Groundwater Database Development
State of Knowledge Report
(Technical Report 11)

Corangamite Salinity Action Plan

REGIONAL DRAFT

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CORANGAMITE CATCHMENT MANAGEMENT AUTHORITY

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introduction

The Corangamite Catchment Management Authority (CCMA) Groundwater Monitoring and Research Database project forms part of the CCMA's National Action Plan (NAP) foundation activity of information gap-filling, and will contribute to the regional knowledge base and benchmark register.

The fundamental goal of the project is to provide the best possible basis for setting the targets required by the NAP, in particular groundwater levels, salinity risk and loads, and end of valley targets. To achieve this goal, data from a range of sources has been combined, quality controlled, and enhanced. In addition, the information gained from the project can provide inputs to the Salinity Management Plan and the Regional Catchment Strategy.

This report investigates the 'state of knowledge' based on the available data sources, and following database development.

CCMA groundwater monitoring and research database

The relational database was developed using Microsoft Access using the table structure described in Table 1.1. A common bore identification field (BOREID) which is the Primary Key in the Location table links the main tables. Duplicate bore records are not permitted in this table.

TABLE	PURPOSE	RECORDS
Location	Primary record table. Contains basic bore data including location, use, depth, date, parish, salinity, elevation, source, and quality codes	9262
Composite	Contains construction related data, including aquifer details, SWL, basic sampled chemistry, pump test data, yield, etc.	5692
Aquifer Properties	Contains aquifer information, screen depths, aquifer lithology, casing details, and basic pump test data	7034
Lithology	Contains logged lithology including depth, colour and texture where recorded	59430
Hydrochemistry	Contains historical monitored hydrochemistry data, including sample dates, depths, and chemical concentrations	3297
SWL	Contains historical monitored water-level data, including sample dates, measured SWL, depth from natural surface, and reduced levels	74789
Stratigraphy	Contains differentiated stratigraphy, and includes depth data, formation name, formation age, and stratigraphic codes	2610

TABLE 1.1. DATABASE TABLE STRUCTURE

The database application, its use, data sharing, and data management recommendations are described in the separate report 'CCMA Groundwater Monitoring and Research Database' (Nolan-ITU; 2002).

data sources

The majority of groundwater data for the State of Victoria is stored in several Government databases, which have evolved over the years to meet the needs for centralised and organized groundwater data storage. These databases endeavour to meet the needs of private and public sector organisations, community organisations, research organisations and individuals.

The major groundwater data storage facilities include the Victorian Groundwater Database (GDB), the Geological Exploration and Development Information System (GEDIS), and the Centre for Land Protection and Research (CLPR) groundwater database. These data storages, which are described further below, provided the main sources of data for the CCMA database.

groundwater monitoring in the Corangamite catchment

A range of monitoring programs operates through the region. The CLPR manages the collection of strategic salinity monitoring data on behalf of the Department of Natural Resources and Environment. The bulk of data obtained for the CLPR groundwater database is collected by paid community members, or 'community link' extension staff employed in related areas. In addition, community volunteer workers collect a small percentage of data, generally for bores installed through salinity management grant schemes and the Landcare Network.

State Observation Network water-level monitoring data is primarily funded by DNRE and stored in the GDB. Sinclair Knight Merz (SKM) manages the data collection, which is partly carried out by SKM staff, and partly by third party contractors. This data is generally collected quarterly, although monthly monitoring occurs within Groundwater Management Areas or Groundwater Supply Protection Areas. In these areas, additional funding is provided by water authorities via the relevant Consultative Committees.

groundwater data characterisation

Different technical aspects of groundwater bore data are stored in the source databases to characterise the bore information. The following brief explanation of some of these aspects can assist with understanding the bore data and its use:

> **Location** – To describe the physical location of the bore. Location data is commonly a set of map co-ordinates (easting and northing) using the Australian Map Grid (AMG)[1] system. Other co-ordinate systems are also used e.g. Latitude and Longitude.

> **Elevation –** This reports the height of the ground surface at the bore in metres above Australian Height Datum (mAHD).

[1] For technical reasons, the CCMA database uses the AMG Zone 54 co-ordinate system to locate bores. Because the AMG Zone 54/55 boundary passes through the CCMA area it was necessary to convert AMG co-ordinates for Zone 55 bores to Zone 54, allowing all bores to be plotted using a common projection. The original Zone 55 co-ordinates are also stored in the database.

- **Bore Type – '**GW' indicates the bore was constructed for groundwater purposes or uses; bores could be constructed for other reasons as well, such as petroleum exploration or geological investigation.
- **Bore Use** – Characterises the uses of the bores, e.g. irrigation, observation, stock and domestic, etc.
- **Depth** – Reports the drilled or constructed depth of the bore.
- **Chemistry** – Where available, hydrochemistry data for groundwater bores can include a range of parameters to characterise the salinity (e.g. total dissolved solids, electrical conductivity), nutrient content (e.g. nitrates and phosphates), hardness, and other chemical aspects of the groundwater.
- **Construction Data –** May include data describing drilling methods, bore casing details, etc.
- **Lithology and Stratigraphy–** Describes the rock and strata types encountered during drilling. Where available, this data is as recorded by the driller (e.g. a drilling log) or by a geologist who may have supervised the drilling operation (e.g. a geologist's log).
- **Aquifer Data –** Reports the depth and lithology of the water-bearing strata.
- **Water-Level Data**- Reports groundwater depth information. For some bores (i.e. observation or monitoring bores) regular measurements of groundwater depth are made to establish a historical record of groundwater level fluctuations.

Note that not all bores have data recorded for all the above aspects.

victorian groundwater database

The Victorian Groundwater Database (GDB) originated during 1989 under the Rural Water Corporation (RWC), which saw the need to consolidate state-wide groundwater data. The GDB inherited data from several sources, including the Victorian Geological Survey's borehole database, and several RWC databases. The GDB is a repository for all licenced groundwater bores in Victoria.

During the mid-1990s, management of the GDB transferred from the RWC to its privatized successors - HydroTechnology - and ultimately under contract to Sinclair Knight Merz Pty Ltd, by the Department of Natural Resources and Environment.

Regional access to the GDB was provided to rural water authorities (Southern Rural Water, Wimmera Mallee Water and Goulburn-Murray Water), and limited data is made available on the Internet via NREs Web host server.

GDB bore data

GDB bore data was obtained from the 1:250 000 map regions surrounding the CCMA area. The raw data, representing 16 166 bores in AMG Zone 54 and 23 479 bores in AMG Zone 55, comprised two each of the following space delimited text files:

- LOC.txt – Bore location details

> AQ.txt – Bore aquifer details

> CHM.txt – Bore chemistry details

> COM.txt – Bore composite (construction) details

> STRAT.txt – Geologists stratigraphic logs

> DLOGS.txt – Drilling logs

> WLS.txt – Historical water level data

Mapinfo GIS was used to query this raw data set to create a subset of bores were that plotted within the CCMA boundary (a total of 8078 bores). Of these, 20 bores reported parishes foreign to the CCMA area and were rejected from the database (Appendix A).

The remaining 8 058 bores were imported into the database using Visual Basic file handling routines to manage the data conversion.

The following comments relate to the imported GDB data:

> **Elevation Data -** Elevation data (RLNS) was not provided for a total of 7 134 of the GDB bores in the CCMA area (88.5%).

> **Bore Type -** 5 195 of these bores are identified as 'Groundwater' bores, 4 are 'Commercial' bores and 2 857 are type 'Not Known'.

> **Bore Use -** 699 of the bores are registered as observation bores.

> **Depth -** A total 272 of the GDB bores have no reported depth, and a further 28 reported a total depth of less than 1 metre.

> **Chemistry Data -** 3 297 hydrochemistry records matching GDB bores were appended to the hydrochemistry table.

> **Construction Data -** 5 692 construction records matching GDB bores were appended to the composite table.

> **Lithology Data -** 15 062 lithology records matching GDB bores were appended to the lithology table.

> **Water-Level Data -** 39 405 water level records matching GDB bores were appended to the SWL table.

> **Aquifer Data -** 7 034 aquifer records matching GDB bores were appended to the aquifer table.

> **Stratigraphy Data -** Of 202 stratigraphic records imported from the GDB, none matched bores in the CCMA area.

GEDIS database

The Geological Exploration and Development Information System (GEDIS) is operated by the Department of Natural Resources and Environment. The database contains bore records of geological, mining and mineral exploration significance for the State of Victoria.

GEDIS bore data

Bore data obtained from the GEDIS database contained 5 412 bores within the CCMA area, and included minerals, petroleum, coal, investigation and groundwater bores. Of these, 4 735 bores were duplicates of GDB bores, and hence only 677 new bore records were imported.

Bore elevation data (RLNS) for 1 786 GDB bores were updated from the GEDIS records, where

reported elevations were not available for the GDB bores.

The GEDIS bore data was provided in four tab-delimited text files:

> BOREHOLE.txt – Basic bore details

> SITE.txt – Site, location, elevation and depth details

> LITHOLOGY.txt – Driller/geologist logs

> STRATIGRAPHY.txt – Geologist stratigraphic records

The following comments relate to the imported GEDIS data:

> **Elevation Data -** A total of 176 of the imported GEDIS bores (26%) had no elevation data (RLNS).

> **Bore Type -** Bore type data was not available for the GEDIS dataset.

> **Depth -** One bore had no depth reported, and a further 3 reported a total depth of less than 1 metre.

> **Chemistry Data -** Chemistry data was not available for GEDIS bores.

> **Lithology Data -** 44 089 lithology records from GEDIS matching CCMA area bores were appended to the lithology table.

> **Water-Level Data -** Water level data was not available for GEDIS bores.

> **Stratigraphy Data -** 2 610 GEDIS stratigraphic records matching CCMA area bores were appended to the stratigraphy table.

CLPR database

The Centre for Land Protection and Research Database was originally derived from GDB data (in 1994). It contains records of bores used for research and monitoring purposes, rather than utilitarian purposes. Data from groundwater monitoring programs is regularly updated in the database to provide an historical repository of data.

CLPR bore data

CLPR bore data obtained for the CCMA area contained 537 NRE bores. Of these, 17 bores were duplicates of existing GDB bores, and hence only 519 new bore records were imported. The CLPR data comprised two each of the following delimited text files:

> GENERAL.txt - – Bore location and site details - (tab-delimited textfile)

> SWL.txt – Historical water level data - (tab-delimited textfile)

> LITH.txt – Drilling logs - (comma-separated textfile)

All the bores are monitored, and 339 have landscape position data. Parish and elevation data was not available for the bores.

The following comments relate to the imported CLPR data:

> **Depth -** A total 444 CLPR bores have depth data reported (85%).

> **Water-Level Data -** 35 384 historic water-level records were available and imported for these bores

> **Lithology -** 279 lithology records (driller's logs) matching these bores were imported.

other data sources

Additional bore data was obtained from the Barwon Region Water Authority. This data consisted of chemistry data, for six urban water-supply bores located in the parish of Gerangamete.

Other sources contacted to supply data for the project were:

> DNRE (Colac)

> University of Ballarat

> Regional Landcare

> Southern Rural Water

> Glenelg Hopkins CMA

Data collected by these organisations include (in some cases) groundwater level and salinity monitoring data associated with monitoring programs. These data, where appropriate, are passed on to the relevant databases for incorporation (i.e the GDB and CLPR database). Accordingly, and to prevent duplication, for input to the CCMA database these data are preferably accessed from the GDB and CLPR.

In other cases, data is either disparate, not readily accessible, confidential, or otherwise unavailable.

Importantly, it is considered that the three major data sources accessed will have disclosed the greater bulk of publicly available data for registered/licensed bores. However it is recognised that other less accessible data may become available in time, and incorporation of this into the database would add to and enhance the existing data.

summary

The CCMA Groundwater Monitoring and Research Database contains 9 260 individual bore records, obtained by aggregating and filtering data from the GDB, GEDIS and CLPR databases, and from Barwon Region Water Authority.

Although the original data sources contain bore data in different formats, these have successfully been enhanced and combined into one relational database.

Figure 2.1 shows the CCMA area, and plotted bore locations from the CCMA Database.

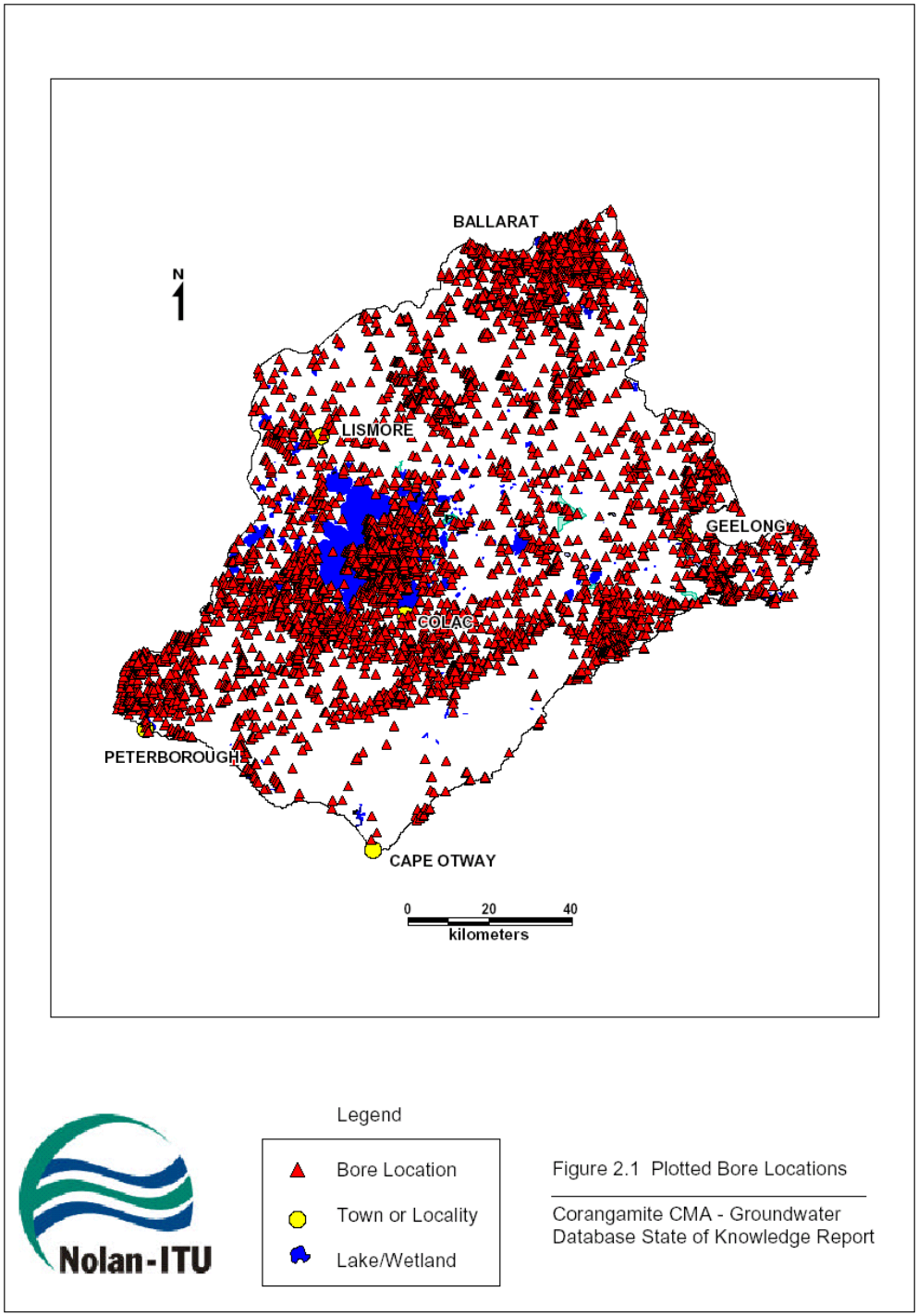

FIGURE 2.1. PLOTTED BORE LOCATIONS

database analysis

general

This section contains analyses of the data incorporated into the database in order to assist in understanding the State of Knowledge of groundwater bore data.

In addition, this section describes the enhancements to data that have been made. These enhancements include:

> Digitising parish information for all bores from GIS;

> Digitising bore elevations from a GIS digital terrain model; and

> Application of quality control ranking schemes to bore location, bore elevation, and

> parish data.

The quality control ranking systems for bore location, elevation and reported parish are described in Appendix B.

depth data analysis

5 377 bores have depths reported below 30 metres (58% of total), and 366 have either no depth reported or a depth less than 1 metre (4% of total).

Depths greater than 1 000 metres are reported for 20 bores. Of these, 2 report depths greater than 3 000 metres - bore 881409 (3 545 metres) and bore 881393 (3 067 metres).

Figure 3.1 shows the distribution of bores with depths below 30 metres. In many cases these will be bores capable of accessing the water table aquifers within the region.

bore location data analysis

All bores in the database have AMG locations. 2 492 of these are located in AMG Zone 55, and these co-ordinates were converted to Zone 54 for commonality. The original Zone 55 coordinates are retained in the database.

Only GEDIS bores had data describing the location method (e.g. surveyed, digitised, etc) and this simplified the initial ranking of location quality for these bores. All other bores imported were (initially) assigned the default location quality D (reliability unknown). This included 2 714 GDB bores, and 17 GEDIS bores (approximately 28% of the database).

Based on the assumption that bores with reported elevation data (RLNS) have been located more accurately, these were assigned location quality F (assumed surveyed).

Based on the assumption that bores with elevation quality D (reliability unknown) and having location co-ordinates reported to the least significant digit have been surveyed,

these were reassigned elevation quality B (co-ordinates from GPS or approximate survey).

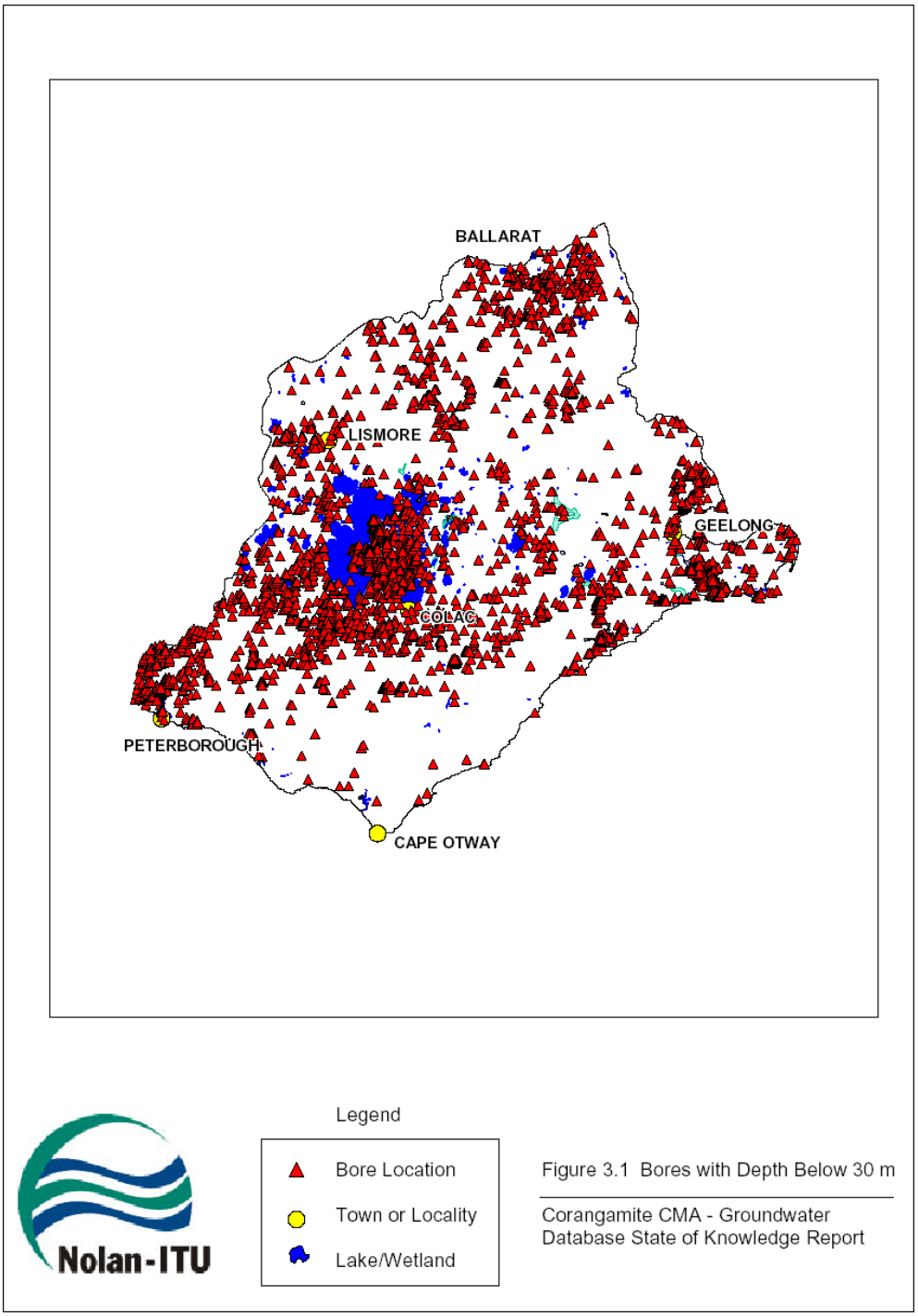

FIGURE 3.1. BORES WITH DEPTH BELOW 30 M

An analysis of plotted bore locations using Mapinfo GIS disclosed that 212 bores had locations coincident with lakes, reservoirs or swamps (note that some of these may be legitimate monitoring locations in areas subject to temporary inundation). To flag this situation to data users, location quality E was assigned to these bores. Table 3.1 summarises the distribution of these bores. The actual bores are listed in Appendix D.

AREA	NUMBER OF BORES
Lake Ondit	1
Lake Martin	1
Lake Murdeduke	1
Lake Corangamite	4
Lake Connewarre	45
Gong Gong Reservoir	1
Swamps	159

TABLE 3.1. BORES IN NON-AQUIFER AREAS

Final location quality statistics for the database are provided in Table 3.2.

LOCATION QUALITY CODE	DESCRIPTION	NUMBER OF BORES	% OF TOTAL
A	Location co-ordinates determined from survey	16	0.2%
B	Location co-ordinates from GPS or approximate survey	274	3.0%
C	Location co-ordinates derived from maps or GIS	721	7.8%
D	Location co-ordinates reliability or source unknown	5 078	54.8%
E	Location co-ordinates fail to correlate with parish or location plots in non-aquifer area (lake or swamp)	630	6.8%
F	Location co-ordinates assumed surveyed (because RLNS data reported)	2 541	27.4%

TABLE 3.2. LOCATION QUALITY RANKING

elevation data analysis

3 215 bores had recorded elevation data (comprising 35% of dataset).

To enhance the dataset, a GIS elevation assignment routine was used to provide digitized elevations from a digital terrain model of the CMA area provided by DNRE. This furnished elevations for 9 198 bores (99.3% of the dataset), and allowed assumptions to be made regarding the likely reliability of the data.

For those bores with source-reported elevations, quality ranking was assigned based on the difference between reported elevation and digitised elevation (Table 3.3). Bores with a difference of less than +/- 2 metres were assigned elevation quality A, difference of less than +/- 10 metres were assigned elevation quality B, all others were assigned elevation quality C. One difficulty with this method is that bores with accurate elevation data but which plot incorrectly (due to coordinate error/inaccuracy) are likely to match poorly with digitised elevations. Accordingly, the elevation quality rankings need to be interpreted cautiously.

LOCATION QUALITY CODE	DESCRIPTION	NUMBER OF BORES	% OF TOTAL
A	Reported bore elevation correlates well with digitised elevation	14	0.2%
B	Reported bore elevation correlates reasonably with digitised elevation	2 808	30.3%
C	Bore elevation reliability unknown or not determined	6 438	69.5%

TABLE 3.3. ELEVATION QUALITY RANKING

parish location quality analysis

An assignment operation was performed using Mapinfo GIS to update the database with digitized parish data, based on plotted bore locations. A comparison between reported parish and digitized parish was then used to analyse and enhance parish quality.

In cases where the reported and digitised parishes match, parish quality A was assigned (7 637 bores, 82% of dataset). In cases where the parishes failed to match, parish quality B was assigned (425 bores, 4.6% of dataset). The remaining 1 200 bores where reported parish was 'Not Known' were assigned parish quality C. Table 3.4 summarises the parish location quality ranking.

LOCATION QUALITY CODE	DESCRIPTION/ASSUMPTION	NUMBER OF BORES	% OF TOTAL
A	Reported parish considered reliable (matches digitised parish)	7 637	82.5%
B	Reported parish failed to match digitised parish (parish or co-ordinates unreliable)	425	4.6%
C	Reported parish not known	1 198	12.9%
D	Parish reliability not determined	0	0.0%

TABLE 3.4. PARISH LOCATION QUALITY RANKING

monitoring bores analysis

The database contains 972 bores that have associated time-series water-level data (10.5% of total). Of these, 505 are DNRE bores from the CLPR Database, and 464 are

GDB bores. Of the 505 CLPR bores, 387 had the monitoring frequencies reported, as follows:

> Monthly monitoring 275 bores

> Bi monthly monitoring 85 bores

> Quarterly monitoring 26 bores

> Occasional monitoring 1 bore

Monitoring frequencies were not provided with the GDB data. Elevations for DNRE monitoring bores were not provided with the CLPR dataset, and have been digitised. Figure 3.2 shows the location of the monitoring bores. Significant areas where monitored bores are absent include the volcanic plains to the west and north-west of Geelong, the stony rises west of Lake Corangamite, and the southern slopes of the Otway Ranges through to the coast.

An analysis of monitoring bores by Parish as well as a ranking by data quality is provided in Appendix C.

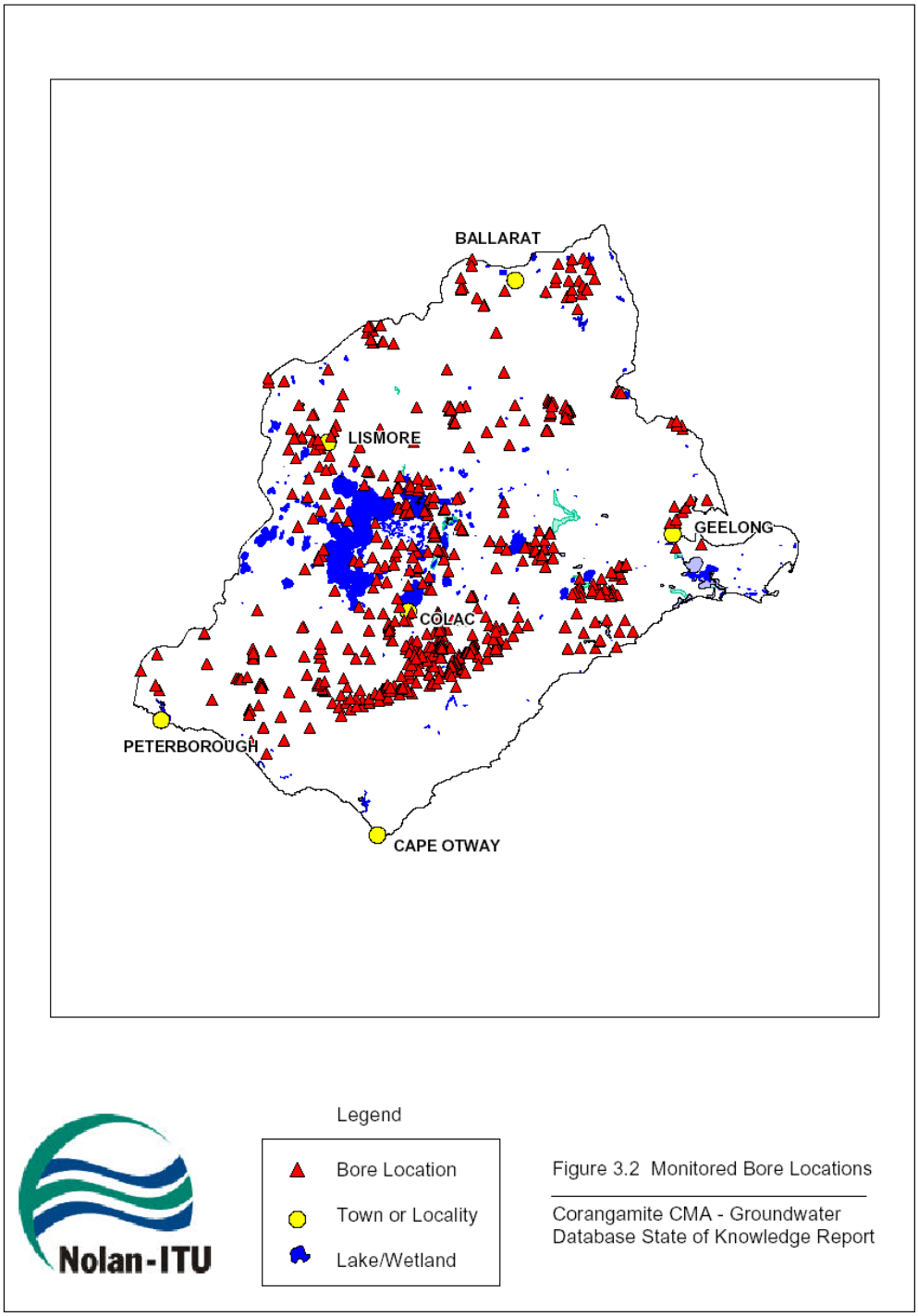

FIGURE 3.2. MONITORED BORE LOCATIONS

bore authority and use analysis

The Bore Authority field describes bore ownership. The Bore Use field describes bore uses and is self-explanatory. In general, standard GDB codes have been retained in the CCMA database for these fields, where appropriate. Table 3.5 and Figure 3.3 summarise the bore authority data and codes, and Table 3.6 and Figure 3.4 summarise the bore use data and codes.

28.5% of the data set are bores with non-groundwater uses (all of these are GDB sourced bores).

BORE AUTHORITY CODE	DESCRIPTION	NUMBER OF BORES	% OF TOTAL
AGSO	Australian Geological Survey Organisation	4	<1.0%
BARW	Barwon Water	6	<1.0%
CNR	Dept' of Conservation and Natural Resources	245	2.6%
DEM	Dep't of Mines	3 070	33.1%
DMID	Dep't of Manufacturing and Industry Development	659	7.1%
EXP	Exploration Company – Minerals/Petroleum	205	2.2%
GAS	Gas & Fuel Corporation	9	<1.0%
GOVT	Government (General)	17	<1.0%
LAND	Private Landholder	2 865	30.9%
MUN	Municipality/Shire	31	<1.0%
NKN	Not Known	1 230	13.3%
NRE	Natural Resources and Environment	519	5.6%
RWC	Rural Water Corporation	376	4.1%
SEC	State Electricity Commission	25	<1.0%
PRIVATE	Private Landholder	1	<1.0%

TABLE 3.5. BORE AUTHORITY BREAKDOWN

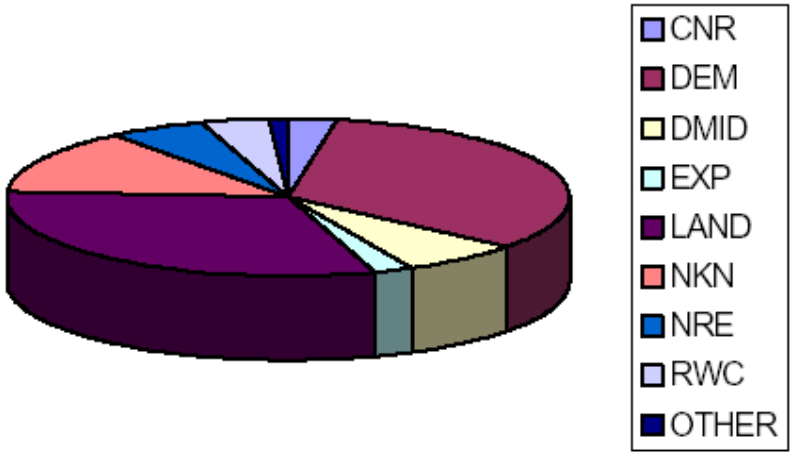

FIGURE 3.3. BORE AUTHORITY BREAKDOWN

PRIMARY BORE USE	DESCRIPTION	NUMBER OF BORES	% OF TOTAL
AI	Agro Industries	1	<1.0%
AQ	Aquaculture	1	<1.0%
CO	Commercial	4	<1.0%
DI	Disposal	2	<1.0%
DM	Domestic	1 631	17.6%
DS	Domestic & Stock	21	<1.0%
DW	Dewatering	8	<1.0%
DY	Dairy	32	<1.0%
IN	Industrial	22	<1.0%
IR	Irrigation	241	<1.0%
IV	Investigation	1 069	11.5%
MI	Miscellaneous	18	<1.0%
MW	Mineral Water	11	<1.0%
NG	Non-Groundwater	2 637	28.5%
NKN	Not Known	1 723	18.6%
OB	Observation	738	8.0%
SE	SEC Bore	24	<1.0%
ST	Stock	1 059	<1.0%
UR	Urban	17	<1.0%

TABLE 3.6. BORE USERS

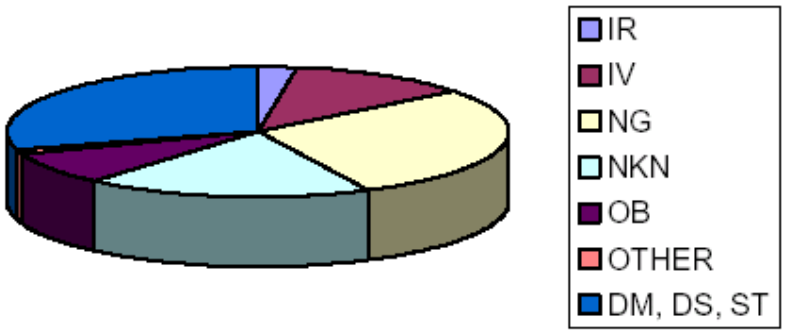

FIGURE 3.4. BORE USE BREAKDOWN

bore lithology data analysis

Lithology records are available for 6 686 bores. 3 695 of these bores are in the depth range below 30 metres. 44 bores have depths greater than 500 metres (Figure 3.5). Records from these deep bores are useful for investigations of regional geological structure, and geology of deeper aquifer systems.

bore hydrochemistry analysis

Salinity data (TSS/EC) is available in the hydrochemistry table for 2 357 bores. Nutrient data (nitrate) is available for 1 486 bores.

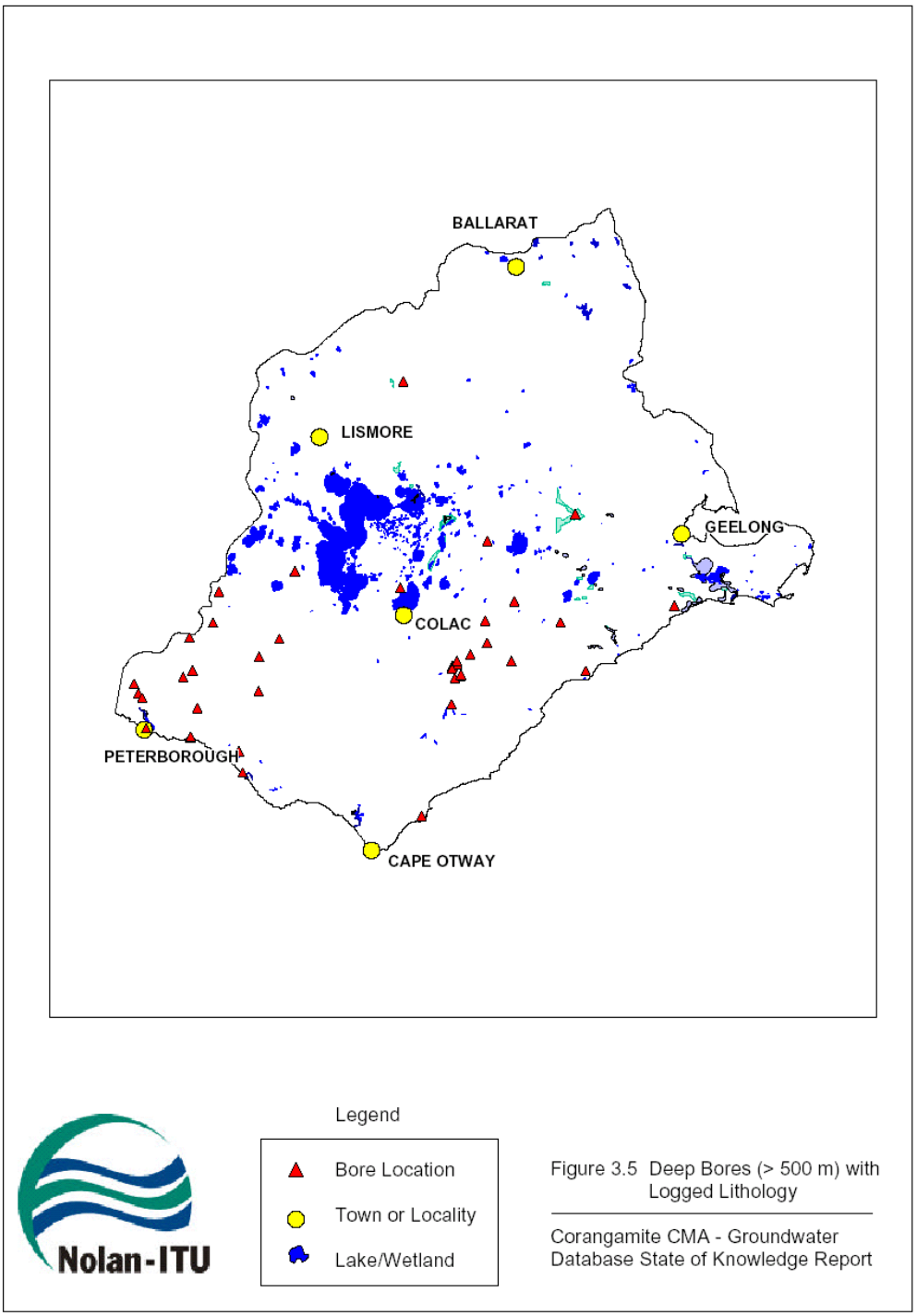

FIGURE 3.5. DEEP BORES (> 500M) WITH LOGGED LITHOLOGY

conclusions and recommendations

A database has been created which incorporates data from several sources, and captures a very high proportion of the accessible groundwater bore and monitoring data for the region. By making key information readily available, the database can assist in meeting the goals and targets of the National Action Plan for Salinity and Water Quality, in particular the NAP goals to:

> Prevent, stabilise and reverse trends in salinity; and

> Improve water quality and secure reliable allocations for human uses, industry and

> the environment.

The data availability also helps the region achieve the NAP requirement for 'Capacity Building', which requires:

"Extending information to communities, including National Land and Water Resources Audit data, so that they can effectively develop and implement their plans".

In addition, by disseminating crucial data to a range of key stakeholders, the database can assist in achieving Regional Catchment Strategy (RCS) goals and targets. These include statutory requirements for the RCS require that it must:

> Assess the land and water resources of the catchments in the region and how they are used;

> Assess the nature, causes, extent and severity of land degradation of the catchments in the region and identify areas for priority attention; and

> Identify objectives for the quality of the land and water resources of the catchments in the region.

Use of the database can help the CCMA in implementing plans to meet targets identified by the RCS. In this regard, particular targets include the requirements to:

> Establish and implement Groundwater Management Plans;

> Establish monitoring systems of groundwater quality and quantity at key points for 16 regional groundwater systems;

> Assess groundwater interactions and impacts on lakes and streams; and

> Increase community capacity through knowledge sharing.

The database will also assist in achieving the Corangamite CMA's aim, which is to:

"Provide an environment that facilitates a community-based team approach to the integrated management of our catchment"

data reliability

The data compilation and analyses highlighted significant data reliability problems, particularly relating to crucial spatial location data. These included:

> Reported parishes failing to match digitised parishes;

> A low proportion of elevation data checking as reliable; and

> Greater than 50% of co-ordinate locations with quality unknown or undeterminable.

In part, these problems are inherited from the original data sources which in general lack the appropriate quality control data. Significantly, only the GEDIS sourced data included information describing spatial data capture method (e.g. surveyed, digitised, etc.).

Data gaps relating to monitoring bores include:

> No information regarding monitoring frequencies for GDB sourced monitoring bore;

> No elevation data provided for the CLPR monitoring bores (these have been digitized in developing the database); and

> Significant areas have been identified where monitored bores are absent.

The analyses presented in this report help to describe the state of knowledge and highlight data gaps, and can be used as a starting point from which to improve and expand upon our understanding of groundwater within the Corangamite CMA. To build upon this foundation, opportunities exist to improve and add to the data, and to ensure the data is readily available for end-users.

data enhancements

To improve the reliability of the data, important enhancements have been made. These are summarised below:

1. Bores reporting parishes outside the CCMA area have been rejected from the data set;
2. Depth data for GDB sourced bores has been updated where possible from GEDIS sourced data for the same bores;
3. Stratigraphic data for GDB sourced bores has been updated where possible from GEDIS data for the same bores;
4. Parish information has been digitised from GIS data;
5. Elevation information has been assigned from a digital terrain model of the CCMA area; and
6. Quality control has been applied to location, elevation, and parish data.

opportunities for further enhancement

To maintain and further improve the data will require that the database is periodically updated to include new bores, and the latest monitoring data for existing bores. In addition, further enhancement of the existing data is recommended to improve the

quality and reliability of the available information. Opportunities for this might include enhancements such as:

> Obtaining depth information for monitored bores (where absent). This could be achieved by referring to the original bore construction documentation where available, or by instigating a program of field measurement, that could be performed concurrently with existing water-level/salinity monitoring programs;

> Improving location quality data for monitored bores. This could be achieved by referring to the original bore surveys where available, or by field survey, and updating the location data and quality control codes in the database. Field survey for co-ordinates and elevations could be conducted economically using portable GPS equipment, and performed in association with existing monitoring programs;

> Conducting a field verification survey of a sample of key observation bores. This would enable a measured assessment to be made of data reliability; and

> Carrying out a regional salinity 'snapshot' at selected government and/or private bores to improve overall salinity knowledge, particularly in aquifer marginal areas, or other areas where saltwater intrusion threats may exist.

In addition to the above, correct locations should be researched for bores that plot in swamps and lakes, and bores where the reported parish is different from the digitised parish. This would be best achieved by referencing the original bore construction documentation.

glossary

AHD	Australian Height Datum. A survey datum analogous to mean sea level
AMG	Australian Map Grid
AMG Zone	A mapping region having a common co-ordinate system tied to the Australian Map Grid
Aquifer	A water-bearing geological formation
CCMA	Corangamite Catchment Management Authority
CLPR	Centre for Land Protection and Research
Drilling Log	A record of sub-surface geology encountered during a bore drilling operation.
Digital Terrain Model	A data file containing a digital representation of a topographic surface
Digitise	To input or output data from a computerised mapping system
DNRE	Department of Natural Resources and Environment
EC	Electrical Conductivity
GDB	Victorian Groundwater Database
GEDIS	
Geologists Log	A record of sub-surface geology encountered during a bore drilling operation, described and recorded by a geologist
GIS	Geographic Information System – a computerised mapping system
GPS	Global Positioning System – A satellite referenced method or device for survey or geographical position determination
Groundwater Bore	A hole, usually drilled or bored into the ground to intersect groundwater. Bores are commonly lined with plastic or metal casings and screens designed to prevent wall collapse and isolate aquifers. Also known as a well.
Hydrochemistry	Chemistry of water or groundwater
Lithology	Rock type
Monitoring Bore	A groundwater bore used for monitoring groundwater levels, pressure, chemistry, or other parameters
NAP	National Action Plan. A joint Australian Federal and State government initiative to address salinity and water quality issues within key catchments and regions
NRE	Department of Natural Resources and Environment
Observation Bore	See monitoring bore
Relational Database	A computer database system that stores data in separate but related table files
RCS	Regional Catchment Strategy. A document setting out how the catchments in a region are to be managed.
RLNS	Reduced Level Natural Surface. The surface elevation of a point expressed in metres above AHD
Stratigraphy	The classification and geology of stratified rock sequences
SWL	Standing Water Level. The depth below surface to groundwater (as measured in a bore)
TSS	Total Soluble Solids

report limitations

This report has been prepared in accordance with an agreement between Corangamite Catchment Management Authority and Nolan-ITU.

The services performed by Nolan-ITU have been conducted in a manner consistent with the level of quality and skill generally exercised by members of its profession and consulting practices.

This report is solely for the use of Corangamite Catchment Management Authority and any reliance of this report by third parties shall be at such party's sole risk and may not contain sufficient information for purposes of other parties or for other uses. This report shall only be presented in full and may not be used to support any other objectives than those set out in the report, except where written approval with comments are provided by Nolan-ITU.

appendix A

bores with reported parish outside CCMA area

BORE ID	PARISH
47066	Ballan
301465	Barkly
141009	Carlsruhe
57586	Creswick
128959	Deutgam
62190	Edington
124152	Enuc
115045	Fingal
128286	Franklin
75265	Lauriston
128103	Livingstone
131781	Mooroolbark
129708	Mouzie
143926	Murchison North
86190	Nowingi
86847	Orbost
89419	Redbank
122667	Ulupna
132324	Woori Yaloak
144690	Yuonga

BORES WITH REPORTED PARISH OUTSIDE CCMA AREA

appendix B

database quality codes

Location Quality Codes	A	Location co-ordinates determined from survey
	B	Location co-ordinates from GPS or approx. survey
	C	Location co-ordinates derived from maps or GIS
	D	Location co-ordinates reliability or source unknown
	E	Location co-ordinates fail to correlate with parish or location plots in non-aquifer area (lake or swamp)
	F	Location co-ordinates assumed surveyed (because RLNS data reported)
Elevation Quality Codes	A	Reported bore elevation correlates well with digitised elevation
	B	Reported bore elevation correlates reasonably well with digitised elevation
	C	Bore elevation reliability unknown or not determined
Parish Quality Codes	A	Reported parish considered reliable (matches digitised parish)
	B	Reported parish failed to match digitised parish (parish or co-ordinates unreliable)
	C	Reported parish not known
	D	Parish reliability not determined

DATABASE QUALITY CODES

appendix C

analysis of monitoring bores and location quality

Parish (digitised)	Total Mon.Bores	Monitored Frequency			
		Bi Monthly	Monthly	Occasional	Quarterly
ARGYLE	7		7		
BAMGANIE	3		3		
BARONGAROOK	2		2		
BIRREGURRA	5	5			
CARPENDEIT	15		15		
CLARKESDALE	1		1		
COMMERALGHIP	7		7		
COORIEJONG	69	1	68		
CORADJIL	17		17		
CORANGAMITE	1			1	
CORINDHAP	4		4		
DUNEED	7	7			
ELLIMINYT	3		3		
ENFIELD	3		3		
GALLA	2			1	1
GERANGAMETE	52		52		
GHERANG GHERANG	13	12	1		
GNARKEET	1				1
HADDON	2		2		
HESSE	2		2		
IRREWARRA	4		4		
LARA	2		2		
LISMORE	5				5
MANNIBADAR	7		7		
MIRNEE	2		2		
MODEWARRE	3	3			
MURROON	37	37			
NALANGIL	13		13		
NATTE MURRANG	7	3	4		
ONDIT	21	4	17		
PARAPARAP	7	7			
PIRRON YALOAK	2		2		
SKIPTON	15		15		
STRUAN	4				4
TOOLIOROOK	14				14
TURKEETH	1		1		
TUTEGONG	1	1			
WAARRE	2		2		
WARRACBARUNAH	6		6		
WHOOREL	5	5			
YARROWEE	5		5		
YEO	8		8		
Totals	**387**	**85**	**275**	**2**	**25**

ANALYSIS OF PARISH SORTED MONITORING BORES AND FREQUENCY

Main Use	Total Bores	Location Quality					
		A	B	C	D	E	F
AI	1				1		
AQ	1				1		
CO	4				4		
DI	2				2		
DM	1631				1504	72	55
DS	21				18	3	
DW	8				7	1	
DY	32				32		
IN	22				21		1
IR	241				229	8	4
IV	1069				629	88	352
MI	18				14	2	2
MW	11				9	2	
NG	2637				837	197	1603
NKN	1726	11	167	327	699	194	328
OB	737		107	393	39	13	185
SE	24				16	2	6
ST	1059				1009	48	2
UR	16	5		1	7		3
Totals	**9260**	**16**	**274**	**721**	**5078**	**630**	**2541**

ANALYSIS OF MAIN BORE USE CATEGORY AND LOCATION QUALITY (REFER TO APPENDIX B FOR EXPLANATION OF BORE QUALITY CODES)

appendix D

bores located in lakes, swamps, and reservoirs

Bore ID	Zone 54 Easting	Zone 54 Northing	Use	Location	Location Name
92703	694772	5779220	ST	lake	
127829	708113	5768594	ST	lake	LAKE CORANGAMITE
114065	710850	5760700	DM	lake	LAKE CORANGAMITE
60833	711752	5768535	NKN	lake	
83612	714899	5759196	NKN	lake	LAKE CORANGAMITE
60920	715510	5763060	DM	lake	LAKE CORANGAMITE
101831	718123	5763396	ST	lake	
57749	723331	5776014	ST	lake	
57761	723420	5775520	ST	lake	
101817	724848	5762851	ST	lake	
102015	724944	5762912	ST	lake	
86784	727129	5763092	IV	lake	LAKE ONDIT
36060	730000	5779040	OB	lake	LAKE MARTIN
113471	750950	5769200	IV	lake	LAKE MURDEDUKE
113172	758100	5768450	OB	lake	
53221	759023	5840207	ST	reservoir	GONG GONG RESERVOIR
105328	771043	5745372	NKN	swamp	
300437	774168	5745219	NG	swamp	
68000	777330	5746700	NKN	swamp	
310283	777390	5747000	NG	swamp	
68165	777487	5746437	NKN	swamp	
68156	777504	5746446	NKN	swamp	
88787	795598	5756201	DM	swamp	
88786	795823	5755966	DM	swamp	
56394	797020	5756179	IV	swamp	
56391	798533	5756996	NKN	swamp	
304393	800443	5759443	NG	swamp	
304391	800495	5760362	NG	swamp	
304359	800646	5763176	NG	lake	LAKE CONNEWARRE
304387	800753	5760519	NG	swamp	
304360	800914	5763199	NG	lake	LAKE CONNEWARRE
304358	800919	5763416	NG	lake	LAKE CONNEWARRE
304388	800977	5760114	NG	swamp	
304361	801233	5763254	NG	lake	LAKE CONNEWARRE
304389	801248	5759581	NG	swamp	
304362	801445	5763284	NG	lake	LAKE CONNEWARRE
304390	801535	5759436	NG	swamp	
304384	801603	5760645	NG	swamp	
304397	801721	5760289	NG	swamp	
304395	801864	5759566	NG	swamp	
304396	802019	5759963	NG	swamp	
304383	802078	5760573	NG	swamp	
304398	802348	5761158	NG	swamp	
304382	802695	5760486	NG	swamp	
304378	802725	5762128	NG	lake	LAKE CONNEWARRE
304399	802835	5760704	NG	swamp	
304376	802859	5761969	NG	lake	LAKE CONNEWARRE
304375	802965	5761478	NG	swamp	
304377	803046	5762043	NG	lake	LAKE CONNEWARRE
304381	803132	5760425	NG	swamp	
304400	803309	5760862	NG	swamp	
304380	803588	5760330	NG	swamp	
304401	803651	5761026	NG	swamp	
304402	803805	5760776	NG	swamp	
304379	804066	5760203	NG	swamp	
304403	804217	5760544	NG	swamp	
48869	807133	5758750	DM	swamp	
48870	807183	5758747	DM	swamp	
48874	807183	5758747	NKN	swamp	
333793	759621	5751612	NKN	lake	
333795	759639	5751540	NKN	lake	
333788	759655	5751607	NKN	lake	

333772	759658	5751665	NKN	lake
333681	759831	5751991	NKN	lake
333679	759842	5752024	NKN	lake
333627	759870	5751971	NKN	lake
333662	759873	5752089	NKN	lake
333764	759876	5752031	NKN	lake
333675	759881	5752007	NKN	lake
333696	759909	5751962	NKN	lake
333668	759926	5752004	NKN	lake
333683	759931	5752080	NKN	lake
333687	759938	5752043	NKN	lake
333669	759955	5752137	NKN	lake
333628	759967	5751956	NKN	lake
333703	759979	5751956	NKN	lake
333700	759987	5752001	NKN	lake
333670	759995	5752196	NKN	lake
333677	759996	5752055	NKN	lake
333649	759997	5752241	NKN	lake
333740	760009	5752116	NKN	lake
333671	760024	5752167	NKN	lake
333711	760035	5752258	NKN	lake
333695	760041	5751977	NKN	lake
333698	760060	5752052	NKN	lake
333742	760069	5752091	NKN	lake
333721	760078	5752313	NKN	lake
333697	760080	5752142	NKN	lake
333738	760089	5752185	NKN	lake
333709	760096	5752254	NKN	lake
333713	760108	5752309	NKN	lake
333768	760119	5752177	NKN	lake
333744	760125	5752061	NKN	lake
333701	760134	5752109	NKN	lake
333719	760135	5752359	NKN	lake
333699	760143	5752176	NKN	lake
333715	760159	5752245	NKN	lake
333723	760162	5752297	NKN	lake
333722	760201	5752160	NKN	lake
333718	760213	5752230	NKN	lake
304442	797049	5763002	NKN	swamp
304434	797702	5763561	NKN	swamp
304433	797920	5763511	NKN	swamp
304417	797992	5764129	NKN	swamp
304432	798117	5763465	NKN	swamp
304426	798143	5763710	NKN	swamp
304416	798199	5764106	NKN	swamp
304436	798276	5763254	NKN	swamp
304431	798309	5763428	NKN	swamp
304425	798343	5763663	NKN	swamp
304415	798418	5764082	NKN	swamp
304430	798495	5763412	NKN	swamp
304424	798545	5763636	NKN	swamp
304414	798609	5764039	NKN	swamp
304443	798647	5762681	NKN	lake
304438	798685	5763186	NKN	swamp
304429	798693	5763369	NKN	swamp
304406	798700	5766075	NKN	swamp
304423	798727	5763586	NKN	swamp
304413	798784	5764004	NKN	swamp
304439	798833	5763153	NKN	swamp
304428	798879	5763355	NKN	swamp
304422	798922	5763564	NKN	swamp
304412	798965	5763963	NKN	swamp
304440	799065	5763110	NKN	lake

304421	799140	5763491	NKN	swamp	
304419	799191	5763742	NKN	swamp	
304411	799205	5763931	NKN	swamp	
304441	799243	5763082	NKN	swamp	
304427	799315	5763252	NKN	swamp	
304420	799365	5763492	NKN	swamp	
304418	799398	5763669	NKN	swamp	
304410	799419	5763832	NKN	swamp	
304409	799440	5763974	NKN	swamp	
304445	799529	5762570	NKN	lake	LAKE CONNEWARRE
304446	799606	5762389	NKN	lake	LAKE CONNEWARRE
304447	799698	5762167	NKN	lake	LAKE CONNEWARRE
304408	799743	5763984	NKN	swamp	
304448	799922	5762281	NKN	lake	LAKE CONNEWARRE
304449	800167	5762204	NKN	lake	LAKE CONNEWARRE
304404	800215	5766794	NKN	swamp	
304450	800294	5762733	NKN	lake	LAKE CONNEWARRE
304407	800301	5764654	NKN	swamp	
304502	800460	5759814	NKN	swamp	
304503	800464	5759465	NKN	swamp	
304500	800545	5760236	NKN	swamp	
304501	800719	5760156	NKN	swamp	
304451	800727	5762995	NKN	lake	LAKE CONNEWARRE
304457	800800	5761310	NKN	lake	LAKE CONNEWARRE
304405	800899	5765964	NKN	swamp	
304455	800902	5762017	NKN	swamp	
304499	800934	5760558	NKN	swamp	
304454	801005	5762225	NKN	lake	LAKE CONNEWARRE
304504	801011	5759813	NKN	swamp	
304505	801111	5759456	NKN	swamp	
304452	801199	5763401	NKN	lake	LAKE CONNEWARRE
304459	801264	5761824	NKN	swamp	
304453	801277	5762450	NKN	lake	LAKE CONNEWARRE
304506	801437	5759376	NKN	swamp	
304507	801443	5760228	NKN	swamp	
304458	801497	5761456	NKN	swamp	
304464	801561	5762617	NKN	lake	LAKE CONNEWARRE
304465	801603	5762913	NKN	lake	LAKE CONNEWARRE
304460	801666	5762222	NKN	lake	LAKE CONNEWARRE
304466	801719	5763175	NKN	lake	LAKE CONNEWARRE
304463	801836	5762687	NKN	lake	LAKE CONNEWARRE
304496	801884	5760987	NKN	swamp	
304467	801914	5763467	NKN	lake	LAKE CONNEWARRE
304494	802081	5761381	NKN	swamp	
304495	802089	5761203	NKN	swamp	
304468	802102	5763833	NKN	lake	LAKE CONNEWARRE
304469	802202	5764297	NKN	lake	LAKE CONNEWARRE
304462	802208	5762562	NKN	lake	LAKE CONNEWARRE
304508	802280	5759658	NKN	swamp	
304509	802302	5760413	NKN	swamp	
304470	802478	5764602	NKN	lake	LAKE CONNEWARRE
304492	802540	5761812	NKN	lake	LAKE CONNEWARRE
304480	802582	5762901	NKN	lake	LAKE CONNEWARRE
304489	802598	5762153	NKN	lake	LAKE CONNEWARRE
304493	802634	5761684	NKN	lake	LAKE CONNEWARRE
304490	802658	5762013	NKN	lake	LAKE CONNEWARRE
304471	802728	5764989	NKN	lake	LAKE CONNEWARRE
304484	802730	5762542	NKN	lake	LAKE CONNEWARRE
304513	802752	5761248	NKN	lake	LAKE CONNEWARRE
304510	802771	5759978	NKN	swamp	
304535	802840	5756972	NKN	swamp	
304491	802853	5761907	NKN	lake	LAKE CONNEWARRE
304488	802891	5762235	NKN	lake	LAKE CONNEWARRE

304481	802926	5762967	NKN	swamp	
304534	802982	5757088	NKN	swamp	
304486	803042	5762494	NKN	lake	LAKE CONNEWARRE
304483	803053	5762749	NKN	lake	LAKE CONNEWARRE
304487	803185	5762322	NKN	lake	LAKE CONNEWARRE
304511	803214	5759761	NKN	swamp	
304482	803214	5762977	NKN	swamp	
304485	803226	5762607	NKN	swamp	
304533	803253	5757143	NKN	swamp	
304514	803254	5761273	NKN	swamp	
304479	803349	5763284	NKN	swamp	
304512	803488	5760505	NKN	swamp	
304531	803512	5757189	NKN	swamp	
304536	803556	5756785	NKN	swamp	
304530	803770	5757336	NKN	swamp	
304529	803981	5757978	NKN	swamp	
304478	804044	5763357	NKN	swamp	
304528	804078	5758530	NKN	swamp	
304516	804164	5760717	NKN	swamp	
304473	804344	5764549	NKN	lake	LAKE CONNEWARRE
304474	804773	5764249	NKN	lake	LAKE CONNEWARRE
304517	804780	5760678	NKN	swamp	
304476	804879	5763737	NKN	lake	LAKE CONNEWARRE
304522	805900	5759501	NKN	swamp	