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THE GEOLOGY AND HYDROGEOLOGY OF THE NOARLUNGA EMBAYMENT

GEOLOGICAL SURVEY

BY

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Rept. No. 83/89
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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept. Bk. No.
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THE GEOLOGY AND HYDROGEOLOGY OF THE NOARLUNGA EMBAYMENT

ABSTRACT

The geology and hydrogeology of the Noarlunga embayment and its margins has been investigated by studying available bore data. Groundwater quality is variable but salinities are generally greater than 1 500 mg/L. Hence, groundwater use is limited to the hardier crops and pastures and irrigation of ovals and parks.

Drill hole logs and seismic survey results delineate a basement high in the area west of Main South Road and drilling is recommended if a more accurate definition of its extent is required.

INTRODUCTION

The Noarlunga embayment is situated approximately 25 kms south of Adelaide (Fig. 1). The Tertiary sediments of the embayment are bounded to the south by the NE-SW trending Clarendon fault scarp, which is by far the most dominant topographic feature in the area. The surface of the embayment rises gently towards the north and is crossed by Christies Creek and Onkaparinga River, which is probably a misfit stream (Bourman, 1972).

Climate is of the Mediterranean type with warm dry summers and cool wet winters. Rainfall varies from 500 mm per annum in the south-west of the embayment to 800 mm per annum in the higher country south of Happy Valley Reservoir (Fig. 2).

The Noarlunga Embayment has been ignored with regards to hydrogeological studies due to the lack of demand for groundwater supplies for domestic and agricultural purposes. However increasing urbanization of Noarlunga City, Hackham, Happy Valley and Reynella creates a potential for an increasing demand on groundwater supplies for the irrigation of ovals, schoolgrounds, parks and household gardens.

Many wells in the embayment have been abandoned (Fig. 3) and the number of irrigation wells is decreasing as vineyards and orchards are sold to make way for residential growth. As can be seen in a recent land use survey (Fig. 4) this growth has extended over a large percentage of the embayment. The South Australian Housing Trust is continuing to purchase large allotments of vacant land which in time will be used for housing.

The aim of this report is to collate and assess all the groundwater data in the embayment as an aid to answering enquiries from residents in the area. Where possible the data has been presented in map form for quick reference.

GEOLOGY (Fig. 5)

The Noarlunga embayment is a sedimentary sub-basin adjoining the eastern margin of the St. Vincent Basin (Fig. 1). The sediments were deposited on Adelaidean bedrock in a wedge shaped half-graben structure with its main axis trending NE to SW (Daily et al. 1976). This half-graben structure was formed during the early Tertiary by the reactivation of the Paleozoic Clarendon Fault which bounds the embayment along its south-eastern margin.

A contour plan showing the thickness of Tertiary sediments is shown in Figure 6. Due to the dip of basement towards the fault and coastline the sediments are thickest in these areas and thin out towards the northern margin of the embayment. The Tertiary sediments were proved to be at least 170 m thick in the coastal area from the sequence intersected in the Seaford Stratigraphic Bore (Cooper, 1980).

Contours of the basin floor derived from bore log data indicate the existence of a basement high to the west of Main South Road (Fig. 7). The contours indicate a rapid thickening of sediments on both sides of the basement high especially in the old Onkaparinga river valley where the river has eroded into basement. In the cross-section A-A' (Fig. 8) the basement high can be seen clearly rising into the Tertiary sequence above in the vicinity of bore No. 6627ww4838 where depth to basement is only 18 m. Traverse cross sections B-B' & C-C' (Fig. 8) also show the distribution and thickness of the major formations.

A seismic investigation was conducted in the vicinity of the possible basement high to confirm its existence (Appendix 1). Because the area is now mainly residential it was only possible to perform a limited investigation and spot depths were derived to weathered basement from only 4 spreads. These depths, in conjunction with depths to basement taken from bore logs, confirmed the existence of a basement high which was not quite as pronounced as that delineated from bore data. However, due to the high degree of basement weathering, the weathered Adelaidean and Tertiary sediments may have similar seismic velocities making it difficult to detect the boundary accurately between the two layers using the seismic refraction method. Thus depth to basement could be a number of metres shallower than was calculated from the seismic results.

The basement high occurs where the character of the Tertiary sediments changes from lithologies reflecting a marine origin near the coast to lithologies reflecting terrestrial and marginal marine depositional environments further inland. The marine transgressions which deposited the Tertiary sediments were not able to surmount the basement high, hereafter called the "Christies High". Thus the Christies High caused the formation of two smaller sub-basins within the embayment, with differing depositional environments.

The Onkaparinga Ridge (Bowering 1979) runs adjacent to the Onkaparinga River and Clarendon Fault and separates the Noarlunga Embayment from the Willunga Basin.

The Maslin Sands form the base of the Tertiary sequence throughout the Embayment. This unit is succeeded by the Tortachilla Limestone, the Blanche Point Formation and the Port Willunga Formation. The marine transgression which deposited the Blanche Point Formation extended further into the embayment than the episodes depositing the Port Willunga Formation and Tortachilla Limestone. Therefore the Port Willunga Formation and Tortachilla Limestone are not present east of the Onkaparinga River, whereas the Blanche Point Formation extends almost to the edge of the basin (Cooper, 1980) (Fig. 6).

STRATIGRAPHY

The stratigraphy described from the Seaford stratigraphic bore (Cooper, 1980) and nearby outcrops applies only to the formations in the vicinity of the Onkaparinga River west of Main South Road. Further inland depositional environments of the sediments vary and lithologies differ considerably but are considered to be Tertiary equivalents.

Adelaidean Basement

Basement consists of Adelaidean phyllite, slate, limestone and sandstone and can be seen cropping out along the Onkaparinga Ridge. Due to the high degree of bedrock weathering within the embayment it is often difficult to delineate sediment/basement boundaries from drillers logs.

Tertiary

Maslin Sands

The Maslin Sands consist mainly of quartz sands and are divided into two units: the North Maslin Sands and the South Maslin Sands (Cooper, 1980).

The North Maslin Sands consist of multi-coloured cross-bedded sands containing numerous clay lenses. The grain size varies from very fine to very coarse. Due to the deltaic origin of these sediments they are frequently associated with lignites. In bore logs the presence of lignite was considered sufficient evidence for identification as Maslin Sands Formation, and no attempt was made to distinguish between North and South Maslin Sands.

The South Maslin Sands were deposited in a marine environment and have a high glauconite content. Grain sizes are usually similar to the North Maslin Sands but the colour varies from brown to green. This unit also contains frequent cross-bedding.

The combined thickness of the North and South Maslin Sands as measured at the Seaford stratigraphic bore and Noarlunga coal bores rarely exceed 40 m, with the North Maslin Sand being the thicker of the two units.

Tortachilla Limestone

The thickness of this unit rarely exceeds 2 m. It can only be easily recognised in bore holes west of South Road where it is of marine origin. Here it is typically a cream coloured cemented limestone, but is occasionally glauconitic and highly fossiliferous.

Blanche Point Formation

This is the thickest unit in the sequence (up to 50 m) and occurs in the vicinity of the Onkaparinga River. The Blanche Point equivalents extend throughout most of the embayment (Fig. 6). This formation includes calcareous silts and clays with some glauconite and spicular silica horizons (Cooper, 1980). The Gull Rock Member of the Blanche Point Formation can be recognised by its distinct cherty banding.

Port Willunga Formation

This formation is characterized near the coast by a yellow, buff and grey coloured succession of clays and sands which are usually glauconitic. The Port Willunga Formation outcrops around the Onkaparinga estuary and along the coast at Seaford and Moana (Sprigg & Wilson, 1959). Figure 6 shows the extent of this formation in the embayment.

Tertiary sediments also crop out at Witton Bluff, Moana, River Road, Blacks Road and in the old railway cutting in Hackham. The locations of these outcrops are shown in Figure 5.

At Witton Bluff there is a gently dipping sequence consisting of South Maslin Sands, fossiliferous Tortachilla Limestone and Blanche Point Formation (Plate 1). The Blanche Point Formation and its unconformity with Pliocene and Pleistocene clays is also visible (McBriar et al., 1977).

In the low coastal cliffs at the southern end of Moana, Blanche Point Formation, and Maslin Sands are faulted against Precambrian ABC Range Quartzite (Plate 2). On River Road in a 10 m high road cutting, relatively flat lying sediments of South Maslin Sands crop out overlain by Tortachilla Limestone and Blanche Point Formation (Plate 3).

In road cuttings along Blacks Road undifferentiated terrestrial Tertiary Sands unconformably overlie highly weathered Precambrian siltstone. This outcrop is one of the few areas within the embayment where the contact between Tertiary sediments and Precambrian basement is seen (Plate 4).

In the Hackham area, Blanche Point Formation crops out in the old railway cutting (Plate 5). Within the Blanche Point Formation, clay bands containing montmorillonite, suitable for use as a drilling mud, were recorded (Olliver, 1965). A number of auger holes were drilled to test the extent of the deposit. Two additional Tertiary units were intersected in the bores. Underlying the Blanche Point Formation, was the Tortachilla Limestone, ranging in thickness from 3 m to 4 m, followed by a section of South Maslin Sands Formation which was at least 8 m thick.

Quaternary and Recent

The Noarlunga embayment and surrounding Adelaidean bedrock are overlain by up to 20 m of Quaternary sediments. These consist of multicoloured clays commonly containing lenticular interbeds of sands and gravels. A common feature of these sediments is a calcrete horizon within the soil profile.

HYDROGEOLOGY

The aquifer systems have been divided into three distinct groups:

i) Shallow Quaternary Aquifers

ii) Tertiary Sands (Including the Maslin & Blanche Point Formation)

iii) Fractured Adelaidean Basement.

There were some problems encountered in differentiating between Quaternary and Tertiary aquifers. Since it is often impossible to distinguish between Maslin Sands and Blanche Point Formation in bore logs they have been grouped together as one aquifer. Due to its limited extent in the embayment, the Port Willunga Formation is not an important aquifer and will not be discussed in this report.

Shallow Quaternary Aquifers

Groundwater in Quaternary aquifers is stored in sands and gravels usually associated with drainage lines and creeks. Away from these drainage lines these sediments contain a high proportion of clay and do not usually make good aquifers.

These unconfined aquifers are exploited mainly for stock and some domestic supplies. There is little potential for developing them for irrigation supplies as most bores yield less than 50 kl/day. Many bores have since been backfilled or abandoned because they lacked useful supplies.

Although the potential of these aquifers is limited, with increasing urban settlement future residents may seek to supplement their mains supplies with bore water from these shallow aquifers. General water table depths and water table contours are shown in Figures 9 & 10.

Tertiary Sands

The Tertiary Sands form the main confined aquifer in the embayment and are separated from the Quaternary aquifers by clay and silt units. This aquifer directly overlies basement but its relationship with the basement aquifers is complex because clays and silts of the weathered basement probably act as a confining bed of variable effectiveness in different areas of the embayment.

Many irrigation bores drilled in the embayment were not completed in Tertiary Sands but drilled into basement because of the difficulty of screening out the fine grained sands. Where the sands are coarser and thick, and with proper development, some bores completed in this aquifer have obtained supplies of up to 300 kL/day, but supplies as low as 40 kL/day are more common for the reasons given above. In some cases even the use of expensive wire-wound screens has proved inadequate in keeping fine sands and silts from entering the casing and damaging pumps.

This aquifer is exploited mainly along the Clarendon Fault and through the central embayment area where the thickest sequences are found and the greatest amount of recharge occurs. Depths to the aquifer are greatest near the fault (up to 120 m) and decrease towards the northern boundary of the embayment (approx. 30 m).

Little is known about this aquifer in the area west of Main South Road and test drilling is required before an accurate appraisal can be made.

Fractured Adelaidean Basement

Because of the difficulty involved in developing adequate supplies in the Tertiary Sands many bores are completed in the underlying Adelaidean. The advantage of this lies in the ease and safety of open-hole completion.

Supplies from the basement aquifers depend on the amount of jointing and fracturing within the rocks. Supplies are usually good varying from 100 kL/day to 600 kL/day. Useful supplies are obtained in bedrock underlying the embayment at depths of up to 120 m. Bores drilled outside the embayment obtain similar supplies and the main advantage of drilling in these areas would be the reduced depths of bores, as low as 50 m, and consequent lower drilling costs.

RECHARGE

Areas with the best prospects for groundwater directly reflect the position of major recharge zones. Recharge occurs in the north-east of the embayment, along the Clarendon block, and the direction of groundwater movement is along the length of the embayment towards the coast. The higher rainfall in this area, (Fig. 2) due to the height of the block, also contributes to the recharging of local aquifers. Infiltration of rainfall along the Clarendon Fault recharges the confined aquifers as well as contributing to the recharge of water table aquifers especially in the immediate vicinity of drainage lines and creeks.

Crawford (1959) suggested that because large supplies of pressure groundwater were available in bedrock in the central portion of the basin, Tertiary sands were providing a continual source of recharge to basement. In the Willunga Basin where similar conditions exist Bowering (1979) also concluded from pump test investigations that there was some leakage. Thus it is likely that there is interconnection between these two aquifers in some areas with Tertiary sands providing some recharge to the bedrock aquifer.

The Onkaparinga River meanders across the southwestern corner of the embayment but bores drilled into the Tertiary or Quaternary sediments in the vicinity of the river do not show any significant improvements in salinities, indicating that recharge from the river is only minimal.

GROUNDWATER QUALITY

Plans showing salinity zones for the three main aquifers are presented in figures 11, 12, & 13. Because there was no observation network established for bores in the embayment the salinities for each aquifer obtained from previous bore data were assumed to be correct. In addition, bore details were often incomplete, lacking depth of waters cut, casing details and strata information. Thus much salinity data could not be used as it could not be determined from which aquifer samples were drawn.

Groundwater qualities from all three aquifers display a similar pattern of increasing salinity away from points of recharge along the Clarendon Fault.

Salinities in the shallow Quaternary aquifers are usually between 1 000 - 4 000 mg/L but there is a gradual increase in salinities away from the main drainage lines and towards the coast, where the sediments tend to have a higher proportion of silt and clay. In these areas salinities can exceed 6 000 mg/L.

In the Tertiary sands, salinities gradually increase from around 1 000 mg/L, along the Clarendon Fault, to over 4 000 mg/L along the northern margins of the embayment. This increase in salinity towards the north occurs because the Tertiary sands have their major recharge zone along the Clarendon Fault in the south-east. Due to insufficient data little is known about the exact salinity patterns in the western half of the embayment although general indications are that they do increase considerably.

The range of salinities in the fractured basement is similar to that in Tertiary sands varying between 1 000 - 4 000 mg/L. There is a general tendency again for increased salinities towards the coast and northern margin of the embayment due to the recharge effect of the Clarendon Fault.

CONCLUSIONS

The Noarlunga Embayment and its groundwater potential for irrigation use is limited to its eastern portion. The Willunga Embayment although similar in its geological history is of far greater importance as a groundwater resource.

Increasing urbanization within the embayment has limited demands for irrigation supplies to newly developing golf courses, ovals, parks etc. Due to a lack of drilling data the true groundwater potential of some areas is unknown. Stock supplies are available in most areas but demands are low and groundwater for domestic use, although limited, will be in far greater demand as a supplement in household use.

Available information indicates the existence of a basement high (Christies High) to the west of Main South Road, running approximately north-south across the embayment. The varying lithologies of sediments on both sides of the Christies High demonstrates that it probably had an effect on the depositional environment of Tertiary sediments on either side.

Groundwater prospects to the west of Christies High are not well known but general indications are that the quality deteriorates. It is possible that this basement high, along with the large percentage of clays and silts within the Quaternary sequence above it, has retarded the movement of recharging groundwater towards the coast, explaining the increased salinities of groundwater to the west of the basement high. Drilling into basement for water supplies would be best recommended in the Christies High area and other areas where Tertiary sediments are thinnest.

RECOMMENDATIONS

Investigation wells should be drilled in the vicinity of and to the west of the Christies High near Noarlunga City to establish the stratigraphy, salinity levels and potential supplies for the Quaternary, Tertiary and basement aquifers.

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APPENDIX 1

PORT NOARLUNGA SEISMIC SURVEY

Introduction

Shallow refraction seismic work has been completed within the hundred of Noarlunga in the vicinity of Christie Downs. This work was proposed to obtain additional information of the depth to weathered basement within the Noarlunga Basin.

A total of four spreads, each consisting of 24 geophones spaced 10 m apart (spread length of 230 m) were completed (Fig. A). Five ounce anzomex boosters were used as an energy source and were detonated in shallow holes at the centre and ends of each spread. First arrival times of the energy at each geophone were recorded via two 12 channel Nimbus ES1210 seismographs. The arrival times were then plotted with respect to the distance of the geophones from the shotpoints. Resulting time-distance curves were then analysed using intercept times and straight slopes to obtain horizontal velocity and depth estimates.

Results and Conclusions

Depth estimates and horizontal velocities were plotted under each shot point to produce cross sections of each refractor down to the weathered basement material. Results show evidence of three distinct layers stratigraphically overlying weathered basement. The surface layer exhibits horizontal velocities in the range of 310 m/sec to 510 m/secc with an average velocity of 420 m/sec and is correlatable with recent top soil. The next layer, with horizontal velocities ranging from 600 m/sec to 825 m/sec (average is 726 m/sec), most likely represents material to the base of the Quarternary. Below this layer, material, with a horizontal velocity range of 975 m/sec to 1 130 m/sec (average of 1 035 m/sec), includes the Blanche Point Formation and Maslin Sands. Horizontal velocities within the weathered basement vary from 2 140 m/sec to 2 400 m/sec (average of 2 550 m/sec) and is associated with weathered slates of the bedrock within the Noarlunga Basin.

Material possessing a velocity in the range of 6 670 m/sec to 8 570 m/sec exists below the weathered slates, as apparent on spreads 1, 2 and 3. This material is presumed unweathered Adelaidean sediments.

A small basement rise is evident in the region of spread 3. This rise extends into the sediments above the slates and may cause a pinch out of the Quarternary sequence in this area.

The lack of 1 000 m/sec material below spread 1 indicate a structural change such as faulting or a facies change within the limestone sequences.

Seismic interpretation and resultant contouring of basement relief verifies the existence of a basement rise in the area of spread 3.

Recommendations

A shallow drill hole is recommended on spread 3 at geophone site 1 to confirm the above interpretation.

A shallow refraction seismic spread is recommended over bore no. 4848 to confirm the depth to slate as 18 metres and to determine the velocity of this layer.

G.D. REED
GEOPHYSICIST

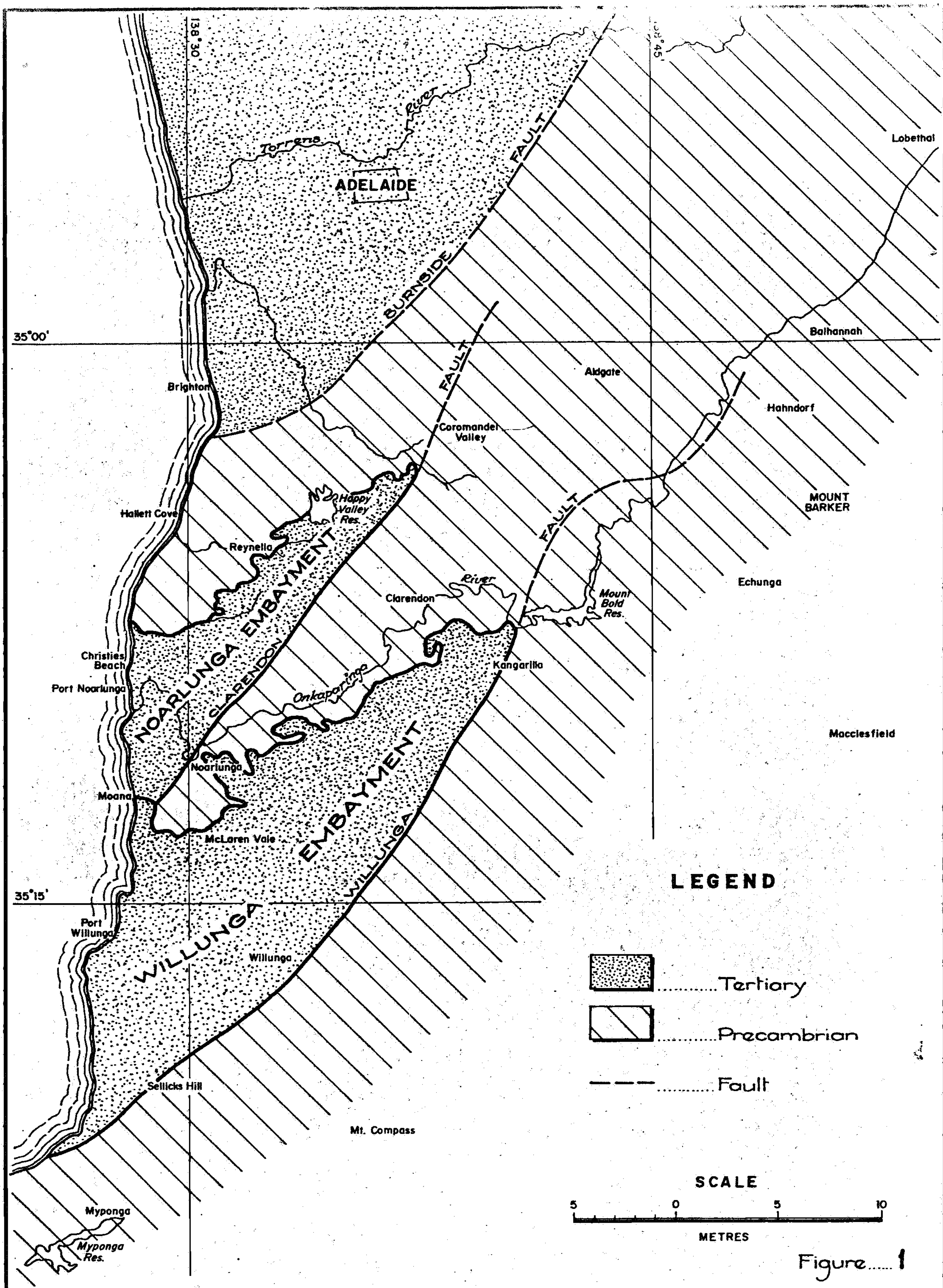

Figure 1

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LOCATION AND REGIONAL GEOLOGY	DATE Oct. '83 / CHECKED	PLAN NUMBER S 17045

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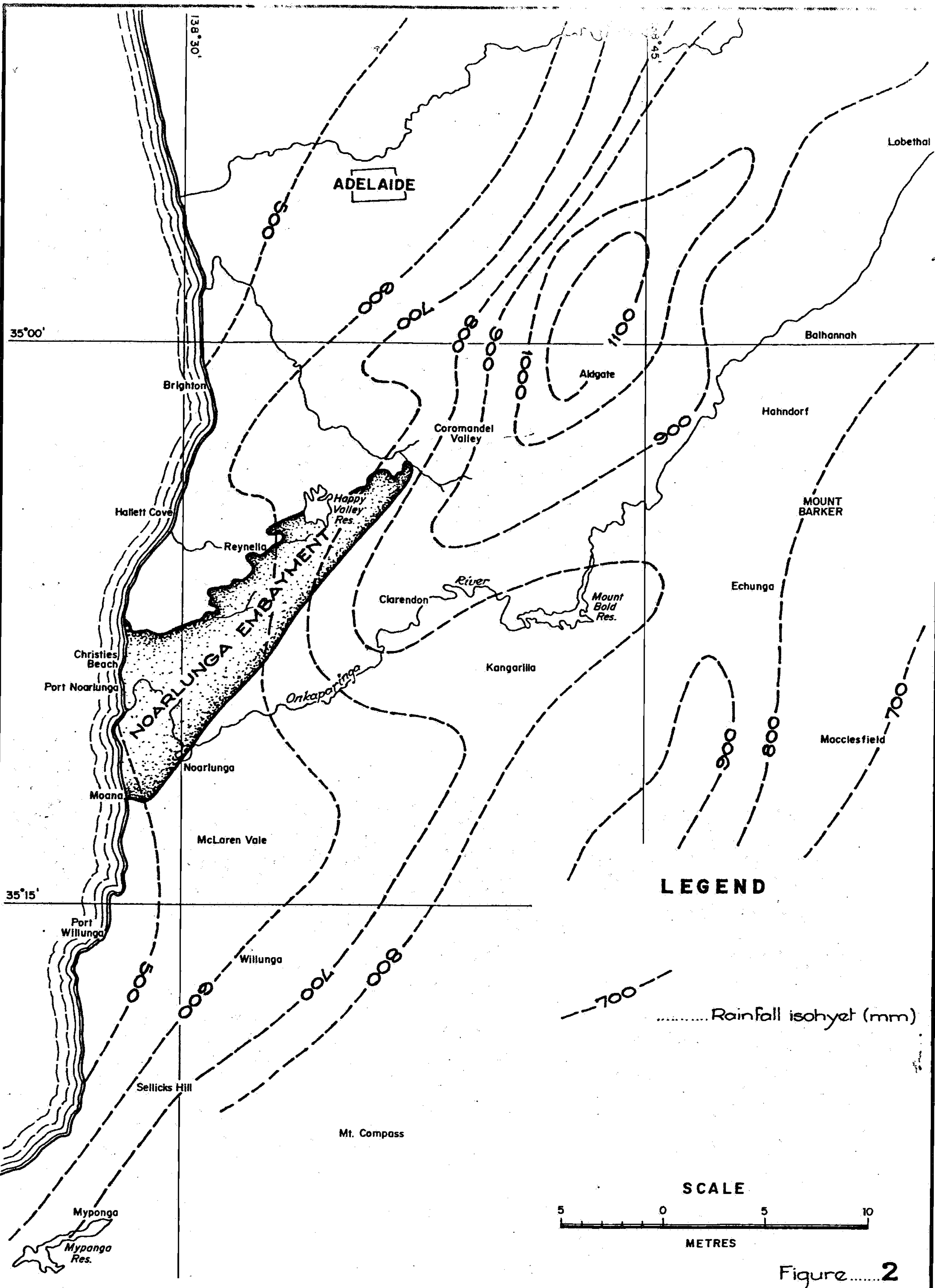

Figure 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

RAINFALL ISOHYETS

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DATE Oct '83	PLAN NUMBER
CHECKED	S 17046

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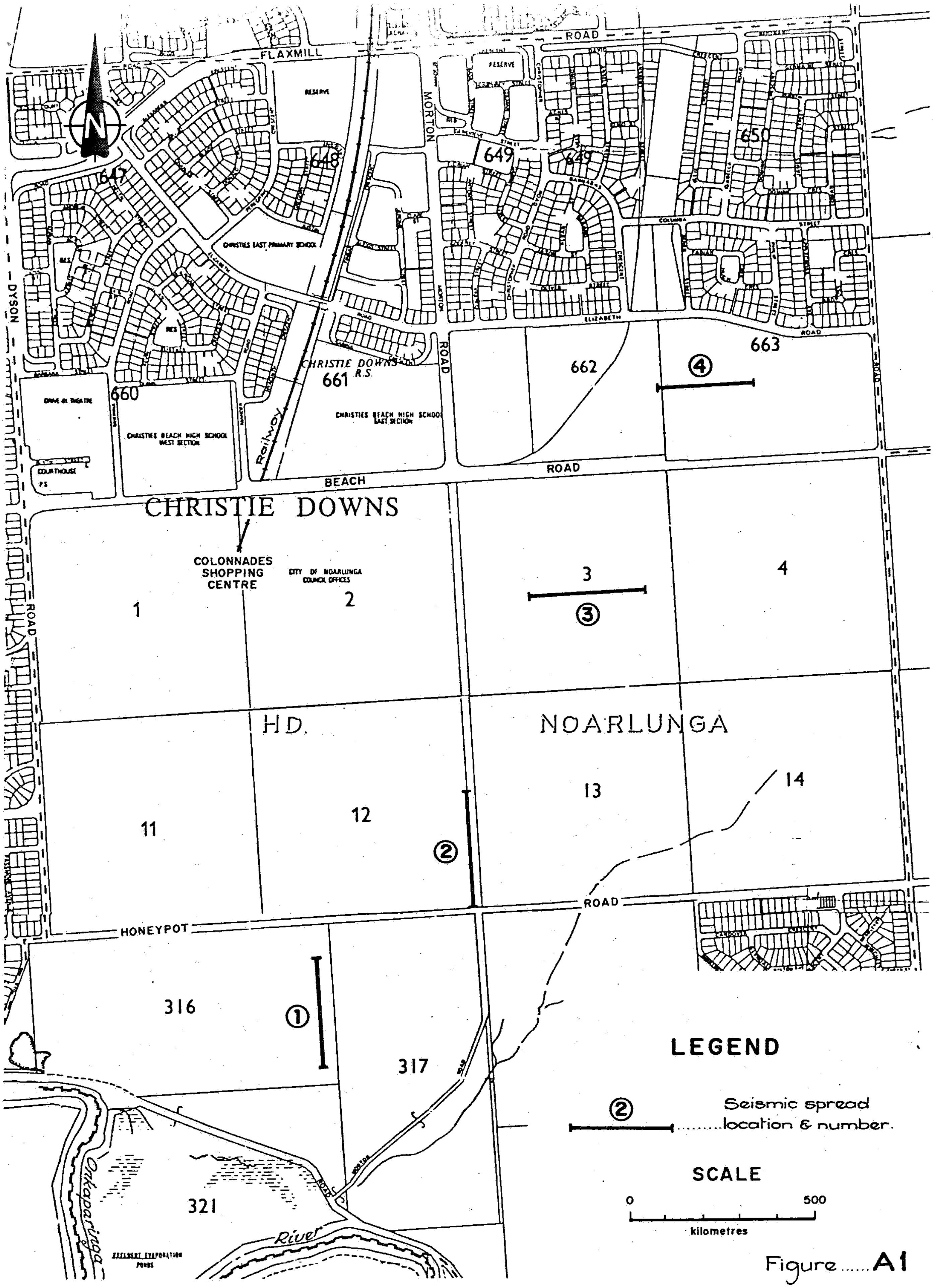

Figure A1

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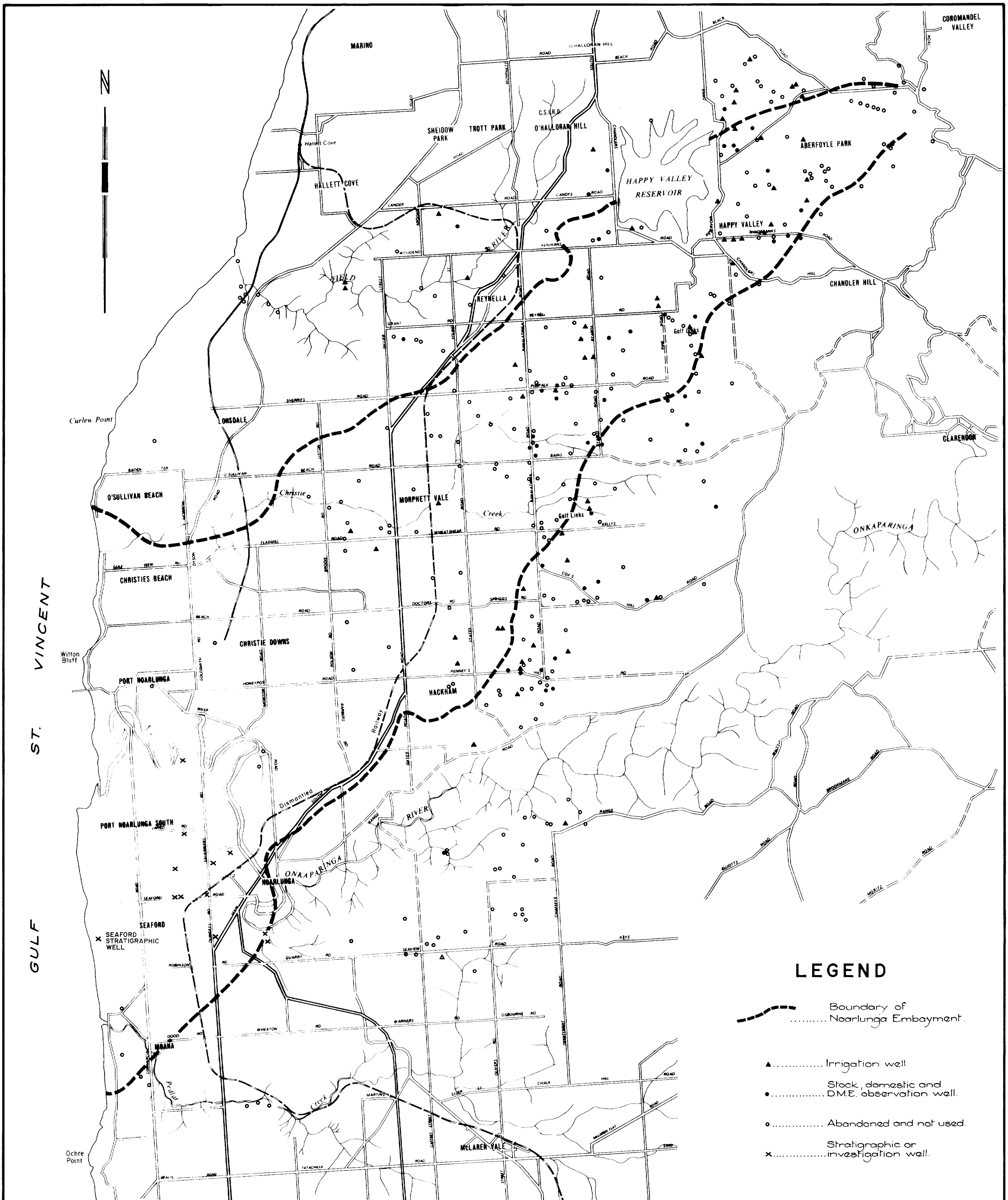

SCALE

1 0 1 2 3 4

kilometres

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B.R.	20·12·83 C D O DATE
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WELL USE	DATE Oct. 1983 CHECKED	PLAN NUMBER 83 - 533

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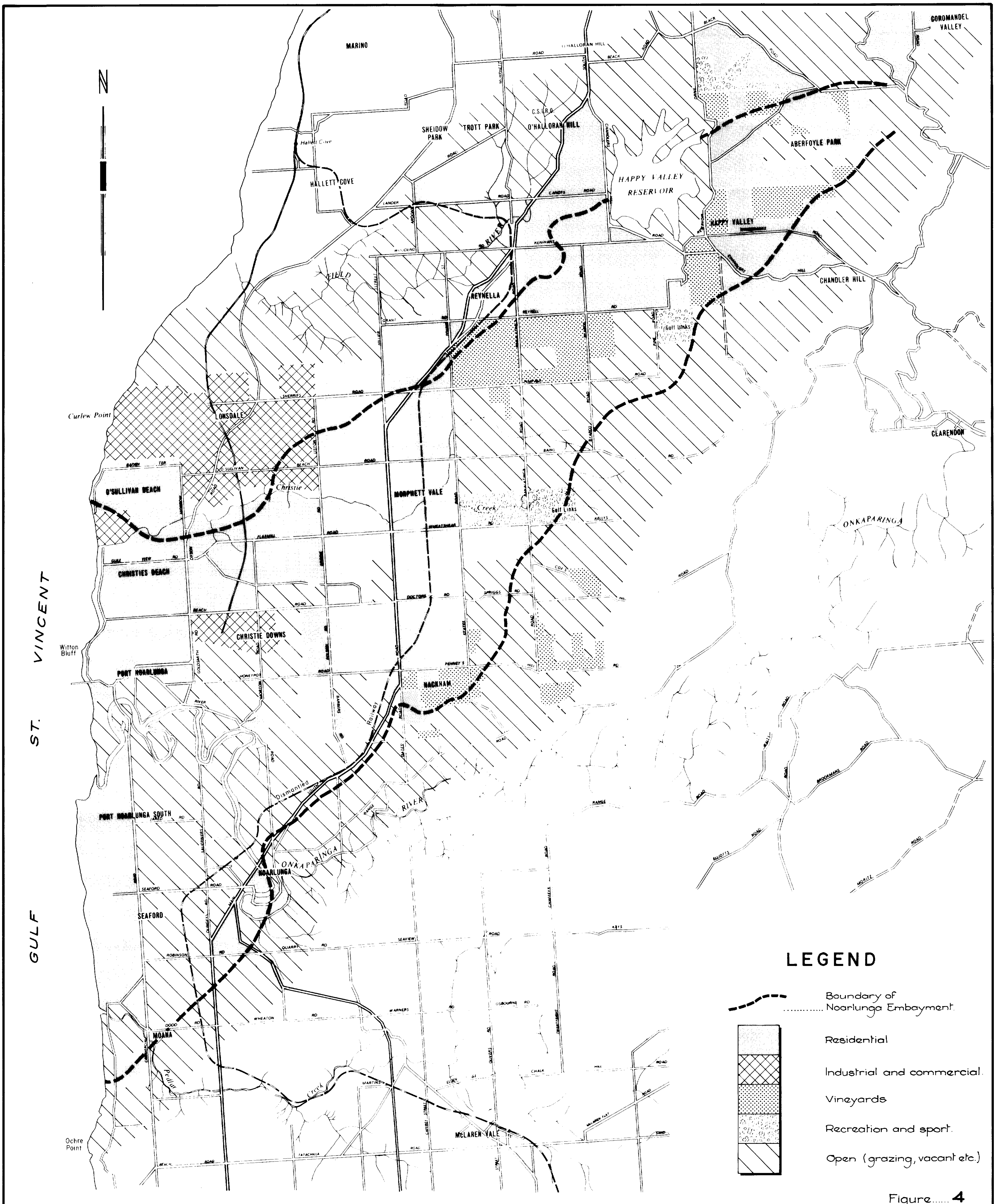


Figure...... 4

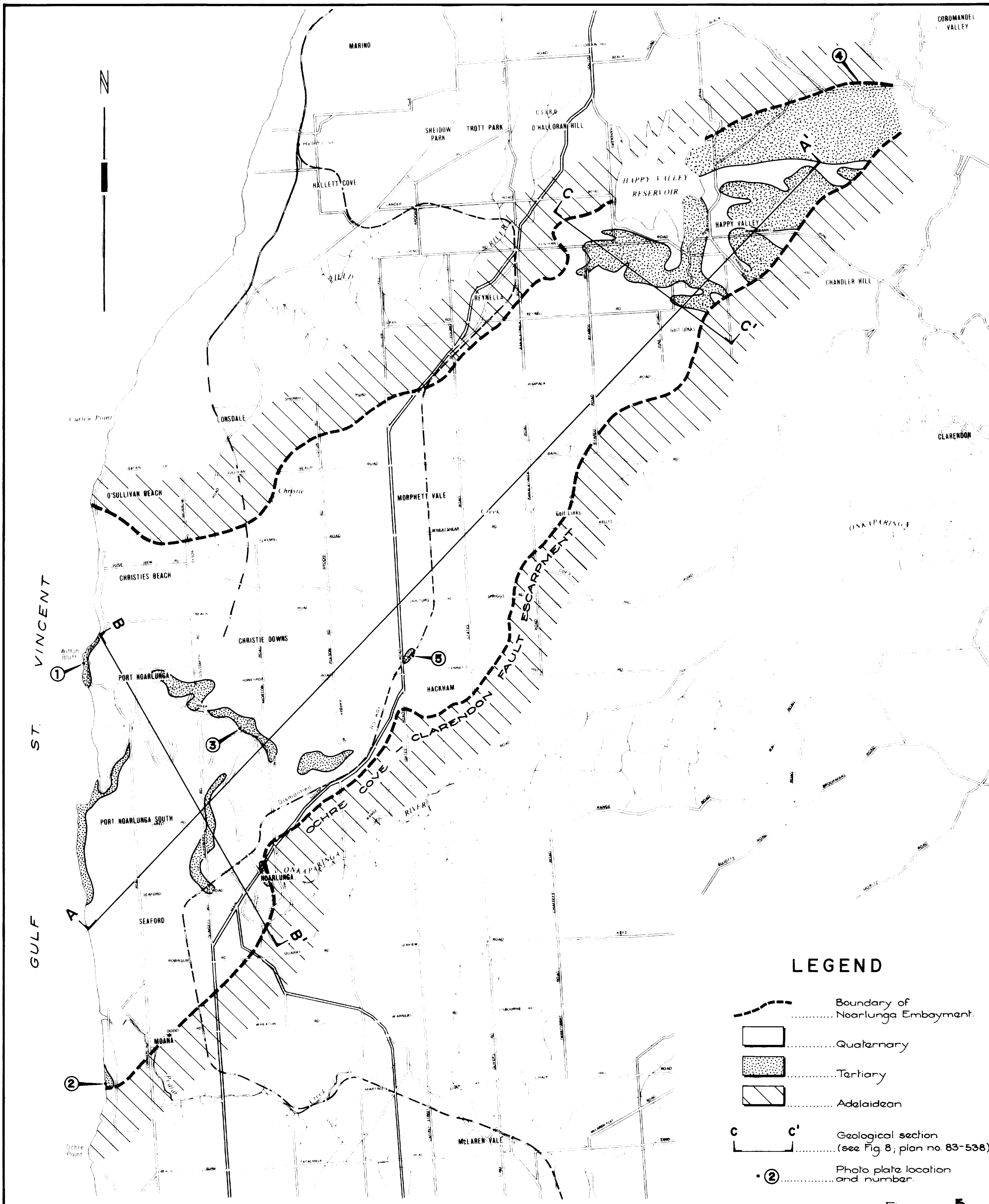
SCALE

1 0 1 2 3 4

kilometres

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B.R	20.12.83	
NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION	DRAWN M.R.	SCALE 1 : 50 000	
LAND USE	DATE Oct. 1983	PLAN NUMBER 83 – 534	

3321



Geology after 1:50,000 Noarlunga Resources Series.

Figure 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B.R.	CDO 20-12-83	DATE
NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION	DRAWN M.R.	SCALE 1 : 50000	
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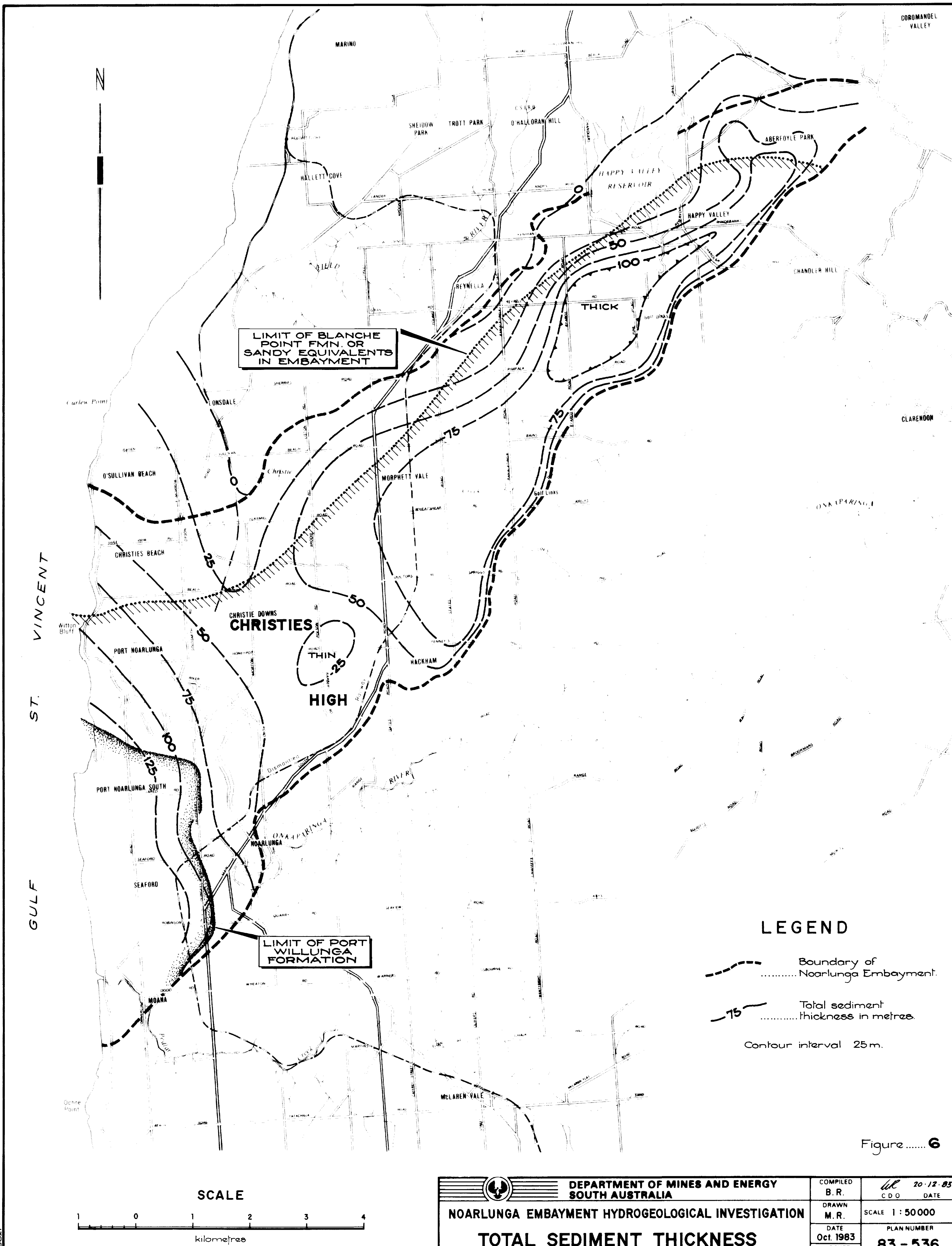

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

TOTAL SEDIMENT THICKNESS

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DATE Oct. 1983	PLAN NUMBER 83-536	
CHECKED		

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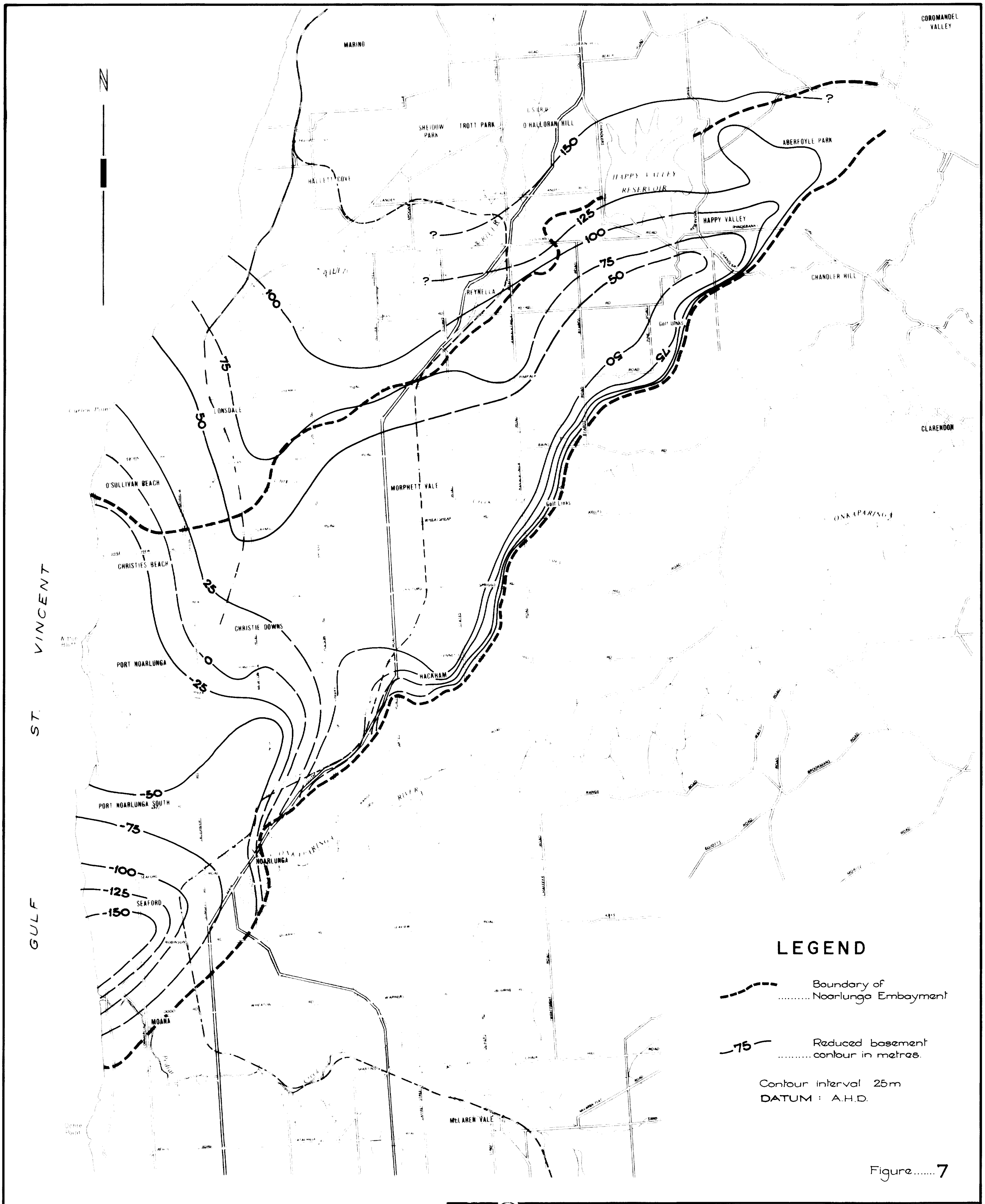

Figure 7

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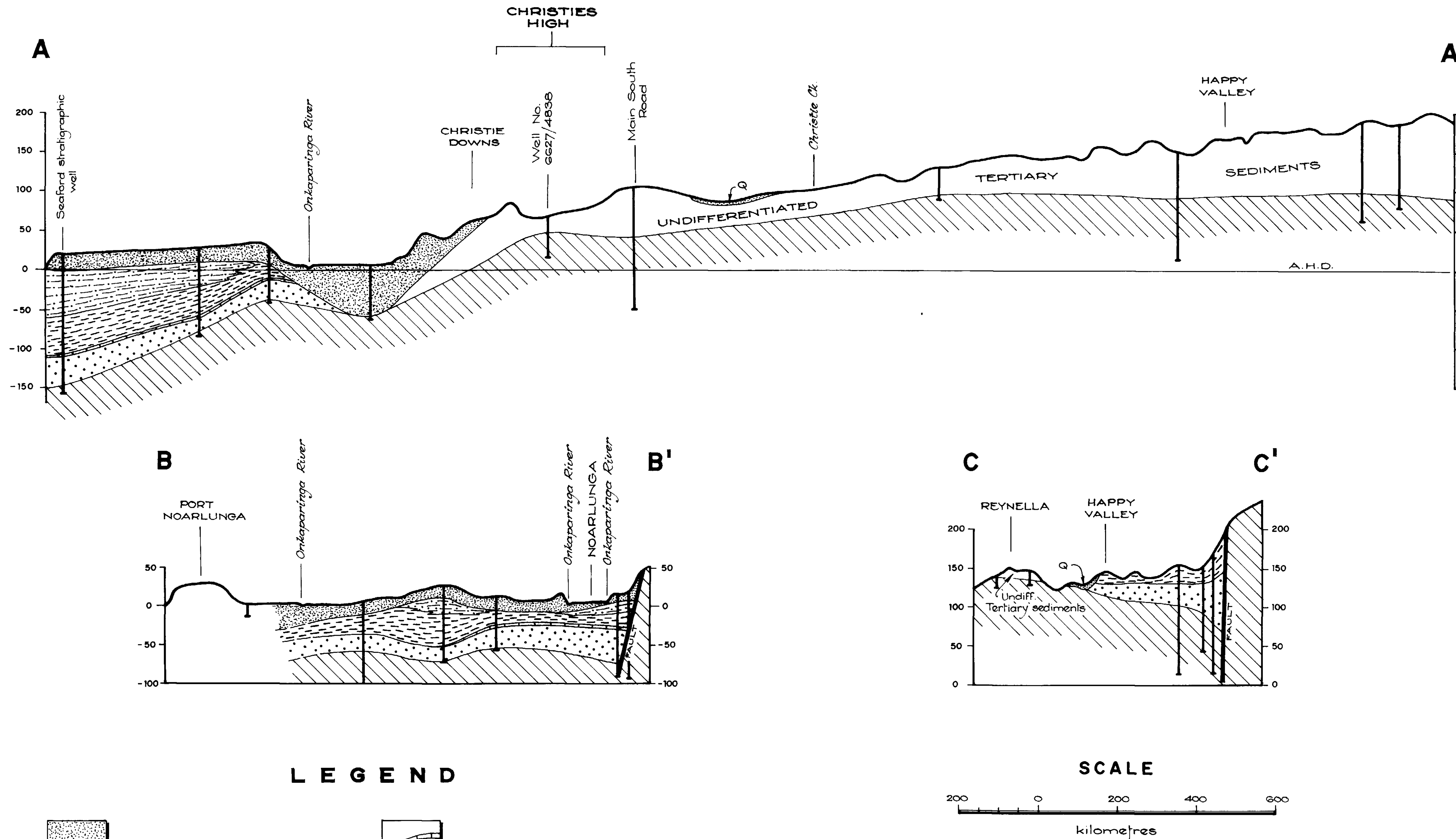

For location of sections see Fig. 5 (83-535)

Figure 8

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

GEOLOGICAL SECTIONS

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DATE Oct. 1983	PLAN NUMBER 83-538	
CHECKED		

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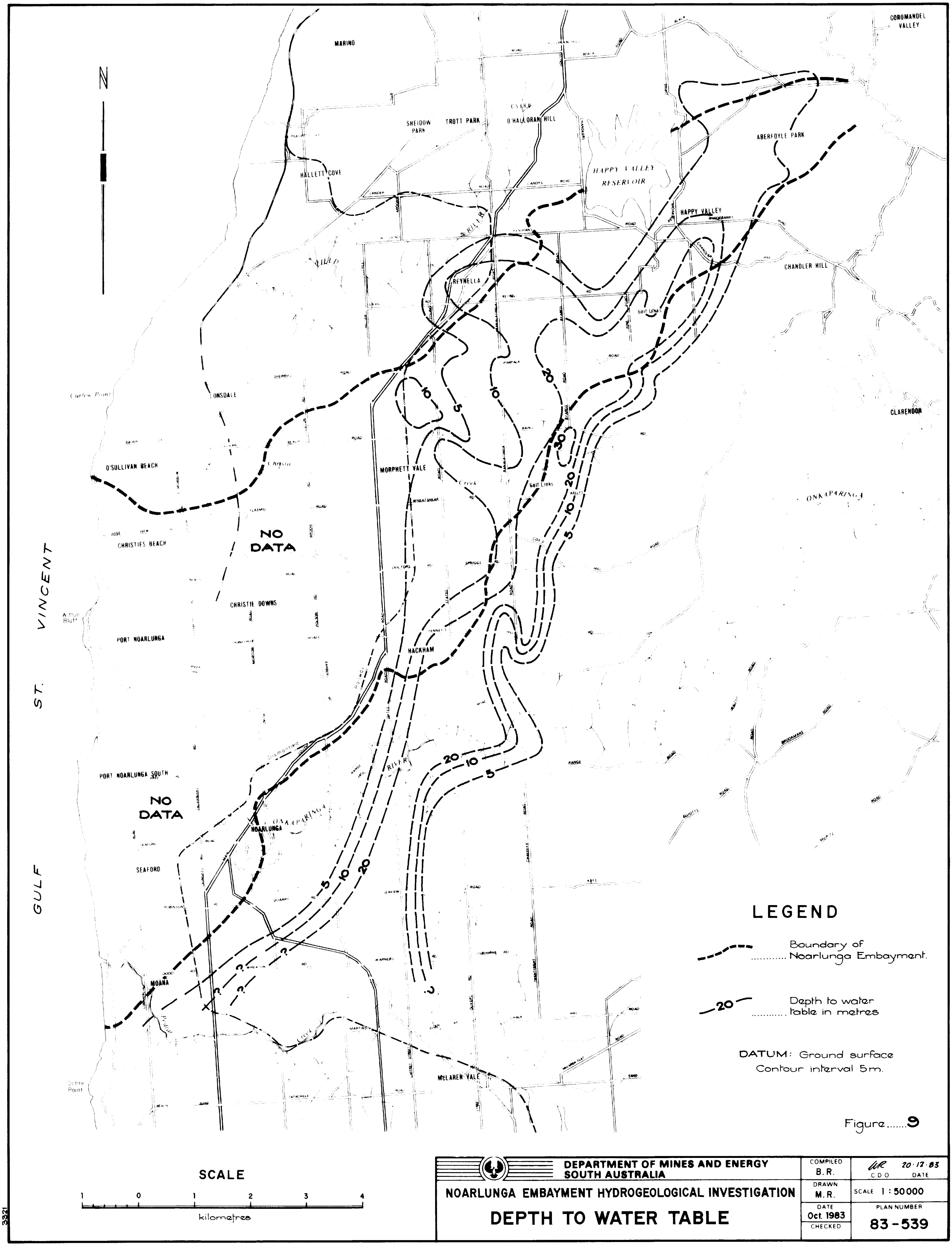

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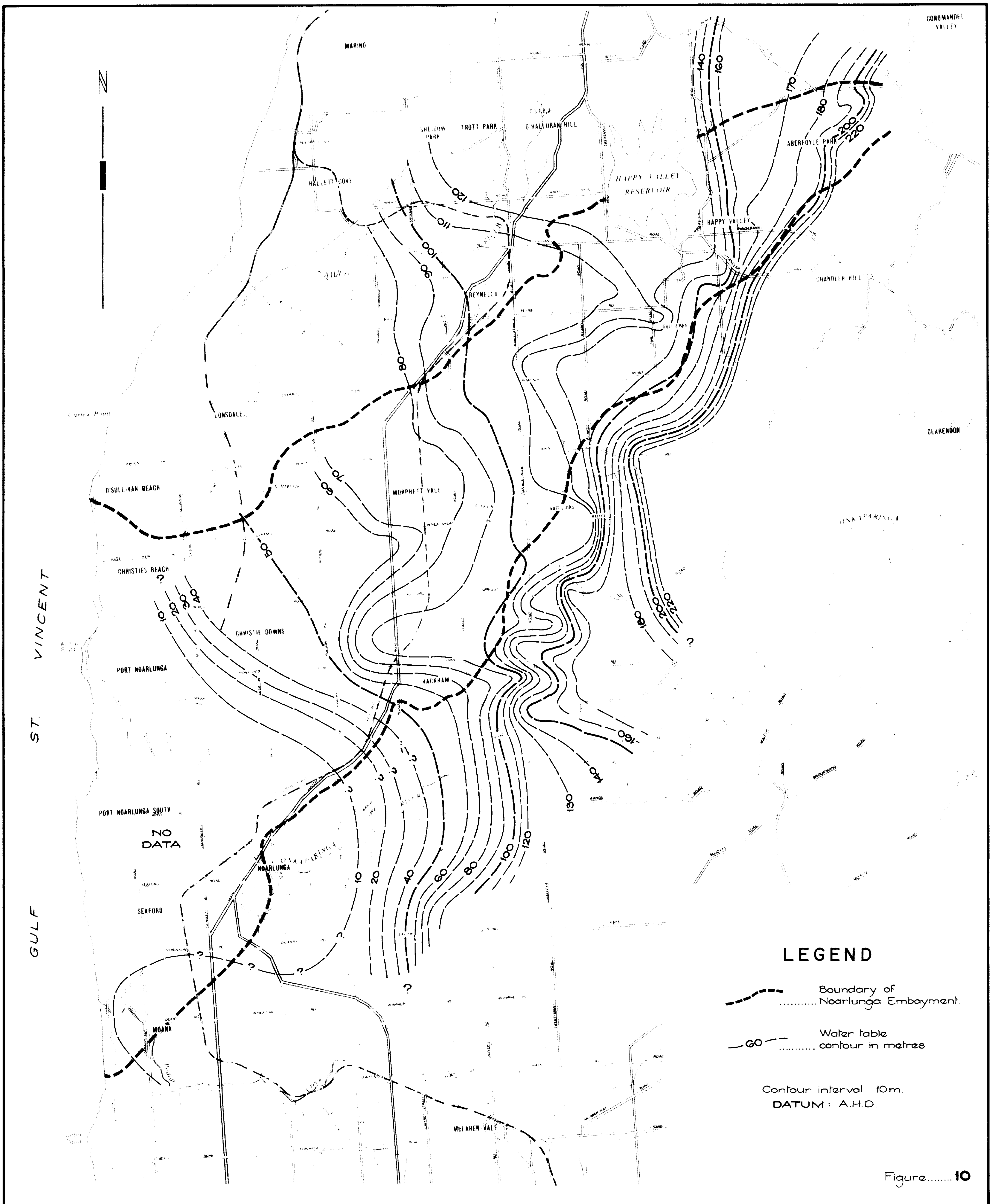

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

WATER TABLE CONTOURS

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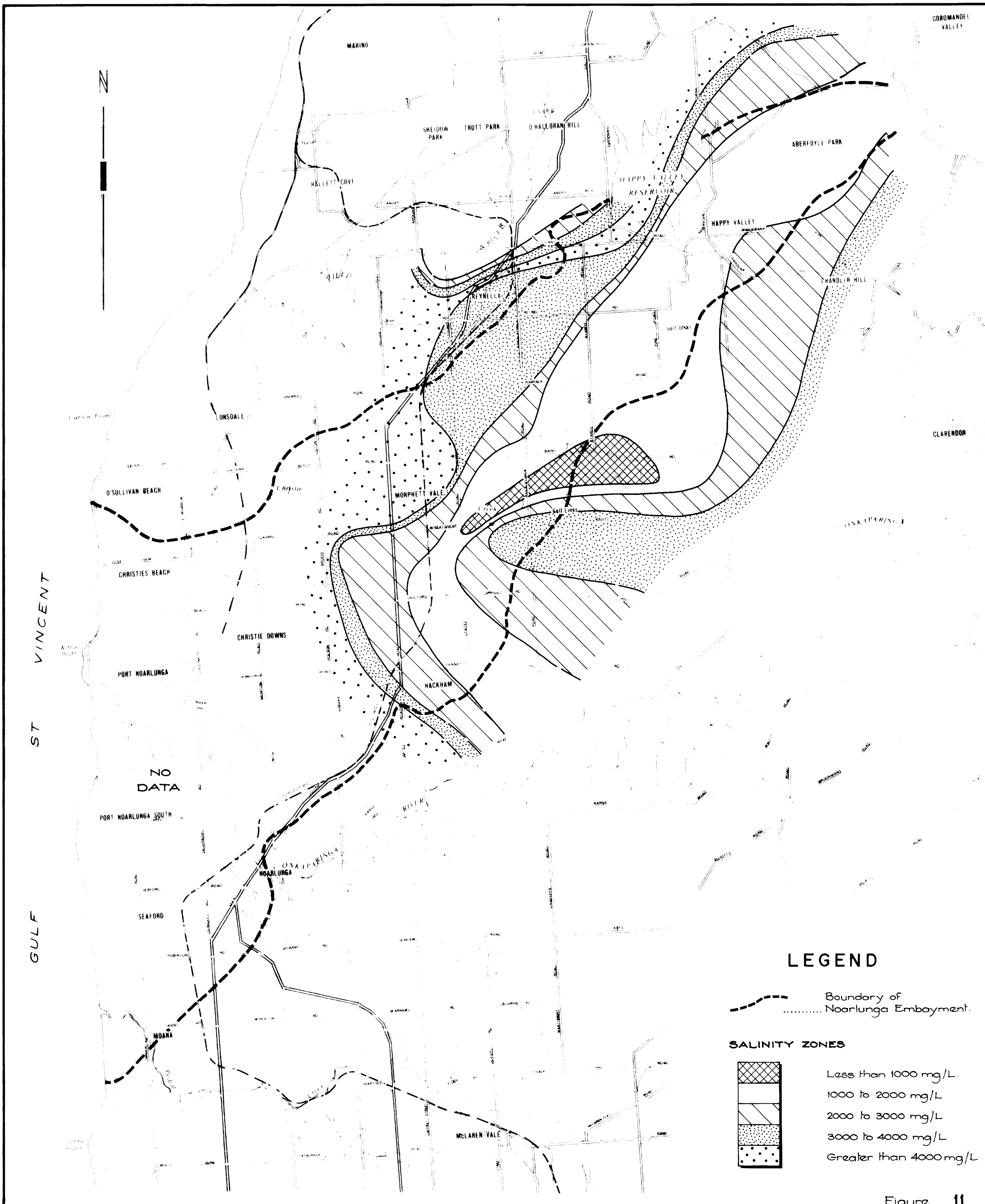

Figure......11

SCALE

1 0 1 2 3 4

kilometres

3321

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B.R.	20·12·83 CDO DATE
NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION	DRAWN M.R.	SCALE 1:50000
WATER TABLE AQUIFERS GENERALISED SALINITY ZONES	DATE Oct. 1983 CHECKED	PLAN NUMBER 83-541

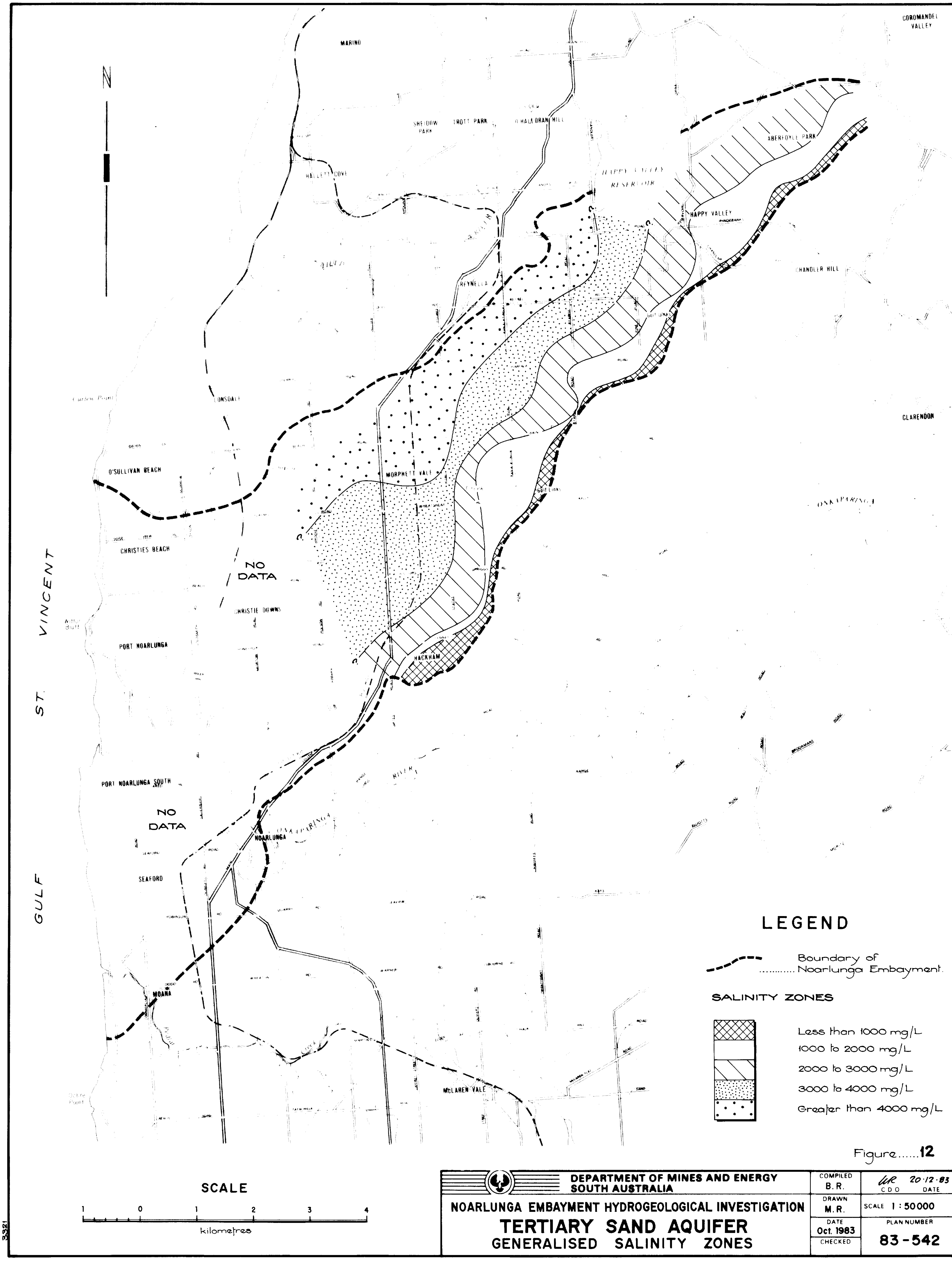

Figure......12

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

TERTIARY SAND AQUIFER
GENERALISED SALINITY ZONES

COMPILED B.R.	CDO 20·12·83 DATE	
DRAWN M.R.	SCALE 1 : 50000	
DATE Oct. 1983	PLAN NUMBER 83-542	
CHECKED		

3321

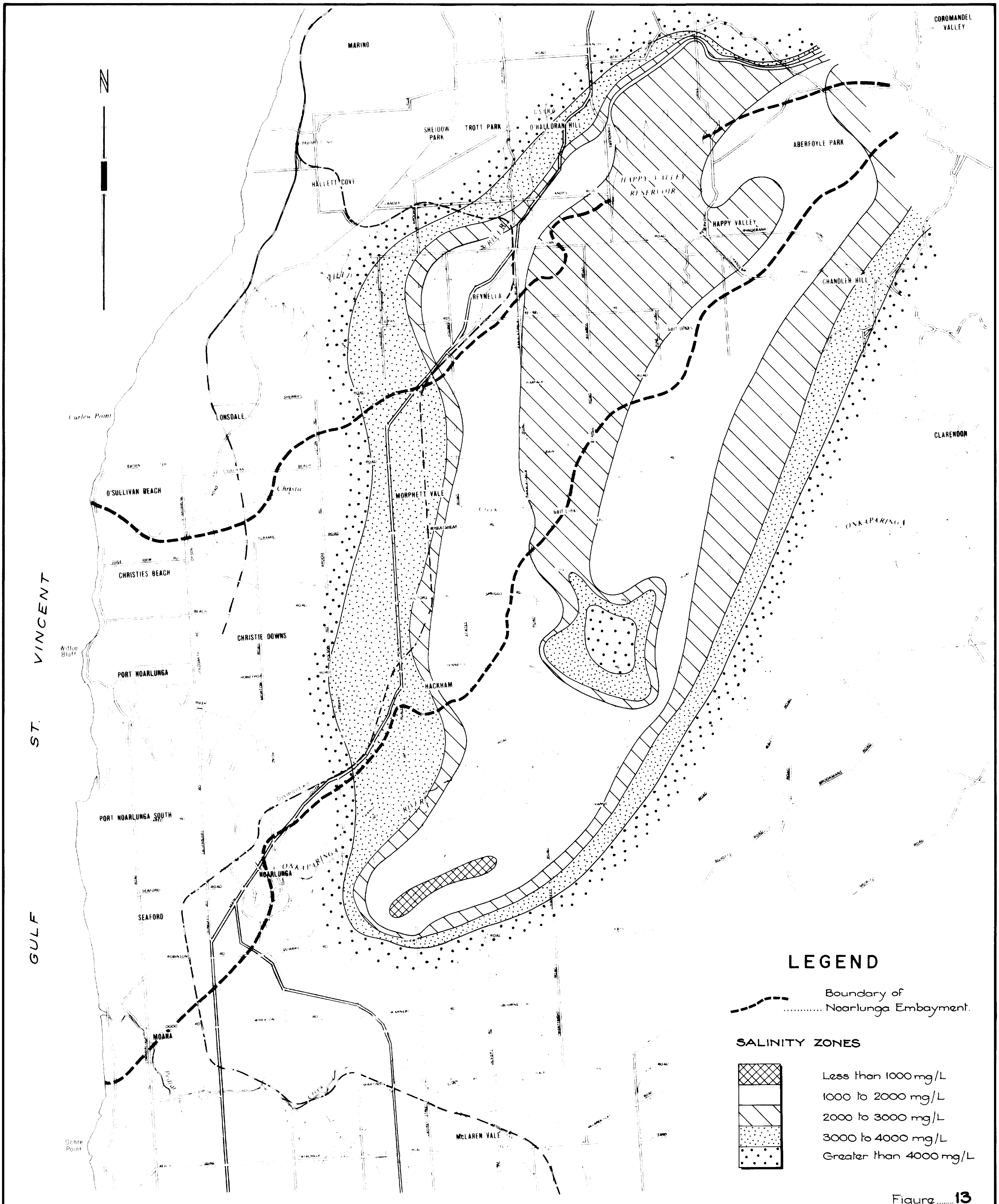

Figure 13

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

NOARLUNGA EMBAYMENT HYDROGEOLOGICAL INVESTIGATION

FRACTURED ADELAIDEAN BASEMENT

GENERALISED SALINITY ZONES

COMPILED B.R.	20.12.83 CDO DATE	
DRAWN M.R.	SCALE 1 : 50000	
DATE Oct. 1983	PLAN NUMBER	
CHECKED	83-543	

PLATE 1. Gently dipping sequence of South Maslin Sands overlain by Tortachilla Limestone, Blanche Point Formation, Witton Bluff.

PLATE 2. Blanche Point Formation, (L.H.S.) faulted (Clarendon Fault) against ABC Range Quartzite, southern end of Moana beach.

PLATE 3. Flat lying South Maslin Sands overlain by Tortachilla Limestone and Blanche Point Formation exposed in road cutting, River Road, Noarlunga.

PLATE 4. Tertiary sands unconformably overlying Adelaidean siltstone, Blacks Road, Coromandel Valley.

PLATE 5. Blanche Point Formation exposed in old railway cutting, Hackham.