CRC FOR CATCHMENT HYDROLOGY
CSIRO LAND AND WATER
MURRAY-DARLING BASIN COMMISSION

ON-FARM AND COMMUNITY SCALE SALT DISPOSAL BASINS ON THE RIVERINE PLAIN

TESTING A GIS-BASED SUITABILITY APPROACH FOR REGIONAL PLANNING

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Foreword

There are increasing pressures to limit salinity increases in the River Murray through minimising salt leaving the irrigated catchments of the Murray-Darling Basin. Part of this strategy is to store drainage disposal water in the irrigation areas themselves using disposal basins. Unfortunately, there are no existing guidelines for siting, design and management of salt disposal basins. The CRC for Catchment Hydrology and CSIRO Land and Water, with support from the Murray-Darling Basin Commission embarked on a project with the overall objective of producing appropriate guidelines for the Riverine Plain of the Murray Basin.

This report is one of several published in this series to support those guidelines. It deals with relevant planning issues and the development of a tool to improve planning practices. There is clearly a balance between storing sufficient disposal drainage water and ensuring environmental safeguards. In choosing reasonable environmental criteria, the use of disposal basins on individual properties is inappropriate for most irrigation areas. It is also uncertain as to whether there is sufficient appropriate and available land within many of the irrigation areas to store all of the drainage disposal water.

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Abstract

Disposal basins are necessary to store saline drainage water from irrigation on the Riverine Plain, in order to prevent unnecessary salinisation of the Murray River. Increasingly, local-scale community and on-farm basins are being used to prevent export of salt outside irrigation areas. This raises a number of questions regarding the availability of suitable land and the impact of these basins. We describe the use of currently available spatial data to assist in regional planning for the environmentally safe use of local-scale saline disposal basins on the Riverine Plain of the Murray-Darling Basin. A GIS-based approach is developed using suitability criteria expected to minimise the risk of off-site effects of basin leakage. The criteria were proximity to surface water features (streams, drains and irrigation channels) and infrastructure (urban areas and roads), watertable depth and salinity, and soil hydraulic conductivity. In most cases the parameters were directly measured, however, for hydraulic conductivity surrogates such as various forms of soil classification and rice irrigation data were necessary. It is important to note that we have made some tentative decisions on threshold values, based on both data quality and experience of the researchers. In reality, these need to be community decisions. It is also recognised that for any individual basin, detailed site investigations will always be required.

We applied the approach to the Murrumbidgee Irrigation Area (MIA), Shepparton Irrigation Region (SIR), Coleambally Irrigation Area (CIA), Murray Irrigation Limited (MIL) area and Kerang-Cohuna region at 1:250,000, the scale at which data are available over the entire Riverine Plain. Confidence in well defined parameters such as proximity to urban settlement and surface water features was higher than for those involving interpreted and/or interpolated point data such as watertable depth, salinity, and hydraulic conductivity. For the latter, confidence decreased as spatial correlation length decreased. Most critically, hydraulic conductivity (the most important factor for basin leakage) was found to be unreliable at this scale. Use of higher resolution data (up to 1:100,000) available for the SIR and MIA improved confidence in watertable depth and salinity but not hydraulic conductivity, where higher resolution soil or geomorphic classifications were used as surrogates. To test the validity of using soil mapping as a surrogate for leakage from basins, rice water use from the MIL region was compared to soil types mapped at 1:125,000 scale. The correlation was poor, reflecting the small spatial correlation length of soil mapping or the inadequacy of traditional soil classifications in capturing leakage information. Consequently the use of detailed soil maps was restricted, in both high resolution analyses, to defining only obviously unsuitable soils.

Despite the above limitations the implications for the case study areas are that: (i) on-farm basins can only be used on an opportunistic basis in the easterly areas (MIA, CIA, SIR) if the chosen environmental criteria are to be satisfied. For westerly areas (MIL, Kerang-Cohuna) on-farm basins could be widely used; (ii) community basins can be used anywhere there is suitable land. However, the cost of purchasing good quality land and transporting water significant distances are important considerations; (iii) the results raise serious questions as to whether there is enough suitable land in the easterly areas to dispose of all of the drainage water produced.

The approach is simple, can be used within the irrigation areas and would help direct discussion on the determination of relevant criteria and thresholds and thus the quantity and sizes of disposal basins required.

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1. Introduction

1.1 Background

The Murray-Darling Basin (MDB) is one of Australia's most important water and land resources. Approximately 73% of all water used in Australia is harvested from the Basin (Fleming, 1982) and approximately 80% of land irrigated in Australia (1.8 million hectares) is located within its boundaries. Approximately 90% of cereal, 80% of pasture, 65% of fruit and 25% of vegetable production in Australia is derived from irrigated agriculture within the Basin (Murray-Darling Basin Ministerial Council, 1987). Meyer (1992) estimated that the annual value of irrigated agriculture in Australia exceeded $4.6 billion (including more than $2.7 billion in export income), the majority of which is from the Murray-Darling Basin. The majority of irrigation occurs in the south-central part of the Basin known widely as the Riverine Plain (Fig. 1).

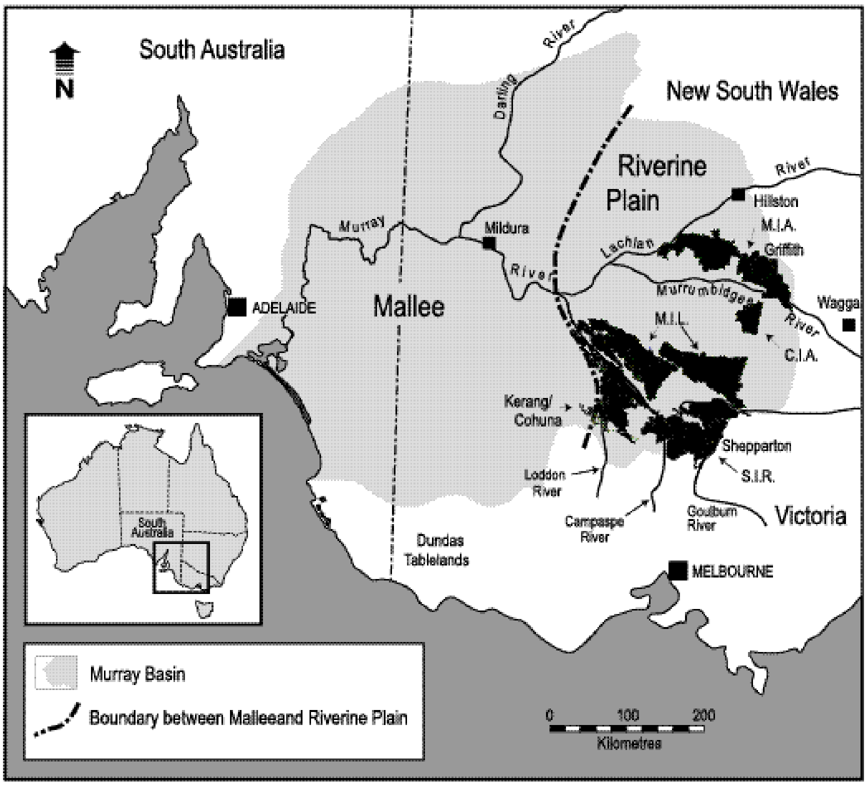

Figure 1: Location map showing the Riverine Plain of the Murray Basin and irrigation areas referenced in the analysis.

The Basin, in its pre-European state, contained vast amounts of salt stored in its soils and groundwater. The use of irrigation, the leakage of water from the associated network of water distribution and drainage channels, and the clearing of deep-rooted perennial plants and their replacement with shallow-rooted annual crops has altered the water balance causing watertables to rise throughout the Basin. This has resulted in mobilisation of the stored salt, soil salinisation and waterlogging, with detrimental effects on agricultural production. In addition, raised watertable levels lead to increased movement of salt to drains, streams and rivers.

To maintain productivity in irrigation areas with shallow groundwater, watertable reduction and control is carried out using measures such as sub-surface drains, and groundwater pumping. This creates the problem of disposing of large volumes of saline drainage water.

1.2
Disposal Issues

There are three main disposal options: disposal in streams and rivers on an opportunistic basis, disposal using a pipeline to the sea, and evaporative disposal on land. Some saline water is currently disposed of into river systems in periods of high flows but the salinity of pumped groundwater and drainage effluent is such that unmanaged disposal in rivers and streams on a continuous basis may result in unacceptable downstream impacts. There appears to be a trend in political and community attitudes towards reduced disposal to the river system. Since the river system has limited capacity to export salt from the irrigation catchment, the remaining options are export using a pipeline to the sea and land disposal to natural or engineered surface storages (saline disposal basins). Previous studies (State Rivers and Water Supply Commission, 1978; Earl, 1982; Gutteridge Haskins and Davey, 1990) have indicated that the pipeline option, compared with other disposal options available at the time, was uneconomic. This leaves evaporative land disposal as the most likely option available, at least in the short to medium term (50 years). As shown by Evans (1989), saline disposal basins are the lowest cost option for high salinity drainage water.

At present there are in excess of 180 saline disposal basins in the Murray-Darling Basin (Hostetler and Radke, 1995). In the past, use of regional scale basins has been the most common approach. These generally accept drainage water from multiple farms and irrigation districts, which are located many kilometres away (hence salt is exported from the area in which it is produced). These basins most commonly use natural depressions in the landscape (e.g. Lake Tutchewop near Swan Hill), however they can be engineered storages (e.g. Wakool Drainage Basin near Deniliquin). Many have occurred by default or have been developed on an ad-hoc basis.

In many instances, regional basins were developed on the most convenient sites from an engineering standpoint, where environmental, socioeconomic and aesthetic impacts and any other community concerns were sometimes ignored. In addition, various unforeseen side-effects (leakage to adjacent farmland, insect, bird and odour problems) experienced in a number of regional scale basins has led in many cases to poor community perception of disposal basins. Moreover, under the Murray Darling Basin Salinity and Drainage Strategy (Murray-Darling Basin Ministerial Council, 1988) severe constraints have been imposed on salt export from a given area. This policy was designed to ensure that the beneficiaries of irrigation are responsible for their own drainage management on the assumption that this would help minimise other environmental effects. While disposal into regional basins will continue in the future, there is a view in some quarters that there is a need to depart from the existing "export the problem" mentality. It may become mandatory that the option to manage drainage effluent at the source be closely examined before resorting to export.

These concerns have led to the use of local basins. These can take the form of on-farm basins, which occupy individual properties (such as those being used for new horticultural developments in the Murrumbidgee Irrigation Area) or community basins, which are shared by a small group of properties (such as the Girgarre Basin near Shepparton). The design and management of both types of basin varies widely and currently there are no set guidelines for their use.

Different irrigation areas have different policies towards the choice of disposal strategy, the division between export outside the irrigation area, and the storage in regional, community and on-farm disposal basins. These different policies have not been uniformly developed nor have they been based on uniform guidelines for the responsible siting and use of on-farm and community disposal basins. Such guidelines are currently being developed and only recently has a set of principles been produced to underpin them (Jolly *et al.,* 1999). Even if they had been developed uniformly, there are likely to be variations in disposal strategies due to the differences in physical characteristics of each irrigation area.

While there appear to be moves toward more local disposal basins, the longer-term consequences of these basins are not clear. For example, is all of the Riverine Plain suitable for local basins and is there enough suitable land in the irrigation areas to store all of the drainage water produced? Also, on a local scale, where would they need to be sited to avoid impact upon infrastructure (roads, railways etc) and the community generally. Before moving to the policy development stage for local basins, these types of questions must be addressed.

1.3
Planning Issues

In general, the issues that affect the use of local basins concern environmental sustainability, aesthetics and competition with productive land. It should be stated, a priori, that some site investigation is required to determine whether a particular site is suitable or not. If a site is not suitable for a disposal basin, it is difficult and expensive to engineer and manage the basin in a sustainable manner. However, it may be possible from available spatial data to determine the probability of finding suitable land, and its general location.

The key issue in siting is leakage from basins, both in terms of rate and impact. There is an expectation that basins will leak and it is acknowledged that a small amount of leakage up to 1mm day^{-1} is beneficial (Muirhead *et al.,* 1997). However, excessive leakage can have adverse impacts on ground and surface water resources. The environmental impacts include degrading a potential groundwater resource, increased salt discharge to the stream network and land salinisation in adjacent areas. Not only is it important to ensure that the leakage rate is low, but also that the adverse impacts of any leakage (and associated contamination) is minimised by not siting basins over good quality groundwater nor allowing any contamination plume to move outside the vicinity of the disposal basin.

It is possible that different policies for disposal may be needed between, and also within, irrigation areas. While export of salt may be philosophically undesirable, it may be necessary if there are insufficient sites available to store the amount of disposal water in a satisfactory fashion. Similarly, if there is a strong likelihood that most land holdings have no suitable land for disposal basins, any policy towards on-farm basins does not make sense. An objective method for the decision process is useful to show why different decisions have been made for different irrigation areas, while maintaining a responsible policy towards environmental sustainability.

This report addresses the question of whether a broad-scale suitability analysis, while useful for planning, is actually feasible. To enable us to do this, we have assumed some likely suitability criteria, suggested a method for combining suitability criteria and applied this to some test areas. However, the overall feasibility is likely to be dependent on whether appropriate data is available, and how closely this data is directly translatable into suitability criteria and less on the choice of criteria. In developing an objective methodology that can be applied across the Riverine Plain, it is necessary to use datasets available across the Riverine Plain at a regional scale. Where available, it may be possible to use higher resolution data within irrigation areas to provide a better analysis.

1.4
Study Objectives

The specific objectives of this study were to:

(i) Investigate the suitability of datasets available for the whole Riverine Plains for use in planning the siting of disposal basins.

(ii) Investigate whether these datasets when used in a suitability analysis can aid decision-making on siting strategies.

(iii) Assess whether higher resolution data available within irrigation areas would improve the suitability analysis.

(iv) Make inferences on the suitability of local basins for the two case study areas used in the development of the methodology and other major irrigation areas in the Riverine Plain.

2. Methods

The Murrumbidgee Irrigation Area (MIA) and Shepparton Irrigation Region (SIR) were chosen to develop and test a suitability analysis at a regional scale (~1:250,000 or ~250m grid resolution). The software used for the analysis was the ArcInfo (ESRI, 1996) Geographic Information System (GIS). All GIS coverages were converted to grids in Universal Transverse Mercator projection, and classes were then amalgamated into a single suitability map using a relational overlay process in the Grid module of ArcInfo. Interpolated surfaces were generated using the Topogrid module.

2.1 Suitability Criteria

Much has been done in the area of land suitability evaluation, particularly by the FAO (1976) in standardising terminology and procedures. This analysis was adapted from methods that are described fully in Dent and Young (1981). In essence, suitability ranges were defined separately for each of the inputs, which were then combined according to relative importance (priorities defined by the user) to derive a manageable number of overall suitability classes from optimal to unsuitable. Without recognized guidelines for criteria needed (or acceptable ranges for them) for siting evaporation basins, those used here are considered a first approximation that are flexible and may be refined as new data become available.

Contamination of land and water resources by leakage is the key sustainability issue for local basins. There are a number of criteria that relate to this contamination. Firstly, what is quality of the groundwater below the basin? Secondly, what is the extent to which any contamination plume can move within the soil and groundwater? Thirdly, how close does a contamination plume get to any surface water features? Other important criteria concern the impacts on humans (aesthetics, odour, insects) and other activities (bird damage to crops or air traffic) and infrastructure (roads, railways). We also note (but do not deal with in this analysis due to lack of data) the impacts in regard to competition with agricultural production (land value, land availability and size of allotments).

There are a number of factors that influence the extent to which any contaminant plume can move. Firstly, the permeability of the sub-soil determines the leakage to the aquifer. Secondly, the depth to groundwater determines the storage available beneath the basin as opposed to that available laterally. Thirdly, the groundwater gradient and permeability of the aquifer determine the movement away from the basin itself. For this analysis, we assume a low permeability soil and shallow saline groundwater (unable to develop gradients) are pre-requisites for suitability.

There are many combinations of soil permeability, depth to watertable and groundwater salinity, some of which will fall into the same suitability classes. Land suitability for use as evaporation basins was defined arbitrarily according to Table 1.

Readily available data were identified which were relevant to the critical factors that reduce leakage and associated risks to the surrounding environment. In this report, we make some tentative decisions on threshold values, based on both data quality and experience of the researchers. In reality, these decisions need to be made by the community.

Table 1. Suitability Classes defined for this study.

Suitability Class	**Definition in terms of leakage risk**	**Definition in terms of inputs**
S1, high suitability	Minimal	Impermeable soil, shallow saline watertable.
S2, moderate suitability	Tolerable	Moderately more permeable soil, deeper watertable and less saline groundwater
S3 marginal suitability	Likely but still worth considering	permeable soils, moderate depth to watertable and reasonably fresh groundwater
N, Not suitable	High	Permeable soils, deep watertable, fresh groundwater where limitations cannot be overcome by input or management

The criteria used for siting evaporation basins were:

1. **Low soil hydraulic conductivity** (heavy impermeable soils) is most important and has the greatest control on leakage. A rate of 1mm day^{-1} was found to be beneficial to basin function (Muirhead *et al.,* 1997) and taken as the optimum, with increasing rates being more detrimental. Other classes were arbitrarily defined for the suitability analysis as: 1-3mm day^{-1} acceptable and >3mm day^{-1} not suitable.
2. **Depth to watertable** was taken as 0-2m for optimum, 2-4m was acceptable and beyond that was not suitable. This criterion was used to avoid significant hydraulic gradients away from the basin and hence the migration of plumes away from the basin.

3. **Groundwater quality** where existing salinity or degradation occurs the risk of contaminating fresh water resources is minimised. Ranges were defined as >7,000mg L^{-1} TDS being optimal, 3,000 - 7,000 acceptable and <3,000 unsuitable, being too potable to risk.
4. **Buffers to urban settlements** allowing suitable distance to avoid odours, aesthetics, insect problems and bird hazards. An arbitrary value of 1 km was chosen.
5. **Buffers to surface water features and other infrastructure** such as streams, irrigation channels, drains, roads and railways are needed to prevent their degradation. Buffer size depends on aquifer hydraulic conductivities and other factors. An arbitrary value of 125m was chosen on the basis of half the cell size of the analysis grids.

2.2 Available Data

To explore what is achievable at a regional scale (1:250,000) it was necessary to know what consistent data were available covering the entire Riverine Plain. There are few datasets available that are: a) relevant to siting disposal basins, b) seamless coverages across the Riverine Plain, c) of appropriate scale or resolution, d) currently obtainable and affordable and e) digital. Those located were:

a) **Soil Land Forms (SLF) of the Murray-Darling Basin** (Bui *et al.,* 1998) is a map of the Murray-Darling Basin that predicted soil land form classes and dominant Principal Profile Forms (PPFs) using land systems, other soil surveys and geomorphic elements of the MIA. Since there is no appropriate soil hydraulic conductivity data, landforms from the Bui *et al.,* (1998) datasets were linked, via PPFs, to a look-up table (McKenzie *et al.,* 1999) to derive a number of soil properties including hydraulic conductivity classes. This was an upgrade of McKenzie and Hook (1992) which provided additional information on the A and B horizons, error ranges based on input data quality (expressed as + or - the number of classes) and a reliability class based on the number of references used to derive the statistics. Hydraulic conductivity classes were distributed on a log scale centred on a median class value (Table 2). Because of the complexity induced by having three PPFs for each soil land form class only the minimum hydraulic conductivity classes were used for either A or B horizon and no attempt was made to account for the error or reliability classes. Hydraulic conductivities derived via this look-up table did not correlate well with expected (known) occurrences.

Table 2. Classification Scheme used by McKenzie et al.(1999).

Class	Median mm hr^{-1}	Median mm day^{-1}	Description
1	0.003	0.72	
2	0.1	2.4	Very slow
3	0.3	7.2	
4	1.0	24	Slow
5	3.0	72	
6	10	240	Moderate
7	30	720	
8	100	2,400	High
9	300	7,200	
10	1,000	24,000	Extreme
11	3,000	72,000	

b) **GIS of the Murray Hydrogeological Basin** (BRS, 1999) provided interpreted map data for depth to watertable (Figs. 2a,b) and salinity (Figs. 2c,d). The depth to watertable data generally had contours no better than 5m and the thresholds chosen for un/suitable watertable classes were subsequently changed to 5m and 10m. Groundwater salinity polygons were coded with a two-digit number where the first is salinity class and the second is aquifer yield. Ranges were considered in tens of units to ignore the yield. The ranges were grouped taking into account the descriptions in Table 3.

Table 3. Salinity classes defined in the GIS of the Murray Hydrogeological Basin (1:250,000 Scale) and their rating in this suitability study.

Salinity (mg/l TDS)	Class	Description	Suitability for Disposal Basins
< 500	10 - 19	All purpose, domestic and irrigation	Not suitable
500 - 1,000	20 - 29	Most purposes	Not suitable
1,000 - 1,500	30 - 39	Most purposes, upper limit for drinking	Not suitable
1,500 - 3,000	40 - 49	Limited irrigation, all livestock	Not Suitable
3,000 - 7,000	50 - 59	Most livestock (not pigs or horses)	Suitable
7,000 - 14,000	60 - 69	Some livestock (beef cattle, sheep)	Very suitable
14,000 - 35,000	70 - 79	Limited industrial use, ore processing	Very suitable
35,000 - 100,000	80 - 89	Limited industrial use, ore processing	Very suitable
> 100,000	90 - 99	Brine production, ore processing	Very suitable

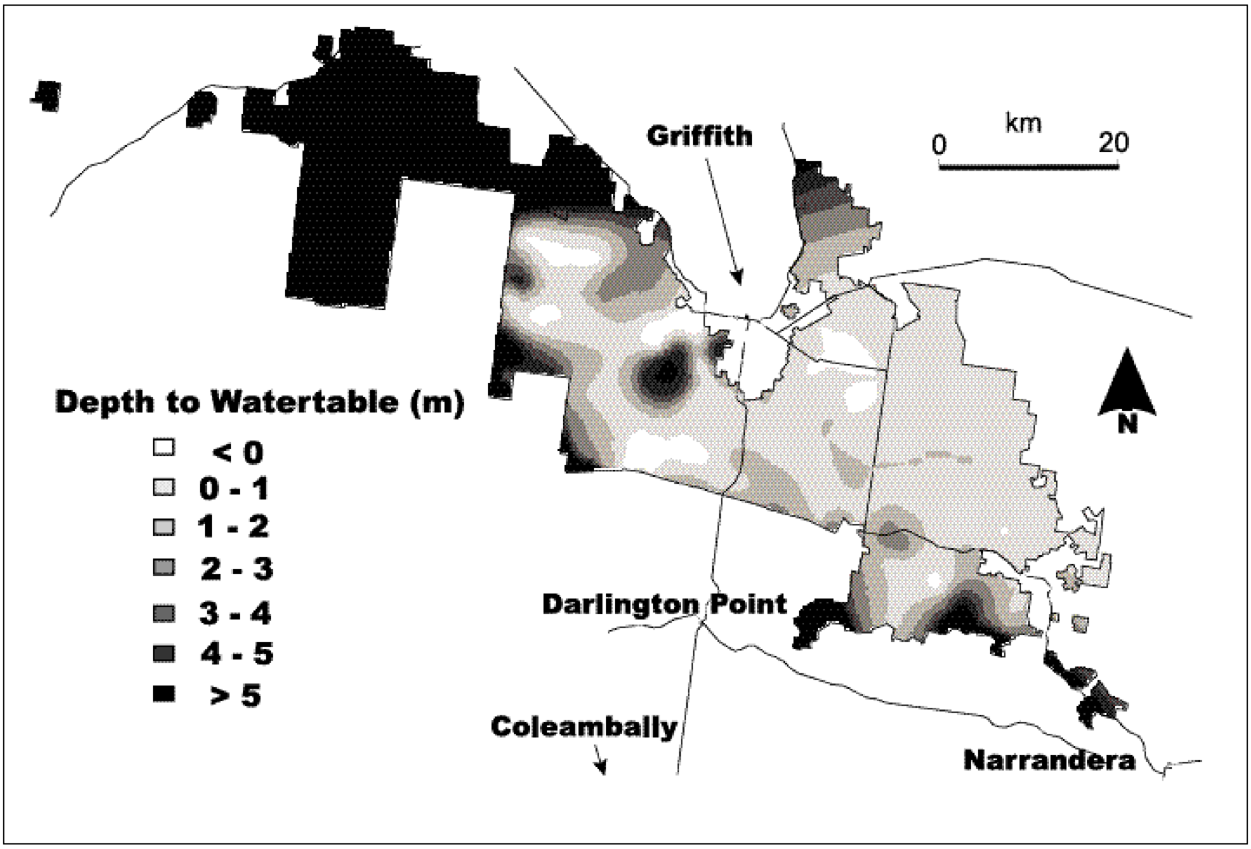

Figure 2a. Regional scale (1:250,000) watertable depth data for the MIA interpolated from GIS of the Murray Hydrogeological Basin (BRS, 1999) contours.

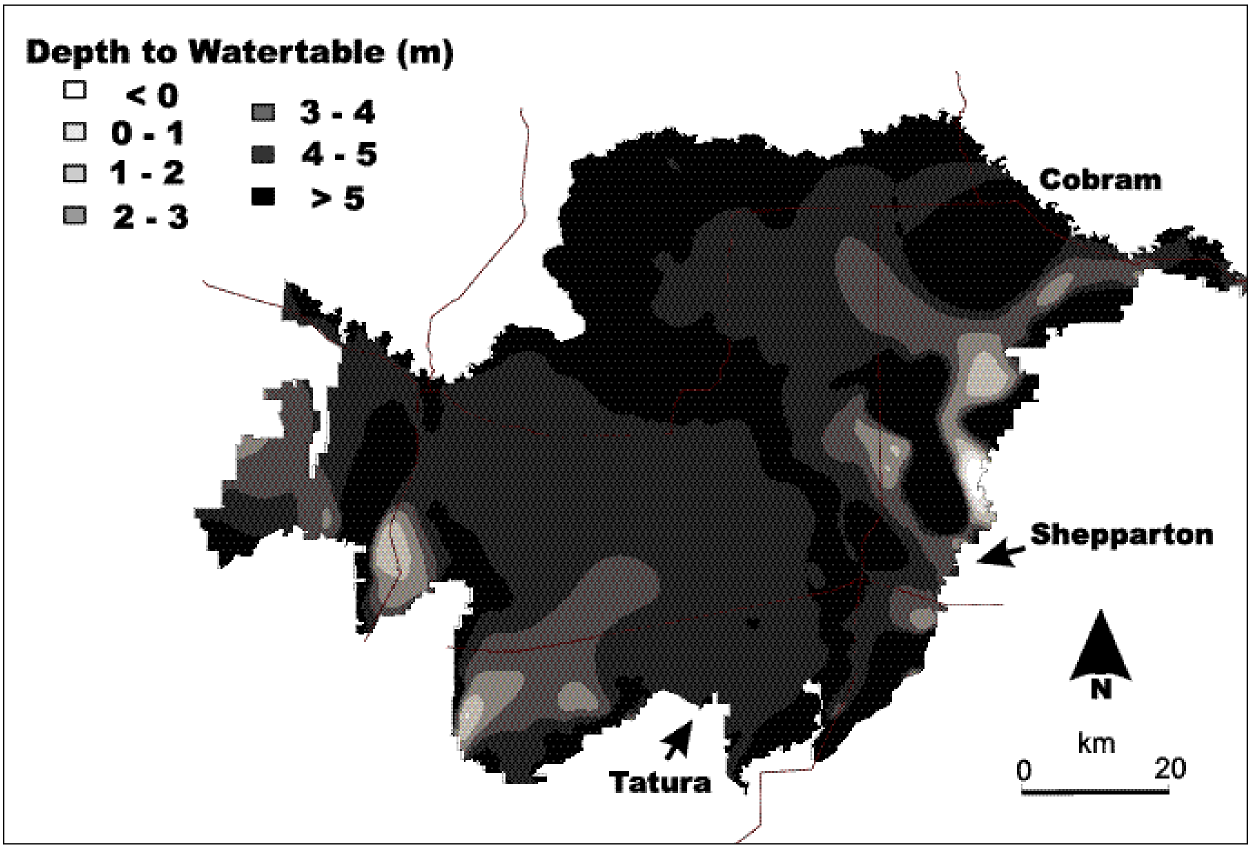

Figure 2b.Regional scale (1:250,000) watertable depth data for the SIR interpolated from GIS of the Murray Hydrogeological Basin (BRS, 1999) contours.

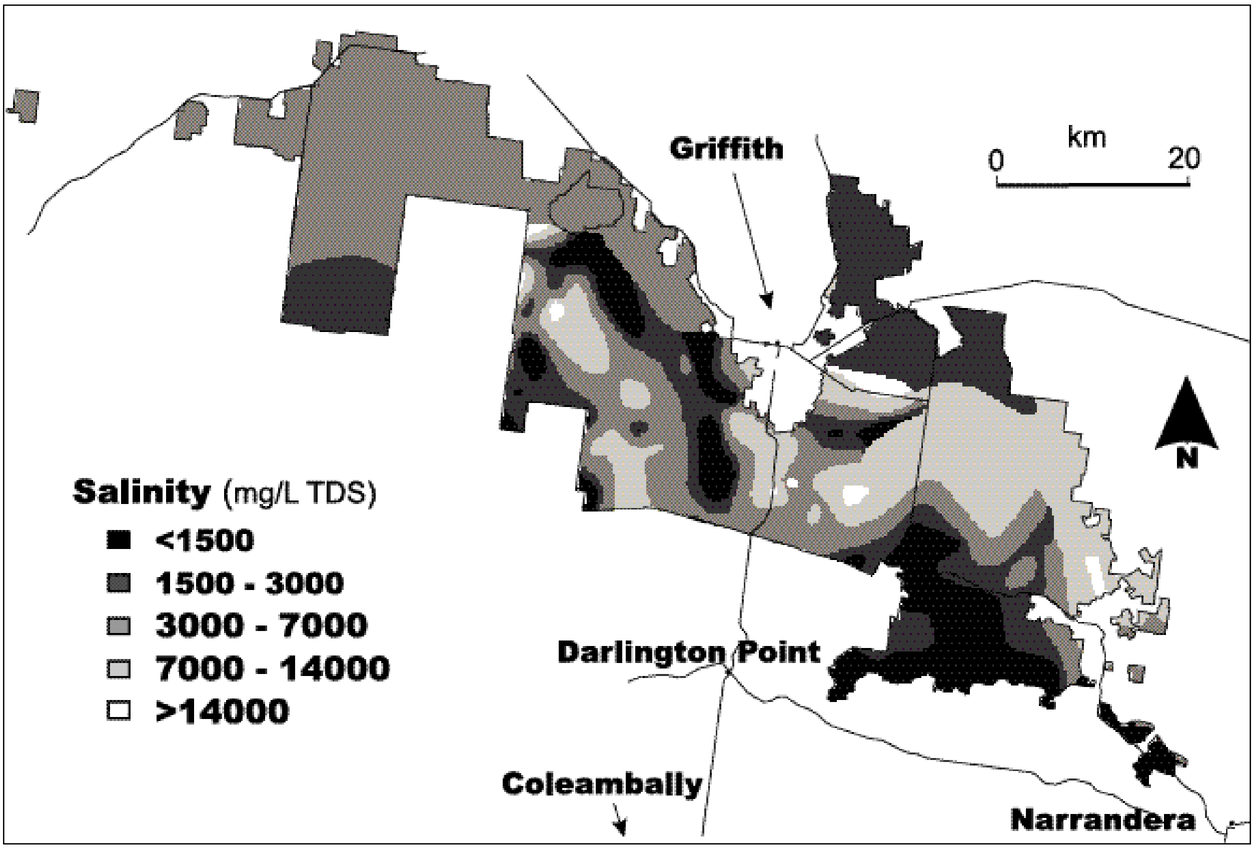

Figure 2c. Regional scale (1:250,000) salinity data for the MIA (source: BRS, 1999).

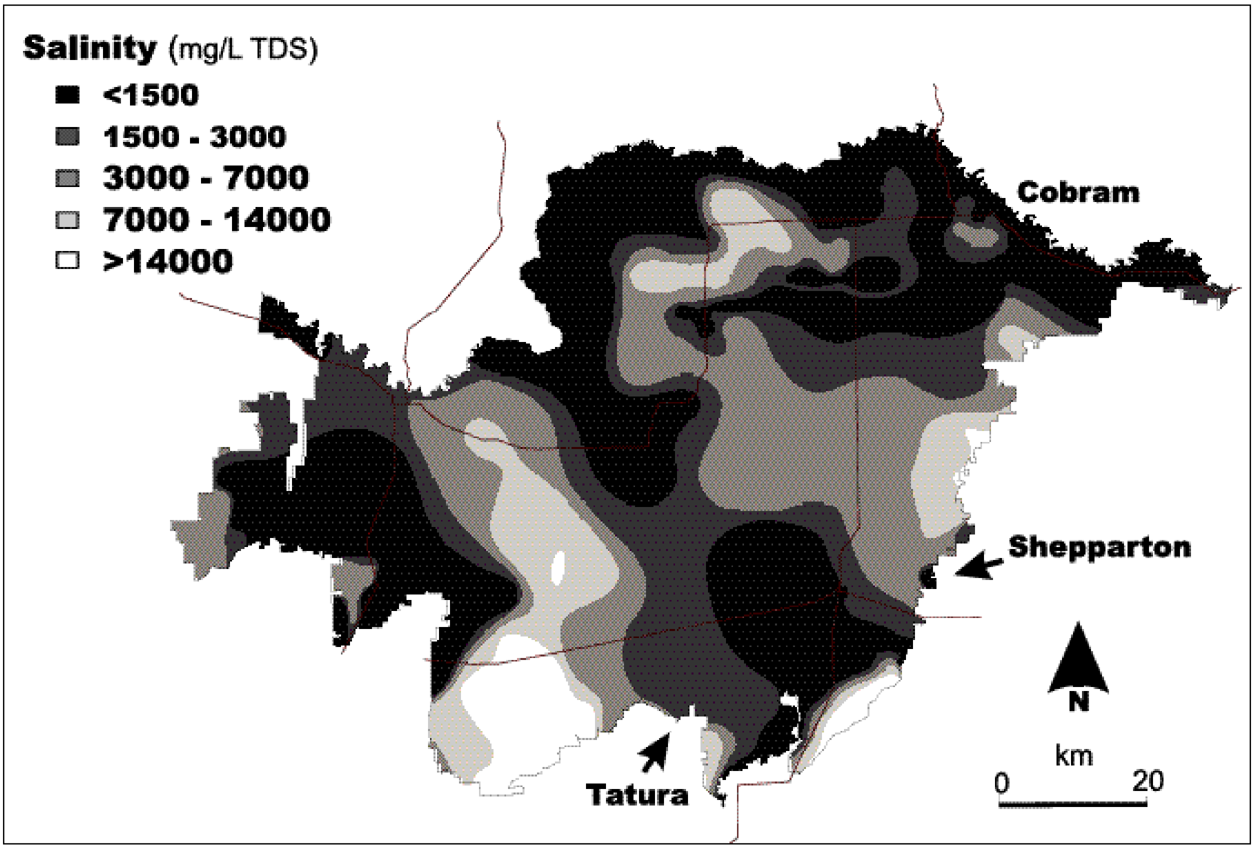

Figure 2d. Regional scale (1:250,000) salinity data for the SIR (source: BRS, 1999).

c) **Geodata 9 second Digital Elevation Model** (DEM), (AUSLIG, 1996). It was intended that elevation data would be used to provide terrain attributes of slope and depressions to further discriminate between classes. Artefacts present in the DEM suggested highly variable data quality. To avoid propagating errors in derived grid layers the DEM was not used for this analysis.

d) **AUSLIG Topo250k** (AUSLIG, 1994) provided surface water features, infrastructure and urban settlement coverages which were used to define buffers of appropriate distances. The information is on the printed 1:250,000 published map series.

Higher resolution data was sought to validate the coarse analysis, but was found to be only available for relatively small areas. Data found included:

a) **Geomorphic elements of the MIA** (Butler *et al.,* 1973) contained soils information under a different classification scheme to the Soil Land Forms data.

b) **Review of hydraulic conductivities of soils of the MIA** (Hornbuckle and Christen, 1999) is a comprehensive summary but these soils attributes were difficult to associate with coverages with different classification schemes.

c) **Soils and land use of the northern Victorian irrigation region** (Skene, 1963; Skene, and Freedman, 1944; Skene and Harford, 1964; Skene and Poutsma, 1962; Butler, 1942; Johnston, 1952), 1:25,000 surveys in Technical Bulletins of the Victorian Department of Agriculture (Fig. 3). These surveys, produced between 1942 and 1965, have a local soil name and a rating for irrigated agricultural suitability. These groups only partly correspond to expected hydraulic conductivities because those assessments were based on a range of criteria and not just soil physical properties.

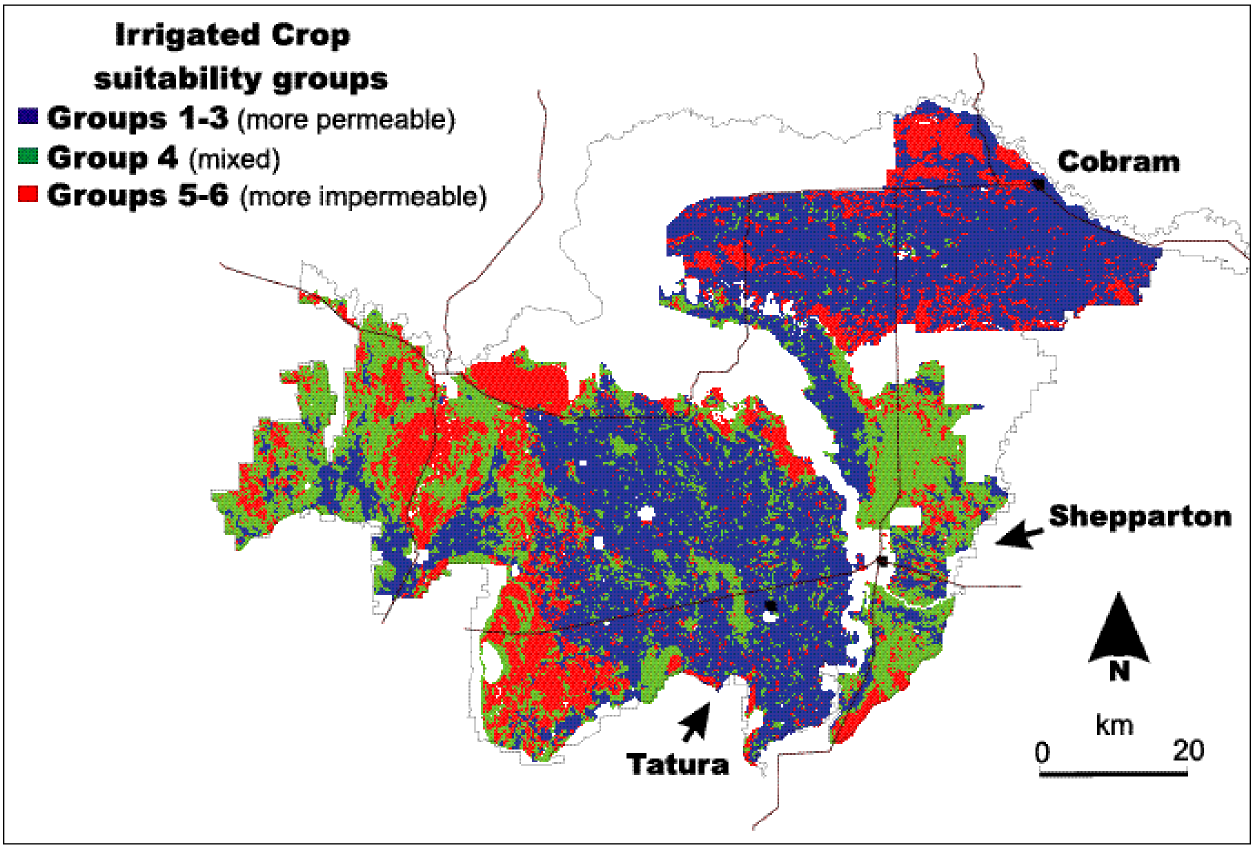

Figure 3. High resolution soil map (1:25,000) for the SIR. Classes were regrouped on the basis of how best the irrigated crop suitability groups fitted into hydraulic conductivity classes. Confidence in this data is reduced because the groups had limited relevance to hydraulic conductivity and coverage is incomplete.

d) **Piezometer databases for the MIA and SIR.** For the MIA, a database was available for 1996 from the Department of Land and Water Conservation (DLWC). Bores screened below 15m were removed before interpolating a grid (Fig. 4a). For the SIR, a database was available for 1996 from Sinclair, Knight Merz (SKM) from which bores deeper than 15m could not be removed for the interpolation (Fig. 4b). A 1996 MIA groundwater salinity surface was also interpolated from the DLWC data (Fig. 4c).

e) **Shallow aquifer potential salinity map of the SIR.** Ife (1987) mapped shoestring aquifers with associated potential salinities at a scale of 1:250,000 (Fig. 4d).

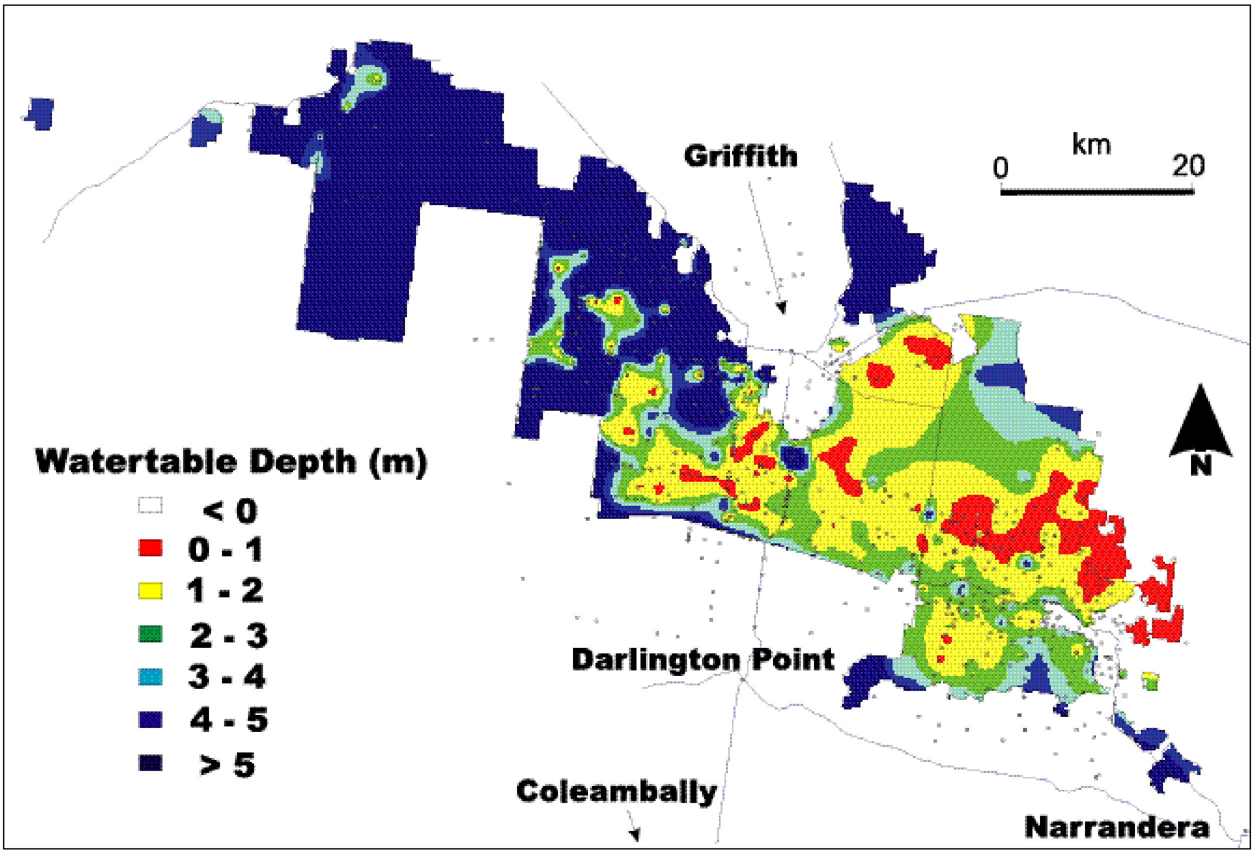

Figure 4a. High resolution watertable surface for the MIA including the distribution of bores in the DLWC data used for the interpolation.

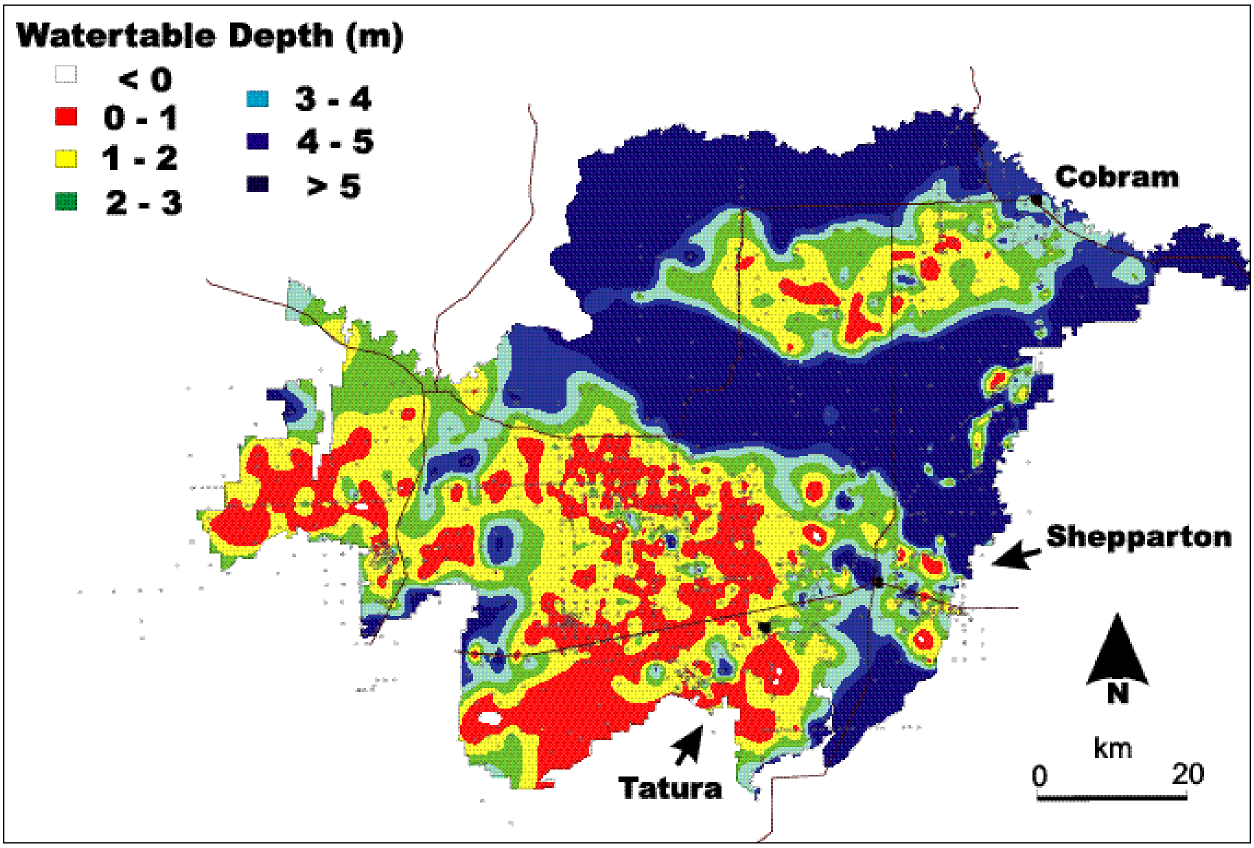

Figure 4b. High resolution watertable surface for the SIR including the distribution of bores in the SKM data used for the interpolation.

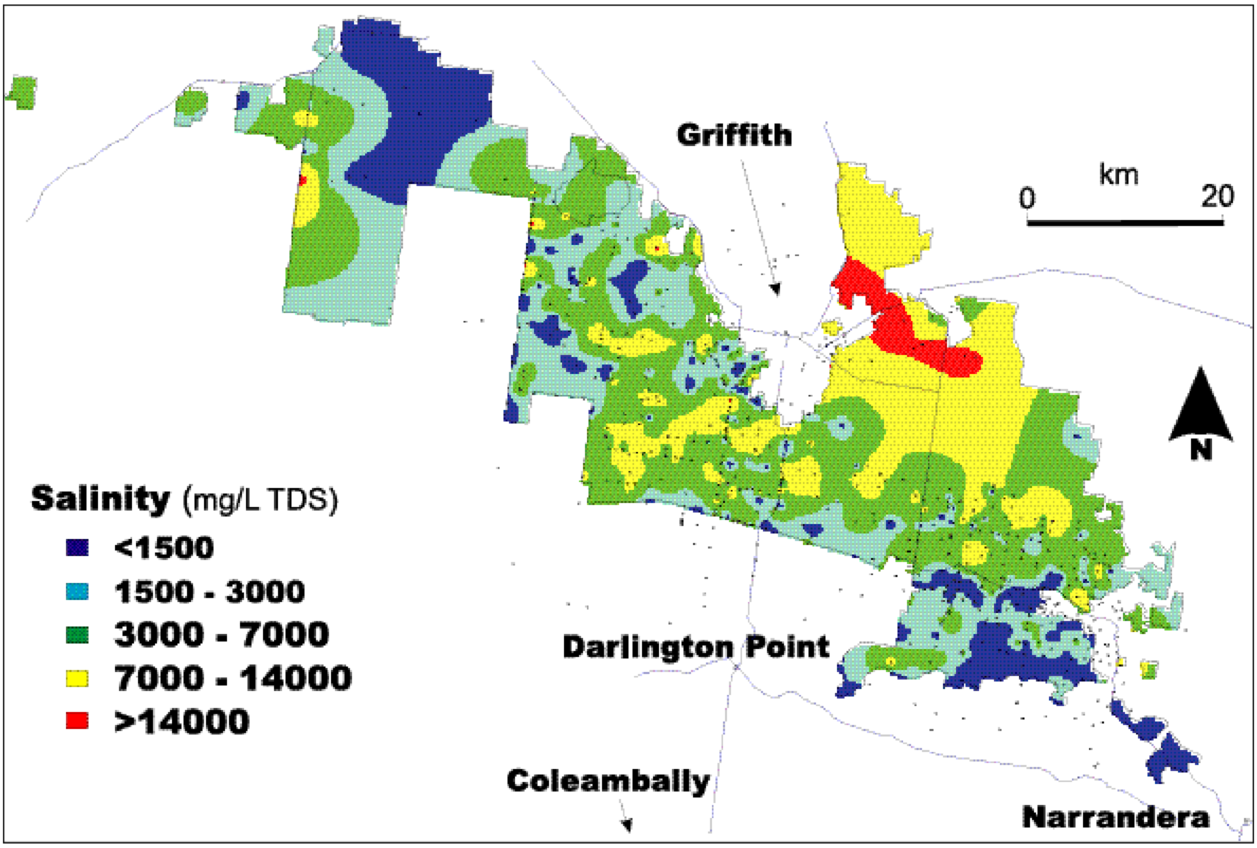

Figure 4c. High resolution groundwater salinity surface for the MIA and the distribution of bores in the DLWC data used for the interpolation.

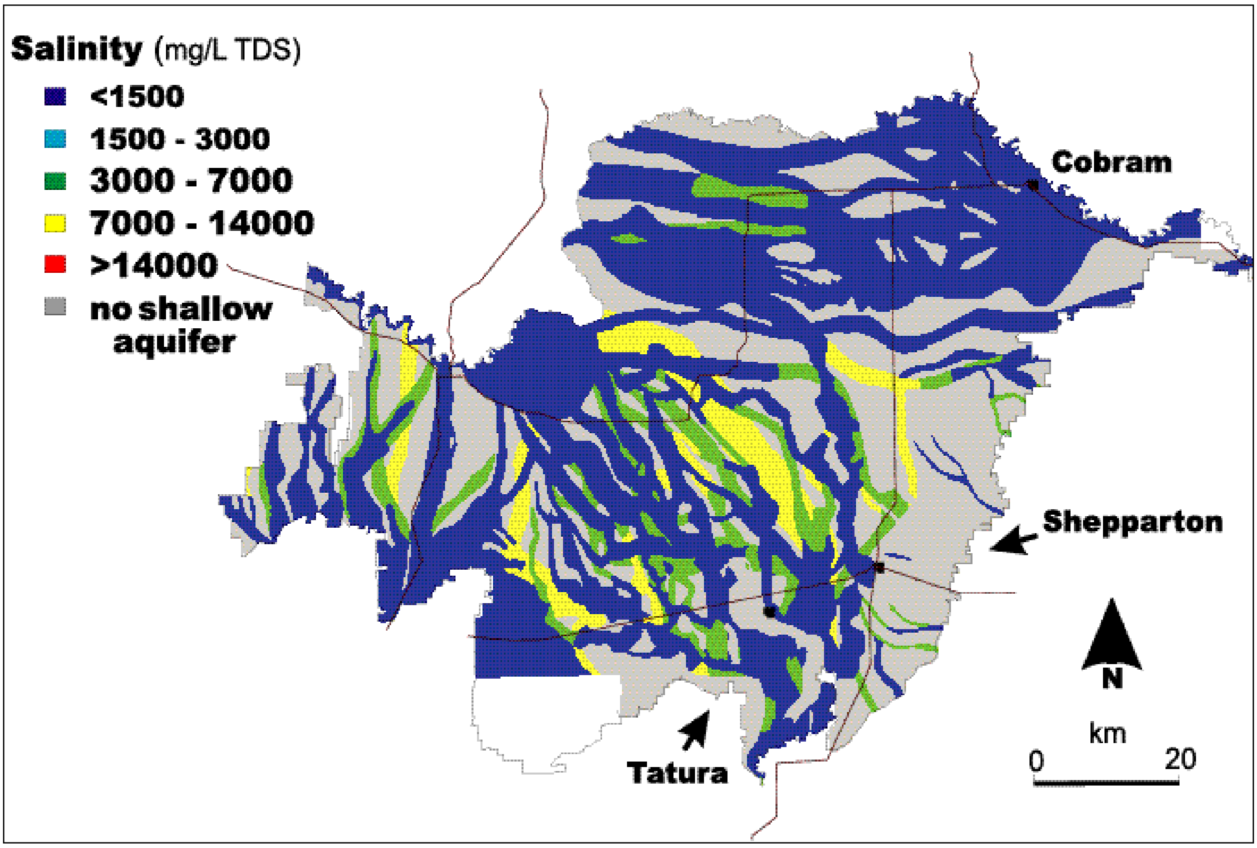

Figure 4d. High resolution shallow aquifer mapping for the SIR which included water quality and yield estimates (Ife,1987). Grey areas, where there are no shallow aquifers, can safely site basins and are processed as if they were highly saline groundwater. White areas within the boundaries were unmapped.

f) **Water use and soil data for the Murray Irrigation Ltd (MIL) area for 1995-6.** This dataset was collected by Murray Irrigation Ltd and contained field information on water use and areas used for rice growing (Fig. 5). The presumption is that areas of low rice water use have low conductivity soils. A higher resolution soils map was also available at 1:125,000 (Fig. 5) that was a reclassification of the soil association map of Smith (1945) into 8 classes from sandhill soils to self mulching clays.

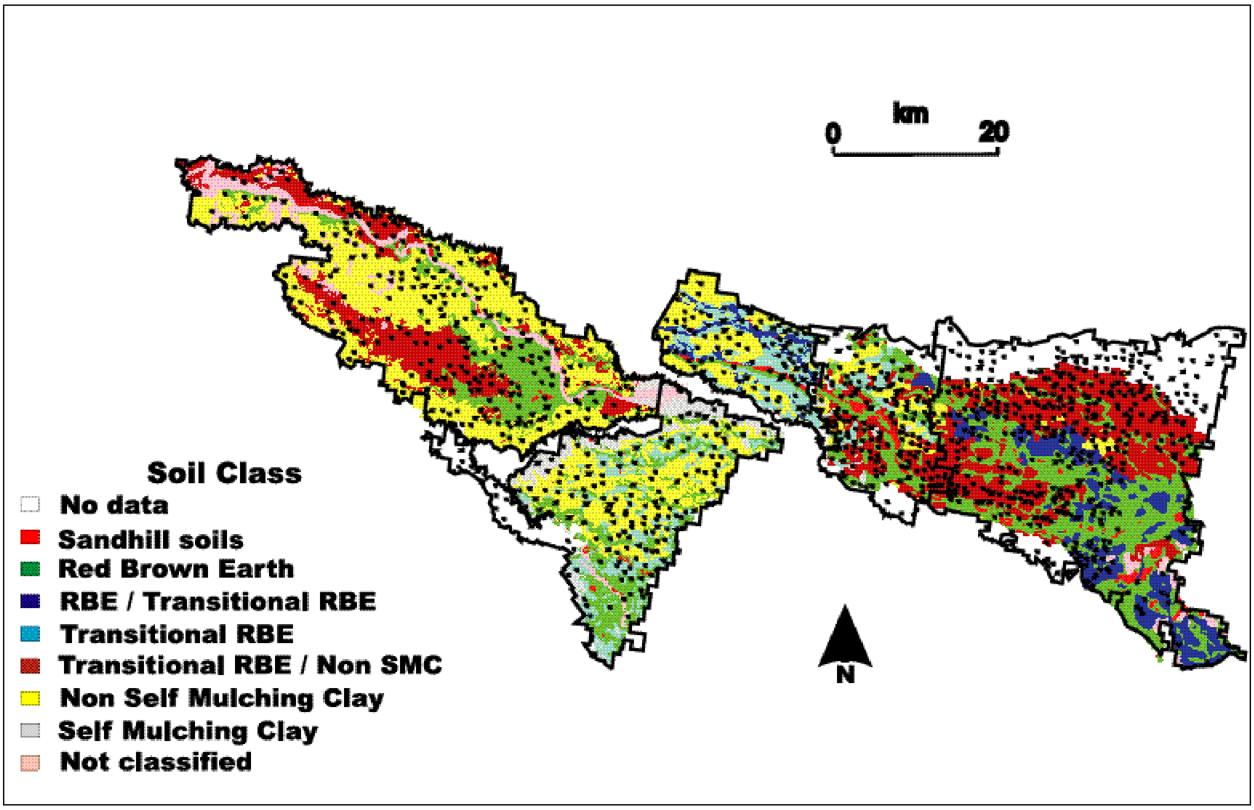

Figure 5. Distribution of water use point data (black dots) for the MIL,located between the MIA and SIR (Fig.1). Comparisons made using the soil types illustrated here are shown in the results section (Fig.20). Incomplete coverage (white areas) is common when using local datasets.

2.3 Test at 1:250,000 Scale

Very little of either study area contained any class 1 hydraulic conductivity which was the only suitable range according to the initial definitions. While the rank of class may give an indication of relative soil hydraulic conductivity, the inclusion of this data, with few low and many extremely high values, was not justified. Other attempts were made to correlate localised higher resolution datasets to this regional data in order to extrapolate to larger regions. Ultimately hydraulic conductivity, or a surrogate for it, was not used as a criterion in the low resolution analysis.

Ranges were applied to the BRS (1999) data, but in the case of watertable depth, the criteria were relaxed from the 2 and 4m thresholds to 5 and 10m thresholds that this data could support (Fig. 13a,b).

Physical attributes such as roads, railways, drains are easily mapped and available in the Topo250k data. They provide a well defined starting point in evaluating areas suitable for disposal basins. Appropriate buffers were applied to each theme in only two ranges, suitable or not suitable and polygon and line coverages were converted to grids with 250m cell size. This has implications when allowing for buffers around features, e.g., a road with no buffer will still be represented by 250m cells which means there will be an effective buffer of approximately 125m on average. Polygons have a similar error associated with the outer edge.

Overall suitability classes were produced through the combination of the criteria. The data and process are illustrated in the results (Figs. 6 to 15). As previously noted the process for combining criteria was adapted from established land suitability evaluation methods (FAO, 1976; Dent and Young, 1981). Essentially the user must decide what combinations of the criteria (and the ranges of suitability identified for them) are relevant and meaningful and also what is a manageable number of overall suitability classes for mapping and reporting. For this analysis we chose 3 suitable classes and 1 unsuitable but there can be as many grades of each as desired.

The actual combination of criteria ranges into overall suitability classes uses a simple conditional overlay function in ArcInfo.

ArcInfo Macro Language (AML) scripts used to reformat datasets for the MIA and SIR appear as Appendix 1, while Appendix 2 lists the AML scripts used to process the overall suitability classes for those areas. A final test of the analysis was to apply it to the other major irrigation areas in the Riverine Plain (Fig. 1) which were the Coleambally Irrigation Area (CIA), MIL and the Kerang-Cohuna region.

2.4
Test at Higher Resolutions

Appropriate conductivity data were also unavailable at high resolution. Instead, irrigated agricultural suitability groups (not based on rice) were amalgamated on the basis of clay content as best they could. With no conductivity estimates attached to soil groups the thresholds could only be defined qualitatively. The resolution of the watertable and salinity data meant that the originally defined ranges of suitability could be used for these criteria. The thresholds and combinations of criteria are shown in the results section (Figs. 16 to 19).

2.5
Validation Test

To our knowledge, there is very little data available for testing the analysis. Obviously, a comparison with higher resolution data gives some level of confidence, but hardly constitutes a validation, particularly when one of the datasets (landforms) is being used as a surrogate for hydraulic conductivity. Even matching soil maps at different scales is difficult due to the difference in mapped attributes. Correlating results with existing evaporation basin locations was undesirable because they were not sited using the criteria defined in this paper.

Maps of rice growing areas provide some indication (generally being on slowly permeable soils) although rice is grown at sites that may not be suitable for evaporation basins, for example, in close proximity to irrigation channels. Leakage estimates (water use per unit area not adjusted for crop evapotranspiration) in the MIL were investigated to provide a validation although, at time of publication, the preliminary results were far from encouraging. The use of these relies on wider availability of water use, detailed soil maps, potential rice growing maps or irrigation leakage data, some of which are commercially and privately sensitive - and hence not widely available.

3. Results

Results are presented in three sections.

1. Regional scale (1:250,000) analysis.
2. Higher resolution analysis.
3. Attempts to estimate hydraulic conductivity.
4. General application of the analysis in other areas of the Riverine Plain.

1. Regional scale (1:250,000) analysis.

A suitability map for each theme used in the analysis illustrates its contribution and the process leading to the overall suitability maps (Figs. 6a,b to 15a,b). To aid comparison between the MIA and SIR the results for each theme appear on the same page as parts a) and b).

Figures 6 to 11 show the influence from individual themes in the Topo250k data. Each figure gives the proportion of suitable / not suitable land. Because of overlaps, the effects are not cumulative. Figure 12 illustrates the cumulative impact of combining all Topo250k themes and shows that 66% (MIA) and 48% (SIR) remain suitable.

Having excluded approximately 50% of the areas on the basis of above ground data we introduce the more uncertain groundwater level and quality data. Figures 13 and 14 show the ranges used for the regional groundwater and salinity data. Their cumulative effects, together with those of the Topo250k data, can be seen in Figure 15 which is the overall suitability map. In the MIA 29% was found to be suitable while the SIR was 18%. The suitable area can only decrease with the addition of other datasets, such as reliable soil hydraulic conductivity data or a surrogate for it.

2. High resolution analysis.

The analysis was performed using high resolution data in various combinations to compare with the low resolution analysis. One such combination is presented in Figures 16 to 18, which used the regional scale Topo250k data as a coarse filter in conjunction with the high resolution watertable and salinity data. In addition, the best available soils data was included. For the MIA this consisted of Soil Land Forms (SLFs) (Bui *et al.,* 1998) which we reclassified on the basis of Principal Profile Forms (PPFs) into three classes of high, unknown and low permeability. For the SIR, the 6 irrigated crop suitability groups were regrouped into the same three classes (Fig. 3). The suitable areas remaining under this scenario was 23% for the MIA and only 9% for the SIR. Visually, the results are plausible but without validation data are impossible to quantify. The maps at least provide an output for local experts to judge. Significant areas where there was incomplete soil data coverage in the SIR (Fig. 3) were excluded from the analysis affecting the summary statistics accordingly.

3. Attempts to estimate hydraulic conductivity.

A series of comparisons between soils and other datasets was undertaken in order to try and improve the estimates, or surrogates, for hydraulic conductivity of which two examples are shown (Figs. 19, 20).

Figure 19 shows the level of detail in the 1:25,000 soil mapping that occurs in one SLF polygon in the vicinity of Girgarre. For this polygon 14% of the soils (groups 5 and 6) were identified as mostly impermeable, 67% were mostly permeable (groups 1, 2 and 3) and 20% appeared too mixed to classify. It was assumed that each SLF polygon could be treated similarly inferring the detail in terms of probabilities to the regional scale dataset. However, because of the computational difficulties and large uncertainties in the high resolution classification this approach was abandoned.

The second example shows an attempt to seek a correlation between soil type and rice water use. Data acquired from the MIL (Fig. 5) produced the poor correlation shown in Figure 20. The expectation was that rice water use, a marginal surrogate for leakage, would increase as clay content decreased and sand content increased (a trend line from top left to lower right). Clearly there is little trend at all which prevents any inference of water use or conductivity to an area with a soil map using the same classification.

4. General application of the analysis in other areas of the Riverine Plain.

The most appropriate data, in terms of extending the analysis to other areas, were found to be the regional scale Topo250k data for hydrologic and infrastructure attributes and the Hydrogeology of the Murray Basin for watertable depth and groundwater salinity. The analysis was applied to the three other major irrigation areas in the Riverine Plain. The overall suitability maps are presented for the CIA (Fig. 21), MIL (Fig. 22) and the Kerang-Cohuna region (Fig. 23).

Comparison of the proportion of each area that is unsuitable (Figs. 15a, 15b, 21, 22, 23) indicates a grouping of the eastern-most areas (MIA, CIA, SIR) between 72 - 82% and another of the western-most areas (MIL, Kerang Cohuna region) of 50 - 53%, which border, or overlap, the Mallee Plain. This is related to significant differences in the proportions of unsuitable groundwater salinities. A summary of all the results is provided (Table 4) to aid comparisons between the areas and the contributions of datasets to the overall suitability maps at different scales.

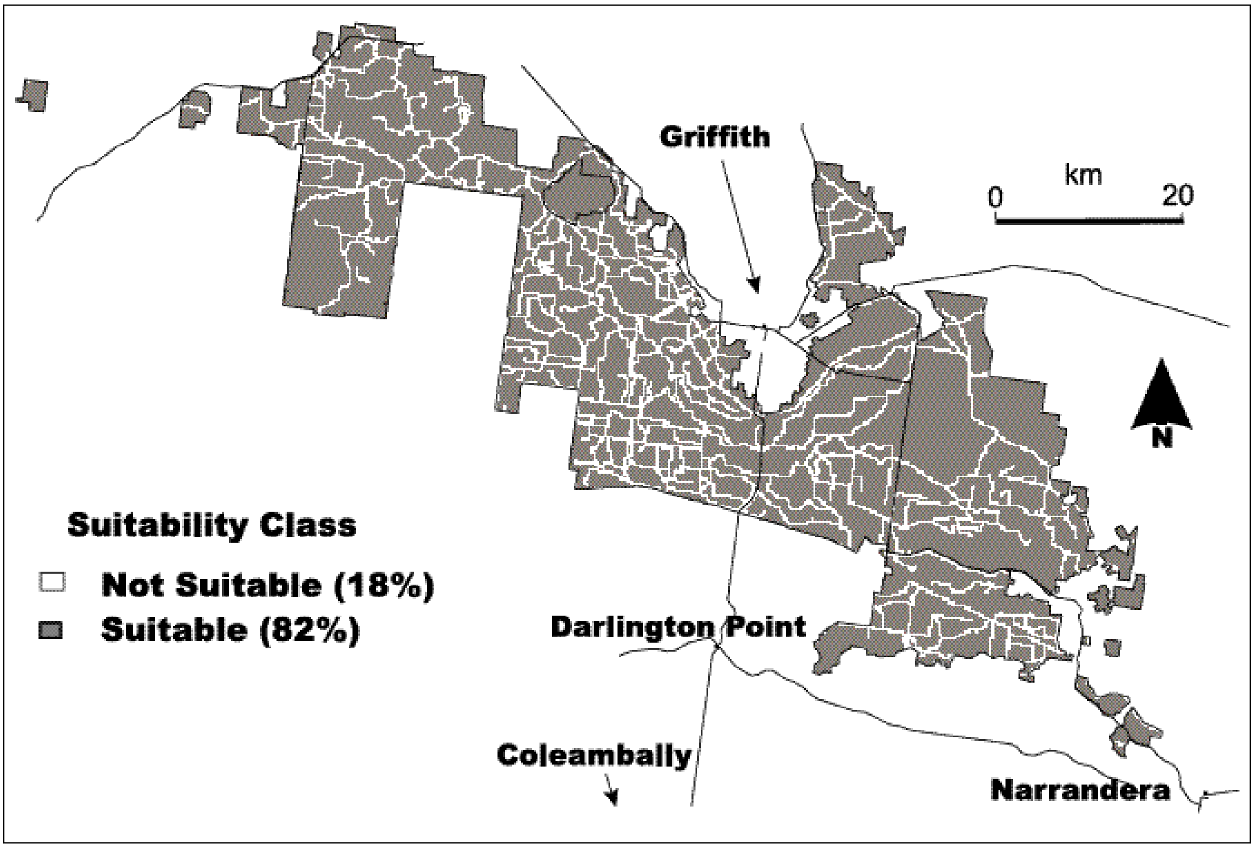

Figure 6a. Suitability of land in the MIA based only on surface water features. No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

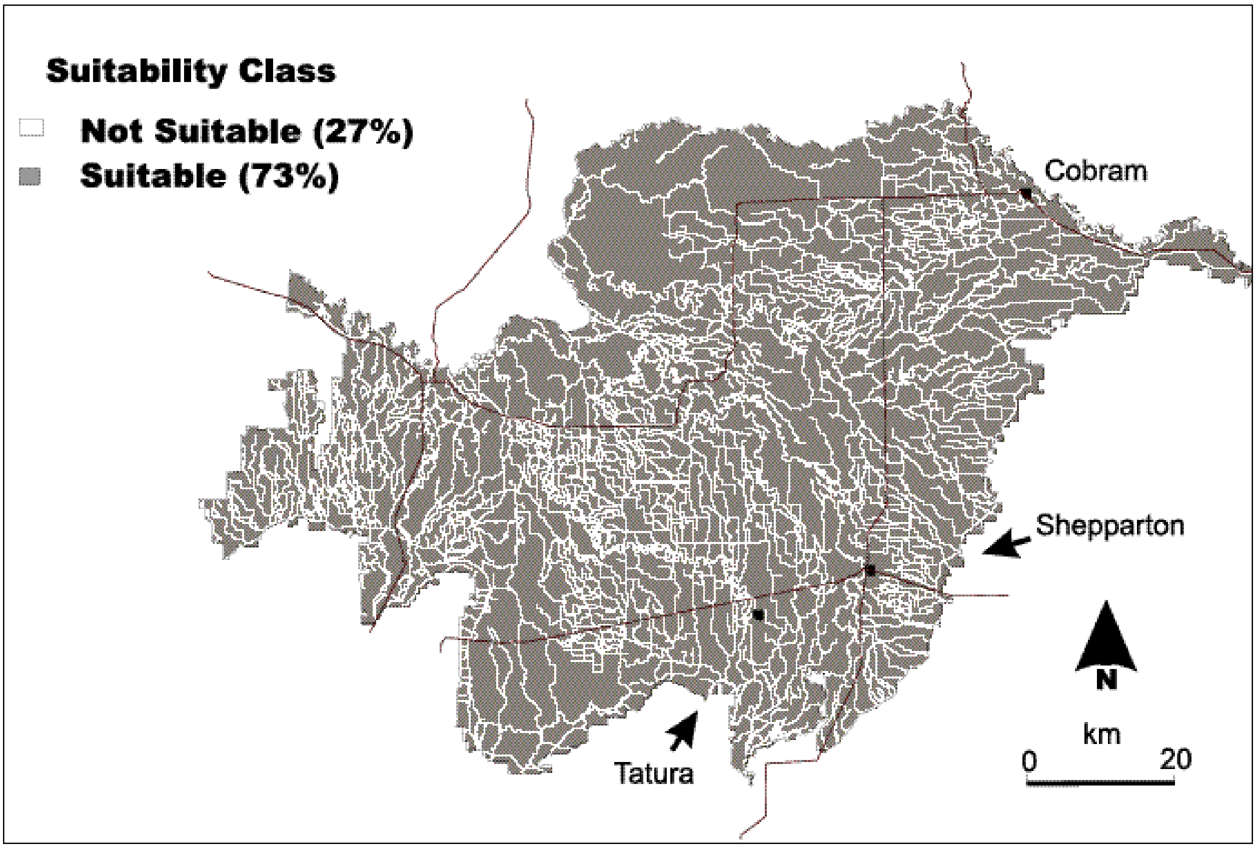

Figure 6b. Suitability of land in the SIR based only on surface water features. No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

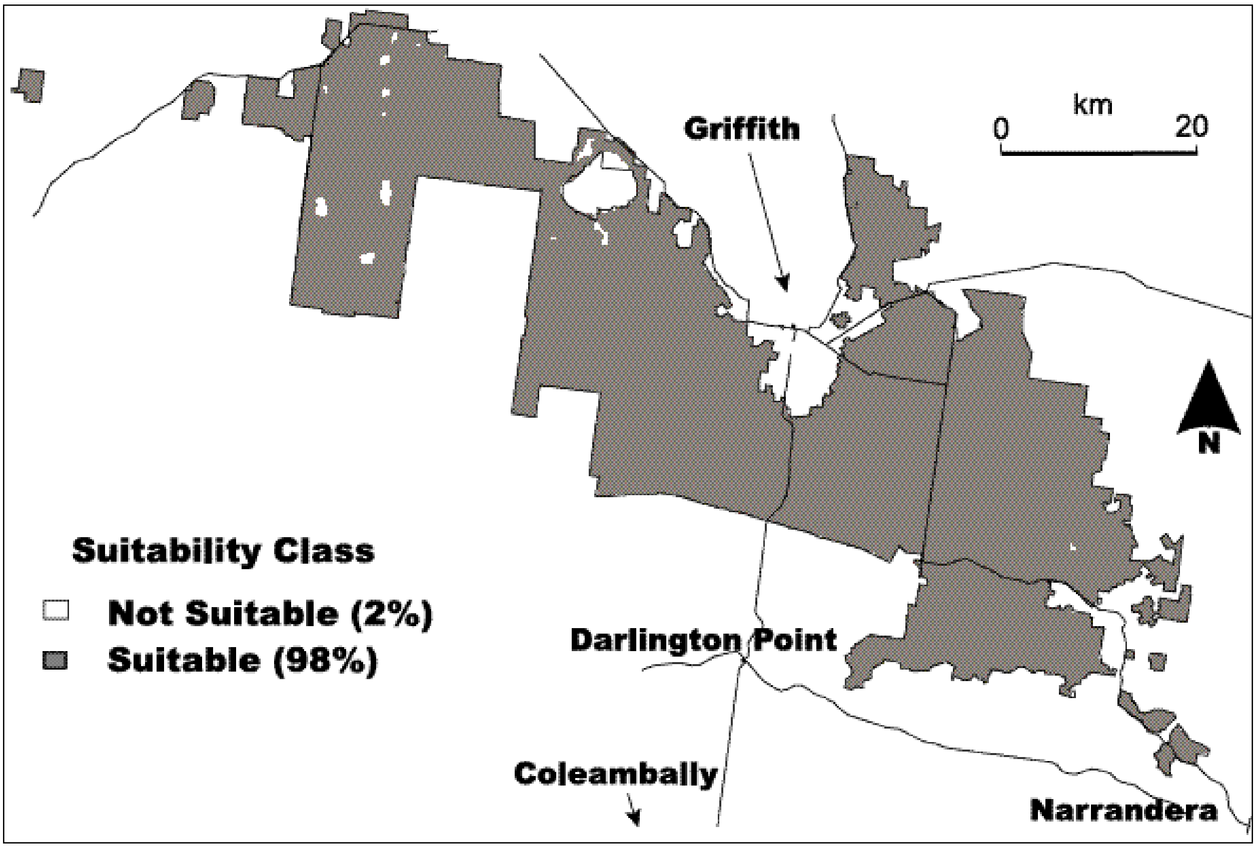

Figure 7a. Suitability of land in the MIA based only on surface water bodies such as lakes and swamps using a 50m buffer before gridding.

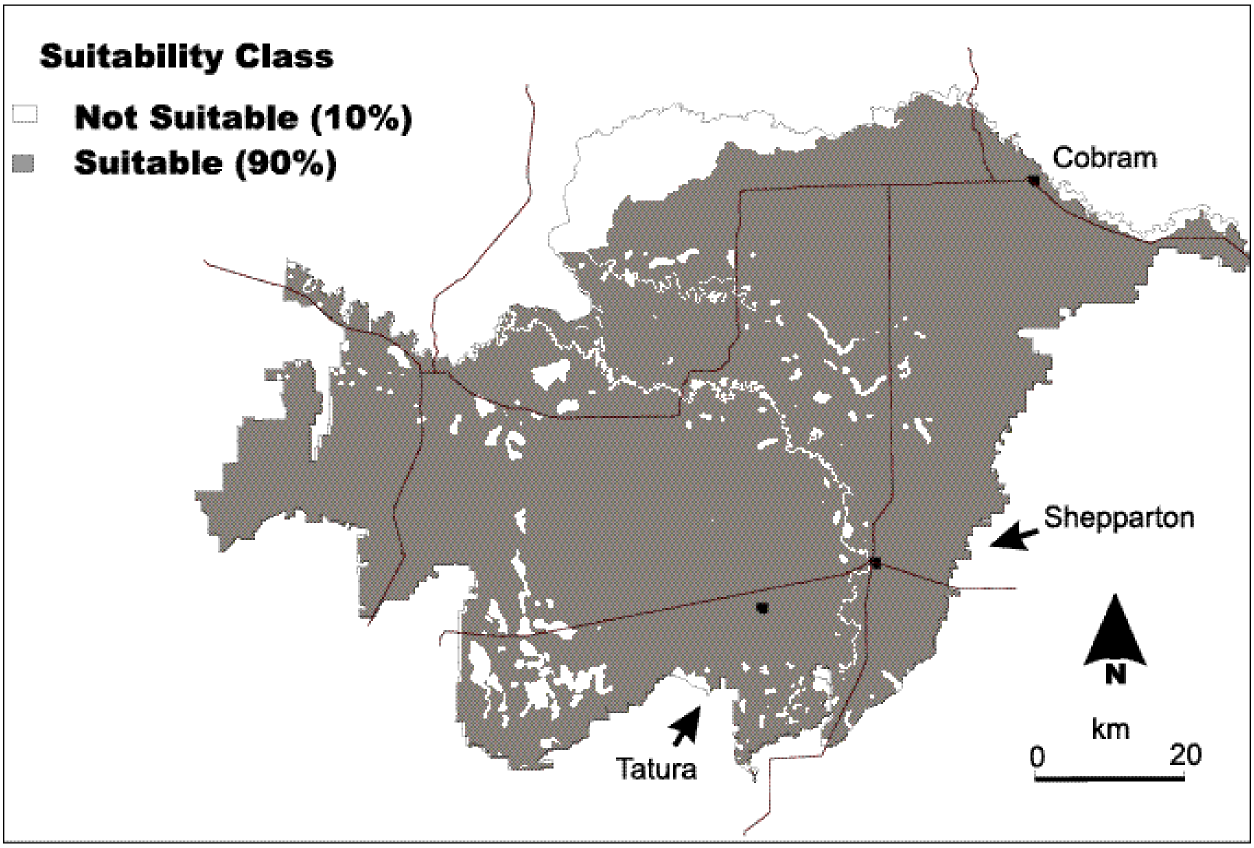

Figure 7b. Suitability of land in the SIR based only on surface water bodies such as lakes and swamps using a 50m buffer before gridding.

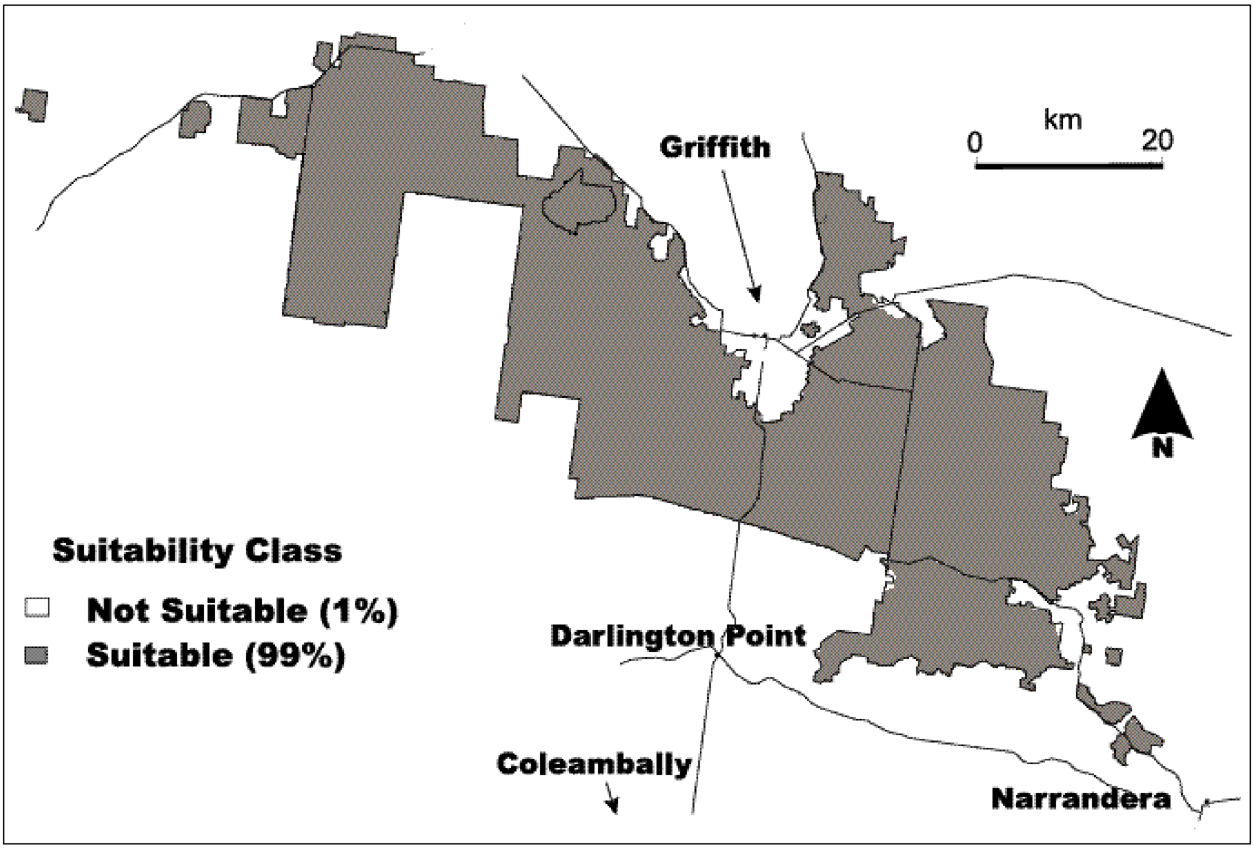

Figure 8a. Suitability of land in the MIA based only on proximity to urban settlement using a 1km buffer before gridding.

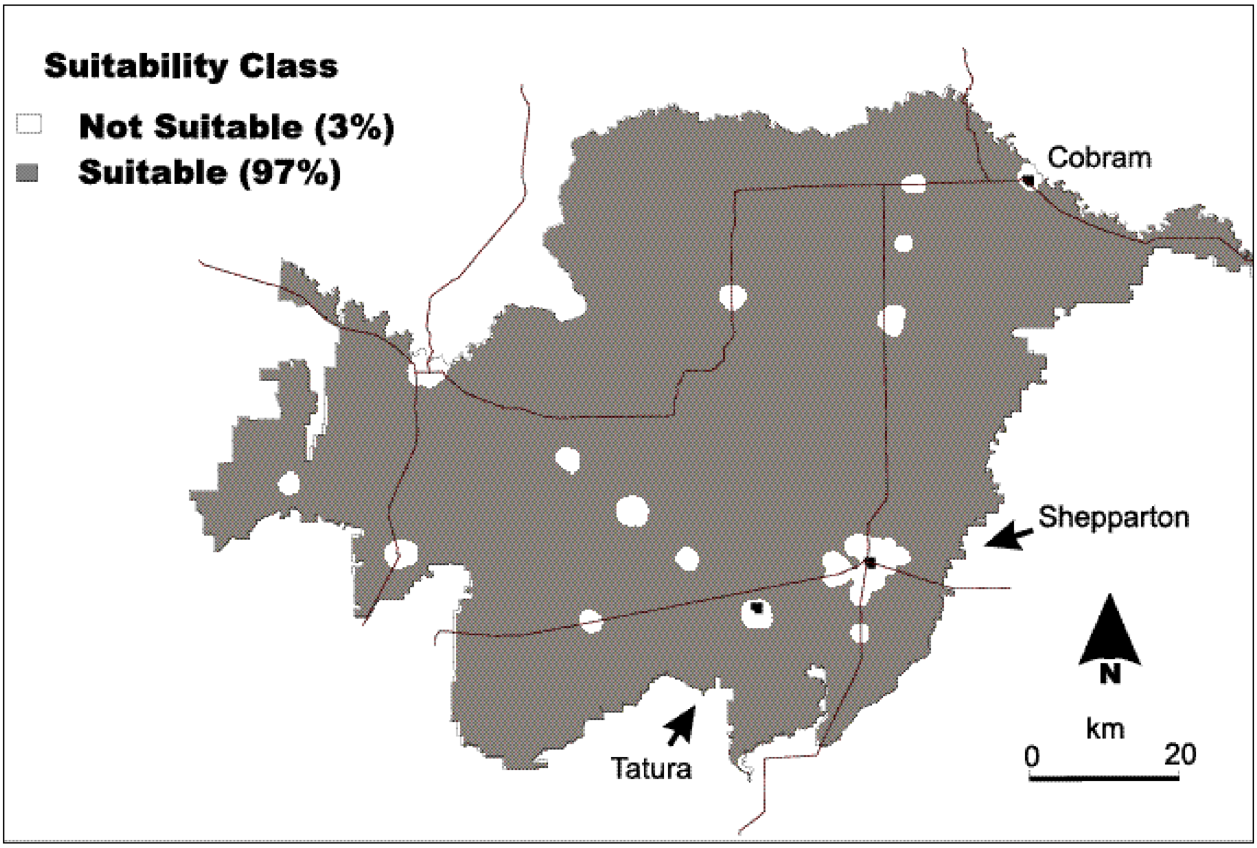

Figure 8b. Suitability of land in the SIR based only on proximity to urban settlement using a 1km buffer before gridding.

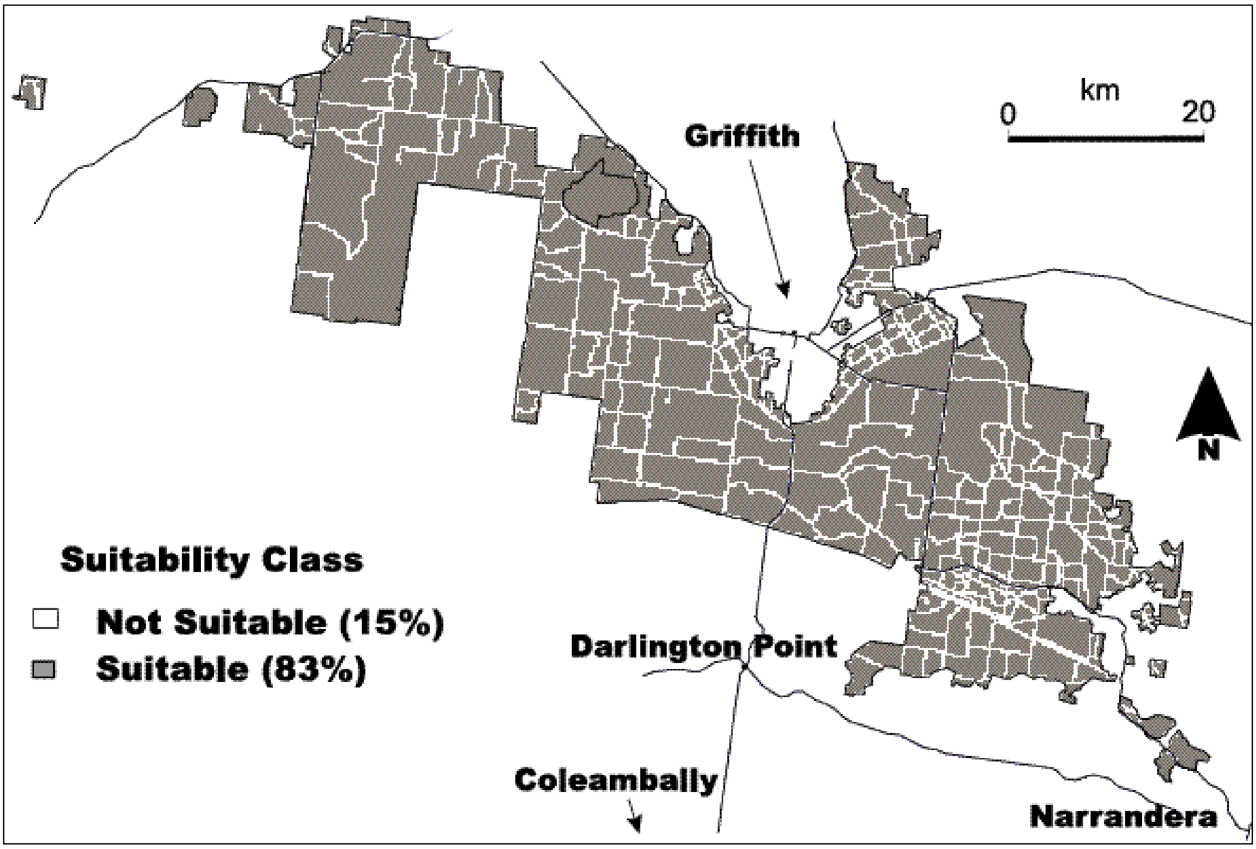

Figure 9a. Suitability of land in the MIA based only on road infrastructure. No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

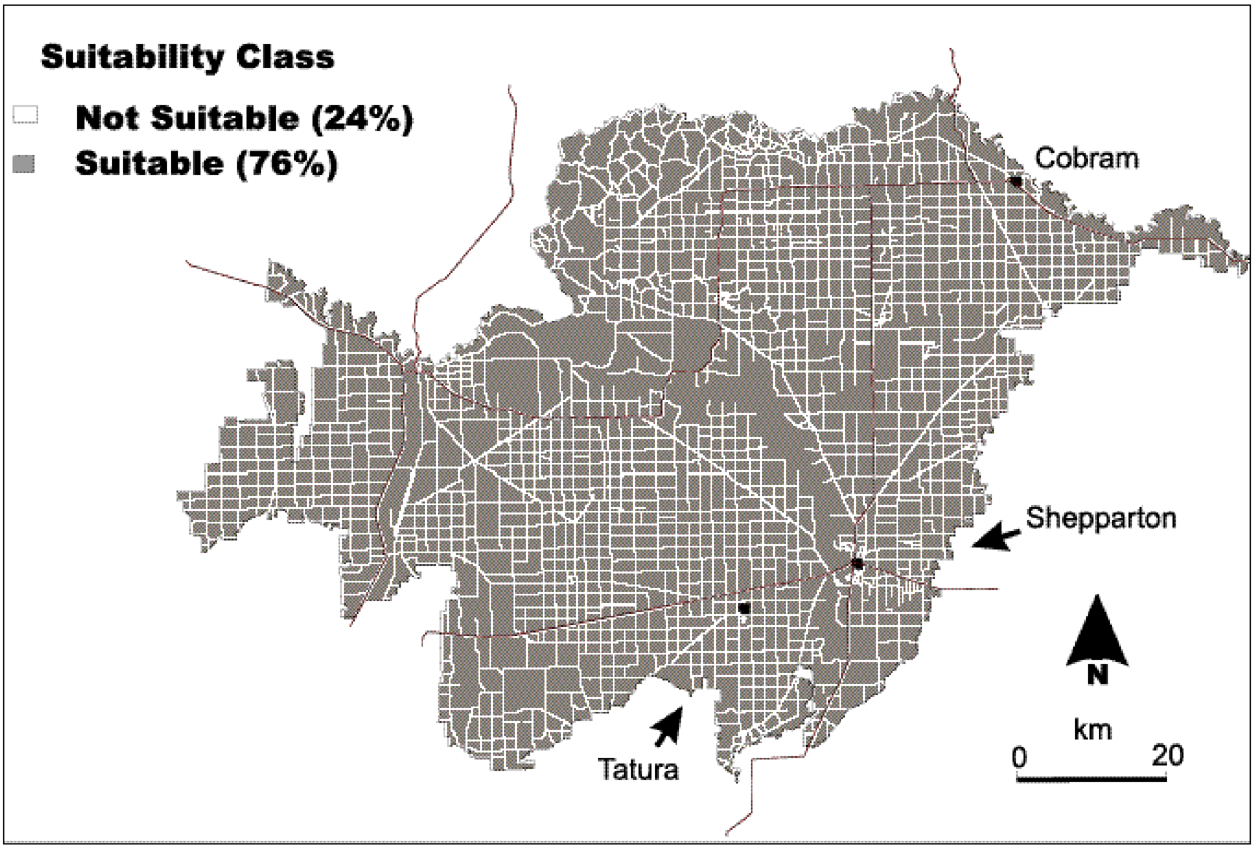

Figure 9b.Suitability of land in the SIR based only on road infrastructure. No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

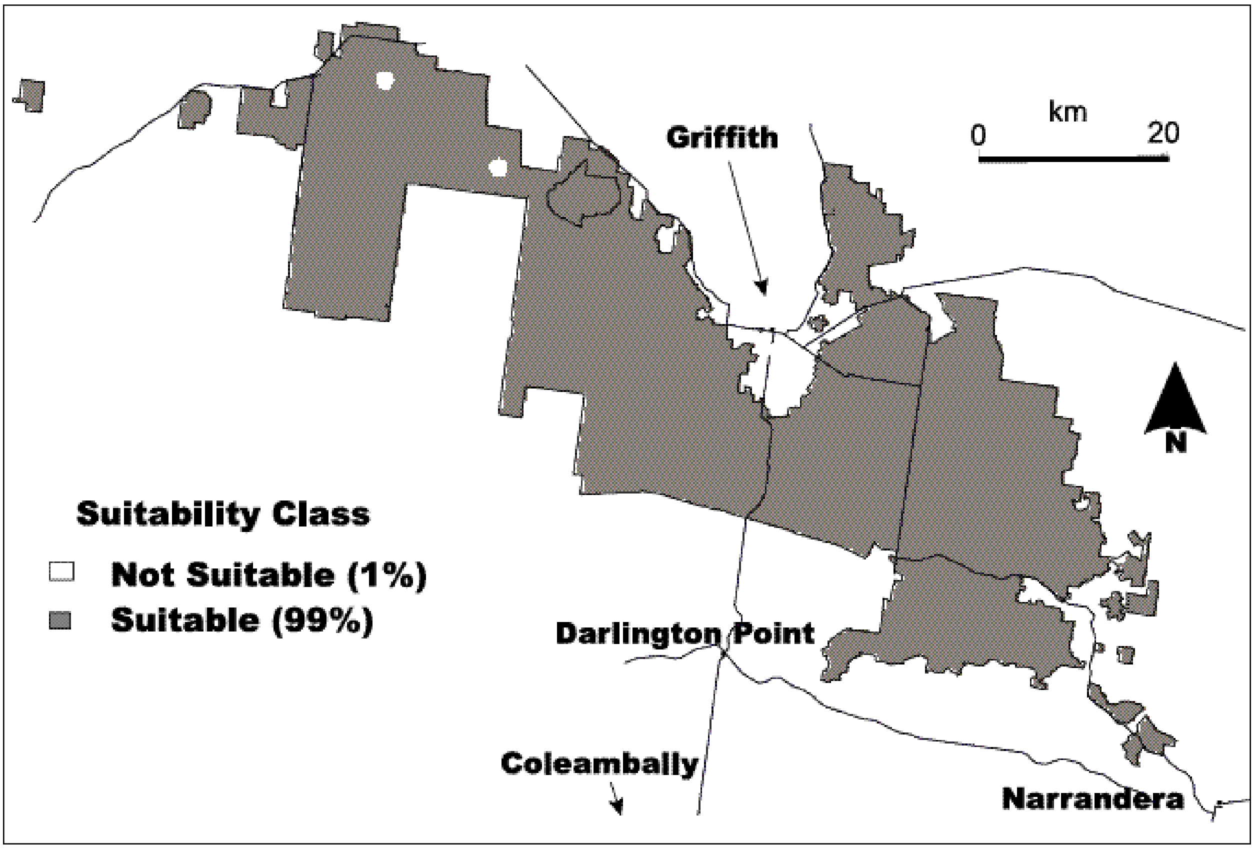

Figure 10a. Suitability of land in the MIA based only on aeronautical infrastructure using a 1km buffer before gridding.

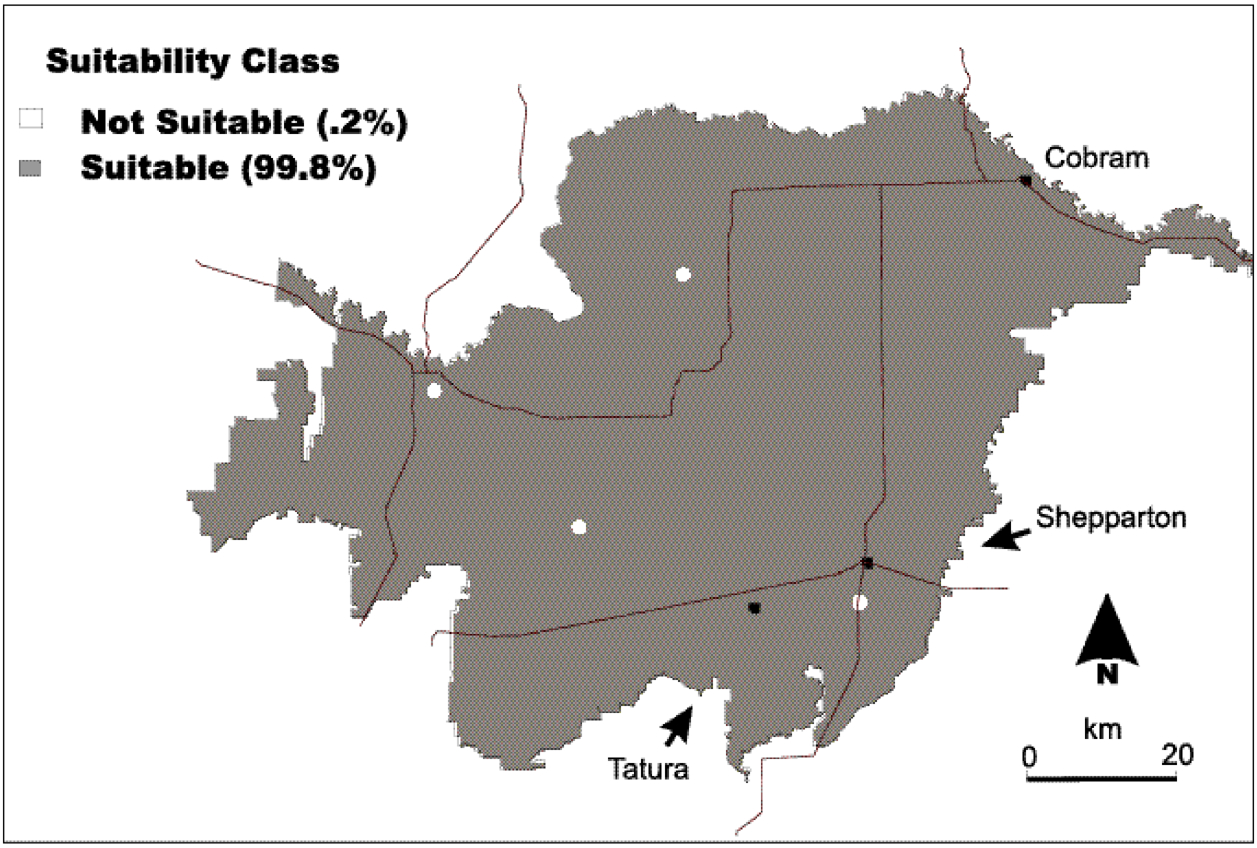

Figure 10b. Suitability of land in the SIR based only on aeronautical infrastructure using a 1km buffer before gridding.

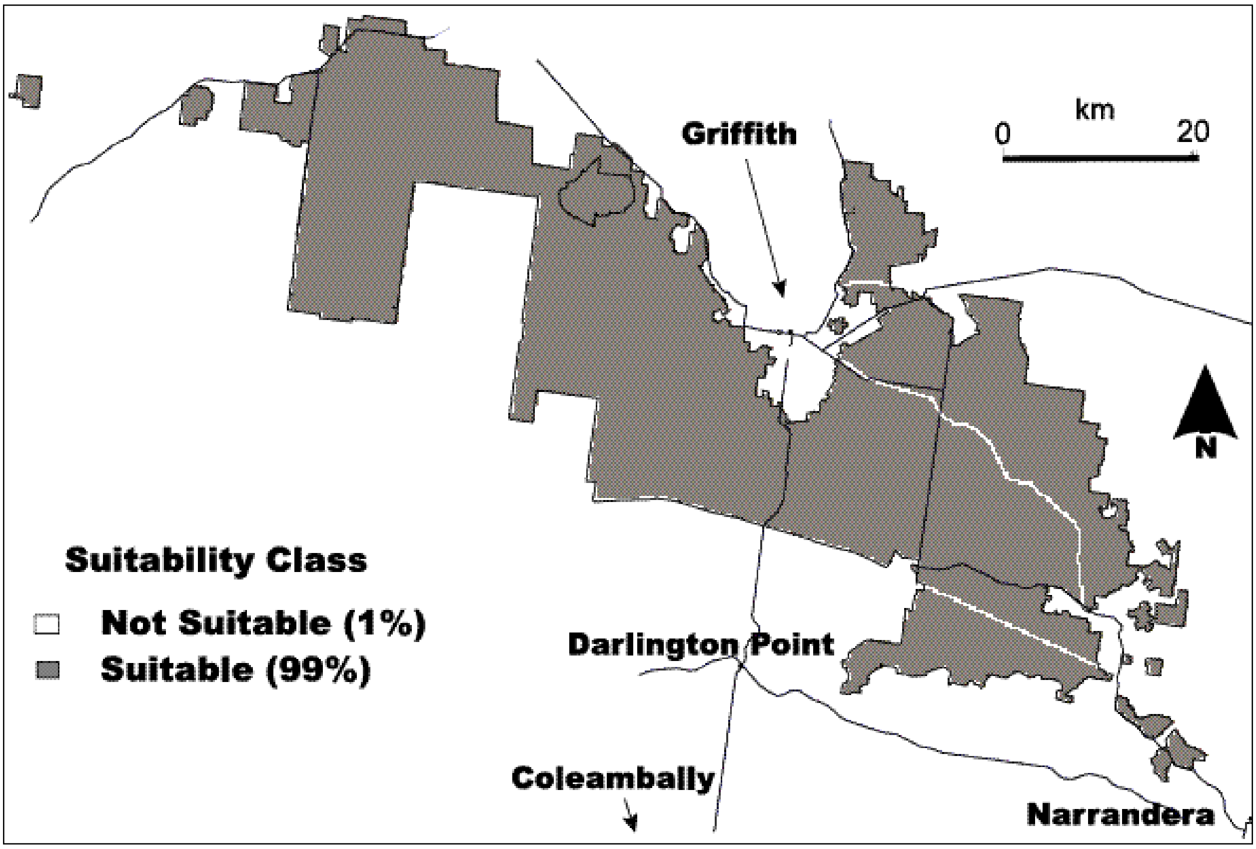

Figure 11a. Suitability of land in the MIA based only on rail infrastructure. No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

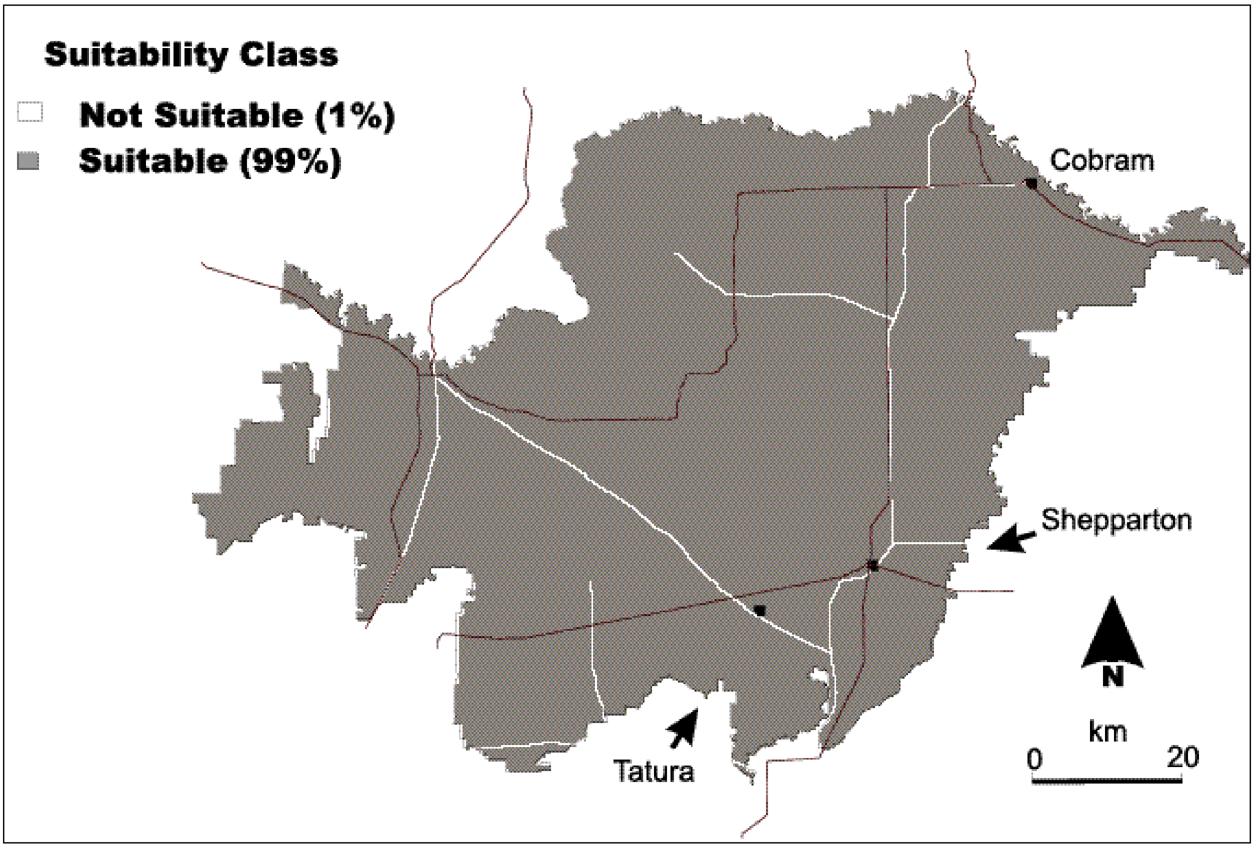

Figure 11b. Suitability of land in the SIR based only on rail infrastructure.No buffer was applied though a cell size of 250m implies an average buffer of 125m (half cell width).

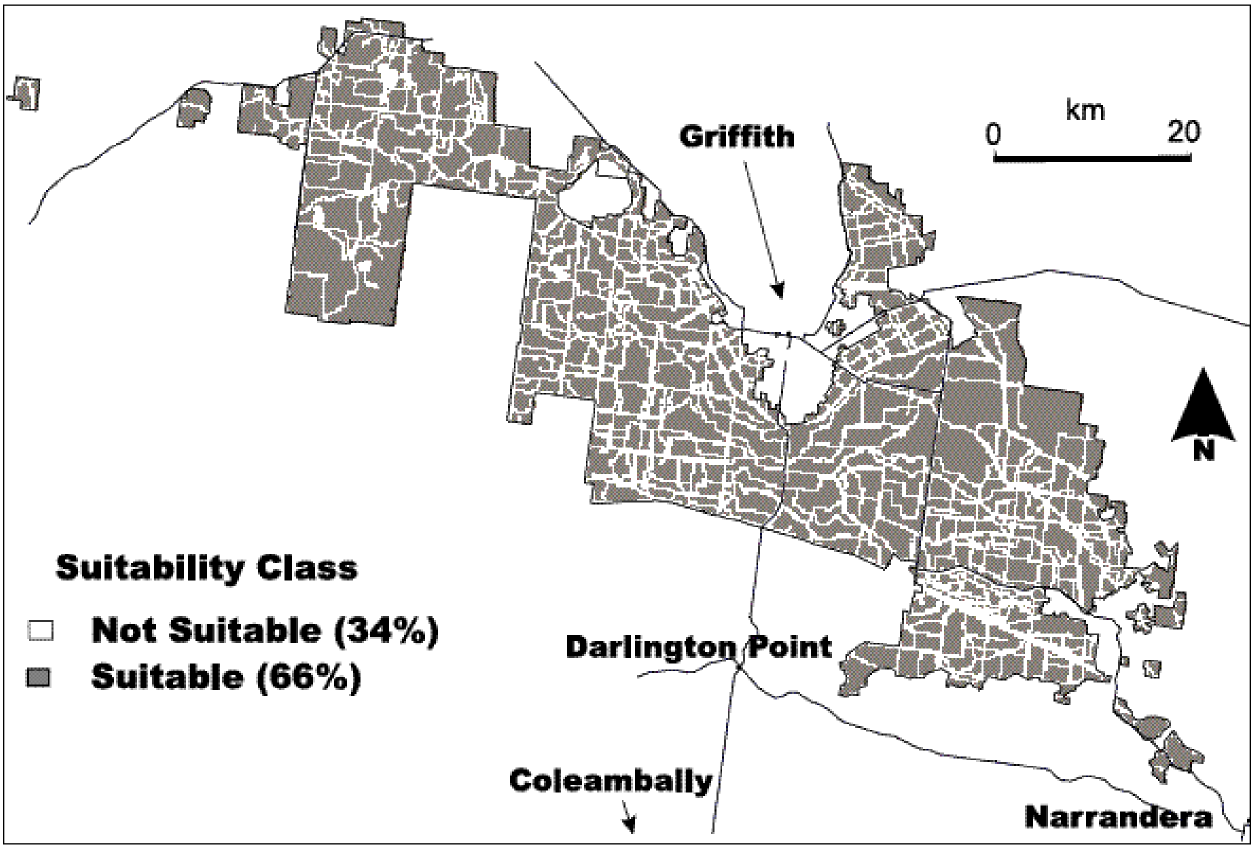

Figure 12a. Suitability of land in the MIA based on the combination of all Topo250k themes.

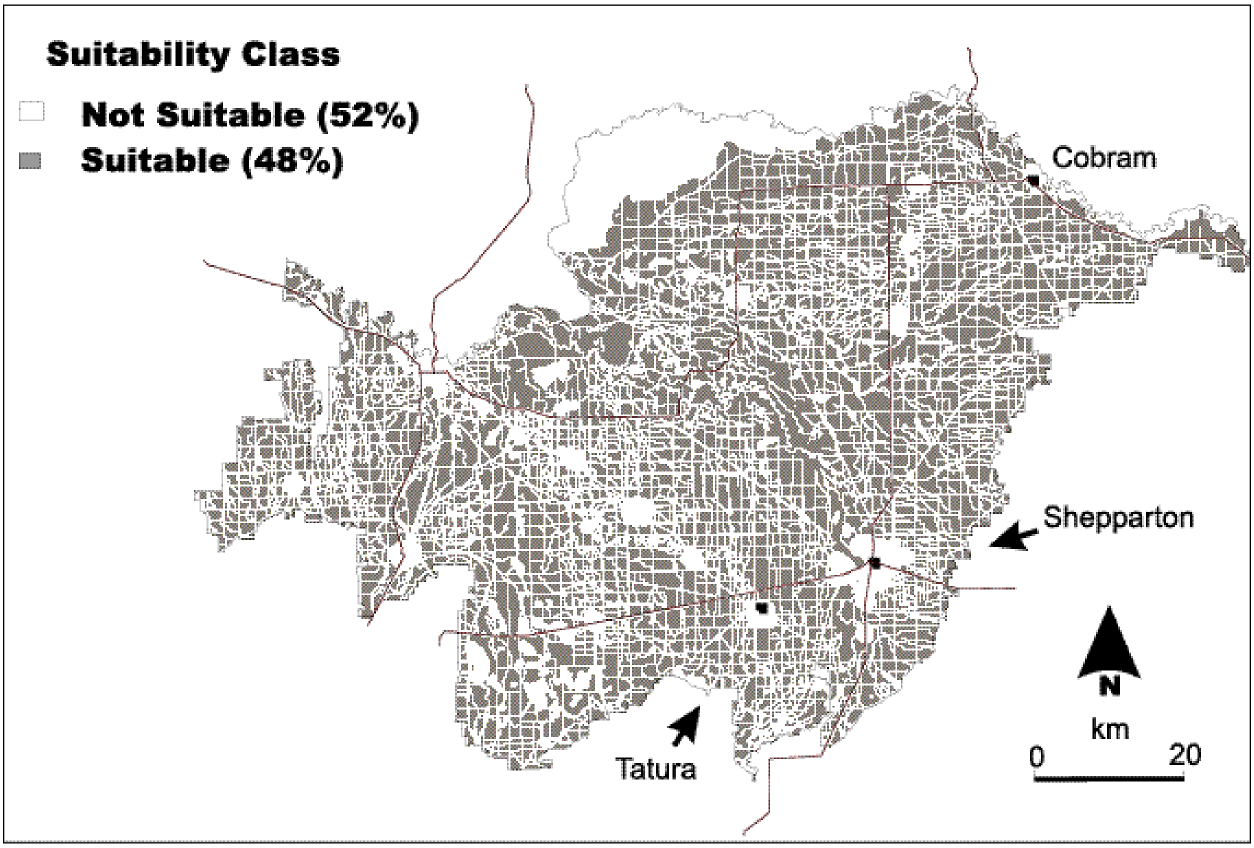

Figure 12b. Suitability of land in the SIR based on the combination of all Topo250k themes.

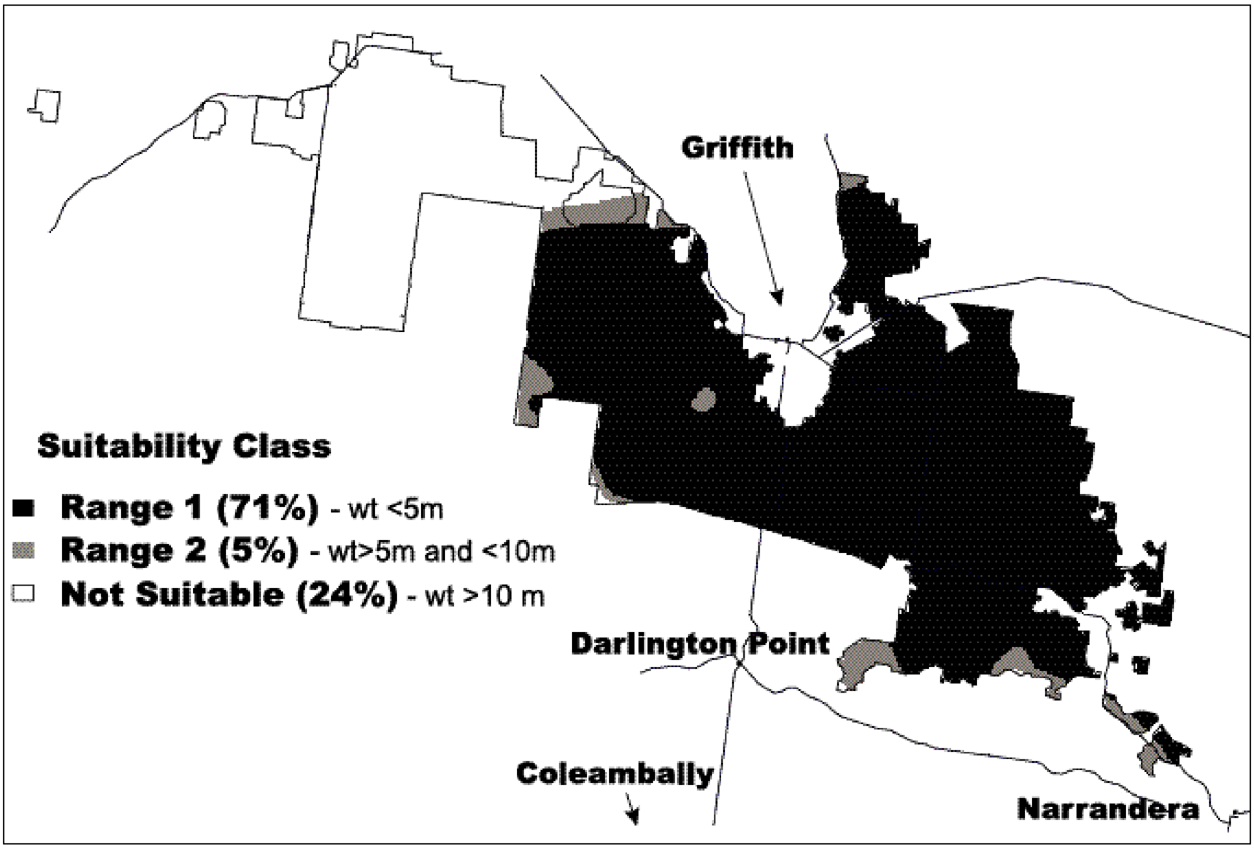

Figure 13a. Suitability of land in the MIA based only on watertable depth classes. Ranges were relaxed to those shown for the regional scale data.

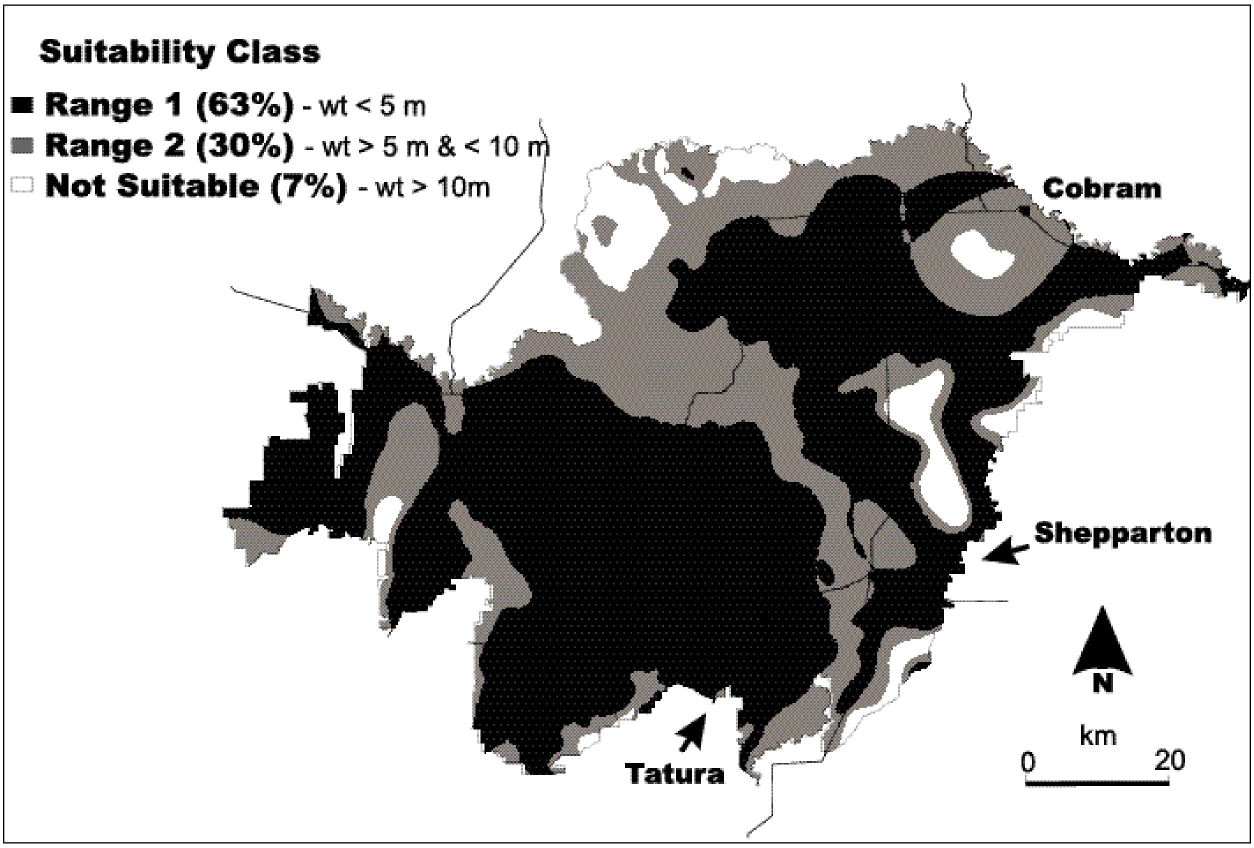

Figure 13b. Suitability of land in the SIR based only on watertable depth classes. Ranges were relaxed to those shown for the regional scale data.

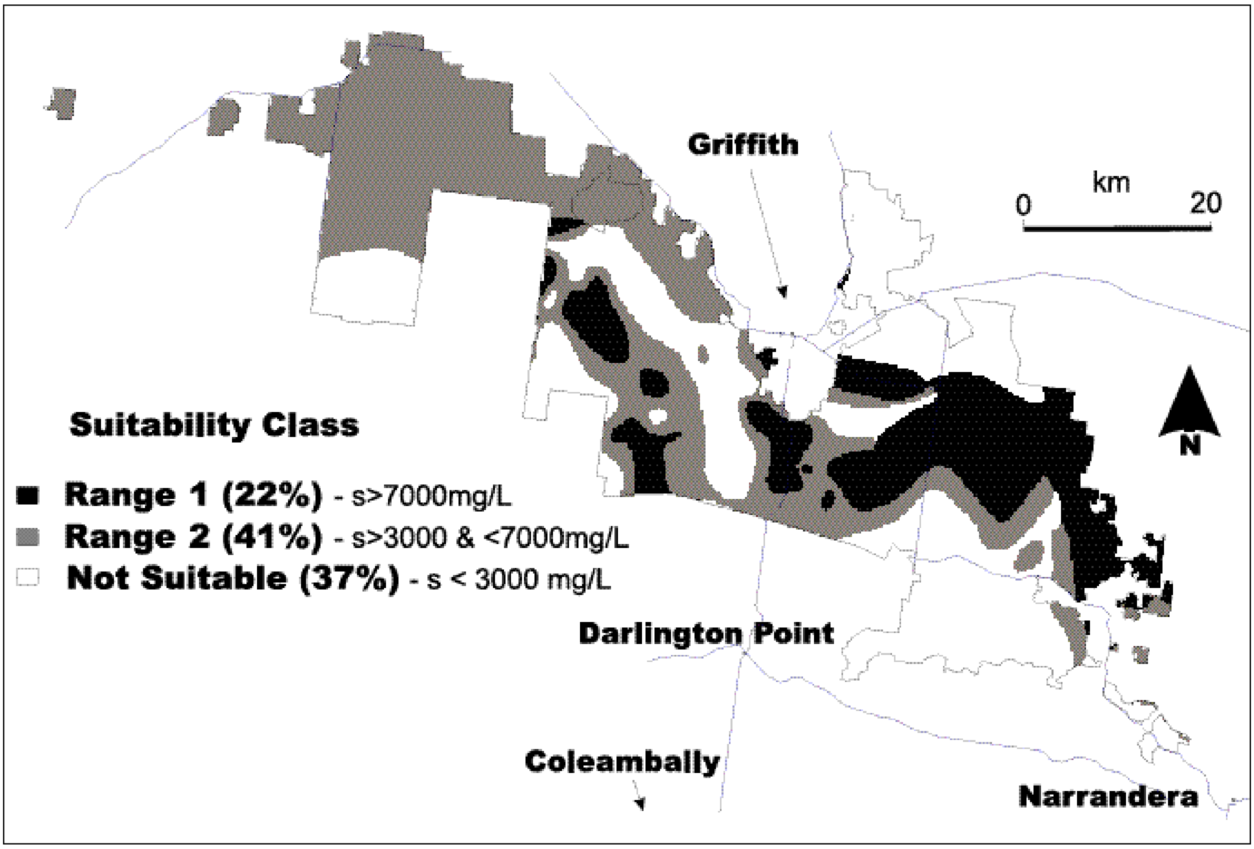

Figure 14a. Suitability of land in the MIA based only on the regional groundwater salinity data.

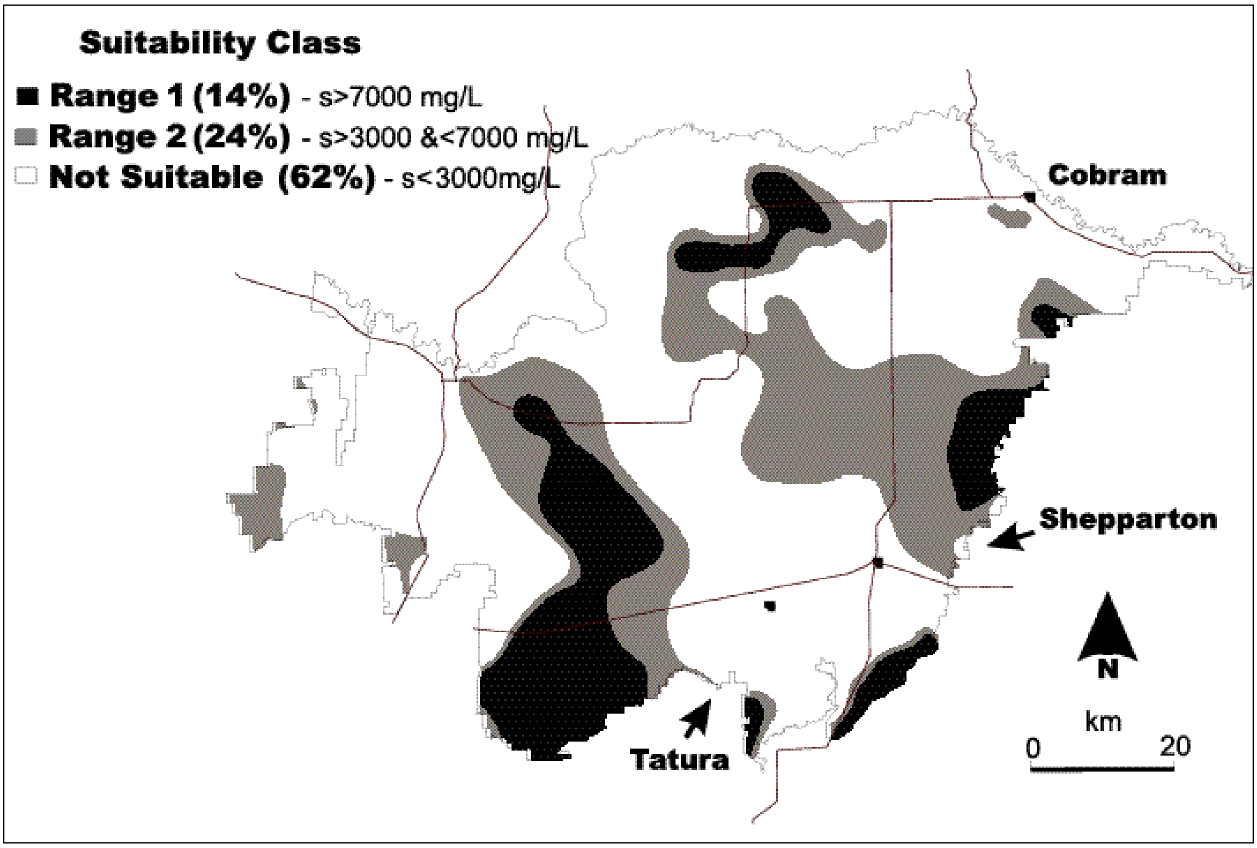

Figure 14b. Suitability of land in the SIR based only on the regional groundwater salinity data.

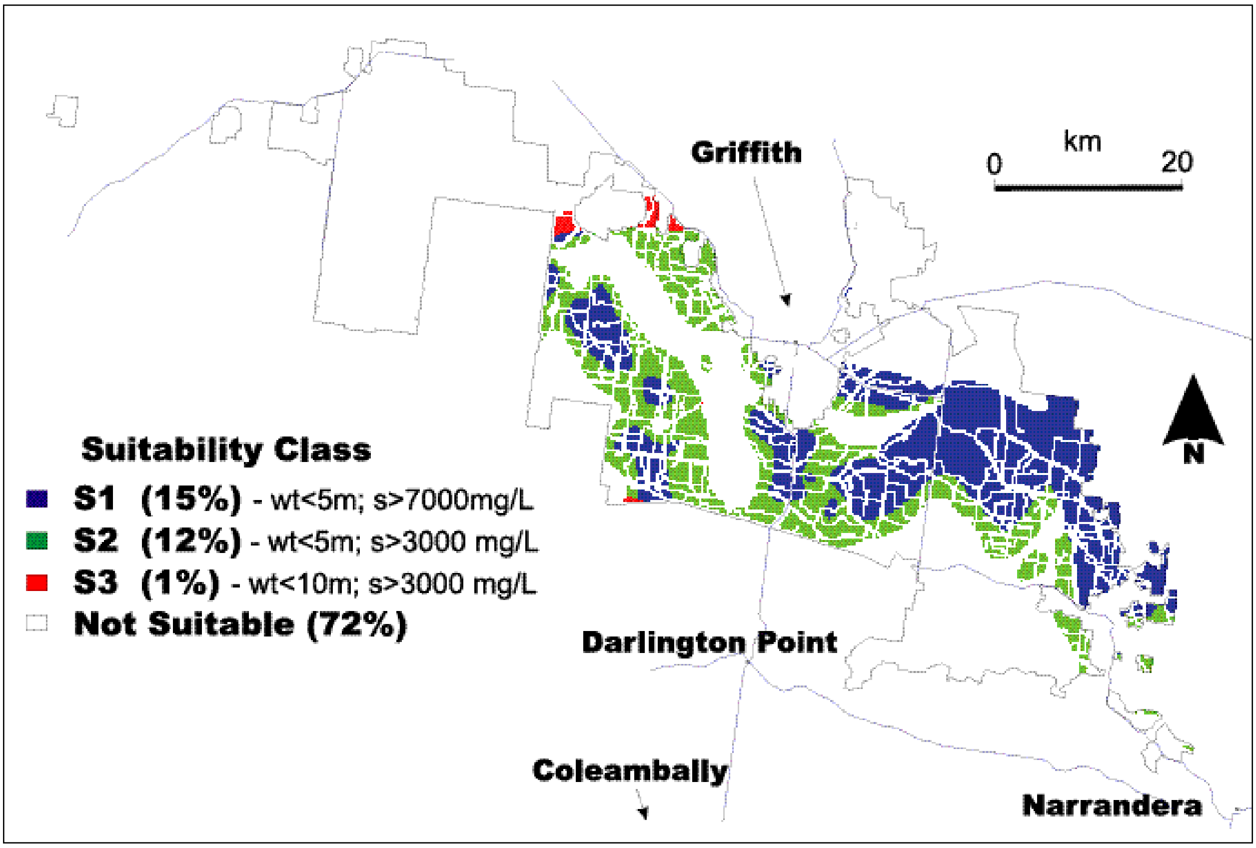

Figure 15a. Overall suitability of land for disposal basins in the MIA based on all themes except hydraulic conductivity. S1 is optimal conditions in all criteria while S2 and S3 have depth to water table and groundwater salinity criteria relaxed.

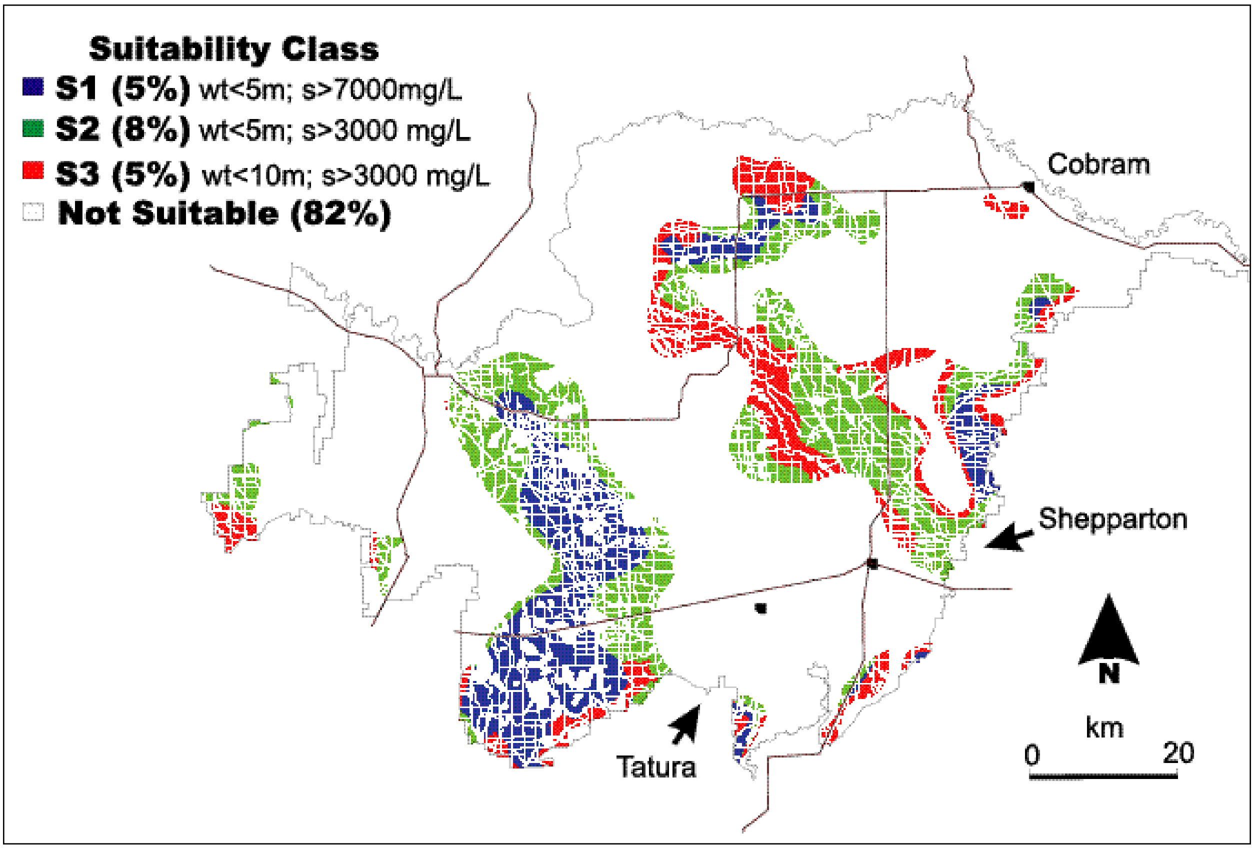

Figure 15b. Overall suitability of land for disposal basins in the SIR based on all themes except hydraulic conductivity. S1 is optimal conditions in all criteria while S2 and S3 have depth to water table and groundwater salinity criteria relaxed.

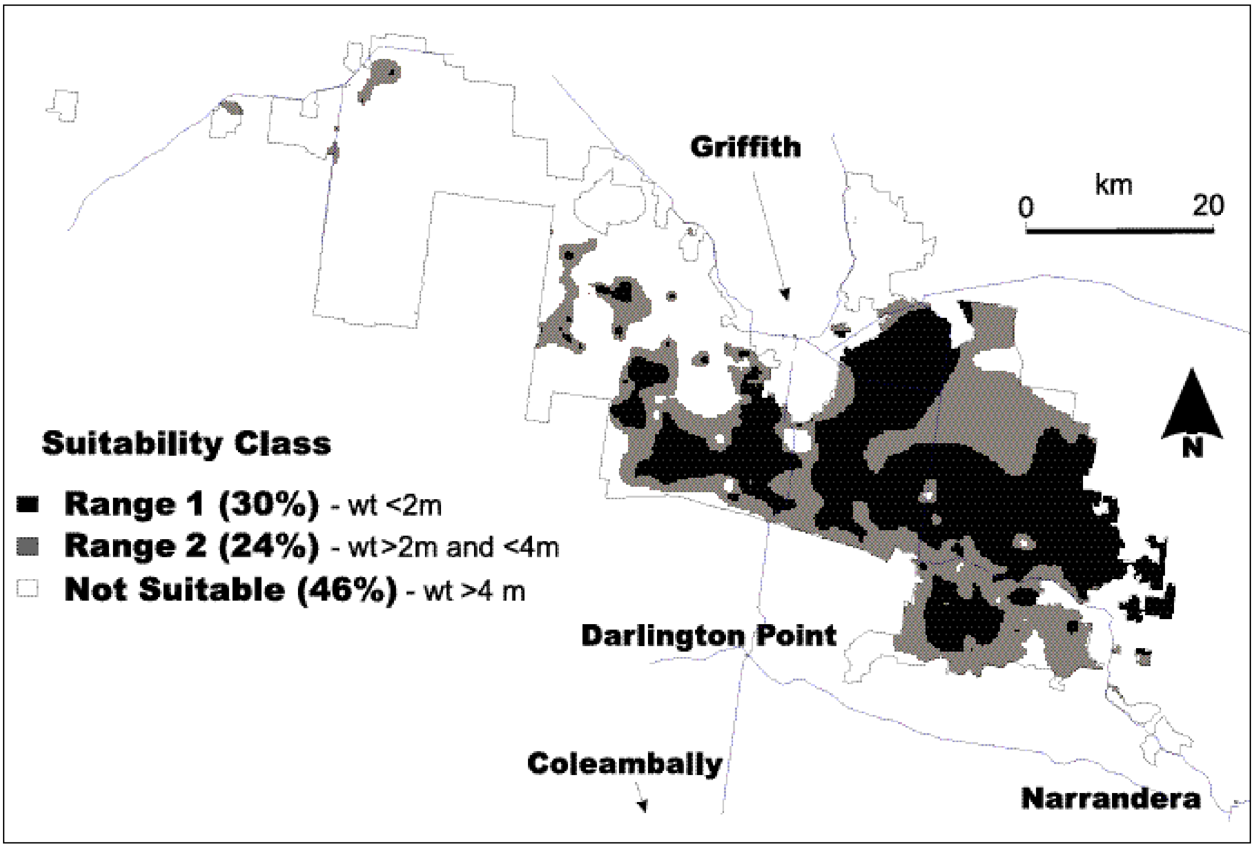

Figure 16a. Suitability of land in the MIA based on high resolution depth to watertable data. Original thresholds of 2 and 4m were used because the data could support it.

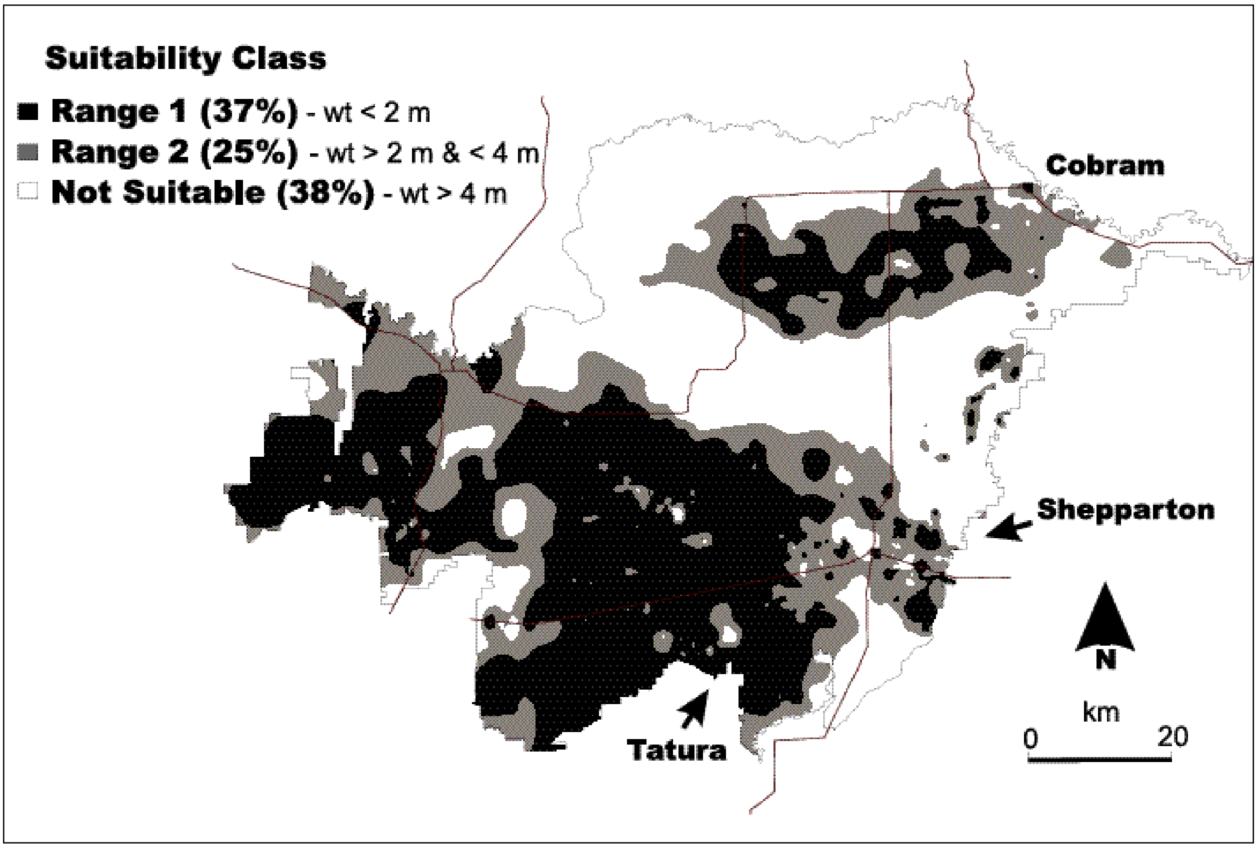

Figure 16b. Suitability of land in the SIR based on high resolution depth to watertable data.Original thresholds of 2 and 4m were used because the data could support it.

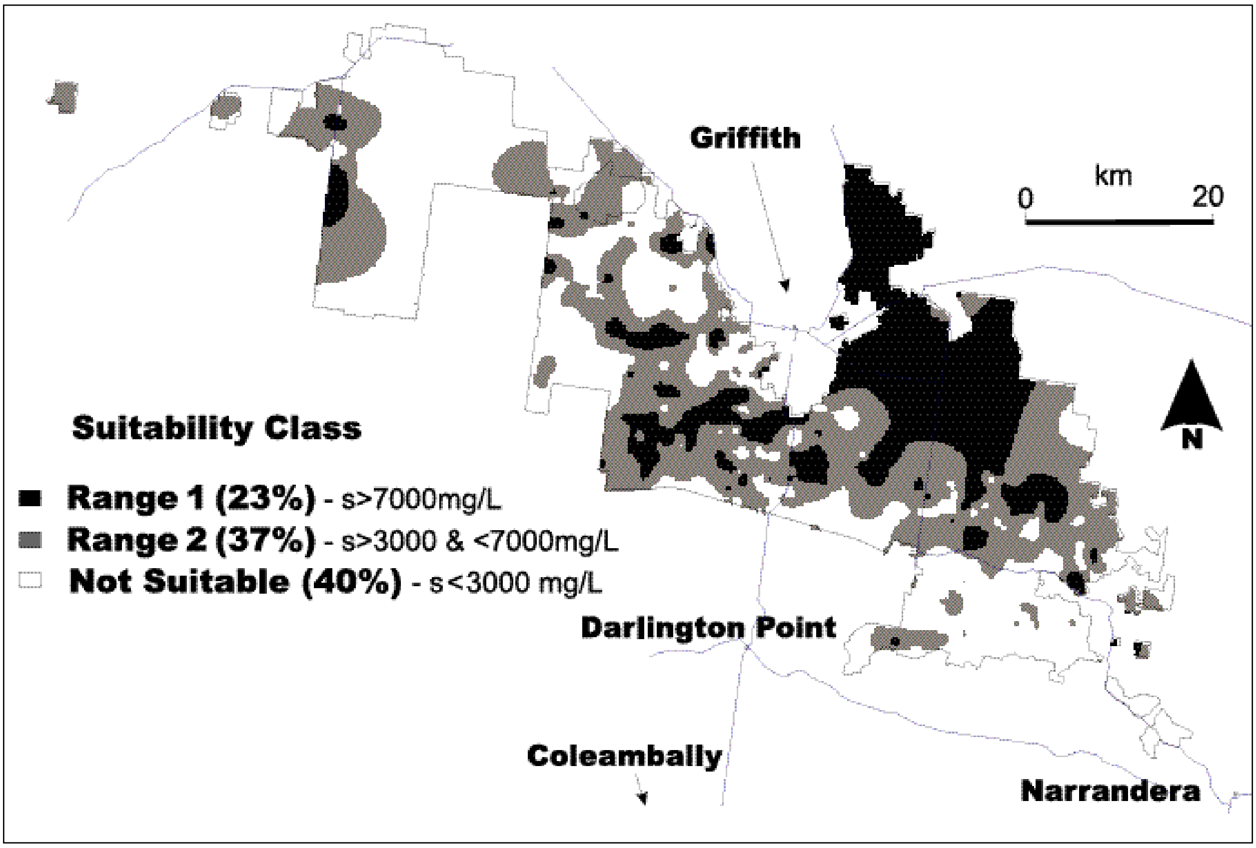

Figure 17a. Suitability of land in the MIA based on high resolution salinity data.

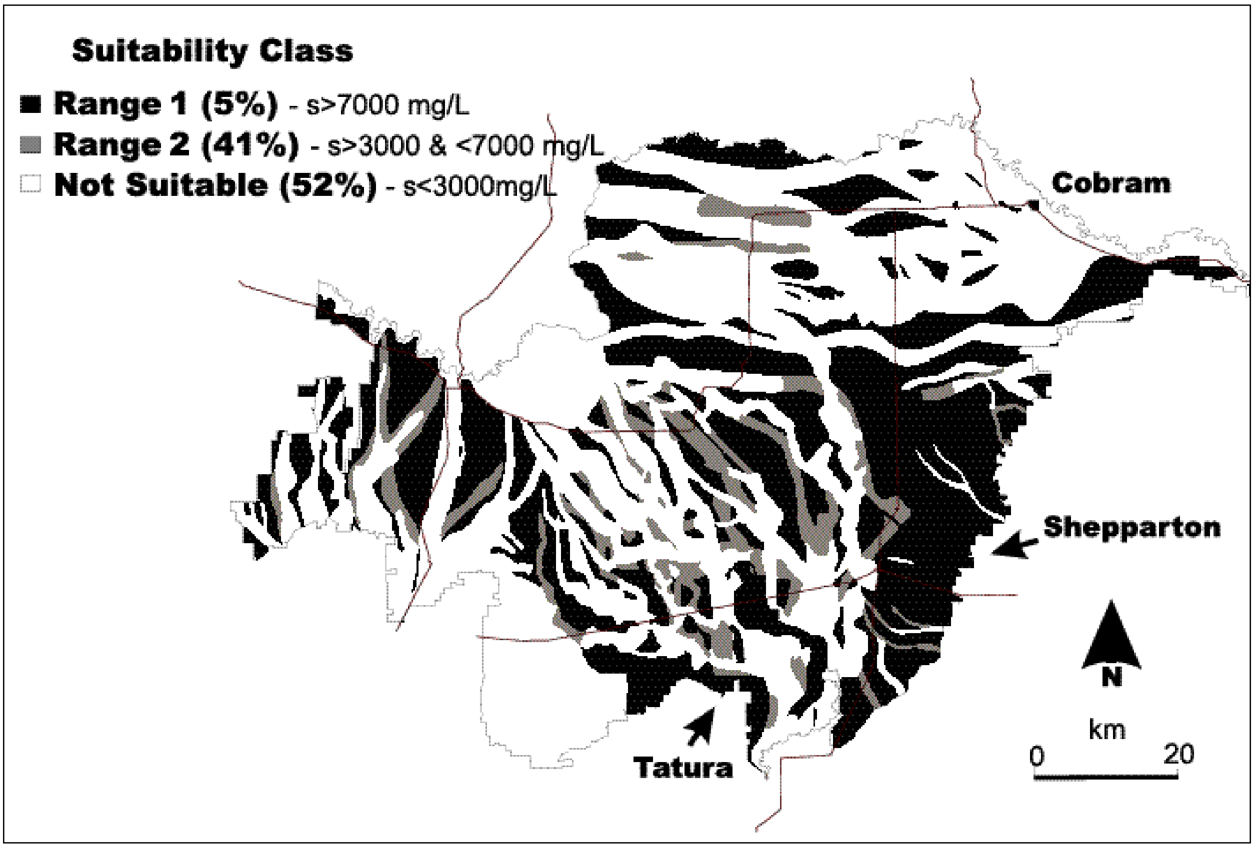

Figure 17b. Suitability of land in the SIR based on high resolution salinity data. Data was in the form of shallow aquifer mapping where the background was assumed to be suitable i.e.'no aquifers'is equivalent to low risk and therefore highly saline groundwater.

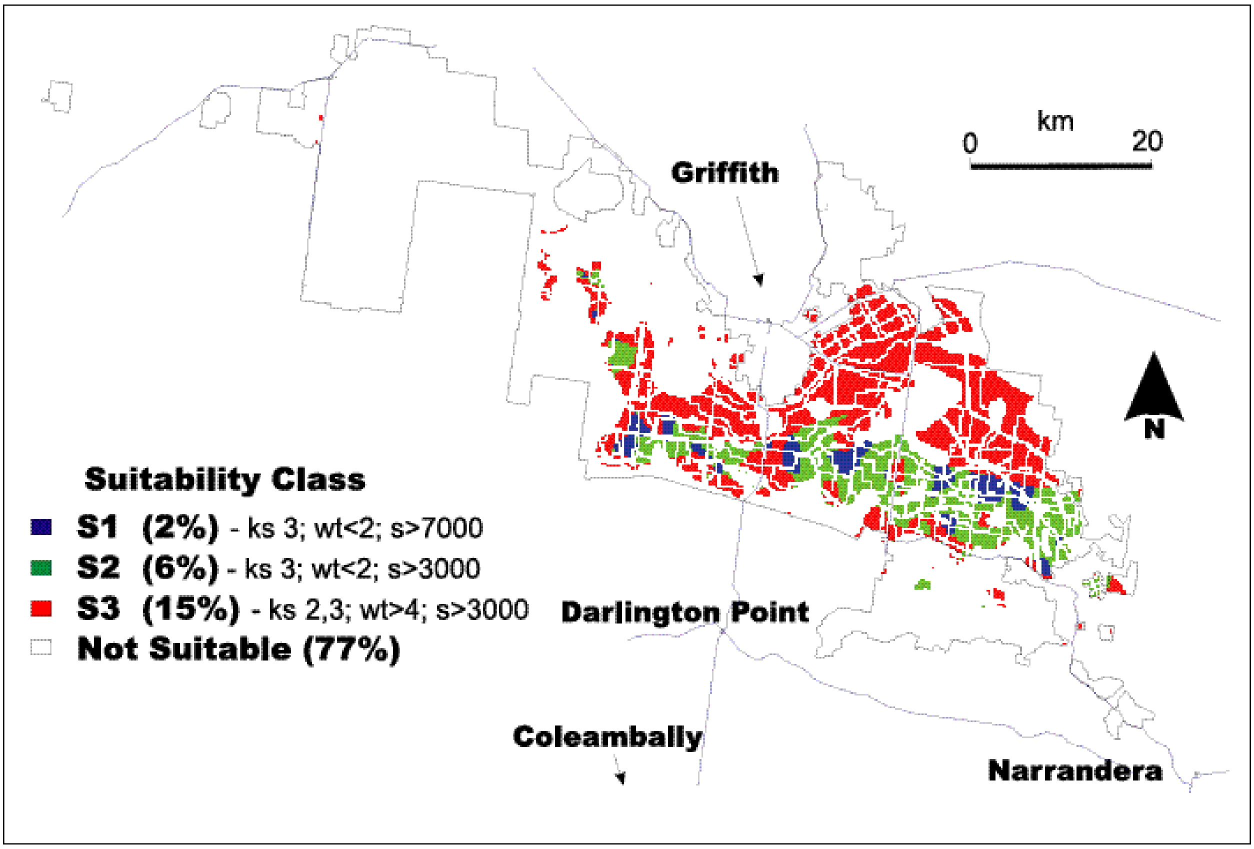

Figure 18a. Overall suitability of land in the MIA using the Topo250k data and the highest resolution watertable depth,salinity and soil hydraulic conductivity. Conductivity classes were estimated for PPFs predicted in the MDB Soil Land Forms.

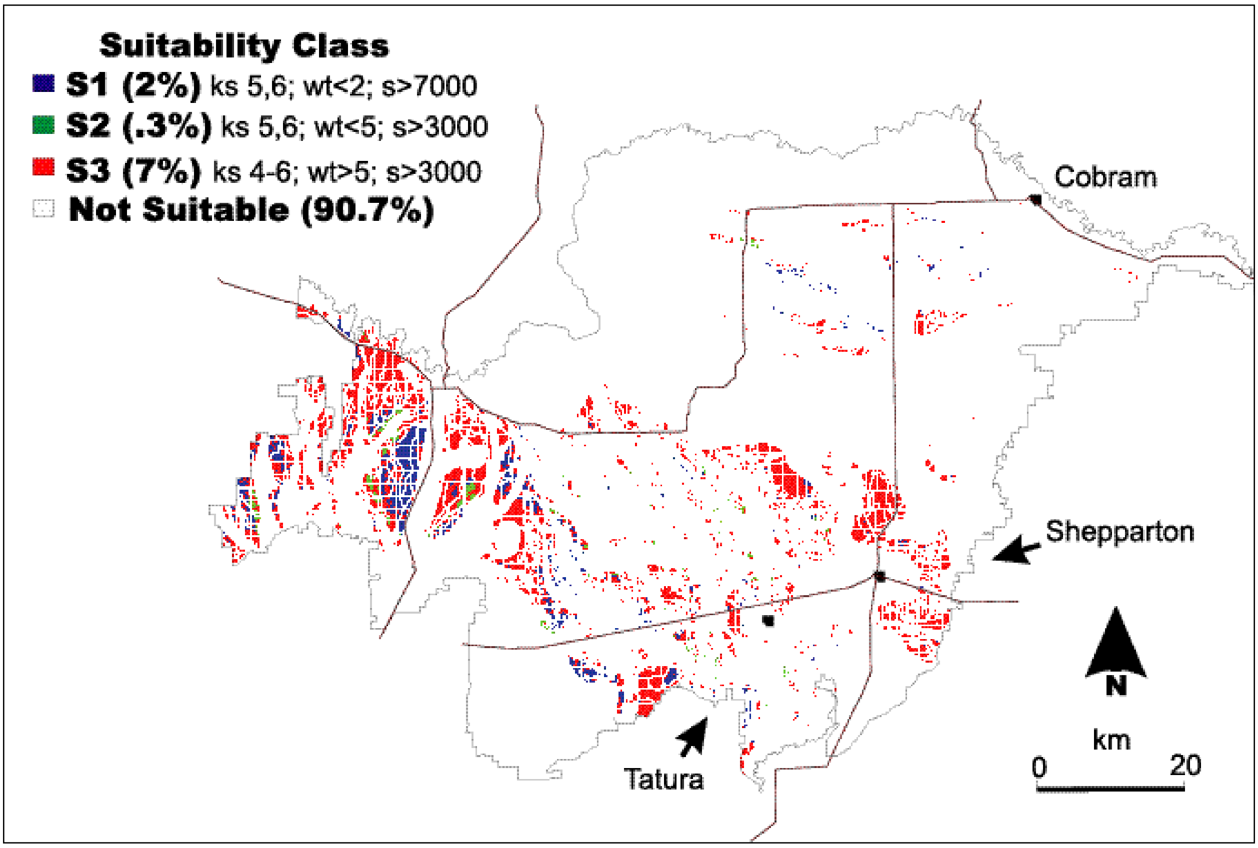

Figure 18b. Suitability of land in the SIR using the Topo250k data and the highest resolution watertable depth,salinity and soil hydraulic conductivity. Conductivity classes were derived by regrouping crop suitability groups from the 1:25,000 soils maps.

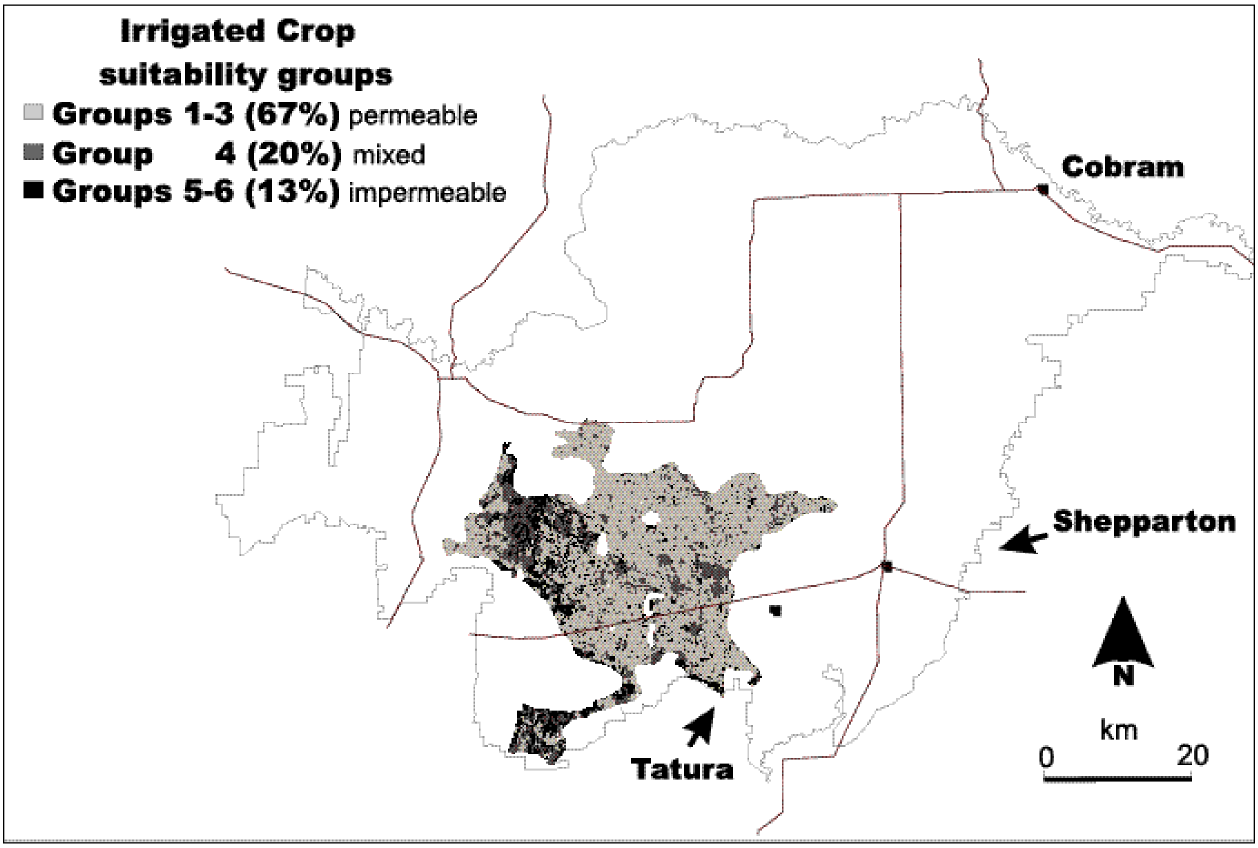

Figure 19.Irrigated crop suitability groups from the 1:25,000 soil mapping of the SIR showing the complexity within one Soil Land Form polygon. The groups have been reclassified to extract estimates of likely proportions of suitable hydraulic conductivity soils.

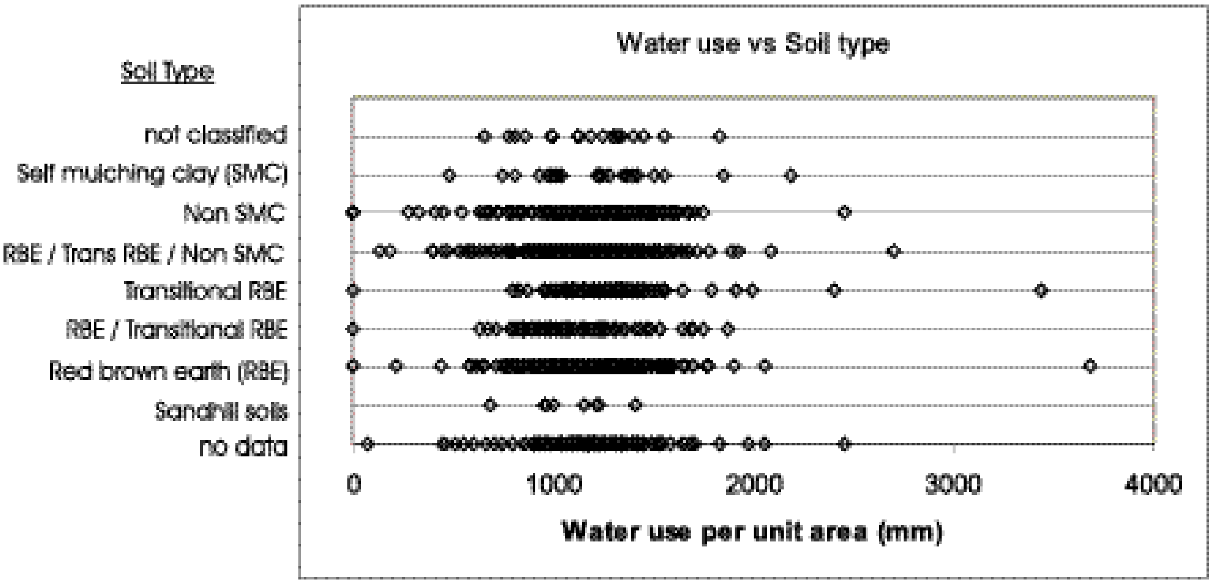

Figure 20.Correlation between rice water use and soil type is non-existent in the MIL indicating further that soil mapping is a very limited surrogate for hydraulic conductivity and leakage.

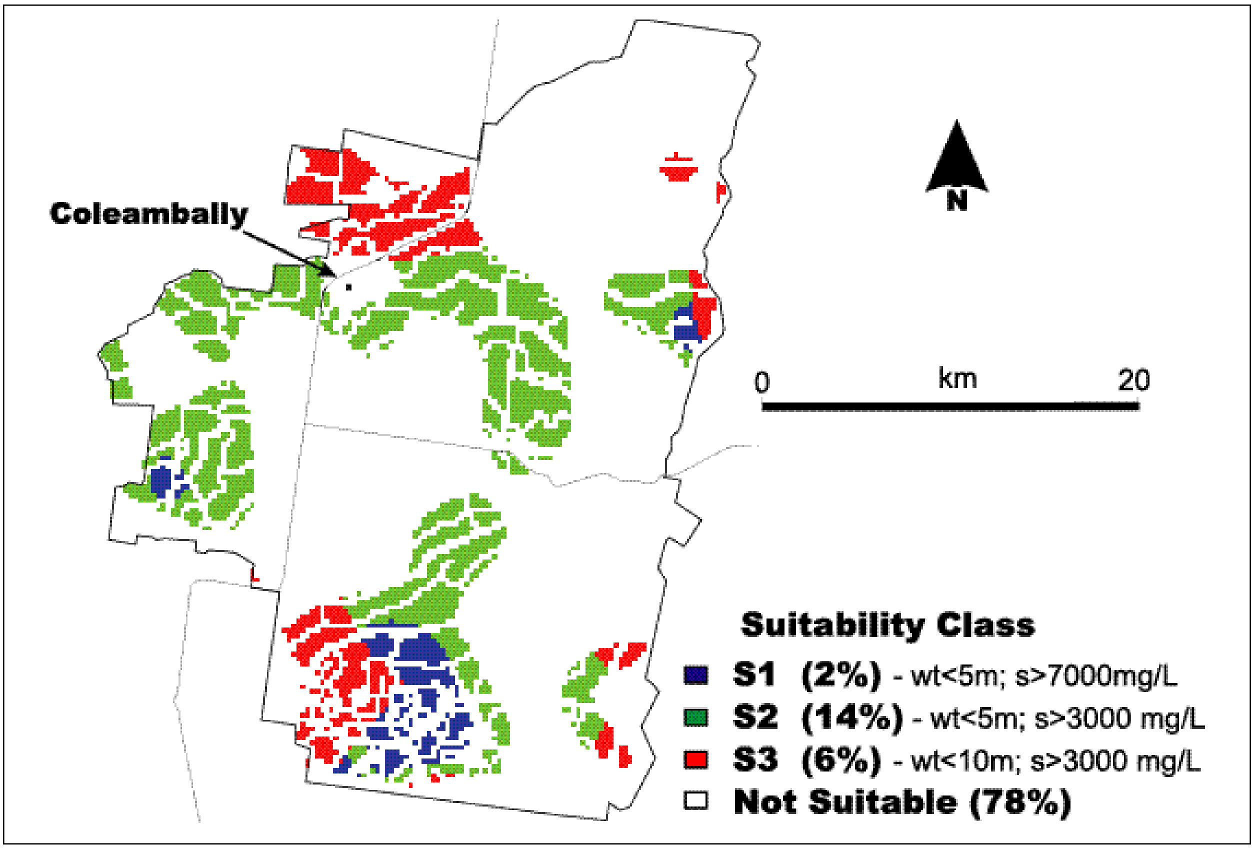

Figure 21.Suitability for the CIA based on 1:250,000 scale Topo250k, watertable depth and groundwater salinity.

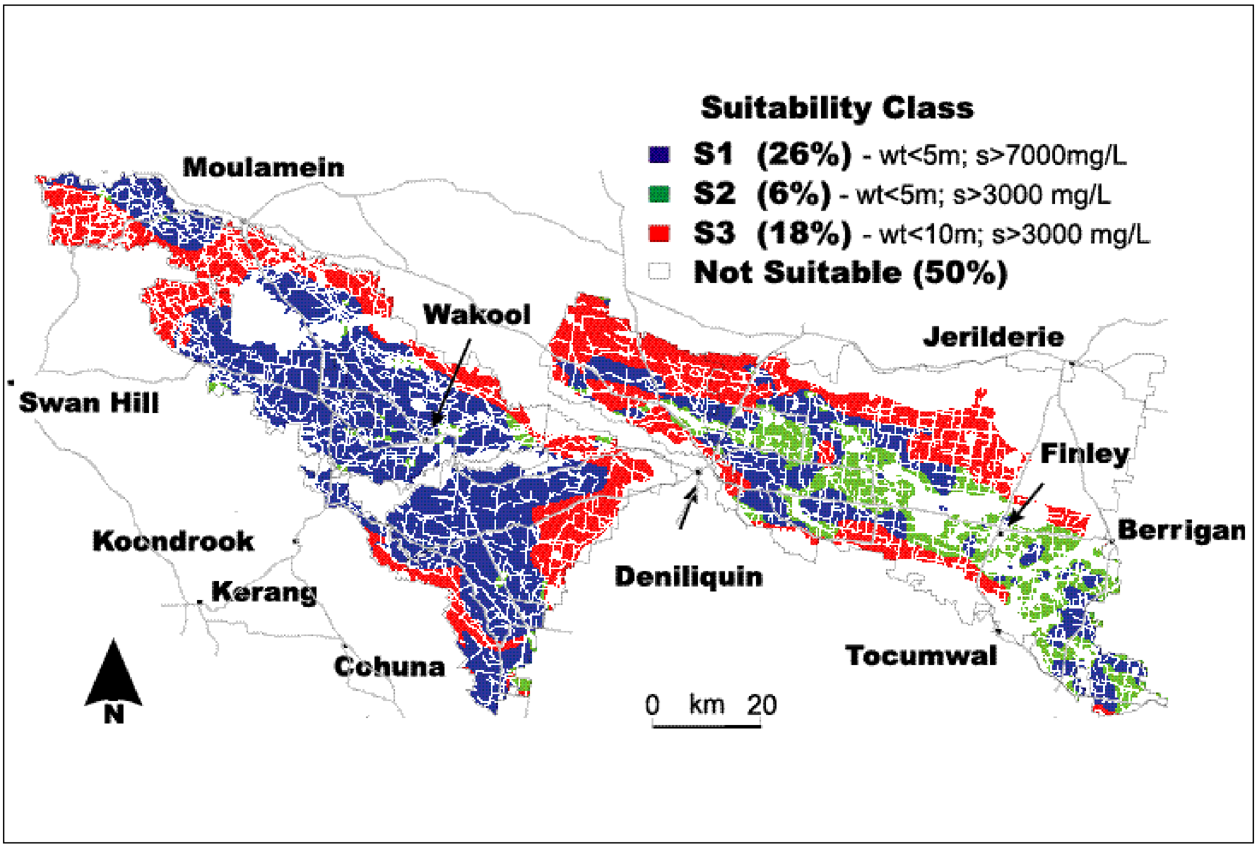

Figure 22.Suitability for the MIL based on 1:250,000 scale Topo250k, watertable depth and groundwater salinity.

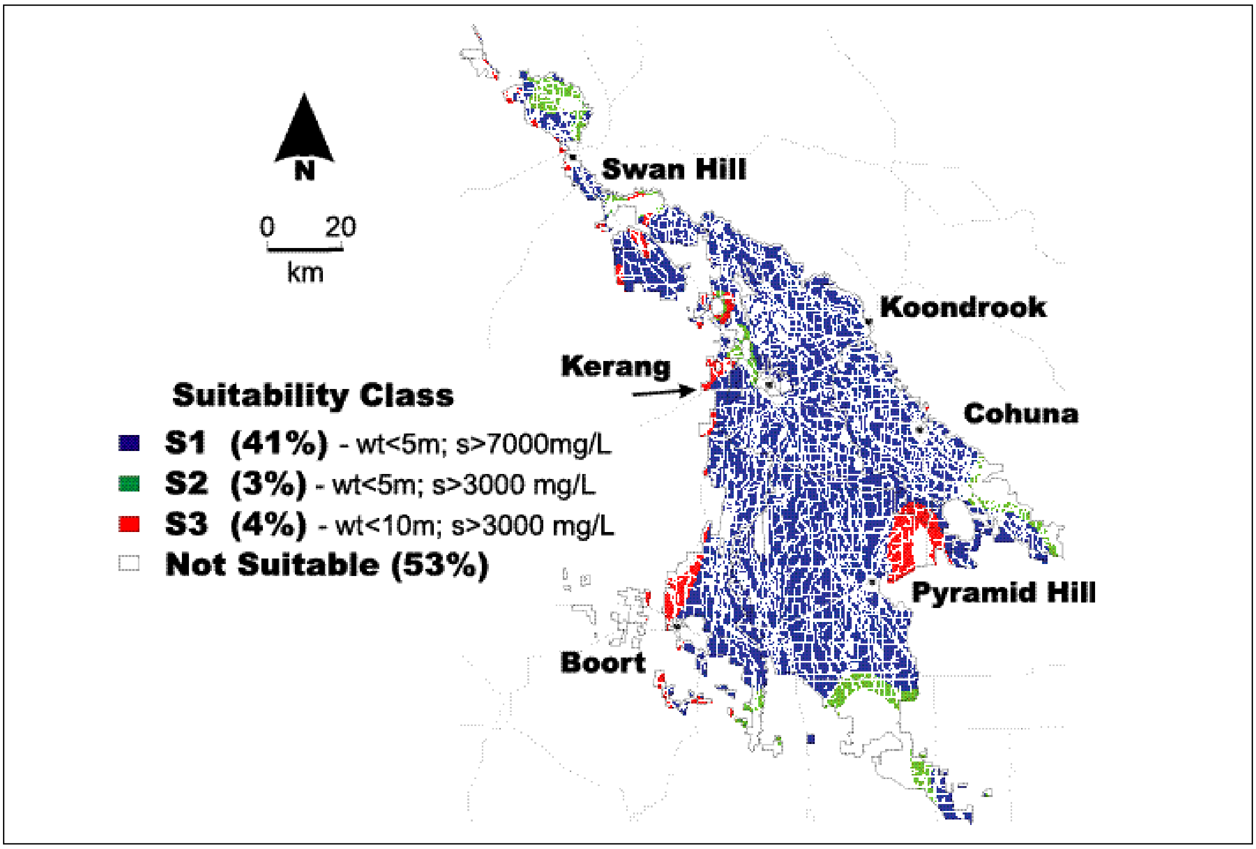

Figure 23.Suitability for the irrigation areas in the Kerang-Cohuna region based on 1:250,000 scale Topo250k, watertable depth and groundwater salinity.

Table 4. Summary of suitability for individual and combined attributes (i.e.% suitable).

Attribute	**MIA**	**SIR**	**CIA**	**MIL**	**Kerang-Cohuna**
Surface Water	82	73	70	81	70
Waterbodies	98	90	100	93	95
Built-up areas	99	97	99	99.7	98
Roads	83	76	84	85	81
Aeronautical	99	99.8	100	99.5	100
Rail	99	99	100	99	98
All Topo250k	66	48	62	64	52
Water table depth Range 1 (<5)	71	63	68	57	91
Range 2 (5-10)	5	30	28	13	6
Unsuitable (>10)	24	7	4	30	3
Groundwater salinity Range 1 (>7000)	22	14	8	67	88
Range 2 (3000-7000)	41	24	31	22	6
Unsuitable (<3000)	37	62	61	11	6
All attributes Suitability Class 1	15	5	2	26	41
Suitability Class 2	12	8	14	6	3
Suitability Class 3	1	5	6	18	3
Unsuitable	72	82	78	50	53
High Res Watertable Range 1 (<2)	30	37	-	-	-
Range 2 (2 - 4)	24	25	-	-	-
Unsuitable (>4)	46	38	-	-	-
High Res Salinity Range 1 (>7000)	23	5	-	-	-
Range 2 (3000-7000)	37	41	-	-	-
Unsuitable (<3000)	40	52	-	-	-
Soils (Ksat est.) Range 1	44	23	-	-	-
Range 2	29	26	-	-	-
Unsuitable	27	51	-	-	-
Overall High Res Suitability Class 1	2	2	-	-	-
Suitability Class 2	6	0.3	-	-	-
Suitability Class 3	15	7	-	-	-
Unsuitable	77	90.7	-	-	-

4. Discussion

4.1 Limitations of Soil and Landform Data

Leakage, both in terms of rate and impact, is the key issue in basin siting, however there is no means to directly measure this spatially. Leakage is determined primarily by soil physical factors (i.e. hydraulic conductivity) and depth to underlying groundwater (i.e. hydraulic gradient between basin water and the watertable).

A priori, it is recognised that to site a basin, detailed site investigations are required. The expectation from this work was that it was possible to broadly determine areas where there was higher probability that a suitable site could be found. This requires a level of homogeneity such that the scale of variation of soil types (i.e. its spatial correlation length) is no finer than the scale at which it is mapped. While it was also expected that the soils would be highly variable due to their alluvial origin, it was hoped that the higher resolution mapping would have been sufficient. The key tests of this assumption were:

a) **Rice water use comparison with soil type.** Given that rice is generally grown on heavier textured soils, it is reasonable to assume that these areas should be suitable for disposal basins. However, the correlation between rice water use and soil type (Figs. 5 and 20) was poor and so we conclude that rice water use is a poor surrogate for leakage. This is because of some inherent problems in the water use data: (i) water allocated to rice may in fact be used for other rice fields, even other crops; (ii) water losses due to leakage from supply channels and other breaches or accidents; (iii) variability in water management and depth to groundwater; and (iv) local climatic variability. Alternatively, leakage may not be well correlated with soil type. This is unlikely as it is well proven that leakage is related to factors including soil texture, cracking etc. Hence, we can only conclude that the poor correlation is due to the mapping itself. Even soil sampling at resolutions such as 200m (currently done for rice growing approvals in the MIL) there can still be significant variability in soil texture. The implication is that finer scale soil mapping will probably not lead to better results. There is a need to find suitable surrogates that correlate well with leakage and can be easily and cost-effectively mapped at a scale no coarser than the correlation scale of the soil variability. A remote sensing technique being trialed in the MIL uses electromagnetic induction (Hume *et al.,* 1999) and radiometric measurements may also have potential. They found that texture and chemistry (sodicity) are critical in determining leakage and is not accounted for in traditional surveys.

b) **Comparison between the low and high resolution datasets.** The low resolution soils data were of little use as there was no confidence in the spatial mapping of hydraulic conductivity. An example of this was the fact there were no estimates predicted for the lowest hydraulic conductivity class (median Ksat = 0.72mm day^{-1}) for either the MIA or SIR, even though field measurements suggest these values are common. This is not surprising given that the hydraulic conductivity look-up table was only designed to provide a general overview, since it was based on a small number of data points that were measured using a variety of techniques. As the previous section showed, even using the hydraulic conductivity to rank soils in terms of leakage was unsuccessful. With little confidence in the hydraulic conductivity look-up table, it was not possible to utilise the information on PPFs to estimate leakage.

The high resolution (1:25,000) soil land use classes developed for the SIR were based on many agricultural factors and not just soil physical characteristics.

In general the low resolution data for both the MIA and SIR compared poorly with the high resolution data. For soils, this was due as much to the mis-match of attributes measured as the differences in detail. Figure 19 illustrates both the lack of a common attribute and the high variability that is possible. For watertable depth data, patterns in the data were similar but only after the thresholds had been altered for the low resolution data (Figs. 13 and 16). This was also the case with unaltered thresholds for groundwater salinity in the MIA (Figs. 14a, 17a), although the situation was markedly different for the SIR where the data originated from completely different sources (Figs. 14b, 17b).

The preceding discussion suggests that none of the available soils data is useful. This is not strictly the case as some soil types, irrespective of resolution, are clearly unsuitable for basins. On the basis of these classifications, patches of unequivocally unsuitable soils could be used in the analysis to exclude areas for disposal basins.

4.2
Role of Higher Resolution Data

As described above, we have concluded that the higher resolution soil land form data are of limited use. In this section, we address whether there are benefits in using higher resolution watertable depth and salinity data.

The main advantage of the low resolution watertable depth data is that it is available over the entire Riverine Plain. However, it suffers a number of problems when used for disposal basin planning because it was generated from a range of data sources and has been interpreted by many people. This leads to problems such as: (i) non-uniform contouring intervals for different areas; (ii) contours often too coarse for this application (i.e. > 2m); and (iii) the data that underlies the watertable surface were not all collected at the same time and were from the late 1980's and early 1990's - watertables in many irrigation areas have changed significantly since then. Use of the high resolution data, available only for selected areas, addresses all of these problems.

Similarly, the low resolution groundwater salinity dataset has the advantage that it is available over the entire Riverine Plain, but it too suffers from variable interpretation and problems of interpolating the underlying data. As for soils, groundwater salinity can be highly spatially variable and this may not be well represented in many cases by the low resolution maps, although the spatial correlation length is likely to be larger than that of soils. Notwithstanding these concerns, it would appear that the low resolution data can be used for planning purposes as they do broadly identify areas where it may be difficult to find a suitable site. The reduced uncertainties in using higher resolution data are dependent on the nature of these data. In the MIA, the improvements in using high resolution data were marginal as the patterns were essentially the same as the low resolution data, although detail was increased. For the SIR, use of the Ife (1987) map of shallow shoestring aquifers and their salinities highlighted smaller important areas of low salinity groundwater where leakage from basins may present serious problems. There may also be differences between the MIA and SIR in how depth to good quality groundwater is defined. It would take a relatively large effort to review all bore logs to obtain a uniform interpretation. Overall, there will always be a degree of uncertainty at all scales such that detailed investigations will need to be undertaken prior to actual siting of basins.

At present, mapped Topo250k surface water features and infrastructure are the only well defined line coverage data available over the whole Riverine Plain at 1:250,000 scale. We have utilised these data with the criterion of an approximate 125m buffer defined by the grid size used for this scale (250m). Currently the Murray-Darling Basin Commission are collating all available data of this type at higher resolutions. When this data becomes available a criterion of less than 125m can be used with a finer analysis grid size. The desired criterion is dependent on soil and groundwater hydraulics and may be highly variable. It is likely that in some instances it will be less than 125m, thus necessitating the use of higher resolution data.

Similarly, Topo250k polygon data on urban settlement are only available over the whole Riverine Plain at 1:250,000 scale. We have chosen an arbitrary value of 1 km. This is essentially a community planning decision and as such will very subjective. While it is unlikely that the criterion would be less than 125m, higher resolution data will enable the representation of smaller settlements.

4.3 Application to Regional Scale Planning

In this section we describe the applicability of the analysis to regional planning in each of the irrigation areas. For both watertable depth and salinity we refer below to the use of the high resolution data.

For the SIR, shallow watertables were restricted to the irrigation areas, which suggests that basins should only be used in these areas. This is consistent with the principle that drainage should not be exported outside the area in which it is produced and rules out substantial areas (38%). Groundwater salinity is low in many of the shoestring aquifers that occupy substantial areas. If these are to be protected then large areas of the SIR may be unsuitable for basins (52%). The high density of surface water features, other infrastructure and urban settlement means that there is much fragmentation and loss of suitable areas. Results from the example using soil hydraulic conductivity of arguable quality (Fig. 18) suggests that a very small percentage (9%) is suitable for basins which has implications for policies of no salt export. Even without considering suitability based on soils, only a small percentage appears suitable for basins.

Similarly, shallow watertables in the MIA were restricted to the irrigation areas, thus ruling out a large proportion of the irrigation area (46%). In the case of groundwater salinity the situation was somewhat different in the MIA due to: (i) differences in aquifer development; (ii) differences in how sampling was carried out (in the MIA, salinity of water from all piezometers less than 15m deep was utilised, whereas in the SIR, Ife (1987) targeted only the shoestring aquifers themselves); and (iii) the variable density of piezometers. For these reasons, the salinity data are very smooth and suggest that a reasonable proportion (40 %) of the catchment is unsuitable on the basis of groundwater salinity.

The Kerang-Cohuna and MIL areas contrast with the MIA and SIR in that much higher fractions appear to be most suitable for disposal basins (41% and 26% respectively), while the CIA is the lowest of all in that only 2% are in the most suitable class. The reason for this difference appears to be groundwater salinity. For Kerang-Cohuna and MIL, 88% and 67% of the area overlie groundwater of salinity of more than 7000 mg/L, while this is only the case for 8%, 14% and 22% for the CIA, SIR and MIA respectively. While, as mentioned earlier, the numbers themselves may be queried, the overall trend and the magnitude of the trend are real. Thus, we believe the analysis is identifying important differences between the irrigation areas.

The results for all irrigation areas raise questions as to the type of local basin that can be used to store drainage water. For on-farm basins to be widely used it would be necessary for suitable land to be available everywhere in the area where irrigation is carried out. Irrespective of the criteria thresholds used, this is clearly not the case in both the MIA and SIR and CIA. Thus, on-farm basins can only be opportunistically used in these areas, but widely across Kerang-Cohuna and MIL. Conversely, community basins can be used anywhere in the catchment where suitable land is available. However, the cost of purchasing good quality land and the costs of transporting water significant distances will be important considerations.

There is also another question as to whether there is enough suitable land overall in each of the catchments to store all of the drainage water produced. Other studies suggest that in the absence of water re-use and other concentration schemes, around 10% of irrigated land will be required to achieve a salt and water balance in an irrigation area without exporting drainage water. The results of this study suggest that, even without using soil information, only 5-15% of both the MIA and SIR appear suitable for basins. It is likely that if soil hydraulic conductivity, and other criteria such as land value, land availability and farm size (proximity to cadastral boundaries) is incorporated, even less than this will actually be available. This means that it may be difficult to find enough area within each of the areas to dispose of all of the drainage water in either on-farm or community basins. This implies that we need to either relax our suitability criteria, or use regional basins.

4.4 Assessment of Overall Suitability

As can be seen above, the analysis can provide useful information, despite the limitations in the data. It should be emphasised that the data is only suitable for broad-scale analysis. They are unable to provide exact details on where basins can be sited, and will never replace detailed site investigations to determine suitable locations for a new basin. It is also important to recognise that because of the large uncertainties in the data, the total areas suitable for basins cannot be known accurately.

There are two issues being addressed in this report. The first is the variation within and between irrigation areas in the opportunity for storing disposal water and hence the fraction that may need to be exported. The second is the focussing of efforts for site investigation into those areas with greatest probability of success. The methodology, as shown above, is useful for these.

The authors argue that the process is in itself as useful as the final map. In the methodology, the steps include determination of relevant criteria, determination of thresholds, acquisition of suitable data, revision of thresholds, combination of overlays and iterations of these steps. Inevitably, the process leads to: careful scrutiny of the data, and perhaps updating datasets; discussion of optimal thresholds and the need for balance between sustainability and availability of land; assessment of overall disposal needs; assessment of balance between storage within irrigation areas and salt export; and focussing on those areas which are deemed suitable.

The overall methodology is simple and transferable to irrigation boards and community groups. Generally, the best data resides within the regions and can improve the analysis. These groups need to determine the volume of drainage water and ways to minimise it as part of the land and water management planning process. The decisions on allowable thresholds affects the amount of land available within the irrigation areas. Hence, there needs to be a balance between the environmental consequences of exporting the salt as opposed to those from storing within the irrigation area. Finally, there are a number of local concerns such as aesthetics and urban planning that may add further constraints to those used here.

5. Conclusions

This study develops a GIS based suitability analysis aimed at regional planning for storing drainage water in local disposal basins. The analysis uses criteria based on sustainability and the impacts of basins on human and other activities. The limiting factor in this kind of analysis is the availability of relevant, reliable and accurate data. Deficiencies were found in both regional and higher resolution data, which impacted on the analysis itself, and on its validation. Also, we have made some tentative decisions on threshold values. These were based on both data quality and experience of the researchers. In reality these decisions need to be made by the community. It is emphasised that for any basins, detailed site investigations will always be required.

More specific conclusions on the analysis method include:

1. There is no satisfactory method of incorporating soils data for determining areas suitable for basins on the basis of leakage. However, they can be used to exclude areas that are unequivocally unsuitable. Attempts at using surrogates such as rice water use were unsuccessful.
2. Higher resolution watertable and salinity data provided more detailed information, but covered smaller, often incomplete areas. When comparing regions, care must be taken because of variations in attributes, interpretations and methods used in local mapping.

Despite the above limitations however, the implications for the case study areas are:

3. On-farm basins can only be used on an opportunistic basis for the eastern irrigation areas such as SIR, MIA and CIA, if the chosen environmental criteria are to be satisfied. For the westerly irrigation areas such as Kerang-Cohuna and MIL, there is much more opportunity for on-farm basins, mainly due to the shallow saline groundwater underlying these irrigation areas.
4. Conversely, community basins can be used anywhere where suitable land is available. However, the cost of purchasing good quality land and the costs of transporting water significant distances will be important considerations.
5. Overall, the results raise serious questions as to whether there is enough suitable land in the easterly irrigation areas to dispose of all of the drainage water produced.

In summary, despite the data limitations, this GIS based method does appear to be a suitable tool for regional scale planning, and could be used by catchment groups and irrigation boards. The process encourages scrutinisation of data; assessment of criteria and thresholds and their importance in balancing environmental requirements and the overall land suitability; and assessment of overall disposal needs.

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Appendices

Appendix 1: AML's for Processing Datasets

AML's used to process datasets for use in the analysis are recorded here. Essentially it is a collection of AML's that record the sequence of processing in an AML style. Not many were run as AMLs but were created as documentation of the method and cut and pasted into Arc sessions as required. Some datatsets are recorded here, despite not being used in the actual suitability analysis, because they were investigated for applicability and/or used in comparisons with other datasets. A limited attempt was made to generalise the directory structure using unix environment variables.

State Rivers and Water Supply Commission, Victoria (1978) Shepparton Region Drainage and the Lake Tyrrell Scheme Part 1, State Rivers and Water Supply Commission, Melbourne.

```
/*******************************
/* REGIONAL SCALE DATASETS: *
/*******************************

/*
/* BOUNDARIES AND EXTENTS:
/*****************************

 Workspace:      $EVAP/..

/*Map extents were defined as lat long and converted to UTM working base:
/* using the projection defined in $EVAP/ll_utm55s.prj:

/* input
/* Projection GEOGRAPHIC
/* Units DD
/* Spheroid CLARKE1866
/* Parameters
/* output
/* projection utm
/* units meters
/* zone 55
/* spheroid australiann
/* yshift   10000000
/* parameters
/* end


/* Bounding / clip covers (long/lat and projected coords):
/*MIA_BOX                    145.100              -34.800              146.600              -33.900
```

```
/*MIA_BOX_UTM          324321.438        6147477.500        463411.062        6248846.500

/*SIR_BOX          144.243      -36.887     146.141       -35.570
/*SIR_BOX_UTM    250181.469   5914485.500  423446.156   6063071.500

/*MIL_BOX          143.500      -36.000     146.000       -35.000
/*MIL_BOX_UTM    180549.578   6010369.500  409870.625   6126486.500


/* map boundaries also obtained and used for clipping:
/*MIABNDRY
/*SIRBNDRY
/*MILBNDRY



/*GRIDS:
/* DEMS were 1st clipped but not used in this analysis.
/* They were the default windows used for setting windows and cellsizes.

/*DEMUTM_MIA   324320.876   6147477.351  463320.876   6248727.351
/*DEMUTM_SIR   250098.579   5914042.236  423348.579   6063292.236



/* PROCESSING OF CLIP COVERS AND GRIDS:
/*meth_gen.aml
&work $EVAP/..

setwindow $EVAP/DEMUTM_MIA
setcell $EVAP/DEMUTM_MIA
miapolgrd = polygrid( MIABNDRY )
miabin = con ( isnull( miapolgrd ), 0, 1 )
setwindow maxof

setwindow $EVAP/DEMUTM_SIR
setcell $EVAP/DEMUTM_SIR
SIRpolgrd = polygrid( SIRBNDRY )
SIRbin = con ( isnull( SIRpolgrd ), 0, 1 )
setwindow maxof



/*DEMs:
/*******

/* Processing of DEMs was halted when it became apparent that
/* there were problems.  AMLs are included for reference.
/* DEMs may be useful when the revised version of the AUSLIG 9
/* second DEM is released.

SI55MIACLP = SELECTPOLYGON(../mdbc/si55, ../mia_box)
DEMUTM_MIA = project (si55miaclp, $PROJ/ll_utm55s.prj, bilinear, 250)

SJ55SIRCLP = SELECTPOLYGON(../mdbc/sj55, ../sir_box)
SI55SIRCLP = SELECTPOLYGON(../mdbc/si55, ../sir_box)
```

```
SIRCLP = mosaic ( SI55SIRCLP, SJ55SIRCLP )
DEMUTM_SIR = project ( sirclp, $PROJ/ll_utm55s.prj, bilinear, 250 )




/*SOILS:
/*******

/* Soils were not used in calculating actual suitability classes
/* however, with more work useful results may be derived using SLF
/* classes directly or the Ksat classes from the interpretation
/* look-up table.

/* METHOD_SOILS.AML
/* the procedure used to process the soil data and lookup tables
/* to derive permeability (in theory for anywhere in the MDB)

/* Written: 25.2.99 T.I.Dowling
/*                        CSIRO, Land and Water, Canberra
/* Last Modified: 27.04.99 ...tid - incorporate Neil McKenzies 2nd
/*                                    version of interppf.lut to derive Ks.
/*                                    Required duplication for A and B horizons


arc project cover ../../mia_box mia_box_lam $PROJ/ll_lam146_tid.prj
arc clip $HOM5/mdbsoils_250000/covers/MDB_SLF mia_box_lam ~
     MDB_SLF_mia poly
arc project cover MDB_SLF_MIA SLFUTM_mia ../lam146_utm55s.prj

arc project cover ../../sir_box sir_box_lam $PROJ/ll_lam146_tid.prj
arc clip $HOME/mdbsoils_250000/covers/MDB_SLF sir_box_lam ~
     MDB_SLF_sir poly
arc project cover MDB_SLF_SIR SLFUTM_sir ../lam146_utm55s.prj

/* Get clipped polygon cover although 1st time round work on the mia/sir boxes

arc clip SLFUTM_MIA $EVAP/../MIABNDRY SLFUTM_MIAC
arc clip SLFUTM_sir $EVAP/../sirBNDRY SLFUTM_SIRC

/* for mapping soil class - shadeset provided with SLF dataset.
shadeset slf.shd
polygonshades SLFUTM_SIRC class
polygonshades SLFUTM_miac class
labeltext SLFUTM_SIRC SLFUTM_SIRC-id # ll
labeltext SLFUTM_miaC SLFUTM_miac-id # ll

/* Version 2 of interppf.aml
/* 1 get excel version, has : ppf ksa ksaerror ksb ksberror reliability
/* 2. strip headers -> tmp
/* 3. dos2unix tmp interppf2v0.csv
/* 4. awk -f addquotes.awk < interppf2v0.csv   (creates interppf2v1.csv)
/* 5. make define and fill lut in info

arc tables
define interppf2v0.lut
```

```
ppf,10,10,c
ksa,5,5,i
ksaerror,5,5,i
ksb,5,5,i
ksberror,5,5,i
reliability,5,5,i

add ppf,ksa,ksaerror,ksb,ksberror,reliability from interppf2v1.csv
q

/* add ppfs in soil landforms map that don’t exist in interppf2v0.lut
/* obtained from Neil McKenzie

/* NOTE - the last one containing the special value ‘98’ is required where no ppf has
/* been predicted so that a large positive value is present.  This allows simpler
/* reselecting of the minimum Ksat’s.
/* where there were non matches in the lut for bui predicted ppf’s they were
/* obtained from McKenzie and added as follows (note spaces were added as in
/* Db2 became Db 2 etc):

arc tables
sel interppf2v0.lut
add
‘Db 2’,7,2,5,3,3
‘Dr 2’,7,3,6,3,3
‘Dr 5.2’,8,2,6,2,3
‘Dy’,7,4,5,4,3
‘Gn’,8,3,6,4,3
‘Gn 1’,8,3,7,3,3
‘Gn 2’,8,3,6,3,3
‘Uc’,9,2,8,3,3
‘Uc 1’,9,2,0,0,3
‘Uc 1.24’,9,2,0,0,3
‘Uc 4’,8,3,7,3,3
‘Uf’,6,4,6,3,3
‘Ug’,3,3,2,3,3
‘Ug 5.36’,4,4,3,2,3
‘Um’,7,4,7,3,3
‘Um 4.13’,8,3,0,0,3
‘ ‘,98,98,98,98,98

q


/* add (or restore if already exists) relates to interppf2v0.lut
/*(copyinfo’d interppf.lut and modified one line with that in it to interppf2v0.lut)

/*create Ksat grids for each ppf of bui
setwindow$EVAP/DEMUTM_MIA
setcell $EVAP/DEMUTM_MIA

KSA1_MIA = polygrid ( SLFUTM_MIA, PPF1_REL//KSA )
KSA2_MIA = polygrid ( SLFUTM_MIA, PPF2_REL//KSA )
KSA3_MIA = polygrid ( SLFUTM_MIA, PPF3_REL//KSA )

KSb1_MIA = polygrid ( SLFUTM_MIA, PPF1_REL//KSb )
```

```
KSb2_MIA = polygrid ( SLFUTM_MIA, PPF2_REL//KSb )
KSb3_MIA = polygrid ( SLFUTM_MIA, PPF3_REL//KSb )

KSaavg_MIA = ((pct1_mia / 100.) * ksa1_mia) + ((pct2_mia / 100.) * ksa2_mia )
+ ((pct3_mia / 100.) * ksa3_mia )

KSbavg_MIA = ((pct1_mia / 100.) * ksb1_mia) + ((pct2_mia / 100.) * ksb2_mia )
+ ((pct3_mia / 100.) * ksb3_mia )

setwindow $EVAP/DEMUTM_SIR
setcell $EVAP/DEMUTM_SIR

KSA1_SIR = polygrid ( SLFUTM_sir, PPF1_REL//KSA )
KSA2_SIR = polygrid ( SLFUTM_sir, PPF2_REL//KSA )
KSA3_SIR = polygrid ( SLFUTM_sir, PPF3_REL//KSA )

KSb1_SIR = polygrid ( SLFUTM_sir, PPF1_REL//KSb )
KSb2_SIR = polygrid ( SLFUTM_sir, PPF2_REL//KSb )
KSb3_SIR = polygrid ( SLFUTM_sir, PPF3_REL//KSb )

KSaavg_SIR = ((pct1_sir / 100.) * ksa1_sir ) + ((pct2_sir / 100.) * ksa2_sir )
 + ((pct3_sir / 100.) * ksa3_sir )

KSbavg_SIR = ((pct1_sir / 100.) * ksb1_sir ) + ((pct2_sir / 100.) * ksb2_sir )
 + ((pct3_sir / 100.) * ksb3_sir )

setwindow maxof

/* relate restore interppf2v0.rel if not already done
/* &R ADD_KS.AML (inserted below) for each cover name to:
/* 1. change missing values in McKenzie lookup to a large special value
/* 2. get lowest Ksat for A and B horizons where they exist
/* 3. get the percentage area they cover.

&r ADD_KS SLFutm_MIA
&r ADD_KS SLFutm_SIR

/* THEN RETURN TO HERE TO GRID THEM UP

setwindow $EVAP/DEMUTM_MIA
setcell $EVAP/DEMUTM_MIA

LOWKSa_MIA = polygrid ( SLFutm_MIA, LOWEST_KSa )
LOWKSb_MIA = polygrid ( SLFutm_MIA, LOWEST_KSb )
LOWEST_KS_MIA = min ( LOWKSa_MIA, LOWKSb_MIA )
pctLOWa_MIA = polygrid ( SLFutm_MIA, pct_LOW_a )
pctLOWb_MIA = polygrid ( SLFutm_MIA, pct_LOW_b )

setwindow $EVAP/DEMUTM_SIR
setcell $EVAP/DEMUTM_SIR

LOWKSa_SIR = polygrid ( SLFutm_sir, LOWEST_KSa )
LOWKSb_SIR = polygrid ( SLFutm_sir, LOWEST_KSb )
LOWEST_KS_SIR = min ( LOWKSa_SIR, LOWKSb_SIR )
pctLOWa_SIR = polygrid ( SLFutm_SIR, pct_LOW_a )
pctLOWb_SIR = polygrid ( SLFutm_SIR, pct_LOW_b )
```

```
setwindow maxof

/* N.B.  Because the lowest Ks can be variable percentage of the soil landform
/* polygon we need to take the percentage area into account with an accompanying
/* map of the probability of finding that Ks in the poly.

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

/* ADD_KS.AML
/* find the percentage area with the minimum Ksat
/* run once for each area from grid changing %covname% below

/* Lastmodified: 28.04.99 ...tid - added error bars and reliability classes

&args covname
&ty processing lowest Ksat's for cover %covname%

/* choices in this analysis are:
/* &sv covname = SLFutm_MIA
/* &sv covname = SLFutm_SIR

/* need to comment these out if re-running the aml on the same cover for any reason
/* or put in the appropriate checks for existence of the items ...

arc additem %covname%.pat %covname%.pat lowest_ksa 2 2 i
arc additem %covname%.pat %covname%.pat lowest_ksb 2 2 i
arc additem %covname%.pat %covname%.pat pct_low_a 4 4 i
arc additem %covname%.pat %covname%.pat pct_low_b 4 4 i

/* error and reliability items
arc additem %covname%.pat %covname%.pat low_Ksa_err1 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksa_err2 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksa_err3 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_err1 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_err2 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_err3 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksa_rel1 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksa_rel2 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksa_rel3 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_rel1 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_rel2 2 2 i
arc additem %covname%.pat %covname%.pat low_Ksb_rel3 2 2 i


/* Need to eliminate 0 (bad) values by assigning them very large numbers

arc tables

/* the case where bui doesn't predict a ppf2 or ppf3 (i.e. blank) returns
/* a zero as undefined value.  This was dealt with by adding a ' ' ppf to
/* interpppf2v0.lut with special value of 98, bigger than any real class

/* the other case is where McKenzie has 0's as special values for missing data.
/* These classes are changed to ksats of 99, i.e. , bigger than any real class
/* to make finding the minimum much simpler.
```

```
sel %covname%.pat

resel ppf1_rel//ksa eq 0
calc ppf1_rel//ksa = 99
asel
resel ppf1_rel//ksb eq 0
calc ppf1_rel//ksb = 99
asel

resel ppf2_rel//ksa eq 0
calc ppf2_rel//ksa = 99
asel
resel ppf2_rel//ksb eq 0
calc ppf2_rel//ksb = 99
asel

resel ppf3_rel//ksa eq 0
calc ppf3_rel//ksa = 99
asel
resel ppf3_rel//ksb eq 0
calc ppf3_rel//ksb = 99
asel


/* Ks1 lowest
asel
resel PPF1_REL//ksa lt PPF2_REL//ksa and PPF1_REL//ksa lt PPF3_REL//ksa
calc LOWEST_KSa = PPF1_REL//ksa
calc pct_low_a = PERCENT1
calc low_Ksa_err1 =  PPF1_REL//ksaerror
calc low_Ksa_err2 =  0
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF1_REL//reliability
calc low_Ksa_rel2 =  0
calc low_Ksa_rel3 =  0
asel
resel PPF1_REL//ksb lt PPF2_REL//ksb and PPF1_REL//ksb lt PPF3_REL//ksb
calc LOWEST_KSb = PPF1_REL//ksb
calc pct_low_b = PERCENT1
calc low_Ksb_err1 =  PPF1_REL//ksberror
calc low_Ksb_err2 =  0
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF1_REL//reliability
calc low_Ksb_rel2 =  0
calc low_Ksb_rel3 =  0

/* Ks2 lowest
asel
resel PPF2_REL//ksa lt PPF1_REL//ksa and PPF2_REL//ksa lt PPF3_REL//ksa
calc LOWEST_KSa = PPF2_REL//ksa
calc pct_low_a = PERCENT2
calc low_Ksa_err1 =  PPF2_REL//ksaerror
calc low_Ksa_err2 =  0
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF2_REL//reliability
```

```
calc low_Ksa_rel2 =  0
calc low_Ksa_rel3 =  0
asel
resel PPF2_REL//ksb lt PPF1_REL//ksb and PPF2_REL//ksb lt PPF3_REL//ksb
calc LOWEST_KSb = PPF2_REL//ksb
calc pct_low_b = PERCENT2
calc low_Ksb_err1 =  PPF2_REL//ksberror
calc low_Ksb_err2 =  0
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF2_REL//reliability
calc low_Ksb_rel2 =  0
calc low_Ksb_rel3 =  0

/* Ks3 lowest
asel
resel PPF3_REL//ksa lt PPF1_REL//ksa and PPF3_REL//ksa lt PPF2_REL//ksa
calc LOWEST_KSa = PPF3_REL//ksa
calc pct_low_a = PERCENT3
calc low_Ksa_err1 =  PPF3_REL//ksaerror
calc low_Ksa_err2 =  0
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF3_REL//reliability
calc low_Ksa_rel2 =  0
calc low_Ksa_rel3 =  0
asel
resel PPF3_REL//ksb lt PPF1_REL//ksb and PPF3_REL//ksb lt PPF2_REL//ksb
calc LOWEST_KSb = PPF3_REL//ksb
calc pct_low_b = PERCENT3
calc low_Ksb_err1 =  PPF3_REL//ksberror
calc low_Ksb_err2 =  0
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF3_REL//reliability
calc low_Ksb_rel2 =  0
calc low_Ksb_rel3 =  0

/* ALL SAME ie lowest
asel
resel PPF1_REL//ksa eq PPF2_REL//ksa and PPF2_REL//ksa eq PPF3_REL//ksa
calc LOWEST_KSa = PPF1_REL//ksa
calc pct_low_a = PERCENT1 + PERCENT2 + PERCENT3
calc low_Ksa_err1 =  PPF1_REL//ksaerror
calc low_Ksa_err2 =  PPF2_REL//ksaerror
calc low_Ksa_err3 =  PPF3_REL//ksaerror
calc low_Ksa_rel1 = PPF1_REL//reliability
calc low_Ksa_rel2 = PPF2_REL//reliability
calc low_Ksa_rel3 = PPF3_REL//reliability
asel
resel PPF1_REL//ksb eq PPF2_REL//ksb and PPF2_REL//ksb eq PPF3_REL//ksb
calc LOWEST_KSb = PPF1_REL//ksb
calc pct_low_b = PERCENT1 + PERCENT2 + PERCENT3
calc low_Ksb_err1 =  PPF1_REL//ksberror
calc low_Ksb_err2 =  PPF2_REL//ksberror
calc low_Ksb_err3 =  PPF3_REL//ksberror
calc low_Ksb_rel1 = PPF1_REL//reliability
calc low_Ksb_rel2 = PPF2_REL//reliability
calc low_Ksb_rel3 = PPF3_REL//reliability
```

```
/* Ks1 and Ks2 SAME and lowest
asel
resel PPF1_REL//ksa eq PPF2_REL//ksa and PPF1_REL//ksa lt PPF3_REL//ksa
calc LOWEST_KSa = PPF1_REL//ksa
calc pct_low_a = PERCENT1 + PERCENT2
calc low_Ksa_err1 =  PPF1_REL//ksaerror
calc low_Ksa_err2 =  PPF2_REL//ksaerror
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF1_REL//reliability
calc low_Ksa_rel2 = PPF2_REL//reliability
calc low_Ksa_rel3 = 0
asel
resel PPF1_REL//ksb eq PPF2_REL//ksb and PPF1_REL//ksb lt PPF3_REL//ksb
calc LOWEST_KSb = PPF1_REL//ksb
calc pct_low_b = PERCENT1 + PERCENT2
calc low_Ksb_err1 =  PPF1_REL//ksberror
calc low_Ksb_err2 =  PPF2_REL//ksberror
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF1_REL//reliability
calc low_Ksb_rel2 = PPF2_REL//reliability
calc low_Ksb_rel3 = 0

/* Ks1 and Ks3 SAME and lowest
asel
resel PPF1_REL//ksa eq PPF3_REL//ksa and PPF1_REL//ksa lt PPF2_REL//ksa
calc LOWEST_KSa = PPF1_REL//ksa
calc pct_low_a = PERCENT1 + PERCENT3
calc low_Ksa_err1 =  PPF1_REL//ksaerror
calc low_Ksa_err2 =  PPF3_REL//ksaerror
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF1_REL//reliability
calc low_Ksa_rel2 = PPF3_REL//reliability
calc low_Ksa_rel3 = 0
asel
resel PPF1_REL//ksb eq PPF3_REL//ksb and PPF1_REL//ksb lt PPF2_REL//ksb
calc LOWEST_KSb = PPF1_REL//ksb
calc pct_low_b = PERCENT1 + PERCENT3
calc low_Ksb_err1 =  PPF1_REL//ksberror
calc low_Ksb_err2 =  PPF3_REL//ksberror
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF1_REL//reliability
calc low_Ksb_rel2 = PPF3_REL//reliability
calc low_Ksb_rel3 = 0

/* Ks2 and Ks3 SAME and lowest
asel
resel PPF2_REL//ksa eq PPF3_REL//ksa and PPF2_REL//ksa lt PPF1_REL//ksa
calc LOWEST_KSa = PPF2_REL//ksa
calc pct_low_a = PERCENT2 + PERCENT3
calc low_Ksa_err1 =  PPF2_REL//ksaerror
calc low_Ksa_err2 =  PPF3_REL//ksaerror
calc low_Ksa_err3 =  0
calc low_Ksa_rel1 = PPF2_REL//reliability
calc low_Ksa_rel2 = PPF3_REL//reliability
calc low_Ksa_rel3 = 0
```

```
asel
resel PPF2_REL//ksb eq PPF3_REL//ksb and PPF2_REL//ksb lt PPF1_REL//ksb
calc LOWEST_KSb = PPF2_REL//ksb
calc pct_low_b = PERCENT2 + PERCENT3
calc low_Ksb_err1 =  PPF2_REL//ksberror
calc low_Ksb_err2 =  PPF3_REL//ksberror
calc low_Ksb_err3 =  0
calc low_Ksb_rel1 = PPF2_REL//reliability
calc low_Ksb_rel2 = PPF3_REL//reliability
calc low_Ksb_rel3 = 0

q

&return GAME OVER


/*********************
/* TOPO250K THEMES: *
/*********************

/* TOWNS:
/* ————————

/* meth_auslig.aml
&work $EVAP/..auslig250k
arc generate map250nam_ll
points
1,144.75,-33.50
2,146.25,-33.50
3,144.75,-34.50
4,146.25,-34.50
5,144.75,-35.50
6,146.25,-35.50
7,144.75,-36.50
8,146.25,-36.50
end
q
arc build map250nam_ll point
arc additem map250nam_ll.pat map250nam_ll.pat name 10 10 c
arc tables
sel MAP250NAM_LL.pat

resel MAP250NAM_LL-id eq 1
calc name = ‘Booligal’
nsel
resel MAP250NAM_LL-id eq 2
calc name = ‘Cargelligo’
nsel
resel MAP250NAM_LL-id eq 3
calc name = ‘Hay’
nsel
resel MAP250NAM_LL-id eq 4
calc name = ‘Narrandera’
nsel
resel MAP250NAM_LL-id eq 5
calc name = ‘Deniliquin’
```

```
nsel
resel MAP250NAM_LL-id eq 6
calc name = ‘Jerilderie’
nsel
resel MAP250NAM_LL-id eq 7
calc name = ‘Bendigo’
nsel
resel MAP250NAM_LL-id eq 8
calc name = ‘Wangaratta’
/*asel
/*list
q

arc project cover map250nam_ll map250nam_tm $EVAP/ll_utm55s.prj



/* BUILT UP AREAS:
/* ————————————————-

mape DGDTMMIA DGDTMSIR
arc clean BGDTM BGDTMcln # .0001 poly

arc buffer BGDTMcln BGDTMbuf # # 1000 # poly
setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
BGDTMbufmia = polygrid ( BGDTMbuf )
BGDTMbufmiac = con ( isnull(BGDTMbufmia) and ../miaGRD gt 0, 0, con ( ../MIAGR
D gt 0, BGDTMbufmia ))

setwindow ../DEMUTM_sir
setcell ../DEMUTM_sir
BGDTMbufsir = polygrid ( BGDTMbuf )
BGDTMbufsirc = con ( isnull(BGDTMbufsir) and ../sirGRD gt 0, 0, con ( ../sirGR
D gt 0, BGDTMbufsir ))



/* SURFACE WATER FEATURES:
/*——————————————————————————————

setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
dgd250mia = linegrid ( DGDTMMIA )
dgd250miac = con ( isnull(DGD250mia) and ../miaGRD gt 0, 0, con ( ../MIAGRD gt 0, dgd250mia ))
setcell 100
dgd100mia = polygrid ( DGDTMMIA )
dgd100miac = con ( ../MIAGRD gt 0, dgd100mia, 0 )
dgd100miac = con ( isnull(DGD100mia) and ../miaGRD gt 0, 0, con ( ../MIAGRD gt 0, dgd100mia ))
setcell 50
dgd50mia = linegrid ( DGDTMMIA )
dgd50miac = con ( ../MIAGRD gt 0, dgd50mia, 0 )
dgd50miac = con ( isnull(DGD50mia) and ../miaGRD gt 0, 0, con ( ../MIAGRD gt 0, dgd50mia ))

setwindow ../DEMUTM_sir
setcell 250
```

```
dgd250sir = linegrid ( DGDTMsir )
dgd250sirc = con ( isnull(DGD250sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, dgd250sir ))
setcell 100
dgd100sir = linegrid ( DGDTMsir )
dgd100sirc = con ( ../sirGRD gt 0, dgd100sir, 0 )
dgd100sirc = con ( isnull(DGD100sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, dgd100sir ))
setcell 50
dgd50sir = linegrid ( DGDTMsir )
dgd50sirc = con ( ../sirGRD gt 0, dgd50sir, 0 )
dgd50sirc = con ( isnull(DGD50sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, dgd50sir ))



/* AERONAUTICAL:
/* ————————————————-

buffer AGDTM  AGDTMbuf # # 1000 # point

setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
agdbufmia = polygrid ( AGDTMBUF )
AGDBUFMIAc = con ( isnull(agdbufmia) and ../miagrd gt 0, 0, con ( ../miaGRD gt 0, AGDBUFMIA))

setwindow ../DEMUTM_sir
agdbufsir = polygrid ( AGDTMBUF )
AGDBUFsirc = con ( isnull(agdbufsir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt  0, AGDBUFsir ))



/* ROADS:
/* ————————-

setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
vgd250mia = linegrid ( VGDTM )
vGD250MIAc = con ( isnull(vgd250mia) and ../miagrd gt 0, 0, con ( ../miaGRD gt 0, vGD250MIA ))

setwindow ../DEMUTM_sir
vgd250sir = linegrid ( VGDTM )
vGD250sirc = con ( isnull(vgd250sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, vGD250sir ))


/* RAILWAYS:
/* ——————————-

setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
rgd250mia = linegrid ( RGDTM )
rGD250MIAc = con ( isnull(rgd250mia) and ../miagrd gt 0, 0, con ( ../miaGRD gt 0, rGD250MIA ))

setwindow ../DEMUTM_sir
rgd250sir = linegrid ( RGDTM )
rGD250sirc = con ( isnull(rgd250sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, rGD250sir ))
```

```
/* WATERBODIES:
/* ——————————————-

setwindow ../DEMUTM_MIA
setcell ../DEMUTM_MIA
wgd50mia = polygrid ( WGDTM50BUF )
wGD50MIAc = con ( isnull(wgd50mia) and ../miagrd gt 0, 0, con ( ../miaGRD gt 0, wGD50MIA ))

setwindow ../DEMUTM_sir
wgd50sir = polygrid ( WGDTM50BUF )
wGD50sirc = con ( isnull(wgd50sir) and ../sirgrd gt 0, 0, con ( ../sirGRD gt 0, wGD50sir ))

/*  Reset window
setwindow maxof



/******************************************
/* BRS - WATERTABLE DEPTH AND SALINITY:
/******************************************

/* AML Commands used to convert BRS (agso wt the first version)
 hydrogeology mapping to covers and grids
/* used in the analysis.  Additional covers which were converted but not used
/* are also included as a record of the process.

/* This was not run as an aml so don't expect it to. Instead the appropriate
/* commands were cut and pasted into an active arc window as required.

/* T.Dowling. CSIRO, Land and Water, Canberra. 14.4.1999


/* SHAL WT  DEPTH:
/*******************

setwindow$EVAP/../MIA_BOX_UTM

arc clip $HOME/hydgeo_mdb_250k_2v1/hydrogeology/shaldep_l $EVAP/../mia_box ~`
     shdep_l_mia line
arc project cover SHdep_L_MIA shdep_miatm $PROJ/ll_utm55s.prj

/* Shallow wt depth surface

arc topogrid shdep250mia 250
boundary $EVAP/../mia_box_utm
datatype contour
enforce off
iterations 30
outputs # # shdep250mia.dia
contour shdep_miatm depth
end


/* Classify grids into meaningful ranges

GW_DCLASS_MIA = con( ShDEP250MIA le 2., 1, con( ShDEP250MIA gt 2. and ~
    ShDEP250MIA le 4, 2, con( ShDEP250MIA gt 4., 3, setnull (1) )))
```

```
/* clip depth to g/w grids

SHDEP250MIAC = con ( $EVAP/../MIABIN gt 0, SHDEP250MIA )
setwindow maxof


setwindow$EVAP/../SIR_BOX_UTM

arc clip $HOME/hydgeo_mdb_250k_2v1/hydrogeology/shaldep_l $EVAP/../sir_box ~
    shdep_l_sir line
arc project cover SHdep_L_SIR shdep_sirtm $PROJ/ll_utm55s.prj

/* Interpolate shallow wt depth surface
arc topogrid shdep250sir 250
boundary $EVAP/../sir_box_utm
datatype contour
enforce off
iterations 30
outputs # # shdep250sir.dia
contour shdep_sirtm depth
end

/* Classify grids into meaningful ranges
GW_DCLASS_SIR = con( ShDEP250sir le 2., 1, con( ShDEP250sir gt 2. and ~
    ShDEP250sir le 4, 2, con( ShDEP250sir gt 4., 3, setnull (1) )))

/* clip depth to g/w grids
SHDEP250SIRC = con ( $EVAP/../SIRBIN gt 0, SHDEP250SIR )
setwindow maxof


/* SALINITY OF SHALLOW AQUIFER:
/*********************************

clip $HOME/hydgeo_mdb_250k_2v1/hydrogeology/shalsy_n $EVAP/../mia_box ~
    shalsy_n_mia poly
project cover SHALSY_N_MIA shsy_miautm $PROJ/ll_utm55s.prj
build SHSY_MIAUTM poly
SAL_MIA = polygrid ( SHSY_MIAUTM, SY )

clip$HOME/hydgeo_mdb_250k_2v1/hydrogeology/shalsy_n $EVAP/../sir_box ~
    shalsy_n_sir poly
project cover SHALSY_N_SIR shsy_sirutm $PROJ/ll_utm55s.prj
build SHSY_SIRUTM poly
SAL_SIR = polygrid ( SHSY_sirUTM, SY )

/* clip salinity grids
&work $EVAP/agso
SAL_MIAC = con ( $EVAP/../MIABIN gt 0, SAL_MIA )

setwindow $EVAP/DEMUTM_SIR
```

```
setcell $EVAP/DEMUTM_SIR
SAL_SIRC = con ( $EVAP/../SIRBIN gt 0, SAL_SIR )
 setwindow maxof

 /********************************
/* HIGH RESOLUTION DATASETS  *
/********************************


/* DEPTH TO WATERTABLE
/* ——————————————————————

/* AML Commands used to convert DLWC and SKM data to covers and grids
/* used in the analysis.  Additional covers which were converted but not used
/* are also included as a record of the process.

/* This was not run as an aml so don’t expect it to. Instead the appropriate
/* commands were cut and pasted into an active arc window as required.

/* T.Dowling. CSIRO, Land and Water, Canberra. 14.4.1999
/* start with piezo point covers from DLWC

copy $EVAP/processing/temp/cov_piezo piezo_mia
copy $EVAP/processing/temp/cov_piezo2 piezo_sir

/* rerun topogrid at 250m resolution

setwindow$EVAP/../MIA_BOX_UTM

/* Interpolate shallow wt depth surface
arc topogrid gwdep250mia 250
boundary $EVAP/../mia_box_utm
datatype spot
enforce off
iterations 20
outputs # # gwdepmia.dia
point PIEZO_MIA wt_level
end

GWDEP250MIAc = con ( $EVAP/../MIABIN gt 0, GWDEP250MIA )

/* Classify grids into meaningful ranges
/*GW_DCLASS_MIA = con( ShDEP250MIA le 2., 1, con( ShDEP250MIA gt 2. and ~
    SHDEP250MIA le 4, 2, con( ShDEP250MIA gt 4., 3, setnull (1) )))

setwindow$EVAP/../SIR_BOX_UTM

/* Interpolate shallow wt depth surface
arc topogrid gwdep250sir 250
boundary $EVAP/../sir_box_utm
datatype contour
enforce off
iterations 30
outputs # # gwdepsir.dia
point PIEZO_SIR wt_level
end
```

```
GWDEP250SIRc = con ( $EVAP/../SIRBIN gt 0, GWDEP250SIR )

/* Classify grids into meaningful ranges only for plotting.
 /*GW_DCLASS_SIR = con( ShDEP250sir le 2., 1, con( ShDEP250sir gt 2. and ~
    ShDEP250sir le 4, 2, con( ShDEP250sir gt 4., 3, setnull (1) )))

setwindow maxof

/* GROUNDWATER SALINITY
/* ————————————————————————————————————

/* AML Commands used to convert DLWC and SKM data to covers and grids
/* used in the analysis.  Additional covers which were converted but not used
/* are also included as a record of the process.

/* This was not run as an aml so don't expect it to. Instead the appropriate
/* commands were cut and pasted into an active arc window as required.

/* T.Dowling. CSIRO, Land and Water, Canberra. 14.4.1999
/* start with Elaines water quality point covers - assume they are correct

copy $EVAP/../sir/watertable/watqual watqual
&sys cp $EVAP/../sir/watertable/watqual.lup
&sys cp $EVAP/../sir/watertable/watqual.rmp .

/* rerun topogrid at 250m resolution
 setwindow$EVAP/../MIA_BOX_UTM

/* Interpolate salinity surface
arc topogrid sal250mia 250
boundary $EVAP/../MIA_box_utm
datatype spot
enforce off
iterations 20
outputs # # salmia.dia
point cov_wt3 ec
end

GWDEP250MIAc = con ( $EVAP/../MIABIN gt 0, GWDEP250MIA )

/* Classify grids into meaningful ranges
/*GW_DCLASS_MIA = con( ShDEP250MIA le 2., 1, con( ShDEP250MIA gt 2. and ~
ShDEP250MIA le 4, 2, con( ShDEP250MIA gt 4., 3, setnull (1) )))

setwindow$EVAP/../SIR_BOX_UTM
setcell $EVAP/DEMUTM_SIR

/* Salinity surface
sal250sir =  polygrid ( watqual, aqu_sal, #, #, 250 )
sal250SIRc = con ( $EVAP/../SIRBIN gt 0, sal250SIR )

/* Classify grids into meaningful ranges (only for mapping, not necessary for
/* analysis because the ranges are set at the time to be more flexible)
/*GW_DCLASS_SIR = con( SHDEP250SIR le 2., 1, con( SHDEP250SIR gt 2. and ~
/* SHDEP250SIR le 4, 2, con( SHDEP250SIR gt 4., 3, setnull (1) )))
```

```
setwindow maxof


/* SOILS
/* ******

/* MIA Geomorphic Elements:
/* ----------------------------------------

PROJECT cover GEO_MIA_G 100tGeo $PROJ/ll_utm55s.prj
build 100TGEOL poly
clip $EVAP/mia/soils/100TGEOL $EVAP/miabndry geomorph_e poly .00001


/* SIR 1:25000 SOILS of Department of Agriculture, Victoria:
/* ------------------------------------------------------------------------------------------

$EVAP/hires/soil/meth_valid.aml

arc project COVER $EVAP/sir/soils/deakin deakin $EVAP/ll_utm55s.prj
arc project COVER $EVAP/sir/soils/eastshep eastshep  $EVAP/ll_utm55s.prj
arc project COVER $EVAP/sir/soils/goulburn goulburn $EVAP/ll_utm55s.prj
arc project COVER $EVAP/sir/soils/mveast mveast $EVAP/ll_utm55s.prj
arc project COVER $EVAP/sir/soils/mvwest mvwest $EVAP/ll_utm55s.prj
arc project COVER $EVAP/sir/soils/rochest rochest $EVAP/ll_utm55s.prj

arc build deakin poly
arc build eastshep poly
arc build goulburn poly
arc build mveast poly
arc build mvwest poly
arc build rochest poly


/* Make a complete hires soil cover for the SIR

arc mapjoin hrs_sir2 poly none $EV/sirbndry
EASTSHEP
GOULBURN
DEAKIN
ROCHEST
MVEAST
MVWEST

y
y
~

/* clean up map boundaries
dissolve hrs_sir2 hrs_sir_disa #ALL POLY
/* create a cover with all SLF attributes as well for comparisons.
union SLFUTM_SIRC HRS_SIR_DISA union_sir
```

Appendix 2: AML's for processing overall suitability classes.

```
/* REGIONAL SCALE SUITABILITY ANALYSIS:
/**************************************


/* name “s5_badwrvgs2.aml” identifies the data layers used and stands for:
/* - built-up-areas,
/* - areonautical,
/* - drainage,
/* - waterbodies,
/* - railways,
/* - vehicles,
/* - groundwater-depth (various alternate clases),
/* - salinity (various alternate clases).

/* In order not to exceed line buffers (256 chrs) covers have been copied
/* to here with very short (cryptic) names as follows:

/* included here but ultimately not used.
/* ksm = ../bui/lowest_ks_mia
/* kss = ../bui/lowest_ks_sir

/* gwm = ../agso/SHDEP250MIA
/* gws = ../agso/SHDEP250sir

/* sm = ../agso/SAL_MIA
/* ss = ../agso/SAL_sir

/* bm = ../auslig250k/BGDTMBUFSIR
/* bs = ../auslig250k/BGDTMBUFSIRC

/* am = ../auslig250k/AGDBUFMIAC
/* as = ../auslig250k/AGDBUFSIRC

/* dm = ../auslig250k/DGD250MIA
/* ds = ../auslig250k/DGD250SIR

/* rm = ../auslig250k/RGD250MIAC
/* rs = ../auslig250k/RGD250SIRC

/* vm = ../auslig250k/VGD250MIAC
/* vs = ../auslig250k/VGD250SIRC

/* wm = ../auslig250k/WGD250MIAC
/* ws = ../auslig250k/WGD250SIRC


&if [exists sm_badwrvgs2 -grid ] &then kill sm_badwrvgs2 all
```

```
&if [exists ss_badwrvgs2 -grid ] &then kill ss_badwrvgs2 all

/* MIA:

sm_badwrvgs2 = ~
con( bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and vm le 0 ~
    and (gwm le  5) and ( sm ge 60 ), 1, ~
con( bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and vm le 0 ~
    and (gwm le  5) and ( sm ge 50 ), 2, ~
con( bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and vm le 0 ~
    and (gwm le  5) and ( sm ge 50 ), 3, ~
con( bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and vm le 0 ~
    and (gwm le 10) and ( sm ge 50 ), 4, ~
     0 ))))

/* SIR:

ss_badwrvgs2 = ~
con( bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and vs le 0 ~
    and (gws le  5) and ( ss ge 60 ), 1, ~
con( bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and vs le 0 ~
    and (gws le  5) and ( ss ge 50 ), 2, ~
con( bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and vs le 0 ~
    and (gws le  5) and ( ss ge 50 ), 3, ~
con( bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and vs le 0 ~
    and (gws le 10) and ( ss ge 50 ), 4, ~
     0 ))))

&r ../s_plt 5 sm_badwrvgs2 ss_badwrvgs2

&return GAME OVER

::::::::::::::::::::::::::::::::::::::::::::::::::::::

/* S_PLT.aml
/* this plot provides a quick look of both areas at processing time.
/* See t250suit.aml for routines used to create Figures for the report.
/* s1.rmp and s1.key are listed below.

clear
&args run_num mianame sirname

pageunits cm
textsize .25
maplimits 0 0 21 29.7
shadeset contrast
mape $EVAP/demutm_mia $EVAP/demutm_sir

grids $EVAP/proc/%mianame% # $EVAP/s1.rmp
grids $EVAP/proc/%sirname% # $EVAP/s1.rmp

linecolor black
arcs $EVAP/../mia/bnds/miabndry
arcs $EVAP/../sir/bnds/sirbndry

linecolor gray
```

```
arcs $EVAP/MAINSTRTMmia
arcs $EVAP/MAINSTRTMsir
linecolor gray
arcs $EVAP/auslig250k/FGDTM
pointtext $EVAP/auslig250k/MAP250NAM_TM name # lc

keyarea  1.5 9.0 10.0 13.0
keybox .4 0.3
keyseparation .25 .25
keyshade $EVAP/s1.key

move 8, 13
&sv hdr = [ quote Suitability analysis #%run_num% ]
&ty %hdr%
text %hdr%

move 8, 12
text ‘ Suitability Class ‘

&return GAME OVER

:::::::::::::::::::::::::::::::::::::::::::::::::::::

/* listing of  s1.rmp and s1.key (contrast.shd)

-100 0 : 1    /* white
   0 1 : 4    /* red
   1 2 : 3    /* yellow
   2 3 : 7    /* green
   3 4 : 2    /* blue

.1
    Not Suitable / no data
.4
    S 1
.3
    S 2
.7
    S 3
.2
    S 4




/*********************************************
/* HIGH RESOLUTION SUITABILITY ANALYSIS:  *
/*********************************************


/* In order not to exceed line buffers (256 chrs) covers have been copied
/* to here with very short (cryptic) names as follows:

/* ksm = ../bui/lowest_ks_mia
/* kss = ../bui/lowest_ks_sir
```

```
/* gwm = ../hires/soil/ .....
/* gws = ../hires/soil/ .....

/* sm = ../hires/sal/ .....
/* ss = ../hires/sal/ .....

/* bm = ../auslig250k/BGDTMBUFSIR
/* bs = ../auslig250k/BGDTMBUFSIRC

/* am = ../auslig250k/AGDBUFMIAC
/* as = ../auslig250k/AGDBUFSIRC

/* dm = ../auslig250k/DGD250MIA
/* ds = ../auslig250k/DGD250SIR

/* rm = ../auslig250k/RGD250MIAC
/* rs = ../auslig250k/RGD250SIRC

/* vm = ../auslig250k/VGD250MIAC
/* vs = ../auslig250k/VGD250SIRC

/* wm = ../auslig250k/WGD250MIAC
/* ws = ../auslig250k/WGD250SIRC


&if [exists sm_badwrvgs2k -grid ] &then kill sm_badwrvgs2k all
&if [exists ss_badwrvgs2k -grid ] &then kill ss_badwrvgs2k all

/* These are for salt 0-3000, 3000-7000 and 7000+

/* MIA:

sm_badwrvgs2k = ~
con( ksm eq 1 and bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and
 vm le 0 ~
    and (gwm le  5) and ( sm ge 60 ), 1, ~
con( ksm eq 1 and bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and
 vm le 0 ~
    and (gwm le  5) and ( sm ge 50 ), 2, ~
con( ksm eq 1 and bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and
 vm le 0 ~
    and (gwm le  5) and ( sm ge 50 ), 3, ~
con( ksm eq 1 and bm le 0 and am le 0 and dm le 0 and wm le 0 and rm le 0 and
 vm le 0 ~
    and (gwm le 10) and ( sm ge 50 ), 4, ~
     0 ))))


/* SIR:

ss_badwrvgs2k = ~
con( ksm eq 1 and bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and
 vs le 0 ~
    and (gws le  5) and ( ss ge 60 ), 1, ~
con( ksm eq 1 and bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and
```

```
 vs le 0 ~
     and (gws le  5) and ( ss ge 50 ), 2, ~
con( ksm eq 1 and bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and
 vs le 0 ~
     and (gws le  5) and ( ss ge 50 ), 3, ~
con( ksm eq 1 and bs le 0 and as le 0 and ds le 0 and ws le 0 and rs le 0 and
 vs le 0 ~
     and (gws le 10) and ( ss ge 50 ), 4, ~
      0 ))))

&r ../s_plt 7 sm_badwrvgs2k ss_badwrvgs2k

&return GAME OVER

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

/* S_PLT.AML:
/* this plot provides a quick look of both areas at processing time.
/* See t250suit.aml for routines used to create Figures for the report.
/* s1.rmp and s1.key are listed with the regional scale version above.
clear
&args run_num mianame sirname

pageunits cm
textsize .25
maplimits 0 0 21 29.7
shadeset contrast
mape $EVAP/demutm_mia $EVAP/demutm_sir

grids $EVAP/proc/%mianame% # $EVAP/s1.rmp
grids $EVAP/proc/%sirname% # $EVAP/s1.rmp

linecolor black
arcs $EVAP/../mia/bnds/miabndry
arcs $EVAP/../sir/bnds/sirbndry

linecolor gray
arcs $EVAP/MAINSTRTMmia
arcs $EVAP/MAINSTRTMsir
linecolor gray
arcs $EVAP/auslig250k/FGDTM
pointtext $EVAP/auslig250k/MAP250NAM_TM name # lc

keyarea  1.5 9.0 10.0 13.0
keybox .4 0.3
keyseparation .25 .25
keyshade $EVAP/s1.key

move 8, 13
/*text ‘Suitability analysis #3’
&sv hdr = [ quote Suitability analysis #%run_num% ]
&ty %hdr%
text %hdr%

move 8, 12
text ‘ Suitability Class ‘
```

```
&return GAME OVER
```

Summary statistics:

```
/******************
/* A major requirement is the gathering of statistics - the following is a list stats derived
/* from which bits can be selected depending on needs.


/* for topo250k value = 0 is suitable
/*                    = 1 is not (i.e. a feature attribute)
/* so % suitable = count(value0) / (count(value0) + count(value1))

&do reg &list mia sir col ker mil
list dgd250%reg%c.vat
list BGDTMbuf%reg%c.vat
list AGDBUF%reg%c.vat
list vGD250MIAc.vat
list rGD250MIAc.vat
list wGD50sirc.vat

/* for all topo250k suitability classes:
/* if each layer is =< 0 (i.e. suitable) then value = 1 (i.e. suitable)

/* so % suitable = count(value1) / (count(value0) + count(value1))
list s4m_badwrv.vat
list s4s_badwrv.vat
list s4c_badwrv.vat
list s4k_badwrv.vat
list s4l_badwrv.vat

/* Groundwater level:
/* where =<  5 is set to 1  (suit range 1)
/*       =< 10 is set to 2  (suit range 2)
/*        > 10 is set to 0  ( unsuitable )
/* so % suitable1 = count(value1)/(count(value0)+count(value1)+count(value2))
/* so % suitable2 = count(value2)/(count(value0)+count(value1)+count(value2))
/* so % unsuitable = count(value0)/(count(value0)+count(value1)+count(value2))

list$EVAP/agso/WT5_10_MIAC.vat
list$EVAP/agso/WT5_10_sirC.vat
list$EVAP/agso/WT5_10_colC.vat
list$EVAP/agso/WT5_10_kerC.vat
list$EVAP/agso/WT5_10_milC.vat

/* Groundwater salinity:
/* original data set had sal&yield i.e. values 10 to 70
/* while latest version has 1 to 7 (used for col ker and mil)
/* where =< 50 (or 5) is set to 0  ( unsuitable )
/*     =< 60 (or 6) is set to 2  (suit range 2)
/*      > 60 (or 6) is set to 1  (suit range 1)
/* so % suitable1 = count(value1)/(count(value0)+count(value1)+count(value2))
/* so % suitable2 = count(value2)/(count(value0)+count(value1)+count(value2))
/* so % unsuitable = count(value0)/(count(value0)+count(value1)+count(value2))
```

```
list $EVAP/agso/SALMIAC3CLASS.vat
list $EVAP/agso/SALSIRC3CLASS.vat
list $EVAP/agso/SALcolC3CLASS.vat
list $EVAP/agso/SALkerC3CLASS.vat
list $EVAP/agso/SALmilC3CLASS.vat

/* Overall suitablility:

list$EVAP/proc/SM_BADWRVGS2.vat
list$EVAP/proc/SS_BADWRVGS2.vat
list$EVAP/proc/Sc_BADWRVGS2.vat
list$EVAP/proc/Sk_BADWRVGS2.vat
list$EVAP/proc/Sl_BADWRVGS2.vat

/* % suitable1 = count(val1)/(count(val0)+count(val1)+count(val2)+count(val3))
/* % suitable2 = count(val2)/(count(val0)+count(val1)+count(val2)+count(val3))
/* % unsuitable= count(val0)/(count(val0)+count(val1)+count(val2)+count(val3))

for hires soil stats see:

list$EVAP/../TREV/HIRES/PROC/KSM_IDJ.vat
list $EVAP/hires/soil/HRSOIL_SIR.vat
```