



The Woodada Formation conformably overlies the unit, with an exception to the north of the formation.

#### 4.2.1.2 Woodada Formation (*Trw*)

The Woodada Formation is located between the Kockatea Shale and the overlying Lesueur Sandstone. The formation consists of inter-bedded fine-grained sandstone and carbonaceous siltstone and has been identified only in the subsurface.

#### 4.2.1.3 Lesueur Sandstone Formation (*Trl*)

The Lesueur Sandstone Formation outcrops southwest of Eneabba and extends northwards beneath the Eneabba Formation. It consists of thick permeable (coarse to very coarse grained) sandstone with infrequent mudstone beds, siltstone and conglomerate. The Lesueur Sandstone unconformably overlies the Woodada Formation and underlies the Eneabba Formation (Mory and Iasky 1996). The formation was deposited in a non-marine origin, most likely of a fluvial environment. The formation outcrops along the Beagle Fault and north and south of the Hill River (Commander 1981).

### 4.2.2 Jurassic

The Jurassic sediments comprise the Eneabba Formation, Cattamarra Coal Measures, Cadda Formation and Yarragadee Formation (see Fig. 10).

#### 4.2.2.1 Eneabba Formation (*Je*)

The Eneabba Formation (Playford et al. 1976) is a Lower Jurassic terrigenous red-bed unit (Mory and Iasky 1996). The unit was named the Eneabba Formation for the basal unit of the Cockleshell Gully, however the name has since been abandoned as it is considered a distinctively different unit (Mory and Iasky 1996).

The formation consists of fine to coarse-grained sandstone interbedded with multicoloured siltstone and shale. Minor carbonaceous shale with thin coal seams is also present (Mory and Iasky 1996). The formation subcrops between the Beagle Fault system in the west and the Lesueur and Wedge Faults, located in the east. The formation lies conformably between the Lesueur and Cattamarra Coal measures south of the formation. To the north the unit unconformably overlies the Kockatea Shale.

#### 4.2.2.2 Cattamarra Coal Measures (*Jc*)

The Cattamarra Coal Measures has historically been referred as the Upper Cattamarra Coal Member of the Cockleshell Gully Formation (Playford and Low 1973). The name, Cockleshell Gully Formation has since been abandoned.

The measures consist of non-marine probably fluvial sandstones interbedded siltstone and shale, which is in part carbonaceous, and seams of coal (Mory and Iasky 1996). The formation occurs at shallow depth west of the Warradarge and Lesueur Faults. The formation also outcrops in a small area east of the Urella Fault. The Cattamarra Coal Measures are approximately 300m thick in the Woodada gas field. The formation conformably overlies the Eneabba Formation.

#### 4.2.2.3 Cadda Formation (*Jd*)

The Cadda Formation was first recognised but not named by Conrad and Maynard (1948) as a marine Middle Jurassic unit composed of shale, siltstone, and very coarse sandstone grading into a limestone. The formation conformably overlies the Cattamarra Coal Measures and the overlying Yarragadee Formation.

#### 4.2.2.4 Yarragadee Formation (*Jy*)

The Yarragadee Formation (Playford et al 1976, Backhouse 1984) is one of the most significant units in the Perth Basin in terms of the formation and thickness. It extends throughout the Perth Sedimentary Basin. The formation east of the Gingin and Dandaragan Scarp is located at considerable depth beneath the easterly dipping Parmelia Formation.

The period of deposition of the Yarragadee Formation is believed to be middle-late Jurassic in a non-marine, mainly fluvial environment (Moncrieff 1989). The unit may reach a thickness of up to 3km (Kern 1988, Commander 1978). The Yarragadee Formation (McWhae et al 1958), consists of laterally discontinuous interbedded sandstones, siltstones that are commonly more than 200m thick. Sandstone is more common in the upper units while the lower units may contain about 50% siltstone and shale interbeds (Briese 1979, Moncrieff 1989). The beds of sandstone are frequently up to 30m thick and usually consist of medium to very coarse, feldspathic, sub angular, and weakly cemented sand. The formation also contains thick siltstone as well as thinly bedded sections of alternating sandstone and siltstone.

The unit lies conformably between the underlying Cadda Formation and the overlying Parmelia Formation.

### **4.2.3 Cretaceous**

The cretaceous sediments within the West Midlands Agricultural Region comprise the Parmelia Formation, Warnbro Group and Coolyena Group (see Fig. 10). The cretaceous sediments are located to the east and south of the area.

#### **4.2.3.1 Parmelia Formation (Kp)**

The Parmelia Formation (Backhouse 1984) has historically been referred to as the upper unit of the Yarragadee Formation. The Parmelia Formation overlies the confining Otorowiri Siltstone Member. The formation extends westwards of the Darling Fault to the Gingin Scarp. The thickness of the sandstone in the Parmelia Formation is variable but is generally in the order of 100m-200m thick. Two thick sandstone-shale members can sometimes be identified within the unit: the basal Otorowiri Member (Kpo) and the Carnac Member (Kpc), occurring in the middle of the formation (Backhouse 1984). The Otorowiri Siltstone Member that marks the base of the Cretaceous sediments is a distinctive unit comprising mainly of siltstone, often referred to as 'blackjack'. The Otorowiri Siltstone Member was encountered in all east to west bore lines drilled in the region (Water Authority of Western Australia 1993).

The formation was deposited in the late Jurassic in a non-marine mainly fluvial environment and consists of interbedded sandstone, claystone and shale (Moncrieff 1989). Deposition of the Otorowiri Member and Carnac Member was mainly in a lacustrine or lagoonal environment. Sandstone of fluvial origin overlies the Carnac Member in the upper part of the Parmelia Formation (Backhouse 1984).

The unit conformably overlies the Yarragadee Formation and is disconformably overlain by the Warnbro Coolyena Groups.

#### **4.2.3.2 Warnbro Group (Kw)**

During the early cretaceous the Dandaragan Trough was overlain with shallow marine sedimentation. The Warnbro Group (Cockbain and Playford 1973) is used to describe the shallow marine sedimentation within the region. The group consists of the Gage Formation, South Perth Shale and Leederville Formation, that unconformably underlies the Parmelia Formation.

The basal unit of the Warnbro Group, the Gage Formation was deposited in a shallow lagoonal or marine environment. The formation comprises 50% sandstone, interbedded with about 50% siltstone and shales.

The most significant formation of the Warnbro Group, the Leederville Formation (Kll) (Cockbain and Playford 1973) consists of interbedded sandstone, siltstone, mudstone and shale laid down during depositional environments (Moncrieff 1989). Mudstone and siltstone are more abundant in the upper part of the unit. Individual sandstone beds are mostly less than 10m thick (Moncrieff 1989), thinner than the Yarragadee. Siltstone and shale layers are more abundant in the upper part of the unit (Briese 1989). The formation reaches a maximum thickness of 600-700m under the Swan Coastal Plain (Yanchep Syncline) and thins eastwards to a maximum of less than 500 metres under the Dandaragan Plateau. It occurs in all areas west of the Dandaragan and Gingin Scarp except in the northwest corner

of the region where the Yarragadee Formation sub-crops. The Leederville Formation is difficult to distinguish from the underlying Parmelia as in the northern Perth Sedimentary Basin there is no unconformity at the interface of the formations (Commander 1981). Because the formations are undifferentiated, and are in hydraulic connection they have been treated as a single aquifer system.

#### **4.2.3.3 Coolyena Group (Kc)**

The Coolyena Group (Cockbain and Playford 1973) consists of the upper cretaceous marine sediments. The group overlies the Warnbro Group and comprises the Osborne Formation at the base, passing up into the Molecap Greensand, Gingin Chalk and Poison Hill Greensand. Recently added to the group is the Dandaragan Sandstone. The unit commonly outcrops along the eroded sections of the Caren Caren and Minyulo Brooks along the Dandaragan Scarp.

The Dandaragan Sandstone Formation is a sequence of medium to coarse-grained sandstone (Mory and Iasky 1996). Dandaragan Sandstone conformably overlies the Leederville Formation on the Dandaragan Plateau that is uncomfortably overlain by the Coolyena Group. It is up to 40m thick along the Watheroo-Jurien Bay borehole line.

The Osborne Formation (Kco) defined by McWhae et al (1958) is of a shallow marine origin laid over an irregular topography (Playford et al 1973). The formation includes a lower sandstone sequence, middle siltstone shale sequence and an upper interbedded shale and sandstone sequence. The unit unconformably overlies the Leederville Formation and is overlain both conformably and unconformably by the Molecap Greensand, Gingin Chalk or Poison Hill Greensand.

Molecap Greensand (Kcm) (Fairbridge 1953) consists of a fine to medium grain silty clay sandstone. The Molecap Greensand was deposited under shallow marine conditions over irregular topography (Playford et al 1973). The Molecap Greensand is overlain conformably by the Gingin Chalk and unconformably overlies the Osborne Formation.

The Gingin Chalk (Glauert 1910) has a shallow marine origin and consists of weakly to moderately consolidated chalk containing thin beds of greensand. The formation is situated with apparent conformity between the Molecap Greensand below and the Poison Hill Greensand.

The Poison Hill Greensand is the most widespread unit of the Coolyena Group. The unit consists of unconsolidated pale yellow clayey sand (Fairbridge 1953). The sand is well rounded, and was once considered channel infill of a Quaternary age (Allen 1977). The Poison Hill Greensand formation overlies the Gingin Chalk and is capped by laterite and associated Quaternary deposits.

#### **4.2.3.4 Lancelin Formation (Kcl)**

The Lancelin Formation underlies the Quaternary sands described by a glauconitic marl. The formation was deposited under marine conditions (Davidson 1995) and has until recently been represented as a unit of the Coolyena Group.

### **4.2.4 Cainozoic**

Playford et al (1976) describes the geology of the Quaternary sediments of the Swan Coastal Plain.

#### **4.2.4.1 Superficial Formation**

The 'Superficial Formation' is a collective name used to describe surface or near surface Quaternary – Tertiary sediments on the Swan Coastal Plain that forms a single predominantly unconfined aquifer system (Allen 1976). The superficial formations consist mainly of silt sand clay and limestone in varying proportions. The formation includes the Bassendean Sand, Tamala Limestone, Guildford Formation and Safety Bay Sands. Along the west, the sandy sediments pass laterally into limestone towards the coast. Moving east from the coast the clay content of the sediments increases.

#### **4.2.4.2 Surficial Deposits**

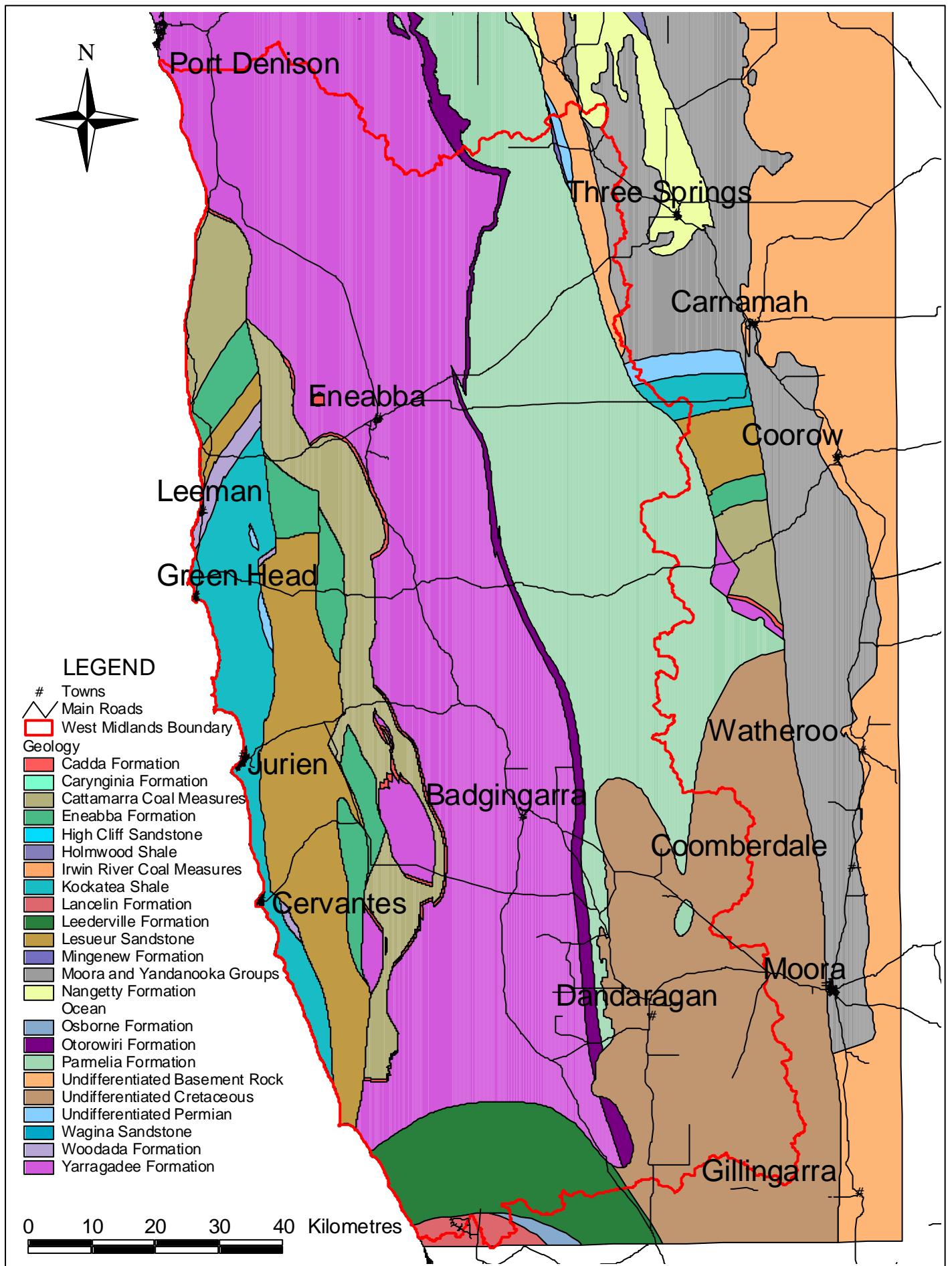
The Cainozoic surficial deposits within the West Midlands region include the Laterite and associated sand, Aeolian sands, alluvial and colluvium deposits, lake and swamp deposits.

The surficial deposits have largely developed from the *in situ* weathering of the underlying geological formations. Over much of the sediments on the Dandaragan Plateau have developed laterite, pisolithic gravels and associated sands (Kay 1999). The laterite is generally confined to the ridges that are of a tertiary age. Two types of laterite outcrop and sub crops are common within the West Midlands Region: a nodular, pisolithic laterite, goethite rich laterite formed on the Osborne Formation and a coarse grained, well rounded, ferruginized sandstone developed on the Poison Hill Greensand (Kay 1999). Laterite is also well developed on the Mesozoic rocks of Arrowsmith Region.

Aeolian sands occur throughout the Dandaragan Plateau. The dunes often form low longitudinal dunes caused from being reworked after deposition. The dunes surround the lakes of the Eneabba Plain.

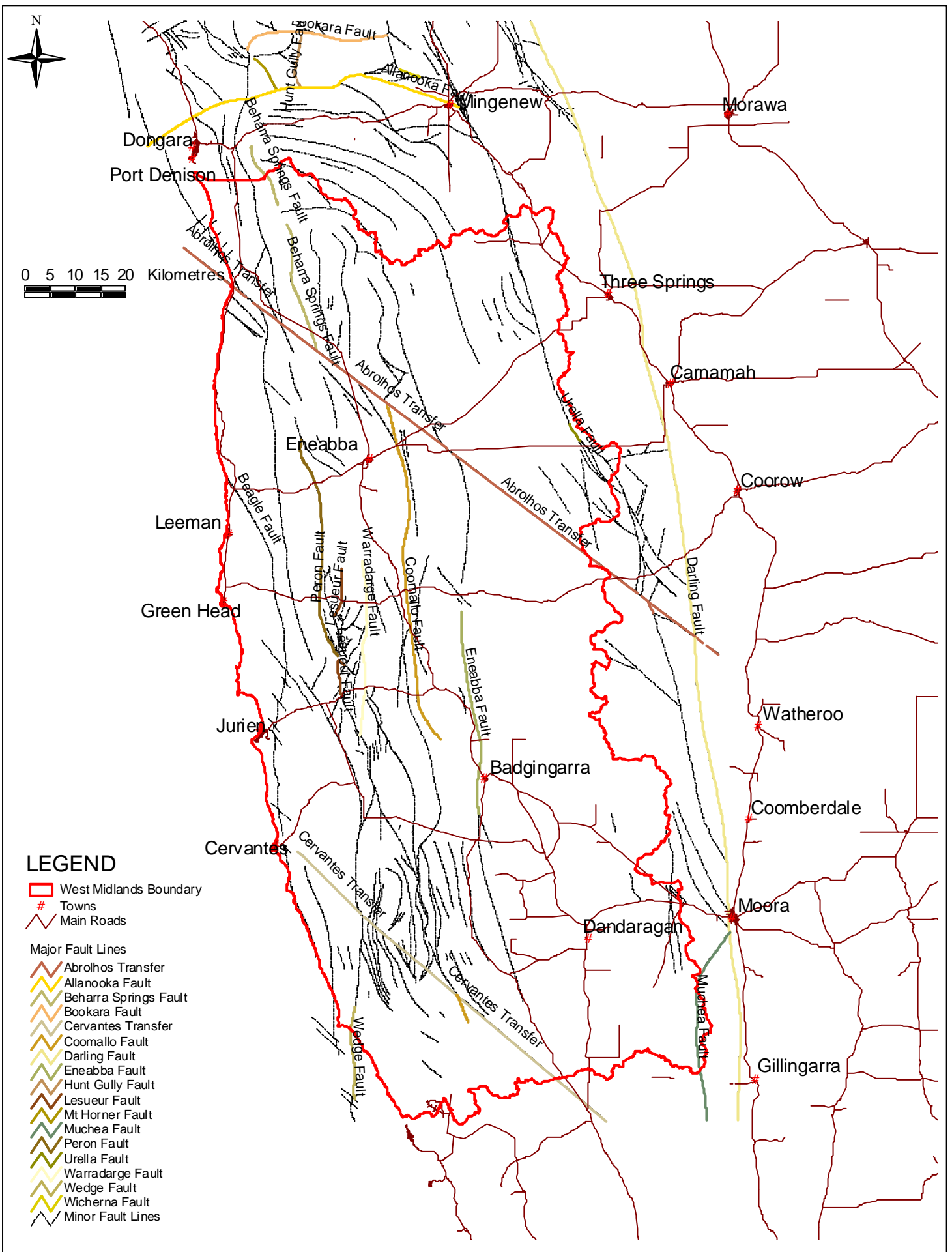
Holocene lake and swamps deposits are present throughout the Dandaragan Plateau. They include clay, sand and diatomaceous deposits generally less than 3m in thickness.

Alluvial and colluvium soils within the Dandaragan Plateau and Arrowsmith Region occur along the river systems and valleys. On the Dandaragan Plateau channel sands up to 150m have in-filled the drainage lines in valleys. Colluvial and alluvial sediments also occurs as outwash fans at the base of the Gingin Scarp. On the Eneabba Plain the deposits overlie strand lines and lagoonal deposits, where mineral sand mining is concentrated.



Geology of the Northern Perth Sedimentary Basin

Figure 10



Faulting of the Northern Perth Sedimentary Basin

Figure 11