Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE

South West Coastal Groundwater Area
Groundwater Management Review

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Report No. WG 84
September 1989

Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE
Groundwater Branch

South West Coastal Groundwater Area Groundwater Management Review

Prepared by R. Hammond

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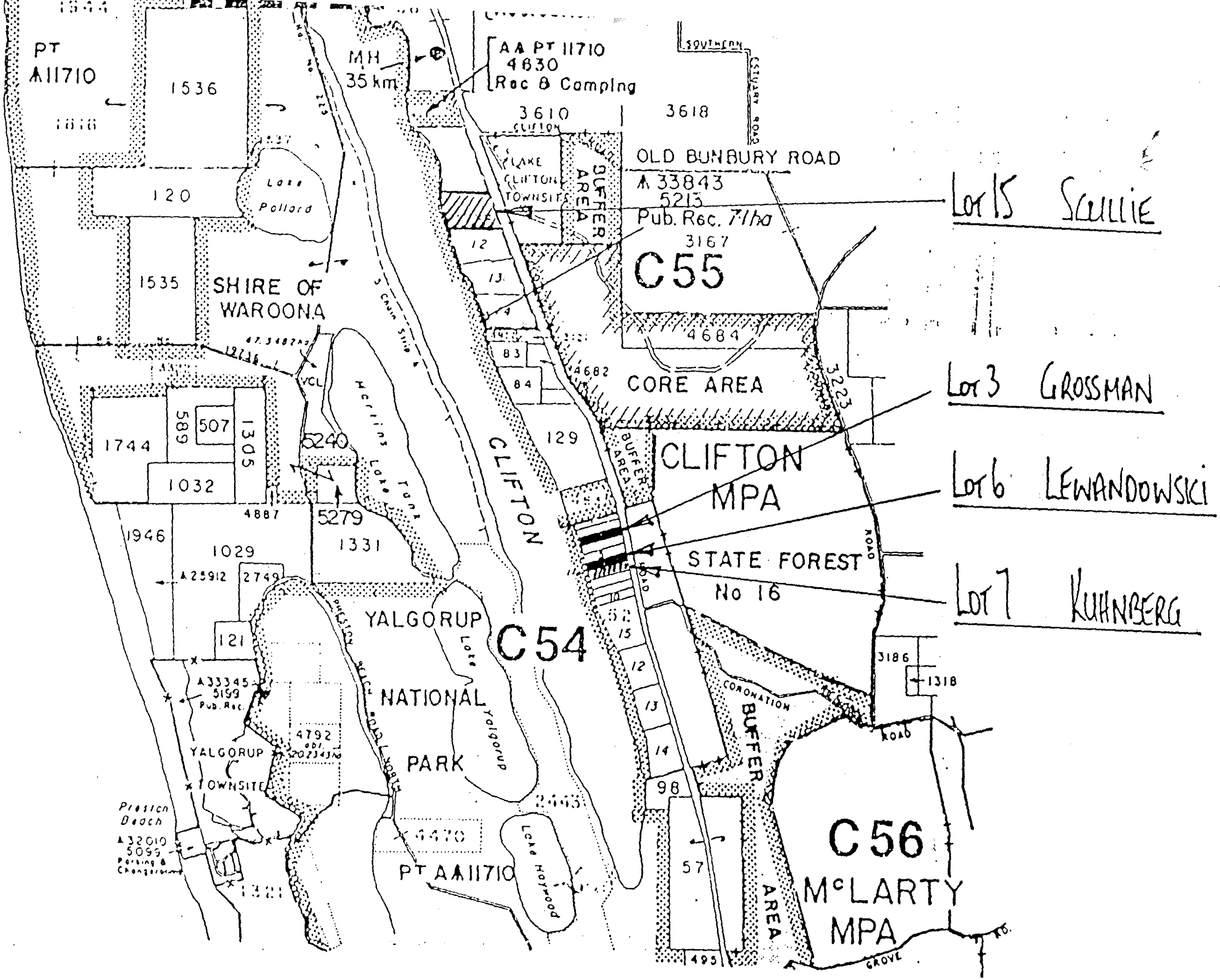

SUMMARY

The South West Coastal Groundwater Area (SWC GWA) (Figure 1) was proclaimed in 1977 when the Water Authority (then Public Works Department) became aware of large groundwater usage for horticulture. The SWC GWA incorporates urban and hobby farm activities in the north near Mandurah, extensive irrigated horticulture east and south of Lake Preston, and industrial development near Kemerton. Besides use for private purposes, groundwater is also drawn for public town water supplies at Park Ridge, Yalgorup, Myalup and Binningup.

The eastern portion of the GWA drains to the Peel-Harvey Estuary and consideration of the impacts of fertilizer use associated with irrigated horticulture has become an integral part of groundwater management in this part of the GWA.

Groundwater use in the area has been licensed for nearly 12 years and various monitoring programmes have been carried out for much of that time. This report reviews the impacts of current groundwater abstraction, re-assesses groundwater availability in the GWA and recommends strategies for future groundwater allocation.

As part of the review the GWA was divided into 11 subareas (Figure 8). These reflect fairly discrete groundwater flow systems and provide a suitable base for implementation of the varied management strategies required over the GWA.

The review has indicated that existing management practices are generally appropriate with adverse impacts of current groundwater use being limited. A gradually increasing groundwater salinity has been identified at 3 locations and attributed to recycling of salts.

The following general allocation strategies are recommended for the SWC GWA:-

1. In the subareas of Mandurah, Falcon, Whitehill, Island Point and Coastal, the limited available groundwater should generally be allocated to domestic or hobby farm activities. The groundwater allocation should generally be based on 750 m^3/ha (375 m^3/ha in Coastal) with licensees advised that the supply can only be obtained from spaced low yielding bores. This is to prevent upconing of underlying saline groundwater. Special Rural lots up to 4 ha should be allocated a maximum of 1 500 m^3/lot/yr. The allocation is similar to that for hobby farms elsewhere in the state and is considered sufficient for domestic activities plus the irrigation of 0.1 ha.

2. In the subareas of Lake Preston, Harvey, Myalup, Wellesley and to a lesser extent Lake Clifton allocations should be made to viable commercial activities. These allocations which will generally be to horticultural projects can be made until the recommended availability for the individual subarea is reached. In addition a local rule limiting abstraction to 4 000 m^3/ha of property (2 000 m^3/ha in Lake Clifton) is recommended. This rate has been recommended to prevent localised recycling problems and is aimed to evenly spread the draw over the subarea. It is generally sufficient to irrigate approximately one quarter of any property but can be varied if:

(a) Existing use within a 500 metre radius of a proposed draw does not exceed a cumulative 4 000 m^3/ha over that area, or

(b) In the case of properties abuting saline water bodies, the existing draw on adjoining properties does not exceed a cumulative 4 000 m^3/ha.

(c) Where existing abstractions already exceed 4 000 m^3/ha in respect of (a) or (b), allocations should not be made which will exacerbate the situation.

3. In Colburra Downs and eastern Wellesley subareas because of the higher groundwater salinities allocations should be considered on an individual basis.

4. In the parts of the Lake Clifton, Colburra Downs and Harvey Subareas draining to the Peel-Harvey Estuary, allocations need to be determined in consultation with the Environmental Protection Authority to ensure that fertiliser management practices associated with irrigated developments are acceptable.

5. Resources in the shallow artesian aquifer (Leederville Formation) should be held for public purposes. This is because there is limited annual recharge and potentially increasing public demand.

SOUTH WEST COASTAL GROUNDWATER AREA
GROUNDWATER MANAGEMENT REVIEW

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SOUTH WEST COASTAL GROUNDWATER AREA
GROUNDWATER MANAGEMENT REVIEW

1.0 INTRODUCTION

The South West Coatal Groundwater Area (SWC GWA) was proclaimed in 1977 under provisions of the Rights in Water and Irrigation Act 1914 (RIWI Act). The Groundwater Area was varied in 1986 to include the Harvey area and again in 1988 to include Mandurah. The location of the proclaimed area and its proximity to other proclaimed areas is shown on Figure 1.

The proclamation occurred after the Public Works Department (now the Water Authority of Western Australia) became aware that groundwater use was expanding rapidly in an area with limited resources. The inclusion of the Harvey area was considered necessary because of increasing groundwater use while the inclusion of Mandurah was a rationalisation of existing GWA boundaries.

Licensed groundwater use within the South West Coastal Groundwater Area includes private domestic and stock, irrigated horticultural (for domestic and export markets), horse agistment, deer farming, poultry farming and marron farming.

The South West Coastal Advisory Committee has been formed under the RIWI Act to advise the Water Authority on licensing matters in the GWA. Membership of the committee includes 3 local landowners, a Department of Agriculture officer and Water Authority officers. The Water Authority chairs the Committee.

This report describes groundwater availability, existing use, monitoring and recommends management strategies for the resources.

2.0 PHYSIOGRAPHY AND GEOLOGY

2.1 Physiography

The SWC GWA lies wholely within the Swan Coastal Plain. It includes a number of very significant wetlands, the biggest of which are the Peel-Harvey Estuary and Lakes Clifton and Preston.

The Harvey River is the most significant natural drainage feature, however, a number of large drains have also been constructed. This has significantly altered catchment drainage. The main physical features are indicated on Figure 2 along with the main drains.

2.2 Geology

The SWC GWA is underlain by sediments of the Perth Basin. Structural divisions of the Perth Basin found are the Dandaragan Trough to the north and the Harvey Ridge in the south (see Figure 3).

Sediment thickness is up to 8 000m and the main water bearing formations (from the surface) are the Safety Bay Sand, Tamala Limestone, Bassendean Sand, Guildford Formation, Jandakot Beds (this group represent the superficial formations), Rockingham Sand (the Tertiary Formation), Osborne Formation, Leederville Formation (the Cretaceous Formations), Yarragadee Formation and Cockleshell Gully Formation (the Jurassic Formations).

The Jurassic Formations are extensively block faulted and overlain by gently folded Cretaceous sediments. The superficial formations are unaffected by faulting or folding.

3.0 HYDROGEOLOGY

3.1 Superficial Formations

The superficial formations are also referred to as the Quaternary formations. Their saturated thickness ranges from 20 to 40 metres with the water table ranging from the surface to 30 metres depth. Horizontal hydraulic conductivity is significantly greater than vertical. There are 3 regional superficial flow systems as indicated on Figure 4 and these are:

(a) Waroona Flow System
(b) Myalup Flow System
(c) Serpentine Flow System

The SWC GWA is comprised almost entirely of the Myalup Flow System.

The Myalup System comprises the Yanget Mound and the Mialla Mound. Groundwater flow, as indicated on figure 4, is away from the mount crests to local drainage features or the coastal lakes and wetlands. Hydraulic conductivity generally increases to the west.

Groundwater salinity in the Myalup Flow System is lowest near the crests of the mounds where it is less than 250 mg/L TDS. It increases with depth and towards the coast (figure 5). Salt water plumes exist below major swamps (e.g. Myalup Swamp) where salinities greater than 1 500 mg/L TDS are found. The water table salinities are shown on Figure 6.

A local flow system is found west of the Peel Estuary and Lakes Clifton and Preston. The regional flow systems have little impact on this coastal flow. The Coastal System comprises a thin lense of fresh water above saline water. The saline groundwater results from the ocean in the west and the saline Harvey Estuary and Lakes Preston and Clifton in the east.

3.2 Rockingham Sand

The Rockingham Sand exists to the north of Mandurah where it is deposited into erosional channels in the Leederville Formation. It is of Tertiary age. Salinities are generally greater than 1 000 mg/L and are often greater than 3 000 mg/L.

3.3 Leederville Formation

The Leederville Formation, the only significant cretaceous aquifer, is found everywhere below the Superficial formations of the SWC GWA. Formation thickness varies between 100 and 300 metres over the SWC GWA. The upper and lower surfaces of the aquifer are shown in the sections on Figure 7. Also shown are the salinities of the aquifer.

The Leederville Formation is composed of interbedded sands and shales. The bedded nature has resulted in significant variation with depth of groundwater quantity and quality.

The salinity of the Leederville groundwater over much of the area is between 1 000 and 3 000 mg/L TDS. Below the Peel Estuary the upper Leederville has been invaded by salt water. As indicated on the sections (Figure 7) isolated areas with salinities of less than 1 000 mg/L TDS exist and correspond to areas of direct infiltration from overlying sediments. The Osborne Formation is found near the Peel Estuary where it acts as an aquiclude.

3.4 Yarragadee and Cockleshell Gully Formations

Aquifers occur in the Jurassic Yarragadee and Cockleshell Gully Formations. The Cockleshell Gully Formation is present below the Leederville Formation throughout most of the SWC GWA except in the southern extremity where the Yarragadee Formation underlies the Leederville Formation.

The Cockleshell Gully and Yarragadee Formations are hydraulically connected and tend to act as a single aquifer system. The variation in thickness and position of the formations is shown in the sections on Figure 7.

Formation salinities are nearly everywhere greater than 3 000 mg/L TDS and therefore, have limited potential for development. The salinity increases to more than 20 000 mg/L with depth. Because of their limited potential they are not discussed in any greater detail in this report.

4.0 GROUNDWATER AVAILABILITY

Groundwater availability in the SWC GWA has previously been based on aquifer throughflow (Ventriss, 1984). Throughflow is derived from aquifer slope after assuming aquifer parameters and using Darcy's Law. The estimates of throughflow are not considered to have changed significantly despite the increase in aquifer knowledge resulting from recent studies like the Harvey Shallow Project (Deeney in prep) or ongoing monitoring.

However the Water Authority is now of the opinion that throughflow is not the most appropriate method of estimating sustainable groundwater availability. The percentage of rainfall which becomes groundwater recharge is believed to provide the best method of estimating groundwater availability. This belief has been formed after detailed computer modelling studies of Swan Coastal Plain aquifers and the results of experimental studies. These studies have generally indicated that recharge of the order of 20% of rainfall is occurring (depending on a number of factors) whereas throughflow estimates correspond to a much lower recharge.

The computer modelling undertaken as part of the Perth Urban Water Balance Study (Cargeeg et al), the Jandakot Public Water Supply Area Groundwater Management Review (Mackie Martin and Associates) and other as yet uncompleted studies (eg Pinjar) have indicated that recharge is a dynamic process. It can vary depending on a number of factors with the following having most impact.

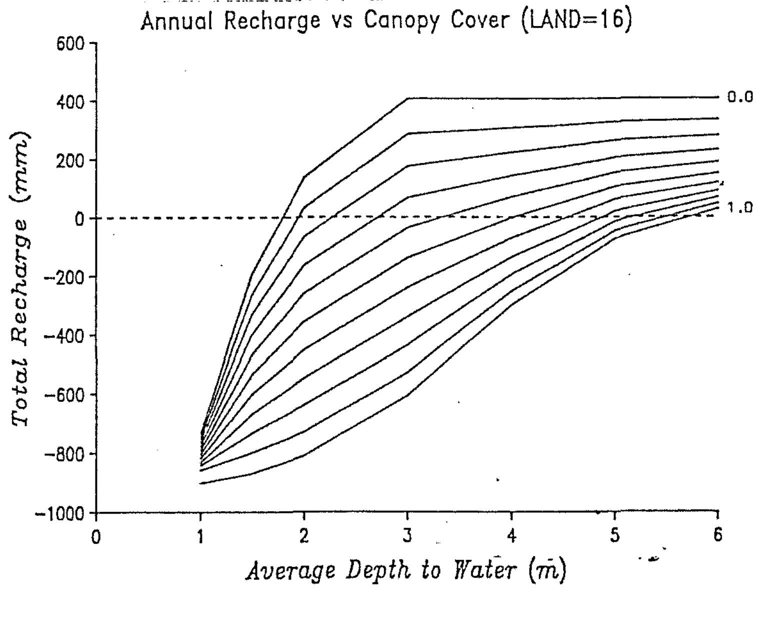
(a) Vegetation Cover

Rainfall recharge varies significantly between that of a natural Banksia Woodland (15 to 30% recharge), a dense Pine plantation (0 to 8% recharge) and pasture (50 to 60% recharge). These estimates of recharge are based on CSIRO experimental studies (Sharma et al) on the Gnangara Mound.

The results of these studies are expected to be directly transferable to the SWC GWA. It is therefore considered that vegetation cover will have a large impact on groundwater availability in the SWC GWA.

(b) Depth to Water Table

The depth below ground surface of the water table has a significant impact on net recharge. This is indicated on the graph below which has been derived from computer modelling.



It is believed that less recharge occurs when the water table is near the surface because of the combined impact of increased evapotranspiration and reduced storage capacity.

(c) Surface Soil

Recharge will decrease significantly as the clay or silt content of the surface increases. Some areas of the SWC GWA have significant clay content at or near the surface which will have a significant impact on recharge.

Recharge to sand or limestone is considered to be equivalent.

(d) Land Use

Land use has a significant impact on groundwater recharge. Buildings (houses, sheds etc) and roads tend to result in a significant increase in recharge as long as excess water is not routed out of the catchment. Irrigated pasture tends to have a higher recharge than non-irrigated pasture.

As groundwater recharge is dynamic and relates to the activities undertaken on the land it is not possible without detailed computer modelling to provide definative estimates of groundwater availability. Instead a subjective estimate of recharge after considering the various interplaying factors must be made.

This is the approach adopted in this report. It has also been used in assessing groundwater availability in other groundwater areas (Cox 1988).

It must be pointed out that recharge cannot be equated with availability. Not all recharge should be abstracted because of a variety of reasons (eg saltwater interface maintenance or wetland preservation) and therefore groundwater availability is usually less than recharge. The level and reason for the discounting of recharge is described for each subarea.

Previous assessments of groundwater availability used the chloride concentration in rain to arrive at an estimate of rainfall recharge. This was generally similar to the throughflow estimate and hence was used to support throughflow as an availability estimate. The chloride concentrations used were based on the CSIRO publication of Hingston and Gailitus. It is now believed that the use of this precipitation chloride did not take into account all chloride incident on the catchment. In particular it did not account for chloride incident as "dry fall". Hingston and Gailitus indicate that their measure of dry fall may be low because of the collection technique applied. Hammond and Mauger (1985) in their salinity study of Jane and Sussannah Catchments have determined that dry fall may be of a similar magnitude to that of precipitation. It is not known what quantity of "dry fall" chloride is incident on the SWC GWA.

5.0 MONITORING PROGRAMS

There are presently 156 wells which are, or have been monitored in the SWC GWA (see Appendix II). These wells are of a variety of types and have their genesis in a number of investigation programs or as anomaly investigations. Detailed locations and construction information is reproduced in the Review of Groundwater Monitoring in the South West Region of Keerath and Hopkins.

Monitoring data is stored on the State Water Resources Information System (SWRIS). SWRIS currently resides on the Water Authority's IBM computer. Plots presented in this report are plots of all data presently available on the SWRIS system.

The monitoring wells can be grouped into a number of programmes and these are indicated below. Each well's statistics are indicated in Appendix II and the location shown on Figure 9.

(a) Geological Survey of Western Australia (GSWA) line wells. These include wells designated as Lines A,B,C,D,E,F and G and the Binningup and Harvey lines. The wells have been constructed so as to monitor a variety of horizons within the superficial formations, Leederville Formation, Yarragadee Formation and Cockleshell Gully Formation.

    Some of these wells have been constructed so as to indicate the salinity profile within the superficial formations and are termed profile wells. Profile wells were designed to monitor potential movement of the salt water interface.

(b) Multiport Wells

    Ten wells have been constructed so as to provide salinity information from multiple discrete horizons within the superficial formation and are termed multiport wells. They were constructed following conjecture as to the effectiveness of the profile wells. They are also designed to monitor potential movement of the salt water interface.

(c) Harvey Shallow Wells

Wells constructed as part of the Harvey Shallow project have recently been added to the monitoring program. They are designed to monitor the superficial formations on an areal basis and to fill in any information holes not covered.

(d) Town Water Supply Wells

Monitoring wells constructed as part of town water supply (TWS) schemes (eg Myalup, Binningup, Miami) are monitored. These wells have all been constructed in the Leederville Formation.

(e) Private Wells

A number of private wells are monitored. They were included, at the owners consent, to monitor salinity changes that may, or were occurring in response to large local abstractions.

(f) Artesian Monitoring Wells

Wells constructed as part of the artesian aquifer monitoring network (A M wells) of the Perth area are monitored. They monitor water levels and salinity of the Leederville and Yarragadee Formation.

(g) Lake Thomson Wells

Superficial formation wells constructed as part of the Lake Thomson monitoring program are monitored.

The existing monitoring network was reviewed during the preparation of this document and a recommended monitoring program is indicated in section 7.0.

6.0 GROUNDWATER AVAILABILITY AND MANAGEMENT

The SWC GWA has been divided into 11 subareas, as shown on Figure 8. The subareas reflect fairly discrete flow systems of the superficial aquifer. For consistency the Leederville aquifer is also considered in terms of these subareas though its flow system is generally more extensive.

The Form of the assessment provided for each subarea is initially by aquifer system and then the following headings.

a. Monitoring
b. Groundwater availability
c. Allocations as at February 1988
d. Town Water Supplies
e. Allocation Strategy

6.1 Mandurah subarea

This area has been previously described as Zone G of the SWC GWA and subareas SP8 and SP9 of the Peel GWA. It includes all of the SWC GWA north of the Peel Inlet.

6.1.1 Mandurah Superficial Aquifer

(a) Monitoring

Wells LT580 and LT640 constructed as part of the Lake Thompson monitoring program are monitored. The data is presented on Figure 10.

Isolated monitoring has also occurred in response to specific projects (e.g. Canal Development) to determine any local impacts.

Information available indicates no adverse long term trends with regard to groundwater levels or quality. Local short term problems have been observed near dewatering sites but these are believed to have recovered.

(b) Availability

Groundwater throughflow is in a general south east direction away from the Stakehill Mound to the north. Recharge also occurs within the subarea by direct infiltration of rainfall.

Areas fronting the coast and Peel Estuary have a thin layer of freshwater above saline water. Saline water is found at the base of the superficial formations over most of the subarea. For this reason excessive localised draw may result in upconing. Due to the relatively low groundwater flow rate within the aquifer recycling of salts could also be a problem if large irrigation areas were permitted.

Availability has been assessed as 5.0 million cubic metres per year. This has been determined based on an estimated 0.4 million cubic metres in flow to the area, 20% of local rainfall becoming recharge and 33% of net throughflow being allowed to pass for saltwater interface maintenance. Total availability is equivalent to about 900 m^3/ha/yr.

(c) Allocation as at February 1989

Groundwater use is difficult to estimate in this area as domestic use is exempt from licensing. There are 39 superficial groundwater licences in this subarea as indicated in Appendix 1. They have a licensed abstraction of 504 400 m^3/year. Most licences have expired and should be surveyed prior to reissue.

(d) Public Water Supplies

There are no public water supplies drawn from the superficial formations in this subarea. Domestic water supplies for Mandurah are obtained from the Mandurah Scheme (conjunctive use of Yunderup Leederville Wells located east of the subarea and South Dandalup Dam).

(e) Allocation Policy

There is ample water available for allocation. It is not appropriate to apply restrictions except to limit local draw to 750 m^3/ha to avoid potential water quality problems. Special Rural Zones should be allocated 1 500 m^3/lot/year.

Any large applications, greater than 50 000 cubic metres per year should be referred to the Groundwater Branch for assessment.

6.1.2 Mandurah Leederville Aquifer

(a) Monitoring

Wells constructed as part of the artesian monitoring network are located in the Mandurah subarea. The data from wells AM62, AM65 and AM67 is presented on Figure 11. Well Mandurah 2 (also referred to as M2 or 1/76) was monitored until 1986 when it was replaced by 1/86 due to a road realignment.

Water level data is recorded from these wells but not quality. Presently water level monitoring is occurring quarterly and quality monitoring is planned to be performed annually. No significant trends are evident (see Mandurah TWS report).

(b) Availability

Groundwater in the upper Leederville has been invaded by saline water (greater than 10 000 mg/L) from the Peel Estuary or Rockingham Sand over most of the sub-area. The Lower Leederville contains groundwater of salinity between 1 000 and 3 000 mg/L. Availability of less than 1 500 mg/L water is limited.

(c) Allocation as at February 1989

There is one licensed well with an allocation of 670 000 m^3/year. The allocation is to the Meadow Springs Gold Course (licensed as Hawkstone Investments) and has expired. At the time of licensing the golf course availability of suitable quality and quantity water was questioned. It is important for aquifer management that the licence is followed up as soon as possible. This is particularly important as the consultants report indicated that there would be overdraw associated with the project.

(d) Town Water Supplies

Quality precludes its use. The aquifer is tapped outside the subarea at Yunderup.

(e) Recommended Allocation Policy

Salinity precludes the aquifers general use but it may be suitable for irrigating ovals and parks. Any use of the groundwater should not be permitted which will result in pollution of the fresher superficial aquifer system. The existing use by Meadow Springs Golf Course may be contributing to this and should be investigated.

As there is greater availability in the superficial aquifer use of the deeper aquifers should be discouraged.

6.2 Falcon Subarea

This area has been previously described as Zone A of the SWC GWA (see Figure 8). It is bounded in the north by the Peel Inlet and in the south by Dawesville. It has saline water to the east (Peel Inlet) and west (Indian Ocean).

6.2.1 Falcon Superficial Aquifer

(a) Monitoring

No superficial monitoring is currently undertaken within the Falcon subarea. Private monitoring has occurred related to development at Halls Head. G Threlfall's private well was monitored up to 1980 (WR No 61319101). Consultant (Rockwater) monitoring reports have indicated localised high nitrate and sulphate concentrations.

(b) Availability

There is no groundwater throughflow to the Falcon subarea. Fresh groundwater is wholely derived from infiltration of rainfall.

The fresh groundwater forms a thin lens floating on saline groundwater. Saline groundwater has resulted from the ocean and the Peel-Harvey Estuary on either side of the area.

The relatively flat lying thin fresh water lens can be easily overdrawn resulting in upconing of underlying saline water.

Availability is difficult to estimate. Based on a chloride balance, Ventriss calculated infiltration to be 6% of rainfall. This appears low based on rainfall recharge observed elsewhere in similar environments where 20% recharge is believed to occur. The calculation may have been conservative because it did not take into account the dryfall chloride component (see section 4.0). It has therefore been assumed that 20% of rainfall as recharge is occurring. Availability must allow for saltwater interface maintenance by only abstracting 50% of recharge. Availability is therefore considered to be about 10% of average annual rainfall.

This availability can only be harvested from low yielding wells. Therefore a net subarea availability is inappropriate. Instead a draw per hectare equivalent to excess local recharge can be abstracted. It is considered that this draw should be based on 750 m^3/ha. This is slightly less than 10% of average annual rainfall but has been adopted to provide some consistency with historical licensing practices.

(c) Allocation as at February 1989

Domestic wells do not require licensing and their use and number is unknown. There are 3 licences with a total allocation of 21 500 cubic metres. (see Appendix I)

(d) Town Water Supplies

There are no town water supplies obtained from superficial aquifers in this subarea. Domestic water supplies in Special Rural subdivisions are obtained from on site private wells or rainwater tanks. Higher density housing divisions (e.g. Falcon) obtain their domestic water supplies from the Mandurah Scheme.

(e) Recommended Allocation Policy

Licensed allocations should be based on 750 m^3/ha/year. To be consistent with Special Rural subdivisions elsewhere in the state it is recommended that SRZ Lots be allocated 1 500 m^3/lot/year for lots 2 ha to 4 ha. Lots greater than 4 ha should be allocated on a 750 m^3/ha basis. Licensees should be advised of the possibility of causing upconing of saline groundwater and advised to obtain their requirements from low yielding wells.

Large individual abstractions should not be allowed.

6.2.2 Falcon Leederville Aquifer

(a) Monitoring

Miami investigation wells 1/75 amd 2/75 are monitored. Well 1/75 was used as a standpipe for local use but Well 2/75 has never been equipped. The data is presented on Figure 12. No significant trends are evident.

A well (1/80) constructed on Point Grey east of the Harvey estuary should be considered when assessing aquifer performance, little data is as yet available on SWRIS so the information is not included here.

There have been reports that salinity is increasing in some private production wells (Halls Head Country Club). This should be investigated.

(b) Availability

Groundwater quality of the Leederville Formation is mainly between 1 000 and 3 000 mg/L (see Figure 7). No direct recharge occurs locally and all throughflow derives from recharge areas east of the Peel Inlet. This implies that fresh throughflow must pass below the Peel Estuary saltwater plume of greater than 3 000 mg/L water which has invaded the upper Leederville (see Figure 7). As a consequence the Leederville aquifer is in a delicate balance despite aquifer thickness in excess of 300 metres. Groundwater draw must therefore be kept to a minimum to avoid saline contamination.

(c) Allocation as at February 1989

Licensed groundwater draw is occurring for the Halls Head Estates and by Threlfall Turf Farm. Further draw is occurring for the Halls Head Country Club and the Shire of Mandurah but these have apparently expired. The exact location and annual abstractions are not known. Previous licences indicated total abstractions to be 1 581 000 m^3/year. The status of these licences requires investigation.

(d) Town Water Supply

There are no town water supplies presently drawing from the Leederville aquifer.

(e) Recommended Allocation Policy

The limited availability should be kept for public purposes. The current status of licences should be investigated particularly as there has been verbal indications that some salinity problems are occurring.
In addition the proposed Point Grey development east of the estuary and therefore outside the subarea may have an impact on availability if it were to proceed.

6.3. White Hills Subarea

The location of the White Hills Subarea is shown on Figure 8. It was formerly known as Zone B and extends from near Dawesville to the northern end of Lake Clifton. Saline water bodies to the east (Harvey Estuary) and west (Indian Ocean) have a significant bearing on the groundwater system.

6.3.1 White Hills Superficial Aquifer

(a) Monitoring

The Geological Surveys Line A monitoring wells are located along White Hill Road. The six wells (2 at site 3) were constructed in 1978 and 1979. Two wells A3A and A5 are currently monitored for water level and salinity profile. Monitoring results for these wells are shown on Figure 13.

Water levels have demonstrated very little fluctuation, approximately 0.5 metre, since monitoring commenced.

The location of the saltwater interface (greater than 3 000 mg/L) in the 2 profile wells varies from approximately 8m AHD in well A3A to approximately 0m AHD at well A5. This is consistent with the development of an elongate freshwater mound with its apex near site A3. Groundwater movement is away from the mound crest to the estuary (site A5) or the ocean.

The salt water interface at site A5 varies seasonally and has moved upwards. This is considered to reflect upconing which may be caused by local domestic wells and suggests that these wells are overtaxing the aquifer.

C Wright's private well was monitored in 1977.

(b) Availability

Groundwater movement in the White Hills subarea is similar to that of the Falcon subarea, the main features being:

i. No groundwater throughflow, recharge occurs via direct infiltration of rainfall;

ii. Fresh groundwater floats on saline groundwater.

iii. Recharge is estimated to be about 20% of rainfall.

iv. Saltwater interface maintenance requires 50% of recharge.

v. Fresh groundwater abstraction must be from low production rate wells to prevent upconing of saline water. Near the estuary and ocean, wells may have difficulty obtaining the required volumes because of the very low abstraction rates necessary.

vi. A bulk allocation is inappropriate as supplies can only be obtained from spaced low yielding wells.

(c) Allocation February 1989

There are 7 licensed properties drawing 39 500 cubic metres per annum from this subarea (see Appendix 1).

(d) Town Water Supplies

The Special Rural subdivisions obtain their water supplies from private domestic wells or rainwater tanks. Higher density developments at Miami/Falcon and Pleasant Grove obtain water supplies from the Mandurah Scheme. There are no public schemes based on the superficial aquifer. Park Ridge obtains water supplies from the Leederville Formation.

(e) Recommended Allocation Policy

Allocation policy should be the same as that for the Falcon Subarea. The main points of which are:

i. Allocations should be based on 750 m^3/ha/year. There may be some difficulty in obtaining this supply from wells located near the estuary or ocean.

ii SRZ Lots of 2 ha to 4 ha should be allocated 1 500 m^3/lot/year.

iii. Users should be advised to limit abstraction rates to prevent saline upconing.

iv. Abstractions should not accrete into large individual draws but be spread among spaced wells.

The existing use in the subarea should be resurveyed. This is because of the apparent evidence of saline upcoming near the estuary (well A5).

6.3.2 <u>White Hills Leederville Aquifer</u>

(a) Monitoring

The Park Ridge TWS wells have been monitored since 1979 for conductivity and the data is plotted on Figure 12. The salinity has remained stable between 600 and 700 mg/L with no adverse trends.

(b) Availability

Groundwater availability is as for the Falcon subarea, with recharge occurring east of the Harvey Estuary.
The Park Ridge TWS wells are screened within a fresh layer of the Leederville Formation. More saline water is found above and below the fresh water. Fresh groundwater resources are in delicate balance and draw should be kept to a minimum.

(c) Allocation February 1989

There are no known private groundwater allocations from the Leederville Formation.

(d) Town Water Supply

The Park Ridge Water Supplies are obtained from a fresh lens in the Leederville Formation. Between 1981 and 1986 200 000 m^3 have been abstracted for public water supplies. Park Ridge's water supply is now being augmented by water from the Mandurah Scheme (see Park Ridge Scheme Review).

(e) Recommended Allocation Policy

Groundwater should not be allocated from the Leederville Formation for private use. The limited resources should be kept for public purposes.

6.4 Island Point Subarea

This area was previously described as Zone C and is shown on Figure 8. It extends from the northern end of Lake Clifton to the southern end of the Harvey Estuary. The Harvey Estuary and Lake Clifton form the eastern and western boundaries respectively.

6.4.1 Island Point Superficial Aquifer

(a) Monitoring

Private wells on the properties of G J Ellis, R G Moyes and R D McKay are monitored and the data is presented on Figure 14. The wells have demonstrated approximately 0.5 metre water level fluctuations.

The Ellis well water level has apparently declined 0.5 metre since 1982. The wells conductivity data indicates no significant salinity trend with fluctuations being of a seasonal nature. Nitrate monitoring data is limited but indicates a downward trend in the range 1 to 5 mg/L.

One multiport well has been constructed in the subarea to monitor saltwater interface movement. The data collected is presented in Figure 15. There has been no discernible movement of the saltwater interface since the well was constructed in 1984.

(b) Availability

The Island Point subarea has saline water bodies to the east (Harvey Estuary) and west (Lake Clifton) resulting in salination of all but the top of the superficial aquifer. The hydrogeological situation in thus very similar to the Falcon and White Hills subareas. That is a thin fresh lens of groundwater floating on saline groundwater. There is limited throughflow with its origins at the Yanget Mound. The volume of throughflow is small.

Availability is based on an estimated 20% rainfall recharge and with 50% of this for saltwater interface maintenance. Again available groundwater can only be harvested by low yielding spaced wells.

(c) Allocation at February 1989

There are 19 licensed properties allocated 167 300 cubic metres per annum (see Appendix 1). A number of licences are expired and these should be reissued if appropriate.

(d) Town Water Supplies

There are no scheme water supplies drawing on the superficial aquifer. Domestic water supplies for the Clifton Downs and Island Point communities are obtained from private superficial wells or rainwater tanks.

(e) Recommended Allocation Policy

The underlying saline groundwater can be easily caused to ingress into the fresher upper water. Therefore rates of abstraction should be kept low.

Allocations should be based on 750 m^3/ha/annum obtained from spaced low yielding wells. SRZ Lots should be allocated 1 500 m^3/lot/year for lots between 2 and 4 ha.

Existing use in the area should be resurveyed with well users made aware of potential problems.

6.4.2 Island Point Leederville Aquifer

(a) Monitoring

There are no artesian aquifer monitoring wells in this subarea.

(b) Availability

The Leederville Formation is thought to contain water in the salinity range 1000-3000 mg/L TDS. Saline water may have invaded the upper section of the formation.

Recharge to the aquifers occurs east of the subarea and therefore availability is by way of throughflow only.

Availability of fresh groundwater is expected to be very small.

(c) Allocation February 1989

No groundater is believed to be allocated from Leederville or deeper aquifers.

(d) Town Water Supply

No town water supplies occur from Leederville aquifer.

(e) Recommended Allocation Policy

As the resources are believed to be limited they should be restricted to public purposes.

6.5 Coastal Subarea

The area west of Lakes Clifton and Preston has been referred to as the Coastal Subarea. It includes the coastal areas of the previous Zones C, D and E and is shown on Figure 8.

6.5.1 Coastal Superficial Aquifers

(a) Monitoring

On Figure 9 the location of Water Authority monitoring wells in the Coastal subarea are indicated. They are wells B1, B2, B3, C1 and C2. Water levels have been recorded at all sites since 1980 though only twice at B1, B3 and C1. No adverse water level trend is apparent from monitoring at sites B2 and C2 between 1980 and 1988.

Conductivity profiles for wells B2 and C2 are indicated on Figure 16. They demonstrate very little movement of the salt water interface since 1982 and indicate 8 to 16 metres of fresh groundwater.

(b) Availability

The Coastal Subarea has saline water bodies to the east and west. This has lead to the development of a saline superficial aquifer except for the upper few metres. Fresh groundwater is solely derived from rainfall recharge. The fresh resources as in the other northern subareas of the SWC GWA form a thin lens floating on saline groundwater.

Recharge is estimated to be about 20%. Due to the limited depth of fresh water it is recommended that draw be restricted to only 25% of this amount, that is about 375 m^3/ha/yr. The groundwater resource can only be obtained from spaced low yielding wells. A large bulk allocation is inappropriate.

(c) Allocation at February 1989

There are 2 licensed properties using 2 150 cubic metres per annum (See Appendix 1).

(d) Town Water Supplies

There are no Town Water Supplies drawing from the superficial aquifer. Local private domestic supplies are obtained from this aquifer or rainwater tanks.

(e) Recommended Allocation Policy

Allocation should be based on 375 m^3/ha/annum with the supply obtained from low yielding spaced wells. SRZ Lots should be allocated 750 m^3/lot/year.

6.5.2 Coastal Subarea Leederville Aquifer

(a) Monitoring

Yalgorup town water supply monitoring wells 3, 6, 7 and 8 are monitored, well 6 was abandoned in 1986. The data is presented on Figure 17. Water levels demonstrate only seasonal fluctuations and salinity has been stable.

(b) Availability

The Leederville Formation salinity varies but is generally in the range 1 000 to 3 000 mg/L TDS. In the north, the upper sequences have been invaded by saline water. There is a thin layer of fresh water (less than 1 000 mg/L) in the southern half of the subarea which corresponds to recharge east of the subarea. Groundwater in the subarea is derived from throughflow.

(c) Allocation February 1989

No artesian groundwater licences have been issued.

(d) Town Water Supplies

The Yalgorup town water supply is obtained from wells screened in the upper Leederville aquifer. Abstraction data is available since 1985 and 28 000 m^3 has been pumped. The scheme is described in the Yalgorup Scheme Review

(e) Allocation Policy

Resources should not be allocated to private users but held for public water supplies.

6.6 Lake Clifton Subarea

The location of the Lake Clifton Subarea is indicated on Figure 8. It extends from the southern end of the Harvey Estuary to the southern end of Lake Clifton. It includes the area east of Lake Clifton to Southern Estuary Road and the eastern side of State Forrest 16.

Most of the subarea was formerly referred to as Zone D.

6.6.1 Lake Clifton Superficial Aquifer

(a) Monitoring

Private wells belonging to R V Armstrong, C M Robinson, F Roberts, R G Quarrill and M A Thornton are currently monitored. The data is presented on Figures 18 and 19 and their location is indicated on Figure 9. They indicate no significant changes in either water levels or salinity, besides normal seasonal fluctuations, since monitoring commenced in 1978.

Nitrate monitoring of the Armstrong well has indicated no significant trends and a range of 1 to 3 mg/L.

Geological Survey wells B4, B5, B6 and H62 are located in this subarea and are shown on Figure 9. The water level data indicates no significiant trends. Well B4 is profiled, and two multiport wells 1/84 and 3/84 are sampled, to monitor salinity with depth. The results are presented on Figures 20 and 21. The data indicates only seasonal movement of the saltwater interface between 1982 and 1987 except for a marked downward (improvement) movement in 1985.

(b) Availability

Groundwater throughflow has been previously estimated by Ventriss to be 123 000 m^3/yr/km based on the hydraulic gradient. That is 1.66 million cubic metres throughflow for the subarea. This equates to a net rainfall recharge of approximately 4% over the subarea.

Groundwater throughflow from the Yanget Mound to this subarea is believed to be limited. Direct local recharge is considered to be the main mechanism of aquifer replenishment. These conclusions are based on investigations carried out for the Harvey Shallow Project (Deeney in prep).

The main factors influencing recharge are described in section 4.0. Those influencing the Lake Clifton subarea recharge are the relatively shallow depth to the water table, the drainage (in some areas), State Forrest No 16 and clayey sediments. All will act to reduce net recharge.

For the purposes of this review the figure of 10% rainfall should be used as the recharge. Following further monitoring and review the local recharge may be better defined.

To provide for saltwater interface maintenance only three quarters of the recharge should be allocated. This corresponds to 7.5% of average annual rainfall and represents approximately 3.0 million cubic metres annually.

As the water table is relatively flat and the aquifer is mostly underlain by saline water the draw should be spread over as much of the area as possible. To this end it is recommended that draw be spaced and based on 2 000 cubic metres/hectare. Instances of increased salinity reported but not documented are believed to be based on recycling of salts. They may also relate to overdraw near Lake Clifton. Future draw must be monitored to assess the effects of the abstraction. Total allocation is unlikely to reach the maximum because of the presence of State Forest No 16 where significant abstraction will not occur.

(c) Allocation at February 1989

There are currently 21 licensed properties allocated 405 650 cubic metres per annum. Existing use should be surveyed to determine present usage.

(d) Public Water Supplies

There is no scheme water currently supplied in this subarea. Communities like those at Tuart Grove obtain domestic supplies from private wells or rainwater tanks.

(e) Allocation Policy

It is considered that 3.0 million cubic metres are available for allocation. Because of the nature of the groundwater system it is recommended that any draw be spread over the subarea as much as possible. Therefore, draw should be based on a local abstraction of 2 000 m^3/ha. Existing and future users near Lake Clifton should be advised that the fresh groundwater floats on saline groundwater and high draw will induce upconing. Existing users already allocated more than 2 000 m^3/ha should be allowed to continue. Lots abiding State Forrest may be allocated more than this rate depending on surrounding properties.

Special Rural Zone properties because of their intended hobby farm status should be restricted to 1 500 m^3/lot/year for lots between 2 and 4 ha.

6.6.2 <u>Lake Clifton Leederville Aquifer</u>

(a) Monitoring

There are no wells monitored within the Leederville and deeper aquifers in the Lake Clifton subarea.

(b) Availability

Leederville Formation groundwater in the range 1 000 to 3 000 mg/L is expected below the Lake Clifton Subarea. In the north of the subarea there may be groundwater of greater than 3 000 mg/L salinity representing a southern extension of the Peel Estuary invasion. Based on the Harvey Borehole Line (Deeney) recharge may occur in the west of the subarea. There may therefore be some groundwater of low salinity.

If it exists this low salinity water will be found in the south of the subarea. Throughflow within the Leederville is limited and is largely committed to the Yalgorup Town Water Supply west of Lake Clifton.

(c) Allocation February 1989

There are no licensed users of artesian aquifers in this subarea.

(d) Town Water Supplies

There are no artesian town water supplies drawn in this subarea. Throughflow must be protected however for the Yalgorup Township to the west.

(e) Allocation Policy

There should be no licences granted to private users. If any public purpose is proposed it should be considered on its merits and potential impacts on the Yalgorup Town Water Supply.

6.7 Colburra Downs Subarea

The Colburra Downs Subarea includes the area west of the Harvey River, east of State Forrest No 16, and south of the Harvey Estuary as indicated on Figure 9. It was formerly part of Zone D. It has been excised from the Lake Clifton Subarea because it contains eastward moving groundwater.

6.7.1 Colburra Downs Superficial Aquifer

(a) Monitoring

Water levels are monitored in well B7. They have indicated no significant trends. The Harvey Shallow Well H63 is being monitored but limited data is as yet available.

(b) Availability

Groundwater throughflow is very small with movement to the north from the Yanget Mound and east to the Harvey River. The main source of groundwater is direct infiltration of rainfall but this is limited by the shallow depth to the water table. Hence the area is extensively drained. Groundwater salinity (at the water table) is generally greater than 1 000 mg/L with most of the subarea containing water of salinity greater than 1 500 mg/L. The higher salinity probably indicates more clayey sediments.

This combination of factors makes assessing groundwater availability difficult. It is recommended that an availability similar to that for the Lake Clifton subarea be adopted, that is about 7.5% of average annual rainfall.

(c) Allocation as at February 1989

There are no licensed abstractions in the Colburra Downs Subarea. The usage in the area should be re-surveyed.

(d) Public Water Supplies

There are no public water supplies in this subarea.

(e) Allocation Policy

Based on an estimated recharge of 7.5% of average annual rainfall 1.6 million m^3/yr is available for allocation within the subarea.

Because of the relatively high salinity and the extensive drainage it is not expected that groundwater demand will be high in this subarea. Yields obtainable will vary due to the varying strata. It is recommended that licence applications be considered individually based on their location with maximum allocations of 50 000 m^3/yr.

This policy will need review if significant demand occurs. Users should be advised of the possible salinity problems in this area. SRZ Lots should be allocated 1 500 m^3/lot/year.

A survey of current usage should be undertaken.

6.7.2 <u>Colburra Downs Leederville Aquifer</u>

(a) Monitoring

There are no monitoring wells in this subarea.

(b) Availability

Availability is limited as was indicated for the Lake Clifton Subarea. There may be some recharge occurring in the south of the subarea.

(c) Allocation at February 1989

There are no licensed abstractions in this subarea.

(d) Public Water Supplies

There are no public water supplies drawn in this subarea.

(e) Allocation Policy

No private abstractions are considered appropriate, for similar reasons to Lake Clifton subarea.

6.8 Lake Preston Subarea

The Lake Preston Subarea extends from the southern end of Lake Clifton to the southern extremity of Lake Preston and the Harvey River Diversion Drain. It includes all land east of Lake Preston to the eastern edge of State Forest No 16. It was formerly referred to as Zone E. The area is shown on Figure 8.

6.8.1 Lake Preston Superficial Aquifer

(a) Monitoring

The location of all monitoring wells is shown on Figure 9 and details are listed at Appendix 2. The monitoring wells are shown on Figure 22 along with the major allocations. Monitoring for the 26 private wells is presented on Figures 23 to 29. Variations in water level and salinity of the private wells are summarised in Table 1 below.

Table 1 Lake Preston Subarea
Private Well Monitoring Summary

Well Description	Water Level	Conductivity
FL & L Armstrong (A)	Seasonal Fluctuation	Small decrease
" (I)	" "	Constant
" (B)	" "	Small decrease
Rose (G)	Small increase	Small increase
" (O)	Seasonal Fluctuation	V.small increase
(M)	Small decrease	V.small increase
(A)	" "	Seasonal Fluctuat.
J Cooling (C)	Seasonal Fluctuation	Small decrease
L&R Armstrong (D)	N.A.	V.large seasonal fluctuation with increasing trend
T W Pearson	N.A.	Small increase
L Sumich (shallow)	Small decrease	Small increase
G H Rose (Manning Block)	Seasonal fluctuation	Seasonal fluctuat.
S Palmer	decrease	V Small increase
L Sumich & Sons (3D)	N.A.	Seasonal fluctuat.
L Sumich & Sons (2D)	N.A.	Small increase
L Sumich & Sons (1D)	N.A.	Seasonal fluctuat.
L Sumich & Sons (1C)	N.A.	Increase
L Sumich & Sons (2C)	N.A.	Increase
L Sumich & Sons (3C)	N.A.	Increase
L Sumich & Sons (1B)	N.A.	Seasonal fluctuat.
L Sumich & Sons (2B)	N.A.	Small increase
L Sumich & Sons (2A)	N.A.	Seasonal fluctuat.
L Sumich & Sons (1A)	N.A.	Seasonal fluctuat.
L Sumich & Sons(butterfly)	N.A.	Small increase
L Sumich & Sons(carrot-wash)	N.A.	" "
L Sumich & Sons (domestic)	N.A.	" "

There are 3 lines of Geological Survey wells which are monitored for water level. They have demonstrated only seasonal fluctuations in water level. Geological Survey Line wells D1, D2, E1B, E2A, E3B are profile wells and wells 4/84, 5/84, 6/84, 7/84, 8/84, 9/84, 10/84, 11/84 are multiport wells. The profile and multiport wells are presented on Figures 30 to 36 and are summarised in Table 2 below.

TABLE 2 Lake Preston Subarea
Summary of Profile and Multiport Wells

Well		Interface Movement
Profile	D1	steady
	D2	seasonal variation.
	E1B	"
	E2A	"
	E3B	"
Multiport	4/84	constant
	5/84	"
	6/84	No interface (top more saline)
	7/84	constant
	8/84	"
	9/84	"
	10/84	No interface
	11/84	constant

The data indicates that there are no significant water level changes. However there is evidence of small increases in salinity in some of the private wells (particularly those of Sumich and Rose). This salinity increase is of concern.

As there is no corresponding evidence of saltwater interface movement it is assumed that the salinity increase is related to recycling of salts. This indicates that the local draw is higher than throughflow and thus not allowing the flushing of salt returning from the irrigation. Local upconing of saline water is possible but is not considered likely particularly as the multiport wells indicate no significant movement. The Sumich salinity increase may be contributed to by the use of higher salinity Leederville Formation water.

Limited monitoring of nitrate has indicated concentrations of up to 89 mg/L N. This suggests that fertilizer is also being recycled. The high nitrate is of concern and the groundwater should not be consumed by infants or pregnant women. An enhanced monitoring program will be carried out to indicate the extent of the problem.

(b) Availability

Ventriss estimated throughflow to be 920 000 m^3/year/km moving from the Yanget Mound to Lake Preston. This represents a recharge of 17% of rainfall over the subarea.

In this report a recharge of 20% has generally been applied (see section 4.0).

Assuming rainfall as recharge of 20% then availability becomes 15% of rainfall after retaining one quarter of throughflow for saltwater interface maintenance. That is 19.8 million cubic metres is available for abstraction annually. Because of the presence of State Forest No 16 it is unlikely that total sub-area abstraction will exceed this total availability.

Based on monitoring and current abstraction this level of abstraction is not considered excessive. However, localised salinity increases have been noted, particularly at the Sumich property. They are believed to relate to recycling of salts caused by excessive local draw. The aquifer in this area is relatively flat and therefore when local draw exceeds local throughflow salts are recycled. The consequence of this is an increase in salinity. The use of the Leederville Formation aquifer with its more saline water may be contributing to the problem. Contributing to the increasing salinity is excessive use of fertilizers.

To avoid such problems, it is recommended that local draw should not be allowed to exceed 3 times the local recharge. Therefore, allocations should be based on 4 000 m^3/ha maximum. The estimate of local safe draw has been derived by comparing actual draw to observed recycling problems. It may need refining as greater use is made of the aquifer and more monitoring data becomes available.

(c) Allocation as at February 1989

There are 25 licensed groundwater abstractions occurring in the Lake Preston Subarea. Their total abstractions are 8 930 300 cubic metres.

Two of the licences are also for draw from the Leederville Formation. These joint licences should be separated and metered. Expired licences should be followed up and existing use should be resurveyed to accurately determine use.

(d) Public Water Supplies

There are no local town water supplies drawn from the superficial formations.

(e) Allocation Policy

Groundwater available for abstraction from this subarea in 19.8 million cubic metres of which 8.93 million cubic metres has already been allocated.

The additional available resource should be allocated so that local draw does not exceed 4 000 m^3/ha. This is to prevent local recycling problems.

Existing users currently abstracting more than 4 000 m^3/ha (e.g. Sumich and Rose) shoud be advised of the problem. As the use has been previously licensed it is inappropriate to enforce reductions. Instead the excess should be held as if occurring on neighbouring properties and they should not be allowed to increase their allocation without demonstrating they will have no detrimental effect on downstream properties. No new allocations should be made west of the Sumich property. Property owners should be advised of the high nitrate concentrations in groundwater resulting from the recycling of fertilizers.

Applications for draw in excess of 100 000 m^3/year should be referred to Groundwater Branch for individual comment. SRZ Lots should be allocated 1 500 m^3/lot/year.

6.8.2 Lake Preston Leederville Aquifer

(a) Monitoring

Well HL1 has been monitored since construction but the data is not yet available on the SWRIS data base. It was constructed as part of the Harvey Borehole Line and has indicated seasonal water level fluctuations. Salinities are not recorded.

b) Availability

The Leederville Formation is 150 to 200 metres thick below the Lake Preston Subarea. It contains partially cemented sand layers which form the aquifer system. The sand is separated by shale layers. Generally, groundwater is of salinity between 1 000 and 3 000 mg/L.

The groundwater is derived from recharge west of the Harvey main drain and east of the subarea by downward perculation from the superficial formations. The recharge is considered to be small and the total available resource therefore small. The Leederville aquifer may be discharging into the Lake Clifton subareas superficial aquifer because it has an upward head.

(c) Allocation as at February 1989

Two licensees draw water from the Leederville Formation, Sumich (425 000 m^3/yr) and Smith and Broadfoot (492 480 m^3/yr). Their licences are combined with superficial aquifer abstractions and are not metered.

This should be remedied so that more understanding of the Leederville aquifer in the area is obtained. It will also be useful in understanding superficial aquifer salinity increases at the Sumich property.

(d) Public Water Supplies

There are no abstractions of artesian groundwater for public purposes within this subarea. However, draw does occur to the northwest and southwest (Yalgorup and Myalup respectively). Any future draw in this subarea must take into account present and future requirements of these schemes.

(e) Allocation Policy

No additional groundwater should be allocated from the Leederville aquifer unless the proponent can demonstrate there will be no adverse impact on public water supplies or existing users.

There is potentially scope for additional draw as Deeney in the Harvey Line report has indicated. This additional water may be best kept for public purposes.

6.9 Harvey Subarea

The Harvey Subarea includes the land east of State Forrest No 16, south of the Harvey River, and north of Myalup Beach Rd. This is shown on Figure 8. The area was formerly described as the newly proclaimed area of Zone E.

6.9.1 Harvey Superficial Aquifer

(a) Monitoring

Wells C9, E7 and E8 plus the Harvey Shallow wells H11, H13, H14, H15 and H16 are currently monitored. However monitoring has only recently commenced on the Harvey Shallow wells and there is limited data available.

Existing data indicates no significant trends. Considering the extensive draining of the subarea this is to be expected.

(b) Availability

In this subarea groundwater movement is eastwards away from the Yanget Mound towards the Harvey River, Harvey main drain and other drains. The extensive drainage when combined with limited monitoring data makes determination of availability difficult.

Based on the low salinity at the water table of 250 to 500 mg/L recharge is assumed to be 20% of rainfall. The subarea is 145.8 square kilometres and 25% of throughflow must be allowed to pass. In addition the area provides recharge to the Leederville Formation which will account for approximately 3% of recharge. Therefore availability is estimated to be 15.7 million cubic metres annually.

Again to limit potential recycling problems local draw should not be allowed to exceed 4 000 m^3/ha.

(c) Allocation as at February 1989

There are 7 licensed abstractions from this subarea with a total abstraction of 557 650 m^3/year. Existing use should be re-surveyed.

(d) Public Water Supplies

There are no public water supplies currently based on the superficial aquifer in this subarea.

(e) Allocation Policy

Groundwater should be allocated on a first come first served basis provided that any criteria set by the Environmental Protection Authority are met. Local draw should not be allowed to exceed 4 000 m^3/ha.

SRZ Lots should be allocated 1 500 m^3/lot/year.

Existing use in the area should be re-surveyed.

6.9.2 Harvey Leederville Aquifer

(a) Monitoring

Well HL2 is currently monitored. It has indicated only minor seasonal water level fluctuations. Salinity is not monitored.

(b) Availability

The Leederville aquifer contains water which is generally between 1 000 and 3 000 mg/L. Local recharge is believed to occur from overlying superficial sediments and has resulted in upper strata salinities being less than 500 mg/L.

Availability from the Leederville is not known but is believed to be small. It is committed in part via throughflow to coastal communities (Yalgorup, Myalup). The impacts of draw in this area are uncertain. Draw may cause increased downward recharge therefore limiting impacts.

(c) Allocation at February 1989

There are no licensed artesian wells in this subarea.

(d) Public Water Supplies

There are no artesian public water supplies. Throughflow is required by coastal communities and their requirements must be considered.

(e) Allocation Policy

Water should not be allocated from artesian aquifers, instead intending users should develop shallow aquifer supplies. When this supply is significantly allocated draw may be considered from the Leederville subject to any proponent defining the consequences.

6.10 Myalup Subarea

The Myalup Subarea extends from Lake Preston in the north to the Leschenault Inlet in the south and from the ocean in the west to Wellesley Road in the east. The boundary is shown on Figure 8. The subarea was formerly known as Zone F.

6.10.1 Myalup Superficial Aquifer

(a) Monitoring

The private wells monitored in the Myalup Subarea are shown generally on Figure 9 and in detail on Figure 37. The main points are summarised in Table 3 below and the data is presented on Figures 38 and 39.

Water levels have shown seasonal fluctuations only. Conductivities have increased in wells monitored for the Coast Pastoral Company and Mr Eardley-Wilmot. Monitoring of the Smith well has indicated a small conductivity decrease. In other monitored private wells conductivity has shown only seasonal fluctuations.

Table 3 Myalup Subarea
Private Well Monitoring Summary

Well Description	Water Level		Conductivity
J C Lewis (C)	seasonal	fluctuation	Seasonal fluctuation
Coast Pastoral (B)	N.A.		Increase
G C Smith & Son (G)	seasonal	fluctuation	Decrease in 1983, then seasonal fluctuation
Eardley-Wilmott (4)	"	"	Seasonal fluctuation
Eardley-Wilmott (NW well)	"	"	Seasonal fluctuation, increase since 1984
Coast Pastoral (western)	"	"	Large seasonal fluctuation, possible increase
Smith (North Production	N.A.		Small decrease
Smith (domestic)	N.A.		Seasonal fluctuation

The Geological Survey have constructed 2 lines of wells designated lines F and G in the subarea. They have been monitored for water level since construction and demonstrated only seasonal fluctuations. Profile line well F1 has had its conductivity monitored and the data is presented in Figure 40. It has demonstrated significant seasonal interface movement but no long term trends are evident.

It is therefore assumed that salinity increases in the Coast Pastoral Company and the Eardley-Wilmot wells are as a result of salt recycling caused by excessive local draw. The Coast Pastoral increase is large, a further investigation is warranted. Particular attention should be taken of the well location.

The Eardley-Wilmott salinity increase may be associated with a saline plume from Myalup Swamp (Figure 5). This is not considered the main cause as the wells are shallow and the saline plume is at the base of the aquifer.

Limited fertilizer monitoring data indicates no significant aquifer pollution however this monitoring program is to be expanded.

(b) Availability

Ventriss has previously estimated throughflow to be 383 000 m^3/km/year. Over the subarea area of 88 km^2 this represents 3 830 000 m^3 or nearly 5% of rainfall.

The Harvey Shallow project of the Geological Survey has indicated a different flow system to that assumed by Ventriss. In particular the Myalla Mound, east of the Myalup Swamp has been defined. A small groundwater mound at the coast between Lake Preston and the Leschenault Inlet has also been indicated. The flow system is shown on Figure 4. Generally, groundwater throughflow in the superficial is westwards except near the coastal mound where there may be some north/south movement.

Because of this additional information and that outlined in section 4.0 it is considered that recharge of average rainfall is 20%. To maintain the saltwater interface one quarter must be allowed to remain.

The groundwater available for abstraction from the subareas therefore considered to be 11.9 million cubic metres.

A saline plume extends west of the Myalup Swamp with its direction of movement being along the base of the superficial aquifer and invading the upper Leederville formation. In addition the coastal 2 km has saline water within the lower superficial and upper Leederville Formation.

Monitoring has indicated some wells with an increased salinity. This has been attributed to locally high abstraction leading to recycling of salts. In the vicinity of the Eardley-Wilmot property the west flowing groundwater meets the coastal mound and then tends to move north. The locally low rate of groundwater flow is contributing to these recycling problems. In addition a saline plume from the Myalup Swamp extends below the Eardley-Wilmot property. The underlying higher salinity water may be contributing to the problem.

To avoid recycling problems it is recommended that local abstraction should not be allowed to exceed 4 000 m^3/ha. This represents 3 times local recharge. Where local draw is already at or near this level of abstraction wells should be monitored and property owners made aware of potential problems.

(c) Allocation as at February 1989

There are 15 licensed abstractions from the superficial aquifer drawing 1 935 500 cubic metres per year. The Coast Pastoral Company draw is from the superficial formations and Leederville Formation. This draw should be metered and licenced separately.

Expired licences should be renewed or cancelled and existing use surveyed.

(d) Public Water Supplies

There are no public water supplies obtained from the superficial aquifer in this subarea (Binningup and Myalup supplies are from the Leederville aquifer).

(e) Allocation Policy

There is considered to be 11.9 million cubic metres available for abstraction of which 1.9 million has already been allocated. Because of the presence of State Forest No 16 it is unlikely all available resources will be abstracted. The available resource should be allocated with the proviso that local abstractions should not exceed 4 000 m^3/ha.

Existing properties showing a tendency to salinity increase should be advised of the potential problems of recycling and upconing. This should apply to properties near Eardley-Wilmot and Coast Pastoral Company. It is recommended that these users be advised to spread their draw over more wells to prevent likely problems and to better harvest the resource.

Potential users on the west of Myalup Swamp should be warned of the higher salinity groundwater. Any additional licences should be carefully considered regarding possible impacts to existing users. Large abstractions in this area should be refused.

SRZ Lots should be allocated 1 500 m^3/lot/year.

6.10.2 Myalup Leederville Aquifer

(a) Monitoring

Leederville aquifer wells are monitored for the Myalup and the Binningup town water supplies. Hydrographs and descriptions are presented in their scheme reviews (see references). Generally water levels have fluctuated seasonally following an initial decline after commissioning. The seasonal fluctuations are probably increased by the pumping. There may be a small decline in level. Salinities have indicated a gradual increase at Myalup from 850 mg/L to 950 mg/L. Binningup salinities have remained between 710 and 740 mg/L.

The Geological Survey Binningup Borehole Line wells BPL1 and BPL2 are also located within the subarea. Well BPL2 water levels are monitored (see figure 41) and indicate significant annual fluctuations in the Leederville Formation and limited fluctuations in the Cockleshell Gully Formation.

(b) Availability

Data from the Binningup line indicates that the Leederville Formation is between 100 and 125 metres thick below the Myalup Subarea (Figure 7). It contains water of salinity between 1 500 mg/L and 3 000 mg/L over its bottom 50 metres. Its upper strata generally contains water of salinity less than 1 500 mg/L. It is less than 500 mg/L below the Myalla Mound where recharge is believed to be occurring from overlying superficial sediments.
Higher salinity water is found west of the Myalup Swamp (greater than 1 500 mg/L) as a result of evapotranspiration concentration within the swamp. Saline water has also invaded the top 50 metres of the aquifer for a distance of approximately 2 kilometres near the coast.

Recharge is believed to occur from overlying superficial sediments east of the Myalup Swamp and west of the Wellesley River. Discharge is believed to occur to the superficial sediments west of the Myalup Swamp and east of the saline coastal intrusion. That water not lost to the superficial formations discharges to the ocean after passing below the coastal saline intrusion.

Groundwater resources of the Leederville Formation are considered to be small. This is because of the adverse tendencies noted in the Myalup and Binningup observation wells.

The cause of the salinity increase at Myalup is being investigated in conjunction with the Geological Survey. It is either a local upconing problem or a regional overdraw problem. An investigation is planned to define the cause.

(c) Allocation as at February 1989

There are 4 licensed abstractions from the Leederville Aquifer with a total abstraction of 1 062 000 m^3/year.

The Coast Pastoral Company abstraction is from both the Leederville and superficial aquifers and this draw should be separated on licences and metered.

A survey of the area should be carried out to determine accurately present use of groundwater from the Leederville aquifer.

(d) Public Water Supplies

The Myalup and Binningup Town Water Supplies are obtained from the Leederville aquifer. Since 1981, 87 686 m^3 has been abstraction from the Myalup Scheme and since 1979, 558 065 m^3 from the Binningup Scheme. The Myalup monitoring has indicated a tendency towards increased salinity the cause of which is presently unknown.

(e) Allocation Policy

Because there is significant water available in the Superficial and evidence exists that overdraw of the Leederville may be occurring, no new licences should be issued.

6.11 Wellesley Subarea

The Wellesley Subarea includes the area east of the Myallup Subarea. It was previously referred to as the recently proclaimed part of Zone F. It includes the area of eastern and southern moving groundwater from the Myalla Mound.

6.11.1 Wellesley Superficial Aquifer

(a) Monitoring

Wells constructed and monitored in the subarea are F8, G8, H8, H2 but the data is not yet available on the SWRIS database. The data indicates no significant water level trends.

(b) Availability

In the Wellesley Subarea groundwater movement is away from the crest of the Mialla Mound to the Harvey River Main Drain, or the Wellesley River Main Drain or the Wellesley River. There is also downward movement to the underlying Leederville aquifer. Evapotranspiration is likely to be high because of the shallow water table and extensive winter swamping. Because of these factors and to protect this area of recharge to the Leederville aquifer it is considered that 10% of rainfall should in the interim be considered the recharge.

A further complication to the groundwater hydraulics of this subarea is the clayey nature of sediments (Guildford Formation Clays) east of the Wellesley River. Here groundwater is likely to be limited and difficult to abstract. Salinity often exceeds 1 500 mg/L. This may relate to the presence of Benger Swamp.

Considering all the above groundwater availability for the subarea should be:

i. East of the Wellesley River - any groundwater which can be abstracted from the superficial formations is available. Any proposal should consider likely impacts on the areas wetlands.

ii. West of the Wellesley River - 10% of rainfall as recharge or approximately 3.0 millions cubic metres. Proposed developments must consider any wetland impacts.

(c) Allocation as at February 1989

There are no licensed groundwater abstractions in the Wellesley Subarea.

The existing use in the area should be re-surveyed.

(d) Public Water Supplies

There are no Public Water Supplies in this subarea.

(e) Allocation Policy

The subarea should be considered as 2 zones, east and west of the Wellesley River.

East of the river any groundwater found should be available for abstraction. Potential users should be advised of the difficulty of obtaining supplies and the likelihood of high salinities.

West of the Wellesley River 3.0 million cubic metres is available for allocation. It should be allocated on a first comes basis. Large local draws should be avoided.

SRZ Lots should be allocated 1 500 m^3/lot/year.

In both zones likely wetland impacts must be considered.

6.11.2 Wellesley Leederville Aquifer

(a) Monitoring

The Geological Surveys Binningup Line Well BLP3, east of the Wellesley River, has been monitored. Water levels within the Leederville Formation have demonstrated small seasonal fluctuations.

(b) Availability

East of the Wellesley River Leederville Formation contains water of a salinity greater than 3 000 mg/L. West of the Wellesley River the Upper Leederville contains water of salinity less than 1 500 mg/L. This groundwater is derived from direct infiltration from overlying sediments. The rate of infiltration is not known but is likely to be 1 to 2% of rainfall.

(c) Allocation as at February 1989

There are no licensed abstractions from this subarea. A survey of use has not been conducted and should be.

(d) Town Water supplies

There are no town water supplies in this subarea. It is however the recharge area for the Leederville aquifer drawn on by communities like Binningup.

(e) Allocation Policy

Groundwater licences should not be issued from this subarea as it is the recharge area for the Leederville Formation, an aquifer already under stress.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommendations made as a result of the review of the South West Coastal Groundwater Area.

1. Monitoring

The current level of monitoring is adequate and has provided sufficient information to determine with reasonable confidence the impacts of groundwater abstraction. As some changes to the allocation policies have been made, partly as a result of the monitoring data, it is essential that monitoring continues. This will provide an indication to the adequacy or otherwise of these allocation policies.

However considering the amount of data available, some changes to the monitoring are believed appropriate. The proposed monitoring program is summarised as:-

Private Wells; quarterly for water level and conductivity and annually for nutrients (total Phosphorus, Sulphate, Chloride and Nitrate/Nitrogen).

Harvey Shallow Wells; quarterly for 2 years then half yearly for water level and conductivity and annually for nutrients.

Multiports and Profile Wells; half yearly.

GSWA Line Wells; half yearly for water level.

Binningup Line; half yearly for water level and conductivity and annual major ion analysis.

Sample collection should occur as near as practicable to the water table peaks (October/November) and troughs (March/April). Samples for nutrient analysis should be collected in the March/April trough in an endeavour to collect the worst scenario from fertilizer/irrigation activities.

The drains near the Summich/Rose properties should be sampled annually for nutrients. This will help indicate if any nutrients are moving towards Lake Preston.

An additional multiport well should be constructed near the Eardley-Wilmot property to indicate the exact cause of the salinity increase.

Regional officers should regularly review monitoring data and bring any anomalies to the attention of Groundwater Branch. The monitoring program should be reviewed by Groundwater Branch after 2 years and subsequently altered to match the findings.

2. Existing Groundwater Use

The South West Coastal Groundwater Area has not been comprehensively surveyed for a number of years. It is essential that an accurate estimate of groundwater use is maintained to adequately manage the groundwater resource. A survey of groundwater use should be conducted at the earliest available opportunity.

It is also essential that an adequate licensing accounting system is maintained. At present this is not occurring. The Water Authority Groundwater Licensing database has been provided for this purpose but it is not being maintained by regional staff. This has resulted in significant delays in the preparation of this report while actual allocations were determined. The allocations considered current are summarised in Appendix I and should be added to the database. There are some uncertainties in the licences indicated in Appendix I and these should be clarified.

The survey of use data when completed should be incorporated in the database.

3. Meters

To adhere to the Board of the Water Authority's metering policy all licensed groundwater allocations of more than 500 000 m^3/year should be metered. This policy should be enforced as licenses come up for renewal.

There are also a number of properties with licences allowing for draw from both the superficial aquifer and the Leederville aquifer. These licences should be separated and an adequate method of estimating aquifer use determined. This may involve the use of meters.

4. Allocation Policy

An appropriate allocation policy for each subarea and aquifer is summarised in the Table 4 below.

The total licensed allocations for each subarea are those believed to be valid in February 1989. The groundwater available for private abstractions is indicated and is generally based on rainfall recharge over the entire subarea. In a number of subareas it is not appropriate to amalgamate the resource. A local availability only is indicated in these areas. It is considered to be the volume per hectare which can be safely abstracted. In some areas (e.g. close to the ocean or the estuary) fresh groundwater will only be obtainable at very low daily abstraction rates and a number of wells may be required to obtain the water.

In some subareas a subarea availability and a local availability is indicated. This local availability is a volume per hectare (usually 4 000 m^3/ha) recommended to help prevent excessive recycling of salts. It may need adjustment with time as more information becomes available. It is intended as a rule of thumb to encourage abstractions to be spread over the subarea without causing unnecessary inconvenience to users. On large properties with large allocations the draw should be spread as much as is reasonable over the property. The rate may need to be varied if:

(a) Existing use within a 500 metre radius of a proposed draw does not exceed a cumulative 4 000 m^3/ha over that area, or

(b) In the case of properties abuting saline water bodies, the existing draw on neighbouring properties does not exceed a cumulative 4 000 m^3/ha.

(c) Where existing abstractions in respect of (a) or (b) already exceed 4 000 m^3/ha allocations should not be made which will exacerbate the situation.

Also indicated on the table are the most significant groundwater problems in each subarea.

5. Existing Local Overdraw

Monitoring has indicated salinity is increasing near large irrigation activities in the Lake Preston and Myalup subareas. Each has been attributed to excessive local abstractions leading to recycling of salts. This problem may be contributed to in the Myalup Subarea by the Myalup Swamp saline groundwater plume. Excessive fertilizer use is also adding to these problems.

To avoid such problems occurring in the future a rule of thumb upper limit for local abstractions has been recommended (see 4 above).

The salinity increase observed at the Sumich properties in the Lake Preston Subarea has already been brought to the licensee's attention. It is recommended that no further licences be granted in the vicinity of this property which will exacerbate the problem. Neighbouring properties (within 500 metres) should be included in this local moratorium so that the net local draw is less than 4 000 m^3/ha. The same should be done for the Rose local overdraw.

The Eardley-Wilmot salinity increase should be brought to the attention of the licensee (if this has not already occurred). It should be pointed out to Mr Eardley-Wilmot and neighbouring irrigators that:

(a) Their local abstractions are high.

(b) They are downstream of a saline groundwater plume eminating from Myalup Swamp.

(c) Their properties are underlain by saline water which excessive draw will cause to upcone.

(d) They should endeavour to further spread the groundwater abstraction by the use of additional wells (excavations in this area).

(e) No additional groundwater allocations will be made in the near vicinity of their properties.

TABLE 4

SUMMARISED ALLOCATION POLICY

Subarea	Aquifer	Areal * Avail. m^3	Local Avail. m^3/ha	Licensed Allocation m^3/year	Special Problems***
MANDURAH	SUPERFICIAL	5 000 000	750	504 400	Saltwater interface near coast and estuary.
"	LEEDERVILLE	small	N.A.	670 000	Confirmation of existing draw required.
FALCON	SUPERFICIAL	N.A.	750	21 500	Very thin freshwater lens, excessive draw will lead to upconing of saline water.
"	LEEDERVILLE	small	N.A.	1 581 000	Confirmation of existing use required.
WHITEHILLS	SUPERFICIAL	N.A.	750	39 500	Very thin freshwater lens, excessive draw will lead to upconing of saline water
"	LEEDERVILLE	small	N.A.	0	
ISLAND POINT	SUPERFICIAL	N.A.	750	167 300	Very thin freshwater lens, excessive draw will lead to upconing of saline water
"	LEEDERVILLE	small	N.A.	0	
COASTAL	SUPERFICIAL	N.A.	375	2 150	Very thin freshwater lens, excessive draw will lead to upconing of saline water
"	LEEDERVILLE	small	N.A.	0	
LAKE CLIFTON	SUPERFICIAL	3 000 000	2 000	405 650	Saltwater interface near Lake Clifton
"	LEEDERVILLE	small	N.A.	0	
COLBURRA DOWNS**	SUPERFICIAL	1 600 000	N.A.	0	Saline water
"	LEEDERVILLE	small	N.A.	0	
LAKE PRESTON	SUPERFICIAL	19 800 000	4 000	8 930 300	Recycling near Sumich property, saltwater interface near Lake Preston
"	LEEDERVILLE	small	N.A.	917 480	
HARVEY**	SUPERFICIAL	15 700 000	4 000	557 650	
"	LEEDERVILLE	small	N.A.	0	
MYALUP	SUPERFICIAL	11 900 000	4 000	1 935 500	Myalup Swamp Saline Plume, Saltwater interface near coast
"	LEEDERVILLE	small	N.A.	1 062 000	
WELLESLEY **	SUPERFICIAL	3 000 000	4 000	0	Limited availability east of Wellesley River
"	LEEDERVILLE	small	N.A.	0	

* Small indicates that there is little water available for private abstraction and should not generally be considered

** Subarea use never surveyed

***Special Rural Zones in all subareas (except Coastal) should be allocated 1 500 m^3/lot/year where lots are between 2 ha and 4 ha.

The overdraw noted at the Coast Pastoral Company's property in the Myalup subarea should be brought to the licensee's attention. The problem is not fully understood and requires further investigation. It is possible that the problem is related to the abstraction of higher salinity Leederville aquifer groundwater.

6. Leederville Aquifer Allocations

No additional Leederville Aquifer allocations should be made to private users. This is because the resource is limited and any availability should be held for public purposes.

Reports that salinity is increasing in production wells in the Falcon subarea requires investigation.

The increase in salinity observed at Myalup is being investigated. A regional overdraw may be occurring from the Leederville formation in this area. As the Myalup Public water supply is obtained from this aquifer the investigation is of high priority.

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APPENDIX I

LICENSED ALLOCATION

APPENDICES

Appendix I

Licensed Allocations

SUMMARY

SUB AREA	AREA m^2	AQUIFER	NO LICENCES	ALLOCATION m^3/year
MANDURAH	53.3	Sup	38	54 400
		Leed	1	670 000
FALCON	34.8	Sup	3	21 500
		Leed	3	1 581 000
WHITE HILLS	35.3	Sup	7	39 500
		Leed	0	0
ISLAND POINT	18.5	Sup	19	167 300
		Leed	0	0
LAKE CLIFTON	44.8	Sup	21	405 650
		Leed	0	0
COLBURRA DOWNS	24.5	Sup	0	0
		Leed	0	0
COASTAL	146.9	Sup	2	2 150
		Leed	0	0
LAKE PRESTON	137.2	Sup	25	917 480
		Leed	2	8 930 300
HARVEY	145.8	Sup	7	557 650
		Leed	0	0
MYALUP	88.0	Sup	15	1 935 500
		Leed	4	1 062 000
WELLESLEY	74.9	Sup	0	0
		Leed	0	0
	TOTAL		108	14 230 030

MANDURAH SUBAREA

Name	Lic. No.	Alloc.	Aqu.
*Benridge Pastoral Co	8067	12 000	Sup
*Ayres R & DP	8068	450 000	Sup
*Spalding MC	8101	7 500	Sup
*Rush GJ	8318	1 500	Sup
*Boyens AL	8408	11 500	Sup
*Coles GR	8409	1 500	Sup
*George D	8413	1 500	Sup
*Fowler KL	8422	1 500	Sup
*Barber T & S	8512	1 500	Sup
*Samuels MF & JP	8568	1 500	Sup
*Polkinghorne CO	8603	1 500	Sup
*How Steven James	8664	650	Sup
Graham R	15046	650	Sup
*Stacey JA & Butun LR	20010	600	Sup
*Ayres Graham Michael	20039	650	Sup
*Nesci V	20306	500	Sup
*Martin DS	20361	600	Sup
*Moyle NV & P	20381	600	Sup
*McFerram R	20384	600	Sup
*Wiggers J & A	20385	600	Sup
*Middleton VJ & CM	20403	4 300	Sup
*Davey DJ	20507	650	Sup
*Worthington MT & LM	20986	500	Sup
Young DJ & PJ	21471	650	Sup
Ayres LK & JM	21490	2 650	Sup
Price ML	21650	2 650	Sup
Kyne PT	21828	650	Sup
Stehn AK & V	21831	650	Sup
Morris TJ	21850	650	Sup
Van-Haeften N	21871	650	Sup
Officer HJ & CC	21994	650	Sup
Cachatoor R	22422	650	Sup
Fowler PCH	22423	1 500	Sup
*Hawkstone Investment	22428	670 000	Leed.
Rand RD	22703	650	Sup
Stone RFK	22704	650	Sup
Treacher LM	22834	650	Sup
*Metropolis P & L	27291	900	Sup
*Green CA & ED	27465	1 500	Sup

TOTAL	Superficial	504 400 m^3
	Leederville	670 000 m^3

* EXPIRED

FALCON SUBAREA

Name	Lic. No.	Alloc. m^3	Aqu.
MTT	15054	5 000	
Threlfall	15014	25 000	Leed.
Dawesville Caravan Park	20346	16 000	Leed.
South Mandurah Sports Club	20357	10 000	
Halls Head Estates	20343	150 000	Leed.
Dudley Park Bowling Club	8643	6 500	?
*ESPLANADE (MANDURAH)	4077	1 000 000	Leed.
*SHIRE OF MANDURAH	4519	30 000	Leed.
*SHIRE OF MANDURAH	4521	150 000	Leed.
*SHIRE OF MANDURAH	5972	110 000	Leed.
*SHIRE OF MANDURAH	6363	100 000	Leed.

TOTAL	Leederville	1 581 000 m^3
	Superficial	21 500 m^3

* Location and current use not known and apparently expired.

Assumed (?) Superficial

WHITE HILLS SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Bruce	15094	500	
Scarboro	15612	1 000	
Petermine	15017	1 500	
Peters	15016	1 500	
Smith	15019	1 500	
Dickson-Spiers	15047	500	
Sarich	15704	33 000	

TOTAL 39 500 m^3

* Expired

Assumed (1) All superficial
(2) Expired licenses are still current

ISLAND POINT SUBAREA

Name	Lic. No.	Alloc.	Aqu.
*Pitman	8601	1 500	
*McKay	8056	60 000	
Moyes	20349	27 000	
Mackenzie	20366	24 000	
*Belinjr	8538	15 000	
Stanton	20353	12 000	
Fagan	8736	1 850	
Bor.H	20337	5 000	
Rogers	15022	650	
Woolchamps	8424	650	
Scadden	20352	650	
Kirton	15033	650	
Hopper	20876	1 500	
Rivew	?	650	
Chappie	8423	650	
Allan	15025	1 500	
Moore	15378	650	
Waters Edge Caravan Park	?	12 750	
Punton	8400	650	

TOTAL 167 300 m^3

* Expired

Assumed (1) All Superficial
(2) expired lic. are still current

LAKE CLIFTON SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Gandini	15050	10 000	
Grossman	15010	1 500	
Cartledge	8557	15 000	
Tyler	8533	22 500	
Quarril	20397	20 000	
Bryce	15685	64 000	
Sawyer	20438	15 000	
Collins	15032	42 000	
Long	?	1 500	
Waroona Shire	15010	500	
Sullivan	20876	1 500	
Lazenby	15013	650	
Long	20527	1 500	
Golding	8054	1 500	
Lee	20876	1 500	
Turnham	15039	1 500	
Armstrong R&V	6675	50 000	
Pipe	20436	126 000	
Wedse	8532	12 000	
Yeomans	20348	16 000	
Harley	15616	1 500	

TOTAL 405 650 m^3

Assumed Superficial

COLBURRA DOWNS SUBAREA

Name	Lic. No.	Alloc.	Aqu.

Assumed None

COASTAL SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Jardine	20874	650	
Cook	20347	1 500	

TOTAL 2 150 m^3

Assumed Superficial

LAKE PRESTON SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Pearson	20472	630 000	
Armstrong	20450	240 000	
Armstrong	20451	240 000	
Schock	?	50 000	?
Ivankovich	15055)		
	15757)	330 000	
Fielder	20350	42 000	
Armstrong (now Vinci)	20453	now 70 000	
Armstrong	20452	188 000	
Maiolo	15227	200 000	
Venables	20441	1 500	
Amarti	?	· 105 000?	
Brown (was Armstrong)	15365	345 000	
*Vaughan (was Giblet)	?6615	360 000	
Armstrong (now Bushwood)	20454	158 000	
Hester	20367	180 000	
Bandis	8541	1 500	
Rose	20459	3 332 000	
Smith & Breadfoot	20351		Leed 492 480 Sup. 20,500
*Vinmar	20369	272 000	
Sumich	20365		Leed.425 000 Sup 1 275 00
Patane	15686	220 000	
Peploe	20344	240 000	
Rose	20460	410 000	
Palmer (Adesso, Palmer)	20412	424 000	
Geanfrancesco	20442	10 000	

TOTAL Leederville Fm 917 480 m^3
Superficial Fm 8 930 300 m^3

* Expired Licences

Assumed: (1) Most are superficial unless stated otherwise
(2) Ivankovich is only one licence
(3) Expired licences included
(4) ? need clarification

HARVEY SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Evergreen Murray Gray Stud	15690	50 000	
Moore	15691	270 000	
Payne	?	650	
Lock & Treasure	15683	90 000	
Denholm	?	?	
Van Burgel ?	15692	17 000	
Angel ?	15693	130 000	

TOTAL 557 650 Allocation m^3

Assumed to be all superficial.
Van Burgel and Angel are assumed to be in subarea.
Denholm Licence No and Allocation are unknown.

MYALUP SUBAREA

Name	Lic. No.	Alloc.	Aqu.
Smith & Sons	20392	650 000	
Buchanan	20345	1 500	
Smith (formerly D&W Lucerne)	20437	120 000	Leed.
Coastal Pastoral Co	20091	680 000	Leed 612 000 Sup 68 000
Pepper trees	8599	120 000	
Gray Caravan Park	8554?	1 500	
Harvey Shire	15777	7 500	
Lewis	20400	330 000	
*Cooling	20331	275 000	
*Earley-Wilmot	203330	275 000	
Papalia	20355	·	Leed.
Papalia	?	?	?
Australind Piggery	15627	20 000	
Reading	6057		Leed.
G P Reading	20355	144 000	Sup
*Woolhouse	8164	1 500	
Teede	6602	1 500	
Tothill	20342	40 000	

TOTAL	Leederville	1 062 000 m^3
	Superficial	1 935 500 m^3

* Expired Licences

Assumed:

(1) Superficial
(2) ? can be sorted out
(3) expired are current

WELLESLEY SUBAREA

Name	Lic. No.	Alloc.	Aqu.

APPENDIX II

SUMMARY OF MONITORING WELLS

Subarea	Well Type	Well Name	Aquifer	WR No	Record*
MANDURAH	MONITORING	1/86	LEEDERVILLE		1986 P
MANDURAH	ART MONITORING	AM62	LEEDERVILLE	61415012	1980P
MANDURAH	ART MONITORING	AM65	LEEDERVILLE	61415009	1981P
MANDURAH	ART MONITORING	AM67	LEEDERVILLE	61415004	1980P
MANDURAH	LAKE THOMPSON	LP580	SUPERFICIAL	61410046	1982P
MANDURAH	LAKE THOMPSON	LP640	SUPERFICIAL	61410058	1975P
FALCON	PRIVATE (DISC)	G THRELFALL	SUPERFICIAL	61319101	1976-1980
FALCON	DISUSED TWS	MI 1/75	LEEDERVILLE	61319011	1976-1984
FALCON	DISUSED TWA	MI 2/75	LEEDERVILLE	61319012	1975P
FALCON (NEAR)	GSWA	MI 1/80	LEEDERVILLE		1980P
WHITE HILLS	PRIVATE (DISC)	C WRIGHT	SUPERFICIAL	61319102	1977
"	GSWA PROFILE	A1	"	61319123	1979-1984
"	GSWA LINE	A2	"	61319124	1979-1982
"	GSWA PROFILE	A3A	"	61319125	1978 P
"	GSWA LINE	A3B	"	61319126	1978-1980
"	GSWA LINE	A4	"	61319127	1979-1982
"	GSWA PROFILE	A5	"	61319128	1979 P
"	DISUSED TWS	MIAMI TWS	LEEDERVILLE	61319012	1976-1984
"	TWS	PARKRIDGE 1/79	"	61319031	1979 P
"	"	" 2/79	"	61319032	1979 P
ISLAND POINT	DISUSED PRIVATE	G J ELLIS	SUPERFICIAL	61319103	1977
"	PRIVATE	G J ELLIS	"	61319104	1977-1983
"	"	R G MOYES	"	61319189	1983 P
"	"	R D MCKAY	"	61319190	1983 P
"	MULTIPORT	2/84	"	61319219	1984 P
COASTAL	GSWA LINE	B1	"	61319129	1979 P
"	GSWA PROFILE	B2	"	61319130	1979 P
"	GSWA LINE	B3	"	61319131	1979 P
"	GSWA LINE	C1	"	61319136	1979 P
"	GSWA PROFILE	C2	"	61319137	1979 P
"	YALGORUP TWS	LAKE PRESTON NO 1 (prod)	LEEDERVILLE	61319001	197
"	"	LAKE PRESTON NO 8	"	61319002	1978-1986
"	"	LAKE PRESTON NO 2 (prod)	"	61319003	1978 P
"	"	LAKE PRESTON NO 3	"	61319004	1981-1986
"	"	LAKE PRESTON NO 6	"	61319005	1981-1986
"	"	LAKE PRESTON NO 7	"	61319006	1981-1986
"	"	LAKESIDE PRESTON 1/85	"	61319007	1985 P
"	"	LAKESIDE PRESTON 2/85	"	61319008	1985 P
LAKE CLIFTON	PRIVATE	R V ARMSTRONG (I)	SUPERFICIAL	61319105	1977
"	"	T SOWDEN	"	61319106	1977-1983
"	"	C M ROBINSON	"	61319191	1983 P
"	"	F ROBERTS	"	61319192	1983 P
"	"	R G QUARRILL	"	61319193	1983 P
"	"	M A THORNTON	"	61319194	1983 P
"	GSWA PROFILE	B4	"	61319132	1979 P
"	GSWA LINE	B5	"	61319133	1979 P
"	" "	B6	"	61319134	1979 P
"	MULTIPORT	1/84	"	61319218	1984 P
"	"	3/84	"	61319220	1984 P
"	HARVEY SHALLOW	H62	"		1988 P
COLBURRA DOWNS	" "	B7	"	61319135	1979 P
COLBURRA DOWNS	HARVEY SHALLOW	H63	"		1988 P

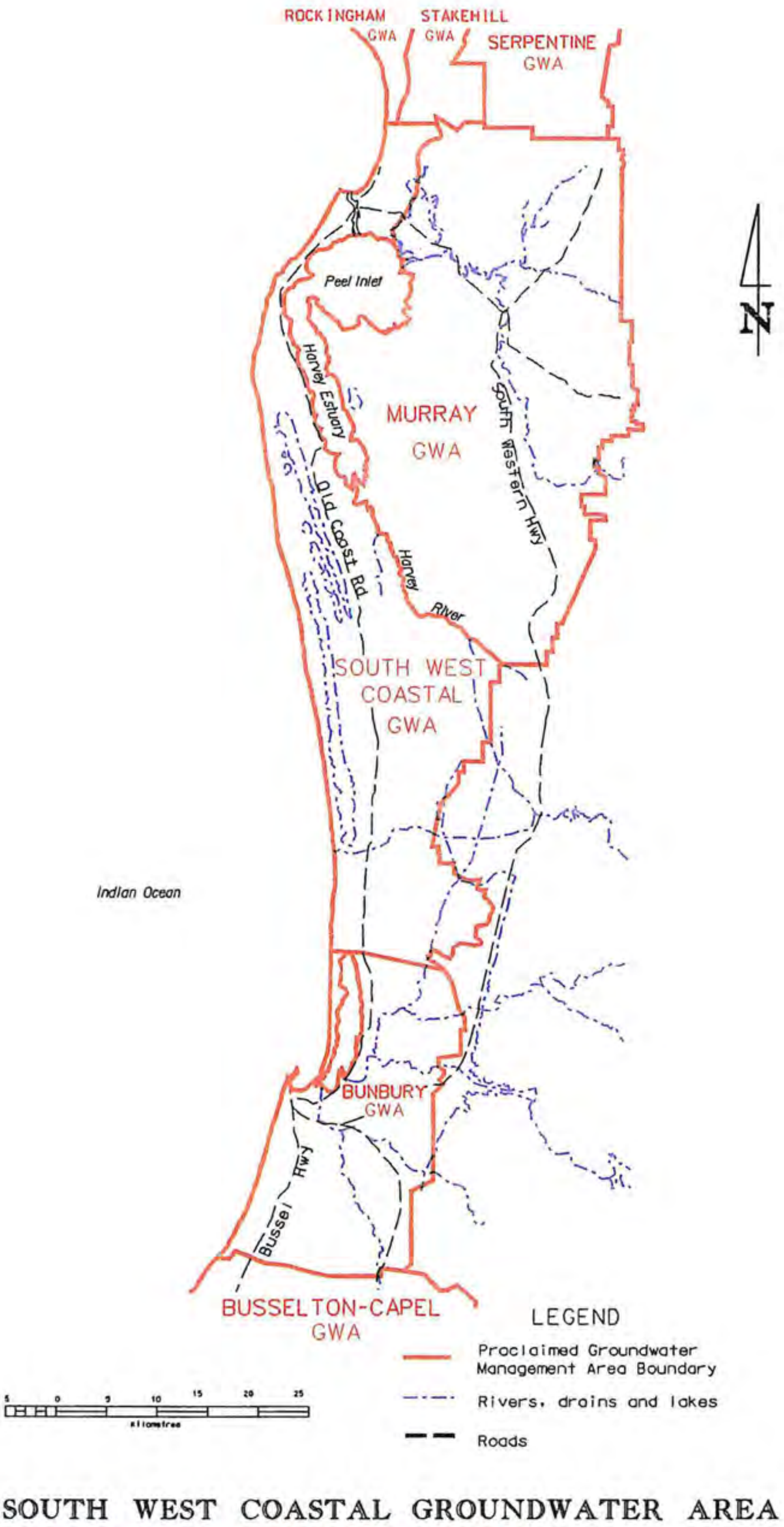
* P = monitored to present

Subarea	Well Type	Well Name	Aquifer	WR No	Record*
LAKE PRESTON	PRIVATE	FE & L ARMSTRONG (A)	"	61319107	1977 P
"	"	" (I)	"	61319108	1977 P
"	"	" (B)	"	61319109	1977 P
"	"	J E GIBLETT (C)	"	61319110	1977-1984
"	"	HESTOR (A)	"	61319111	1977-1983
"	"	ROSE (A)	"	61319112	1977 P
"	"	" (G)	"	61319113	1977 P
"	"	" (O)	"	61319114	1977 P
"	"	" (M)	"	61319115	1977 P
"	"	J COOLING (C)	"	61319116	1977 P
"	"	L SUMICH & SONS (A)	"	61319117	1977-1983
"	"	L&R ARMSTRONG	"	61319122	1983 P
"	"	T W PEARSON	"	61319195	1983 P
"	"	L SUMICH (shallow)	"	61319196	1983 P
"	"	G H ROSE (Manning)	"	61319197	1983 P
"	"	S PALMER	"	61319198	1983 P
"	"	L SUMICH & SONS 3D	"	61319204	1984 P
"	"	" 2D	"	61319205	1984 P
"	"	" 1D	"	61319206	1984 P
"	"	" 1C	"	61319207	1984 P
"	PRIVATE	L SUMICH & SONS (2C)	SUPERFICIAL	61319208	1984 P
"	"	" (3C)	"	61319209	1984 P
"	"	" (1B)	"	61319210	"
"	"	" (2B)	"	61319211	"
"	"	" (2A)	"	61319212	"
"	"	" (1A)	"	61319213	"
"	"	" (Butterfly)	"	61319214	"
" "	"	" (carrot wash)	"	61319215	"
	"	" (domestic)	"	61319216	"
"	GSWA LINE	C4	"	61319138	1979 P
"	"	C5	"	61319139	1979 P
"	"	C6	"	61319140	1979-1982
"	"	C7	"	61319141	1979-1982
"	"	C8	"	61319142	1979-1982
" "	GSWA PROFILE	D1	"	61319144	1979 P
"	"	D2	"	61319145	1979 P
"	GSWA LINE	D3A	"	61319146	1979 P
"	GSWA PROFILE	D3B	"	61319147	1979-1984
"	GSWA LINE	D4	"	61319148	1979 P
"	"	D5	"	61319149	1979 P
"	"	E1A	"	61319150	1979 P
"	GSWA PROFILE	E1B	"	61319151	1979-1985
"	"	E2A	"	61319152	1979-1985
"	GSWA LINE	E2B	"	61319153	1979 P
"	"	E3B	"	61319154	1979 P
"	GSWA PROFILE	E3B	"	61319155	1979-1985
"	GSWA LINE	E3C	"	61319156	1979-1982
"	"	E4A	"	61319157	1979-1982
"	"	E4B	"	61319158	1979-1982
"	"	E4C	"	61319159	1979-1982

*P = monitored to present

Subarea	Well Type	Well Name		Aquifer	WR No	Record*
LAKE PRESTON	GSWA LINE	E5A		SUPERFICIAL	61319160	1979 P
"	"	E5B		"	61319161	1979-1982
"	"	E8		"	61319164	1979 P
"	MULTIPORT	4/84		"	61319221	1984 P
"	"	5/84		"	61319222	1984 P
"	"	6/84		"	61319223	1984 P
"	"	7/84		"	61319224	1984 P
"	"	8/84		"	61319225	1984 P
"	"	9/84		"	61319226	1984 P
"	"	10/84		"	61319227	1984 P
"	"	11/84		"	61319228	1984 P
"	GSWA LINE	HL1		LEEDERVILLE		1988 P
"	HARVEY SHALLOW	H64		SUPERFICIAL		1988 P
HARVEY	GSWA LINE	HL2		LEEDERVILLE		1988P
"	HARVEY SHALLOW	H11		SUPERFICIAL		1988 P
"	"	H13		"		1988 P
"	"	H14		"		1988 P
"	"	H15		"		1988 P
"	"	H16		"		1988 P
"	GSWA LINE	C9		"	61319143	1979P
"	GSWA LINE	E6		"	61319162	1979 P
"	GSWA LINE	E7		"	61319163	1979-1982
MYALUP	PRIVATE	J C LEWIS	(C)	SUPERFICIAL	61319118	1977 P
"	"	COAST PASTORAL	(B)	"	61319120	1977-1986
"	"	G C SMITH & SONS	(G)	"	61319121	1977 P
"	"	EARDLEY-WILMOT	(4)	"	61319199	1983 P
"	"	"	(NW)	"	61319200	1983 P
"	"	COAST PASTORAL	(west)	"	61319201	1983 P
"	"	SMITH	(north)	"	61319202	1983 P
"	"	"	(domestic)	"	61319203	1983 P
"	GSWA PROFILE	F1		"	61319165	1979 P
"	GSWA LINE	F2A		"	61319166	1979 P
"	"	F2B		"	61319167	1979-1982
"	"	F3		"	61319168	1979-1982
	"	F4		"	61319169	1979 P
"	"	F5		"	61319170	1979 P
"	"	F6		"	61319171	1979-1982
"	"	F7		"	61319172	1979-1982
"	"	F8		"	61319173	1979-1982
"	"	G2A		"	61319174	1978 P
	"	G2B		"	61319175	-
"	"	G3A		"	61319176	1978-1982
"	"	G3B		"	61319177	1978 P
"	"	G3C		"	61319178	1978 P
"	"	G4		"	61319179	1978 P
"	"	G5		"	61319180	1978-1982
"	"	G6		"	61319181	1978-1982
"	"	G7		"	61319182	1979 P
"	"	BP1		LEEDERVILLE	?	1984 P
"	"	BP2		"	?	1984 P
WELLESLEY	"	BP3		"	?	1984 P
"	"	G8		"	61319183	1979 P
"	HARVEY SHALLOW	H8		SUPERFICIAL		1988 P
"	"	H2		"		1988 P

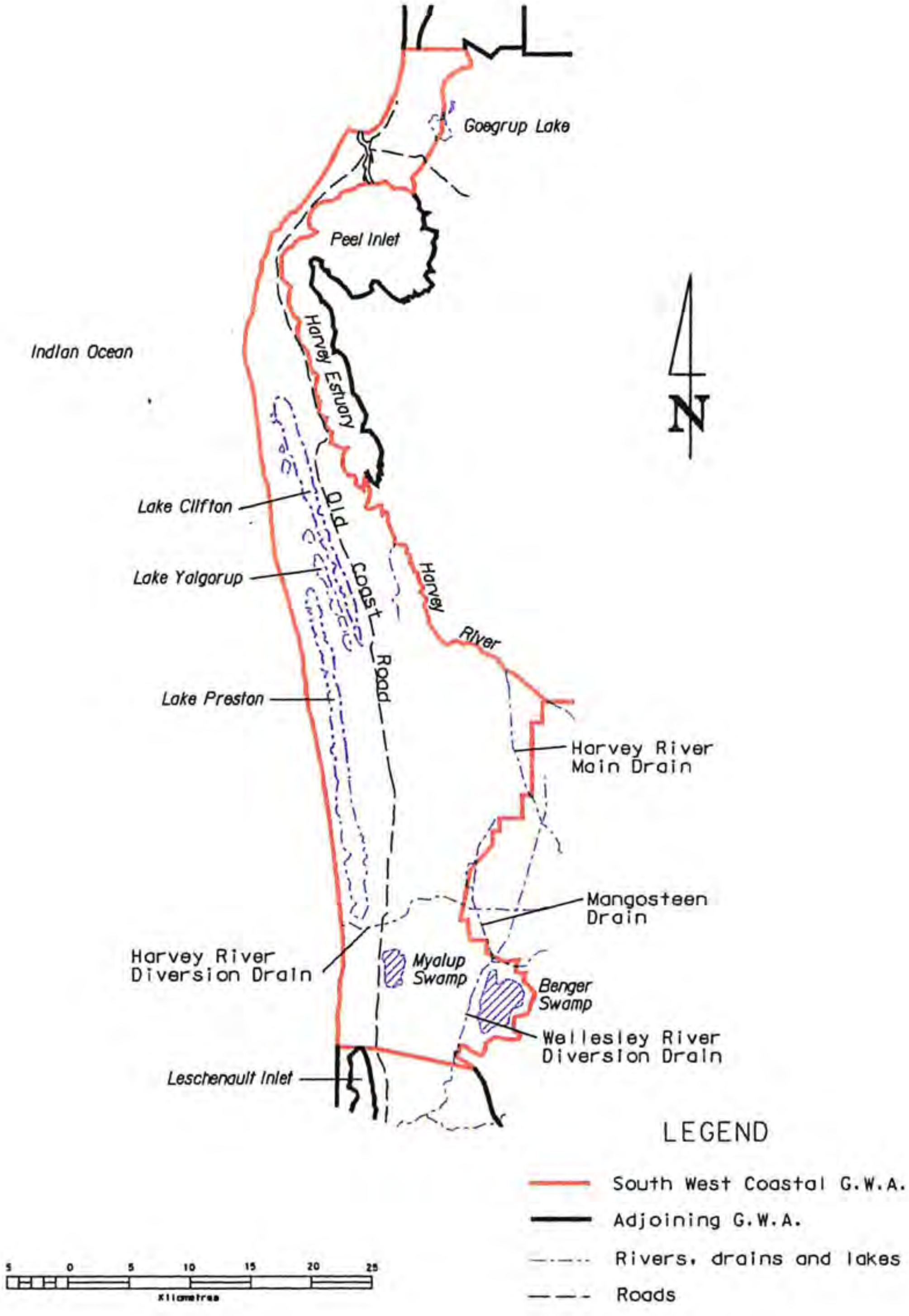
*P = monitored to present



SOUTH WEST COASTAL GROUNDWATER AREA

GENERAL LOCALITY PLAN

Figure 1



SOUTH WEST COASTAL GROUNDWATER AREA

MAIN PHYSICAL FEATURES

Figure 2

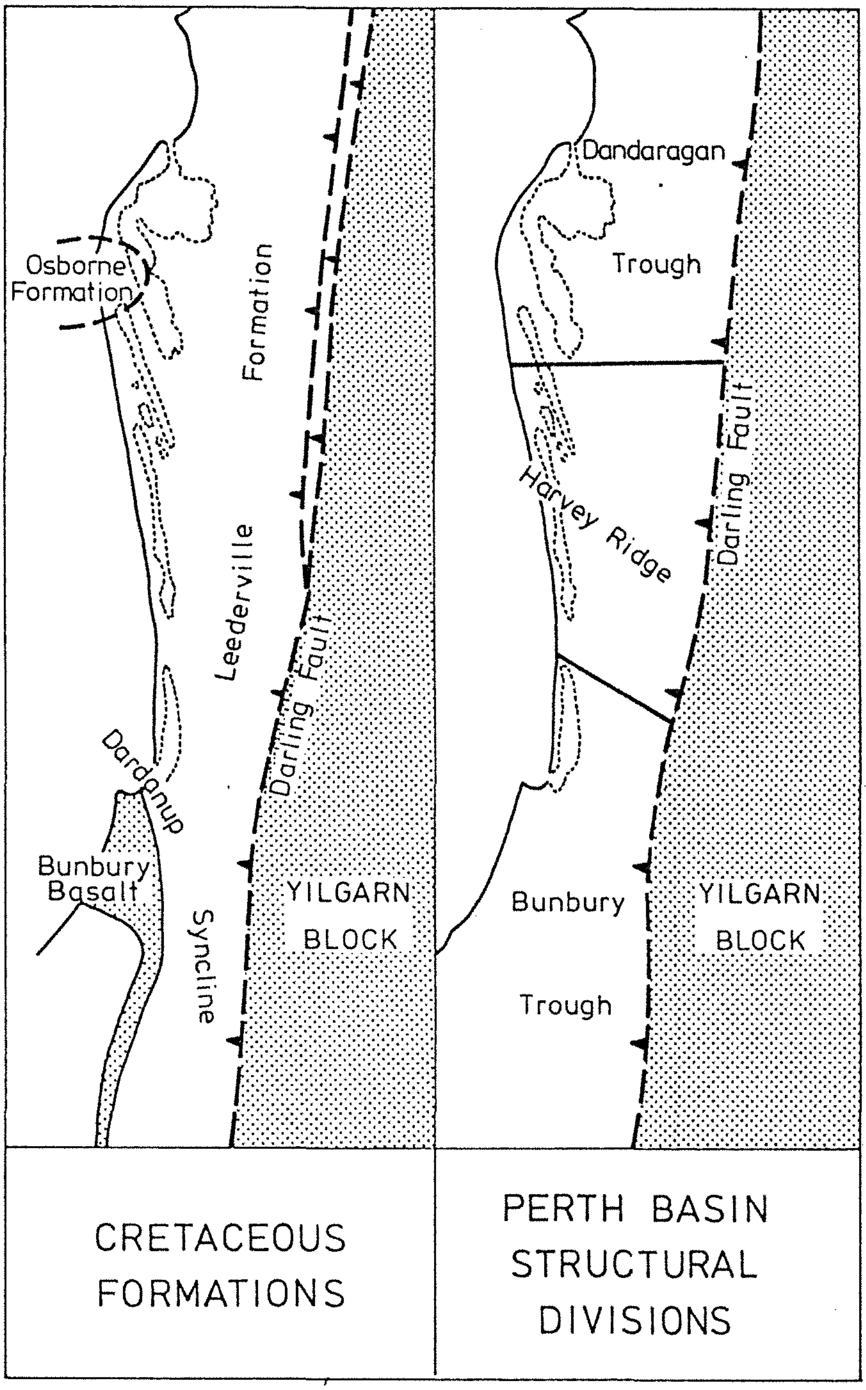
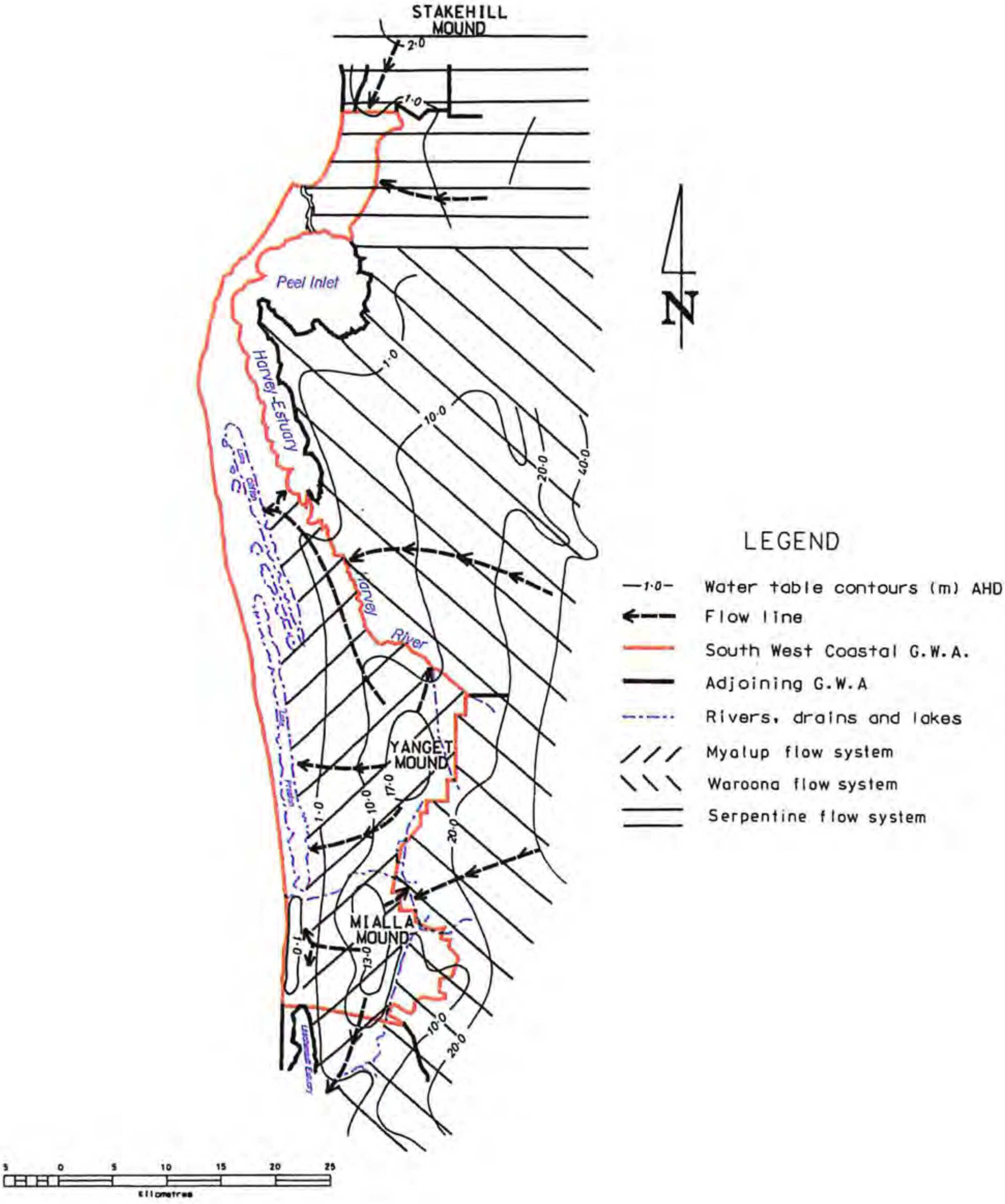


FIGURE 3. GENERAL STRUCTURAL GEOLOGY.



SOUTH WEST COASTAL GROUNDWATER AREA

SUPERFICIAL FORMATION FLOW SYSTEMS

Figure 4

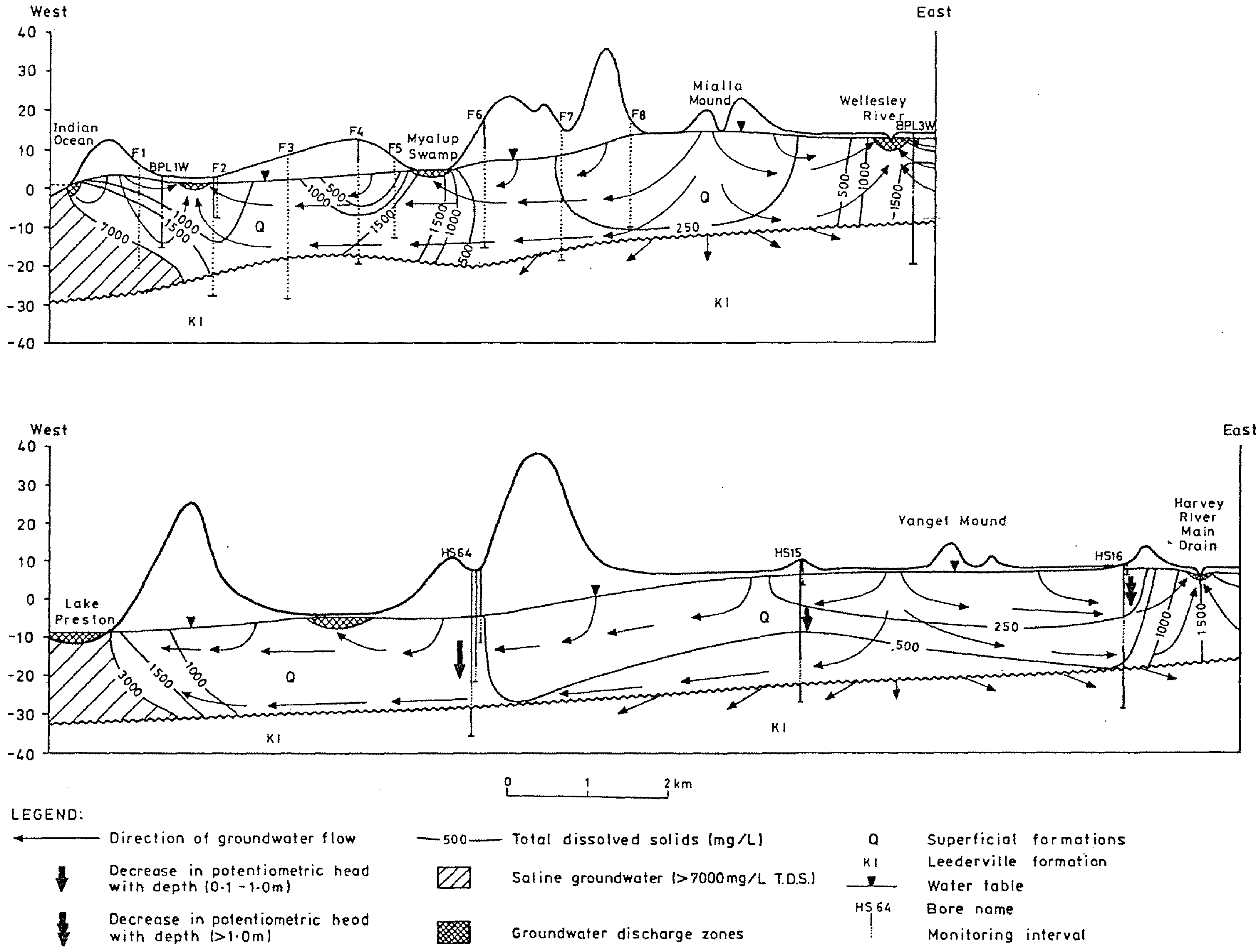
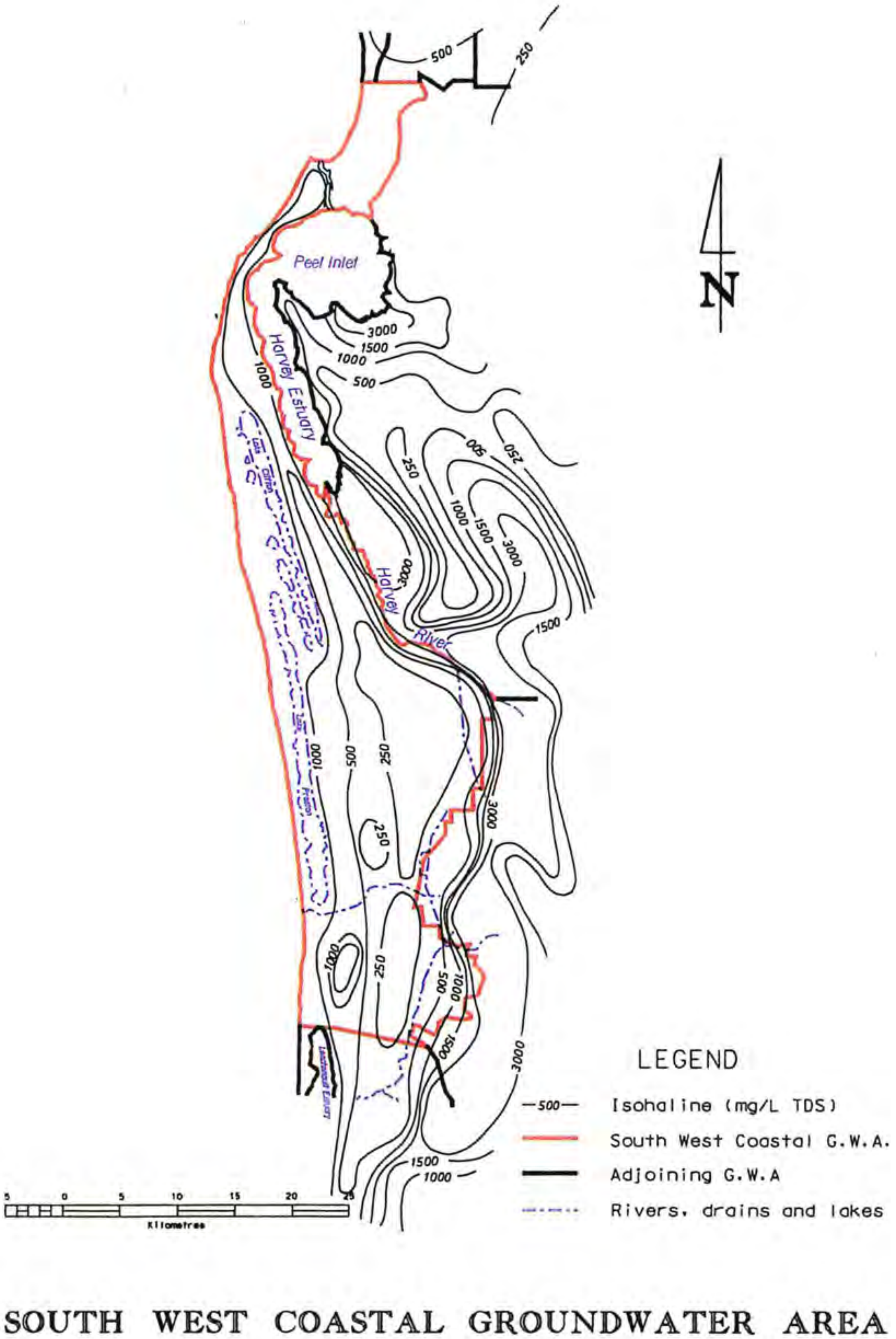
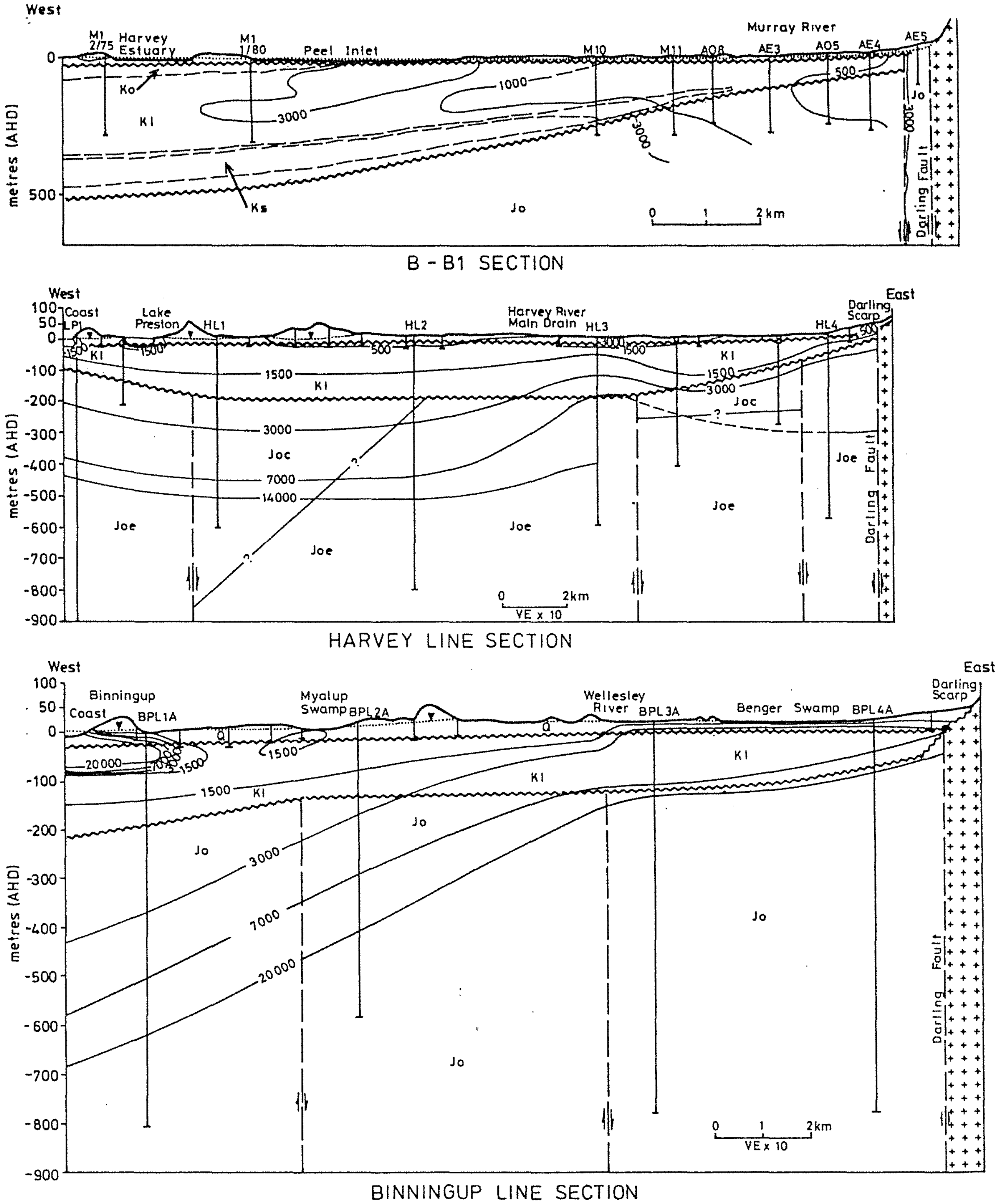


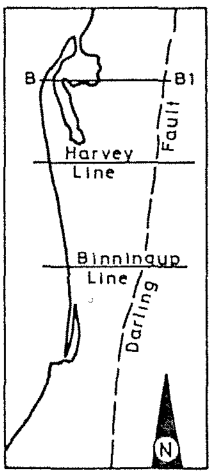
FIGURE 5. HYDROGEOLOGIC CROSS SECTIONS, SUPERFICIAL FORMATIONS



SOUTH WEST COASTAL GROUNDWATER AREA
SUPERFICIAL WATER TABLE SALINITIES

Figure 6

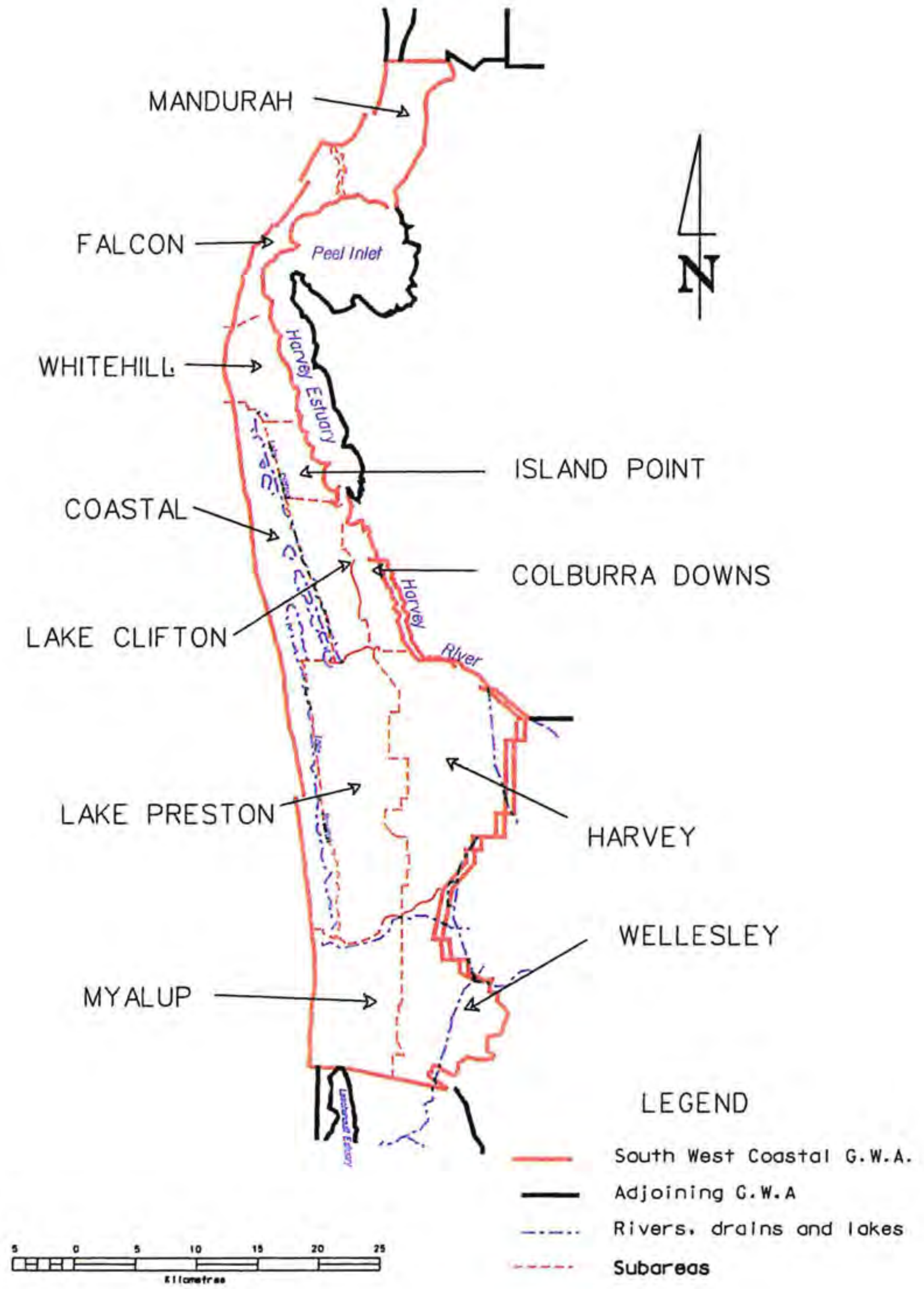




LEGEND:

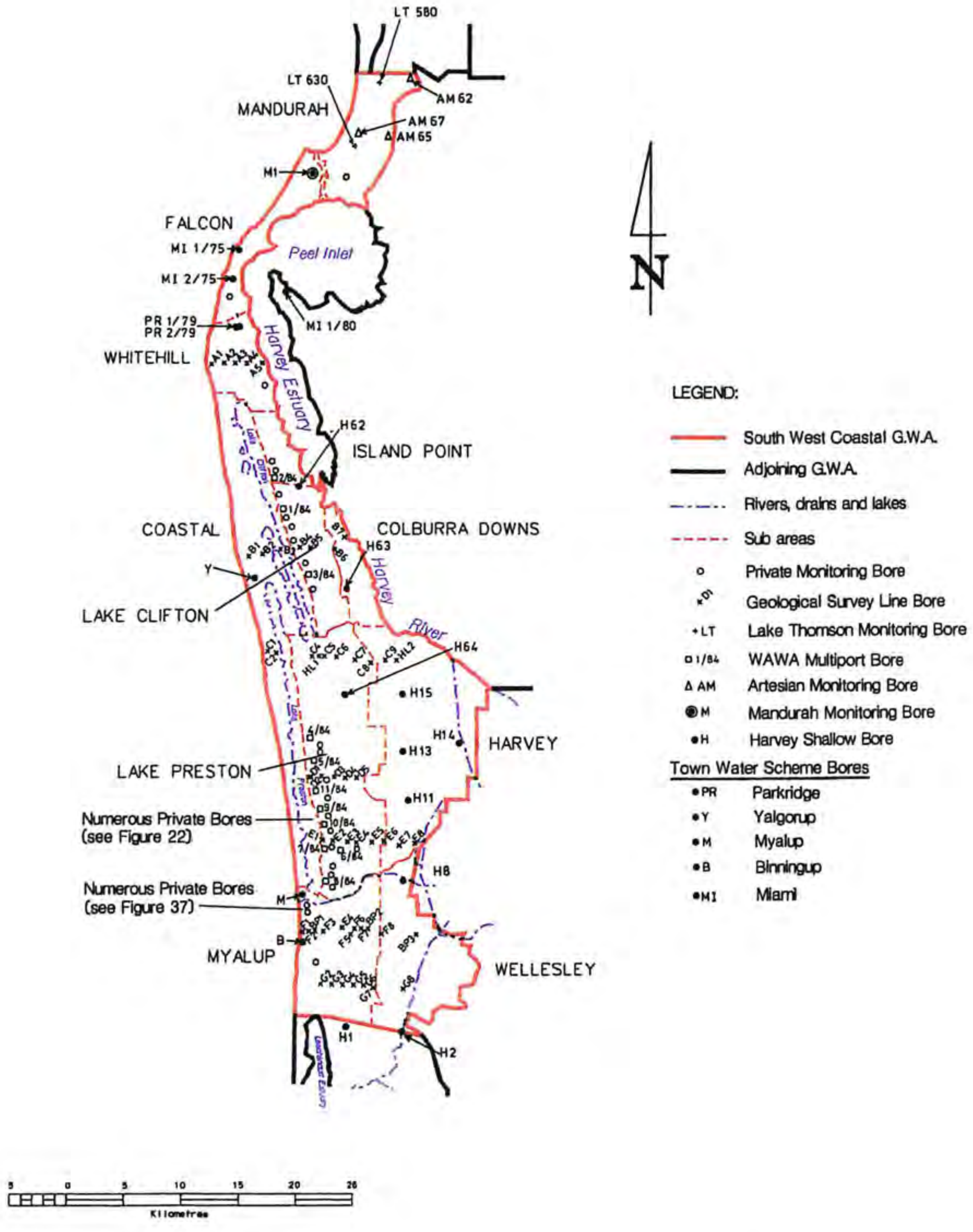
Q	Superficial formations	Ks	South Perth shale
Ko	Osborne formation	Kg	Gage formation
Kl	Leederville formation		Precambrian rock
Jo	Cockleshell Gully formation		Unconformity
Joc	(Cattamarra member)	BPL 2A	Binningup line bore
Joe	(Eneabba member)	—3000—	Isohaline (mg/L T.D.S.)

FIGURE 7. HYDROGEOLOGIC SECTIONS LEEDERVILLE FORMATION AND DEEPER AQUIFERS.



SOUTH WEST COASTAL GROUNDWATER AREA
SUBAREAS

Figure 8



SOUTH WEST COASTAL GROUNDWATER AREA

LOCATION OF MONITORING BORES

Figure 9

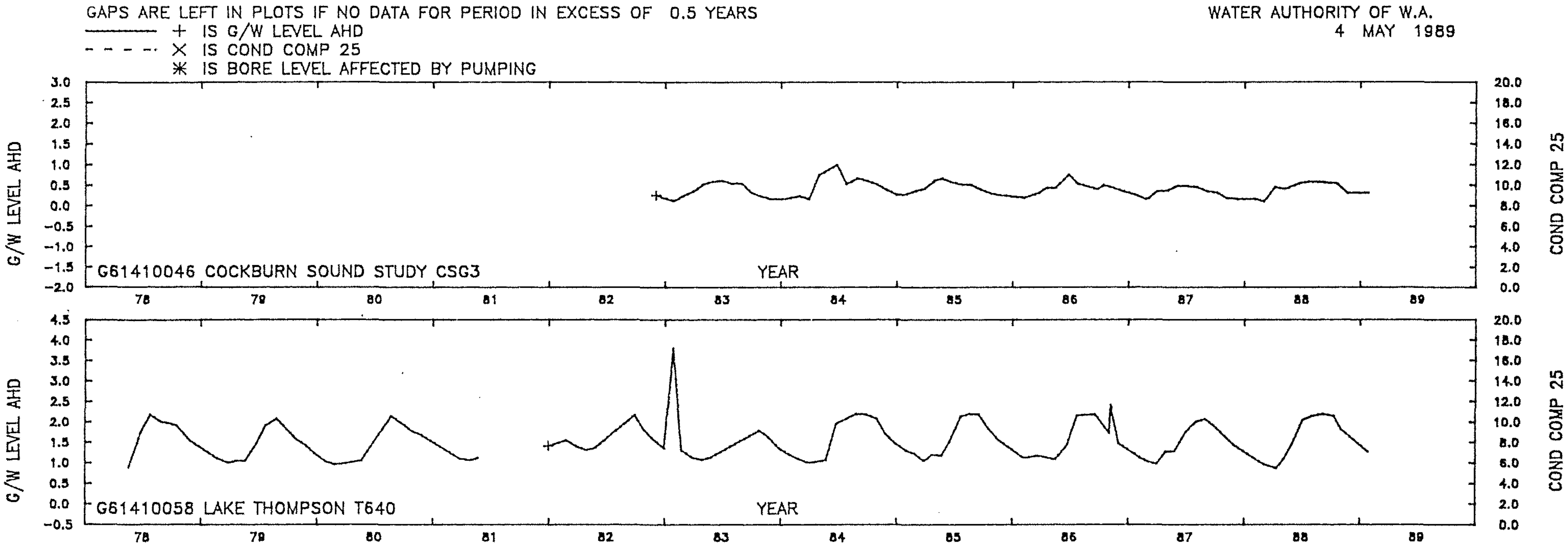


Figure 10. MANDURAH SUPERFICIAL MONITORING BORE DATA

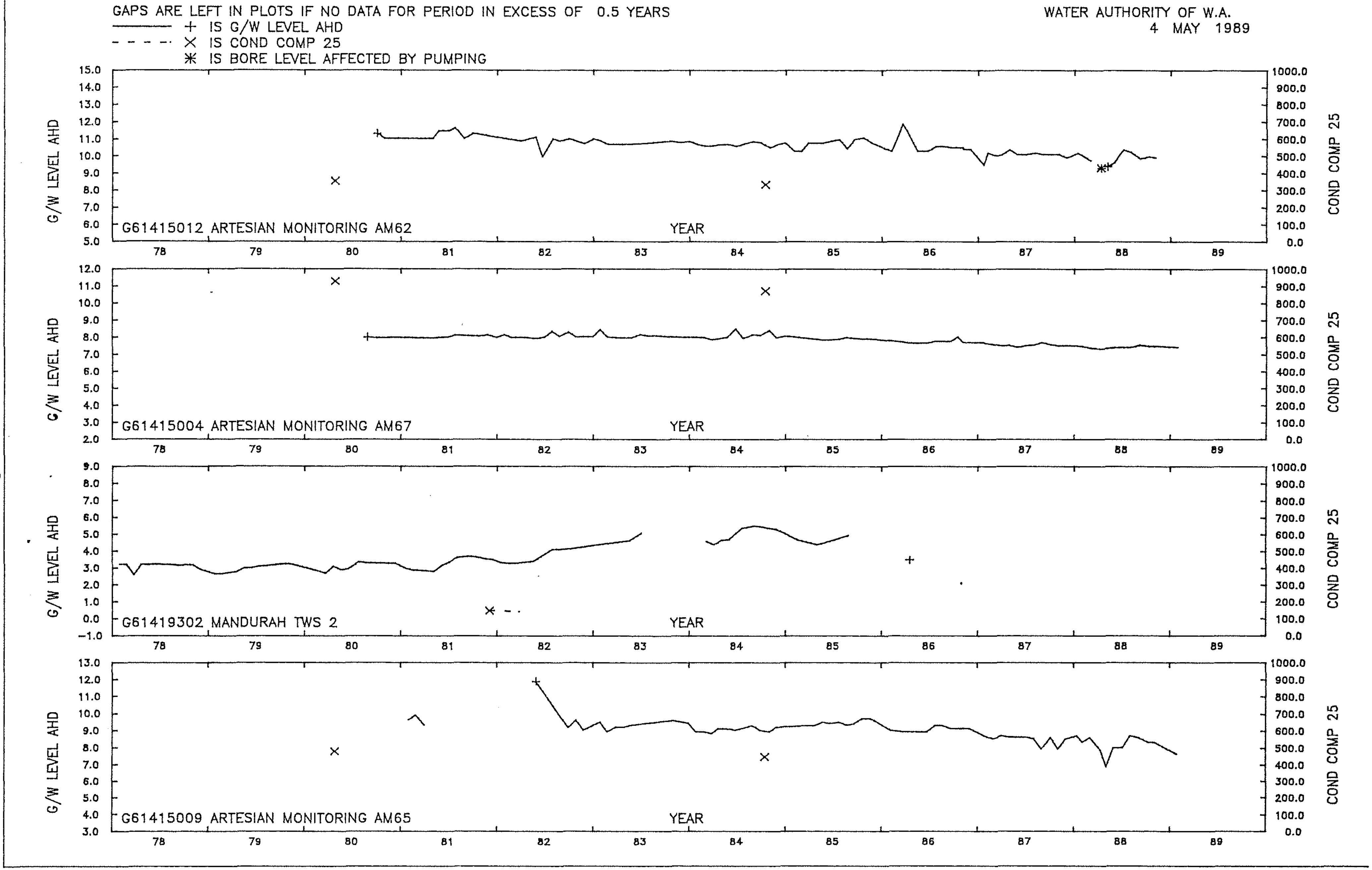


Figure 11. MANDURAH ARTESIAN MONITORING BORE DATA

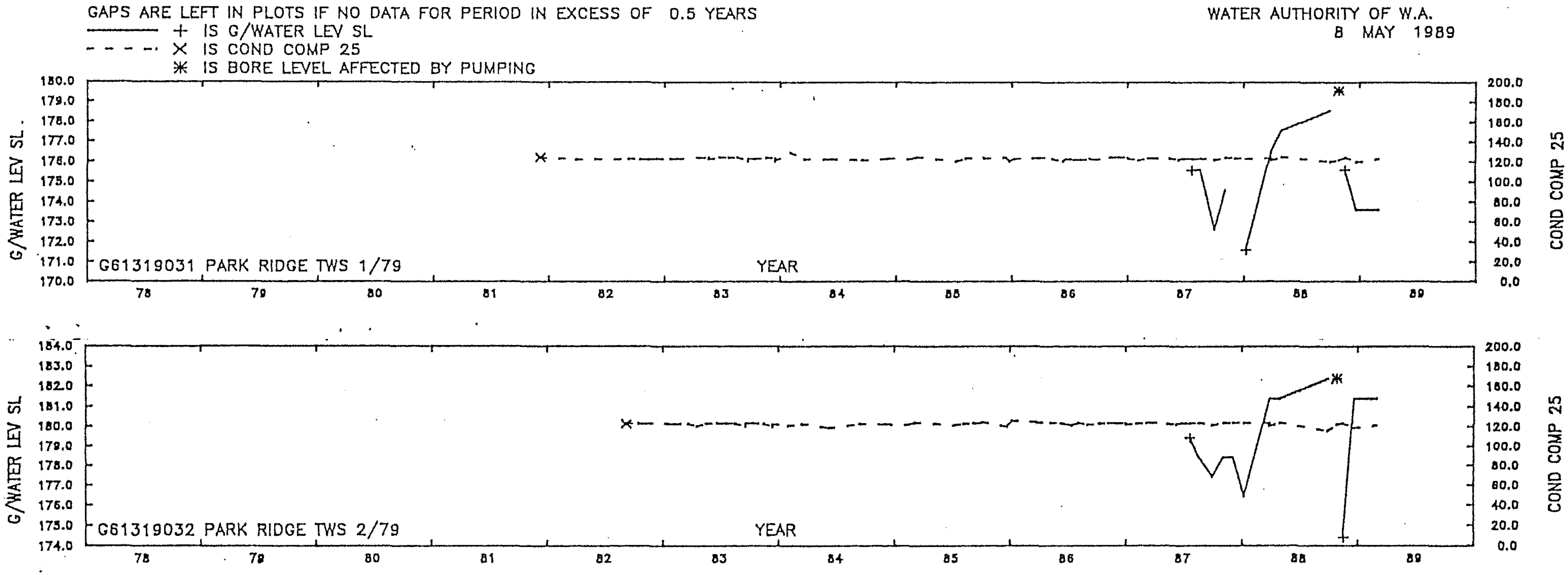


Figure 12. FALCON LEEDERVILLE BORE MONITORING DATA

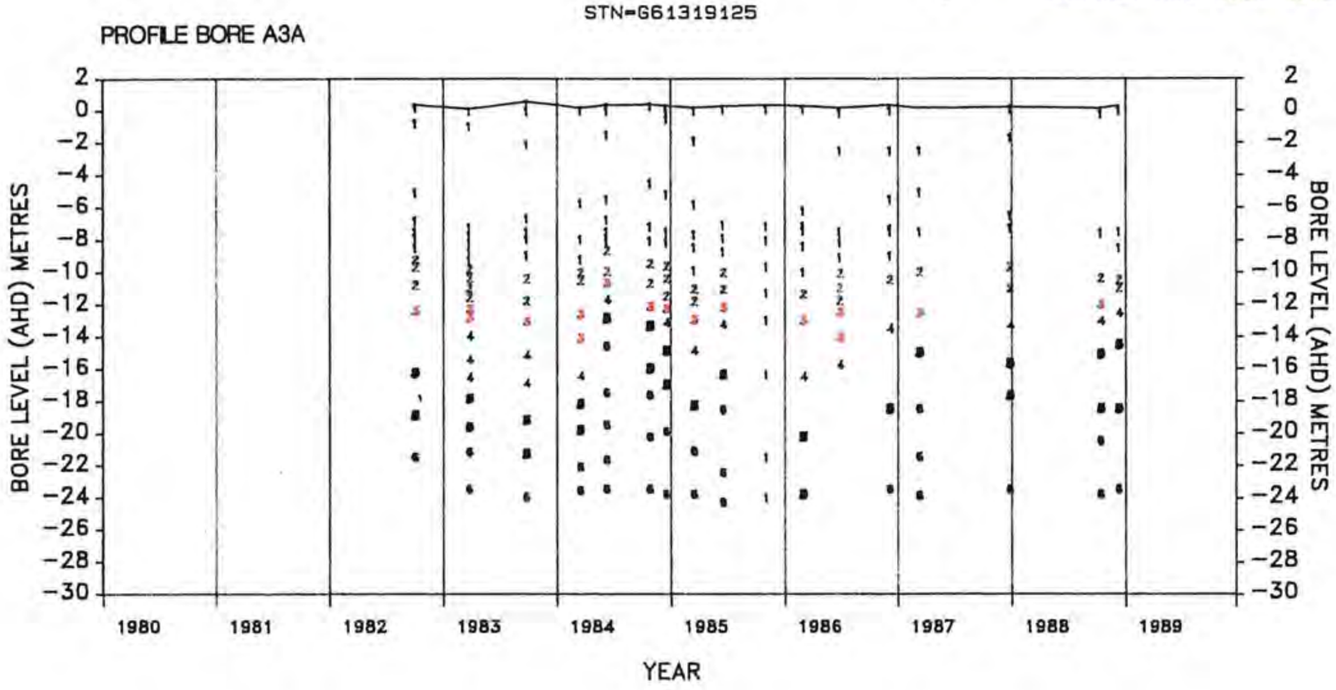
SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO 500	MG/L
2	500	TO 1000	MG/L
3	1000	TO 1500	MG/L
4	1500	TO 2000	MG/L
5	2000	TO 3000	MG/L
6	GREATER THAN 3000		MG/L



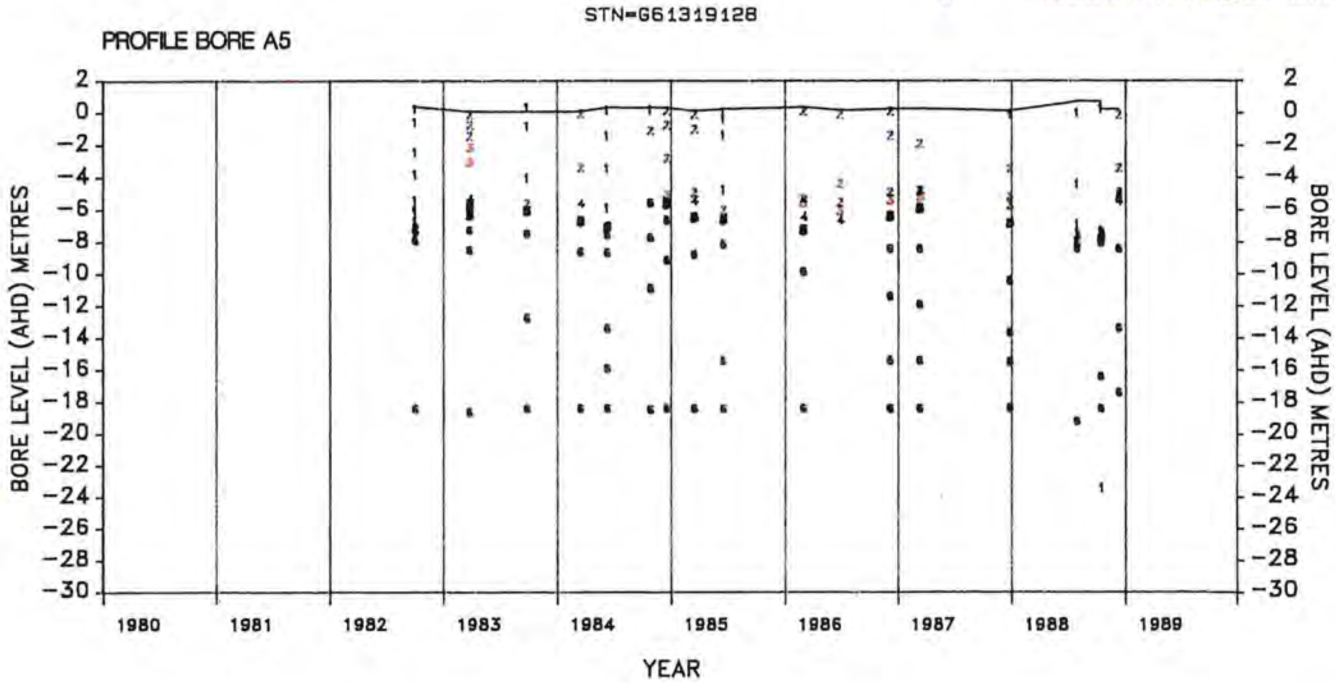
SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO 500	MG/L
2	500	D .000	MG
3	1000	TO 1500	MG/L
4	1500	TO 2000	MG/L
5	2000	TO 3000	MG/L
6	GREATER THAN 3000		MG/L



WHITE HILLS PROFILE BORES A3A AND A5 **Figure 13.**

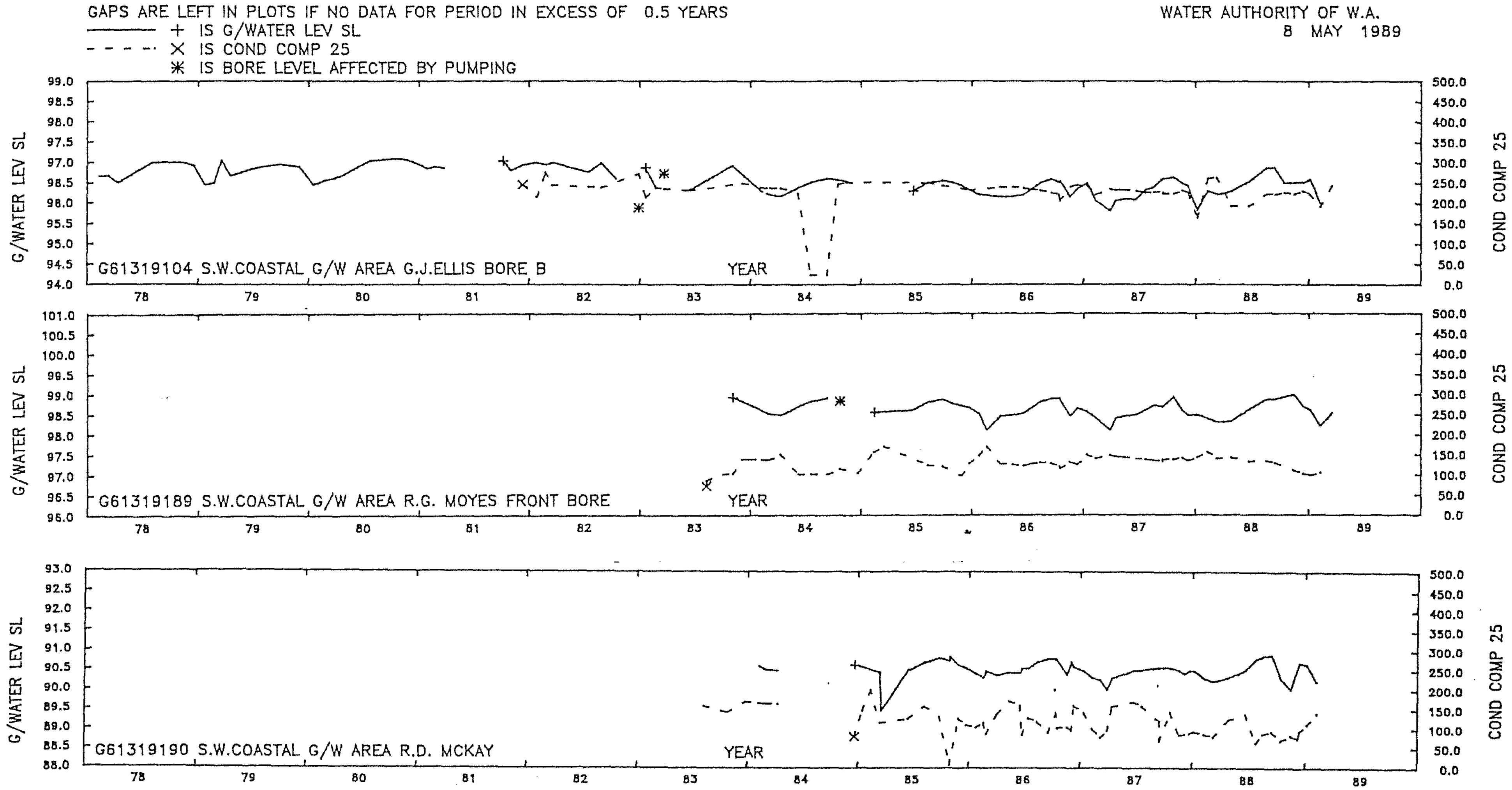


Figure 14. ISLAND POINT PRIVATE BORE MONITORING DATA

SOUTH–WEST COASTAL GROUNDWATER AREA

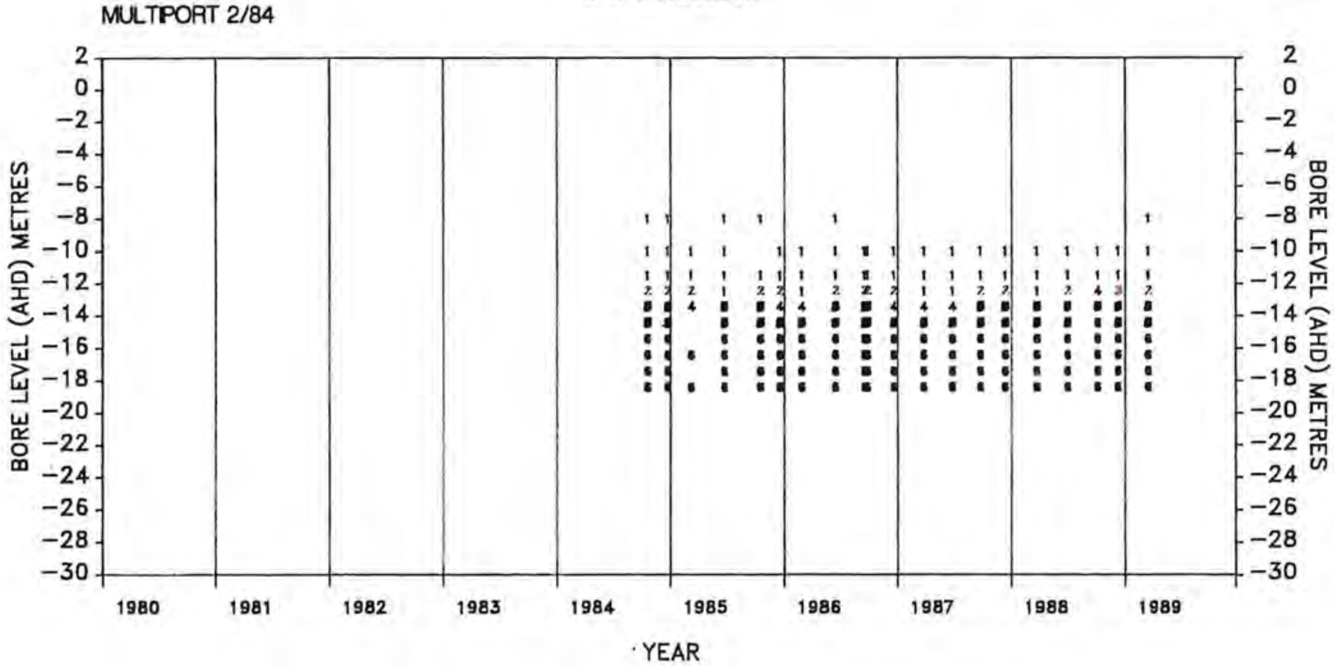
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	2000	TO	3000	MG/L
6	GREATER THAN 3000			MG/L

STN-661319219



ISLAND POINT MULTIPORT BORE 2/84 **Figure 15.**

SOUTH–WEST COASTAL GROUNDWATER AREA

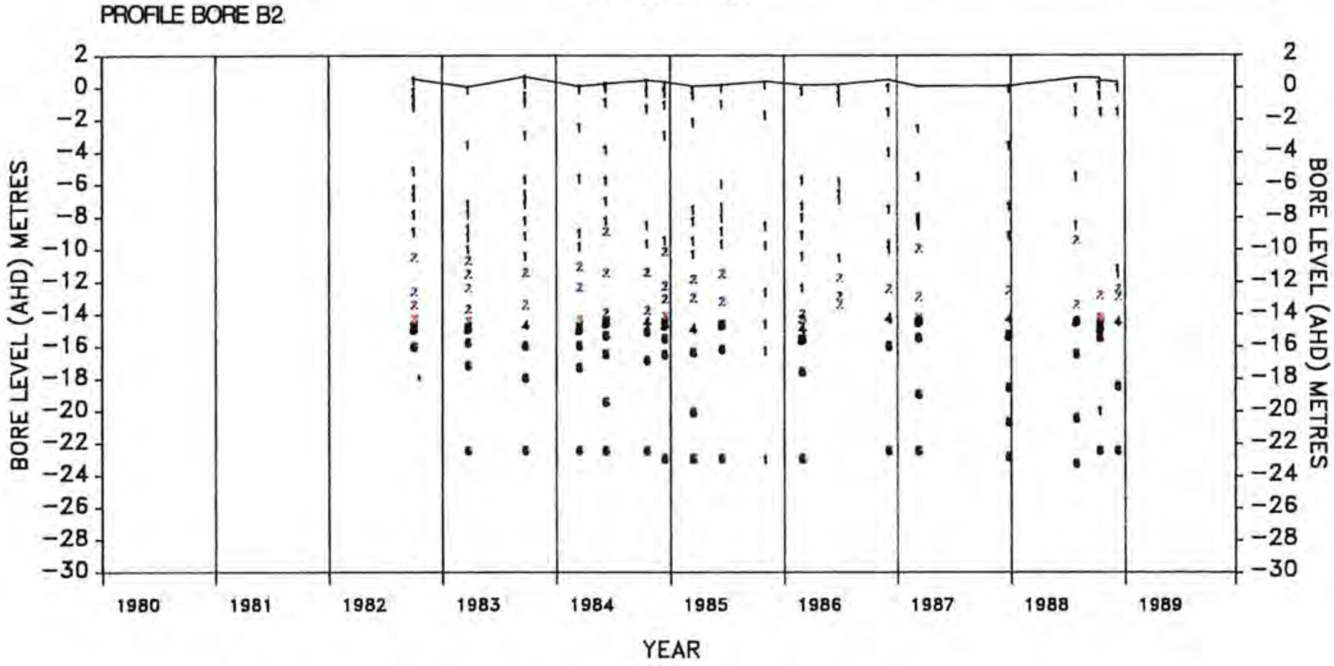
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0 TO 500	MG/L
2	500 TO 1000	MG/L
3	1000 TO 1500	MG/L
4	1500 TO 2000	MG/L
5	**2000 TO 3000**	**MG/L**
6	GREATER THAN 3000	MG/L

STN=G61319130



SOUTH–WEST COASTAL GROUNDWATER AREA

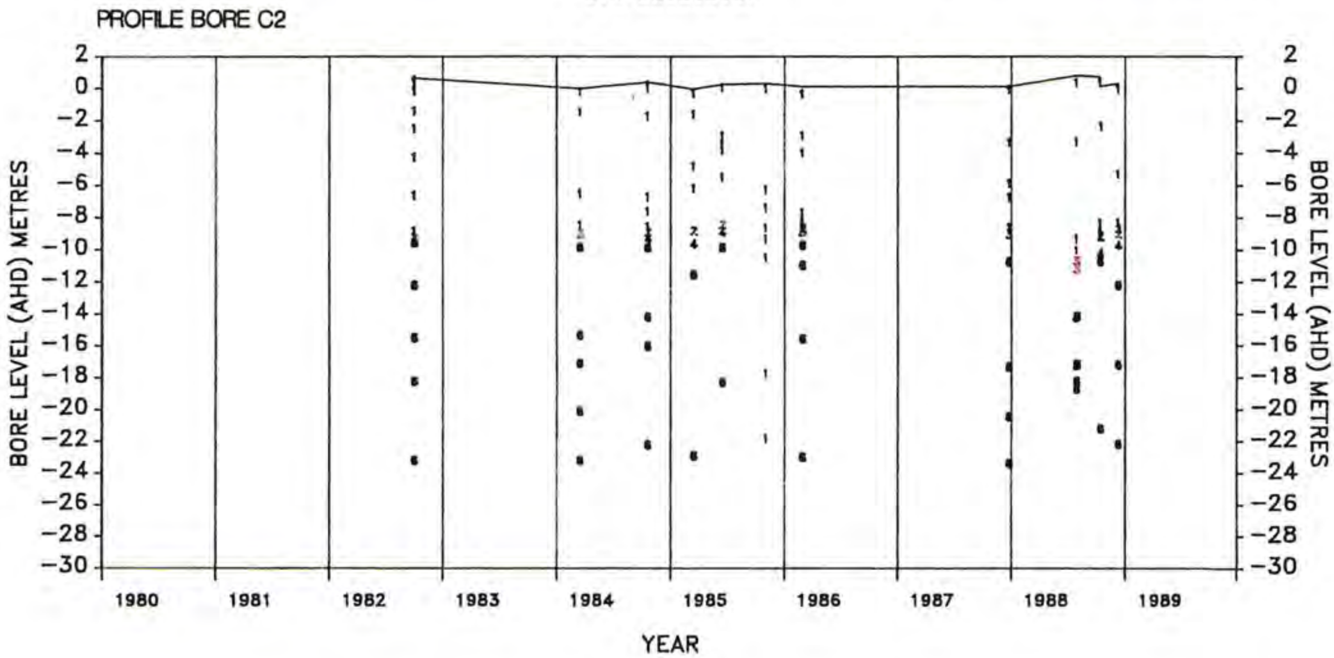
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0 TO 500	MG/L
2	500 TO 1000	MG/L
3	1000 TO 1500	MG/L
4	1500 TO 2000	MG/L
5	**2000 TO 3000**	**MG/L**
6	GREATER THAN 3000	MG/L

STN=G61319137



COASTAL PROFILE BORES B2 AND C2 **Figure 16.**

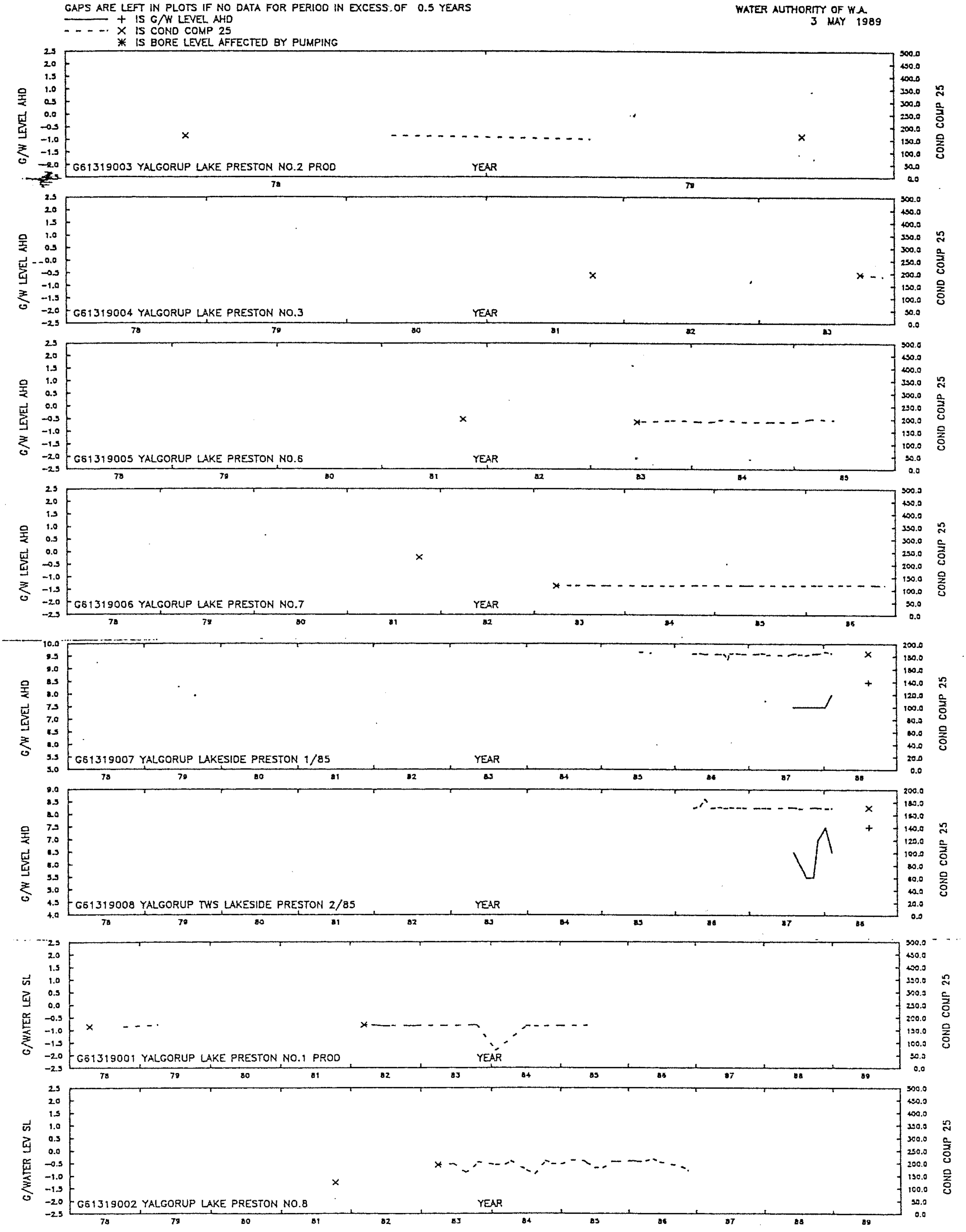


Figure 17. YALGORUP LEEDERVILLE BORE MONITORING DATA

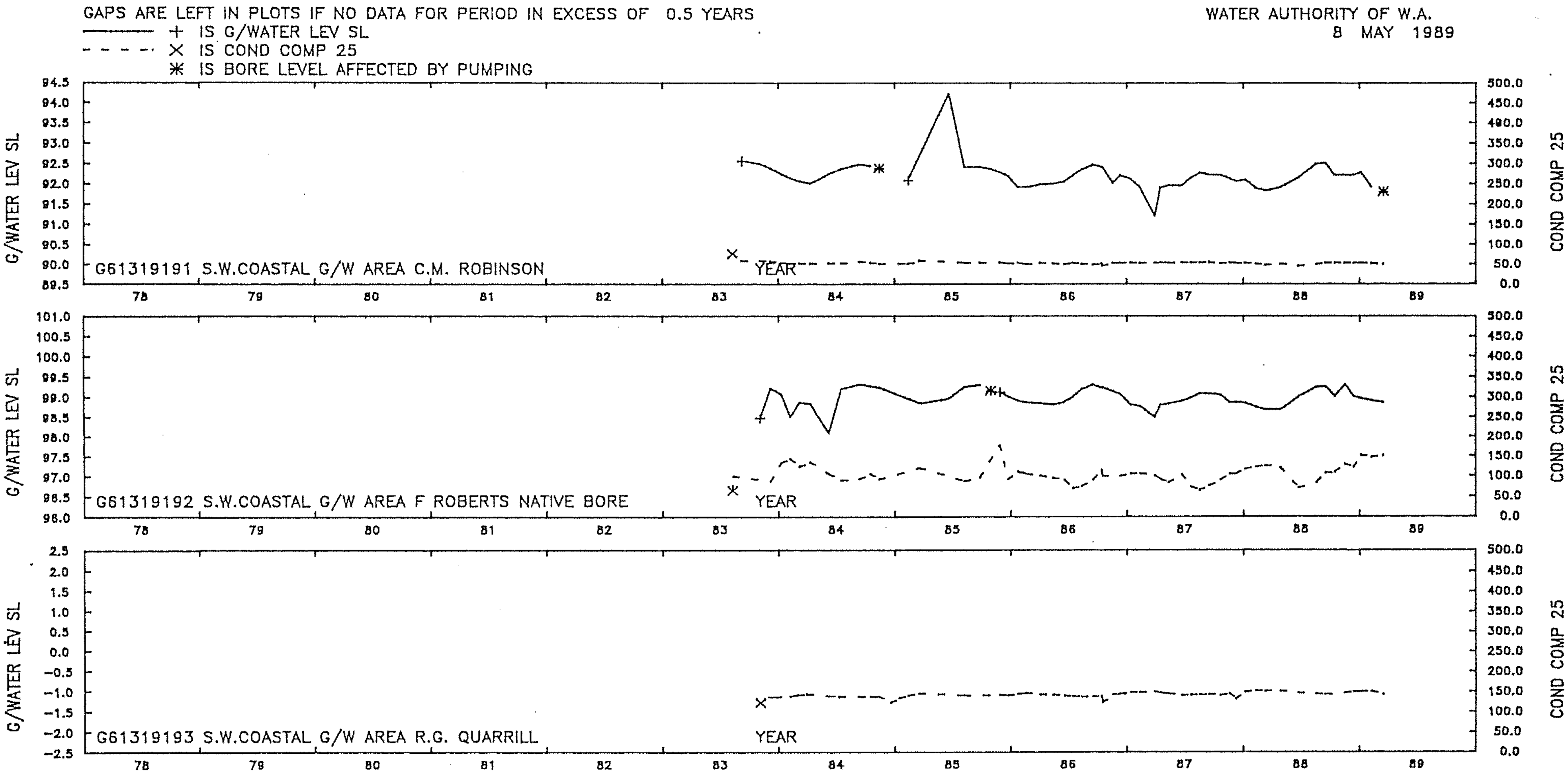


Figure 18. LAKE CLIFTON PRIVATE BORE MONITORING DATA

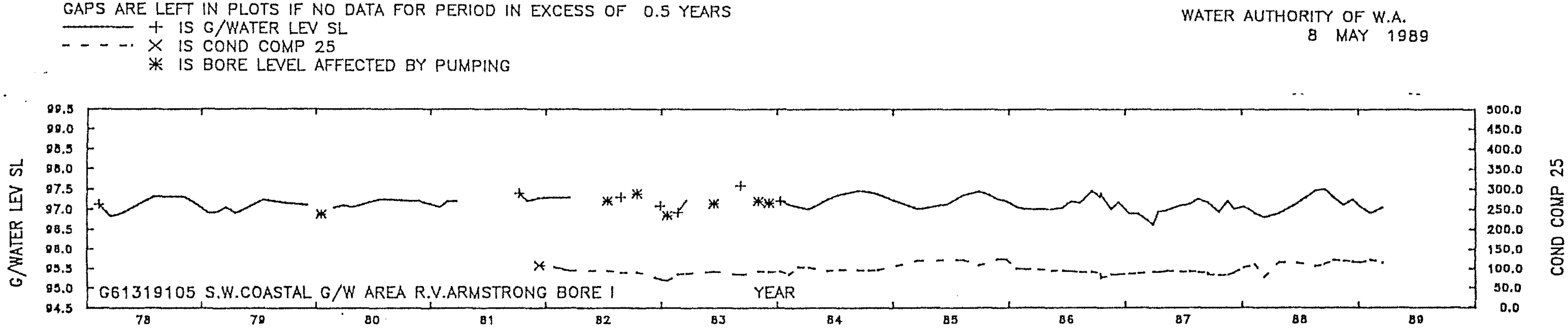


Figure 19. LAKE CLIFTON PRIVATE BORE MONITORING DATA

SOUTH–WEST COASTAL GROUNDWATER AREA

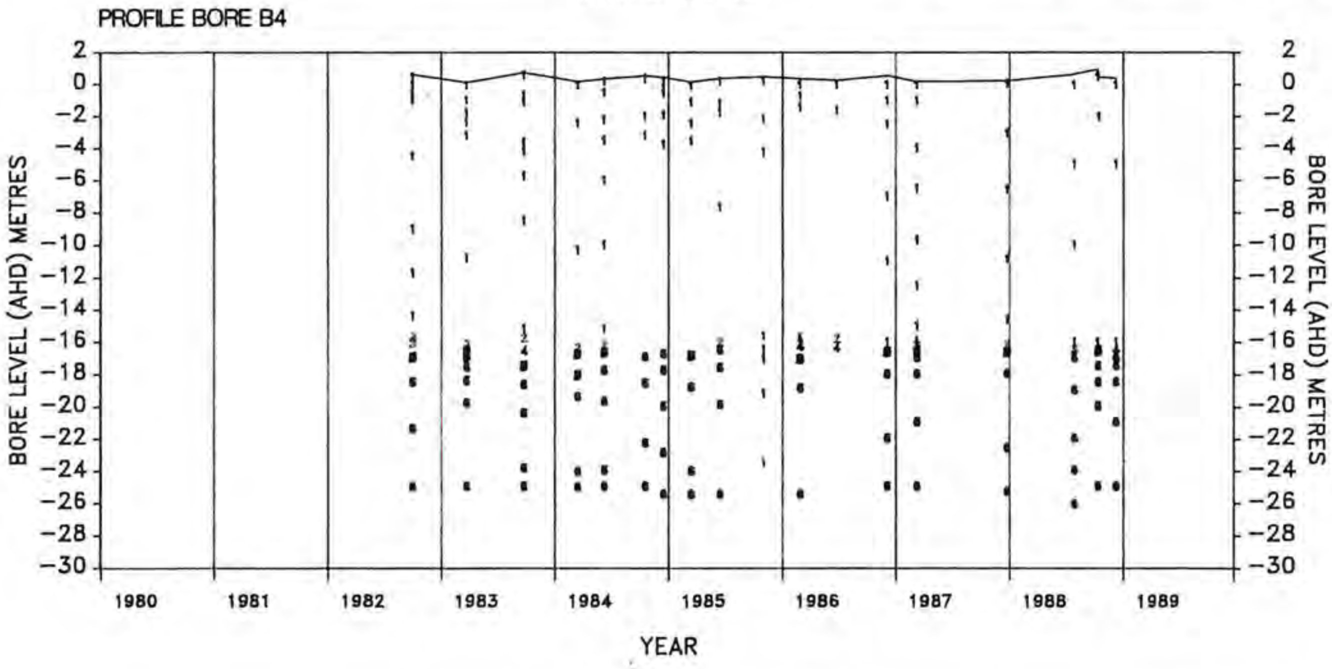
PROFILE DATA

LEGEND

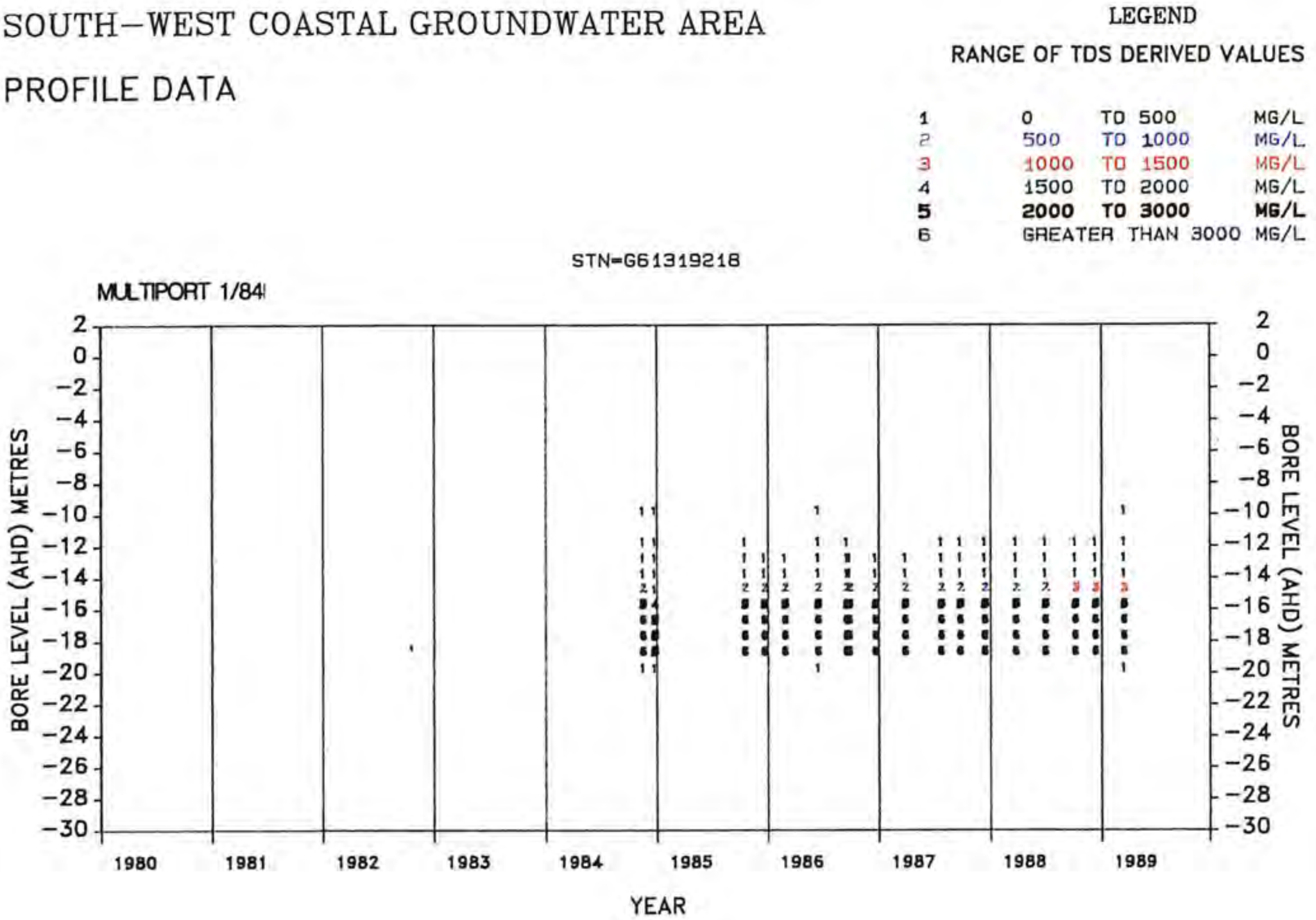
RANGE OF TDS DERIVED VALUES

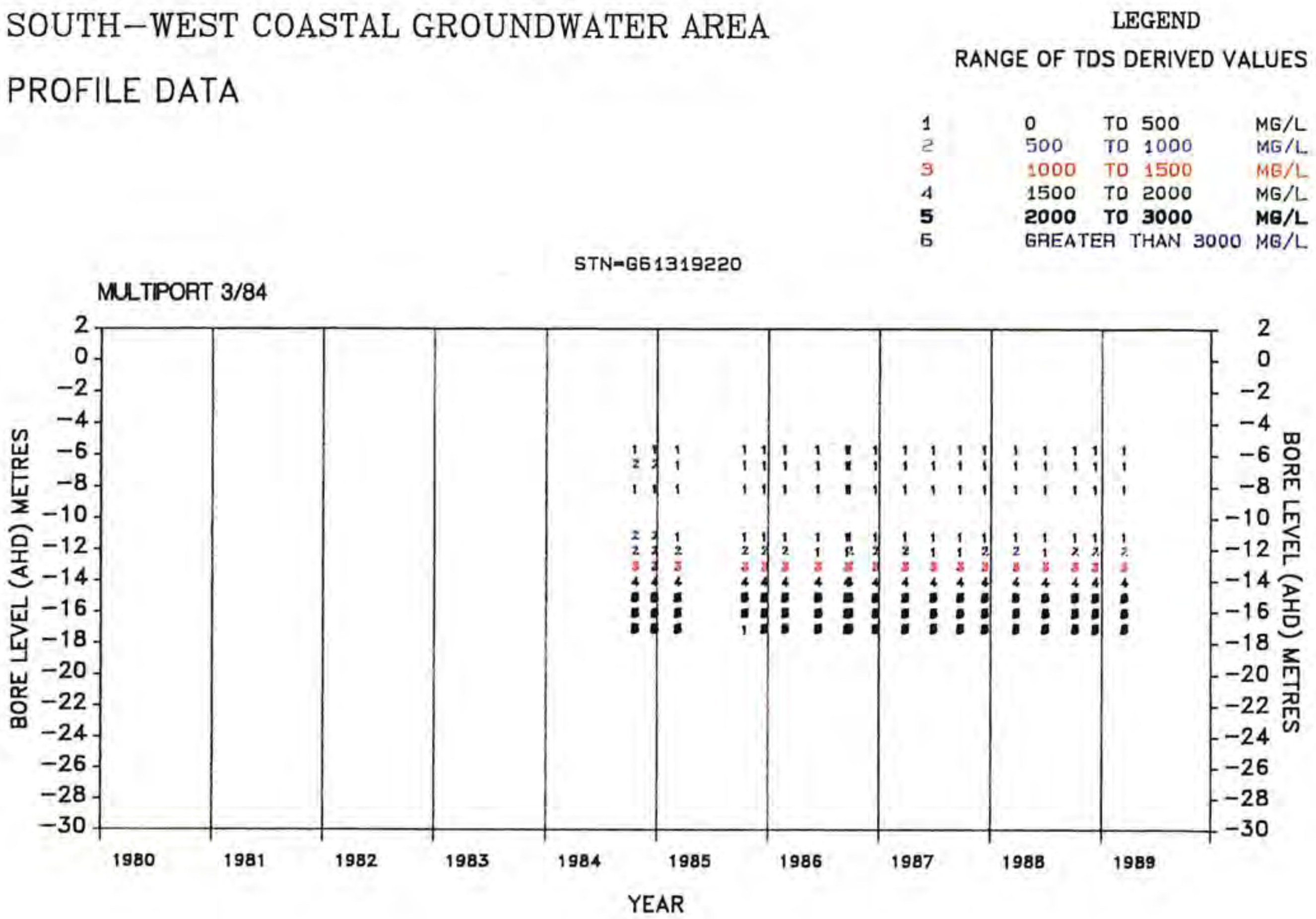
1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	**2000**	**TO**	**3000**	**MG/L**
6	GREATER THAN 3000 MG/L			

STN=G61319132

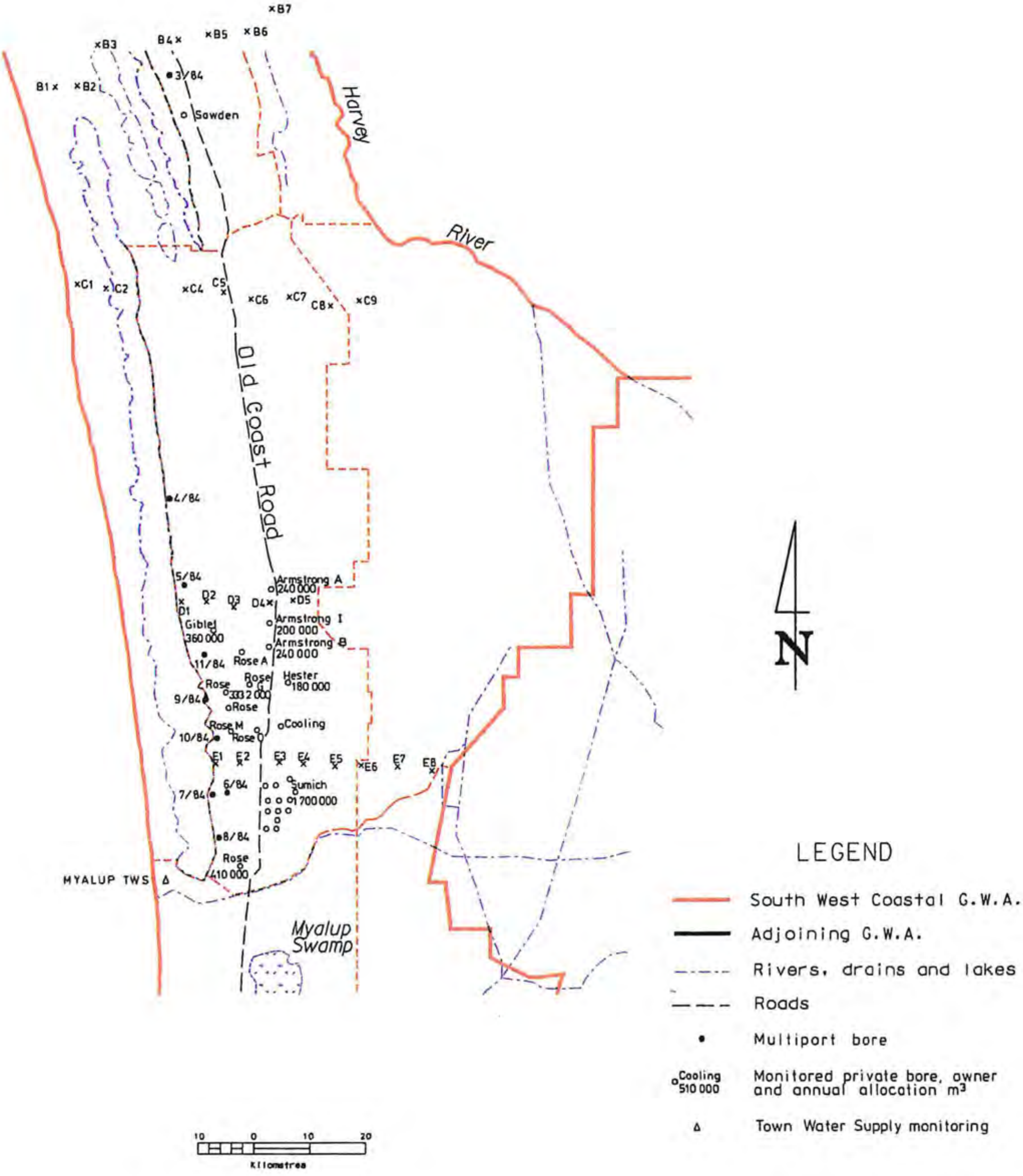


LAKE CLIFTON PROFILE BORE B4 **FIGURE 20.**





LAKE CLIFTON MULTIPORT BORES 1/84 AND 3/84 Figure 21.



SOUTH WEST COASTAL GROUNDWATER AREA

LAKE PRESTON MONITORING LOCATIONS AND MAJOR ALLOCATIONS

Figure 22

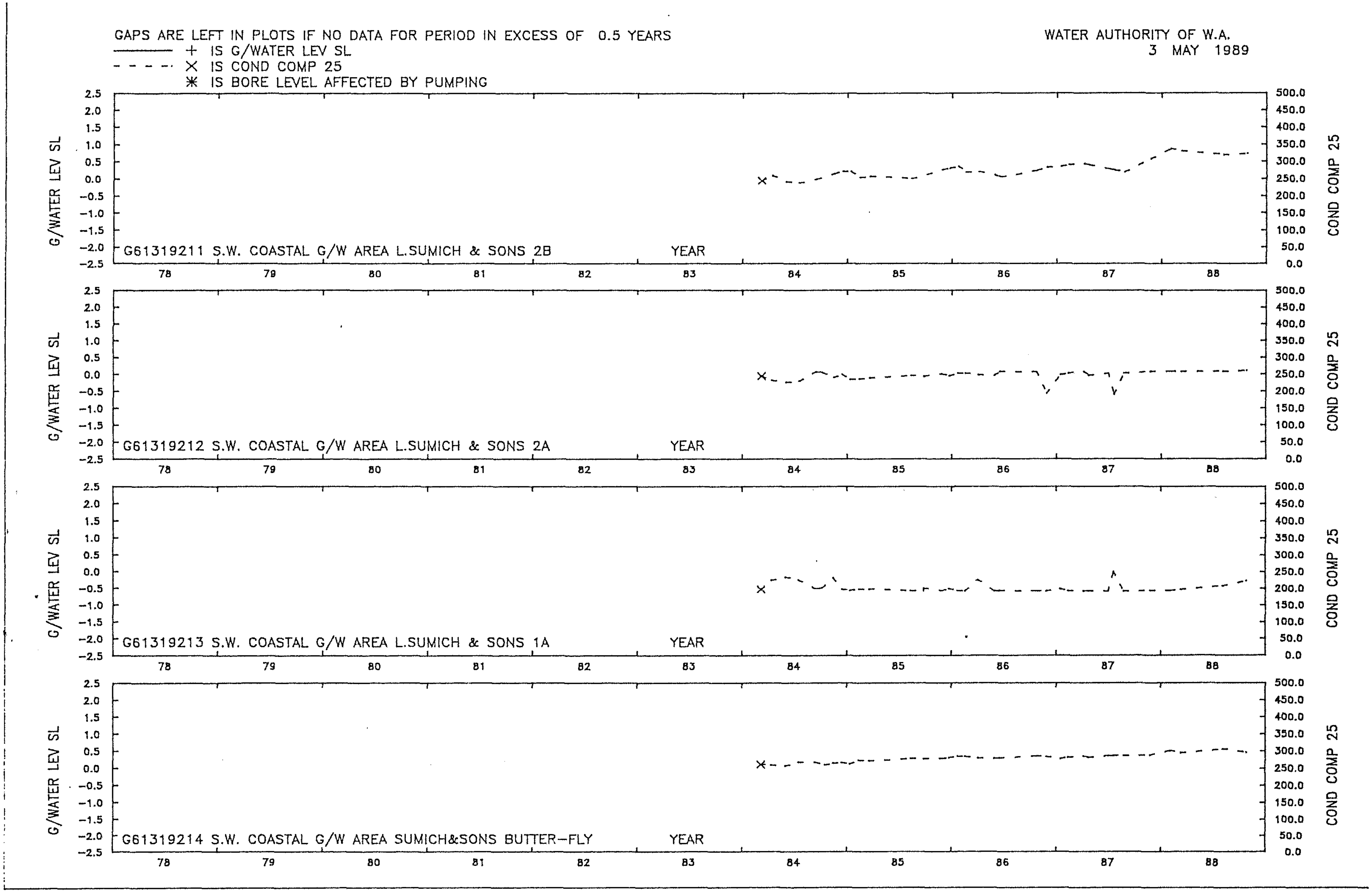


Figure 23. LAKE PRESTON PRIVATE BORE MONITORING DATA

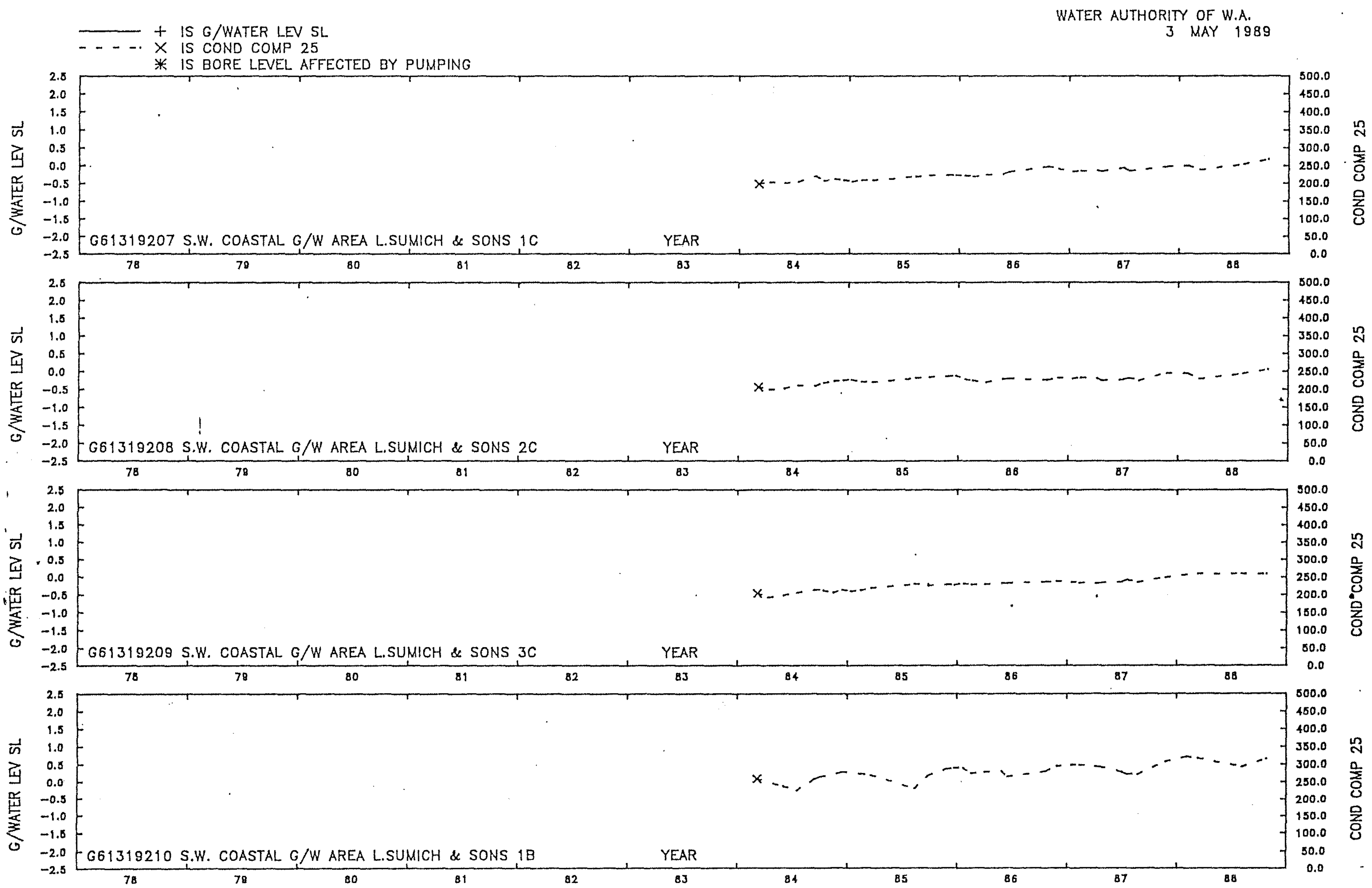


Figure 24. LAKE PRESTON PRIVATE BORE MONITORING DATA

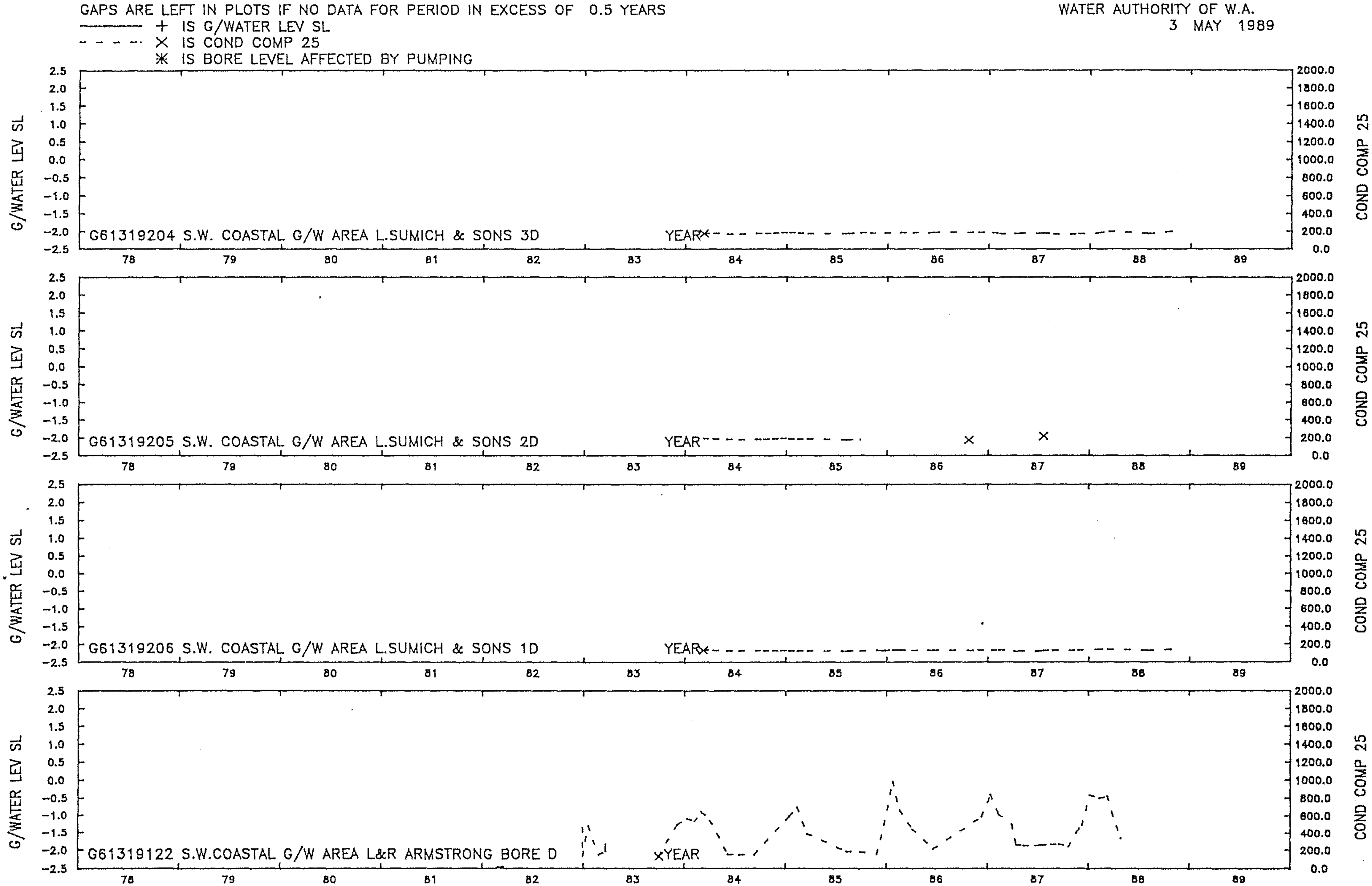


Figure 25. LAKE PRESTON PRIVATE MONITORING DATA BORE

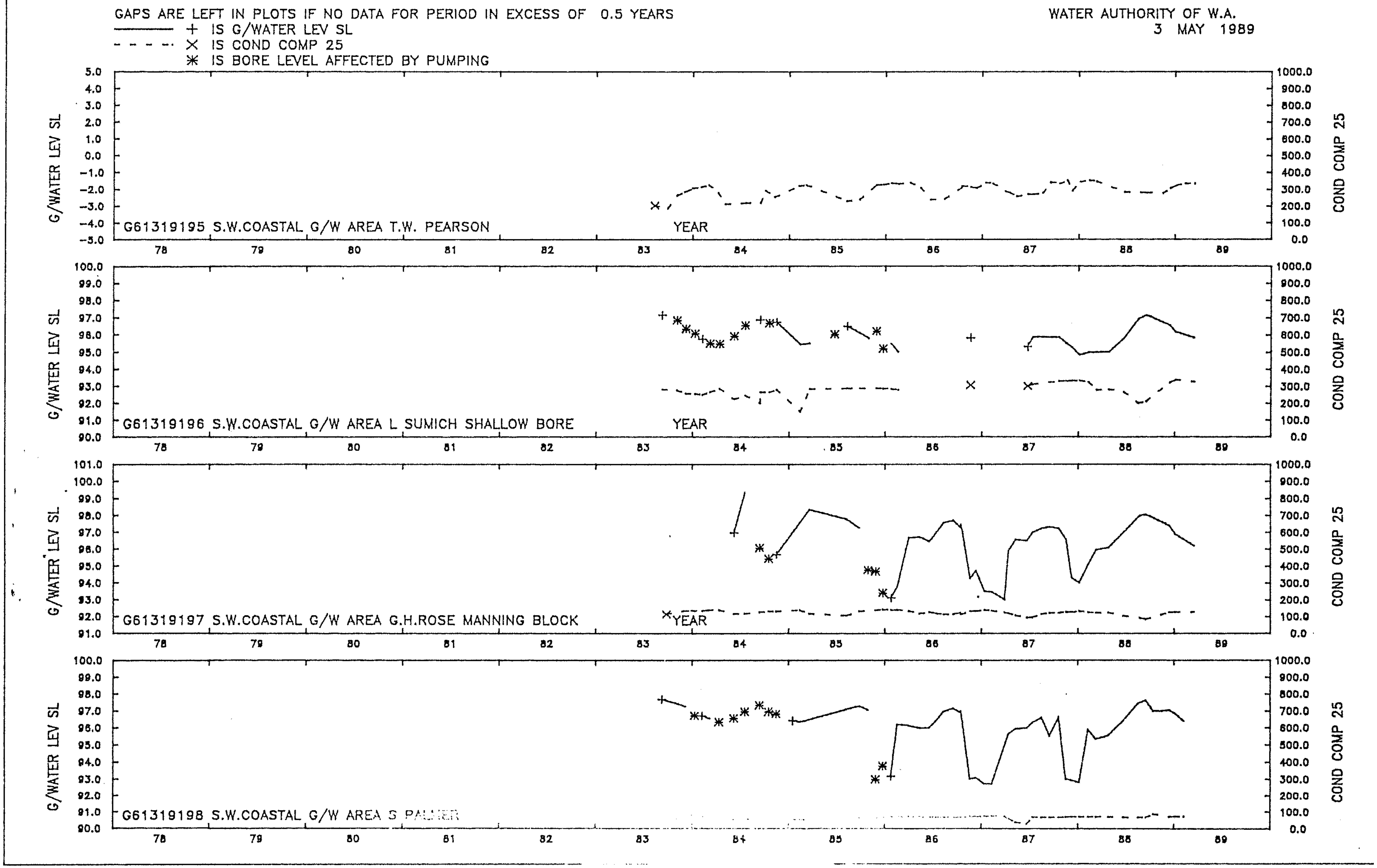


Figure 26. LAKE PRESTON PRIVATE BORE MONITORING DATA

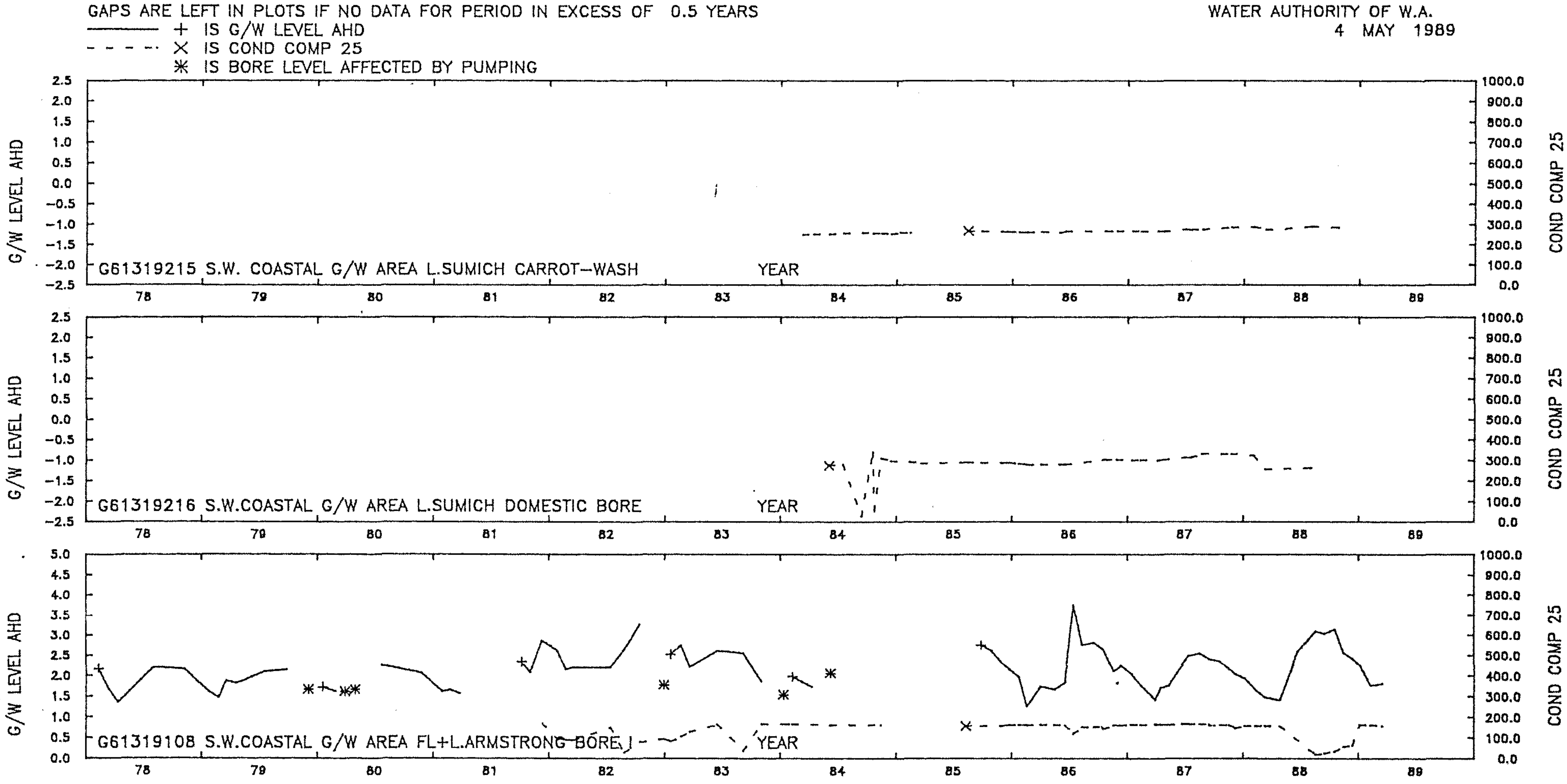


Figure 27. LAKE PRESTON PRIVATE BORE MONITORING DATA

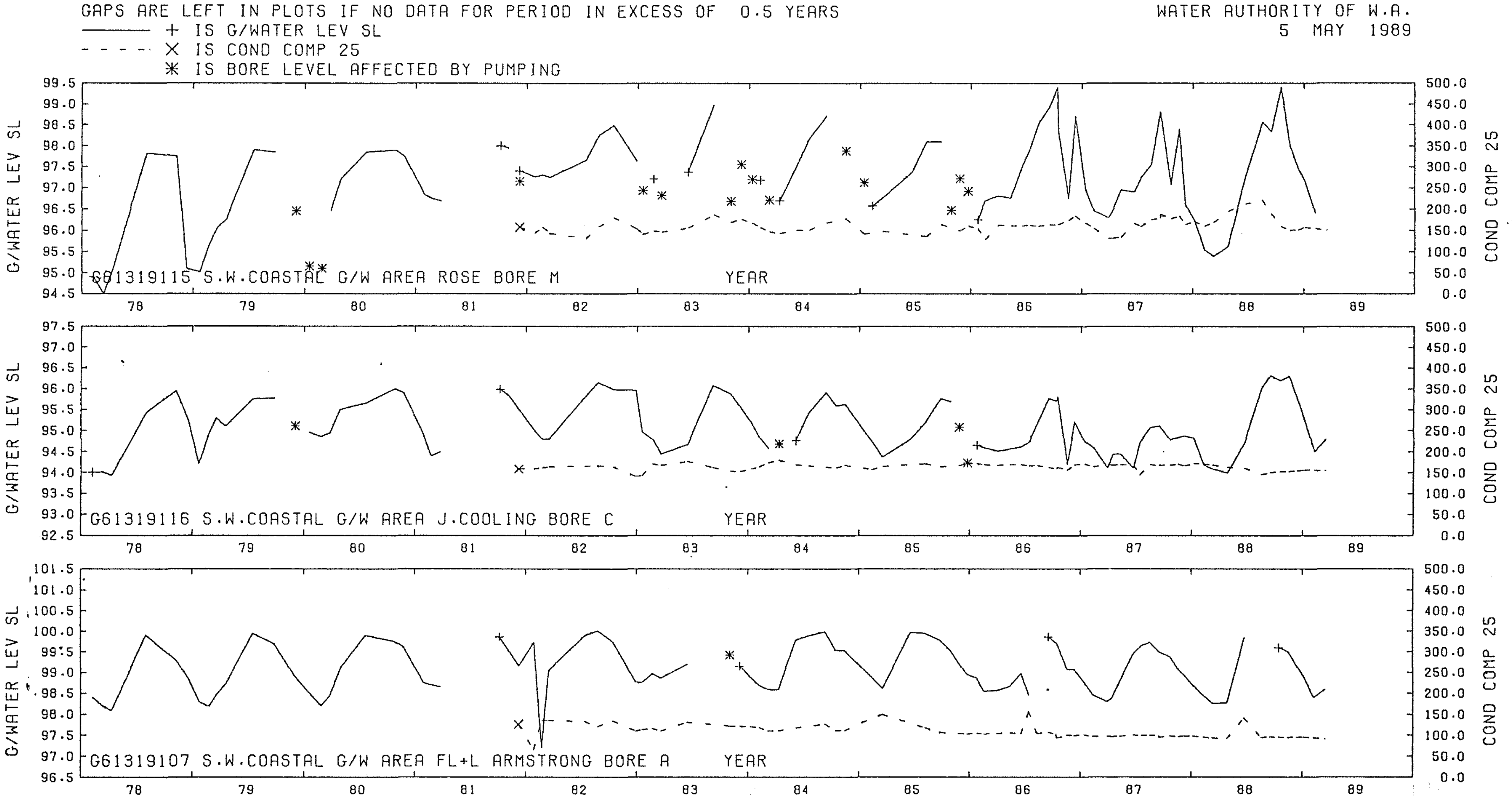


Figure 28. LAKE PRESTON PRIVATE BORE MONITORING DATA

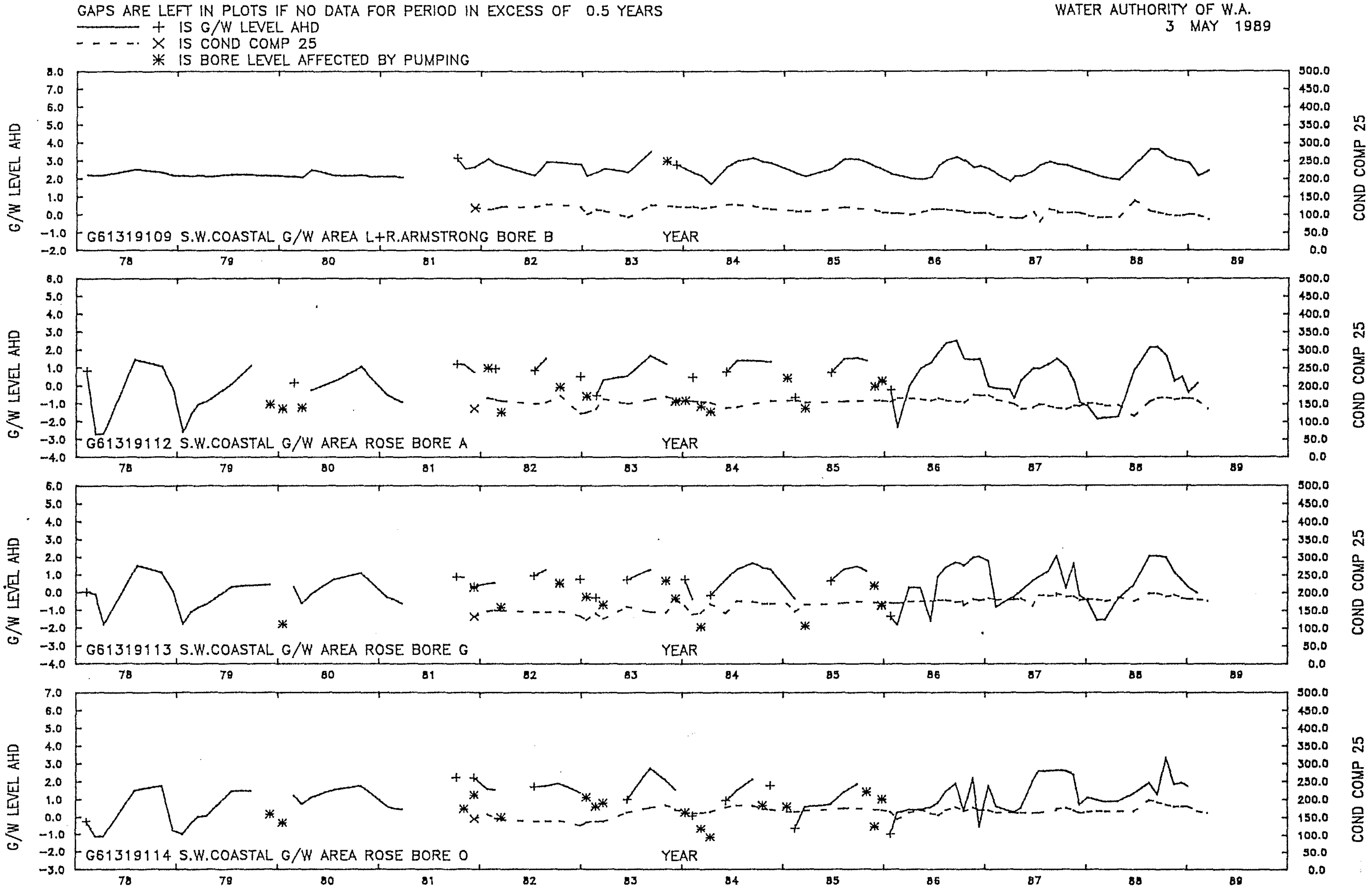


Figure 29. LAKE PRESTON PRIVATE BORE MONITORING DATA

SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

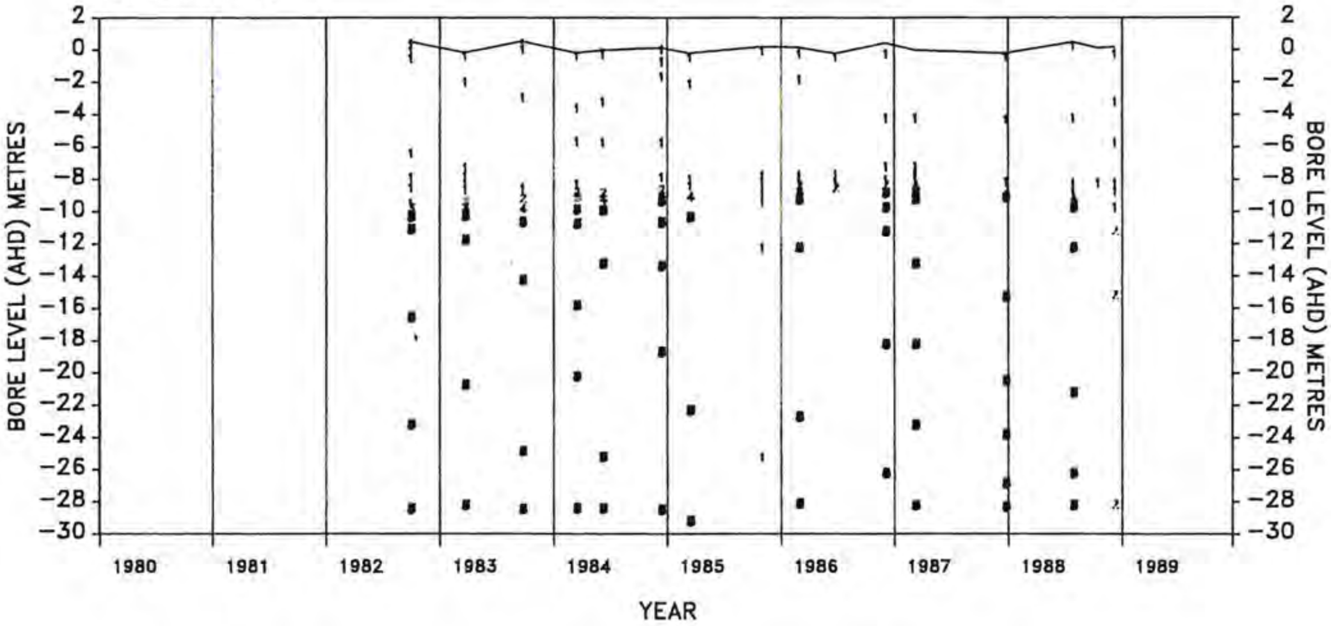
LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500		MG/L
2	500	TO	1000		MG/L
3	1000	TO	1500		MG/L
4	1500	TO	2000		MG/L
5	**2000**	**TO**	**3000**		**MG/L**
6	GREATER	THAN	3000		MG/L

STN=G61319144

PROFILE BORE D1



SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

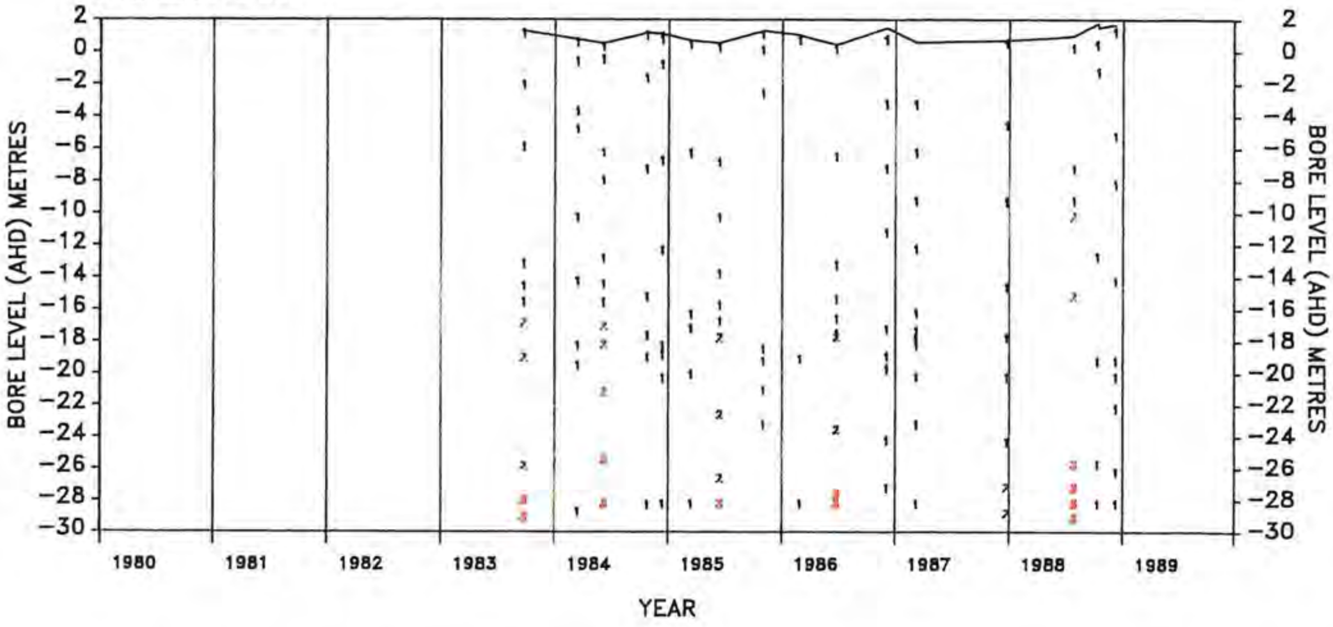
LEGEND

RANGE OF TDS DERIVED VALUES

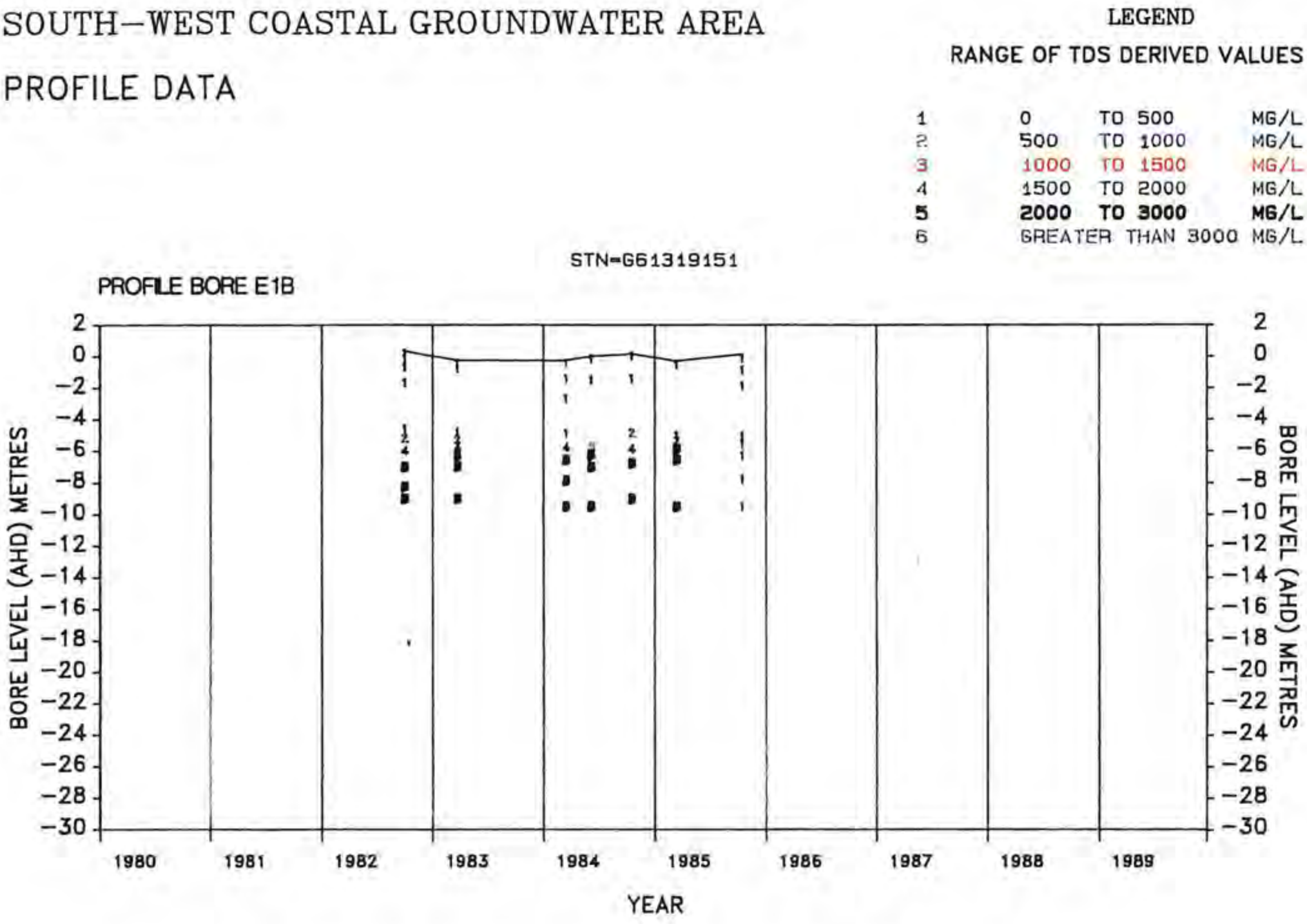
1	0	TO	500		MG/L
2	500	TO	1000		MG/L
3	1000	TO	1500		MG/L
4	1500	TO	2000		MG/L
5	**2000**	**TO**	**3000**		**MG/L**
6	GREATER	THAN	3000		MG/L

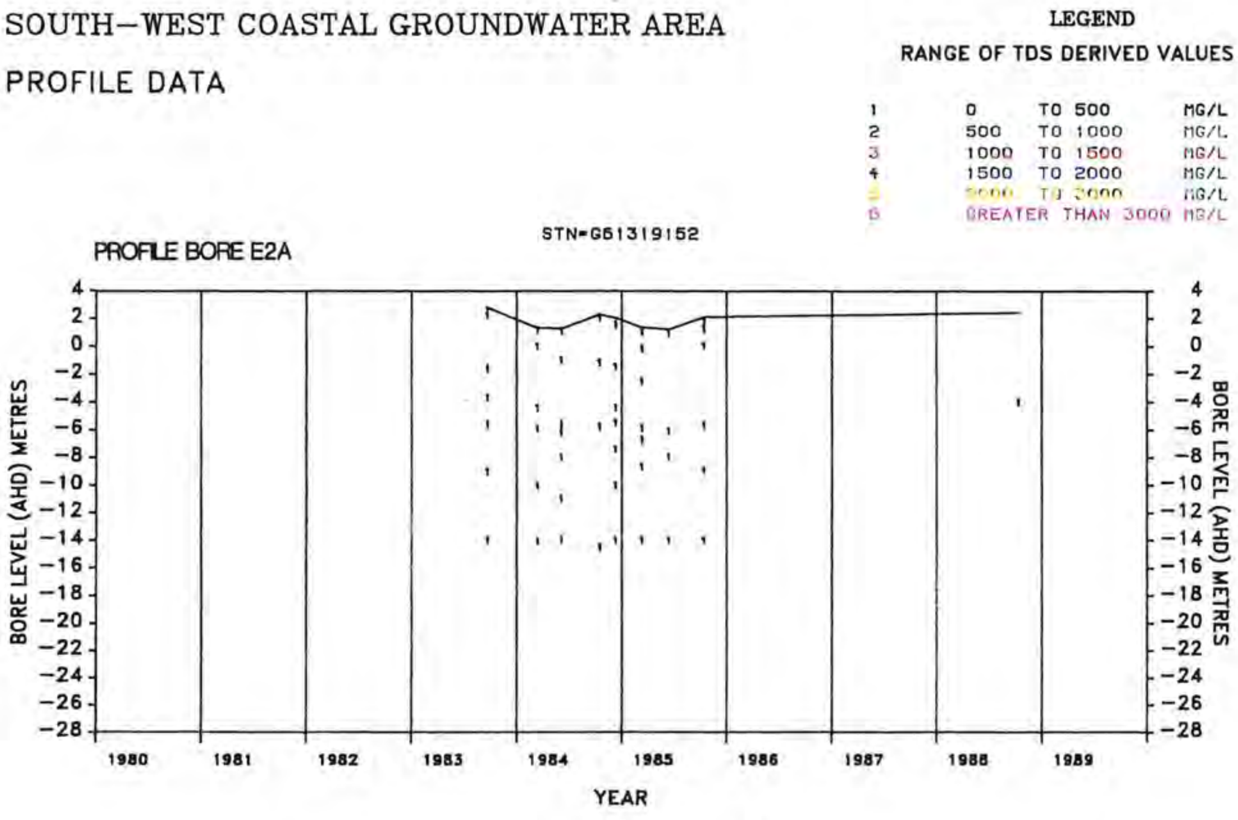
STN=G61319145

PROFILE BORE D2



LAKE PRESTON PROFILE BORES D1 AND D2 **Figure 30.**





LAKE PRESTON PROFILE BORES E1B AND E2A **Figure 31.**

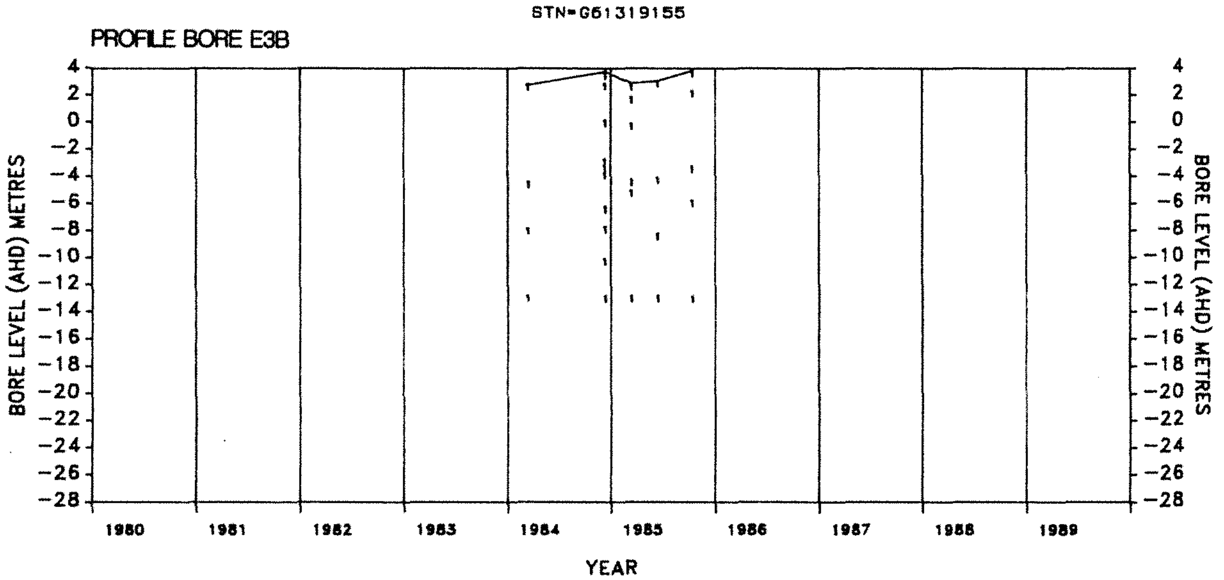
SOUTHWEST COASTAL GROUNDWATER AREA

PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	2000	TO	3000	MG/L
6	GREATER THAN 3000			MG/L



LAKE PRESTON PROFILE BORE E3B **Figure 32.**

SOUTH–WEST COASTAL GROUNDWATER AREA

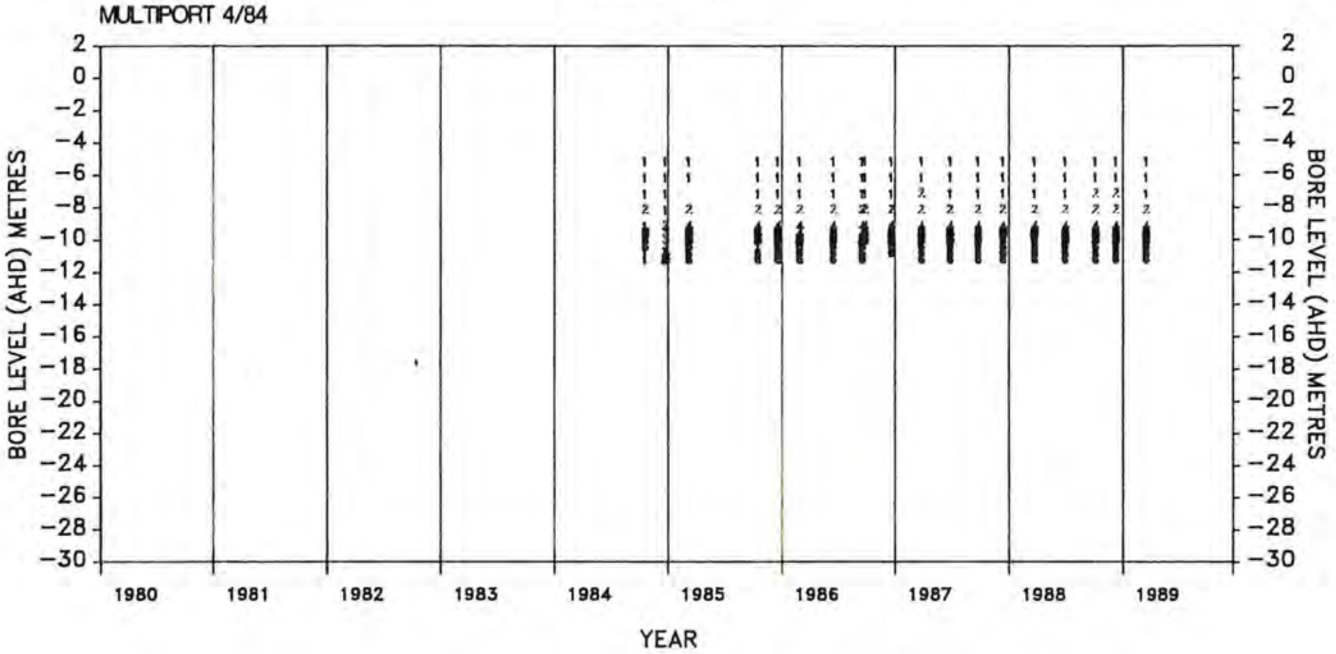
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	**2000**	**TO**	**3000**	**MG/L**
6	GREATER THAN 3000			MG/L

STN=G61319221



SOUTH–WEST COASTAL GROUNDWATER AREA

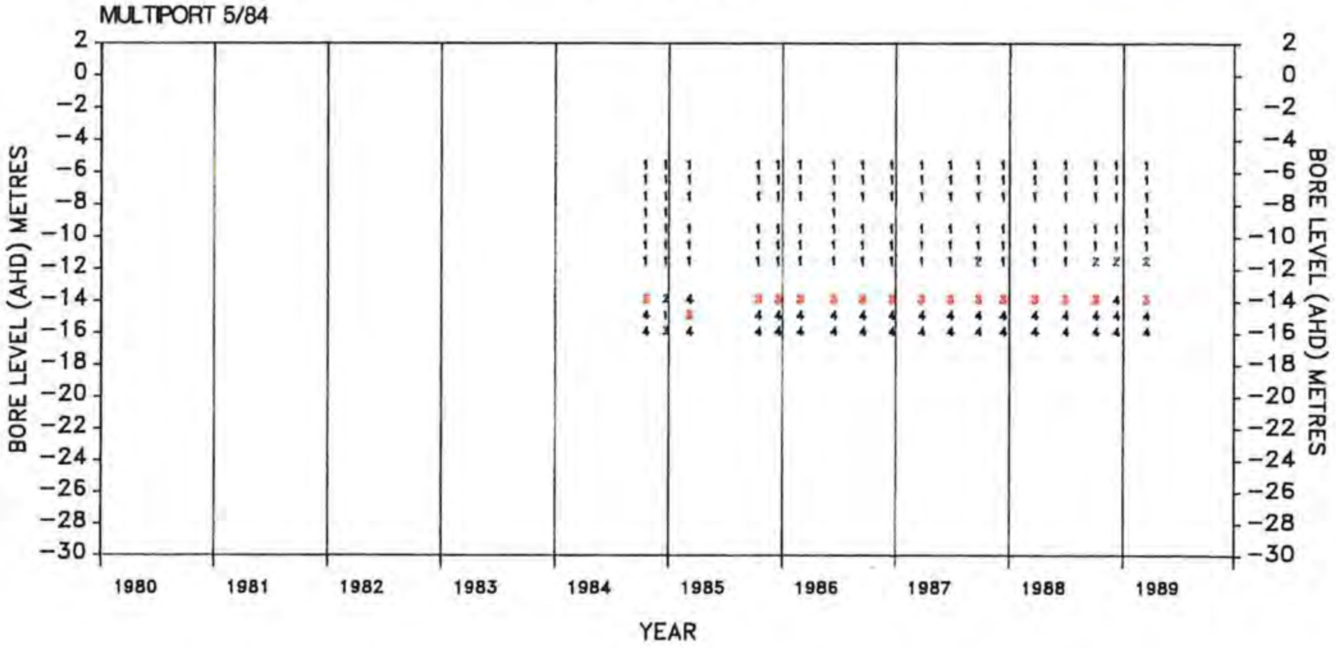
PROFILE DATA

LEGEND

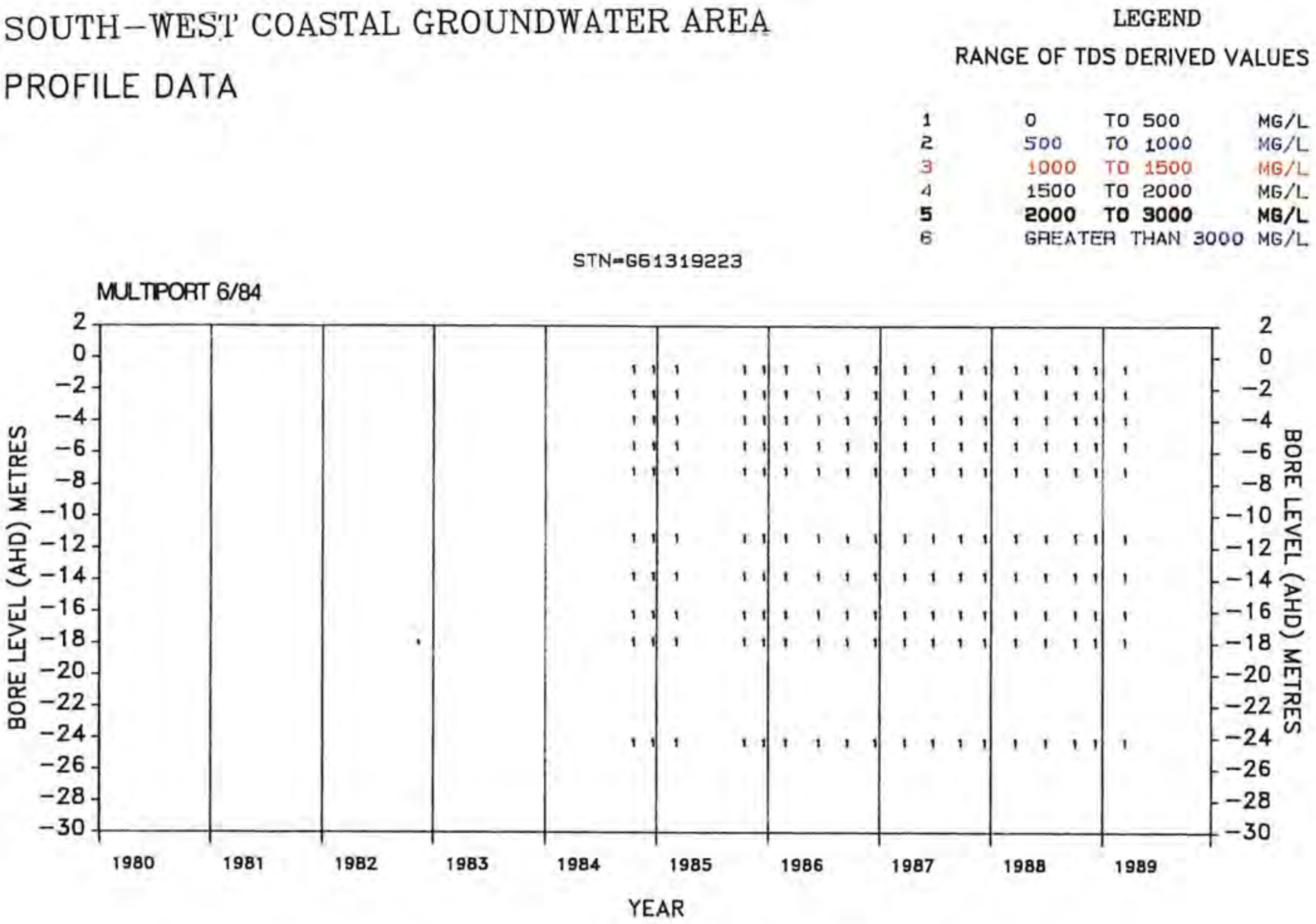
RANGE OF TDS DERIVED VALUES

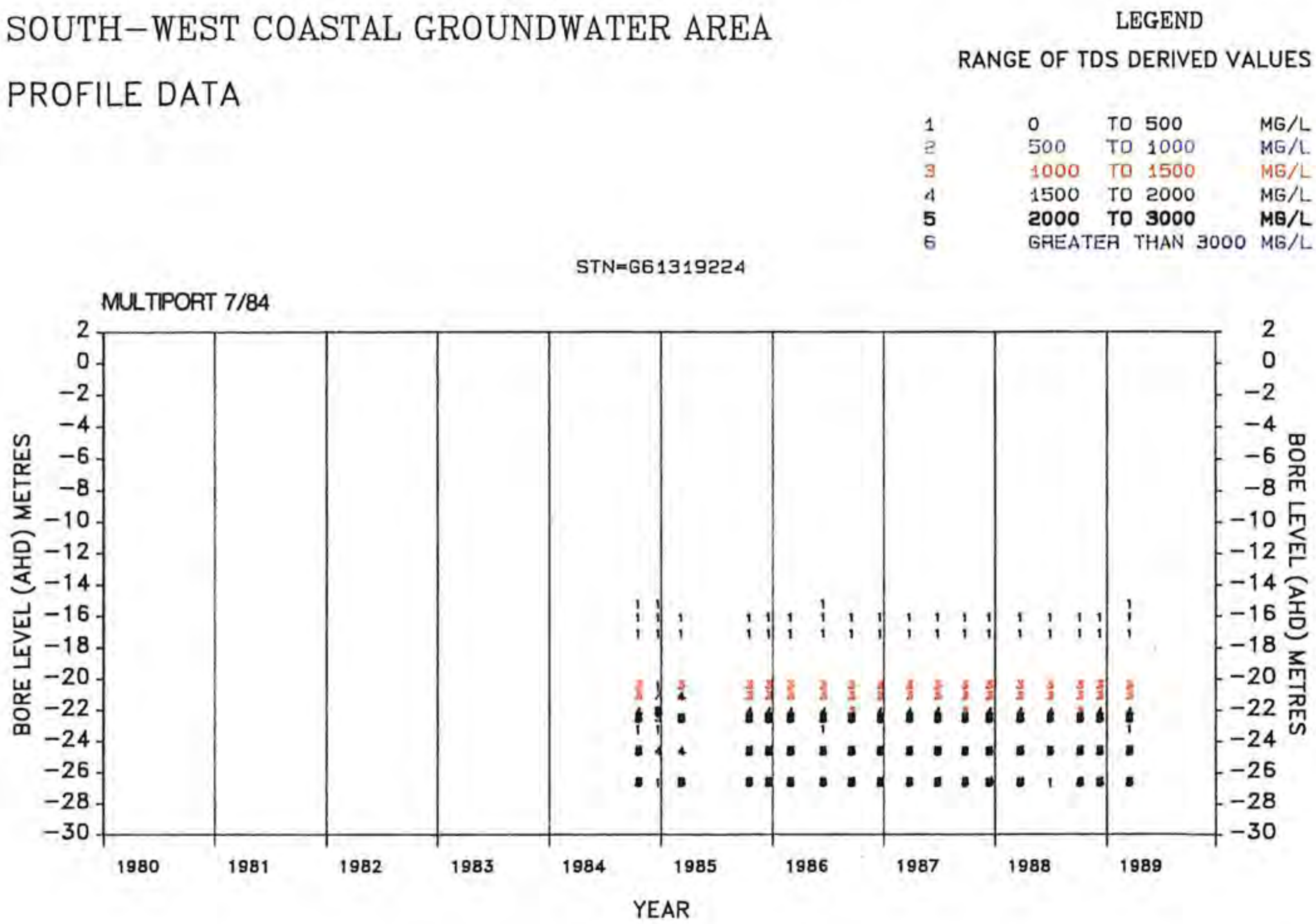
1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	**2000**	**TO**	**3000**	**MG/L**
6	GREATER THAN 3000			MG/L

STN=G61319222



LAKE PRESTON MULTIPORT BORES 4/84 AND 5/84 · Figure 33.





LAKE PRESTON MULTIPORT BORES 6/84 AND 7/84 **Figure 34.**

SOUTH–WEST COASTAL GROUNDWATER AREA

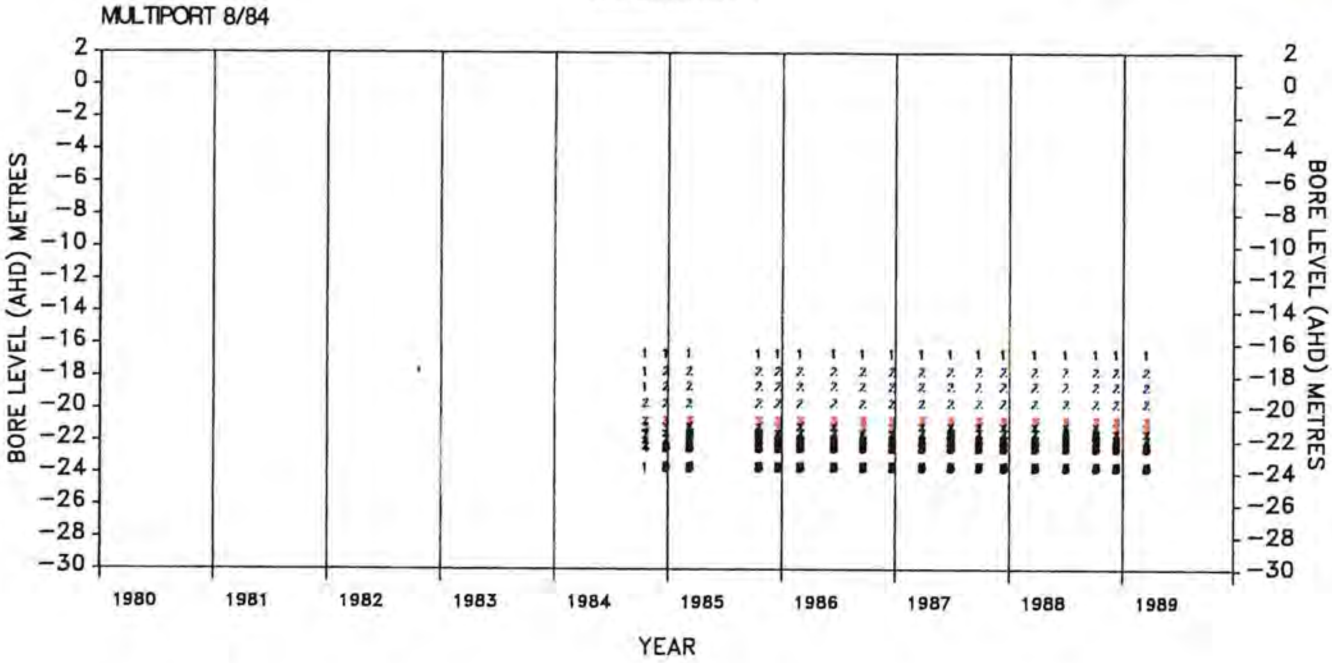
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	2000	TO	3000	MG/L
6	GREATER THAN 3000			MG/L

STN=G61319225



SOUTH–WEST COASTAL GROUNDWATER AREA

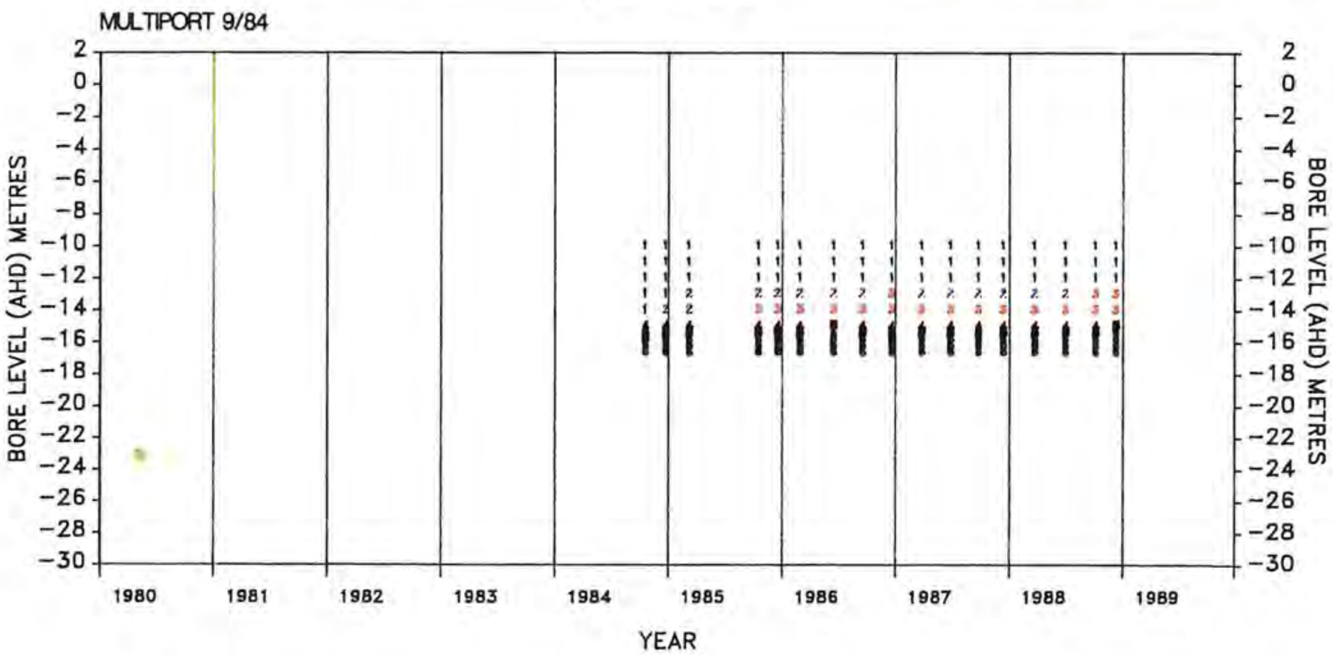
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	2000	TO	3000	MG/L
6	GREATER THAN 3000			MG/L

STN=G61319226



LAKE PRESTON MULTIPORT BORES 8/84 AND 9/84 Figure 35

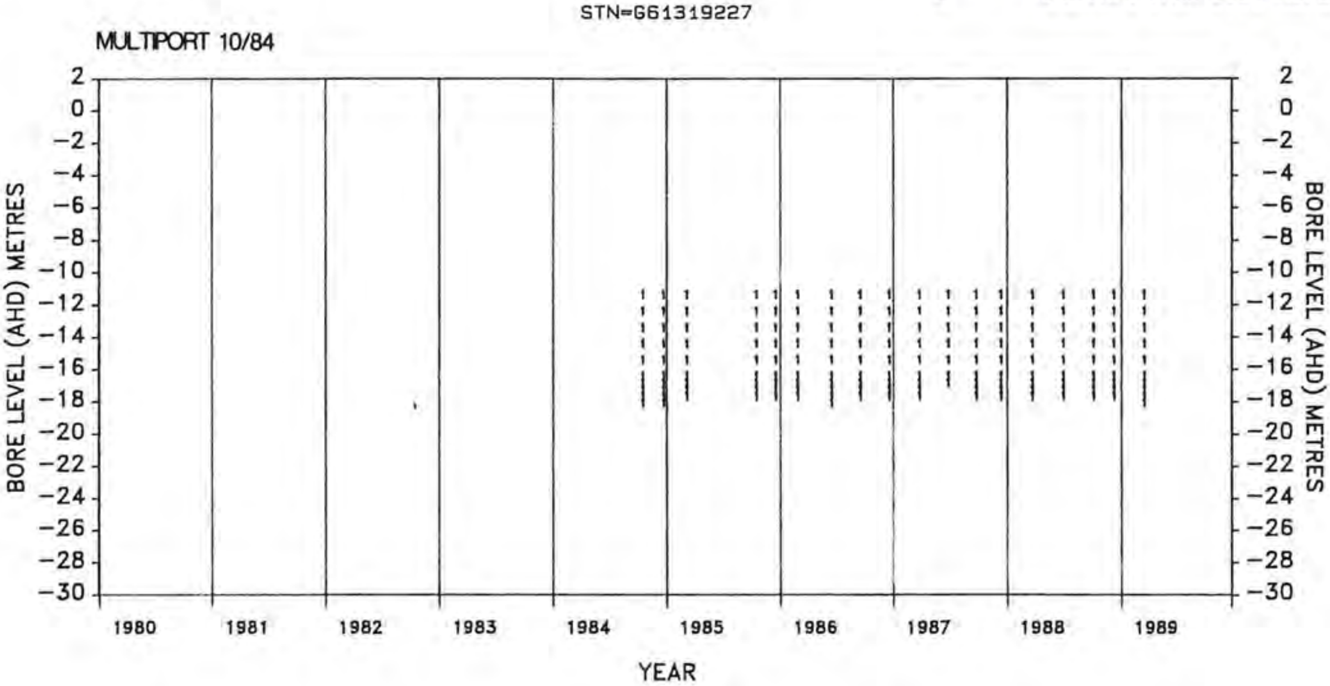
SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	**2000**	**TO**	**3000**	**MG/L**
6	GREATER THAN 3000			MG/L



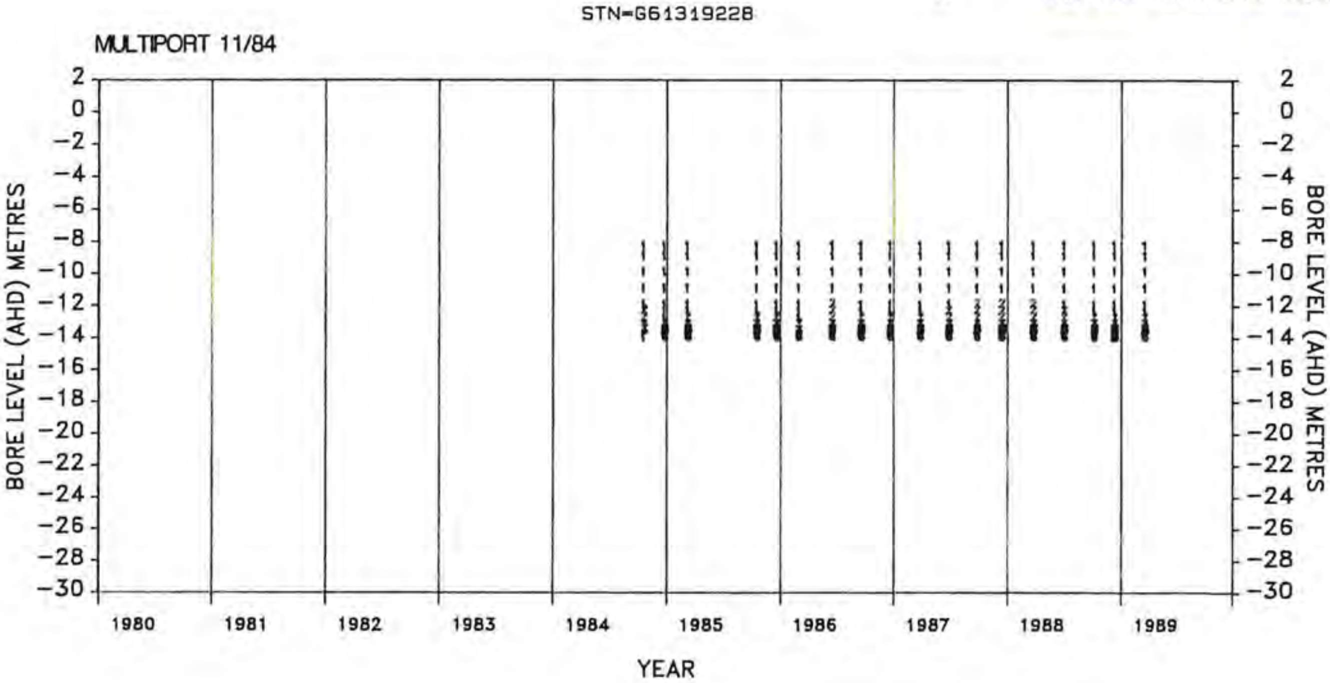
SOUTH–WEST COASTAL GROUNDWATER AREA

PROFILE DATA

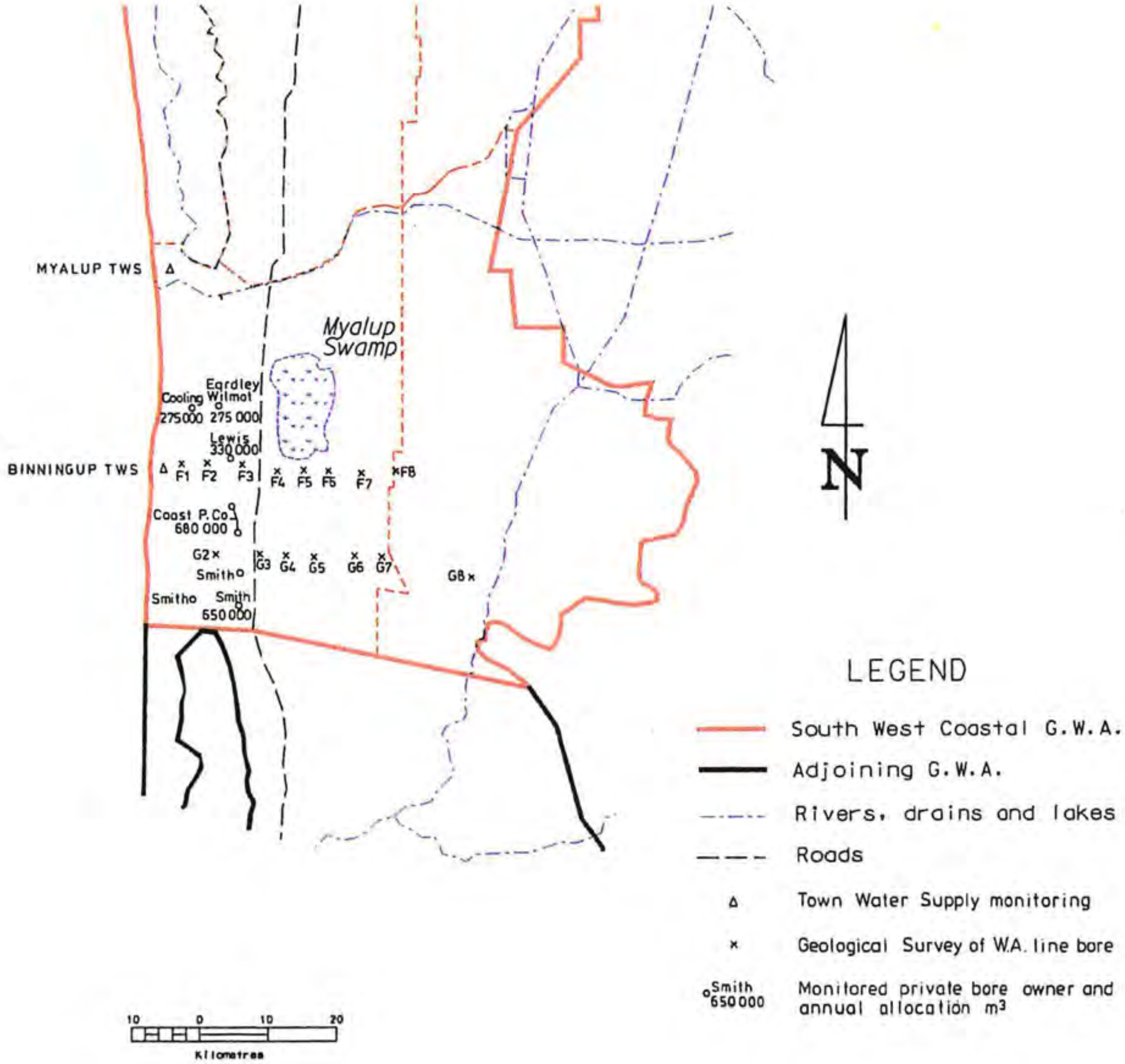
LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	**2000**	**TO**	**3000**	**MG/L**
6	GREATER THAN 3000			MG/L



LAKE PRESTON MULTIPORT BORES 10/84 AND 11/84 Figure 36



SOUTH WEST COASTAL GROUNDWATER AREA

MYALUP MONITORING LOCATIONS AND MAJOR ALLOCATIONS

Figure 37

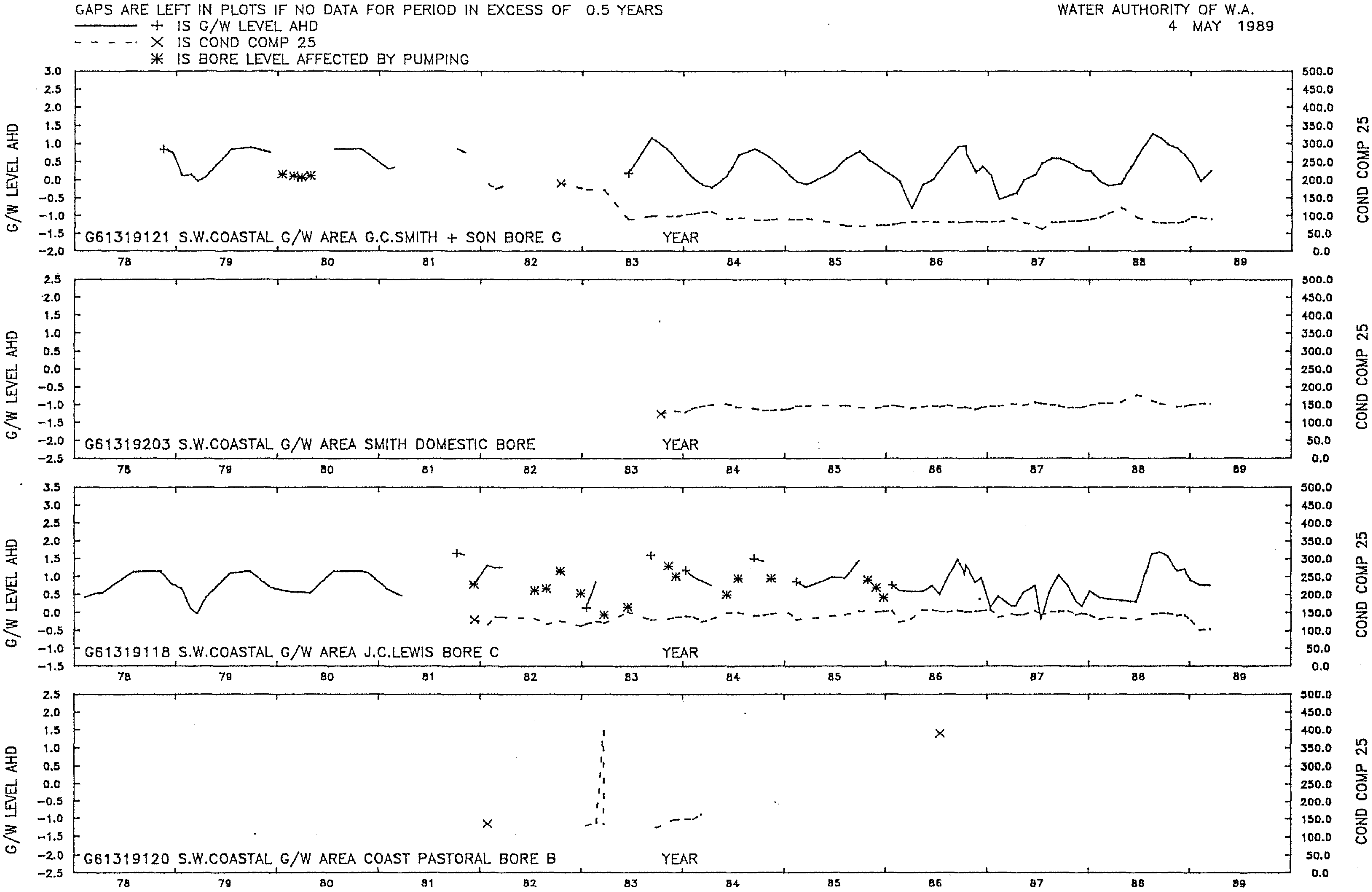


Figure 38. MYALUP PRIVATE BORE MONITORING

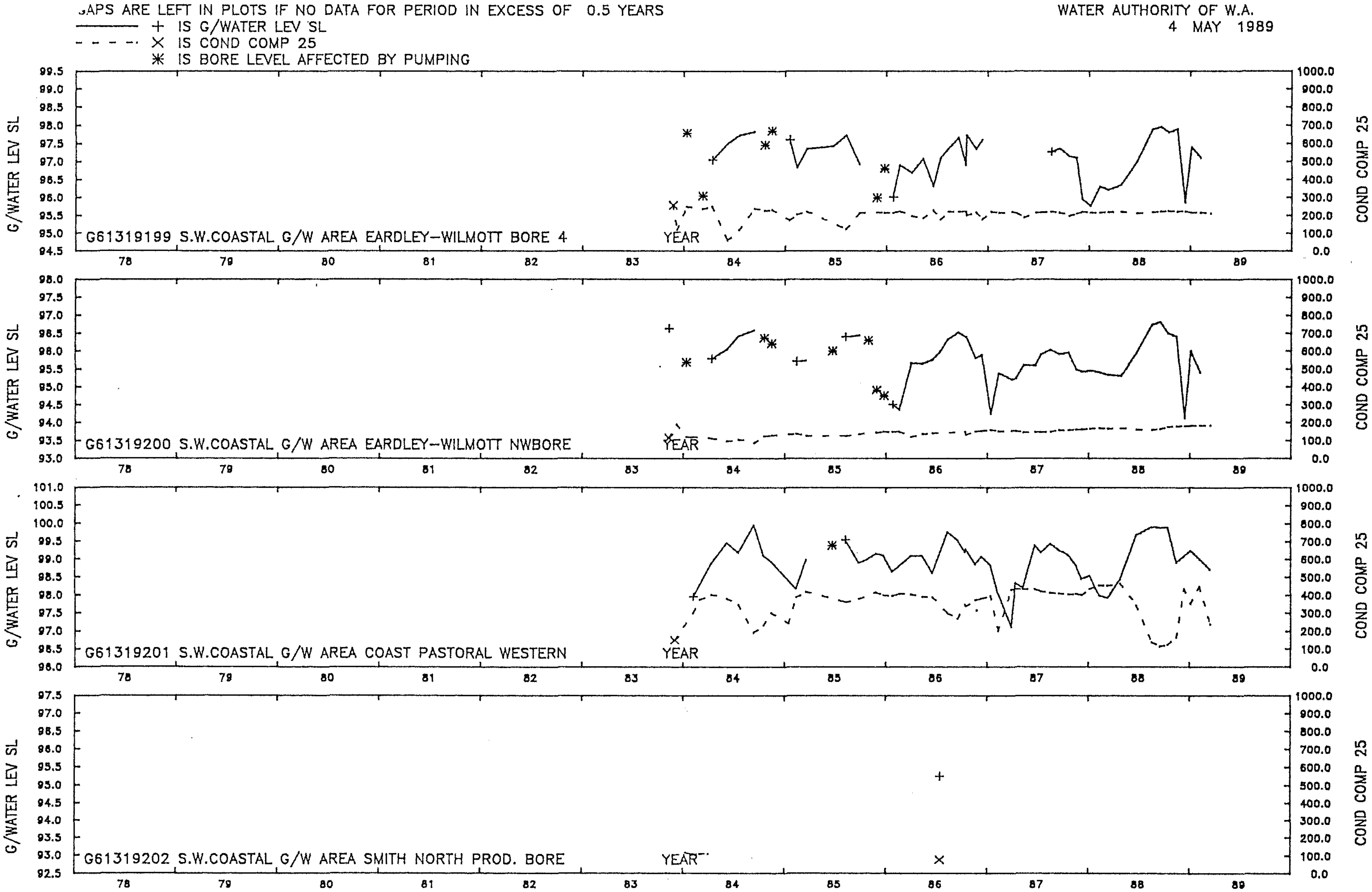


Figure 39. MYALUP PRIVATE BORE MONITORING

SOUTH–WEST COASTAL GROUNDWATER AREA

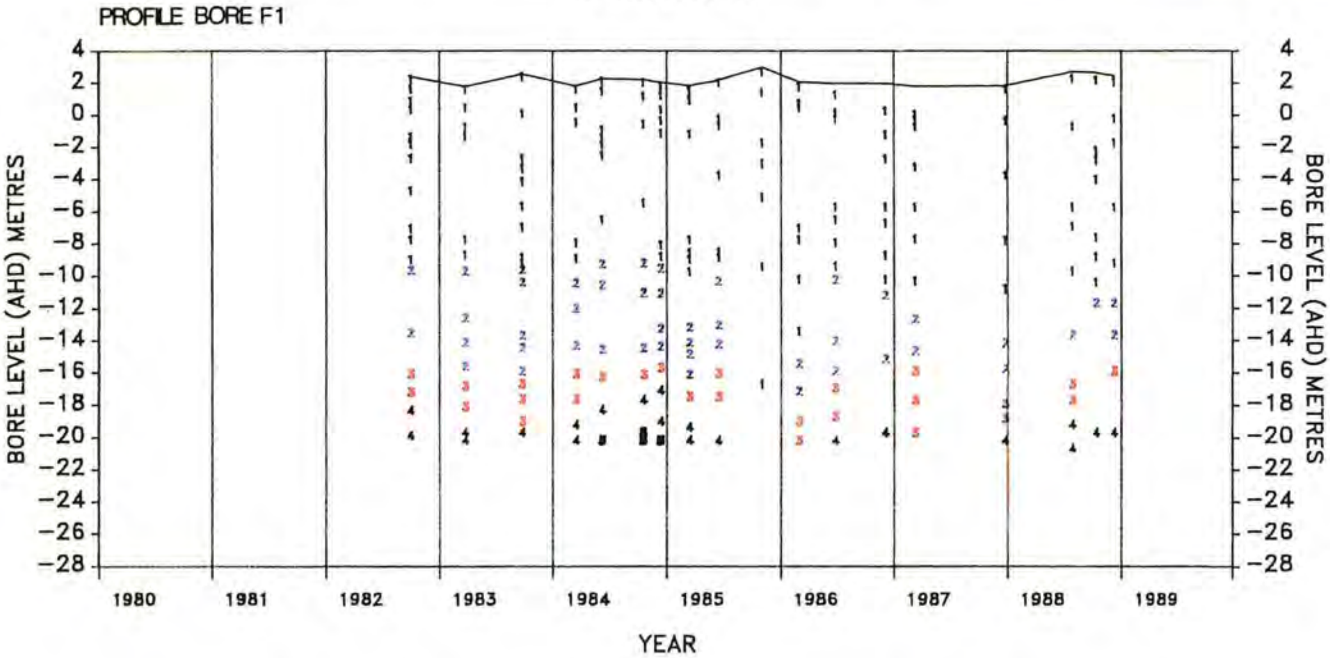
PROFILE DATA

LEGEND

RANGE OF TDS DERIVED VALUES

1	0	TO	500	MG/L
2	500	TO	1000	MG/L
3	1000	TO	1500	MG/L
4	1500	TO	2000	MG/L
5	2000	TO	3000	MG/L
6	GREATER THAN 3000			MG/L

STN=G61319165



MYALUP PROFILE BORE F1 **Figure 40**