DEPARTMENT OF INFRASTRUCTURE PLANNING AND ENVIRONMENT
NATURAL SYSTEMS DIVISION

Water Resource Mapping
Barkly Tablelands

REPORT 23/2003
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SUMMARY

Three maps summarising water resources across the Barkly Tablelands have been prepared. They show the options available for developing a water supply. For a particularly area these indicate the most suitable type of water supply and their potential uses.

A CD-ROM containing basic groundwater information has also been compiled. It includes the three maps in digital format and some interactive maps (GIS) with basic bore and infrastructure data.

The Barkly Tablelands lies above the Georgina Basin, a large geological basin with extensive aquifers formed in fractured and cavernous limestone. This makes groundwater widely available and often the best option for stock supplies. Surface water storages are used but there is potential for greater utilisation of excavated tanks and dams.

INTRODUCTION

General

A set of three "Water Resource Maps" has been produced as the major output of a study of groundwater and surfacewater resources of the Barkly Region. The area covered includes most of the Barkly Tablelands and adjacent areas. It extends westwards from the Queensland border to the Stuart Highway (Figure 1). The study was funded jointly by the NT Government and the National Heritage Trust (formerly Landcare). Eric Rooke (DIPE, Alice Springs) did the majority of the work. Steven Tickell assisted with the completion of the final map and also compiled this report.

Fieldwork took place between 1996 and 1998 and involved drilling test holes, geophysical borehole logging, test pumping and location of existing bores with GPS.

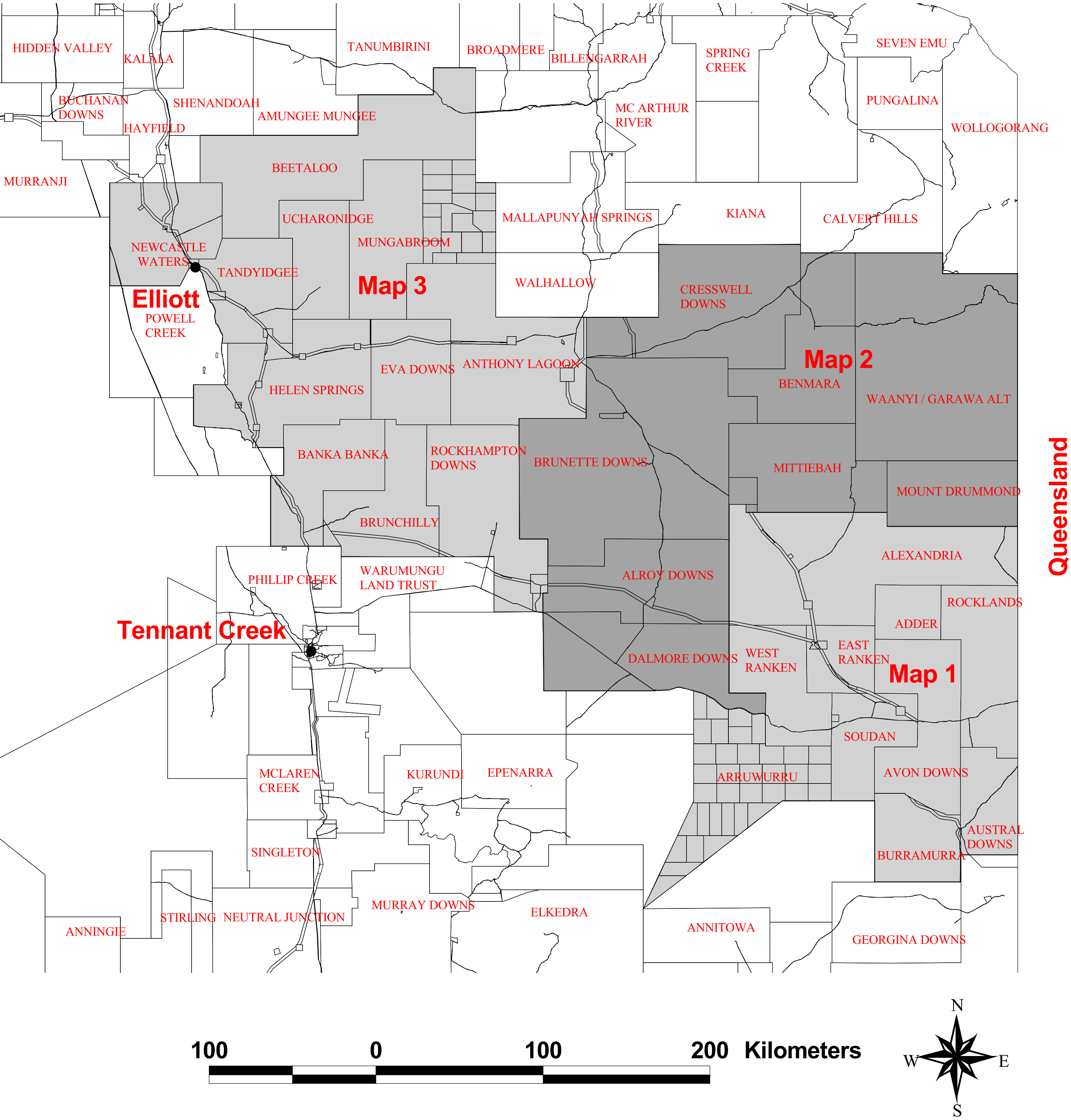
Figures 4 to 11 in this report are based on borehole data taken directly from the department's HYDSYS database. This information is derived from the drilling reports submitted by the drillers on completion of each bore. No checking of the data was done for errors such as incorrect locations. The large number of bores drilled on the Barkly should be sufficient to counteract a small proportion of incorrect information and to give a good idea of regional variations of the various groundwater properties.

The various map layers included in the accompanying Arc Explorer GIS project are listed in Appendix 1.

Climate

The area has a semi-arid subtropical climate. Average annual rainfall varies from around 300mm in the south through to 600mm in the north. Rain occurs predominantly during the summer months and annual totals show moderate variability from year to year. The rainfall distribution can also be variable due to the regions vast extent. Annual pan evaporation is of the order of 3 to 3.5 metres. Maximum temperatures in January average around 38^0C while in July they are around 27^0C.

Figure 1
Locality map



Landform, soil and vegetation
The area covered by the three maps falls within four broad geomorphic zones, namely: black soil plains, laterite plains, bedrock hills and desert country (Figure 2). The black soil plains, commonly referred to as the Barkly Tablelands is an extensive and largely treeless black soil plain extending some 500km from northwest to southeast and some 200km from northeast to southwest.

The plains have very gentle relief. The lowest areas such as the lakes, lie at around 200 metres above sea level. The margins of the plains lie between 220 and 250 metres above sea level but tend to be higher on the northeastern side. The highest areas rise to 270 metres above sea level and are on Mittiebah and Mount Drummond.

The plains abut the "Desert Country" in the southwest. This comprises a gently undulating landscape with sandy soils and low open woodland / grassland. It represents a relict dunefield, which is partially developed on the outwash slopes of the Ashburton Range. Traces of the dunes are visible on satellite imagery. Drainage is poorly developed with streams from the Ashburton Range to the west generally terminating in floodouts within the "Desert Country". Few streams manage to completely cross the area to the black soil plain in the east. Slopes are to the northeast, falling from about 300 metres above sea level adjacent to the ranges down to 200 metres at the edge of the black soil plain.

The areas classified as "Bedrock Hills" includes the Ashburton Range in the west and hilly country in the far northeast. They are well dissected with a dense dendritic drainage systems cut into hard Proterozoic bedrock, predominantly sandstone. Soils are thin and rocky with abundant sandstone outcrop and a cover of low open woodland. The Ashburton Range rises to 350 metres above sea level with a relief around 50 metres. The area in the northeast reaches a maximum elevation of just over 400 metres above sea level and mostly drains north to the Nicholson River system.

From Beetaloo east to Creswell Downs on the northern margin of the black soil plain is a "Laterite Plain" formed by a laterite capping on Cretaceous aged sedimentary rocks. Its highest point is 280 metres above sea level along the drainage divide that separates inland drainage from north flowing streams that drain to the Gulf of Carpentaria. From there it slopes gently to the southwest or south. It has been partially dissected, resulting in a few patches being isolated from the main body to the north. A good example is the large boomerang shaped area that extends from Mungabroom to Beetaloo (Figure 2). Soils vary from gravelly lateritic earths on the undissected plain through to cracking clays and sands in drainage lines. Vegetation cover includes Acacia open forest and low Eucalypt woodland.

GEOLOGY
Rock sequences of three main ages: Precambrian (older than 550 million years), Cambrian (500 million year) and Cretaceous (100 million years), make up the geology of the area (Figure 3).

The Precambrian rocks comprise sandstone with lesser amounts of siltstone and dolomite. They are exposed in the "Bedrock Hills" landform unit described above and

Figure 2

Geomorphic Zones

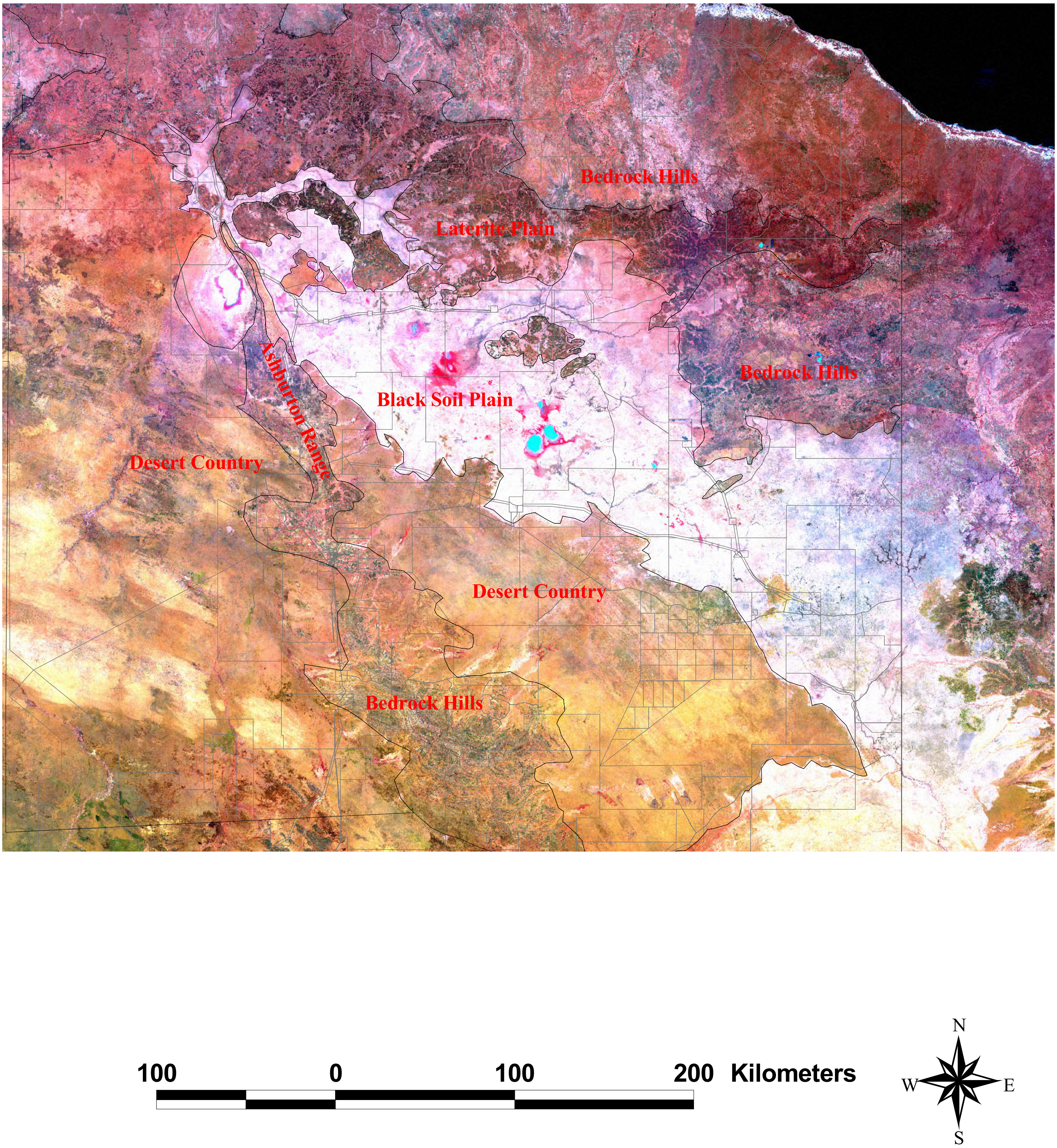
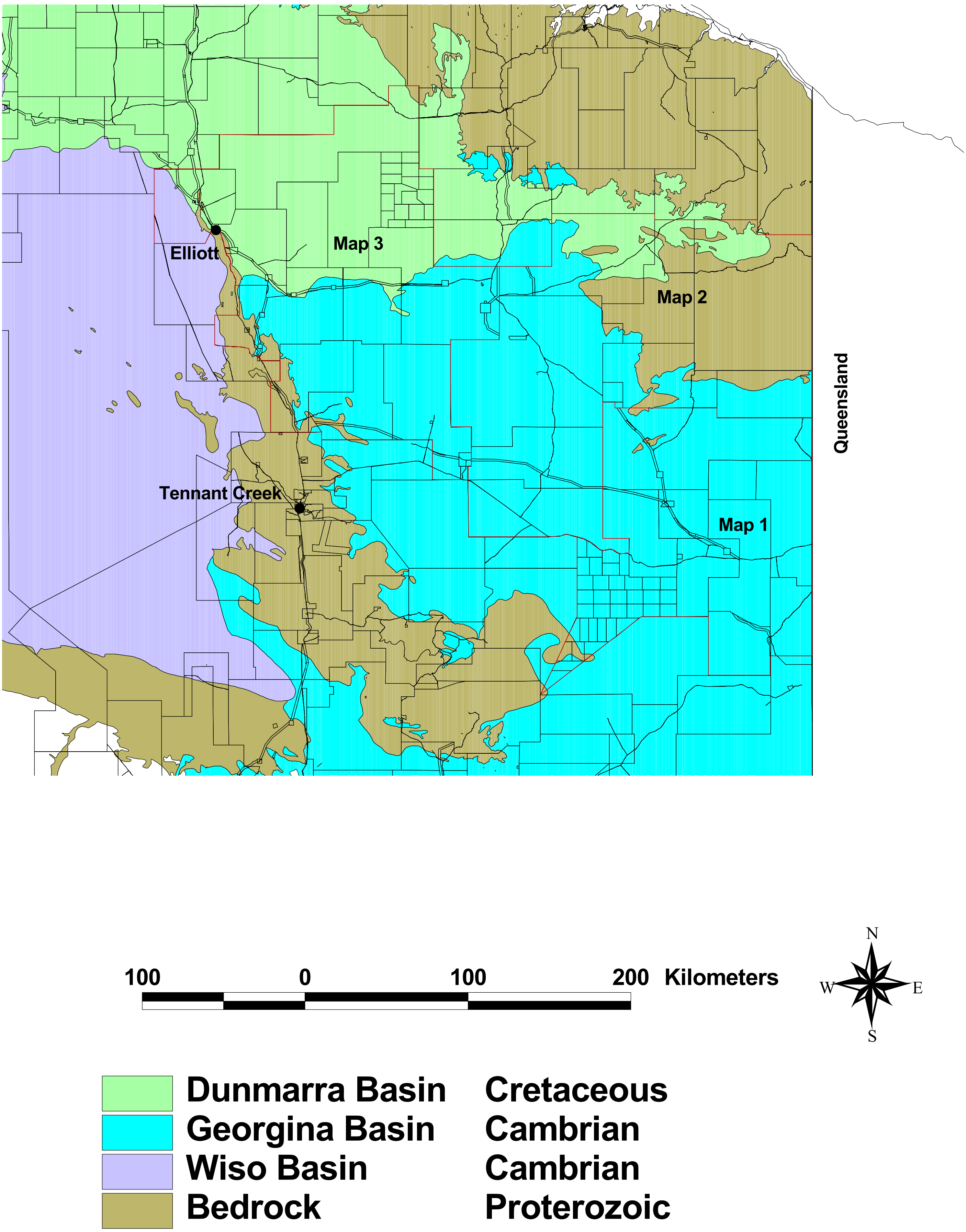


Figure 3

Regional Geology



are also found at depth beneath the younger rocks across the whole area. The rocks are folded and faulted to varying degrees and outcrop moderately well. They are mostly hard, non-porous and fractured.

Limestone, siltstone and sandstone of Cambrian age underlie most of the mapped area except where the older Precambrian rocks are exposed. They were deposited in two geological features known as the Georgina and Wiso Basins. The former extends from Mataranka in the north, the Plenty Highway in the south, Tennant Creek in the west and into Queensland in the east while the latter is located west of the Stuart Highway. The study area lies predominantly within the Georgina Basin. The beds are near flat lying and are rarely cut by faults in this section of the basin. The rocks form distinct layers, which have been named on the numerous 1:250000 scale geological maps that cover the area. The current terminology is somewhat complicated as there is a multitude of geological formations mapped in different areas and some of them may refer to the same unit.

Limestone makes up the bulk of the Cambrian rocks along with its magnesium rich variety dolostone. It is a hard rock that is commonly fractured and contains solution cavities varying from millimetre to metre scale. The rock is gray when fresh, massive to well bedded and often has concretions or nodules of chert in specific horizons. Sandstone and siltstone beds are also common as well as a whole range of variations of the three main rock types, such as sandy limestone, silty limestone, dolomitic sandstone etc.

In the western part of the area two formations are recognised in the Cambrian sequence, the Gum Ridge Formation and the overlying Anthony Lagoon Beds. The former is largely limestone and dolostone while the latter is siltstone and dolomitic siltstone with thin limestone interbeds.

In the north of the area in the Dunmarra Basin (Figure 3), softer clays and sandstone of Cretaceous age overly both Precambrian and Cambrian rocks. The region has been dominated by erosion since the Cretaceous. Since then, thin and patchy occurrences of Miocene (15 million years) freshwater limestone have accumulated. These are restricted to the Tablelands and some of the limestone has recently been reinterpreted as having formed in soils rather than in a sedimentary environment (Hussey et al 2001). During the Quaternary (less than 2 million years) sand dunes formed a thin sheet of sand in the south and minor alluvial and lake deposits formed mainly on the Tablelands.

WATER RESOURCE MAPS

The purpose of the maps is to give a broad scale picture of the water resources. This can then be used along with other relevant data such as soils and infrastructure, to assist in property planning and in the optimum use of the water resources.
The main information shown on the three maps includes

- typical bore yield
- groundwater salinity
- Suitability for stock dams.

Each mapsheet has a central main map on which these three factors are combined to produce "Water Resources Development Options". For a particularly area these indicate the most suitable type of water supply and their potential uses. For example an area with good potential for stock dams and small supplies of brackish groundwater would be classed as useful for stock only. On the other hand if large supplies of fresh groundwater were available then the potential uses for the water would include stock, domestic and irrigation. Note that the potential uses relate to the water attributes only. For example not all soils are suitable for irrigation, even if adequate water is available.

The criteria used for classifying the uses of the water are shown in the following table.

Groundwater		
Use	*Water Salinity(mg/l)*	*Bore yield(l/sec)*
Stock	less than 3000	
Domestic	less than 1000	
Irrigation	less than 1500	more than 2.5
Surfacewater		
only considered as stock water		

Three smaller scale maps show "Simplified Geology", Groundwater Resources" and "Surfacewater Resources". The geology was taken directly from the published 1:250000 scale geological maps produced by the Australian Geological Survey Organisation and the Northern Territory Geological Survey. Geology is often a major controlling factor for the distribution, quantity and quality of groundwater. For example limestone tends to slowly dissolve as acidic surfacewater moves down through fractures. These can be gradually enlarged, forming aquifers comprising networks of relatively large channels including caves. Such aquifers can potentially store large volumes of water and supply high yields to individual bores. On the other hand a rock such as siltstone can only support minor aquifers formed by localised networks of fine fractures.

The three dimensional distribution of the rocks influences aquifer distribution. In the Georgina Basin for example the Gum Ridge Formation, the lowermost aquifer in the basin, rises to the surface along the basins western edge. Eastwards from there it gets progressively deeper until it is beyond the economic depth for a stock bore.

The "Groundwater Resources" map shows both the water quality (salinity) and bore yield. Water quality has been estimated from records of existing bores, while bore yields are derived from existing bores and the underlying geology. Both yield and salinity classes represent average values. Within an area with yield mapped as less than 2.5 litres/second some bores may encounter higher yields but the majority will be within that range.

The "Surfacewater Resources" map gives an indication of the suitability for stock dams (excavated tanks and small embankment dams). It is based mainly on the 1:1,000,000 scale Land Systems mapping done by CSIRO, supplemented by geological maps in areas not covered by the Land Systems map. The assessment has taken soil type and slope into account as well as the presence of existing dams.

GROUNDWATER

Groundwater is water stored in rock formations within fractures (cracks), cavities and the spaces between sand grains. An aquifer is a formation that yields sufficient water to supply a bore. Some important aspects of aquifers and groundwater quality on the Barkly Tablelands are described below:

Types of Aquifer

There are two main types of aquifers in the study area: rocks that are fractured and rocks that are both cavernous and fractured. The latter type is the most extensive, occurring in the limestones of the Georgina Basin. They are usually very extensive and can yield moderately large quantities of water. On a broad scale the limestone could be considered to form a single continuous aquifer across the Tablelands.

The fractured rock aquifers on the other hand tend to be localised and yields are mostly low. These occur within siltstones and sandstones of the Georgina Basin and in the older rocks in areas such as the Ashburton Range and the Gulf country.

Aquifer Depth

This varies systematically across the area and is influenced mainly by the elevation of the land surface. Figure 4 shows depths to the top of the slotted interval in the bore casing. This is used here as an approximation for aquifer depth. In low-lying areas aquifers are shallower, while in higher areas the aquifers are deeper. Aquifer depths mostly range from 50 to 125 metres below the ground.

Standing water level

Water levels commonly vary between 30 and 100 metres below ground level. The watertable is a near horizontal surface so the standing water level is also controlled by the elevation of the land surface. Water levels are shallowest in low-lying areas and deepest in higher areas. (Figure 5).

Yield

The majority of bores in Georgina Basin aquifers have airlift yields (recorded at the time of drilling) between 0.5 and 5 litres/second. This is often not a true representation of the potential of the aquifer because stock bores are normally only drilled deep enough to obtain the required supply, typically 2 litres/second. The limestone formations generally continue to greater depths so there is potential for higher yields if bores were drilled deeper.

An indication of the potential for higher yields can be seen in the number of bores reported to have "lost circulation" during drilling (Figure 6). This usually occurs when the air pumped into the borehole is lost in cavernous limestone and there is insufficient pressure to return drill cuttings or water to the surface. In such cases no airlift yield is obtained and test pumping is the only way to determine the capability of the bore. Cavernous limestone can form a high yielding aquifer if the cavities are widely developed and interconnected.

Figure 4

Aquifer Depths

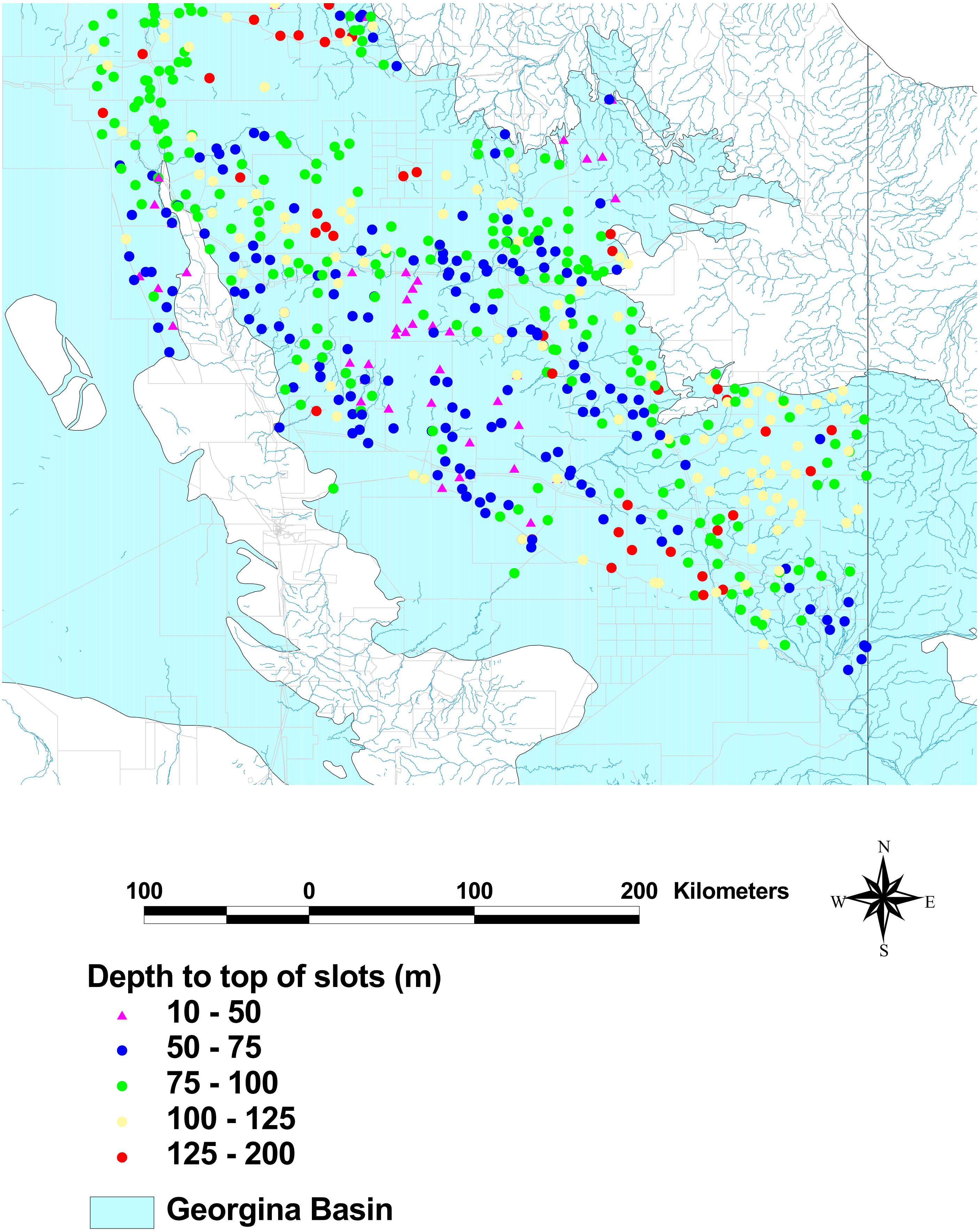
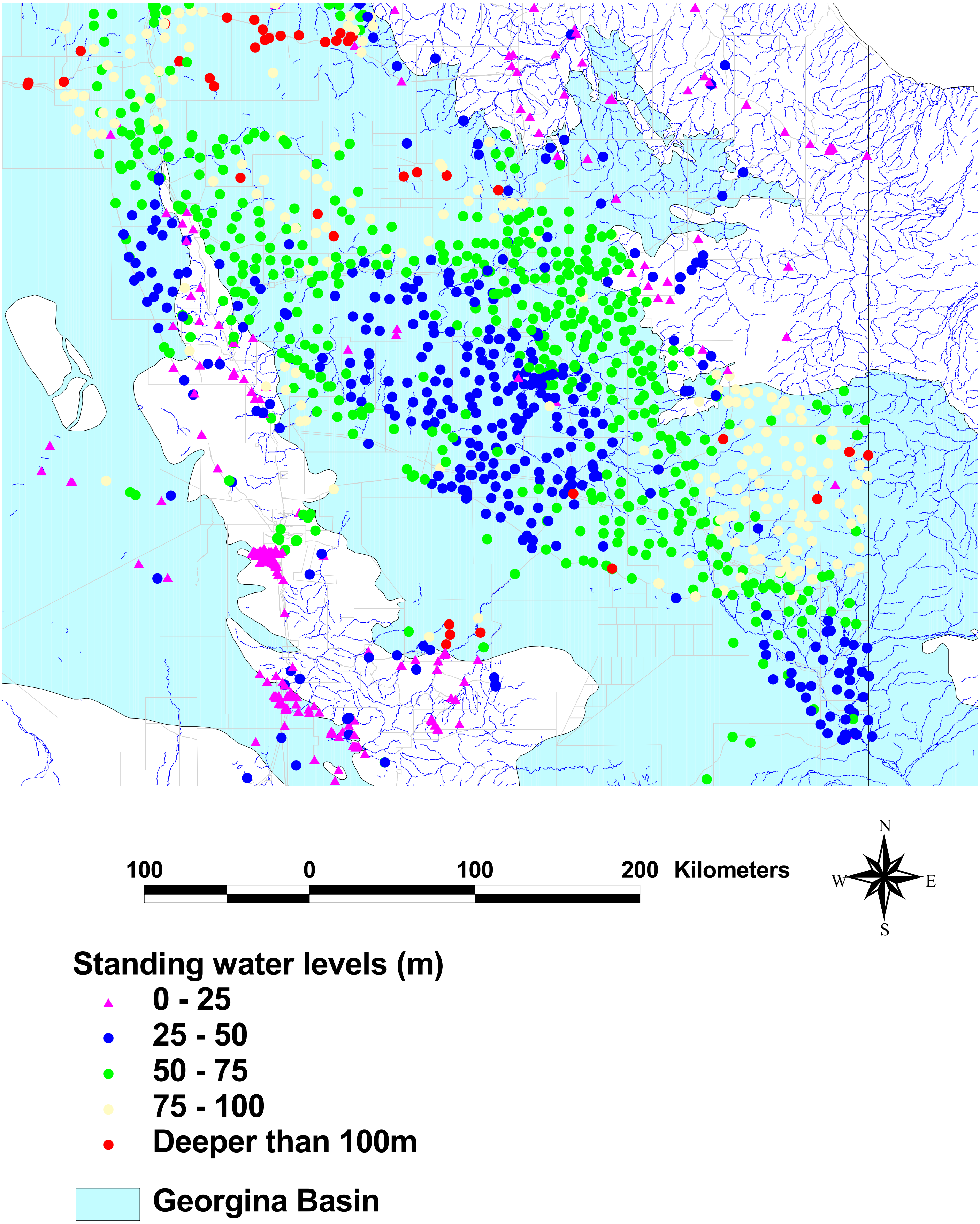


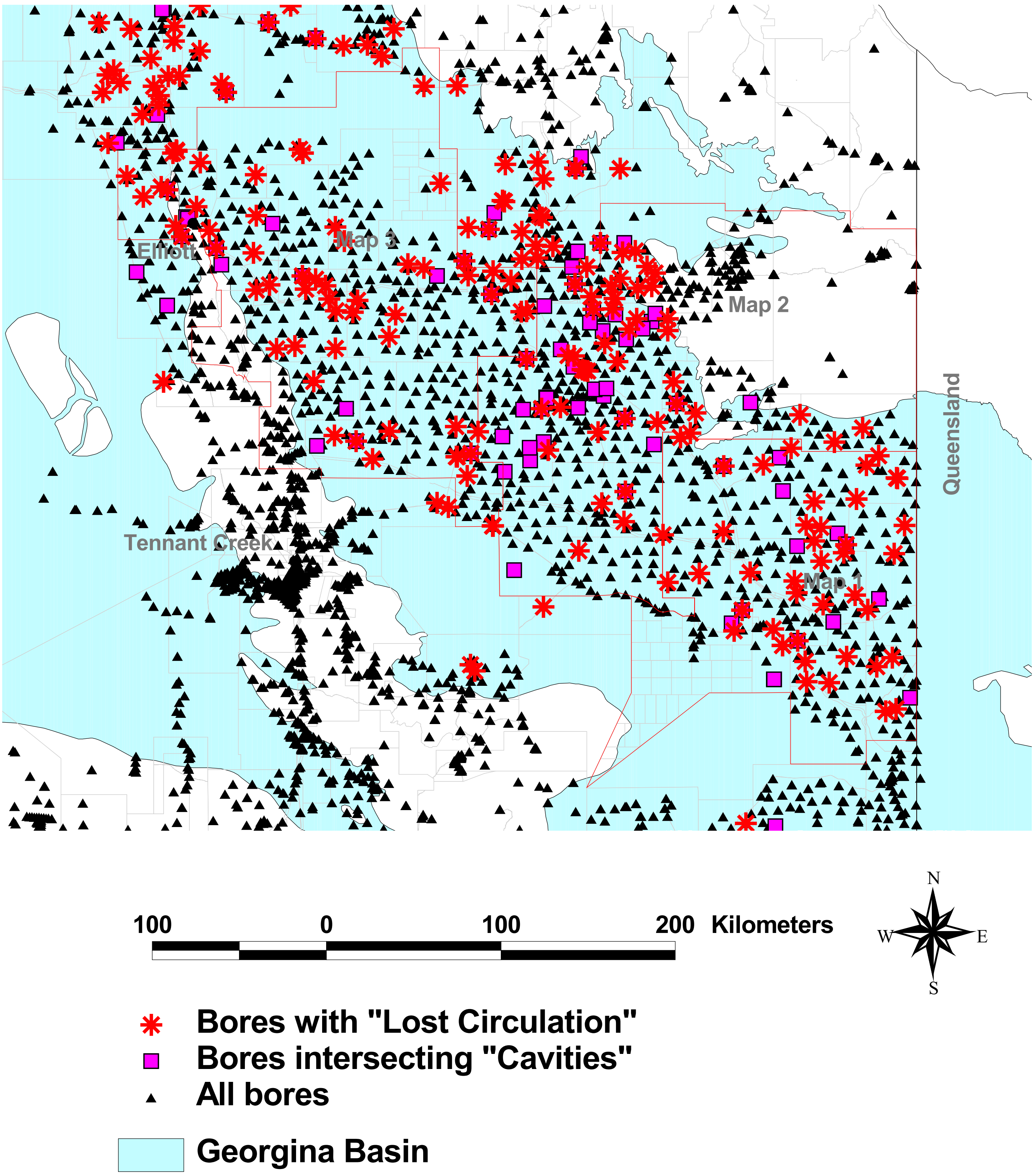
Figure 5

Standing Water Levels



Bores with"Lost Circulation" or "Cavities"

Figure 6



In the limestone aquifers there is a high success rate. Relatively few bores are abandoned due to insufficient supply. Figure 7 shows bores reported as “dry”, “dud bore”, “insufficient water” or “no supply”. Some of these may not have been drilled deep enough, while others may have been abandoned due to lost circulation and assumed to have no water.

Fractured rock aquifers in areas surrounding the Georgina Basin are generally less prospective with a much greater chance of not obtaining sufficient water. Careful site selection in these areas based on rock type and location of fractures using aerial photographs will considerably improve the success rate.

Water Quality

The groundwaters are predominantly fresh with Total Dissolved Solids (TDS) in the range 500 to 1500 mg/L (Figure 8). There is a significant area of brackish water centred on Brunette Downs where the TDS ranges up to around 10000 mg/L. Fresher waters (less than 500 mg/L TDS) occur in the Alexandria area.

The Total Dissolved Solids comprises a number of types of ions (salts) derived either from the rock itself or from the surfacewaters that recharge the aquifers. Sodium and bicarbonate are the dominant ions in the fresh groundwaters while in brackish waters, sodium and chloride are dominant with lesser amounts of calcium, magnesium, sulphate and bicarbonate. Excessive concentrations of certain of these ions can limit the uses of the water. The maximum recommended values for human consumption and for cattle are listed in Appendix 2. Note that the recommended values are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt can affect the user. In the case of stock, these can include the age and condition of the cattle, the time of year, the distance they walk each day and whether or not they have access to other water sources.

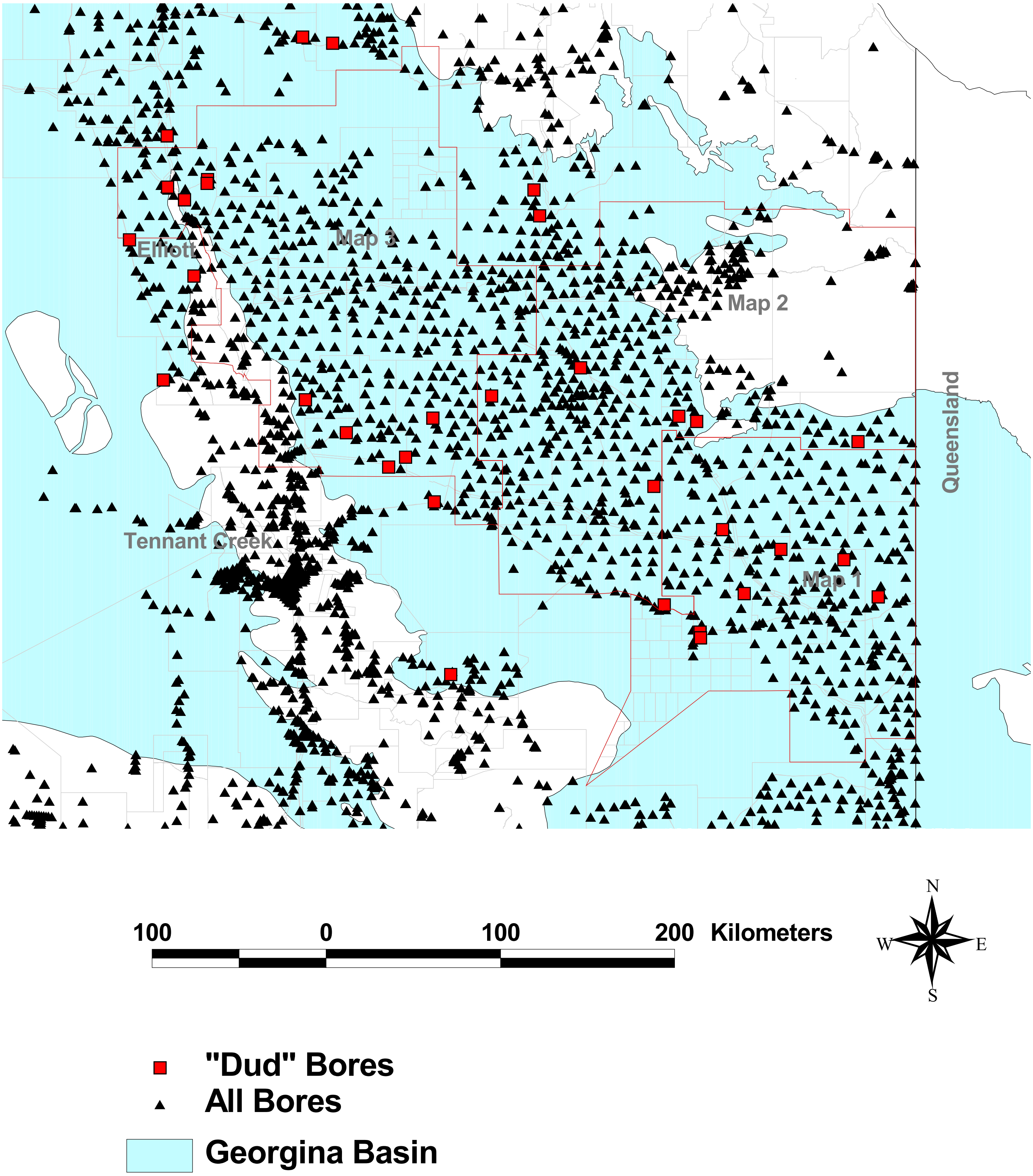
On the Barkly, the chemical components that can commonly limit the use of the groundwater include sulphate, fluoride and the Total Dissolved Solids (Figures 8, 9 & 10). High concentrations of these salts occur mainly in the central part of the Tablelands, centred on Brunette Downs. Further information on suitability of waters for stock is available from the Chief Veterinary Officer, NT Department of Business, Industry and Resource Development.

Regional Groundwater Flow

Water moves from the surface down into aquifers to become groundwater. This process is termed “recharge”. It then moves laterally through the aquifer to eventually discharge at points lower in the landscape into springs and streambeds.

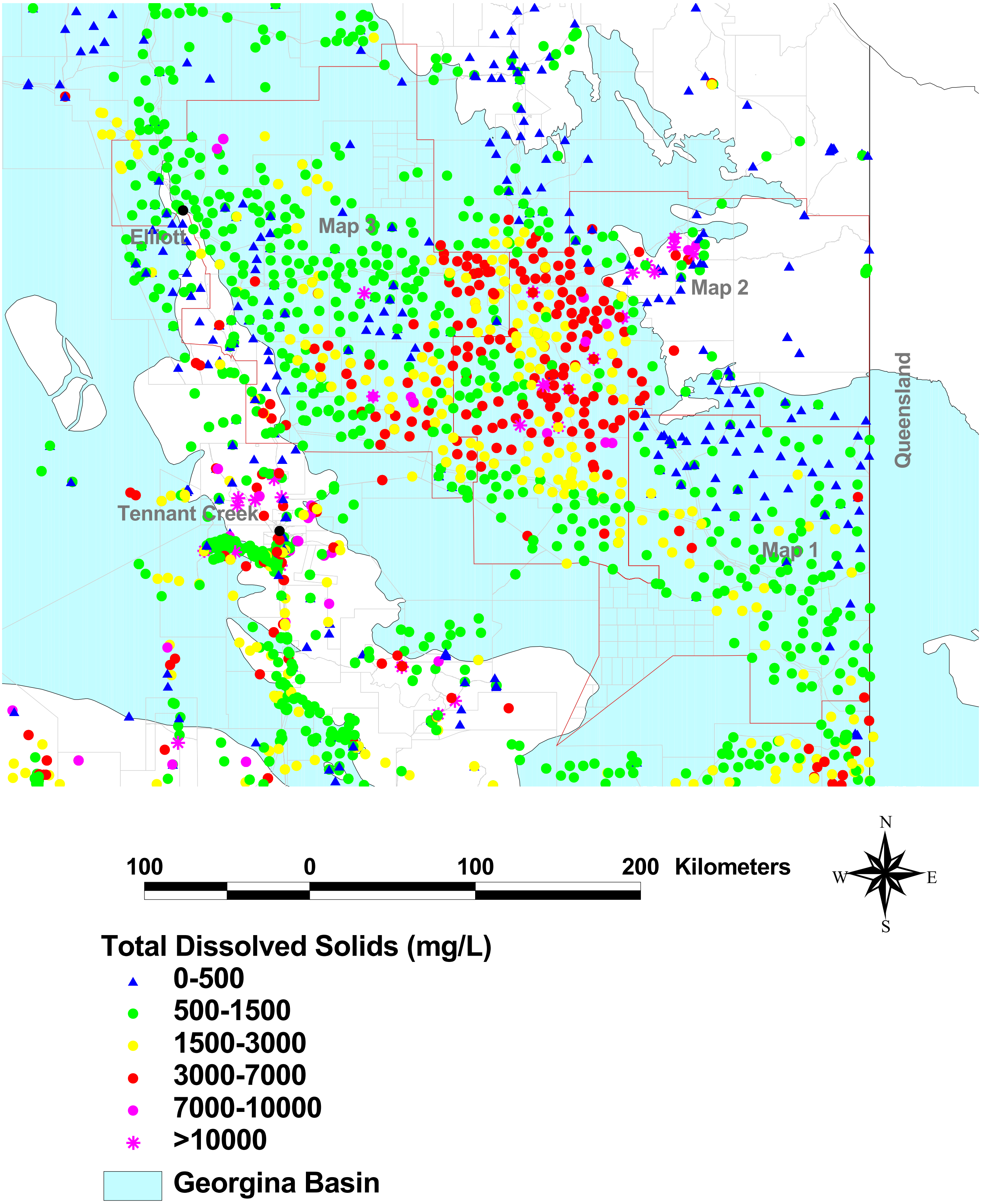
Areas that receive high recharge are reflected in the Total Dissolved Solids content of the groundwaters (Figure 8). If water soaks rapidly into the ground its TDS remains low because there is little chance for salts to be concentrated by evaporation or for salts to be dissolved out of the surrounding rocks. There are several areas that stand out as having low TDS waters, notably Alexandria station and surrounding properties, the northeastern and southwestern margins of the Georgina Basin and the area around Tarrabool Lake. A certain amount of recharge probably occurs over the whole area but it is likely to be greatest at the above locations. The underlying geology influences

Figure 7 "Dud" Bores



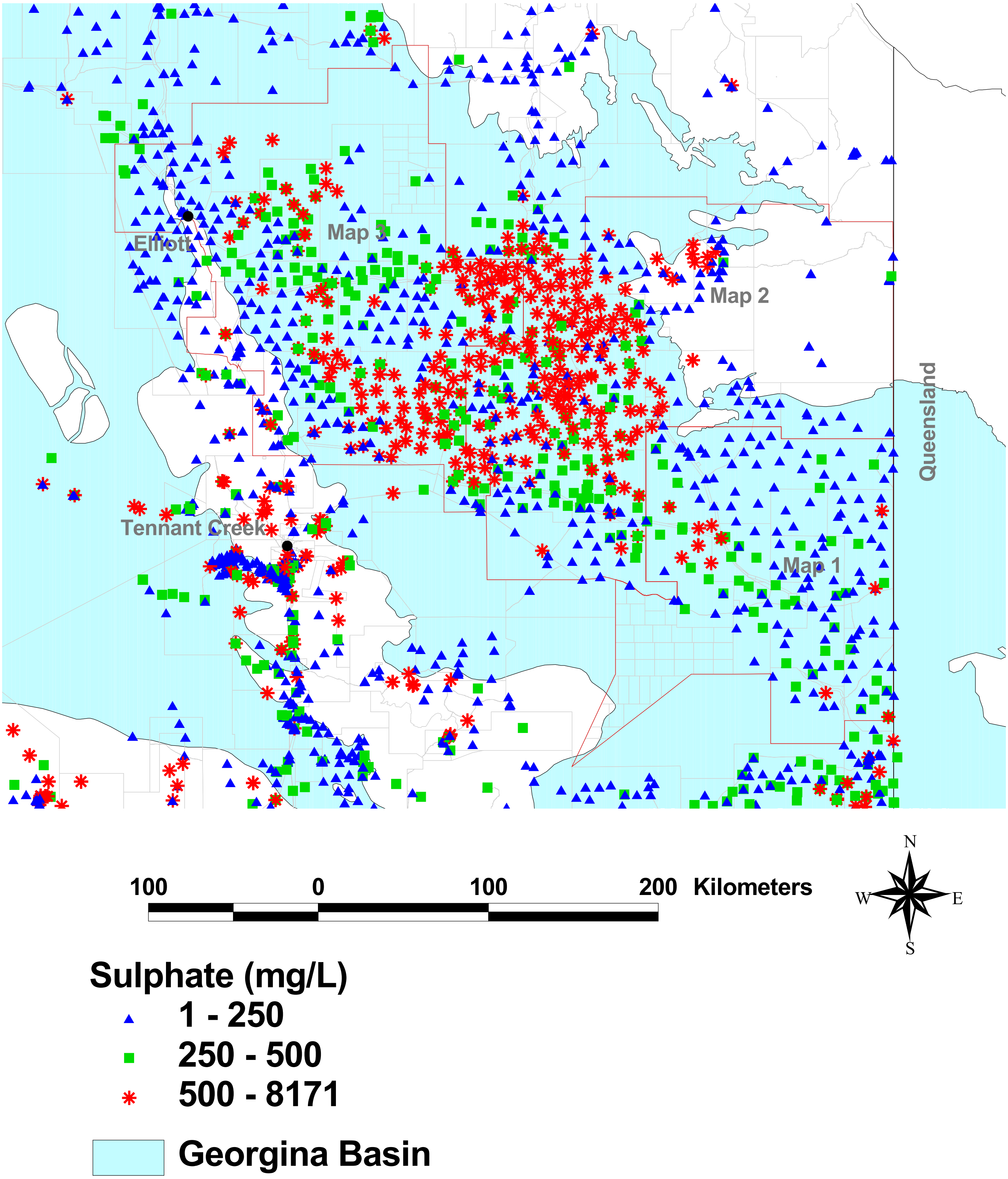
Groundwater TDS

Figure 8



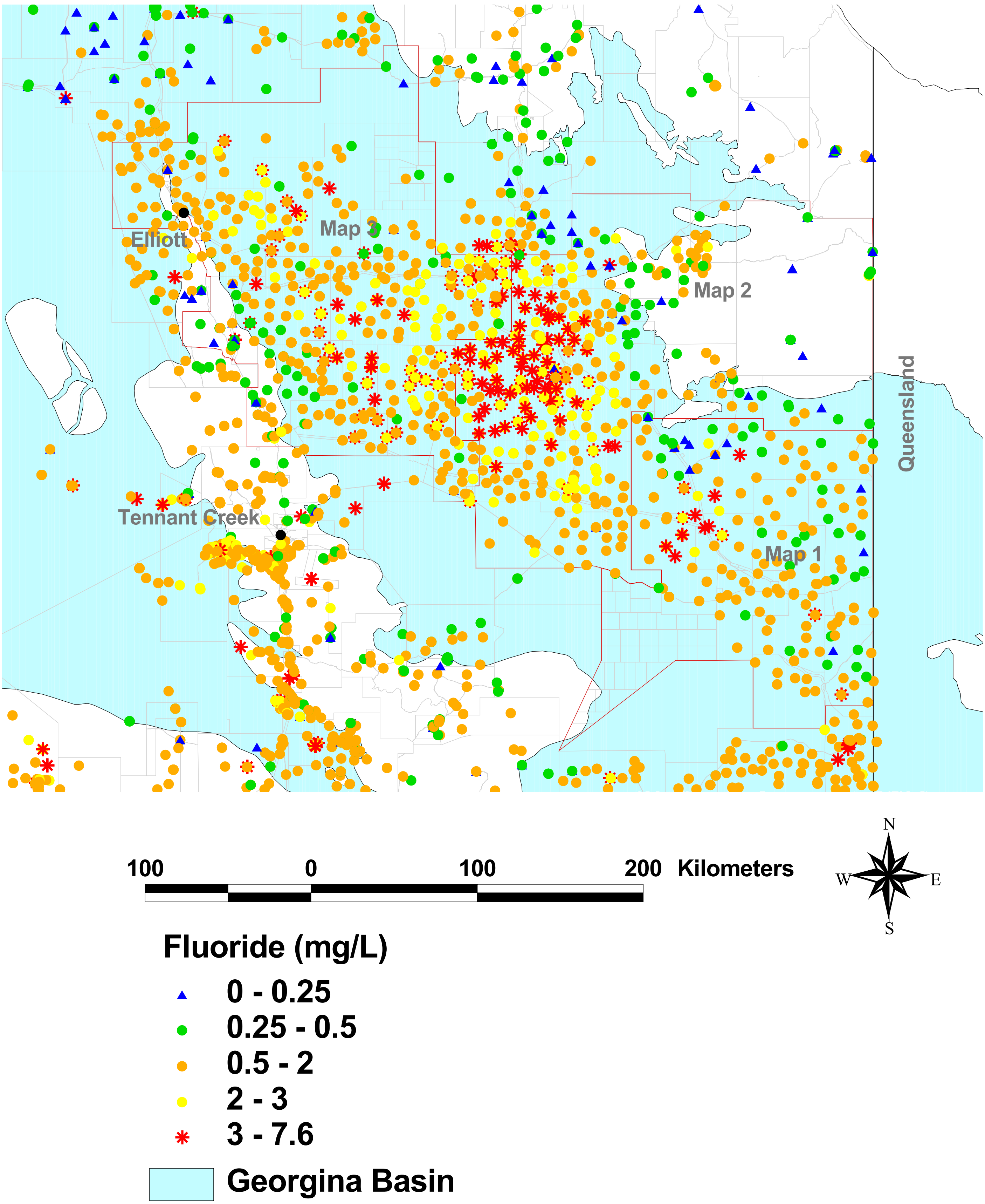
Groundwater Sulphate

Figure 9



Groundwater Fluoride

Figure 10



the recharge rate in the first two areas. The Camoweeal Dolomite and the Gum Ridge Formation directly underlie them. Both formations are known to be particularly cavernous and have sinkholes associated with them.

The higher TDS values observed on Brunette Downs and surrounding areas are due to salts dissolved from the rock. There is evidence that the underlying Anthony Lagoon Beds and equivalent formations contain deposits of sodium chloride (common salt) and calcium sulphate (gypsum) that formed when the sedimentary rocks were laid down. These rocks contain a high proportion of low permeability siltstone that restrict the amount of recharge to a level such that a considerable amount of the original salts are still retained in the rock.

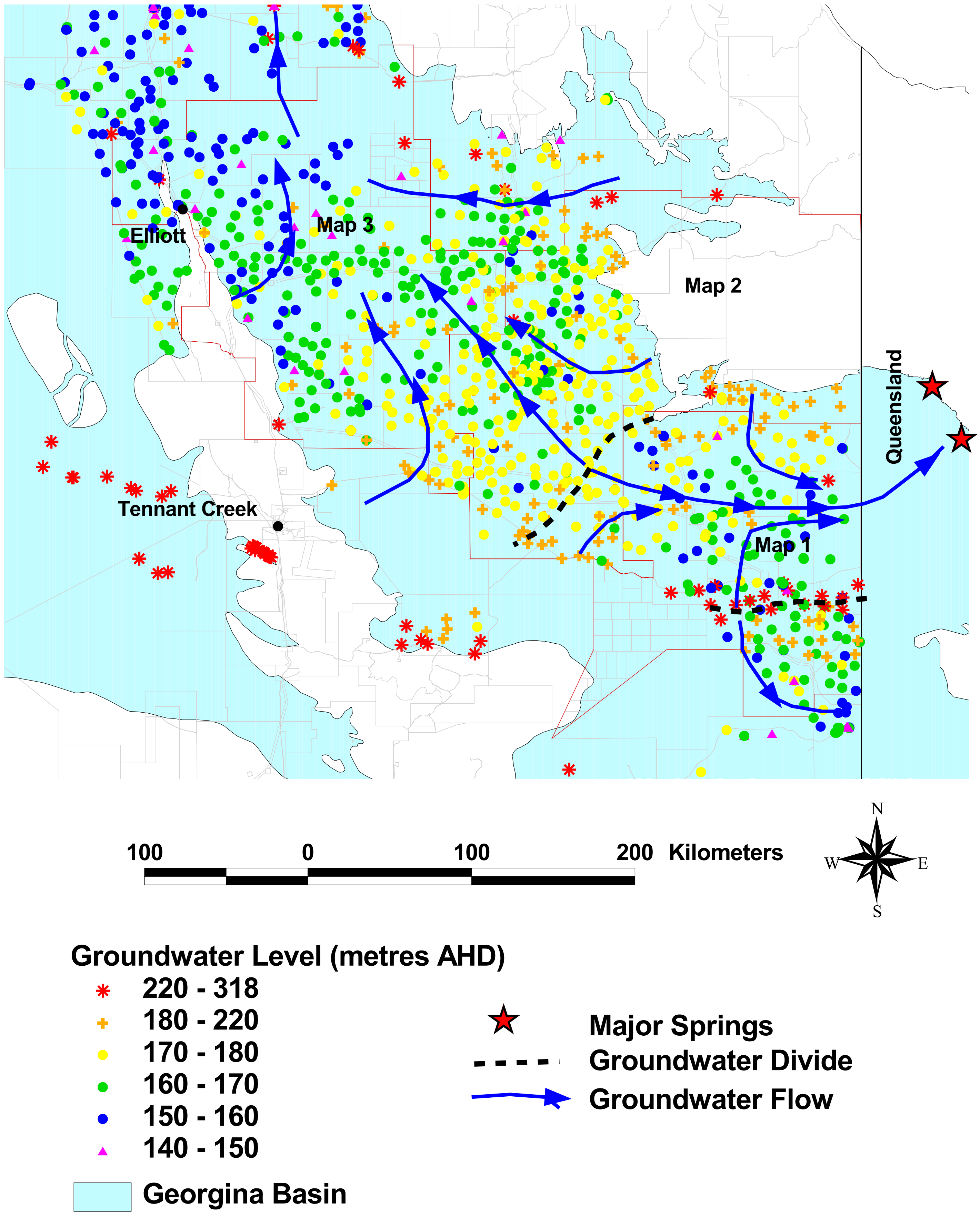
The pattern of regional groundwater movement can be deduced from water levels measured in bores. Figure 11 shows groundwater levels plotted relative to sea level. Groundwater moves from higher to lower elevations under the influence of gravity. The actual gradients are very low, of the order of a 10 metres drop per 100 kilometres and the rate of flow is correspondingly slow, of the order of a few metres/year. The water levels show a groundwater divide extends from Mittebah to Dalmore Downs separating northeast and southeast flows. There is also a component of flow from the basin margins inwards.

There are two known outlets for the Georgina Basin groundwaters; the springs that drain into the Roper River at Mataranka and springs draining into Lawn Hill Creek and the Gregory River in Queensland. These two sets of springs are the end points of the northeast and southeast flow paths respectively. Dry season flows in these rivers are largely derived from groundwater discharge from the Georgina Basin aquifers. In the Roper River these flows vary from 2 to 7 cubic metres/second, while in the Gregory River and Lawn Hill Creek the combined flows range from 1 to 5 cubic metres/second. The total outflow from the basin is therefore in the range 3 to 12 cumecs. The variation is due to differing amounts of rainfall in preceding years.

Using a simple water balance, the recharge to the Georgina Basin can be estimated. If the system is in balance (ie. water levels remain more or less constant from year to year) then recharge will be equal to the volume discharged to the Roper or Gregory Rivers plus the volume extracted from bores. Outflow to rivers averages 7 cubic metres/second, which equates to 221 X 10^6 cubic metres per year. An estimate of annual water usage for stock (based on cattle numbers) is 8.7 X 10^6 cubic metres per year (National Land & Water Audit 2002). The annual recharge is equal to the outflow plus the usage (230 X 10^6 cubic metres per year) divided by the area of the basin (228000 km^2) and works out to be about 1mm/year. Considering that rainfall varies between 300 to 600mm across the area, only a very small proportion of it recharges the aquifers, most is either lost directly to evaporation, utilised by plants or runs off to the sea in those catchments that have external drainage.

Groundwater Levels

Figure 11



Note:9 second DEM used to derive ground elevations at each borehole.

SURFACEWATER

Drainage

Drainage is mostly internal except for a small area adjacent to the Queensland border on Mount Drummond and the eastern part of Alexandria in the headwaters of the Nicholson and Gregory Rivers, which flow to the Gulf of Carpentaria (Figure 12). The area to the southeast of Alexandria forms the headwaters of the Georgina River which flows southeast into Queensland and then to Lake Eyre in South Australia. A low drainage divide on Alexandria separates the Georgina system from the major part of the plains to the northeast. That area comprises three main areas of local internal drainage centred on Lakes Sylvester, Tarrabool and Woods respectively.

Watercourses that drain the Tablelands are intermittent and only flow after major rains. Some waterholes in the region retain water for extended periods but few are permanent. Several lakes including Lakes Wood, Tarrabool, BeBurgh and Sylvester are centres of internal drainage on the plains. They normally contain water only during the wet season and for a short time after but runs of several above average wet seasons may allow them to hold water for several years. Cyclonic events occasionally influence the Tablelands and these can result in widespread heavy rainfalls and the filling of the lakes. Such an event occurred in March 2001 and the abundance of surface water can be seen on a satellite image recorded soon after (Figure 13). Compare the extent of the lakes after an average wet season (Figure 12) to that after an above average wet season (Figure 13).

Excavated tanks and dams

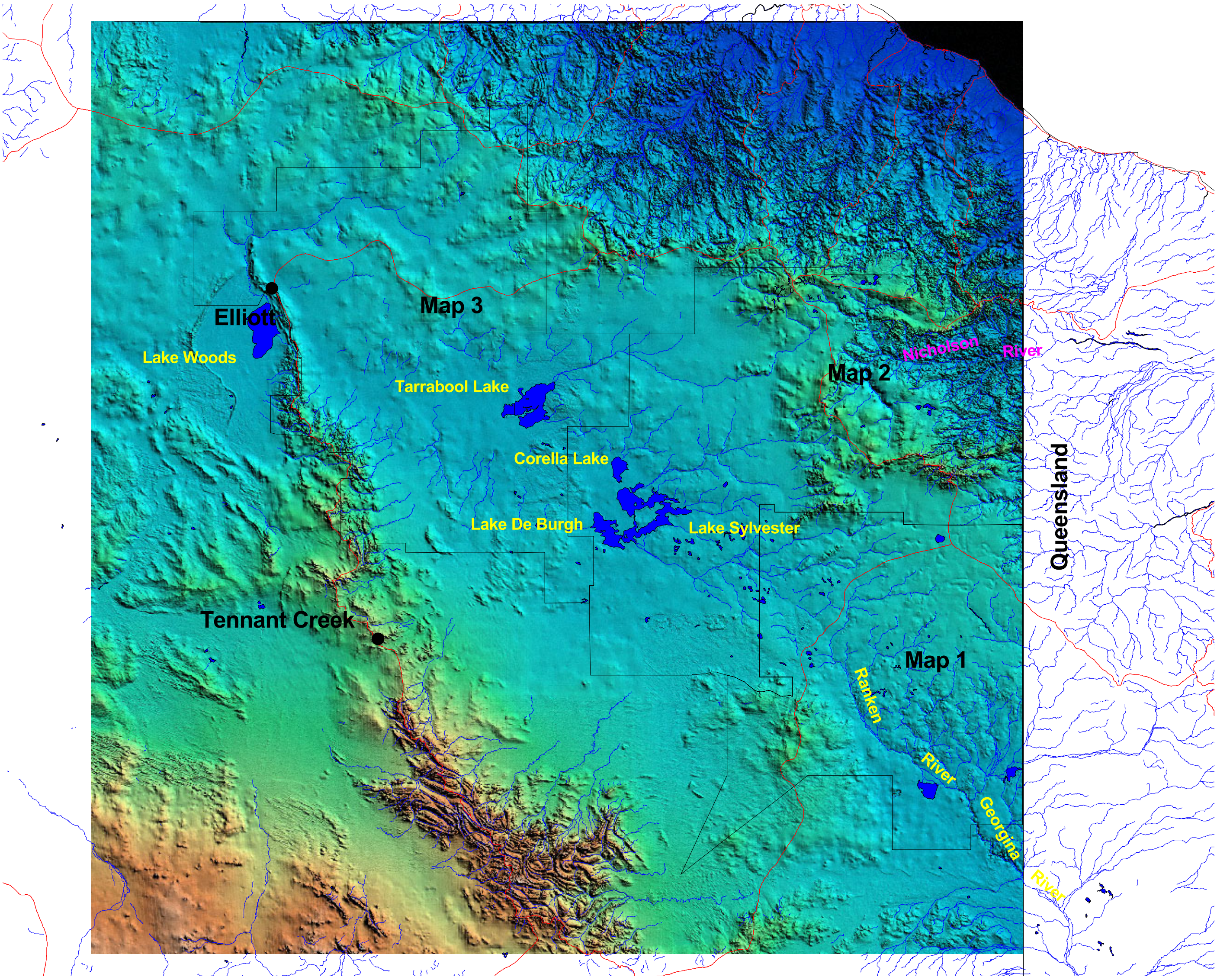
Tanks and dams only form a minor source of stock water on the Tablelands due mainly to the abundant groundwater supplies available. Two main types of surfacewater storage discussed here are excavated tanks and embankment dams. The former basically consists of a large hole in the ground. They may or may not have a surrounding embankment for additional storage capacity. The embankment must be at a level where it can overtopped by floodwaters. Embankment dams consist of a wall built across a drainage line.

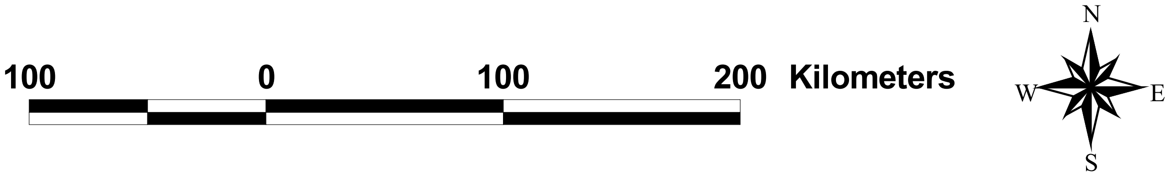
An important requirement for a site for an excavated tank is that there is sufficient depth of easily excavated soil. The soil must also be capable of holding water. With an annual pan evaporation around 3 metres or more, a tank must be deeper than that, in order to have water available for stock throughout the Dry season. No matter how large the surface area of a water body, the same depth of water will be lost to evaporation. The depth of the tank must be calculated based on the evaporation, stock numbers and the length of time that the supply is required. Tanks are usually located on floodways where the velocity of the water is not great enough to cause siltation problems. Given that there are existing successful excavated tanks on the Tablelands, more widespread use of tanks could be made, particularly if groundwater sources are locally inadequate due to either poor quality or quantity.

In the case of embankment dams it is also important to impound a sufficient depth of water in excess of the annual evaporation rate if a useable supply is to be obtained. Another factor to be considered with this type of dam is the structural stability of the wall. Relatively high walls may be necessary to get sufficient depth of storage and these require a high standard of design and engineering to withstand flood conditions.

Figure 12

Drainage and Topography

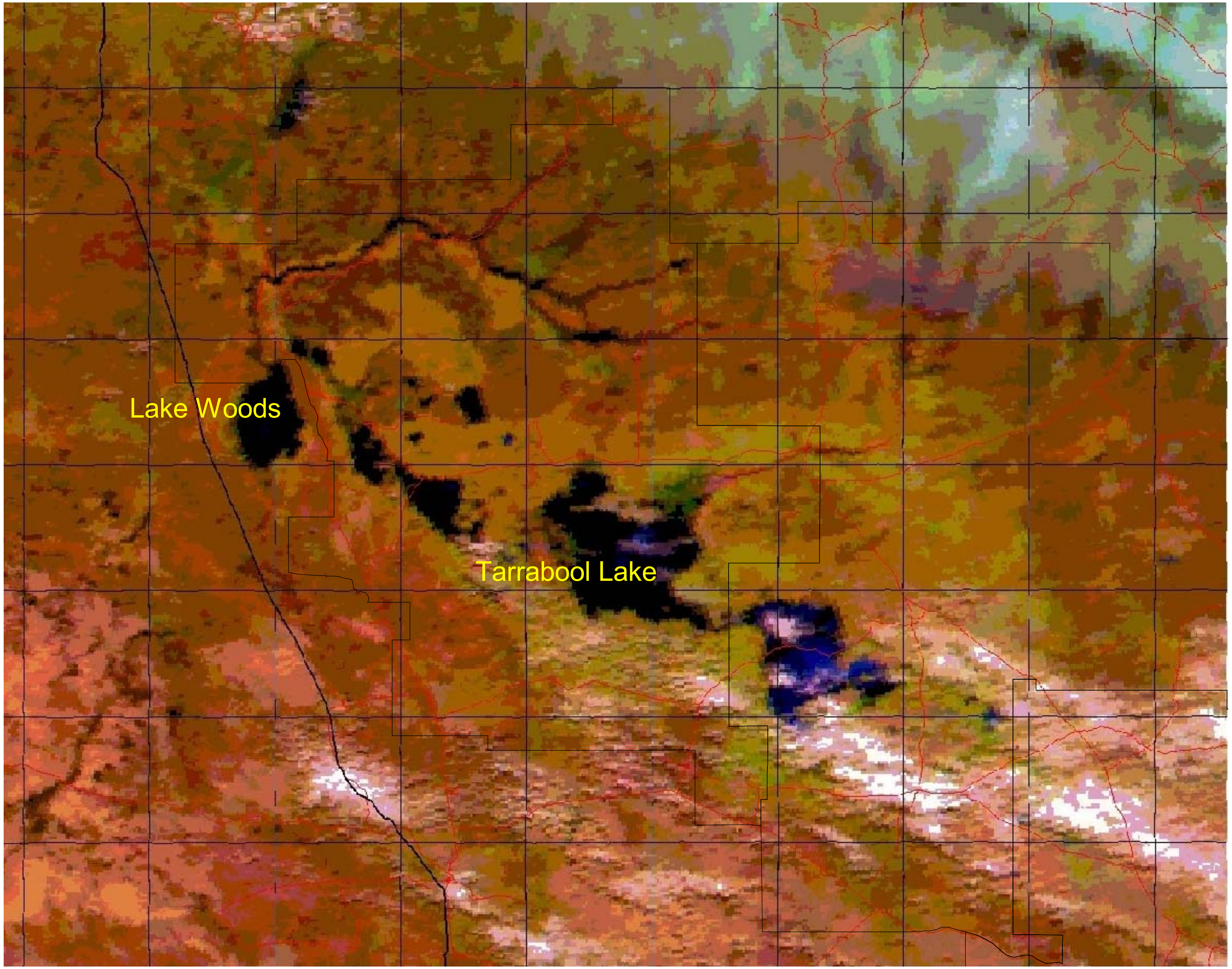




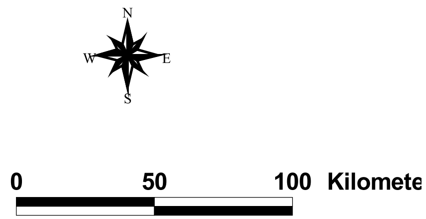
Catchment boundaries
Streams

* Note the coloured background shows topography
It was derived from the 9 sec. Digital Elevation Model of Australia, AUSLIG

Figure 13
Satellite Image of the western Barkly Tablelands



NOAA Image
29 March 2001



Embankment dams may be more suited to areas with sufficient topographic relief such as the “bedrock hills” and “laterite plains” geomorphic zones (Figure 2). On the Tablelands suitable sites may be limited by the lack of relief.

WATER RESOURCE DATA – *What is available and where to get it.*

In the Northern Territory drillers are required to submit information to the Department of Infrastructure, Planning and Environment (formerly Water Resources) on any water bore they drill. This commonly includes details of the strata, water intersections, water levels, airlift yields, bore construction and chemical analysis of the water. The information is freely available to the public and can be obtained from either the Darwin or Alice Springs offices of the department. The contact details are listed below:

Alice Springs
Rural Advice Officer
Conservation and Natural Resources Division
Dept of Infrastructure Planning and Environment
PO Box 2130
Alice Springs NT 0871, Australia
Tel: 08 8951 9215
Fax: 08 8951 9222

Darwin
Rural Advice Officer
Conservation and Natural Resources Division
Dept of Infrastructure Planning and Environment
PO Box 30
Palmerston NT 0831, Australia
Tel: 08 8999 3632
Fax: 08 8999 3666

Map Layer	Description	Other data within the layer (use the "Identify" tool to access this)
BORE_CHEM	Chemical analyses of groundwaters	Major ions(mg/l)
BORES	All recorded bores	Bore number, depth drilled(m), standing water level(swl) (m),Date drilled, airlift yield(litres/second)
CAVITIES	Bores with descriptions including "cavities", "caves" or "cavernous" in the log, this is an indication of a cavernous aquifer and so a potential high yield	Bore number
DUD_BORES	Bores recorded as being "Duds", ie. dry or insufficient water to warrant construction.	Bore number
LOSTCIRCULATION	Bores which recorded "lost circulation" during drilling, this is an indication of a cavernous aquifer and so a potential high yield	Bore number
SLOTS	Slot details for bores	Bore number, depth to top and bottom of slotted interval(m) , diameter of slotted casing(mm)
ROADS	Major roads	Names
DRAINAGE	Rivers and streams	Names
RIVER_BASINS	Major river basin boundaries	
MAP_AREAS	Location of the three printed Water Resource maps	
CADASTER	Station and stock route boundaries	Station names
250K_INDEX	Location of standard 1:250000 scale map sheets	Map name and number
TDS_MAP(TDS)	Generalised Total Dissolved Solids(salinity) zones in the groundwater	
DEVELOPMENT_MAP (DEV_OPTION)	Options for various types of water uses	Option numbers, as shown on the printed maps
SURFACEWATER_MAP (SUITABILITY)	Broad scale suitability for surfacewater storages	detailed geomorphic zones
GEOL_SIMPLE(REGION)	Simplified geological map(rock formations)	
GEOMORPHIC_ZONES (NAME)	The four broad geomorphic zones described in the report	
BASINS	The extent of limestone basins	
NOAA_29_3_01_LL.JPG (IMAGE)	Satellite image taken on 29/3/2001, showing major flooding	
NOAA_31_3_01_LL.JPG (IMAGE)	Satellite image taken on 31/3/2001, showing major flooding	

Appendix 1 Map layers included in the ArcExplorer GIS project on the accompanying CD-ROM

Appendix 2

GROUNDWATER QUALITY FOR CATTLE

All groundwaters contain various kinds of dissolved salts (minerals). If present in excessive concentrations some of these can limit the uses of the water. When a bore is drilled, a water analysis is normally carried out to determine if any of the salts exceed guideline values. This sheet provides some information to help interpret the water analyses.

SOURCE OF DISSOLVED SALTS

The salts originate from minute quantities dissolved in rainwater and from the chemical breakdown of rocks. Nitrate is also produced in the soil by natural biological activity. Over long periods of time evaporation concentrates them to varying degrees.

GUIDELINE VALUES

The maximum recommended values listed below are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects cattle. For example these might include the age and condition of the cattle, the time of year, the distance they walk each day and whether or not they have access to other water sources. The guidelines given below are conservatively chosen in order to cover most situations.

Total Dissolved Solids(TDS) **10,000 mg/L**

TDS is the sum of all the salts present and it provides a convenient guide to water suitability. There may also be a need to assess concentrations of specific salts causing purgative or toxic effects, especially if the TDS is greater than 2500 mg/L.

If TDS is in the range 4000 to 5000 mg/L stock may have an initial reluctance to drink or there may be some scouring, but they should adapt without loss of production. From 5000 to 10,000 mg/L loss of production and a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually.

Calcium **1000 mg/L**

Levels above 1000 mg/L may cause phosphorus deficiency by interfering with phosphorus absorption in the gastrointestinal tract.

Magnesium

In high doses magnesium can cause scouring and diarrhoea in cattle. Levels up to 2000 mg/L have been observed to have no adverse effects. There is insufficient information available at present to set a guideline value.

***Sulfate* 2000 mg/L**

No adverse effects should be expected below 1000 mg/L. Between 1000 and 2000 mg/L sulfate can cause diarrhoea, particularly in young cattle. Concentration above 2000 mg/l can cause chronic or acute health problems.

***Nitrate* 400 mg/L**

Excess nitrate can cause toxic symptoms and even death by reducing the oxygen carrying capacity of the blood. Stock may tolerate higher nitrate concentrations in drinking water provided nitrate concentrations in feed are not high. Levels above 1500 mg/L are likely to be toxic and should be avoided.

***Fluoride* 2.0 mg/L**

Excess fluoride can cause tooth damage to growing animals and brittle bones and lesions in older animals. If livestock feeds or salt licks contain fluoride, the drinking water limit should be reduced to 1.0 mg/L.

***pH* 5.5 - 9.0**

pH is a measure of the acidity or alkalinity. Values less than 6.5 indicate acidic water and can result in corrosion of pipes and fittings. When pH is more than 7.5 the water is alkaline and crustation of pipes with calcium carbonate can occur.

The composition of mineral supplements to stock feed must be considered when stock waters are near to the guideline limits, especially for fluoride and sulfate. Further information is available from the Chief Veterinary Officer, NT Department of Business, Industry and Resource Development.

Water Treatment

Various methods are available for improving water quality to acceptable limits. These are relatively expensive and so for stock supplies most treatments would be uneconomic.

GROUNDWATER QUALITY FOR DOMESTIC USE

All groundwaters contain various kinds of dissolved salts (minerals). Small quantities of many of these are essential to good health. Excessive concentrations however, can limit the uses of the water. When a bore is drilled, a water analysis is normally carried out to determine if any of the salts exceed guideline values. This sheet provides some information to help interpret the water analyses.

SOURCE OF DISSOLVED SALTS

The salts originate from minute quantities dissolved in rainwater and from the chemical breakdown of rocks. Nitrate is also produced in the soil by natural biological activity. Over long periods of time evaporation concentrates them to varying degrees.

GUIDELINE VALUES

The maximum recommended values listed beside each salt are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects the user. These can include a person's age and the total volume of water consumed. The guidelines given below are conservatively chosen in order to cover most situations.

Nitrate **50 mg/litre**

Based on health considerations a limit of 50mg/litre is recommended for babies less than three months old and 100mg/litre for older children and adults. Nitrate levels can be reduced if necessary with the ion exchange process.

Fluoride **1.5mg/litre**

This limit is based on health considerations. Excess fluoride can be removed by treating water with aluminium sulphate or bone char.

Iron **0.3mg/litre**

Above this limit, taste may be unacceptable but it does not pose a health problem. High iron concentrations give water a rust brown appearance resulting in staining of laundry, pipe encrustation and odour problems. A common way to remove iron is to aerate the water by cascading it into a tank and allowing the iron floc to settle.

Hardness **200mg/litre**

Hardness is a measure of the amount of calcium and magnesium in the water. Hard waters can cause the build up of scale in hot water pipes and fittings. They also require more soap to obtain a lather. Softening the water can reduce it.

***pH* 6.5 - 8.5**

This is a measure of the acidity or alkalinity. Values less than 6.5 indicate acidic water and can result in corrosion of pipes and fittings. When pH is more than 7.5, the water is alkaline and encrustation of pipes with calcium carbonate can occur. pH can be adjusted to a more desirable level with the addition of either an appropriate acid or alkali.

***Total Dissolved Solids(TDS)* 500mg/litre**
***Chloride* 250mg/litre**
***Sulfate* 250mg/litre**
***Sodium* 180mg/litre**

Above these limits for TDS, chloride, sulfate and sodium, taste may be unacceptable but it does not pose a health problem. Reverse osmosis, ion exchange or distillation can reduce TDS and the other salts. If most of the TDS is due to hardness softening the water can reduce it. People with severe hypertension or heart disease should seek medical advice if sodium exceeds 20mg/litre in drinking water.

Water Treatment

Various methods are available for improving water quality to acceptable limits. These are relatively expensive but small-scale treatment units using reverse osmosis and ion exchange are commercially available for household use. The main methods include:

Reverse Osmosis
Water is pumped through a very fine membrane, which allows water to pass through, but retains most of the salt.

Ion Exchange
Water is passed through a filter containing special resins, which can remove undesirable salts.

Distillation
Distillation units boil water and condense the steam. This process removes all salts.

Reference

National Health and Medical Research Council & Agriculture and Resource Management Council of Australia and New Zealand, 1996 Australian Drinking Water Guidelines, National Water Quality Management Strategy