# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



## RECORD

RECORD 1985/46

MURRAY BASIN HYDROGEOLOGICAL PROJECT

PROGRESS REPORT 14

for half year ending 30 September 1985

compiled by



W.J. Perry

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TABLE OF CONTENTS

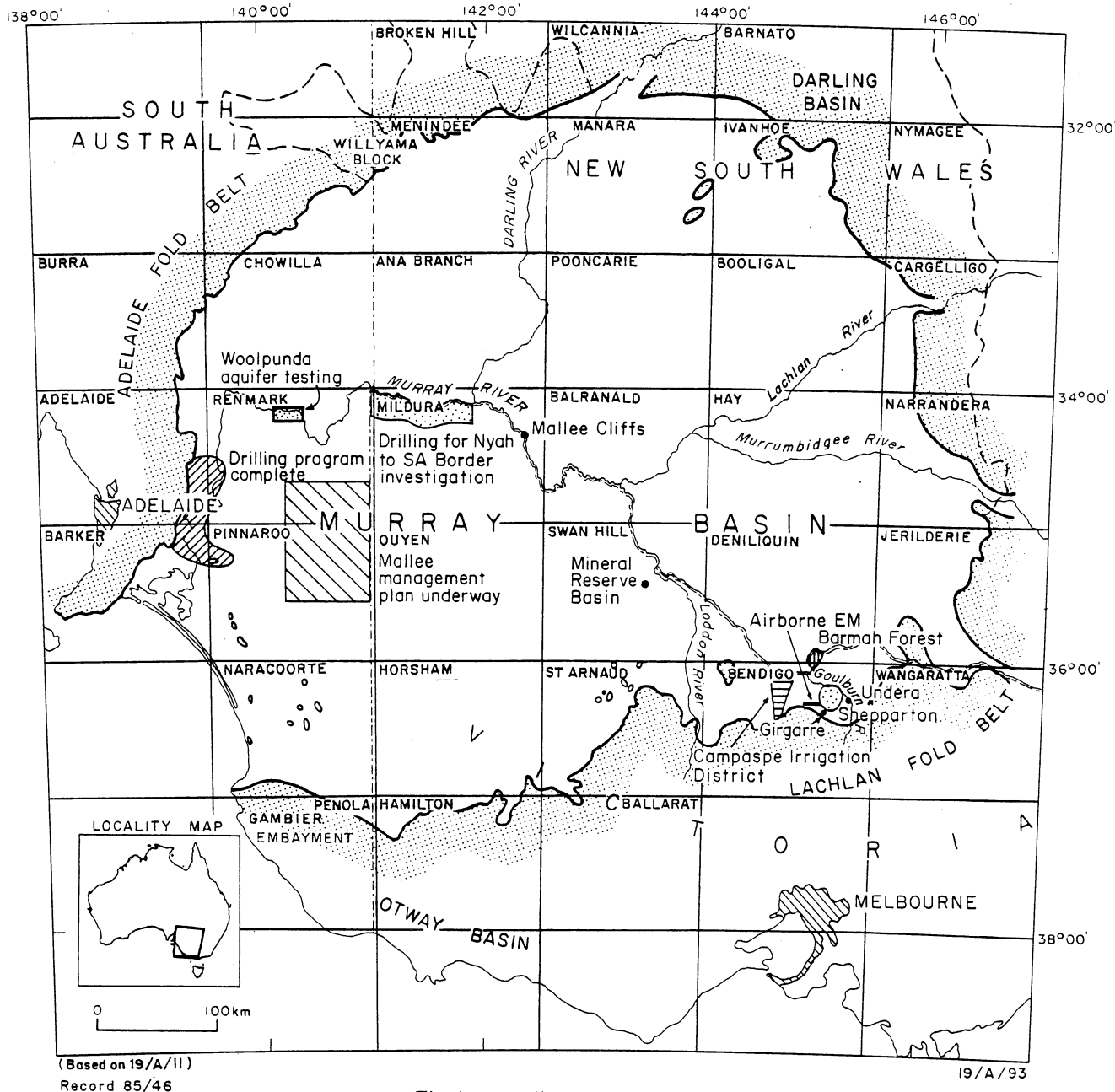



Fig. 1. Locality map

# INTRODUCTION

During the period the increased activity in groundwater modelling is indicated by the reports from various organisations, and by the account of the Southern Rinerine Plain Modelling Workshop held in September. At BMR a report on the Murray Basin subsurface stratigraphic data base is in press, work continued on the bulletin describing the geology of the basin, on an interpretation of geophysical features observed on total magnetic intensity images, and on compilation of existing hydrogeological data.

## SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY

**by**

**S.R. Barnett**

A drilling programme on the western margin has finished with seven observation wells being completed in the Renmark Beds confined aquifers. A further nine holes were drilled on Sirotem traverses over suspected shallow basement in the Swan Reach and Wynarka areas. Of interest was a quartz-biotite schist intersected at a depth of only 10 m in a hole 8 km west of Swan Reach. Suitable private wells are being selected for geophysical logging and levelling.

An aquifer testing programme on town water supply wells in the Mallee region yielded an average transmissivity value of 500 $m^3$/day/m for the Murray Group limestone aquifer. A management plan for the Mallee Proclaimed Region is being formulated (with EWS) on the basis that water use currently approximates groundwater inflow and recharge (about 5000 Ml per annum). A controlled mining situation is being considered. Monitoring of observation networks is continuing.

Further drilling and aquifer testing is being carried out for the Woolpunda Groundwater Interception Scheme. Eight observation wells have been drilled for the latest test. Modelling has suggested that upward leakage from the Renmark Beds confined

aquifers is quite significant in producing the observed water table configuration, notably a broad mound south of the river between Waikerie and Overland Corner.

A detailed assessment of hydrogeological data obtained from drilling programmes over the whole basin in SA has commenced. A three layer computer model of the Murray Basin south of the Murray and extending into Victoria has been initiated. The eastern boundary is the limit of the Murray Group limestone aquifer.

## WATER RESOURCES COMMISSION OF NEW SOUTH WALES

**by**

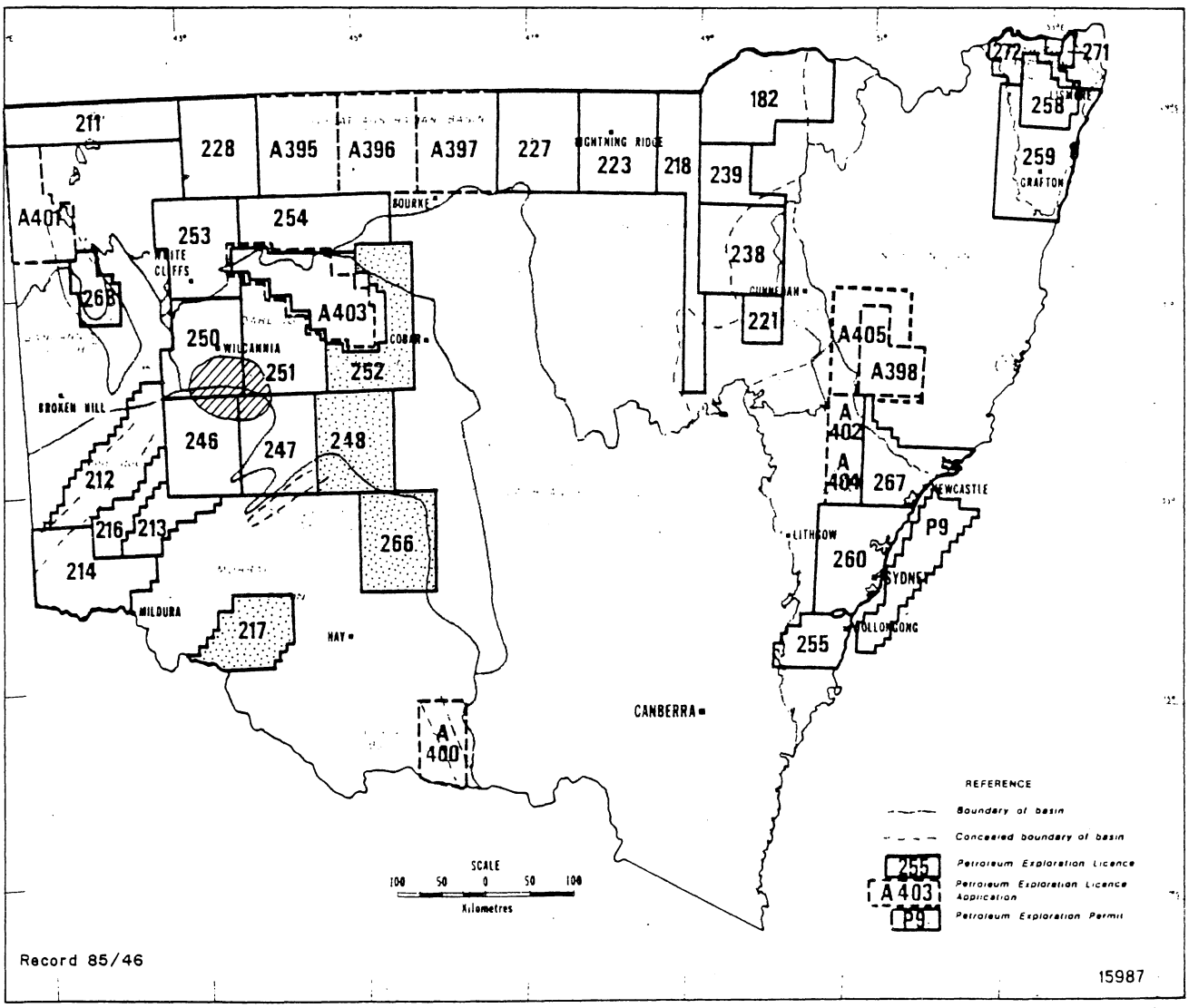
**D.R. Woolley**

The following includes material to the end of October 1985.

### 1. DRILLING

Six of the seven bores in the Tocumwal-Deniliquin area have been completed. They indicate alluvial depths up to 300 metres with sand and gravel aquifers, in some cases up to 40 metres, capable of yielding large supplies of groundwater to suitably constructed bores. These aquifers contain low salinity groundwater east of Deniliquin although this pattern is disrupted somewhat by the Cadell Fault. Further drilling both to the north and west of Deniliquin will be required, on the basis of these results, to determine the extent of groundwater resources in this area.

The first of the eleven bores proposed in the area between Jerilderie and Corowa has been completed. This program aims at determining the groundwater regime in this area with a view to planning proposals for irrigation and coal extraction. The groundwater salinity in this area is known to range between 1,000 and 4,000 mg/l TDS.




Relenquished PEL's

Reflection seismic Blantyre Trough

Fig.2. NSW Petroleum Exploration Titles, June 1985.

Drilling has commenced in the Prungle area, about 70 km north-west of Balranald. This project involves one bore to bedrock (at between 250 and 400 metres below surface) and six shallow (20 metre) bores being sunk to determine the groundwater regime of all aquifers and monitor changes to the water table due to clearing. The project involves various government departments as well as staff from the Australian National University.

Results from the Micropalaeontological examination of strata samples at Mallee Cliffs by V. Scheibnerova (Dept. of Minerals and Energy, N.S.W) have been received. The results are to be published and will be reported on by that Department.

## 2. GEOPHYSICAL SURVEYS

Seismic refraction traverses with a total length of 373 km were carried out in the Lachlan and Murrumbidgee groundwater areas of the Murray Basin.

The results indicate a NNE trending pre-Tertiary bedrock ridge that occludes the Renmark Group and in some areas the Pliocene aquifers west of Balranald. A report on this work is currently being prepared and should be available by the end of 1985.

## 3. RADIO-CARBON DATING

C-14 samples taken, in conjunction with the Australian Atomic Energy Commission to augment those taken by BMR, in the Lower Lachlan area west of Hillston are currently being evaluated by BMR. Analysis of these results will give a more complete view of groundwater in this area.

## 4. GROUNDWATER MODELLING

While not strictly part of this project, the Commission is currently participating in a joint project with Victorian water authorities to produce a groundwater flow model which will

include the Riverine Plain in N.S.W. south of Jerilderie.

Modelling of the groundwater regime in this area will enable management options in the area of study to be evaluated.

## 5. STAFF

A hydrogeologist has commenced duties at Leeton. Part of this officer's duties relates to this project.

**GEOLOGICAL SURVEY OF NEW SOUTH WALES**

**by**

**D.H. Probert**

## 1.COAL EXPLORATION

### OAKLAND BASIN

The Coal Cliff Collieries Pty Ltd and Mitubishi Development Pty Ltd have now formed two separate joint ventures as follows:

1. Oakland South Exploration Joint Venture comprising A207 and 250 (formerly Mitubishi).

2. Oaklands North Exploration Joint Venture comprising A345 (formerly Coal Cliff Collieries).

The Coal Cliff Collieries Pty Ltd manages the two joint ventures.

A further exploration programme has commenced to further define optimum coal quality zones for mine planning feasibility studies.

C.R.A. Ltd, the parent company of Coal Cliff Collieries, has prepared a proposal for development of a large open cut coal mine and power station based on the Oaklands coal. This proposal has been discussed with Government and with the Electricity

Commission. The proposal was recently presented to the McDonell Inquiry into Electricity Generation Planning and is being considered by the Inquiry.

The proposal calls for mining of 5.3 Mt of coal per year initially, increasing to 10.6 Mt per year when the power station is increased to full size (4 x 660-700 Mw units). Cooling water may be obtained at least partly from dewatering of the mine and possibly from ground water.

## 2. PETROLEUM EXPLORATION

PEL's 248, 252 and 266 have been relinquished by BHP Petroleum.

PEL 217 (COMSERV title held by Claremont Petroleum) was not renewed.

BHP Petroleum have recently recorded 2 series of seismic lines 244 km and 227 km respectively in the Blantyre Trough area.

Claremont Petroleum are currently recording their Popiltah seismic survey which covers the area between the Ennisvale and Popiltah wells in the Tarrara Trough (PEL's 212, 214). Three phases of the survey are programmed of 130 km, 140 km and 50-100 km. Targets are Permo-Carboniferous structures.

## 3. MINERALS EXPLORATION

CRA Exploration have applied for a series of exploration licences for heavy minerals sands within the New South Wales section of the Basin.

## RURAL WATER COMMISSION OF VICTORIA

**by**

**R. Evans**

The Rural Water Commission of Victoria is engaged in the following hydrogeological investigations in the Murray Basin:

1. Shepparton Phase A Groundwater Control - A number of existing pumpsites which extract groundwater from the upper Shepparton Formation to provide water table control, were reviewed and more observation bores were installed where required. These sites are all located in the Shepparton Region.

2. Campaspe Irrigation District Salinity Investigations

   - Observation bores around two trial pumpsites in this area have been read fortnightly and water table contours have been drawn. The project is being evaluated.

   - A study of water usage from Campaspe drains was carried out to determine the effects of groundwater discharge on diverters.

   - Groundwater flows in the Campaspe deep lead were modelled to determine the effects of intensive pumping from the lead on groundwater quality.

3. Girgarre Salinity Investigations - The Girgarre groundwater model of the topmost aquifers in the Upper Shepparton Formation was calibrated using monthly piezometer levels from over 80 observation bores for a 2 year period.

   - Hydraulic conductivities were tested at the site of a proposed evaporation basin which will take highly saline groundwater from a groundwater control pumpsite.

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4. Undera Recreation Reserve - Observation bores were drilled in this reserve to locate an aquifer which could be pumped to alleviate the high water table problems. Five trial wellpoints were installed and tested and the project was documented.

5. Barmah Forest - Nineteen observation bores were drilled in the Barmah Forest to assess water table levels during normal seasons and in times of flood.

6. Regional Hydrogeological Investigations - Drilling on the Kanyapella Section continued, with bores being drilled to 25 metres depth along an east-west section from Echuca to the Goulburn River.

- Modelling of groundwater flows in the shallow aquifers at Tongala and Katunga commenced.

- Farm Exploratory Drilling - Drilling assistance was carried out on a number of properties in the Shepparton Region to locate usable aquifers.

7. Mineral Reserve Basins - Exploratory drilling at eleven proposed interceptor sites was completed and 7 day pumping tests were carried out at all sites. A hydrogeological report on these investigations was prepared.

8. Airborne EM.

A report has been received from Geoterrex Pty. Ltd. who carried out an airborne electromagnetic survey in the Shepparton Region in April 1984. The results of this research project are currently being reviewed and are also being followed up with land based EM surveys. Results to date indicate a promising technique for low-cost broad scale aquifer delineation to enable more rational location of bore holes.

9

9. Nyah to South Australian Border Hydrogeological Investigation.

Drilling over the last 6 months has involved constructing 40 observation bores between Merbein and the S.A. border, up to 30 km south of the Murray River. Deep unconfined Parilla Sand aquifer was evident in the south western sector of the investigation area. The maximum water table depth so far discovered is 67 m at Meringur. Regular monitoring of groundwater and Murray River water levels continued.

10. Mallee Cliffs Groundwater Interception Investigation.

Meetings have been held with the River Murray Commission and the W.R.C. of NSW to develop strategies for dealing with this area of high saline inflow. A contract will be let to a consultant in early 1986 to undertake the design of the scheme.

**DEPARTMENT OF INDUSTRY, TECHNOLOGY AND RESOURCES, VICTORIA**

**by**

**C.R. Lawrence**

This report summarizes a meeting - the Southern Riverine Plain Modelling Workshop - held in September, on current and prepared groundwater modelling projects in the Murray Basin and the data needs of these projects. The Workshop provided an opportunity for the Modelling Sub-Committee of the Murray Basin Hydrogeological Project to meet, and also for the development of a regional groundwater modelling project of the Victorian portion of the Riverine Plain and the adjoining portion of N.W.W.

**ATTENDANCE**

| | |
|---|---|
| DITR (Vic) | Dr. C. Lawrence (Chairman) |
| | Dr. P. Macumber |
| | Mr. R. Lakey |
| | Mr. M. Reid (Secretary) |
| | Mr. M. Pratt |
| RWC (Vic) | Dr. Richard Evans |
| | Mr. W. Trewhella |
| | Mr. D. Ife |
| | Mr. T. Oakes |
| WRC (NSW) | Mr. N. Merrick |
| | Mr. G. Gates |
| DARA (Vic) | Dr. R. Wildes |
| | Mr. C. Lyle |
| DCFL (Vic) | Mr. P. Dyson |
| | Ms. F. Lewis |
| BMR (Commonwealth) | Mr. Ray Evans |
| Dept. Ag. (NSW) | Mr. D. Marston |
| DWR (Vic) | Mr. G. McConnell |

DARA - Dept. of Agriculture and Rural Affairs, Victoria
DITR - Dept. of Industry Technology and Resources, Victoria
RWC - Rural Water Commission, Victoria
WRC - Water Resources Commission, N.S.W.
DCFL - Dept. of Conservation, Forests and Lands, Victoria
BMR - Bureau of Mineral Resources, Commonwealth, Dept. of Resources and Energy
DWR - Dept. of Water Resources, Victoria

## 1. REGIONAL PERSPECTIVE

Dr. P.G. Macumber (Dept. of Industry, Techology & Resources)

The main purpose of the proposed regional groundwater modelling is salinity research. Two key points about the Riverine Plain/Murray Basin groundwater system are: 1. That it is non-steady state, and 2. that catastrophic events have a marked effect on the system and, in the case of flooding, often irreversible effects.

The Murray Basin is a closed groundwater basin with the Murray River as the main discharge feature. With the spread of salinization, the Murray River salinity must increase also.

Relatively small increases in the surface water budget substantially alter the groundwater equilibria in the Basin.

Riverine Plain regional aquifers are filling up with no sign of regional equilibrium being reached - even the lower Loddon Valley is not in equilibrium despite already high pressures and significant discharge occurring. Similar rising trends have been observed in the Mallee and the Highlands.

The lower Lodden Valley is a regional discharge zone. The 1973 to 1975 wet period expanded this zone approximately 20 km towards the Highlands. The Campaspe, Murray and Goulburn Valleys are presently recharge zones with the deep regional aquifers acting as deep drains. This deep drainage, however, diminishes as the aquifers continue to fill, so that more water remains in the local flow systems and permanent high saline water tables result.

The lake/lunette systems reflect past high saline water table conditions.

Northern Victorian observation bores have recorded rises in water levels over time. Some remain steady during normal years with significant rises after a catastrophic wet event and others record a steady rise even during normal years.

Even bores within the discharge zone of the Loddon Valley have recorded rising pressures including a big response to the 1973-1975 wet. In the Campaspe Valley, rates of pressure rise vary from 0.25 m/year in the Elmore area to 0.1 m/year north of Rochester. In the Goulburn Valley, rates of rise average 0.15 m/year.

Even in dryland areas such as Waggarandall and Tabilk and in the highlands piezometers have recorded very similar overall rates of rise to those in irrigation areas.

If groundwater pressures in the deep regional aquifers continue to rise, the effectiveness of these aquifers as deep drains will diminish to the point where permanent high saline water tables will occur over widespread areas.

Future salinity control schemes must take these rising pressures into account. For example, dewatering and re-use of groundwater, by themselves, will still tend to increase stream and groundwater salinities in the long term.

It is seen that the two main aspects to be accommodated in the proposed regional Riverine Plain model are:

1. Hydrologic thresholds - catastrophic events (i.e. major wet and dry events).

2. Regional trends

## 2. REGIONAL PROJECTS

### 2.1 Murray Basin Project

Ray Evans - Bureau of Mineral Resources

(a) Compilation of geological data is almost completed - information from approximately 2000 bores. Report on geology is 75% completed. Geological sheet of the Murray Basin (Campbell Brown) is close to completion.

(b) 1:250 000 hydrogeological sheets are being prepared. Some in NSW are in various stages of completion.

(c) Modelling is in the initial stages only. The model is a 3D finite difference model with 6 active layers and 2 inactive layers. The active layers are as follows:-

- Shepparton Formation - aquifer
- Pliocene sands, comprising Parilla Sand, Calivil Formation and Loxton sands - aquifer
- Bookpurnong Beds - semi-confining layer
- Renmark Group - aquifer
- Murray Group limestones - semi-confining layer
- Ettrick Marl - confining layer.

The model has a 17 x 13 grid with a node size of 57 x 47 km. It is later intended to split the grid down to 1:50 000 sheet size.

**Present status:** Steady state calibration stage.

### 2.2 NSW Water Resources Commission (Noel Merrick and George Gates)

Presently, drilling is being carried out in the Deniliquin-Mathoura-Tocumwal area. Observation bores are being established with 3 or 4 aquifer levels being tapped at each site, namely,

Shepparton Formation
Calivil Formation
Olney Formation
Olney Formation | - Renmark Group
Warina Sand |

The next areas of investigation will be the Berriquin and Wakool areas. The Wakool area will be studied in connection with the evaporation ponds project which involves disposal of saline groundwater from a bore dewatering system. 40 bores service an area of some 16 000 ha. The water table has been lowered from about 1 or 2 m to 5 m. It is proposed at this stage to dispose of the evaporation pond bittern salts by deep well injection into the Olney Formation.

Bores are being sited using seismic refraction interpretation. Water levels will be read every 2 months and each bore will be sampled for chemical analysis. It is intended to install 30 automatic water level recorders. A report on the drilling programs is expected to be completed in approximately 2 years time.

Patterns and rates of rise in groundwater levels similar to North Victoria have been observed in the southern Riverine Plain of NSW. The highest rate of rise observed is approximately 0.25 m/year. Estimated groundwater accessions average 2-3 ML/irrigated hectare/annum under rice and 0.5-1 ML /irrigation hectare/annum under other crops. The figure for rice may be significantly higher in some areas.

In the Denimein Irrigation District, 6% of the area had a water table within 4 m of the surface in 1970. By 1977, 22% of the area had a water table within 4 m and by 1980, 27%.

The Berriquin and Denimein Districts are to be modelled (shallow aquifers only) by consultants in the near future in an endeavour to predict salt loads into the new channel and hence

the Edward River.

2.3 Victorian Rural Water Commission (Dr. Richard Evans, Bill Trewhella and David Ife)

High water table occurrence can be traced back to the 1930's with the situation rapidly worsening in the 1950's and 60's. In the Shepparton Region 40% is irrigated. 40% has a water table within 3 m of the surface and 20% has a water table within 2 m. It has been estimated that the total accession to the water table in irrigation areas is about 100 mm/year on average and that 20% of this leaks down to the deep aquifers.

The Commission is currently working on a generalized shallow aquifer model for all the river systems (i.e. Murray, Goulburn, Campaspe, Loddon). Soil types and groundwater pumping will be taken into account.

The types of modelling proposed for the near future fall into two categories, namely,

1. Real field situations - recharge/discharge

2. Generalized modelling and sensitivity analysis

The Girgarre (Vegter scheme) model comprises 90 cells, each 1km x 1km. A distribution of Q's (flows) was obtained which tallied with the transmissivities (T), hydraulic conductivities (K), storage coefficients (S) and heads. The Q's were then related to crop type. The model produced recharge values ranging mainly between 0.5 and 1 ML/ha/year. The lower values occurred in dryland and perennial pasture areas. Recharge rates were higher in areas where groundwater was pumped, indicating greater vertical leakage. Discharge values varied between 0.5 and 2 ML/ha/year.

It would be preferred in future to run an optimization program in conjunction with this and similar models to fix certain data and, say, leave one variable (eg. Q).

Another future area of study could be the effect on leakage of deep groundwater pumping (eg. Campaspe Valley).

## 2.4 Dept. of Agriculture and Rural Affairs, Victoria (B. Wildes and C. Lyle).

Much work is currently being done in studying the effect of various agricultural practices on water-table accessions and the salt profile, and of re-using water of different qualities. Modelling is being undertaken to define water balance in the soil zone. Soil moisture analyses and mass balances of non-adsorbent ions are being carried out on a continuous basis.

At the Tongala Research Farm, there is a 200 m grid network of shallow observation bores (2 or 3 m) and a 500 m grid network of 12 m observation bores. The observation bores are measured weekly and cover an area of 600 ha.

The volume of discharge to and from the drains and the volume and quality of groundwater pumped have been measured on a weekly basis for 4 years.

Water table accessions at the Tongala Research Farm of up to 50 mm/year have been estimated but much of this is re-used. The groundwater pumping appears to have stabilized the water table at between 1 and 1.5 m. The pumping averages 2 ML/yr/ha.

Research has found that increasing the electrolyte content of water increases its leaching ability. Re-using saline water at Tongala has increased the leaching fraction as much as threefold.

Work is underway on a finite-difference model of the unsaturated zone which will be used to predict recharge/discharge

fluxes and salt movement.

Evaporation tests in laboratory conditions have been performed on undisturbed soil cores 25 cm in diameter. Evaporation has been measured for different water table levels, namely, 50, 60 and 90 cm. Results so far suggest that under irrigated conditions, areas with water tables as shallow as 60 cm can yield productive pastures. Soil moisture and salt distribution in the cores have also been analysed. In the near future, it is proposed to run similar tests on cores 80 cm in diameter and 2 m depth.

2.5 Dept. of Conservation, Forests and Lands, Victoria (P. Dyson and F. Lewis)

Similar groundwater pressure trends to those observed in the plains have been observed in the highland areas. Even observation bores in forested highland areas are recording similar pressure increases to cleared areas. The responses under forested areas mostly reflect a regional transfer of pressure rises under neighbouring cleared areas.

The bedrock fracture systems are proving to be larger and more complex than was previously thought. Recent bores drilled near Bendigo are capable of yielding between 20, 30, l/s from fractured bedrock.

There is a serious situation developing in the highland areas with many streams now having saline base flows. One of the worst affected streams is Axe Creek which is a tributary of the Campaspe River and removes an estimated 15,000 tonnes per annum (or 600 kg/ha/annum) of salt. Salinized highland areas are increasing steadily in number and size.

Increasing salinity trends were observed in the highlands in the late 1950's and rapid expansion of saline areas occurred during the very wet period from 1973 to 1975. Unfortunately, bore hydrograph data does not exist prior to 1975.

Attempts have been made to quantify groundwater recharge for different soil types and landscapes. For example, in rocky ridge areas, water level fluctuations of 5 to 6 m are common during wet years and in lower, weathered areas with duplex soils, fluctuations are commonly 1 to 2 m during wet years.

Geomorphic mapping is in progress to try to isolate or at least broadly identify major recharge areas, eg. rocky ridges and major fault zones.

The major jointing in the sedimentary bedrock is across strike. In support of this is the observation that the preferred drawdown is usually along strike.

Bendigo mine data indicate that significant water-bearing fracture zones may even occur deeper than 200 metres.

Potentiometric patterns in the highlands conform to catchment areas rather than regions, therefore future groundwater models will be run on a catchment basis.

There is continuing research into alternative dryland management with a view to reducing water table accessions. Some encouraging results have been obtained at an experimental lucerne plantation where the water table has been lowered by 3 metres.

There is a need for a systematic stream sampling program to accurately evaluate the amount of salt moving out onto the plains from the highland catchment.

## 3. SOUTHERN RIVERINE PLAIN MODEL - OVERVIEW AND OBJECTIVES

R. Lakey (Dept. of Industry, Technology & Resources)

The southern Riverine Plain is a hydrogeological unit and should be modelled as such. Salinity and water-logging are regional problems and the situation with regard to each is

similar in Northern Victoria and Southern NSW.

Modelling is the next logical step after a flow net analysis and it enforces a disciplined approach to collection of data. The data base used for the Southern Riverine Plain model will be supplied to each of the participating organizations.

A sound hydrogeological framework must be established to enable further detailed studies to be carried out, eg. catastrophic climatic events and their effect on the groundwater system.

A large scale regional model such as the Southern Riverine Plain model is required initially to gauge the effect of the large irrigation districts. It is intended to identify, rank and quantify the main outputs of the model and evaluate the shifts in equilibrium of the regional groundwater system.

The model area has been subdivided into a 7.5 x 7.5 km grid and the boundaries are roughly defined as follows:

Western - Leaghur Fault
southern - Eastern Highlands, south of Bendigo
Eastern - Eastern Highlands, east of Ovens Valley
Northern - Billabong Creek

The area will initially be modelled over 2 layers; (i) the Shepparton Formation and (ii) the Calivil Formation and Renmark Group. However, the number of layers will be altered at a later stage. For example, a bedrock layer, despite its complexities, will have to be added eventually and the Calivil Formation and Renmark Group may be split into separate layers. No rigid framework has been established as yet so that, for example, if the need is felt to modify the boundaries, it can and will be done.

The model will be calibrated for the period from 1970 to 1985 and time steps will be seasonal (ie. 4 per year).

One of the outputs of the U.S.G.S. software package employed for the model is a cell by cell flow value and direction which will enable a detailed volumetric water balance to be carried out. This in turn will help to provide a long term insight into stream salinities.

The first stage of the model will indicate further data requirements and future direction of work. Ultimately, it is hoped to produce a model which can be useful to all groups concerned with salinity research.

The 7.5 x 7.5 km grid size is not suited to pick up narrow features such as the upper Campaspe Valley and the Colbinabbin Range. Nevertheless, the software package has the capability for a variable grid size if so required.

Another feature of the software package is that data from each new bore can be easily inserted into the model.

To allow for the Parilla Sand in the north-western sector of the model it requires only an adjustment of the hydraulic conductivity. Otherwise, the Parilla Sand will be treated as a lateral equivalent of the Shepparton Formation.

As the best available data comes from the most recent years, 1984/85 data will be used to test the steady-state simulation. Data from a few years earlier, say 1981, will be used to test the transient simulation.

In the model refinement process, a catchment or sub-catchment area may be chosen to test the model in that area against observed conditions. Once refined, the model will provide parameters for sub-regional modelling.

At a later stage, it is intended to run a solute transport model which, it is hoped, will provide an extremely useful guide as to patterns of flow, recharge/discharge, etc.

# 4. DATA AVAILABILITY, FORMAT AND PREPARATION

## 4.1 Geology and Topography

Basic geological information is lacking in some areas of the Southern Riverine Plain model. For example, the Broken River/Broken Creek catchment and the area between Wakool and Kerang.

If required, 1 foot surface contour maps of irrigation zones are available. However, the best available maps for the whole model area appear to be the Gutteridge, Haskins and Davey 10 foot contour maps.

Owing to the lack of data on vertical hydraulic conductivity ($K_v$), it will probably be necessary to do a sensitivity analysis with $K_v$. Near-surface $K_v$, however, often tends to be higher than near-surface $K_h$, therefore allowances may somehow have to be made for this in the model.

Generally speaking, the Shepparton Formation sequences in NSW are very similar to the sequences in Victoria. Much the same can be said for the Calivil Formation and Renmark Group sequences.

## 4.2 Water levels

On July 1, 1985, the new common bore numbering system was introduced in Victoria and this also incorporates a new parish number list. Approximately 33, 000 bores have to be renumbered. Most of these are RWC bores.

The NSW Water Resources Commission (WRC) have been producing 2 water table contour maps each year for the past 10 years for each of the irrigation districts within the NSW model area. There may also be water table maps dating back to 1970. The WRC will be supplying all available water table maps for the Victorian portion. The 1985 map is expected to be ready by the

end of the year. The Victorian maps show depths below surface rather than RL's.

## 4.3 **Extractions**

Obtaining extraction data is one of the most difficult tasks. Values will be required node by node on a seasonal basis.

In NSW, most stock and domestic (S & D) bores do not require a licence. As an estimate, a figure of 3 ML/year/bore could be used for S & D groundwater extraction. S & D bore location maps and data will be supplied by WRC. Irrigation bore and licence data have already been supplied.

Groundwater extraction in the NSW portion of the model is not generally considered by the WRC to be significant, especially when compared to surface water usage. However, in recent years, many large irrigation bores have been constructed in the Berriquin Irrigation District (incls. Tocumwal and Finley areas) and WRC will look at this area more closely.

The RWC has been conducting a field survey to check on groundwater extraction for irrigation.

Groundwater pumping in Northern Victoria has not been considered significant until the 1970's. Since the 1982/83 drought, in particular, there has been a big increase in the number of irrigation bores. It is estimated that approximately 10% of groundwater irrigators are not licenced and therefore not on record.

The RWC is proposing installation of meters on irrigation bores. There are currently no metered bores in Northern Victoria.

For an average irrigation season, the following percentage estimates of groundwater entitlement used have been made:

| | |
|---|---|
| Murray Valley | 90-100% of entitlement used |
| Goulburn Valley | 80% of entitlement used |
| Campaspe Valley | 60% of entitlement used |

The RWC will supply a plan of authorized groundwater usages. An up-to-date computer listing of extraction licences has already been supplied.

### 4.4 **Irrigation Intensity**

Information on irrigation intensity is somewhat lacking in Northern Victoria. However, an irrigation intensity map of the Shepparton Region exists in the 1978 RWC report on the Shepparton Region Drainage and Lake Tyrrell Scheme. It will be necessary to obtain data on annual deliveries for Northern Victoria.

The NSW WRC produce irrigation intensity maps on a district by district basis each year and these are included in the annual reports.

NSW records of annual deliveries are kept and their analysis would be tedious and time-consuming.

### 4.5 **Cropping Patterns/Schedules**

Information on cropping patterns and schedules (incl. percentage of land used for cropping, pasture, etc.) in NSW and Victoria is contained in diversion records, NSW and Victorian Dept. of Agriculture and Rural Affairs reports, Gutteridge, Haskins and Davey reports and NSW WRC district and divisional summaries.

C. Lyle (DARA) and David Marston (NSW Dept of Agriculture) suggested the use of LANDSAT photographs to determine patterns and plant water usage. LANDSAT photos date back to the early seventies and photos for different times of each year could be used. The technique would be to overlay a grid on the LANDSAT

photo, mark out the different crop types and then transfer the grid onto a soil map. Weighted figures could then be applied to each node indicating the relative degree of plant water usage scale of 1 to 5).

## 4.6 **Soil Distribution Maps**

There is good soil map coverage of the irrigation areas but not the dryland areas. To compile a map of the model area showing the distribution of the basic soil types would be difficult but could be attempted if required.

The soil maps will be used to obtain a weighted distribution of infiltration capacities. Weighted figures will be applied to each node indicating the relative degree of infiltration. Care will be needed to allow for topography and drainage, etc.

Geomorphic maps such as the 1:500 000 Geomorphic Map of the Riverine Plain (Butler et al, 1973) could be used to assist with soil and infiltration interpretation in the dryland areas.

## 4.7 **Irrigation Accessions**

Considerable information is available, although accurate estimates of irrigation accessions have been difficult to make.

Channel leakage must be included into the gross irrigation accessions. Estimates of channel loss vary widely from 5% up to 25%.

## 4.8 **Channels and Streams**

The NSW WRC and RWC will supply stream and channel gauging data. Unfortunately, there is a shortage of accurate streamflow data in Northern Victoria.

Baseflow analyses could be carried out to determine the groundwater component of streamflow.

## 4.9 Evapotranspiration

There are few data available on evapotranspiration. Broad scale estimations based on crop type and evaporation data will have to be made. Evaporation data are available from some Bureau of Meteorology weather stations (eg. Deniliquin, Swan Hill). However, in areas of significant topographic change, the evaporation data may not be meaningful.

The NSW WRC diversion records contain rainfall and evaporation data on a monthly basis.

The evapotranspiration extinction depth is generally thought to average about 2 metres and this value will initially be applied throughout the model area. If necessary, however, the extinction depth can be manipulated easily in the model.

**BUREAU OF MINERAL RESOURCES**
**DOCUMENTATION OF GEOLOGICAL DATA**
**by**
**C.M. Brown**

### Aeromagnetic imagery

During the review period C.M. Brown was mainly concerned with the interpretation of regional total magnetic intensity data in the form of a shadow pixel map of the Murray Basin produced by colleagues in the Division of Geophysics. In particular, Brown was involved in providing a geological interpretation of a number of geophysical domains concealed beneath the Murray Basin. In addition, he was involved in writing an interpretation of the tectonostratigraphic framework of the Murray Basin region.

The magnetic data indicate that arcuate or curvilinear structural trends under the Murray Basin do not conform with those of the exposed Lachlan Fold Belt to the east, and suggest that the domains concealed beneath the Murray Basin, together

with those exposed in the Victorian Highlands to the south, form a distinct tectonostratigraphic terrane. Beneath the southwestern Murray Basin ?Proterozoic-Early Cambrian metasediments of the Padthaway Ridge of the Kanmantoo Fold Belt display a northwesterly trending structural grain and a previously unsuspected continuity of structural trend with Adelaidean-Cambrian rocks of the Mount lofty Ranges to the west, despite the present day southwesterly trend of the ranges. Farther to the east Cambrian volcanics of the Black Range and Stavely areas, which were previously thought to form separate greenstone belts, appear to be components of a single highly magnetic domain which extends to the northwest for at least 400 km (Stavely Belt). To the north a similar, but northeastely trending domain can also be interpreted as volcanics (Lake Wintlow Belt). Together these two magnetic domains appear to form a volcanic arc with a concave to the east configuration, underlying the western Murray Basin. To the southeast of the Murray Basin Cambrian volcanics of the Heathcote and Mount Wellington Belts, also previously treated as distinct provinces, may be parts of a single sheet. The magnetic data indicate that metasediments of the ?Cambro-Ordovician Stawell belt form a distinct domain separate from the metasediments of the Ordovician Bendigo Belt, which can itself be subdivided into a number of geophysically distinct domains. In addition, the magnetic pixel map has also allowed greater definition of areas of shallow metasedimentary basement beneath thin sediment cover, as well as the location of concealed granitoid bodies and associated contact aureoles.

The magnetic domains and structural features can be interpreted in terms of a number of concealed Proterozoic and Palaeozoic structural belts and tectonostratigraphic terranes. Much of the Murray Basin may be underlain by a former microcontinental block of Precambrian crust, now stitched to the Precambrian craton to the west. Deformation of the Kanmantoo and Adelaidean Fold Belts, at the western margin of the basin, can be attributed to convergence between the microcontinental block and the craton in the Late Cambrian-Early Ordovician. The Stavely and Lake Wintlow Belts could have formed a volcanic arc located

at the suture between the microcontinental block and the craton. In addition, the Heathcote and Mount Wellington Belts and some of the Ordovician metasedimentary successions may form allochthonous sheets, which were possibly emplaced from the east during Late Ordovician and subsequent Siluro-Devonian convergence between the sub-Murray microcontinental block (Victorian Microcontinent) and a further microcontinental block (Molong Microcontinent) underlying the adjacent Lachlan Fold Belt to the east.

**Preparation of subsurface structure contour and isopach maps**

Early in the period, data verification plots of the main aquifers and stratigraphic units were produced, but as reported previously the initial results of contouring on the Intergraph computer graphics system were not satisfactory. A contour package has now been purchased and is currently being amended to allow ' than' values to be taken into account when contouring.

**AQUA Field Conference**

Brown, Stephenson and Kellett attended the AQUA Field Conference held at Mildura in July 1985. Stephenson gave a talk on Lake Bungunnia (see abstract below). Brown gave a brief talk concerning the influence of the underlying Pliocene sand on the distribution of dunefields in the Murray Basin - despite the fact that rainfall and evaporation contours are aligned east-west, the dunefields are best developed in the west rather than in the north. This reflects the availability of Pliocene sand in those areas underlain by a near-surface former Pliocene strand plain. In contrast, sand and silty loess plains rather than dunefields have developed over those areas underlain by the fluvio-lacustrine Shepparton Formation (around the northern and southern Murray Basin), despite a more arid climate in northern areas.

**Progress on publications**

During the review period A.E. Stephenson was mainly involved in writing sections of the BMR Bulletin on the geology of the Murray Basin, but following his departure from the Division of Continental Geology in early August this involvement has been on a part-time basis. Stephenson submitted a paper entitled 'Lake Bungunnia - A Plio-Pleistocene megalake in southern Australia' for publication. The following is an abstract:-

'Between 2.4 Ma and 0.7 Ma a Plio-Pleistocene megalake, Lake Bungunnia, existed in the western Murray basin, Australia. New data have enabled an accurate estimate to be made of parameters affecting the lake. A study of hydrologic and geologic constraints has enabled the palaeoclimatology of southeast Australia during the Pleistocene to be quantified. Lake Bungunnia could not exist under current climatic conditions, and an average rainfall of at least 500 mm per year over the catchment of the Murray-Darling river system was likely, considerably more than at present. Possible histories for Lake Bungunnia are examined and related to the geologic record. Demise of the megalake heralded the onset of aridity in southern Australia, and modern landforms date from that time. Salt lakes in part of the Murray Basin may be directly descended from Lake Bungunnia, and could give a complete hydrologic record of the development of modern conditions.'

## HYDROGEOLOGICAL PHASE

**by**

**R. Evans**

Compilation of existing data at 1:250 000 scale continued throughout the period. Those sheets where work is progressing are OLARY, MENINDEE, MANARA, IVANHOE, CHOWILLA, ANA BRANCH, POONCARIE, BOOLIGAL, CARGELLIGO, BALRANALD, DENILIQUIN, and JERILDERIE. The most interesting results so far generated by this asessment are the widespread distribution of the Renmark

Group aquifer and the important role this aquifer has in the basin dynamics. New data are also becoming available which enable the sedimentary model produced in the geological phase to be refined and updated.

Field work, including sampling, took place on BOOLIGAL and POONCARIE sheets during April-May. This sampling was aimed at defining regional hydrochemical and isotopic trends. The isotopic sampling will form the basis of a paper on the isotope hydrology of the Lachlan River - Willandra Creek areas, expected to be finished by June 1986.

Results from previous sampling exercises are still unavailable owing to laboratory problems. This situation is expected to be rectified in the near future.

Work on the three-dimensional finite-difference model of heads in the basin has reached an impasse. Problems arose regarding the validity of the input data as detailed by Forth and Williamson. Refinements have been made to some of the transmissivity values and this has resulted in steady state simulations becoming unstable. This coupled with software problems has meant that data promised to Committee members are not yet available.

## RECENTLY PUBLISHED AND UNPUBLISHED REPORTS ON THE GEOLOGY AND HYDROGEOLOGY OF THE MURRAY BASIN

TRUSWELL, E.M., SLUITER, I.R., & HARRIS, W.K., 1984 - Palynology of the Oligocene-Miocene sequence in the Oakvale-1 corehole, western Murray Basin, South Australia. BMR Journal 9(4), 267-295.

TUCKER, D.H., ANFILOFF, V., & LUYENDYK, A., 1985 - New large area standard format magnetic pixel maps of Australia. Bulletion of the Australian Society of Exploration Geophysicists, 16, 2/3, 294-299.

BROWN, C.M. in press (1985) - Murray Basin, southeastern Australia: stratigraphy and resource potential - a synopsis. BMR Report 264. (contribution to ESCAP atlas of Stratigraphy).

BROWN, C.M., & STEPHENSON, A.E., in press (1986) - Murray Basin, southeastern Australia, subsurface stratigraphic database. BMR Report 262.

O'BRIEN, P.E., in press (1985) - Stratigraphy and sedimentology of Late Palaeozoic glaciomarine sediments beneath the Murray Basin, and their palaeoclimatic significance. BMR Journal of Australian Geology and Geophysics.

# APPENDIX

## Murray Basin Hydrogeological Project

### Description and status

This project is a long-term study which is being undertaken jointly by South Australian, Victorian and New South Wales geological surveys and water authorities and by the Commonwealth Bureau of Mineral Resources, Geology and Geophysics. It is co-ordinated by a Steering Committee comprising members of those organisations.

The Murray Basin is a geological structure with an areal extent of some 300 000 km$^2$. In each of the three States, the basin sediments contain very large groundwater reserves. Where the groundwater has a low salinity it is increasingly being used for irrigation and town water supply purposes. In much of the basin, the groundwater is suitable only for stock use and is extensively used for this purpose. In other parts of the basin, the groundwater is too saline for any use. There is a complex interaction between groundwater and surface water which may be beneficial, as in recharge areas in some parts of the basin, or harmful as in areas of saline groundwater discharge to rivers. In recent years, the states involved have stepped up the rate of assessment of the groundwater regime in the basin.

The primary aim of the Project is to improve the understanding of the groundwater regime of the basin by examining it as a single entity, unencumbered by State boundaries. Since a knowledge of the geology of an area is basic to the understanding of groundwater occurrence, a geological study of the basin is an essential part of the Project and, as a consequence, it will also be possible to make an assessment of other mineral resources.

The Project was planned initially to last five years and is organised in five phases:

(1) Geological synthesis, using all available geological and

geophysical data.

(2) Hydrogeological assessment, on the basis of available data.

(3) Documentation of deficiences in geological and hydrogeological information and formultion of proposals for appropriate work programs.

(4) Additional work as approved which could include stratigraphic drilling, aquifer testing, biostratigraphic analysis and isotype hydrology studies.

(5) Development of numerical model(s), if found to be appropriate in the light of the data then available.

The geological synthesis is nearing completion, and a draft document reporting results, with accompanying 1:1 scale geological maps, is expected to be finished by mid 1986.

Phase 2 began at BMR in 1983. Hydrogeological data available from the States are being entered into a BMR data base designed for the Project; BMR and State workers will prepare a report assessing these data, and the results will be illustrated on several maps including the following:

1:1 million scale maps showing water table, potential contours and salinity variations for the three or four most important hydrostratigraphic units;

1:2.5 million scale maps showing (i) amount of water abstracted-added per unit area (ii) recharge-discharge areas, distribution of aquifer parameters for a 7 layer hydrogeological model. (Both Victoria and South Australia have tested the feasibility of making a preliminary model of the basin as a whole based on a coarse (75 km) rectangular grid).

The hydrogeological assessment and phase 3, the documentation of deficiencies in geological and hydrogeological information,

are scheduled for completion in 1986.

Additional work required in Phase 4 (e.g. stratigraphic drilling, geophysical investigations) may be conducted by BMR or by appropriate State authorities. The development of a numerical model (Phase 5), if found to be feasible, may be undertaken by BMR or by State authorities. The Project will depend on the close co-operation of staff from all organisations involved, and some movement of staff between organisations for short periods will be necessary. Throughout the study, individuals and organisations will be encouraged to publish results of various aspects of the work. Results of the overall Project will be incorporated into joint publications.