproofing of Masonry' in Volume Two. These provisions ensure that buildings are protected from rising moisture in soils, as well as ensuring that concrete footings and brickwork are sufficiently resistant to degradation from environmental moisture effects.

3.4 URBAN SALINITY IN THE CRANBOURNE AREA

A number of studies by Sinclair Knight Merz (SKM) identified shallow water tables in the Cranbourne and surrounding area with associated potential salinity hazard (SKM 2005, 2006, 2007).

The SKM 2005 study utilized existing information on standing water levels reported in various groundwater databases and topography together with data from new bores installed as part of the investigation to estimate the depth to groundwater and identify groundwater related development constraints. The SKM report "highlighted the potential for the occurrence of shallow groundwater to be a risk for parts of the Casey Cardinia" (SKM 2007; sic). Cranbourne South was one area identified at high risk (SKM, 2007). The Development Constraints map in the SKM 2005 report included the Cranbourne South area in either the severely constrained or the (development) not recommended category. However, the SKM Development Constraints Map categorisation did not recognise that developments can be designed and constructed with materials that are capable of providing the required performance in areas with a salinity hazard or potential salinity hazard. In this regard they are at variance with provisions in the Australian Building Code and relevant Australian Standards, and a number of Salinity Management Plans prepared for other municipality Councils including the Blacktown City Council (Appendix C – Salinity Management Guidelines; Blacktown City Council Growth Centre Precincts Development Control Plan 2010) and Wagga Wagga City Council (Building in a Saline Environment – Urban Salinity Prevention. – Wagga Wagga City Council, October 1999) and the Jenee Shire Council (Development Control Plan No. 16. - Building in a Saline Environment, Junee Shire. July 2004.

While actions can be taken to reduce a salinity hazard, predicting how a dynamic system dependent on many variables will perform over the typical 50-year design life of buildings is difficult. The "Guide to Residential Slabs and Footings in Saline Environments" (Cement Concrete & Aggregates Australia, 2005) considered that the best approach for sites with a salinity hazard or the potential to develop a salinity hazard, is to accept that at some point in the future a hazard could exist and to ensure that building materials are capable of providing the required performance in such an environment.

4.0 DWARF GALAXIAS HABITAT

4.1 EXISTING HABITAT

The dwarf galaxias habitat ponds are located in former (man-made) sand extraction pits (Figure 4.1). The hydraulic relationship between the water in the pits and local groundwater was investigated by JLCS (2011b). The field investigation included installation of purpose located monitoring bores, measuring groundwater levels and chemistry, pond water chemistry, and surveying the elevation of the base of the identified dwarf galaxias habitat ponds and the standing water level in the ponds.

FIGURE 4.1 Location of Existing and Proposed Dwarf Galaxias Habitat Ponds

Comparison of measured groundwater elevation with the surveyed elevation of the base of the ponds indicates that the water table was higher than the water surface in sand pit ponds during all monitoring rounds undertaken by JLCS (the July 2011, November 2012, March 2013 and May 2013). The analysis indicated that the water level in the ponds in May 2013 was about 1.2 m lowered than in July 2011 (Plate 4.1). Consequently, the ponds in the sand pits were groundwater sinks, fed by groundwater inflow (discharge). The water level in the ponds was lower than the surrounding groundwater as a result of evaporation losses from the ponds.

Note: Photographs taken with different camera settings

PLATE 4.1 July 2011 and May 2013 Photographs of Sand Pit Ponds- View to North

The water level data indicates that the sand pit ponds are through flow type water bodies (the ponds represent water table outcrops). Because the ponds were established on a sloping water table, the capture zone is asymmetrical with the capture area greater in the up-hydraulic gradient (southeast) direction (Figure 4.2).

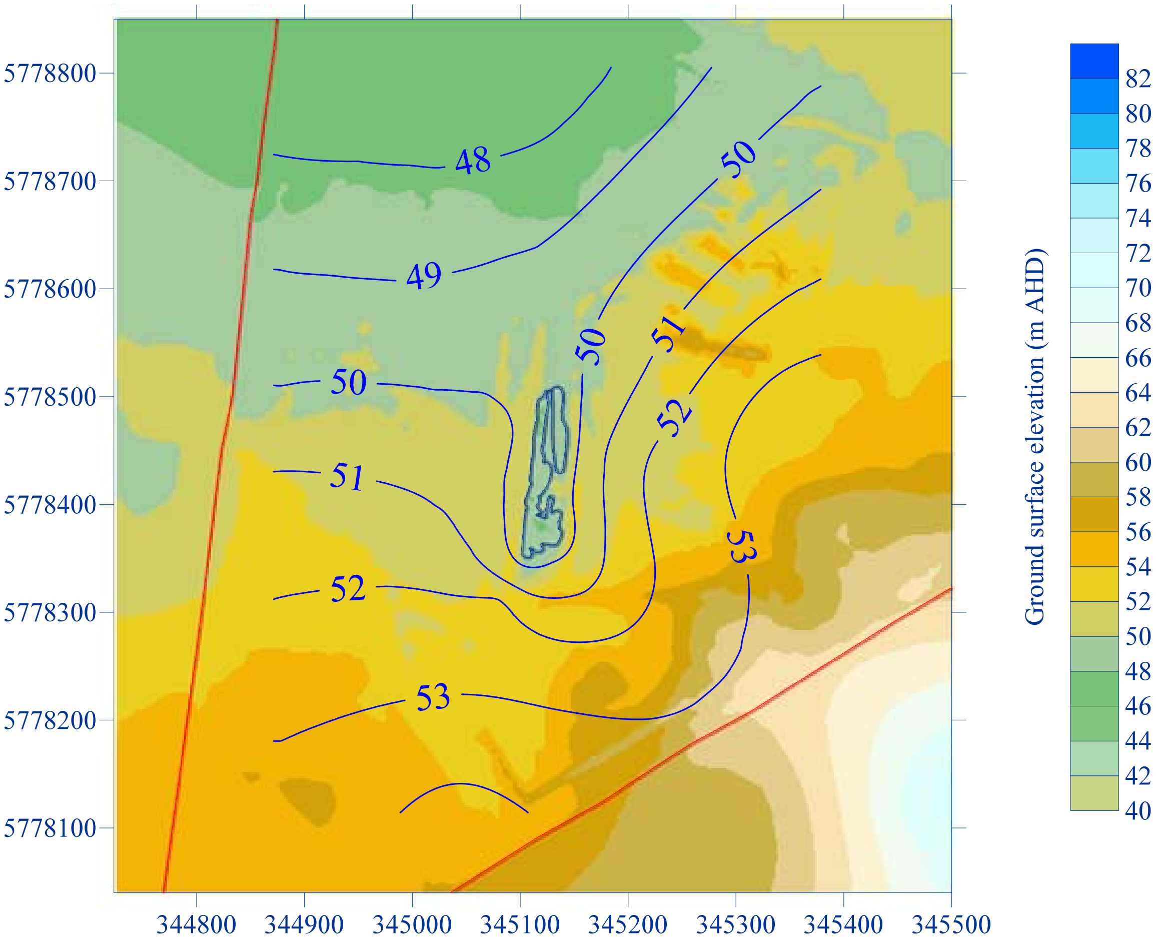


FIGURE 4.2 July 2001 Water Table Contours Around Sand Pit Ponds (After JLCS 2011b)

McGuckin (2013) reported that the existing dwarf galaxias habitats in the sand pit ponds not ideal habitat for the dwarf galaxias. Localised flooding since 2008 has allowed for the invasion of the eastern gambusia (*Gambusia holbrooki*) and fish surveys made since that time have found the abundance of dwarf galaxias has dropped dramatically. Shaded habitat (which would favour dwarf galaxias) is minimal, comprising less than 10% of the habitat that exists in the sand pits. The majority of the habitat present in the sand pit/s is open water, habitat that favours the eastern gambusia. McGuckin considered that if no intervention is made to the sand pits, it is likely that the dwarf galaxias population will disappear within 5 to 10 years (McGuckin, 2013).

4.2 RELOCATED HABITAT

McGuckin recommended constructing a purpose designed pond to provide a more suitable habitat for dwarf galaxias. The new pond will be constructed about 149 m north of the existing ponds and cover about 1,500 square meters. The water depths will be up to three m. [The actual surface area of water will vary depending on the water level in the pond.] Shallow margins will be constructed on the wetlands, as these habitats are favoured by the dwarf galaxias. Dense submergent aquatic and riparian vegetation will be planted on the north and western sides of the new pond to reduce summer water temperatures and maintain some shaded areas favoured by dwarf galaxias. The deeper water will provides refuge if other parts of the pond dry up, providing permanent water throughout summer and refuge habitat during drought periods (McGuckin, 2013).

5.0 SITE SETTING AND CHARACTERISTICS

5.1 CLIMATE

The climate in the Cranbourne area is temperate with warm summers and cooler winters with a tendency for maximum rainfall in winter. Climatic averages, derived from measurements at the Royal Botanic Gardens at Cranbourne (BoM station 086375) located about two km east of Brompton Lodge are presented in Table 5.1. Average annual rainfall is about 740 mm. Average annual minimum and maximum temperatures are about 7.6 and 19.1 °C, respectively.

TABLE 5.1 Climatic Averages, Royal Botanic Gardens, Cranbourne

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temp	25.3	25.6	23.3	19.8	16.3	13.9	13.3	14.5	16.4	18.8	21.1	23.3	19.3
Highest daily temperature	44.0	46.0	39.7	34.5	25.2	22.5	20.1	25.5	28.4	35.0	38.0	41.3	46.0
Mean daily min temperature	14.2	14.6	13.8	11.5	9.7	8.1	7.9	7.6	8.1	11.2	11.2	13.0	7.6
Lowest daily temperature	19.0	19.1	17.8	15.3	13.3	11.4	10.9	11.5	12.5	14.0	15.5	17.2	
Mean monthly rainfall	34.5	33.7	30.7	25.7	20.0	16.5	16.0	18.5	21.5	25.5	28.5	31.7	
Highest rainfall	53.0	53.7	42.6	71.1	64.1	79.1	68.4	79.5	85.0	78.5	76.2	65.5	815.4
Lowest rainfall	130.4	171.3	75.5	153.0	153.4	176.8	123.6	144.5	179.2	129.1	156.6	133.6	1101.5
1sth monthly rainfall decile	9.7	0.8	12.2	21.8	18.0	17.7	20.3	20.9	38.4	26.1	31.4	9.2	543.3
5th monthly rainfall decile	16.6	12.2	16.0	25.0	26.3	43.5	29.2	51.2	48.8	33.0	41.8	23.0	641.9
9th monthly rainfall decile	42.5	50.6	45.6	63.0	65.2	73.2	60.8	84.3	71.9	68.9	77.2	66.7	831.6
Mean number of raindays	103.0	106.4	66.6	121.7	119.4	134.1	115.4	109.8	132.7	125.3	114.9	114.8	1052.6
Mean daily evaporation	10.3	8.8	11.8	15.1	19.1	19.9	19.8	20.1	18.7	16.0	13.6	11.8	185.0

Notes: Temperature in °C; rainfall and evaporation in mm: Source: Commonwealth Bureau of Meteorology Website (accessed May 2013).

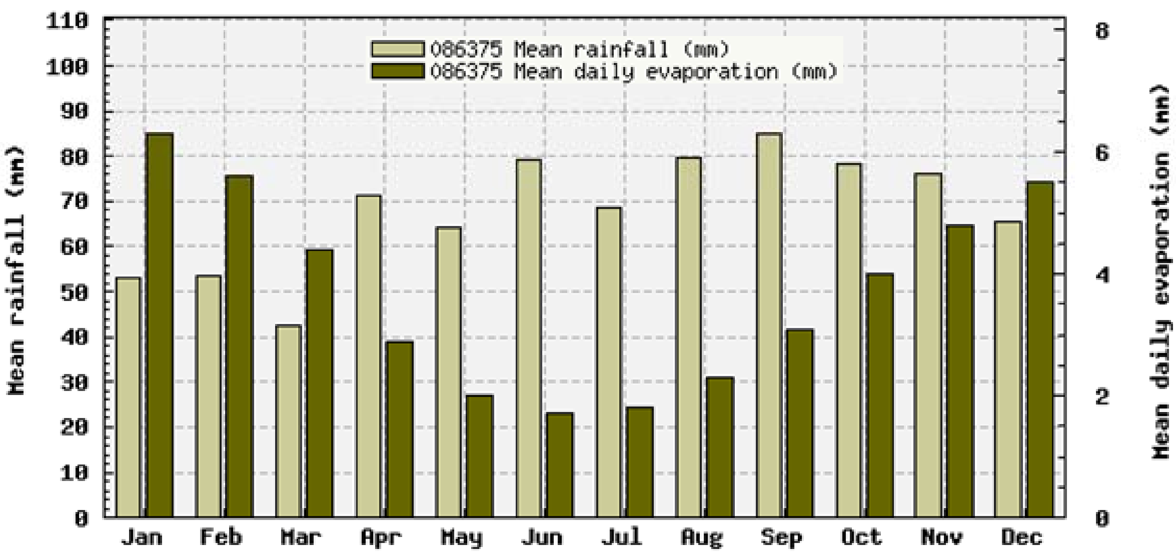


FIGURE 5.1 Mean Rainfall and Daily Evaporation, Royal Botanic Gardens

5.2 TOPOGRAPHY AND DRAINAGE

Brompton Lodge is situated on the flanks of the elevated spine of the Mornington Peninsula here referred to as the "Mornington Uplands" (part of the Southern Uplands) that forms the drainage divide between Port Phillip Bay and Western Port Bay; the site is located within the Port Phillip Catchment. The uplands are flanked by coastal plains that extend to Port Phillip Bay to the west and Western Port Bay to the southeast. Swamps occupy the central portion of both coastal plains, the Carrum Swamp near Port Phillip Bay and the Koo Wee Rup Swamp near Western Port Bay (Figure 5.1).

The elevation across the swamps varies from near sea level to less than 10 metres Australian Height Datum (m AHD). The elevation across the surrounding coastal plains is mostly in the range 10 to 60 m AHD. Remnant strand-line sand dunes elevated from four to six m above the surrounding land surface occur around the margins of the coastal plains. The dunes in the Cranbourne Area were named the "Cranbourne sand" by Holmes, et al. (1940). The Mornington Uplands locally range from about 60 to 100 m AHD elevation.

Drainage away from the Mornington Uplands on the coastal plains is poorly developed. Prior to development for agricultural land use drainage was controlled by a series of dunes developed parallel to the coast, however drains now divert much of the runoff into the respective bays.

The ground surface at the Brompton Lodge site attains an elevation of about 67 m AHD in the northeastern corner of the site and between 56 and 62 m AHA along the Cranbourne-Frankston Road frontage. The ground surface slopes down to the northwest away from the topographic high areas to less than 42 m AHD in the northwestern corner of the site Figure 5.3 and 5.4.).

The ground surface in the south central portion of the site has been altered by sand extraction activities including general scraping and excavation of a number of small pits, and sand and overburden stockpiles. The sand extraction topographic modification are evident in the site digital elevation model (DEM) presented in Figure 4.3.

The Brompton Lodge precinct is located in the upper reaches of the Eastern Contour Drain catchment. The site is drained by two unnamed ephemeral creeks (referred to as Channel 1 and Channel 2 by McGuckin, 2011). These creeks which also drain a relatively small area of more elevated land to the southeast of the Cranbourne-Frankston Road exit Brompton Lodge near the site's northwestern corner (Figure 4.4).

There are a few five farm dams on the site plus a number of ponds formed in former sand extraction pits. Perusal of Near Map airphotographs taken during the period November 2009 to August 2011(14 photographs) indicates that the ponds in most of the sand pits are not permanent. The exceptions are ponds in the pits designated as Sand Pit l, Sand Pit 2 and Sand Pit 5 (Figures 5.4 and 5.5). [Note that Sand Pit 1 and Sand Pit 2 are actually two arms of a single pit.] The water bodies in Sand Pit 1 and Sand pit 2 are both aligned approximately south-north and are interconnected by a shallow "channel" at the northern end of the ponds. Sand Pit 1 covers a larger area and is deeper than Sand Pit 2. Overflow from Sand Pit 5 flows into Sand Pit 2.

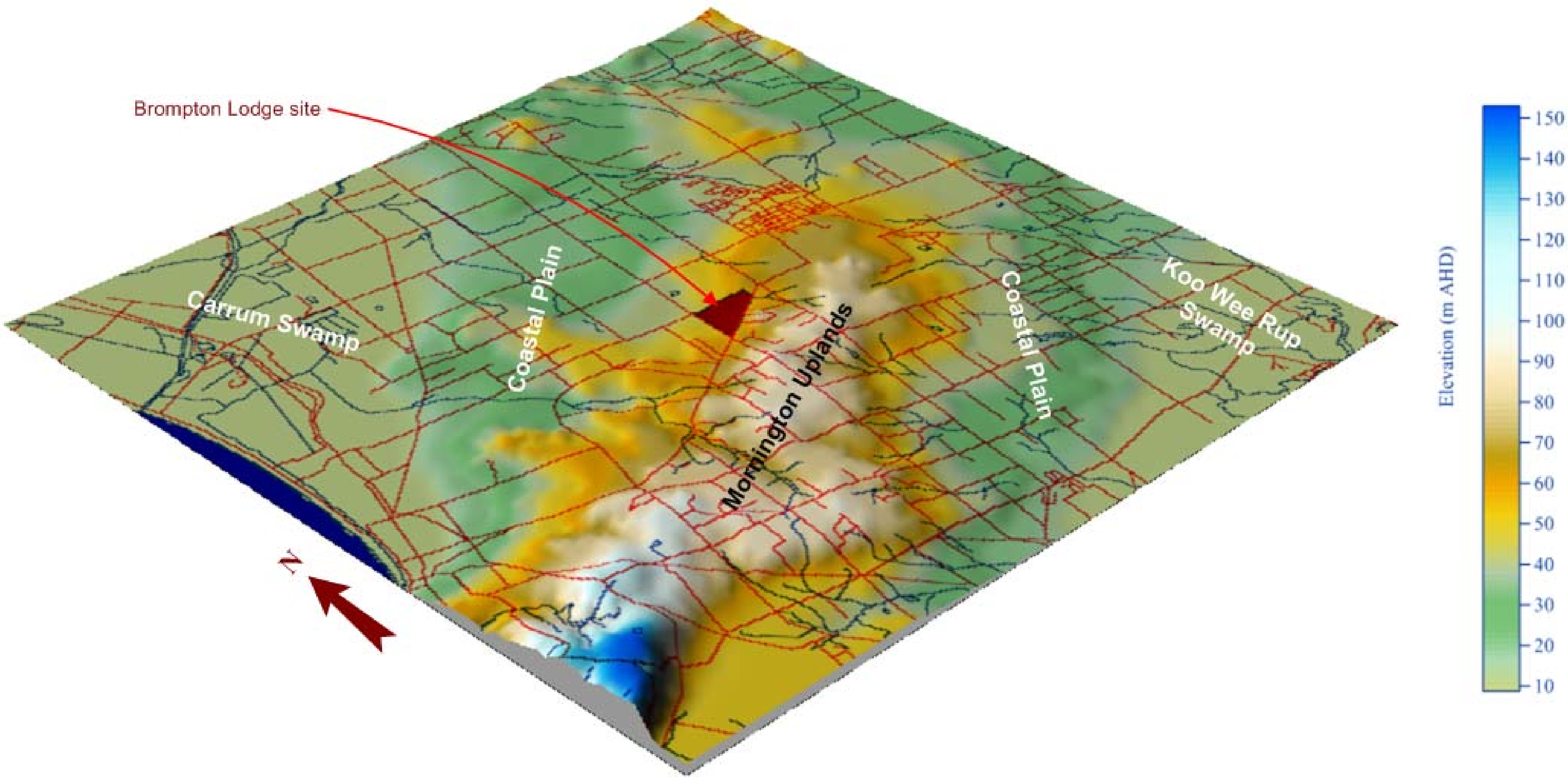


FIGURE 5.2 Cranbourne Area Digital Elevation Model

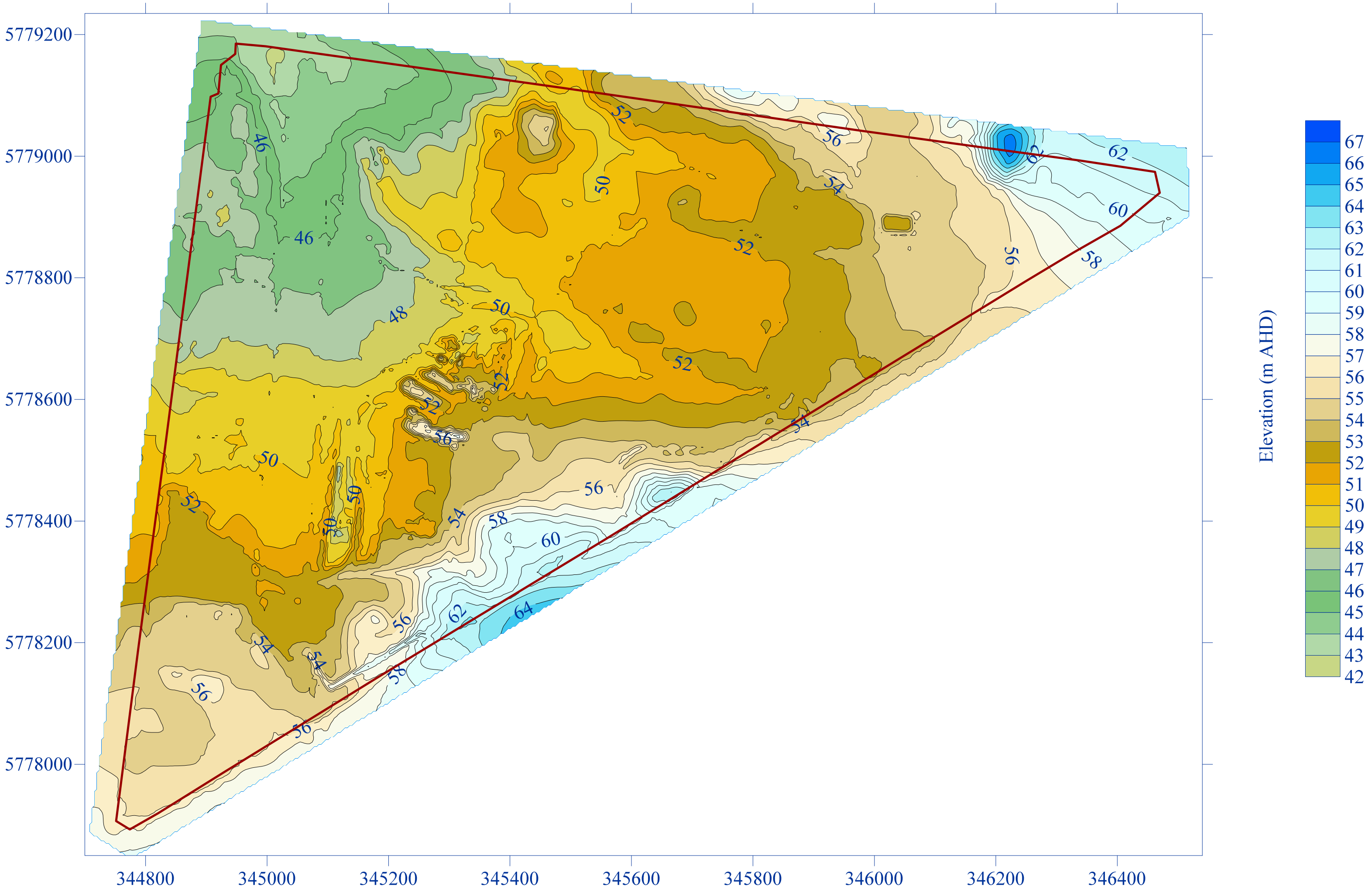


FIGURE 5.3 Brompton Lodge Topographic Contours

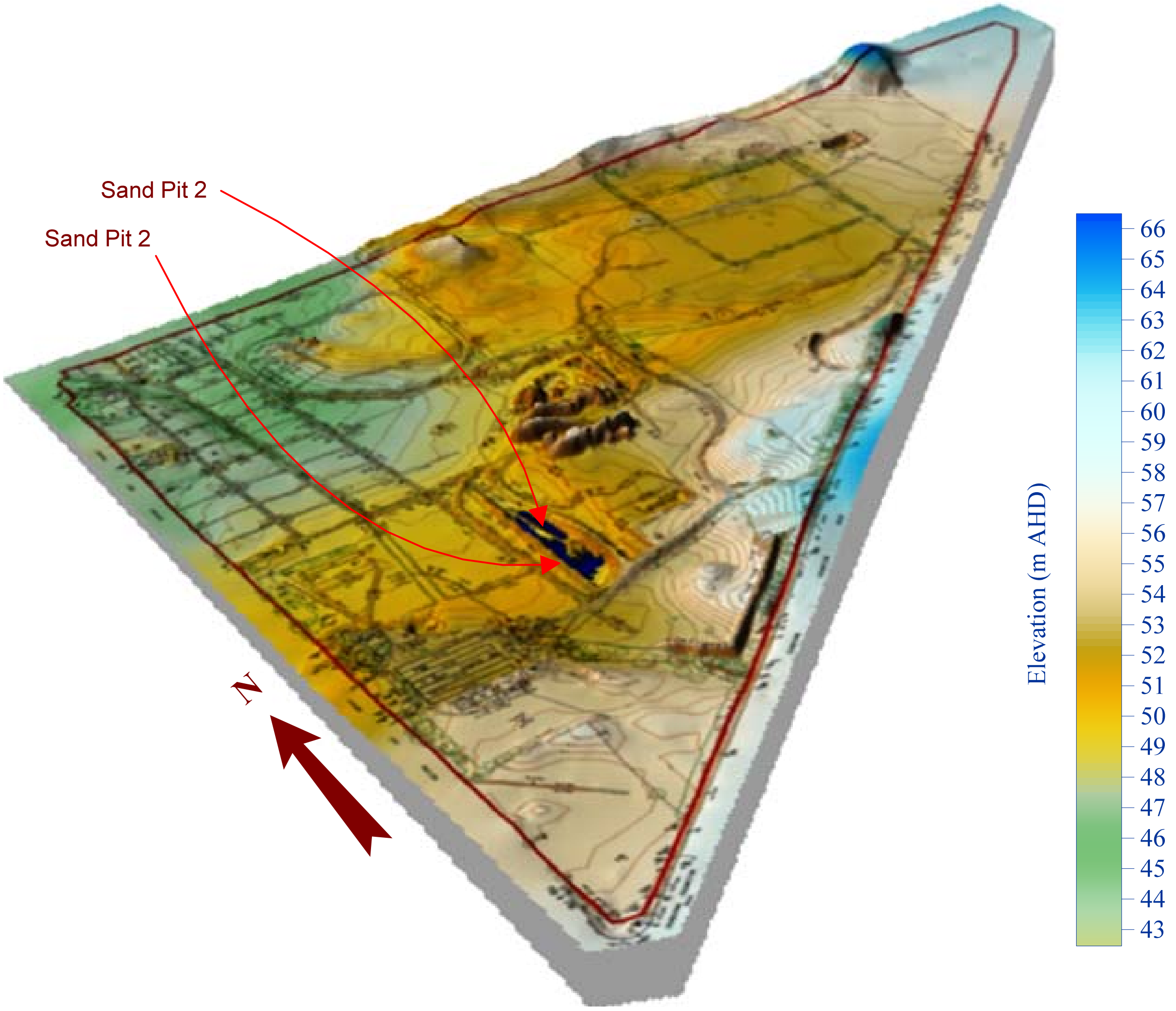


FIGURE 5.4 Brompton Lodge Existing Surface Digital Elevation Model

McGuckin (2011) considered that water from Channel 1 flow into Sand Pit 1 (Site 3) and, as the water depth in Sand Pit 1 increases into Sand Pit 2 (Site 4) during flood events. The flood water path way is most likely along the shallow depression between Channel 1 and Sand Pit 1.

5.3 HYDROGEOLOGY

Cranbourne is situated near the junctions of the Port Phillip and the Western Port sedimentary basins. The basins are separated by outcropping to subcropping predominantly consolidated sedimentary basement rocks (bedrock) on the upthrown Mornington Horst (Figure 5.6). Basement rocks beneath the basins in the Cranbourne area consists of sedimentary rocks of Silurian age (Melbourne Formation) with igneous intrusive basement (granite or granodiorite) at some locations. Both sedimentary basins are relatively shallow and have been infilled by a similar sequence of Cainozoic (dominantly Tertiary) sedimentary and volcanic rocks. The Tertiary sediments are overlain in places by Quaternary dunes and swamp deposits.

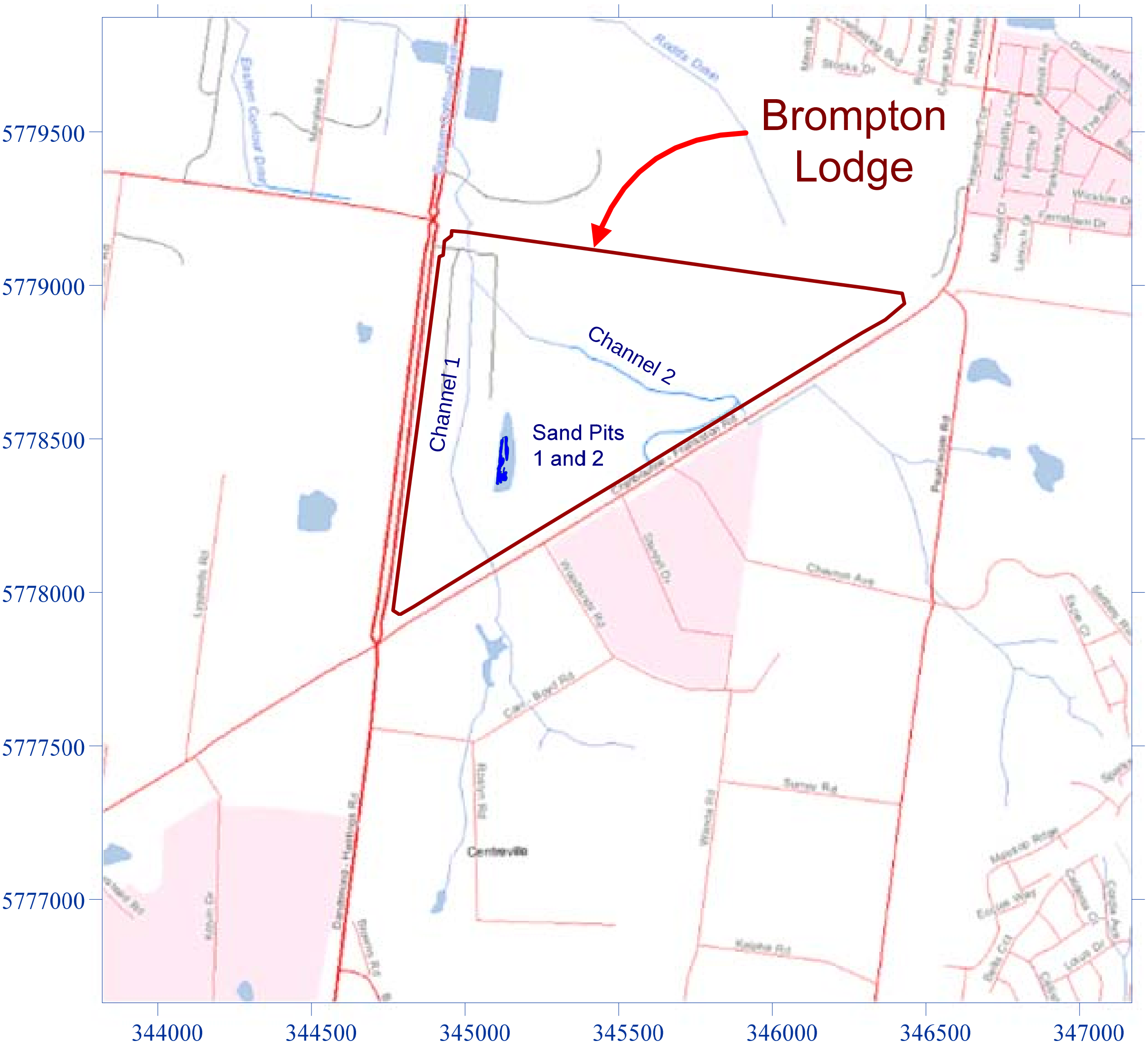


FIGURE 5.5 Brompton Lodge and Surrounds Drainage

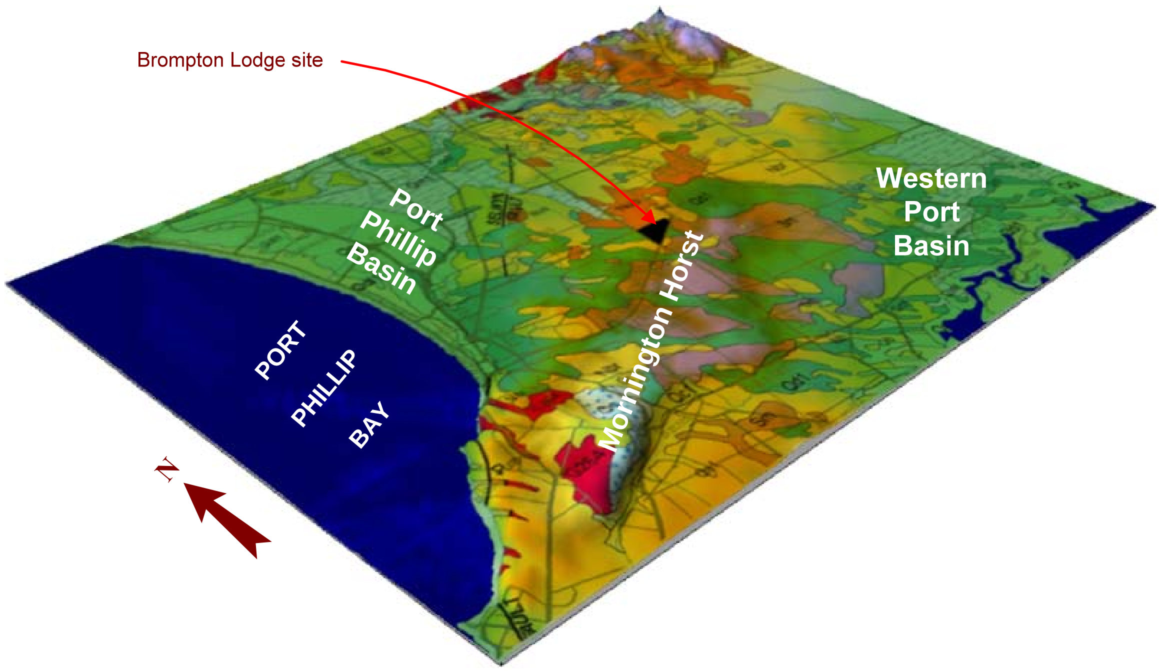


FIGURE 5.6 Cranbourne Area Tectonic Setting

The surficial/outcrop geology maps presented in this report were extracted from maps produced by the Geological Survey of Victoria as part of the statewide Seamless Geology Project (Welch et al., 2011).

The general stratigraphic sequence in the Cranbourne area is summarised in Table 5.2. The regional outcrop geology is shown in Figure 5.7 and the (vertical) relationship of the various stratigraphic units is shown in the generalised north-south geological cross-section from Caulfield to Frankston presented in Figure 5.8. The local geology at Brompton Lodge and surrounding area is shown in more detail in Figures 5.9 and 5.10.

5.3.1 Melbourne Formation

The Silurian aged Melbourne Formation consists of a consolidated and fully lithified sequence of tightly folded mudstone, sandstone siltstone and shale. The sediments are commonly cross-bedded but rarely show graded bedding. The Melbourne Formation outcrops along the upthrown Mornington Horst and in the Uplands to the north. The formation occurs at varying depth beneath the adjoining Tertiary sedimentary basins [Port Phillip Basin (northeast) and Western Port Basin (southeast)]. The depth to the top of the Melbourne Formation increases progressively away from its outcrop areas. The Melbourne Formation outcrops in the northeastern corner of and southeast of the site along the elevated flanks of the Mornington Horst (Figures 5.11 and 5.12).

TABLE 5.2 Cranbourne Area Stratigraphy

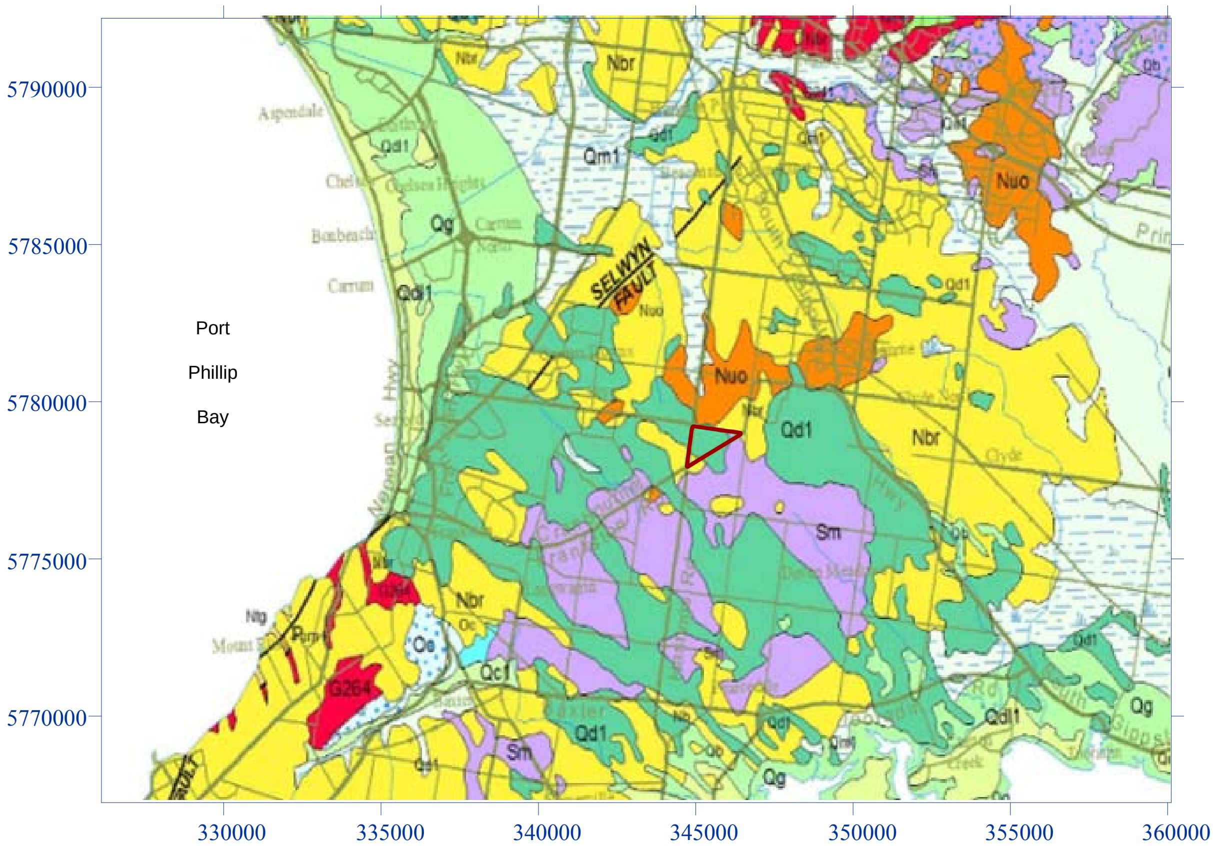
Age	Stratigraphic unit	Lithologic description
Quaternary	Unnamed dune & sand sheets	Sandy silt to silty sand: fine to minor coarse grains, dark brown/grey to yellow/brown. Consistency is generally loose.
	Unnamed swamp & lagoonal deposits	Clay, silt, peat, mud
Tertiary	Brighton Group	Highly variable (laterally and vertically) facies consisting of fine to coarse sands, clayey sands, sandy clays and peaty sands. Gravel lenses are common. Colour varies from a pale grey, red/brown, grey/brown, yellow/brown, pale grey, grey/brown clayey sands or sandy clays. Sands are generally described as loose. Occasional white sands underlying green/black and brown sands.
	Fyansford Formation	Variable (laterally and vertically) facies consisting of fine to coarse sand (often calcareous) and occasionally fossiliferous silt, sand, sandy silt, some gravel (particularly at the units base), occasional hard marl and calcite nodules. Sands are generally described as loose. Colour varies from dark grey/green, green/brown, silty sand to pale green/yellow fine sand. Occasional thin limestone and peaty bands.
	Older Volcanics	Olivine basalt, titanaugite, basalt, basaltic clay, pyroclastics, tuff
	Werribee Formation	Sand, clay, ligneous clay, silt, brown coal.
Silurian	Melbourne Formation	Moderately to extremely weathered light grey to grey/blue sandstone and mudstone. Extremely weathered to clayey zones in upper surfaces. Soft to hard. Occasional joints dipping at 45 degrees. Generally fractured. Thinly bedded.

The Melbourne Formation is predominantly a fractured rock type aquifer but it can be a porous media type aquifer where deeply weathered. The aquifer is unconfined where it outcrops but is confined to semiconfined where it is overlain by younger rocks. Bore yields which are dependent on the degree of fracturing are mostly small, typically windmill supplies but higher yields occur where the formation is highly fractured. Hancock (1992) reported that groundwater salinities were greater than 4,000 mg/L TDS where the formation permeability is low but is commonly less than 2,000 mg/L TDS where more open and permeable fracture zones are encountered.

5.3.2 Werribee Formation

The basal Tertiary unit underlying much of the Tertiary basins is the Werribee Formation (Childers Formation in the Western Port Basin). The formation occurs subsurface in a limited area (approximately 200 km) south of the Beaumaris Monocline between Mentone and Frankston where it is represented by up to 40 m of sand gravel, clay and lignite and minor brown coal underlying Older Volcanic basalts. The average salinity of groundwater from the Werribee Formation occurrence beneath the southeastern suburbs of Melbourne is 1,500 mg/L TDS with a range from about 200 to 4,000 mg/L TDS (Leonard, 1992a).

The Werribee Formation is unlikely to be present beneath Brompton Lodge.



Quaternary	Qdl1	Coastal dune deposits	Sand, silt
	Qd1	Unnamed inland dune deposits	Sand, silt
	Qm1	Unnamed swamp and lake deposits	Clay, silt, peat
	Qm1	Unnamed alluvial deposits	Clay, sand, silt, gravel
Tertiary	Nbr	Brighton Group Red Bluff Sandstone)	Sand, ferruginous sand, sandy clay, clay, silt, occassional gravel
	Nuo	Monbul Volcanic Group (Older Volcanics)	Basalt, basaltic clay, tuff
Devonian	G264	Mount Eliza Granodiorite	Granite, granodiorite
Silurian	Sm	Melbourne Formation	Siltstone, mudstone, sandstone, greywacke, conglomerate, shale

Brompton Lodge Site

FIGURE 5.7 Cranbourne Area Outcrop Geology (After Welch, et al., 2011)

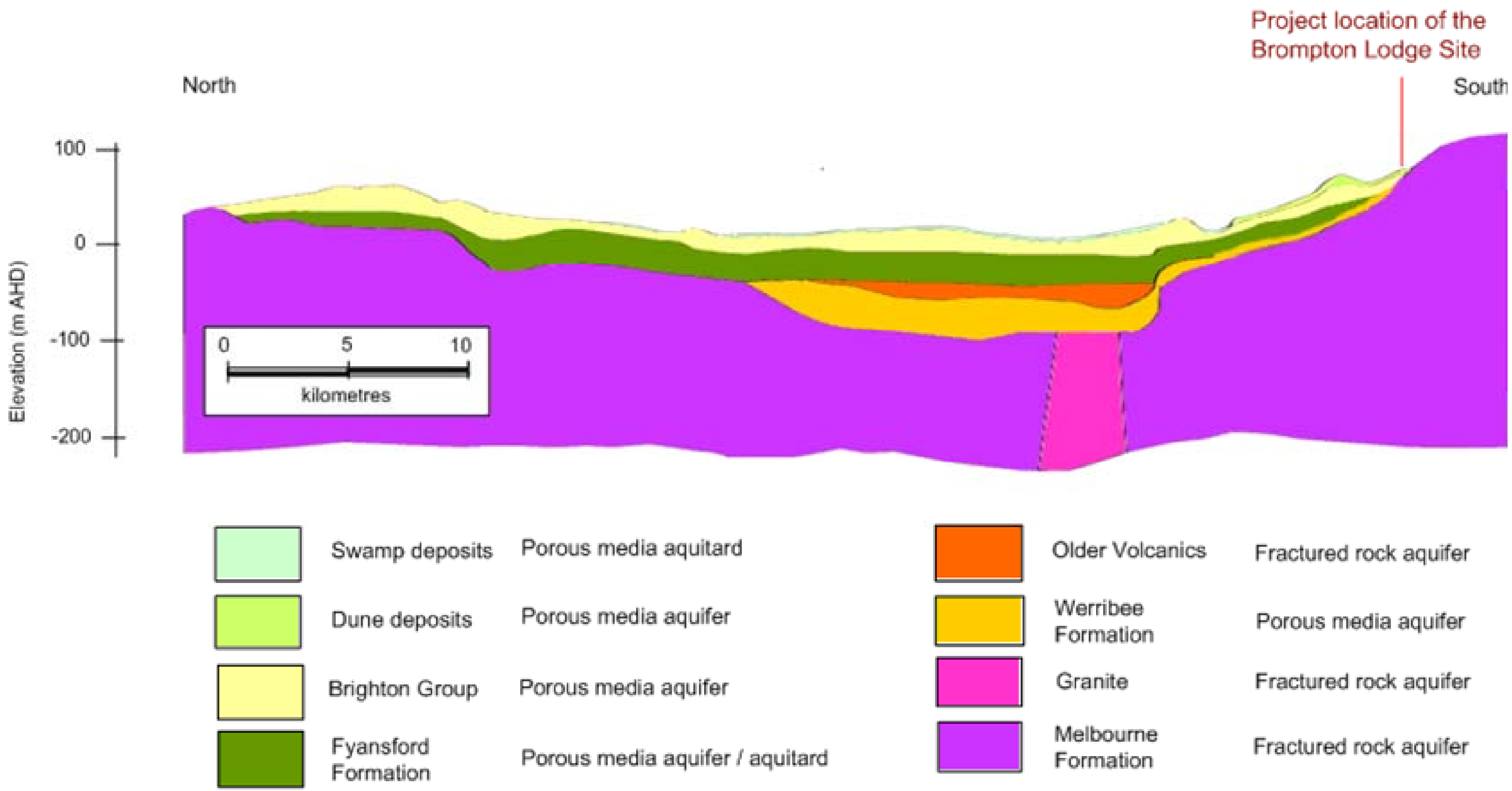
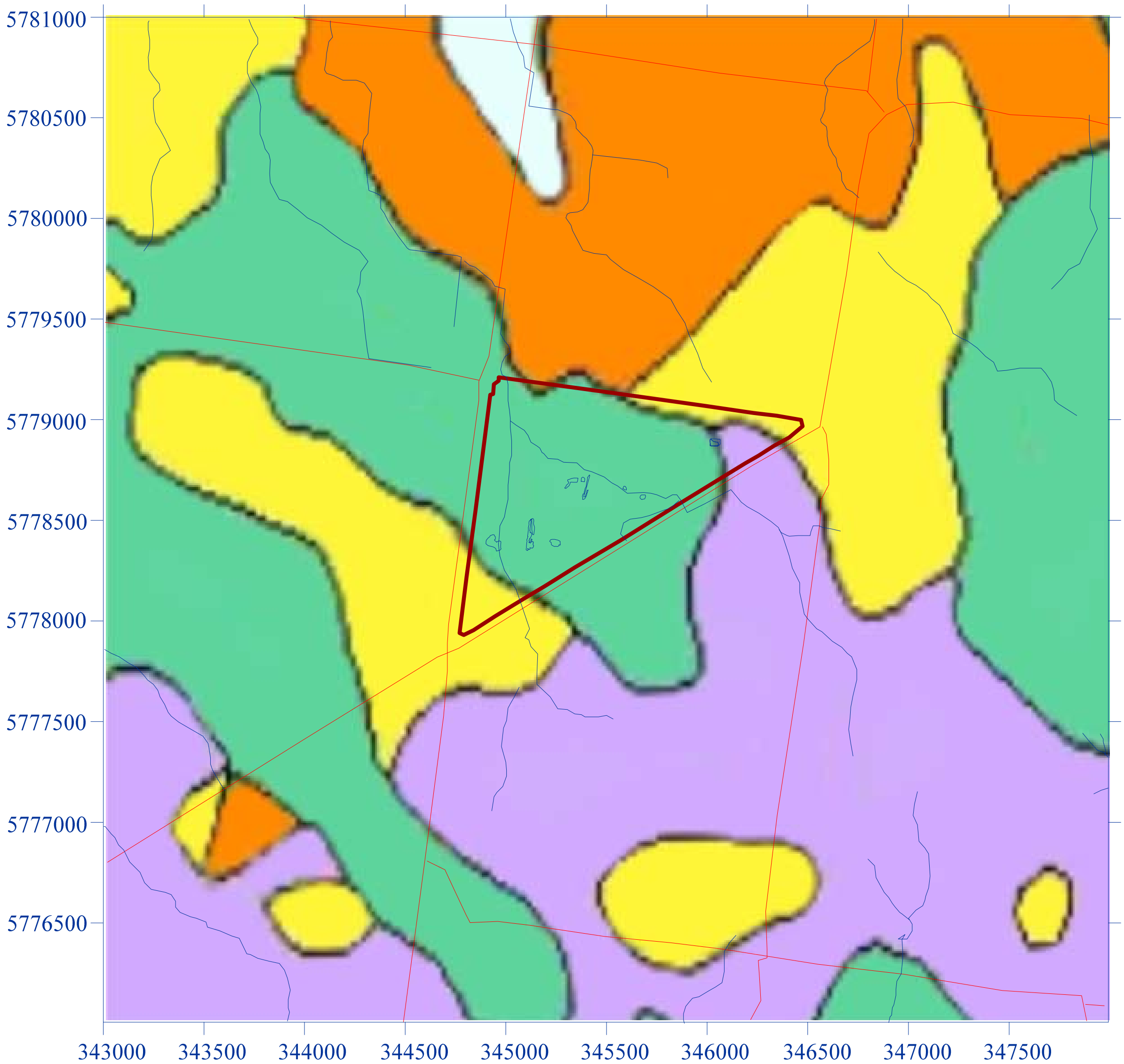


FIGURE 5.8 Approximate North-South Generalised Geological Cross-Section, Caulfield to Frankston (modified after Leonard, 2006)



Quaternary	Qd1	Unnamed inland dune deposits	Sand, silt
	Qm1	Unnamed alluvial deposits	Clay, sand, silt, gravel
Tertiary	Nbr	Brighton Group Red Bluff Sandstone)	Sand, ferruginous sand, sandy clay, clay, silt, occassional gravel
	Nuo	Monbul Volcanic Group (Older Volcanics)	Basalt, basaltic clay, tuff
Silurian	Sm	Melbourne Formation	Siltstone, mudstone, sandstone, greywacke, conglomerate, shale

Brompton Lodge

FIGURE 5.9 Brompton Lodge Local Area Outcrop Geology (After Welch, et al., 2011)

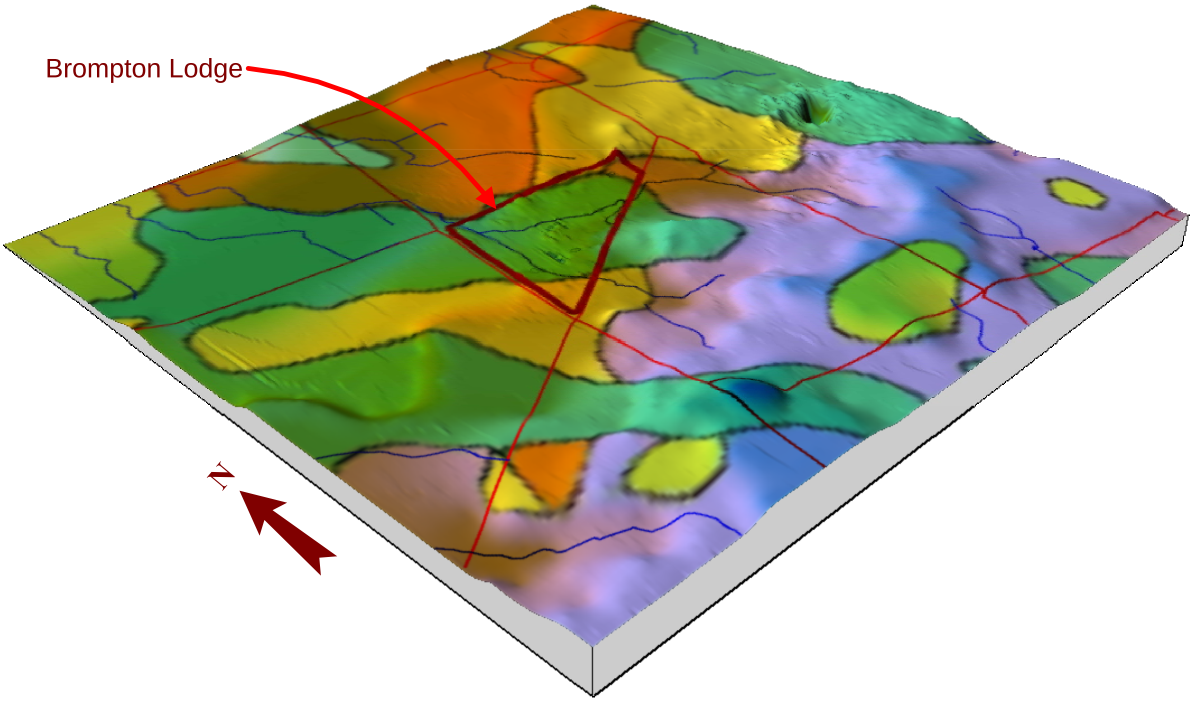


FIGURE 5.10 Brompton Lodge Local Area Outcrop Geology Draped Over DEM

5.3.3 Older Volcanics

The Older Volcanics consist mainly of basalt which is often weathered to basaltic clay. The unit extends from Port Phillip Bay into Western Port Bay with outcrops in the Cranbourne area. In its outcrop in the Cranbourne area the basalt is of sheet-like form and attains thicknesses in excess of 40 m. The basalt is most likely not continuous towards Port Phillip Bay but has infilled valleys in the underlying Werribee Formation or basement rocks. These valley flows are between five and 10 m thick and are overlain by up to 80 m of sediments.

The Older Volcanics is a fractured rock type aquifer that yield small to moderate supplies of variable quality groundwater; groundwater salinity ranges from less than 500 to 8,000 mg/L TDS, with an average value of 1,900 mg/L TDS. The quality of groundwater tends to be better in the Cranbourne area where the basalt outcrops or is only covered by a thin veneer of younger sediments.

Older Volcanics outcrop close to the northern boundary of the site and could be present beneath the northern portion of the site (Figures 5.5 and 5.6).

5.3.4 Fyansford Formation

The Fyansford Formation was deposited in a marine to marginal marine environment. It extends subsurface from near St. Kilda to Frankston and inland (eastwards) to an approximate northwest-southeast line from Burnley to Dandenong. However, the distribution of the formation within this area is inconsistent and is a reflection of the local pre-deposition topography. The formation is composed of grey-green glauconitic clayey silts and clays to fine grained grey-brown sandy silts and silty sands. The sandy facies are generally fossiliferous and calcareous with occasional interbedded limestone horizons. Thin layers of carbonaceous silt and clay, locally impure coal and calcareous sand or sandy calcarenite have been reported towards the base of the formation, (Abele et al, 1988).

The salinity of groundwater from the Fyansford Formation is generally between 800 to 3,000 mg/L TDS but is more saline, up to more than 4,500 mg/L TDS in the Carrum-Chelsea area (Leonard, 1979). Permeable zones within the formation can yield moderate groundwater supplies. The formation has been targeted as an irrigation water source at a number of golf course and some horticulture activities (Hancock, 1992).

The Fyansford Formation is most likely not present at the Brompton Lodge site.

5.3.5 Brighton Group

The lithology of the Brighton Group (Baxter Formation in the Western Port Basin) is highly variable with facies varying from clay and silt to sand and gravel. The group includes glauconitic, silty and shelly sand which are difficult to distinguish lithologically from the underlying Fyansford Formation. The group is partly ferruginised. The numerous shallow bores (rarely deeper than about 20 m) in the southeastern suburbs mostly tap the Brighton Group. Salinities range from less than 500 up to 7,500 mg/L TDS (Leonard, 1979) but are mostly less than 2,500 mg/L TDS (Hancock, 1992). Bore yields are generally less than four L/sec (Leonard, 1992).

The Brighton Group outcrop or subcrop beneath a thin veneer of Quaternary sediments beneath the southeastern suburbs of Melbourne. The group outcrops in both the northeastern and southwestern corners of the site (Figures 5.5 and 5.6) and would be present beneath Quaternary dune deposits across most of the remainder of the site.

5.3.6 Unnamed Quaternary Deposits

The Quaternary deposits of the Carrum Swamp in the Port Phillip Basin and the more extensive Koo Wee Rup Swamp in the Western Port Basin consist of clay, silt, mud and peat. Similar swamp deposits have been mapped along the Eumemmerring Creek to the east of the Carrum Swamp and in an irregular shaped area extending from the edge of the Carrum Swamp near Lyndhurst to Cranbourne.

Extensive sand sheets, ridges and dunes cover much of the area between the Carrum and Koo Wee Rup swamps. The sand deposits overlie the Tertiary Brighton Group (and Western Port Basin equivalents, the Baxter Formation) or the Silurian Melbourne Formation. The sand is fine to medium-grained containing no coarse fraction (Bowen, 1967), is less than 15 m thick and elevated by 4 to 6 m above the surrounding topography.

Where saturated, the Quaternary dune sands can be locally important aquifers containing low salinity groundwater whereas the swamp deposits are generally low permeability aquitards.

Quaternary dunes overlie the Brighton Group across the majority of the Brompton Lodge site except for small areas of Brighton Group and Melbourne Formation outcrops in the southwestern and northeastern corners of the site, respectively.

5.3.7 Groundwater Recharge and Flow

Recharge into areas of outcropping aquifer material is mainly by direct infiltration of rainfall. Deeper aquifers are recharge via cross-formational flow (vertical leakage and/or lateral inflow). Groundwater discharge is into the near off-shore zones within the bays or into topographic lows including the Carrum and Koo Wee Rup swamps.

Regional groundwater flow is generally in a radial pattern from more elevated inland areas towards Port Phillip Bay or Western Port Bay. However, local groundwater flow direction may be at variance to the generalised regional flow direction reflecting the local recharge/discharge regime. The groundwater divide along the Mornington Peninsula is considered to be coincidental with the surface water divide. Consequently groundwater flow beneath the Brompton Lodge site would be towards Port Phillip Bay.

6.0 GROUNDWATER MANAGEMENT AREA

The Brompton Lodge site is located within the Frankston Groundwater Management Area (Frankston GMA0. The Frankston GMA extends along Port Phillip Bay from Frankston to Carrum and inland to Dandenong South and Cranbourne. The Cranbourne-Frankston Road forms the southeastern boundary of the Frankston GMA (Figure 6.1). The amount of groundwater that can be extracted from all formations within the Frankston Groundwater Management Area (GMA) has been set at 3,200 ML per year (Victorian Government Gazette G44 pp 2397, 2 November 2006).

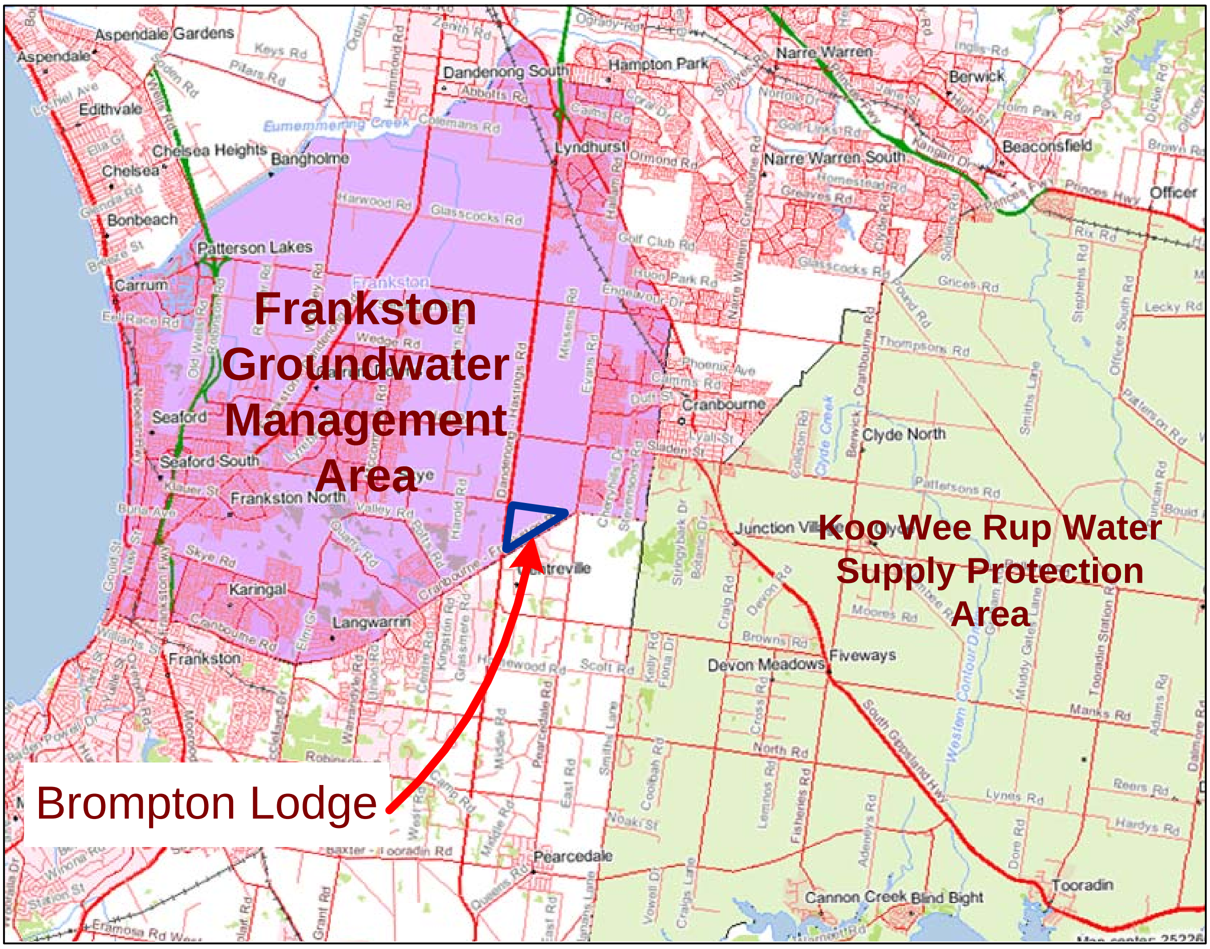


FIGURE 6.1 Local Groundwater Management Areas

7.0 GROUNDWATER INVESTIGATIONS

Field investigation at Brompton Lodge included installation of a network of monitoring bores, and measuring groundwater levels and chemistry. The various groundwater investigations and water quality testing programs are described in this chapter and the test results are discussed in the following Chapters.

7.1 MONITORING BORES

URS installed 17 bores at Brompton Lodge Groundwater occurrence at the Brompton Lodge during December 2007; the URS bore were installed at 12 separate locations across the site with a shallow and deeper bore at five of the locations. JLCS installed three bores (BH13, BH14 and BH15) were installed along an approximate west-east line through Sand Pits 1 and 2 during July 2011 as part of the current project. Coffey installed five monitoring wells (MW1-MW5) to assess potential groundwater contamination around the refuelling areas (MW1-MW3), the poultry sheds (MW4) and down gradient of the major areas of potential contamination (MW5). - Monitoring bore details are summarised in Table 7.1 and bore location are plotted on an air photograph image and a site survey base map and in Figures 7.1 and 7.2, respectively.

The URS 2008 report did not have bore coordinates; these were obtained by georegistering the bore location plan in the URS report and digitising bore positions. Field observations indicated that the URS plotted bore positions were approximate only. The elevation of the ground surface at the bore headworks was not included in the URS report; this was obtained by subtracting the casing stick-up measured in the field by JLCS from the top of casing elevations. Watsons surveyed the MGA coordinates and elevations of the top of bore casing of the three bores installed by JLCS.

Details of the bores installed by Coffey were extracted from the Brompton Lodge Phase 2 Environmental Site Assessment report (Coffey, 2013).

Bore logs included in previous site investigation reports (URS, 2008; JLCS 2011a: Coffey 2013) indicate that the near surface geology beneath Brompton Lodge consists of fine grained material (predominantly sandy-silty clay, silty-clayey sand with lesser sand).

7.1 GROUNDWATER LEVEL MONITORING

The water levels in the monitoring bores were measured by URS (the measurement date was not provided in the URS report; based on the bore installation completion date, 20 December 2007, and the statement in the URS report limitations section that the report was prepared between 17 and 31 January 2008, JLCS has assumed that the water levels were measured during early January 2008. [URS referred to the elevation of the “water level” as Standing Water Level which is incorrect.] The water levels in the URS and JLCS bores were measured on 18 July 2011 and in the bores close to the dwarf galaxias habitat ponds on 4 August 2011 by JLCS. Water levels in all of the onsite monitoring bore were measured by JLCS on 30 November 2012, by Coffey 13 January 2013 and by JLCS on 20 March 2013 and 3 May 2013.

TABLE 7.1 Brompton Lodge Monitoring Bore Details

Bore	MGA94 Coordinates		RLTC (m AHD)	RLNS (m AHD)	S/U (m)	Depth (m)	Screens (m bgl)		Filter (m bgl)		Seal (m bgl)		Stratigraphic Unit screened
	Easting	Northing					From	to	from	to	from	to	
BH1A	345070.57	5778305.74	52.78	52.08	0.70	17.50	14.5	17.5	3.5	17.5	0.5	3.5	Melbourne Fm
BH1B	345075.47	5778302.48	52.80	52.21	0.59	1.98	0.5	1.7	0.2	1.7	0.1	0.2	Dune sand
BH2A	345825.26	5778609.13	53.11	52.39	0.72	16.00	8.5	16.0	8.5	16.0	10.0	8.5	Dune sand-Brighton Gp-Melbourne Fm
BH2B	345826.34	5778612.40	52.77	52.35	0.42	2.20	0.5	2.2	0.2	2.2	0.1	0.2	Dune sand
BH3A	345375.06	5779044.11	51.39	50.66	0.73	8.50	0.2	6.2	0.2	6.2	0.0	0.2	Dune sand
BH3B	345375.06	5779039.22	51.25	50.74	0.51	2.20	1.7	2.2	0.2	2.2	0.1	0.2	Dune sand
BH4A	346162.36	5779020.73	58.73	57.90	0.83	14.00	4.5	10.5	3.8	10.5	3.0	3.8	Melbourne Fm
BH4B	346161.82	5779027.26	58.12	57.50	0.62	2.20	0.5	2.2	0.2	2.2	0.1	0.2	Brighton Gp
BH5A	345139.09	5778611.38	50.48	49.73	0.75	9.00	3.0	9.0	2.0	9.0	1.5	2.0	Dune sand
BH5B	345128.53	5778612.96	50.15	49.67	0.48	2.20	0.5	2.2	0.2	2.2	0.1	0.2	Dune sand
BH6	345049.37	5778107.82	54.72	54.24	0.48	3.00	1.0	3.0	0.5	3.0	0.2	0.5	Brighton Gp.
BH7	344799.26	5777953.88	56.13	55.70	0.43	3.00	1.0	3.0	0.5	3.0	0.2	0.5	Brighton Gp.
BH8	344961.28	5778982.13	47.51	47.05	0.46	2.60	0.6	2.6	0.5	2.6	0.2	0.5	Dune sand
BH9	345102.11	5778800.52	47.31	46.90	0.48	3.00	1.0	3.0	0.5	3.0	0.2	0.5	Dune sand
BH10	344905.32	5778792.90	47.39	46.99	0.44	2.70	0.7	2.7	0.5	2.7	0.2	0.5	Dune sand
BH11	345155.94	5779064.23	45.85	45.24	0.61	2.70	0.7	2.7	0.5	2.7	0.2	0.5	Dune sand
BH12	344876.83	5778497.40	50.36	49.91	0.45	3.00	1.0	3.0	0.5	3.0	0.2	0.5	Dune sand
BH13	345073.45	5778468.64	50.96	50.37	0.59	4.50	1.50	4.50	1.2	4.5	0.7	1.2	Dune sand
BH14	345199.32	5778428.69	51.99	51.44	0.55	4.50	1.50	4.50	1.2	4.5	0.7	1.2	Dune sand
BH15	345353.76	5778458.72	54.13	53.59	0.56	5.50	1.50	4.50	1.2	4.5	0.7	1.2	Dune sand
MW1	344986.16	5778326.79	52.248	52.352	-0.1	4.0	2.5	4.0	2.0	4.0	1.0	2.0	Dune sand
MW2	344993.97	5778316.74	52.353	52.435	-0.1	4.0	2.5	4.0	2.0	4.0	1.0	2.0	Dune sand
MW3	344991.34	5778305.64	52.634	52.666	0.0	4.0	2.0	4.0	1.8	4.0	1.0	1.8	Dune sand
MW4	344842.38	5778495.42	50.687	49.885	0.8	4.0	2.5	4.0	2.0	4.0	1.5	2.0	Dune sand
MW5	344948.25	5779156.33	45.124	44.349	0.8	4.0	2.5	4.0	2.0	4.0	1.0	2.0	Dune sand

Notes: RLNS determined by subtracting field measured casing stick-up (S/U) from surveyed top of casing.

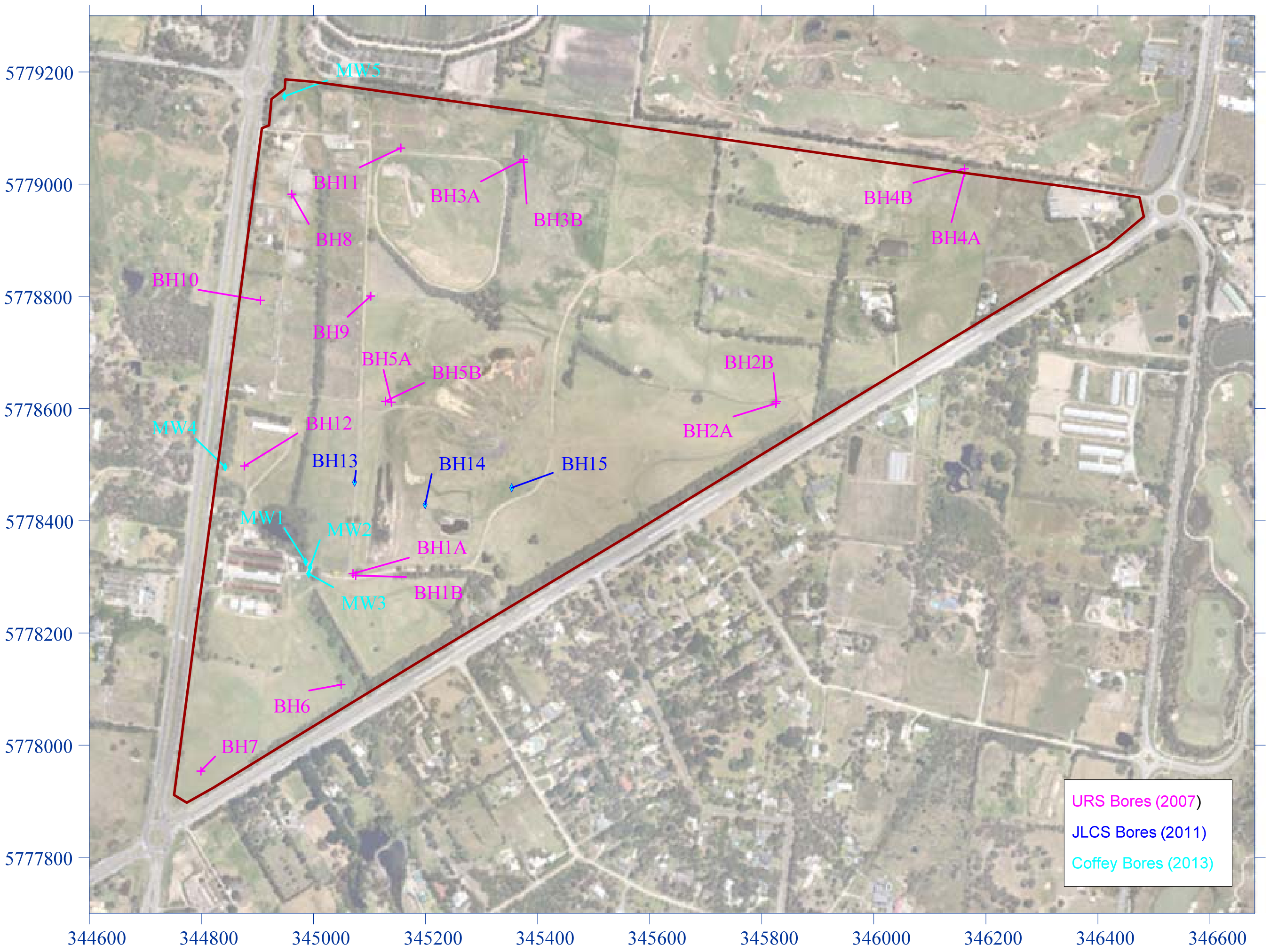


FIGURE 7.1 Brompton Lodge Monitoring Bore Locations, Satellite Image Base Map

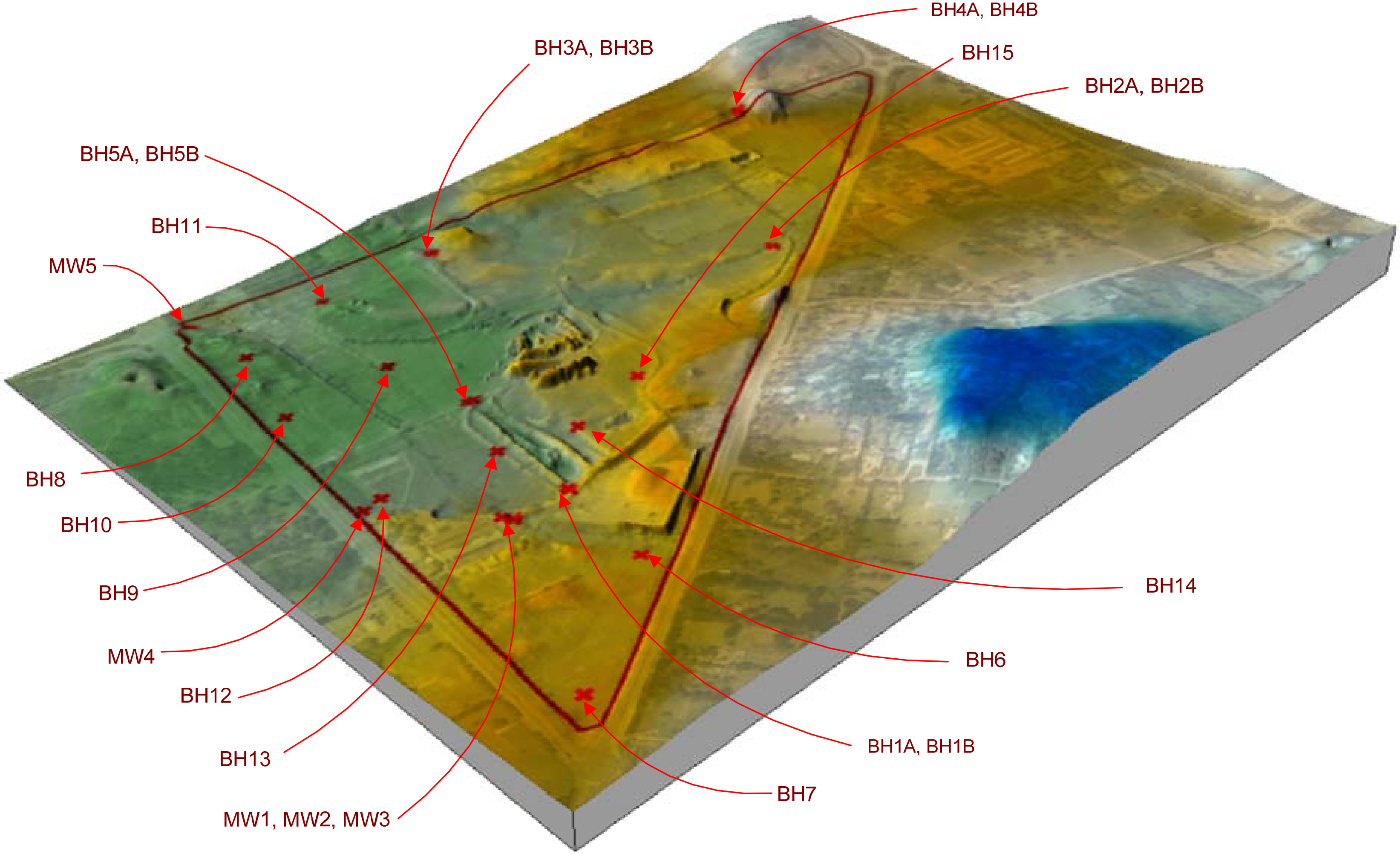


FIGURE 7.2 Monitoring Bore Locations Plotted on Aerial Photograph Draped Over Digital Elevation Model

7.2 GROUNDWATER QUALITY

7.2.1 Basic Water Quality Parameters

Basic water quality parameters (EC, pH, TDS, major anions and cations) have been measured a number of times since groundwater investigations commenced in 2007. The EC and pH of groundwater sampled from 16 of the 17 initial bores (one bore was dry) installed by USR in 2007 were tested in the field in January 2008. Groundwater from the shallow bores sampled on 18 July 2011 by JLCS were analysed for a range of standard water quality parameters. The samples were analysed by MGT-LabMark Environmental Laboratories. Samples of water collected from Sand Pit 1 and Sand Pit two (designated as SW1 and SW2). The EC, TDS and pH of groundwater in the Brompton Lodge monitoring bores were measured in the field in January 2013 as part of a Phase 2 Environmental Site Assessment.

7.2.1 Groundwater Contamination Parameters

Groundwater samples from selected bores were analysed for targeted suites of potential groundwater contaminants based on different land uses across the site. Potential contamination sources identified by Coffey included the poultry farm area; above and underground fuel storage tanks, horse agistment area, incinerator and burn-off areas; and waste disposal area (Coffey, 2013).

7.3 FIELD OBSERVATIONS

Much of the Brompton Lodge site was water-logged during the site inspection on 18 July 2011. Wet areas were noted close to the bores even near bores where the groundwater level was more than 0.5 m below ground level. Water logged conditions were not observed during the November 2012, March 2013 and May 2013 groundwater monitoring rounds by JLCS. These observations indicate that the water logged conditions were due to surface water rather than being indicative of a very shallow (near surface) water table. No evidence of salinisation was observed during any of the five site inspections by JLCS.

The water level recovery in the Brompton Lodge monitoring bores was slow to very slow after groundwater sampling events indicating that the permeability of the sampled intervals is low (i.e., small hydraulic conductivity values).

8.0 GROUNDWATER DEPTH, ELEVATION AND FLOW

8.1 GROUNDWATER LEVEL

The groundwater levels measured in the Brompton Lodge monitoring bores are presented in Tables 8.1 and 8.2. Standing Water Levels (SWLs) were recorded as metres below top of casing (m btc) and converted to metres below ground level (m bgl), and elevation (reduced levels in m AHD). [Where the bores were "dry", the Standing Water Levels (SWLs) are recorded as "greater than" the bore depth and corresponding water level elevations are recorded as "less than" the elevation of the bottom of the bore.]

Groundwater depth measurements show that the depth to groundwater varies beneath Brompton Lodge from less tan 0.5 m up to more than 7.0 m below ground level (bgl). The water table is a subdued reflection of the local topography and is deeper beneath the higher elevated area in the northeastern corner and along the site's southeastern boundary of the site and shallowest beneath the main east-west drainage line (Figure 8.1).

Detailed analysis of the water table around the water filled sand pits (Sand Pits 1 and 2) by JLCS (2011) indicated that the elevation of the water surface in Sand Pits 1 and Sand Pit 2 was lower than the elevation of the surrounding water table. Consequently, the ponds in the sand pits are groundwater sinks, fed by groundwater inflow (discharge). The water level in the ponds was lower than the surrounding groundwater as a result of evaporation losses from the ponds. JLCS (2011) concluded that the ponds are through flow type water bodies (the ponds represent water table outcrops).).

Bore hydrographs showing changes in the elevation of the measured water level in each bore over time are plotted in Figure 8.2; Figure 8.2 includes hydrographs for all bores (not individually identified) to provide an "overview" of water level trends. Detailed hydrographs for individual bores are presented in Figures 8.3 to 8.3, inclusive. Comparison of the hydrographs with monthly rainfall (recorded at the nearby Cranbourne Botanical Gardens; plotted in Figure 8.1) indicates that groundwater levels are broadly sympathetic with local rainfall with water level changes tending to lag behind rainfall events.

8.2 GROUNDWATER FLOW

The water table contours generated using the May 2013 monitoring data are presented in Figure 8.8. The contours indicate that groundwater flow beneath Brompton Lodge is in a general northwesterly direction i.e., the water table locally slopes from the southeast to the northwest. The flow lines are distorted around the ponds in the former sands pits with flow lines converging towards the pit ponds. [The flow lines would most likely also be distorted by discharge into other surface water features at the site but insufficient data is available to map the influence of these features on groundwater flow.] Because the ponds were established on a sloping water table, the capture zone is asymmetrical with the capture area greater in the up-hydraulic gradient (northeast) direction. A three-dimensional visualisation of the drawdown in the water table resulting from groundwater discharge into the pits is presented in Figure 8.9 (based on July 2011 monitoring data).

TABLE 7.2 Groundwater Level Measurement Data

Bore	Jan-08		Jul-11		Aug-11		Nov-12		Jan-13		Mar-13		May-13	
	SWL	RLWL	SWL	RLWL	SWL	RLWL	SWL	RLWL	SWL	RLWL	SWL	RLWL	SWL	RLWL
BH1A	1.02	51.06	0.09	51.99			0.81	51.27	1.99	50.8	2.15	50.63	2.25	50.53
BH1B	1.11	51.1	0.13	52.08	0.21	51.89	0.96	51.25	Dry	<50.21	Dry	<50.21	Dry	<50.21
BH2A	2.03	50.36	0.85	51.54					1.77	51.34	2.1	51.01	2.35	50.76
BH2B	1.45	50.9	0.37	51.98					2.23	50.54	2.29	50.48	Dry	<50.15
BH3A	2.78	47.88	1.3	49.36			1.48	49.18	2.45	48.94	1.56	49.84	2.52	47.88
BH3B	1.88	48.86	1.38	49.36			Dry	<48.54	Dry	<48.54	Dry	<48.54	Dry	<48.54
BH4A	7.38	50.52	5.93	51.97			5.68	52.22	6.19	52.18	6.25	52.13	6.36	52.01
BH4B	>2.2	< 55.30	0.4	57.1			1.76	55.74	Dry	<55.3	Dry	<55.3	Dry	<55.3
BH5A	1.81	47.92	1.04	48.7			51.7	48.51	2.58	47.9	2.75	47.73	2.9	47.58
BH5B	1.56	48.11	0.35	49.32	0.8	48.87	1.23	48.44	2.23	47.92	2.41	47.75	Dry	<47.47
BH6	1.31	52.93	0.18	54.06	0.4	53.84	0.77	53.48	2.04	52.68	2.07	52.65	1.9	52.82
BH7	2.92	52.78	1.96	53.74			1.24	54.46	2.08	54.06	2.54	53.59	2.85	53.29
BH8	1.28	45.77	0.6	46.45				<44.5	Dry	<44.5	Dry	<44.5	Dry	<44.50
BH9	0.69	46.14	0.05	46.85	0.16	46.67	0.49	46.34	1.4	45.91	1.42	45.89	1.31	46
BH10	0.95	46	0.03	46.96	0.12	46.83	0.81	46.14	1.74	45.65	1.75	45.65	1.71	45.68
BH11	0.89	44.35	0.08	45.16			0.64	44.6	1.91	43.94	2.05	43.81	2.21	43.65
BH12	1.3	48.61	0.24	49.67	0.31	49.6	0.93	48.98	1.83	48.53	2.04	48.33	2.23	48.13
BH13	1.02	51.06	0.3	50.07	0.46	49.91	1.13	49.24	2.2	48.77	2.35	48.62	2.44	48.52
BH14			2.86	48.58	0.22	51.22	0.71	50.73	1.9	50.09	2	49.99	2.35	49.64
BH15			0.18	53.41	0.09	53.51	0.7	52.89	1.75	52.38	1.9	52.23	2	52.13
MW1									1.91	50.34	1.72	50.52	2.01	50.24
MW2									1.95	50.41				
MW3									2.33	50.31	2.66	49.97	2.51	50.12
MW4									2.06	48.63	2.06	48.62	2.12	48.57
MW5									2.29	42.83	2.37	42.76	2.44	42.68

Notes: 1) SWL; Standing Water Level (m bgl). 2) RLWL; Reduced Level Water Level (elevation, m AHD)

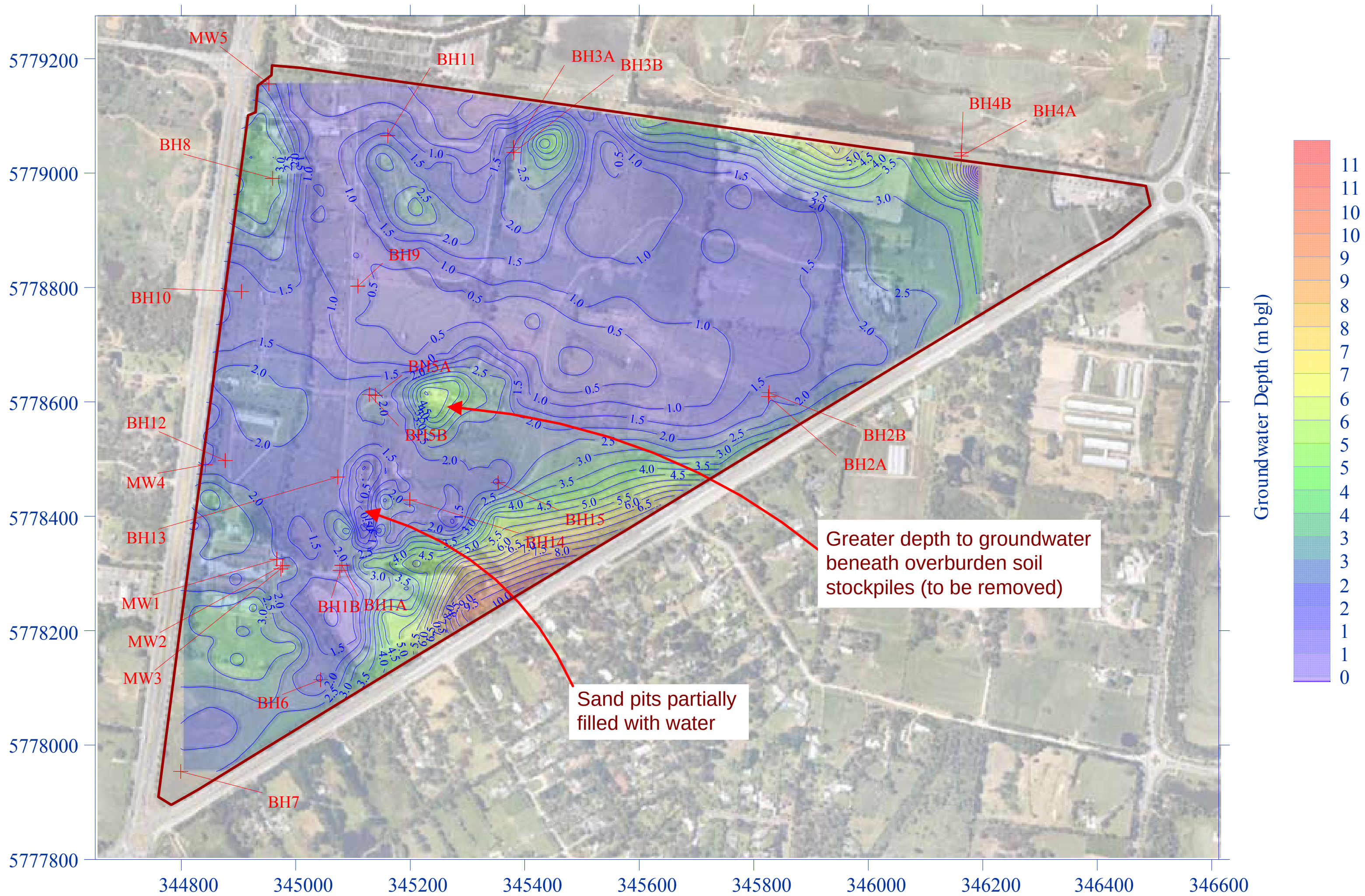


FIGURE 8.1 May 2013 Depth to Groundwater

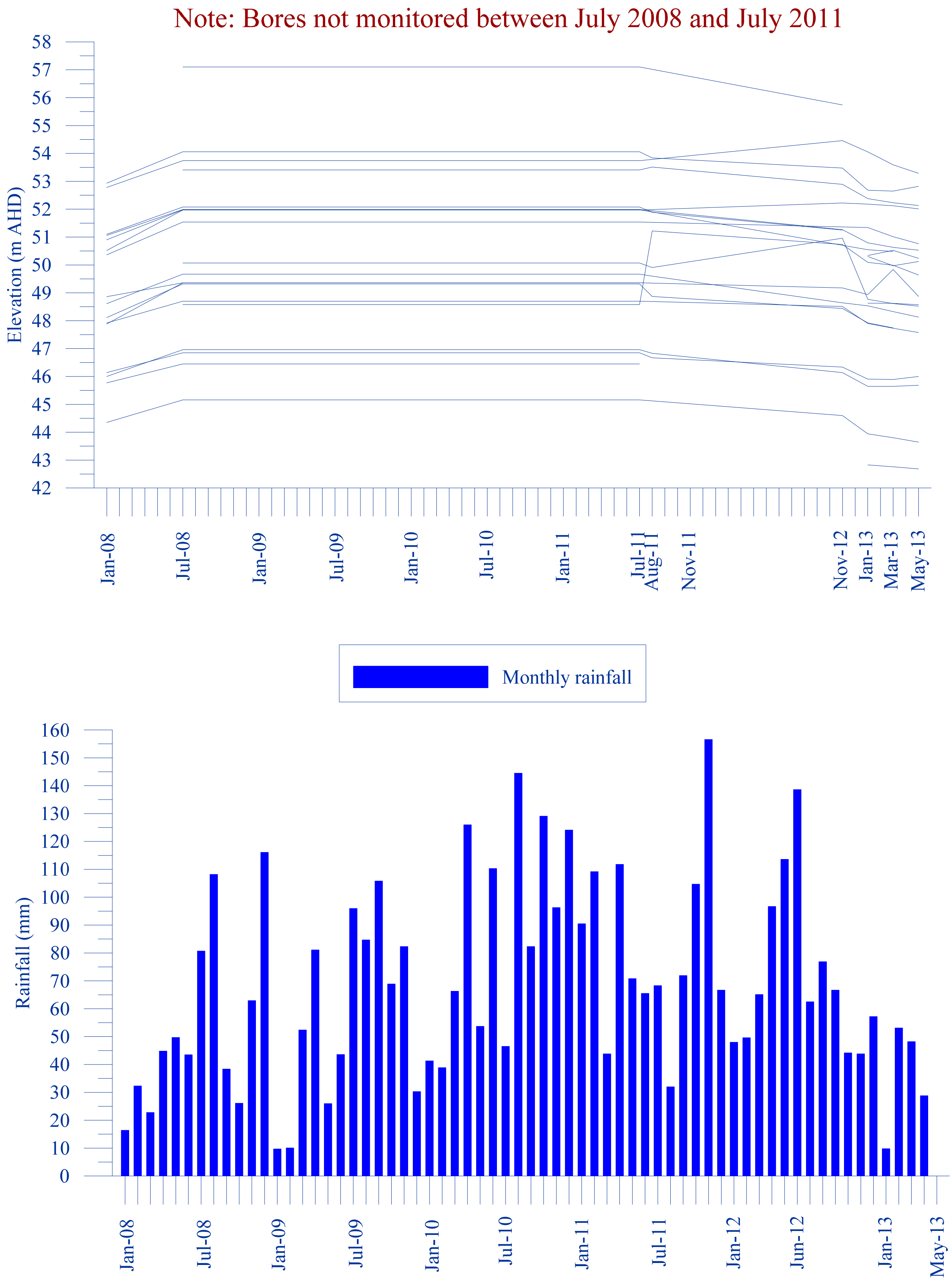


FIGURE 8.2 Brompton Lodge Monitoring Bore Hydrographs and Monthly Rainfall

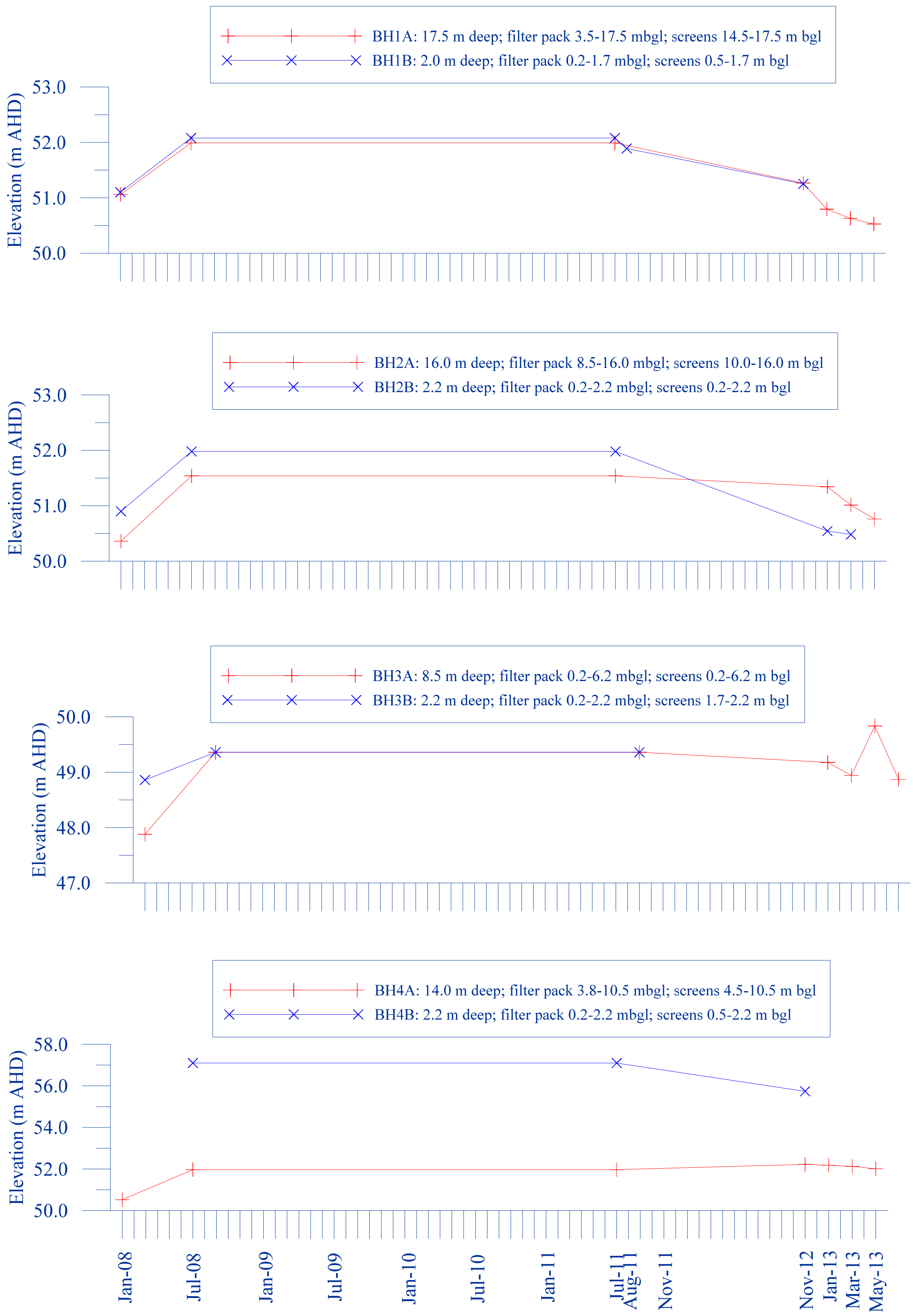


FIGURE 8.3 Monitoring Bores BH1, BH2, BH3 and BH4 Hydrographs

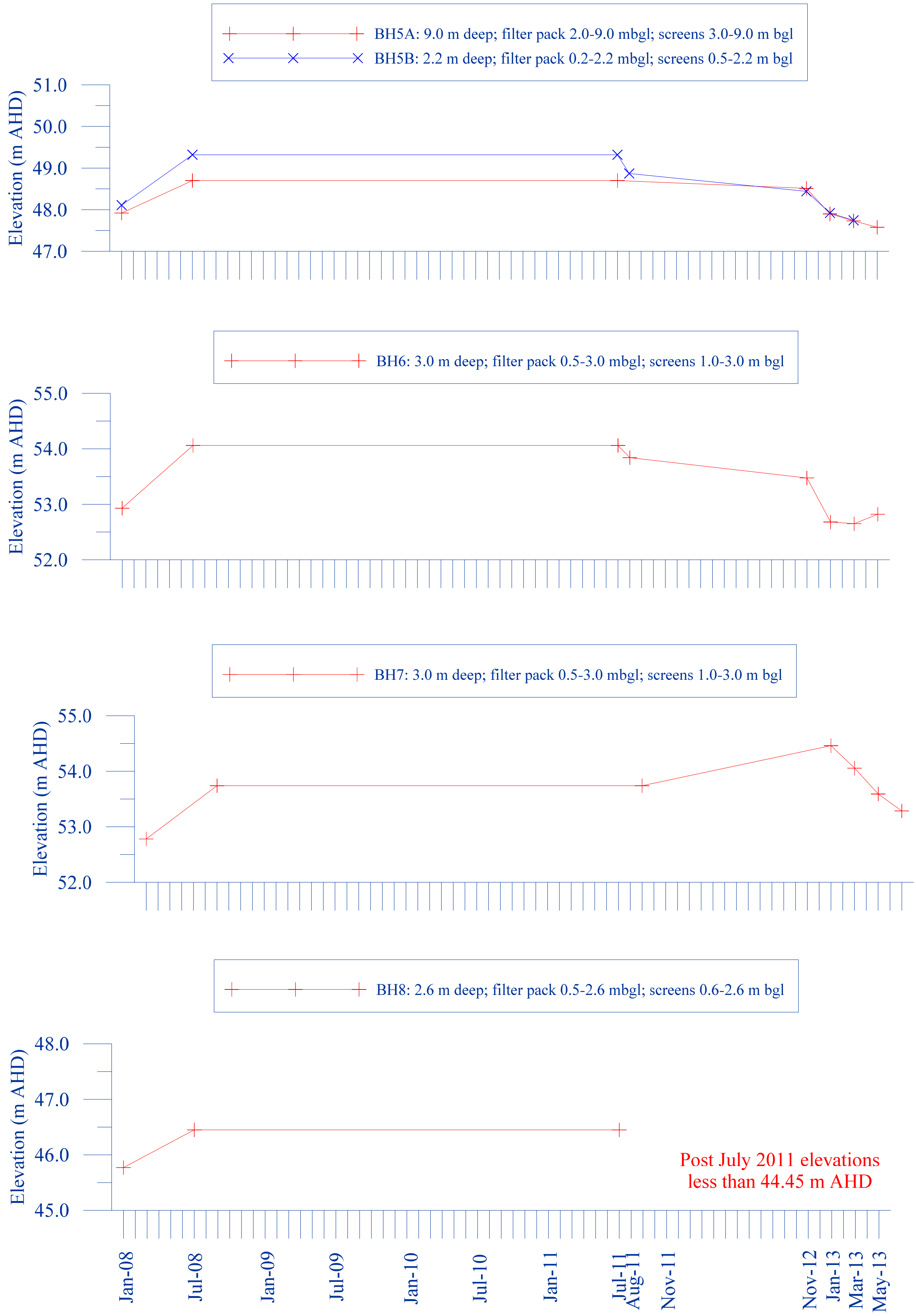


FIGURE 8.4 Monitoring Bores BH5, BH6, BH7 and BH8 Hydrographs

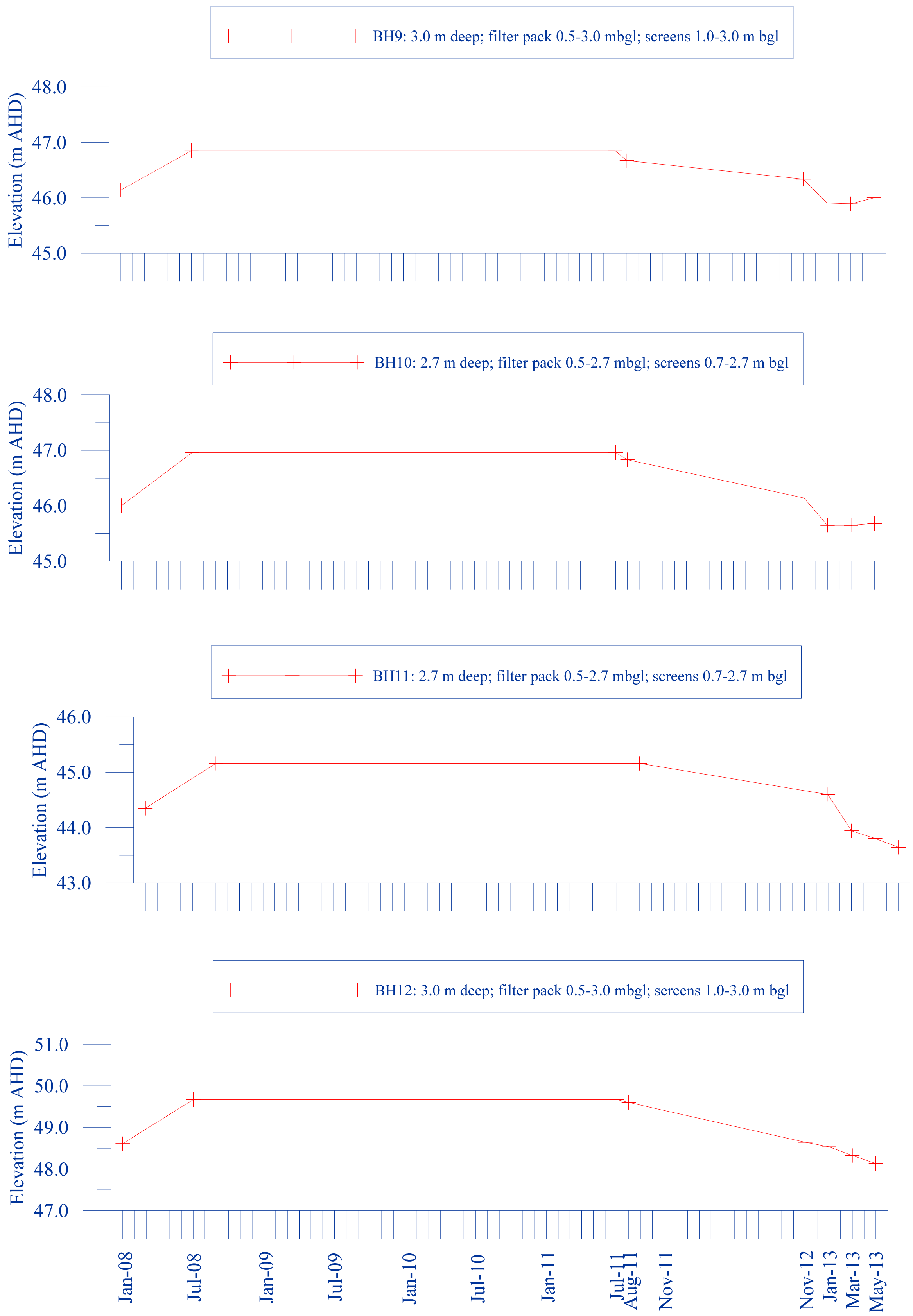


FIGURE 8.5 Monitoring Bores BH9, BH10, BH11 and BH12 Hydrographs

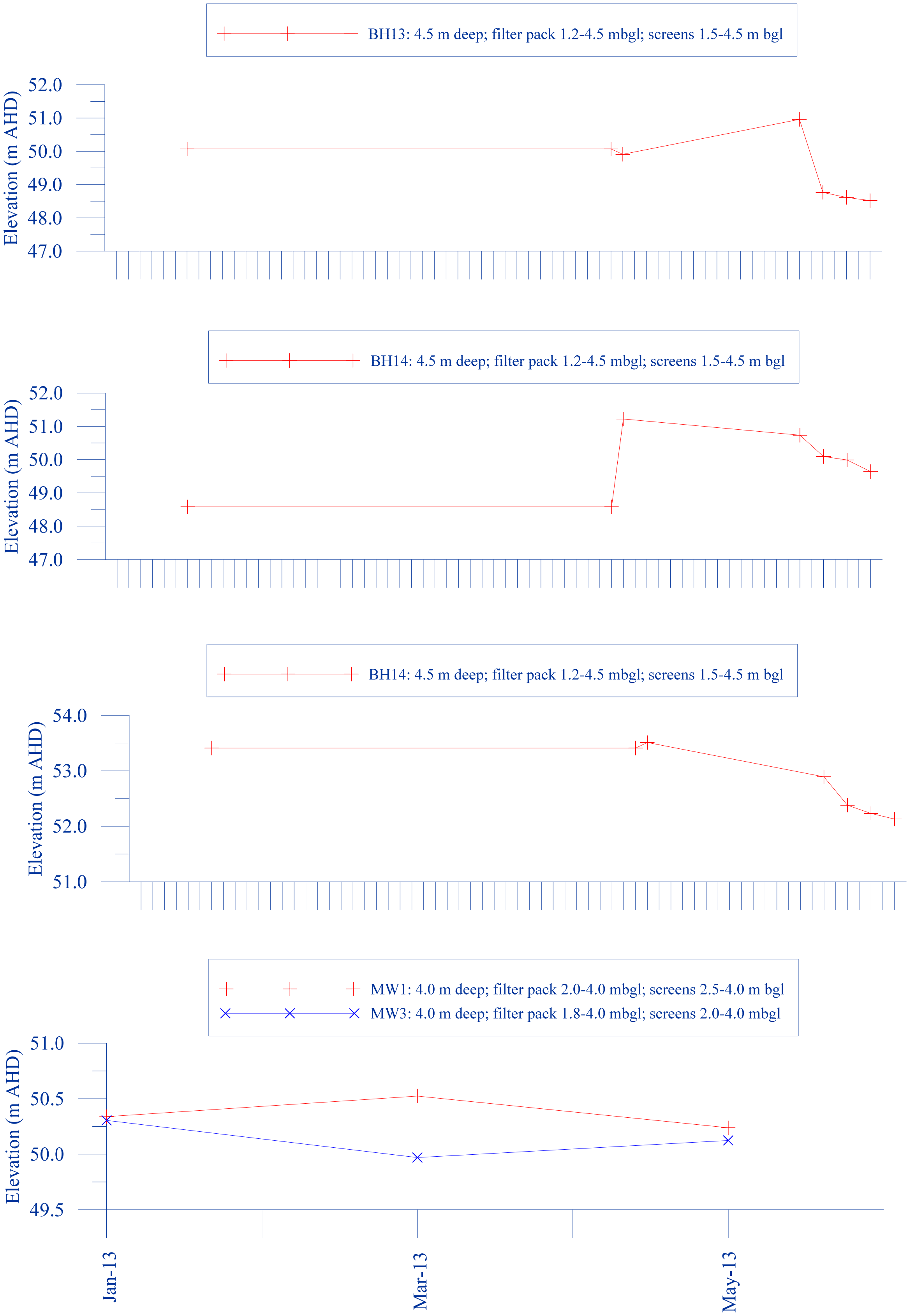


FIGURE 8.6 Monitoring Bores BH13, BH14, BH15, MW14 and MW3 Hydrographs

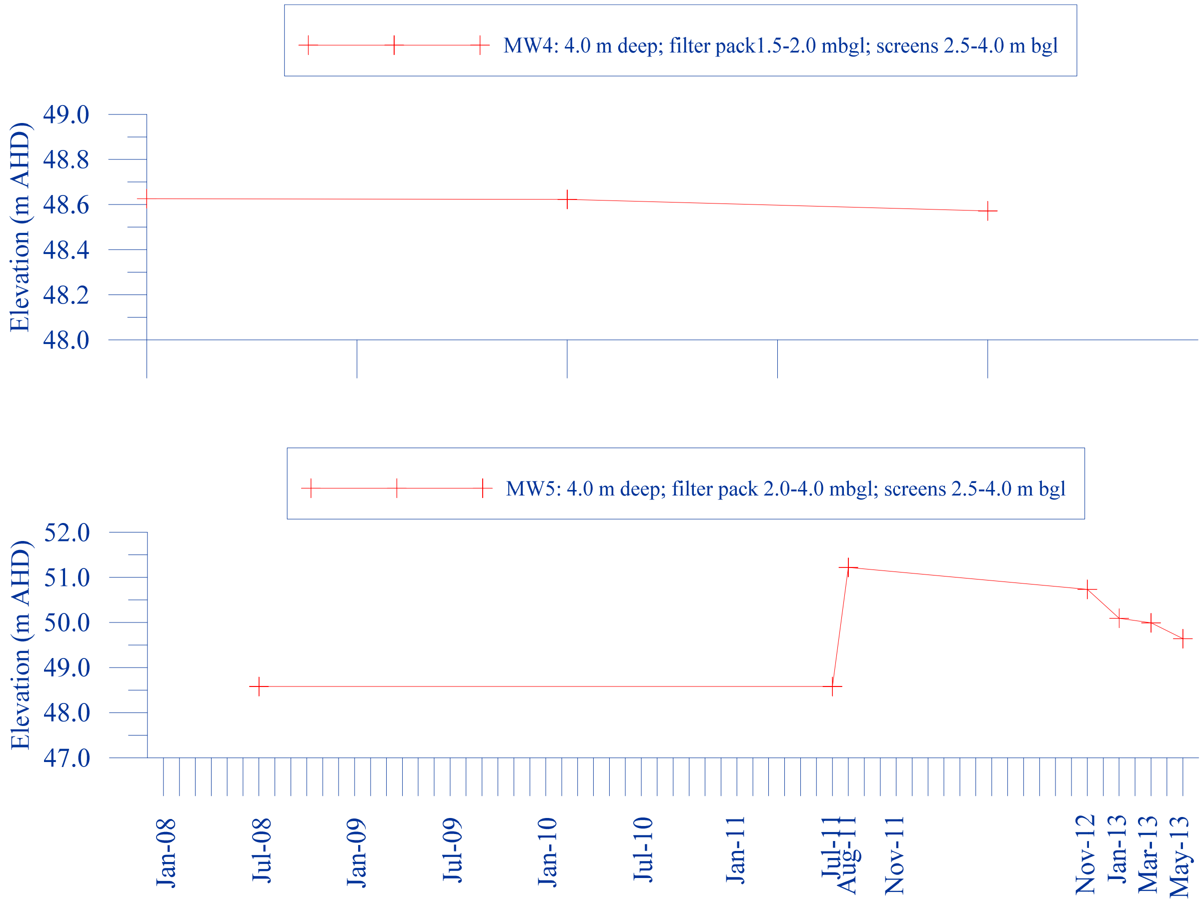


FIGURE 8.7 Monitoring Bores MW4 and MW5 Hydrographs

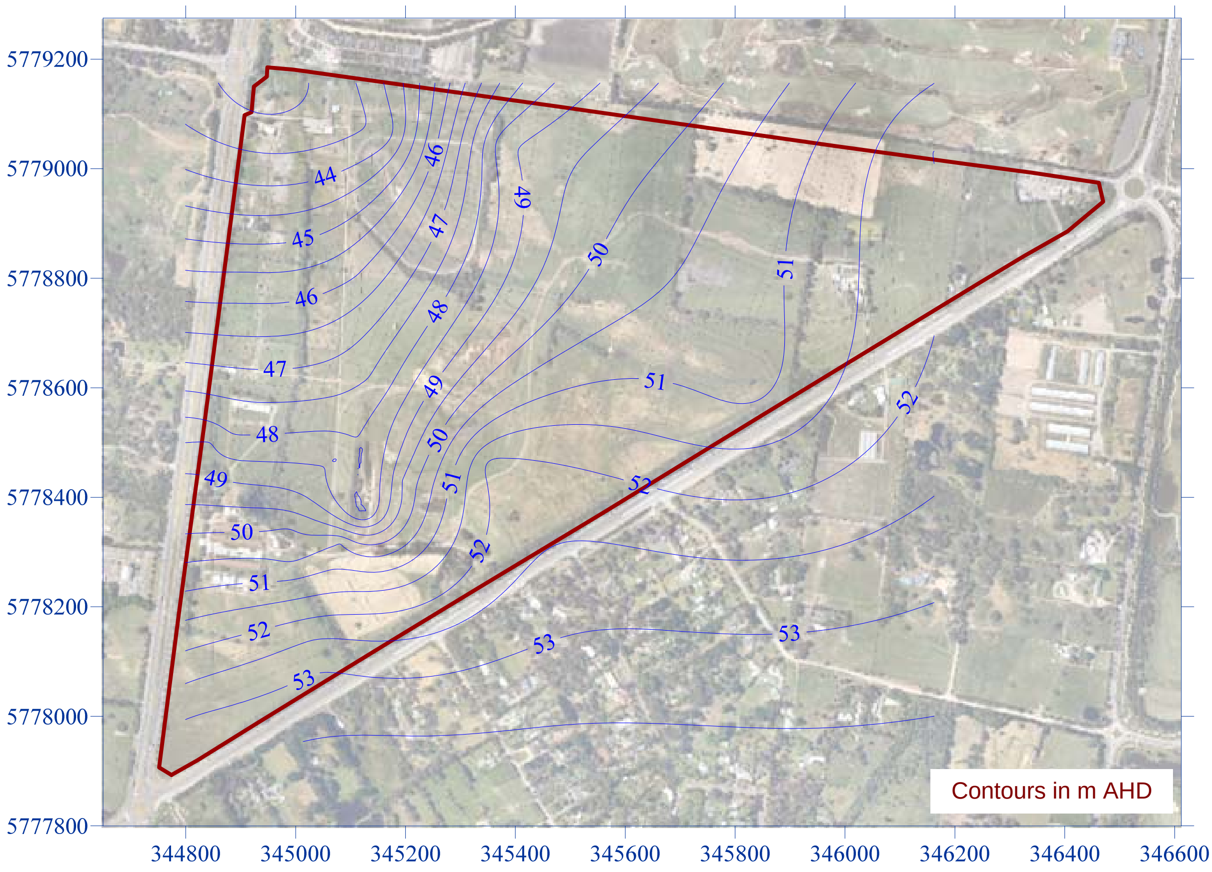


FIGURE 8.8 May 2013 Water Table Contour Map

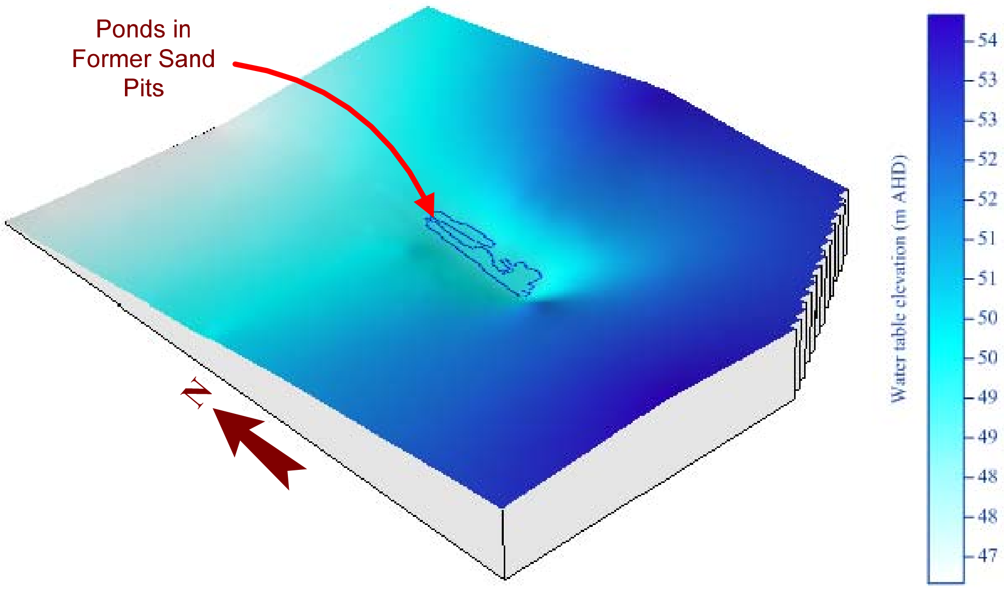


FIGURE 8.9 Three-Dimensional Visualisation of Water Table Near Sand Pit Ponds, August 2011 Data (After JLCS, 2011)

9.0 GROUNDWATER QUALITY, BENEFICIAL USES AND IMPACT

9.1 GROUNDWATER QUALITY

The Standard Groundwater Quality testing results are summarised in Table 8.1. The concentrations of total dissolved solids (TDS) in the groundwater and pit water samples collected on the 18 July 2011 are posted on a site base map in Figure 9.1. The TDS concentrations in the groundwater ranged from 200 to 10,000 mg/L with average and median concentrations of 1,537 and 520 mg/L, respectively. The TDS high, 10,000 mg/L, is an outlier which is 6,600 mg/L higher than the second highest TDS concentration and could be a spurious result.

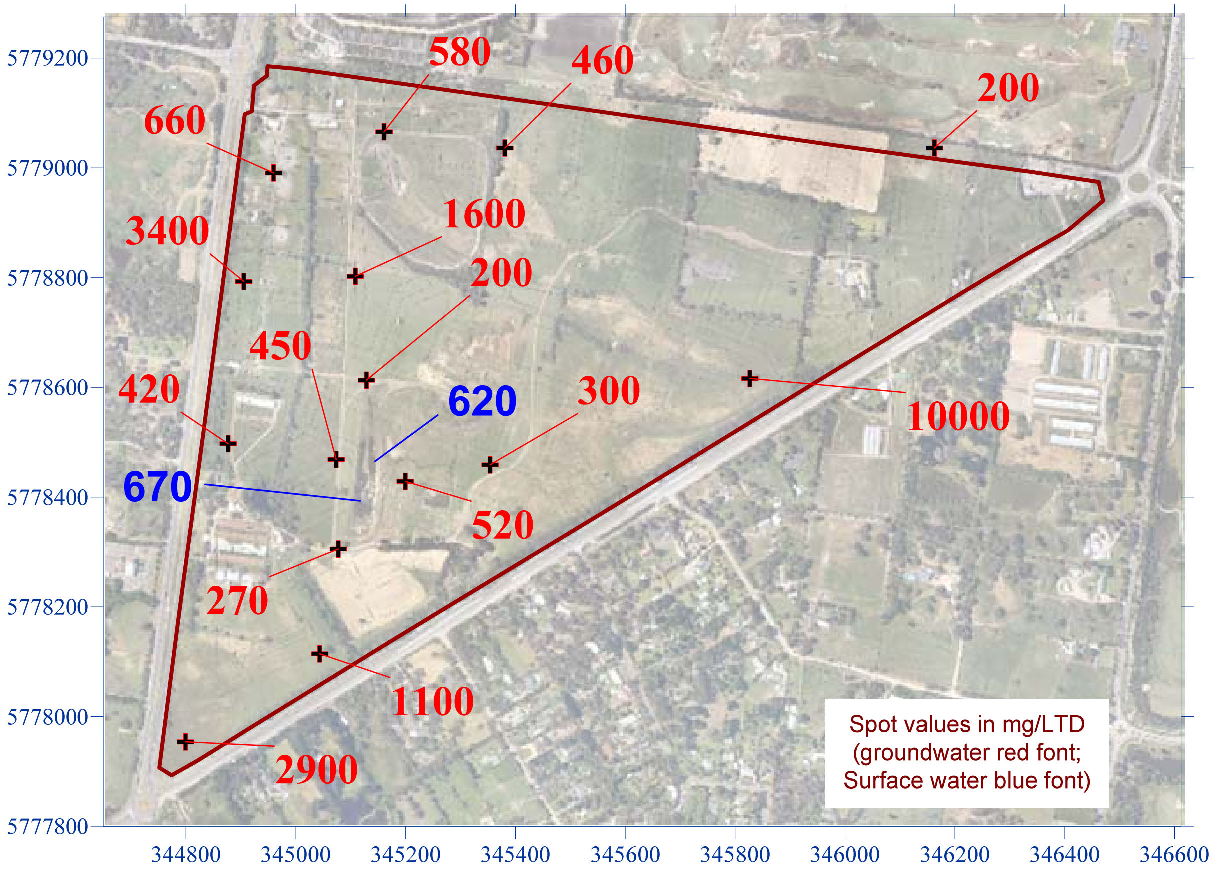


FIGURE 9.1 Water Salinity Spot Values, 18 July 2011 Data

TABLE 9.1 Brompton Lodge Basic Water Chemistry Test Results

Bore	Jan-08 (URS)		Jul-11 (JLCS)															Jan-13 (Coffey)		
	EC	TDS*	pH	EC	TDS	pH	Na	K	Ca	Mg	Cl	HCO3	CO3	SO4	NO3-N	PO4o	PO4t	ECf	TDS lab	Ph fld
BH1A	1778	1156	6.47	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	992	400	7.49
BH1B	1070	696	6.26	390	270	6.5	32	37	15	8.6	31	140	< 10	< 5	< 0.02	0.27	0.94	Dry	Dry	Dry
BH2A	3650	2373	6.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3210	1900	5.97
BH2B	11050	7183	5.88	16000	10000	6.5	2500	<5	26	550	5300	270	< 10	76	< 0.02	< 0.05	0.6	16750	DRY	6.29
BH3A	3040	1976	5.96	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	Dry	Dry
BH3B	1654	1075	6.06	670	460	7.0	56	36	32	23	56	250	< 10	< 5	< 0.02	0.83	1.9	Dry	Dry	Dry
BH4A	1382	898	6.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1403	900	5.87
BH4B	NS	NS	NS	300	200	6.5	38	4	13	7.6	17	100	< 10	5.2	< 0.02	0.73	1.8	Dry	Dry	Dry
BH5A	503	327	5.37	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	500	620	5.58
BH5B	541	352	5.19	290	200	6.1	47	6.9	5.2	4.6	38	53	< 10	11	< 0.02	< 0.05	0.47	Dry	Dry	Dry
BH6	1134	737	7.13	1600	1100	6.4	210	0.9	24	74	240	200	< 10	83	< 0.02	< 0.05	0.28	1425	2000	5.61
BH7	4210	2737	7.02	4800	2900	6.7	990	9.4	< 5	66	1400	200	< 10	50	< 0.02	< 0.05	0.81	4390	2500	6.27
BH8	1127	733	5.58	950	660	5.9	76	31	77	17	140	39	< 10	17	52	0.08	0.23	Dry	Dry	DRY
BH9	2189	1423	5.13	2600	1600	4.1	390	<0.5	15	100	910	< 20	< 10	< 5	< 0.02	< 0.05	0.44	2600	2700	5.43
BH10	2,742	1782	5.61	5800	3400	4.8	850	6.8	69	220	1900	< 20	< 10	44	< 0.02	< 0.05	0.44	3760	2400	4.73
BH11	775	504	4.48	920	580	5.4	130	24	11	28	300	23	< 10	< 5	< 0.02	0.12	3.4	928	760	5.19
BH12	625	406	6.12	630	420	6.3	88	35	< 5	20	120	80	< 10	21	0.05	< 0.05	0.63	609.5	2700	5.79
BH13				700	450	5.5	140	< 5	< 5	10	150	58	< 10	18	0.03	< 0.05	4.2	576	19000**	5.46
BH14				800	520	5.0	150	< 5	< 5	18	290	< 20	< 10	< 5	< 0.02	< 0.05	0.16	937	1000	5.75
BH15				490	300	4.9	72	9.6	< 5	17	130	< 20	< 10	11	5.8	< 0.05	0.66	419	2000	4.65
MW1																		1508	840	5.93
MW2																		2190	3800	6.06
MW3																		987	580	6.09
MW4																		590	3400	4.97
MW5																		570	1200	6.05

Note: 1) January 2008 monitoring by URS; July 2011 monitoring by JLCS; January 2013 monitoring by Coffey. 2) * TDS determined by JLCS multiply the EC measurement by 0.65 (average of ratio determined for July 2011 samples). 3) PO4o Orthophosphate, PO4t total phosphate. 4) Units are mg/L except EC (µs/cm) and pH (pH units). 5) ** TDS result for groundwater in the January 2013 sample from bore BH13 was an outlier and consider spurious by JLC based on previous test results and the EC measured by Coffey,. The salinity of groundwater from BH13 sampled in May 2013 was 710 µS/cm.

The anion and cation concentrations in the tested July 2011 groundwater and sand pit water samples converted to milliequivalents per litre (meq/L) are plotted on a Piper Diagram in Figure 9.2. Most of the tested water samples were sodium chloride type water. The exceptions were samples from BH1B, BH3B and BH4B which were sodium bicarbonate type water.

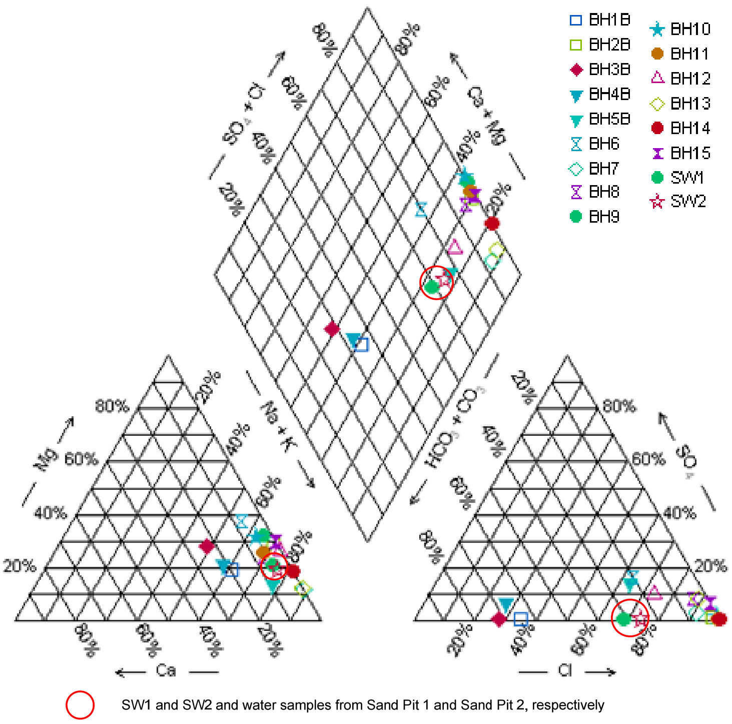


FIGURE 9.2 Groundwater and Pit Water Piper Diagram

The measured groundwater pH in 50 tested groundwater samples varied from acidic (4.1) to slightly alkaline (7.49) with a median of 6.0 pH units. The acidic pH is considered to be due to oxidation of pyrite.

9.2 GROUNDWATER CONTAMINATION

Coffey (2013) tested groundwater samples for selected chemicals of concern based on historic land use (Tables 9.2 and 9.3). Review of the Coffey report was outside the scope of the JLCS Hydrogeological Assessment, however, the results of the groundwater contamination testing program are briefly discussed in the following Sections for reporting completeness.

Metals

Groundwater samples were tested for As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn. A range of metals were detected in the sampled groundwater. However, JLCS considers that the detected metal concentrations are within the expected range for metals in groundwater and are not indicative of groundwater contamination.

Nitrogen

The nitrate concentrates (reported as NO3-N) were low (<2.0 mg/L) and within the range for uncontaminated groundwater.

Concentrations of Ammonia-N (NH3-N) in the tested groundwater samples varied between 0.08 mg/L (BH9) and 1.3 mg/L (MW5) with reported concentrations mostly less than 0.4 mg/L. Coffey considered that the reported ammonia concentrations were the result of groundwater contamination. However, ammonia is can be present in rainwater (source of groundwater recharge) and is produced naturally be decay of organic materials plants, dead animals and other organisms (Health Canada, 2013). Low concentration of ammonia (0.2 mg/L) can be present in natural, uncontaminated groundwater (Bouwer and Crowe, 1988).

Elevated ammonia levels above typical background concentrations were only detected at BH6 (0.47 mg/L; cattle grazing paddock), BH13 (1.1 mg/L; cattle grazing paddock) BH14 (0.41, mg/L; cattle grazing paddock), BH15 (0.4 mg/L; cattle grazing paddock), and MW5 (1.3 mg/L: horse adjistment paddock). Coffey concluded that..."*The ammonia impact noted in groundwater from the all the down-gradient monitoring wells is indicative of septic systems and/or sewerage systems at the site having leaked.*" However, only three of the tested bores were located down hydraulic gradient from on-site residences — BH12 (0.11 mg/L NH3-N) and MW4 (0.22 mg/L NH3-N) both about 60 m down hydraulic gradient from the nearest residence, and MW5 (1.3 mg/L NH3-N) about 80 m down hydraulic gradient from an onsite residence. Only MW5 groundwater was significantly elevated however the NH3-N concentration in this bore is comparable with that recorded in groundwater from bore BH13 (1.1 mg/L NH3-N) which is located in the middle of a cattle grazing paddock and not near any residences. MW5 is located in a small area previously used to paddock racehorses. This suggests that the detected ammonia in bores MW5 and BH13 was more likely derived from stock urine and possibly fertilizers rather than septic tank systems. This conclusion is supported by the low Nitrate-N concentrations in the tested groundwater (would expect higher nitrate concentration if the source was septic tank systems).

The Coffey report compared the ammonia levels in the groundwater to the guideline for Recreational Water Quality and Aesthetics (0.01 mg/L). The Recreational Water Quality and Aesthetics guideline is not readily applicable to water in the subsurface but may be applicable where groundwater discharges into receiving water such as into the proposed surface water bodies (wetlands, ponds, sediment Basins). However, the concentration of ammonia would be reduced significantly below the stated guideline concentration by dilution with surface water in the various waterbodies.

All potential sources of ammonia in groundwater will be removed as Brompton Lodge is developed.

Coffey concluded that the on-site beneficial use for groundwater was not precluded by concentrations of nitrate and ammonia: JLCS concurs with this conclusion.

TABLE 9.2 Ammonia, Nitrate, Metals and BTEX Concentrations

Bore	NH3-N	NO3-N	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	B	T	E	X tot
BH1A	0.12	<0.02	0.004	<0.0002	<0.001	0.005	<0.001	<0.0001	0.006	0.011				
BH1B														
BH2A	0.09	<0.02	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.002	<0.001	<0.001	<0.001	<0.003
BH2B														
BH3A														
BH3B														
BH4A	0.04	1.5	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.001	<0.001	<0.001	<0.001	<0.003
BH4B														
BH5A	0.17	<0.02	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	0.003	-	-	-	-
BH5B														
BH6	0.47	0.05	0.019	O.0002	0.002	<0.001	<0.001	<0.0001	0.008	0.008	<0.001	<0.001	<0.001	<0.003
BH7	0.1	<0.02	0.008	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.002	<0.001	<0.001	<0.001	<0.003
BH8														
BH9	0.08	<0.02	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.056	0.006				
BH10	0.13	<0.02	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.05	0.11				
BH11	0.17	<0.02	0.002	<0.0002	0.001	<0.001	<0.001	<0.0001	0.006	0.02				
BH12	0.11	0.04	0.005	O.0002	0.001	<0.001	<0.001	<0.0001	0.003	0.004				
BH13	1.1	0.04	0.048	<0.0002	0.004	0.026	0.066	<0.0001	0.028	0.038				
BH14	0.41	<0.02	0.004	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	0.018				
BH15	0.4	3.5	0.002	<0.0002	0.003	0.032	0.012	<0.0001	0.009	0.027				
MW1			0.004	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.007	0.006	<0.001	<0.001	<0.001	<0.003
MW2			0.008	<0.0002	0.005	<0.001	<0.001	<0.0001	0.006	0.009	0.01	0.014	0.084	0.15
MW3			0.004	<0.0002	0.001	<0.001	<0.001	<0.0001	0.003	0.005	<0.001	<0.001	<0.001	<0.003
MW4	0.22	2.0	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	0.008				
MW5	1.3	1.6	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.006				

Notes: 1) Concentrations in mg/L. 2) B, benzene; T, Toluene; E, Ethylbenzene; X, xylenes (total). 3) After Coffey, 2013.

TABLE 9.3 Hydrocarbon Concentrations

Bore	Naphthalene	C6-9	C10-14	C15-28	C29-36	C6-36	C10-16	C16-34	C34-40	C6-10	OCPs	OPPs	PAHs
BH1A													
BH1B													
BH2A	<0.05	<0.02	<0.05	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.02	<DL	<DL	<DL
BH2B													
BH3A													
BH3B													
BH4A	<0.05	<0.02	<0.05	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.02	<DL	<DL	<DL
BH4B													
BH5A	-	-	-	-	-	-	-	-	-	-	<DL	<DL	<DL
BH5B													
BH6	<0.05	<0.02	<0.05	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.02	<DL	<DL	<DL
BH7	<0.05	<0.02	<0.05	<0.1	**9**	**9**	<0.05	**9**	**9**	<0.02	<DL	<DL	<DL
BH8													
BH9													
BH10													
BH11													
BH12													
BH13													
BH14													
BH15													
MW1	<0.05	<0.02	<0.05	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.02	<DL	<DL	<DL
MW2	<0.05	260	<0.05	100	<0.1	**0.1**	<0.05	**0.2**	<0.1	**0.33**	<DL	<DL	<DL
MW3	<0.05	<0.02	<0.05	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.02	<DL	<DL	<DL
MW4													
MW5													

Notes: 1) Concentrations in mg/L. 2) After Coffey, 2013

Petroleum Hydrocarbons

Petroleum hydrocarbons were not detected in most tested groundwater samples. The exceptions were the groundwater from MW2, one of three bores near the former underground fuel storage tanks and BH7 in the southwestern corner of the site. There are no obvious potential on-site sources of hydrocarbons near BH7.

Groundwater from MW2 contained concentrations of BTEX and TPH (C6-C9 and C10-C36 fractions) above the LOR. No guidelines exist for ethylbenzene, toluene, xylene (m & p) or TPH fractions but the concentration of benzene exceeded the guidelines for Recreational Water Quality and Aesthetics. However, the concentration of benzene would be significantly reduced farther from the contamination source by mixing with native groundwater and reduced even further by surface water in any discharge area.

Pesticides

No organochlorine pesticides (OCP) or organophosphorus pesticides (OCP) were detected in any of the tested groundwater samples (concentrations below the).

9.3 GROUNDWATER BENEFICIAL USE

The beneficial use of groundwater was determined from criteria given in the State Environmental Protection Policy (Groundwater of Victoria) 1997. The Groundwater SEPP provides a number of beneficial use categories based on the salinity of the natural/uncontaminated) groundwater. Segments of the groundwater environment and beneficial uses to be protected in each segment are indicated in Table 9.4. The SEPP requires that identified beneficial use is protected and refers to various water quality guidelines for the assessment of water samples depending on the beneficial use category.

TABLE 9.4 Beneficial Uses of Groundwater Segments

Beneficial use	**Segments (mg/L TDS)**				
	A1 (0-500)	**A2 (501-1,000)**	**B (1,001-3,500)**	**C (3,501-13,000)**	**D (> 13,000)**
Maintenance of ecosystems	✓	✓	✓	✓	✓
Potable water supply –desirable	✓				
Potable water supply –acceptable		✓			
Potable mineral water supply	✓	✓	✓		
Agriculture, parks, gardens	✓	✓	✓		
Stock watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation	✓	✓	✓	✓	
Building and structures	✓	✓	✓	✓	✓

The concentrations of total dissolved solids (TDS) in the groundwater ranged from 200 to 10,000 mg/L with median concentration of 520 mg/L, respectively. The shallow groundwater beneath Brompton Lodge is therefore in groundwater environment segments A1/A2 (about 46 per cent of the tested samples were in groundwater environment segment A1 and 66 per cent in segment A2). The beneficial uses of the local groundwater to be protected under the SEPP *Groundwaters of Victoria (1997)* environment segment c are:

- maintenance of ecosystems
- Potable water supply (desirable or acceptable)
- Potable mineral water supply
- Agriculture, parks, gardens
- Stock watering
- Industry
- Primary contact
- Buildings and structures

The “Maintenance of Ecosystems” beneficial use is protected for all segments of groundwater in Victoria, and is one of the most sensitive beneficial uses to be protected. Groundwater discharge zone have not been identified but are considered to into Port Phillip Bay (near offshore) about eight kilometres from Brompton Lodge.

The groundwater would mostly be suitable as a source of drinking water provided that it is not contaminated or that extraction does not induce migration of more saline groundwater into the pumped supply bore. However, this use is considered to be unrealistic as the proposed subdivision will be connected to a reticulated (surface water supply system).

Potable Mineral Water Supply is not a protected beneficial use as the groundwater is not classified as a mineral water in accordance with the definition in SEPP Groundwater of Victoria, is not effervescent (with respect to CO2) and the area is not a proclaimed Mineral Water Reserve under the Water Act 1989 or is in a recognised mineral water province.

Use of Segment A groundwater for agriculture irrigation and watering parks and gardens is a protected beneficial use under the SEPP Groundwaters of Victoria. The land at Brompton Lodge will not be used for agriculture when subdivided but it possible that future land owners could utilise groundwater for garden watering. However, this use might not be realised because of high bore installation, running and maintenance costs, and the availability of a alternative water supplies (e.g., reticulated water or treated waste water via the third pipe system).

“Stock watering” and “Industrial Water” are unrealistic beneficial uses as the proposed future use of the site is for residential subdivision.

The “Primary Contact Recreation” beneficial use category relates to the use of groundwater to fill swimming pools or where groundwater discharges into a water body that could be used for swimming. It is possible that swimming pools could be constructed on large lots and that these could be filled by groundwater from the underlying Quaternary/Brighton Group sediments. The demand for this use is likely to be very small given the high bore installation, running and maintenance costs, and availability of a reticulated supply.

The "Building and Structures" beneficial use is protected for all segments of groundwater in Victoria. Groundwater should therefore not be made corrosive to buildings and structures due to onsite activities

10.0 POTENTIAL IMPACTS ON BUILDING MATERIALS

Groundwater can have a detrimental impact on concrete and steel structures depending primarily on the chemistry of the water. The exposure classification for concrete structures in water is based on the concentrations of soluble sulphate (expressed as SO3) and chloride in the groundwater, and groundwater pH whereas the classification for steel in water is based on the chloride concentration, pH and resistivity (Table 10.1). The exposure classification for both material types depends on soil permeability; 1) soil conditions A, high permeability soils (e.g., sands and gravels) below the water table; and 2) soil conditions B, low permeability soils (e.g., clays, silts) or all soils above the water table (AS 2159-2009).

TABLE 10.1 Exposure Classification for Concrete and Steel Piles in Groundwater

Material	SO3 (mg/L)	pH	Cl (mg/L)	Resistivity (ohm.cm)	Soil Condition A	Soil Condition B
Concrete piles	<1,000	>5.5	<6,000	Not specified	Mild	Non-aggressive
	1,000-3,000	4.5 - 5.5	6,000 – 12,000	Not specified	Moderate	Mild
	3,000- 10,000	4.0 – 4.5	12,000 – 30,000	Not specified	Severe	Moderate
	>10,000	<4	>30,000	Not specified	Very severe	Severe
Steel piles	Not specified	>5	<1,000	>5,000	Non-aggressive	Non-aggressive
	Not specified	4 - 5	1,000 – 10,000	2,000 – 5,000	Mild	Non-aggressive
	Not specified	3 – 4	10,000 – 20,000	1,000 – 2,000	Moderate	Mild
	Not specified	<3	>20,000	<1,000	Severe	Moderate

Notes: 1) Source, AS 2159-2009; 2) Soil conditions A, high permeability soils (e.g., sands and gravels) below the water table; and 3) Soil conditions B, low permeability soils (e.g., clays, silts) or all soils above the water table

The soils intersected in the shallow monitoring bores at Brompton lodge varied from very fine grained (clay and, silty clay) to medium grained (clayey sand and sand) with a number of different lithologies intersected every bore. Classifying the soils based on the criteria in AS 2159-2009 was therefore very subjective. [JLCS adopted a conservative approach and categorized the groundwater in the most aggressive category based on the predominant downhole lithology.] The exposure classification for concrete piles and steel piles in the groundwater at Brompton Lodge are presented in Table 10.2. The assessment indicated that the groundwater beneath the site is mostly non-aggressive or mildly aggressive to concrete and non-aggressive to moderately aggressive to steel.

TABLE 10.2 Brompton Lodge Groundwater Exposure Classification

Material	Bore	SO3 mg/L	Exposure Classification	pH units	Exposure Classification	Cl mg/L	Exposure Classification	Resist. Ω.m	Exposure Classification
Concrete	BH1B	< 4	N-A	6.5	N-A	31	N-A	2,564	N-S
	BH2B	60.8	N-A	6.5	N-A	5300	N-A	63	N-S
	BH3B	<4.0	Mild	7.0	Mild	56	Mild	1,493	N-S
	BH4B	4.2	Mild	6.5	Mild	17	Mild	4,545	N-S
	BH5B	8.8	N-A	6.1	N-A	38	N-A	3,448	N-S
	BH6	66.4	Mild	6.4	Mild	240	Mild	625	N-S
	BH7	40.0	N-A	6.7	N_A	1400	N-A	192	N-S
	BH8	13.6	N-A	5.9	N-A	140	N-A	1,000	N-S
	BH9	<4.0	Mild	4.1	Moderate	910	Mild	286	N-S
	BH10	35.2	N-A	4.8	N-A	1900	N-A	167	N-S
	BH11	<4.0	N-A	5.4	N-A	300	N-A	909	N-S
	BH12	16.8	N-A	6.3	N-A	120	N-A	1,587	N-S
	BH13	14.4	Mild	5.5	N-A	150	Mild	1,333	N-S
	BH14	<4.0	Mild	5.0	Mild	290	Mild	1,075	N-S
	BH15	8.8	Mild	4.9	Moderate	130	Mild	2,041	N-S
Steel	BH1B	< 4	N-S	6.5	N-A	31	N-A	2,564	N-A
	BH2B	60.8	N-S	6.5	N-A	5300	N-A	63	Moderate
	BH3B	4.0	N-S	7.0	N-A	56	N-A	1,493	Moderate
	BH4B	4.2	N-S	6.5	N-A	17	N-A	4,545	Mild
	BH5B	8.8	N-S	6.1	N-A	38	N-A	3,448	N-A
	BH6	66.4	N-S	6.4	N-A	240	N-A	625	Severe
	BH7	40.0	N-S	6.7	N-A	1400	N-A	192	Moderate
	BH8	13.6	N-S	5.9	N-A	140	N-A	1,000	Mild
	BH9	4.0	N-S	4.1	Mild	910	N-A	286	Severe
	BH10	35.2	N-S	4.8	N-A	1900	N-A	167	Moderate
	BH11	4.0	N-S	5.4	N-A	300	N-A	909	Moderate
	BH12	16.8	N-S	6.3	N-A	120	NA	1,587	Mild
	BH13	14.4	N-S	5.5	N-A	150	N-A	1,333	Mild
	BH14	4.0	N-S	5.0	Mild	290	N-A	1,075	Mild
	BH15	8.8	N-S	4.9	Mild	130	N-A	2,041	Mild

Notes: 1) Resis., Resistivity; 2) N-S, Not Specified; 3) N-A, Non-Aggressive; 4) Mild, Mildly Aggressive; 5) Moderate, Moderately Aggressive. 6) Soil conditions A, high permeability B, low permeability.

11.0 SURFACE WATER MANAGEMENT WORKS

Groundwater is an important consideration in the design and operation of surface water management engineering works. Details of the proposed surface water management works are presented in the Surface Water Management Strategy report prepared by Neil Craigie and Associates (Craigie, 2013; proposed works summarised in Chapter 2).

The interaction between groundwater and surface water in the proposed dwarf galaxias habitat pond, the wetland/retarding basin and sediment basin SB2 was assessed using data from the May 2013 monitoring round (lowest measured water levels), topographic contours provided by Watsons and design surface contours of the base of the three water bodies determined by Craigie (2013).

A modified topography grid was generated by replacing the topographic contours in the areas of the proposed water bodies with the design surface contours prepared by Craigie (see Figure 2.) and generating a modified grid using the Surfer terrain mapping software (V11; Golden Software, 2013). The May 2013 water table elevations and the elevation of the standing water in the sand pit ponds was also gridded to generate water table contours (Figures 11.1 and 11.2). Topographic profiles of the existing and design ground surface elevation, and the May 2013 water table elevation were generated using "grid slice" capabilities in Surfer. The xyz data files were imported into the Grapher software program (V10, Golden Software, 2013) which was used to plot the profiles (Figure 11.3).

The water table mapping indicates that the water table under the worst measured case (lowest measured elevation) was above the design base of the proposed dwarf galaxias habitat pond, the wetland/retarding basin and sediment basin SB2 (Figure 11.3). Consequently, groundwater will discharge into these water bodies which will distort the local water table configuration and cause a steepening of the hydraulic gradients close to the water bodies. Upslope frontages to the waterbodies will be well below groundwater inflows allowing free inflow. Downslope frontages will be at or above groundwater levels. Groundwater inflow rates into the water bodies will be small which means that in the absence of external water inputs evaporation will result in gradual drawdown of water levels in offline ponds between inflow periods.

The water table mapping also indicated that the normal Top Water Levels (NTWL's) in the constructed waterbodies in the east part of the site would be up to one m below the water table.

The quality results show that groundwater is reasonably fresh with just one bore showing brackish quality (Chapter 9). This infers there is no significant threat of salt bleaching around the high side of ponds where the water table is above Normal Top Water Level's.

The shallow depth to groundwater indicates that lining of the waterbodies will either be minimal in extent or not required in order to stop seepage outflow losses to groundwater.

The generally slow water level recovery in the bores after sampling indicates that the sands are very fine and/or silty-clayey with relatively low permeability. This finding is consistent with the description of the downhole lithology intersected in the on-site monitoring bores Drawdown cones in low permeability soils are deeper and more localised than those in more permeable soils. Consequently, the ponds and wetlands will only influence local groundwater levels and not the whole site.

The low inflow is only a potential concern in the proposed dwarf galaxias habitat pond which is to be protected from all surface runoff. Wetlands and ponds which are directly online with urban development drainage systems will receive sufficient water supply to offset evaporation effects at most times (Craigie, 2013).

A number of options to ensure that the proposed dwarf galaxais habitat pond has a secure water supply have been identified. The identified options are:

- The top up supply from nearby stormwater treatment systems (could require appropriate treatment to provide suitable quality water and would need to be constructed to prevent predator access into the pond).

- Construct a supply bore near the habitat. The bore could be controlled by a water level switch set to activate the pump if the water level in the habitat falls below a specified level. The likely very low bore yield means that the bore would need to be carefully design and constructed to maximise bore efficiency. However, there would still be some uncertainty because of highly likely very low bore yield.

- Excavate a deep trench/wick into the base of the pond so that there water would remain in the pond even if the water falls more than expected due to stress on the system such as reduced recharge under future climate change conditions.

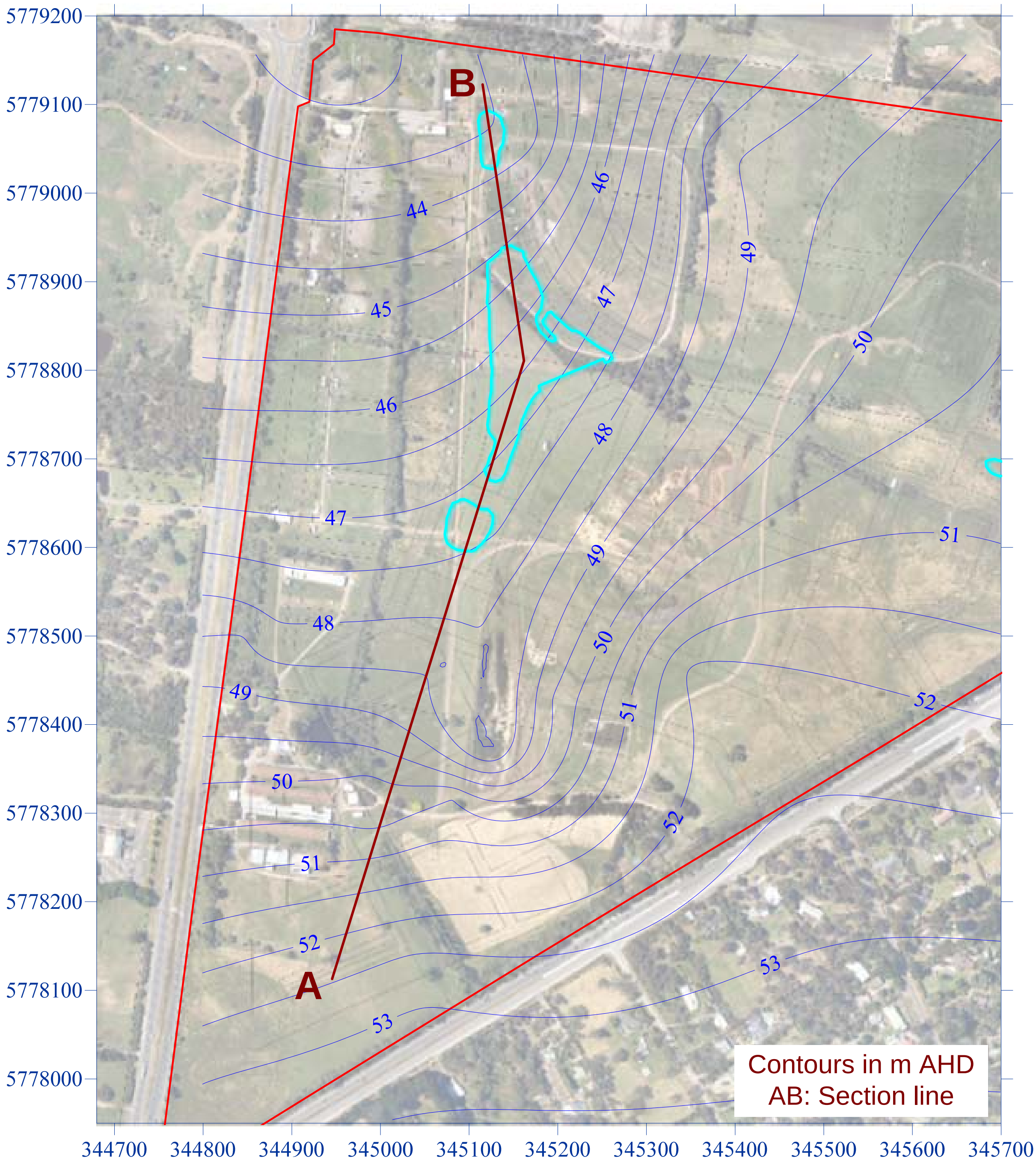


FIGURE 11.1 Water Table Contours , Eastern Portion of Brompton Lodge

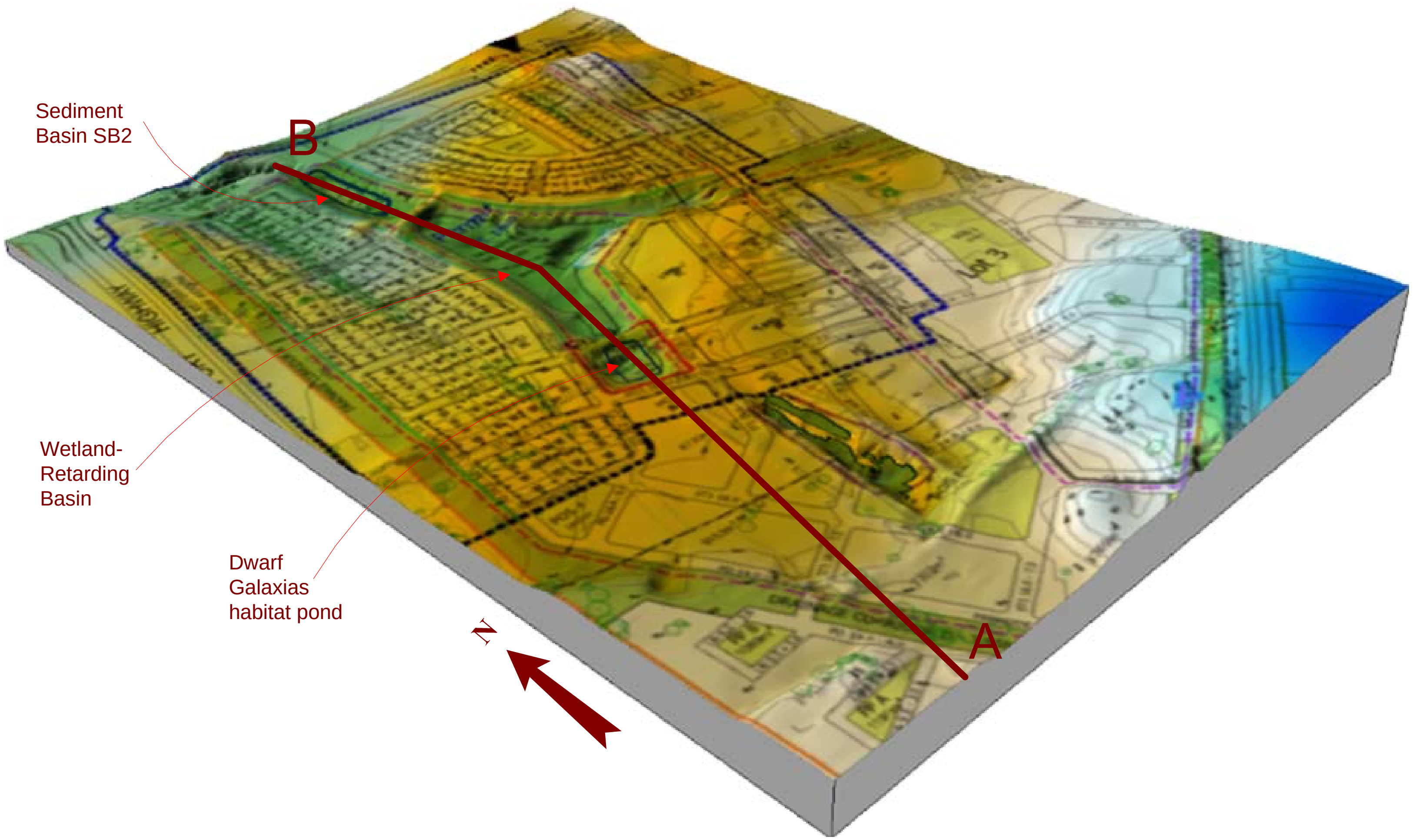


FIGURE 11.1 Adjusted Digital Elevation Model Eastern Portion Brompton Lodge

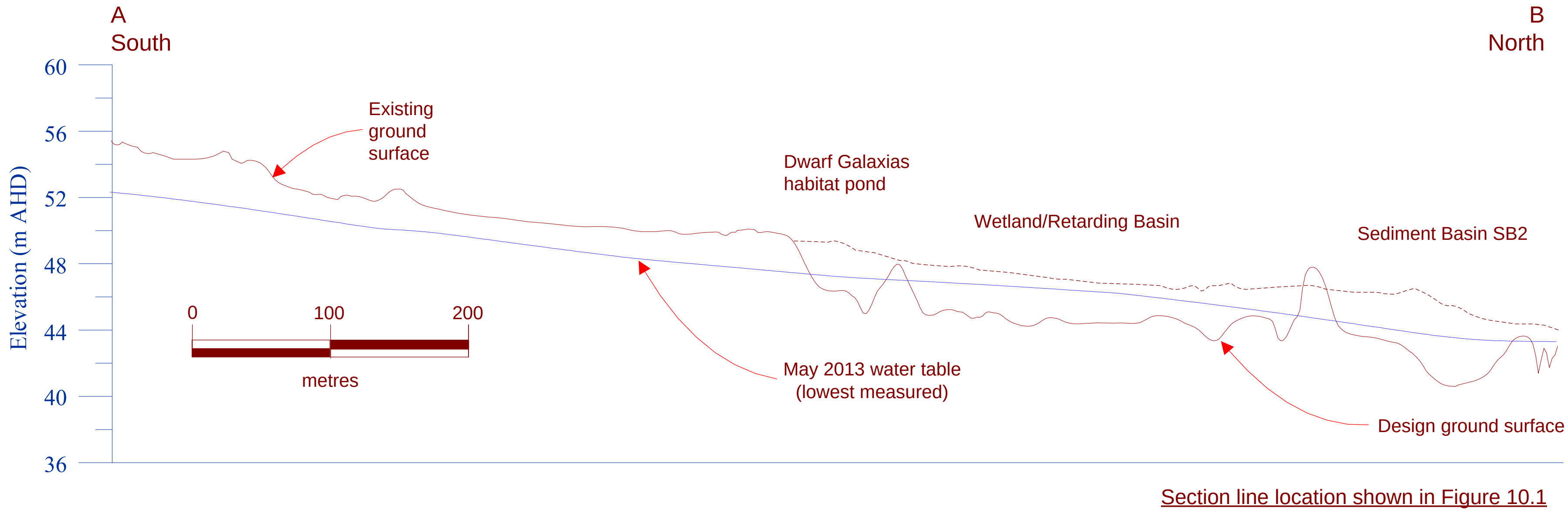


FIGURE 11.3 Approximate South-North Topographic, Design Surface and Water Table Profiles

12.0 SALINITY HAZARD MANAGEMENT

The presence of shallow groundwater beneath part of Brompton Lodge constitutes a minor salinity hazard with associated albeit very low potential salinity risk. The salinity hazard will be reduced by site drainage and development work. The salinity risk can be mitigated by using appropriate building methods and materials, and employing appropriate water management.

12.1 PROTECTING THE BUILT ENVIRONMENT

Development of detailed designs to protect all elements of the built environment is beyond the scope of this Hydrogeological Assessment. However, some general measures are identified in the following Sections to protect the integrity of the built environment. [It should be noted that the information provided in this Chapter particularly in relation to protecting buildings is not comprehensive and not issued by a qualified engineer.]

12.1.1 Buildings

Possible management options to minimise the impact of the water and salt processes on buildings include but are not limited to:

- Installation of damp proof courses.
- Water proofing slabs.
- Providing a layer at least 50 mm thick of sand underneath slabs.
- Curing concrete for at least seven days to ensure a hard dense surface that reduces saline water infiltration.
- Installing plastic membrane behind retaining walls.

Note that the above listed measures are typically implemented as standard practice in all new buildings in Victoria.

12.1.2 Buried Services

Buried services (i.e., stormwater and sewer pipes, etc.) can be affected by saline groundwater conditions. The available data indicates that buried services at site will could be below the water table over part of the site. The groundwater is fresh to brackish and is mostly non-aggressive to mildly aggressive to concrete and steel. All buried services should be constructed using appropriate materials and should be designed assuming continuously saturated conditions as a precautionary measure.

12.1.3 Roads, Pavements and Driveways

Rising water tables and salinity can also affect road infrastructure. The effects of salinity on pavements include 1) rutting or potholing in granular pavements, 2) differential shape loss resulting in rough pavements, and 3) seal "blister" leading to loss of seal, water infiltration and potholing corrosion of steel reinforcement and subsequent spalling of concrete crumbling of concrete kerbs. Vorobieff (2005) reported salinity is most likely to only affect sprayed seals and concrete surfaces that have not been designed taking high salt contents into consideration. A key finding of the research by Vorobieff (2005) was that standard construction practices may be insufficient for roads in salinity affected areas. Possible methods to assist roads withstand the effects of salinity include (Vorobieff, 2001):

- raise the pavement level with suitable material and stabilise the top layer/s to strengthen the material to carry heavy traffic,
- stabilise the subgrade to reduce susceptibility to moisture changes,
- design subsurface drainage systems, and
- plant trees in road reserves to lower the water table.

13.0 POTENTIAL IMPACT ON GROUNDWATER QUALITY

The main activities at the proposed subdivision that could potentially adversely impact local groundwater resources are associated with stormwater, sewerage and wastewater management. Measures that should be implemented to manage stormwater, wastewater and sewerage to protect the integrity of groundwater beneath the site are described briefly in the following Sections.

13.1 STORMWATER MANAGEMENT

Stormwater management methods should be based on best practice and the principles of Water Sensitive Urban Design (WSUD) to minimise adverse impacts on the environment. The guiding principles of WSUD are centred on achieving integrated water cycle management solutions for urban development, linked to an Ecologically Sustainable Development (ESD) focus aimed at:

- Reducing potable water demands through water-efficient appliances, rainwater and greywater reuse;
- Minimizing waste water generation and treatment of waste water suitable for effluent reuse opportunities and/or released to receiving waters;
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters;
- Using stormwater in the urban landscape to maximize the visual and recreational amenity of developments;
- Protecting natural systems.

If these principles are applied, stormwater will not have any significant adverse impact on local groundwater (including beneficial uses).

13.2 SEWERAGE AND WASTEWATER MANAGEMENT

Individual dwellings will be serviced with reticulated water supply and a reticulated sewerage system, sewerage and wastewater from the development will therefore not impact on groundwater beneficial uses.

14.0 KEY FINDINGS, & MANAGEMENT REQUIREMENTS

Groundwater level and quality have been extensively investigated and monitored at Brompton Lodge via a network of monitoring bores across the site Data from the monitoring bores together with topographic mapping (including mapping the existing dwarf galaxias habitat ponds) has been used to develop a conceptual hydrogeological model and to assess groundwater-surface water interactions under existing and design conditions.

14.1 KEY FINDINGS

Key findings of the Hydrogeological Assessment of the Brompton Lodge site include:

- Brompton Lodge is located between the southern margin of the Carrum Swamp and outcropping Silurian bedrock on the Mornington High.

- The property is located predominantly on Quaternary dune deposits overlying Brighton Group and Silurian basement rocks.

- The depth to groundwater across the site varies from less than 0.5 m bgl to more than six m bgl. The water table is a subdued reflection of the topography and is deeper beneath the more elevated northeastern corner of the site and southeastern boundary and shallower in the flatter-lying area beneath the main (approximate) east-west drain. The hydraulic gradient is relatively steep across the western part of the site and much flatter to the east.

- Water logged conditions were observed across much of the property during the site inspection on 18 July 2011. Water logging was less severe on the 4 August 2011 inspection. Water logged spoil was observed near to bores with groundwater levels more than 0.5 m below ground level indicating that the water logging was not due to the shallow groundwater conditions. However, no water logging was evident during the November 2012, March 2013 or May 2013 monitoring rounds.

- The salinity of the shallow groundwater beneath Brompton Lodge ranged from 200 to 10,000 mg/L but was mostly less than 1,000 mg/L TDS (median 520 mg/L TDS). The groundwater is within the groundwater environment Segment A as defined in the SEPP Groundwaters of Victoria. The beneficial uses of groundwater to be protected under the SEPP are maintenance of ecosystems, potable water supply, agriculture, parks and gardens, stock watering, industry, primary contact and buildings and structures. The proposed development is not expected to impact on beneficial uses of local groundwater and will not have adverse impacts on groundwater dependent ecosystems provided that the lots are serviced.

- Low level groundwater contamination by ammonia and petroleum hydrocarbons was detected at the site during a Phase 2 Site Environmental Assessment. The slight increase in Ammonia-N concentration is considered to be due to on-site agriculture land use (cattle grazing and fertiliser). The hydrocarbons were detected in one of three monitoring bores installed near an above ground storage and a former underground storage tank.

These contamination sources will cease or be removed as part of the subdivision works. The soils in the area of the fuel tanks will be excavated and the quality of the soil at base of the excavation validated prior to filling with clean fill. The concentration of contaminants in the groundwater will be attenuated by flow through the ground, and the concentration will be further reduced by dilution if the groundwater discharges into the proposed water features. Consequently, the identified (very) low level groundwater contamination will not preclude any of the proposed land uses (residential development, waterways, open space, etc.).

- The shallow groundwater is non-aggressive to concrete and mildly to moderately aggressive to steel (based on conservative exposure classification categorization).

- Land salinisation was not observed at the proposed development site during site reconnaissance by JLCS. [Particularly attention was paid to identifying indicators of land salinisation, i.e., bare soil, salt stains, salt indicator plants, etc.].

14.2 SURFACE WATER MANAGEMENT GROUNDWATER CONSIDERATIONS

The depth to groundwater in the current low-lying areas to the west and northwest of the proposed dwarf galaxias pond, wetland retarding basin and sediment basin SB2 will be increased by the addition of 1-2 m of fill material to raise the design ground surface level to a minimum of 600 mm above the design 100 year ARI flood levels.

This infers that inverts of constructed waterways across the site would be expected to reasonably match or sit below the groundwater contours. Normal Top Water Levels (NTWL's) in constructed waterbodies in the east end of the site would be expected to sit up to 1 m below the groundwater contours.

The waterbodies proposed in the west part of the site (in the Permit 1 application area) will be below the water table. Consequently, groundwater will discharge into the water bodies which will distort the local water table configuration and cause a steepening of the hydraulic gradients close to the water bodies. Upslope frontages to the waterbodies will be well below groundwater inflows allowing free inflow. Downslope frontages will sit at or above groundwater levels.

The quality results show that groundwater is reasonably fresh with just one bore showing brackish quality.

This infers there is no significant threat of salt bleaching around the high side of ponds where groundwater levels are above NTWL's.

Groundwater yields in all bores are low. The generally slow water level recovery in bores after sampling indicates that the lithology is predominantly silty-clayey- clayey sand to sandy clay with relatively low permeability. Drawdown cones in low permeability soils are deeper and more localised than those in more permeable soils. Consequently, formation of ponds and wetlands will only influence local groundwater levels and not the whole site.

The observed shallow depth to groundwater, low aquifer permeability and generally low salinity indicates that lining of the water bodies will either be minimal in extent or not required in order to stop seepage outflow losses to groundwater.

Groundwater inflow rates into the water bodies will be small which means that in the absence of external water inputs evaporation will result in gradual drawdown of water levels in offline ponds between inflow periods.

The low yield is only a potential concern in the proposed dwarf galaxias habitat pond which is to be protected from all surface runoff. Wetlands and ponds which are directly online with urban development drainage systems will receive sufficient water supply to offset evaporation effects at most times.

The dwarf galaxias habitat pond water supply issue is best addressed by using top up supply from nearby stormwater treatment systems, subject to water quality and predator access prevention measures being incorporated into those works. Options for ensuring the long-term sustainability of the proposed dwarf galaxias habitat pond include:

- The top up supply from nearby stormwater treatment systems (could require appropriate treatment to provide suitable quality water and would need to be constructed to prevent predator access into the pond).

- Construct a supply bore near the habitat. The bore could be controlled by a water level switch set to activate the pump if the water level in the habitat falls below a specified level. The likely very low bore yield means that the bore would need to be carefully design and constructed to maximise bore efficiency. However, there would still be some uncertainty because of highly likely very low bore yield.

- Excavate a deep trench/wick into the base of the pond so that there water would remain in the pond even if the water falls more than expected due to stress on the system such as reduced recharge under future climate change conditions.

14.3 GROUNDWATER/SALINITY MANAGEMENT REQUIREMENTS

The salinity risk at Brompton Lodge is very low and is expected to decrease as the site is developed. But, as predicting how a dynamic system dependent on many variables will perform over the typical 50-year design life of buildings is difficult, JLCS considers that it is prudent to assume that at some point in the future urban salinity could occur and to ensure that building materials are capable of providing the required performance in such an environment. Possible management options to minimise the impact of the water and salt processes on buildings include installation of damp proof courses, water proofing slabs, providing a layer at least 50 mm thick of sand underneath slabs, curing concrete for at least seven days to ensure a hard dense surface that reduces saline water infiltration, and/or installing plastic membrane behind retaining walls (these measures are typically implemented as standard practice in all new buildings in Victoria).

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16.0 LIMITATIONS OF THIS REPORT

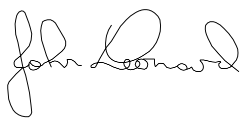
The advice provided in this report relates only to the project described herein and must be reviewed by a competent Engineer or Scientist before being used for any other purpose. JOHN LEONARD CONSULTING SERVICES Pty Ltd accepts no responsibility for other use of the data.

Where drill hole or test pit logs, laboratory tests, geophysical tests and similar work have been performed and recorded by others the data is included and used in the form provided by others. The responsibility for the accuracy of such data remains with the issuing authority, not with JOHN LEONARD CONSULTING SERVICES Pty Ltd.

The advice tendered in this report is based on information obtained from the investigation locations, test points and sample points and is not warranted in respect to the conditions that may be encountered across the site at other than these locations. It is emphasized that the actual characteristics of the subsurface and surface materials may vary significantly between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Sub-surface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind when assessing the data. However, it is our opinion that the test point's chosen are representative of conditions on the site.

It should be noted that because of the inherent uncertainties in sub-surface evaluations, changed or unanticipated sub-surface conditions may occur that could affect total project cost and/or execution. JOHN LEONARD CONSULTING SERVICES Pty Ltd does not accept responsibility for the consequences of significant variances in the conditions.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure-specific and some experienced-based. This report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by JOHN LEONARD CONSULTING SERVICES Pty Ltd. JOHN LEONARD CONSULTING SERVICES Pty Ltd accepts no responsibility for any circumstances which arise from the issue of the report which has been modified in any way as outlined above.



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May 2013

John Leonard
JOHN LEONARD CONSULTING SERVICES PTY LTD