DRYLAND SALINITY MAPPING IN CENTRAL AND SOUTH WEST NEW SOUTH WALES: COLLATION AND DOCUMENTATION OF INFORMATION

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EXECUTIVE SUMMARY

National Parks and Wildlife Service (NPWS), NSW are undertaking work aimed at assessing the impact of land salinisation on terrestrial biodiversity, both now and in the future. They have commissioned a study to collate information and, where possible, data regarding the range of salinity mapping projects currently being undertaken in four inland catchments of New South Wales (Central West, Lachlan, Murrumbidgee and Murray Catchments).

A broad range of groups, known to be actively working on projects relevant to the NPWS project, were surveyed by questionnaire and follow-up interviews. The information requested related to the gathering of data descriptions, data collection methods and data storage locations/contacts for relevant raw data. In all, twenty-one people were contacted and interviewed.

Data was partitioned into five categories, depending on the method used to collect the raw data. The various categories of data were: directly measured current outbreaks; indirectly measured current outbreaks; areas of modelled (current) outbreaks; future areas at risk generated by composite or strongly inverse techniques; and future areas of outbreaks generated by process models.

The results of the survey showed that there was a broad range of groups undertaking projects related to salinity outbreak mapping. However, the large majority of these projects were involved with the collection of salinity data by methods other than direct mapping. The only project undertaking mapping by direct methods was the DLWC project on Dryland Salinity Outbreak Mapping.

This study concluded that there are no broad scale data that show the current distribution of salinity outbreaks that is of direct relevance to impacts of salinity on biodiversity projects. Information is currently being collected by a Statewide project on Dryland Salinity Outbreak Mapping. However, it is understood that no data is likely to be collected specifically for woodland areas as part of this project, and the time to complete the project is still sometime into the future.

Generally, there is a piecemeal and disconnected approach to salinity mapping in the four catchments surveyed. The work is being carried out by many organisations and agencies and appears to not necessarily be producing the outputs that are required for comprehensive natural resources management.

Much effort has been invested in the collection of both ground-based and airborne EM data. Some of these products are being marketed as salt maps. This data is of little use to impacts of salinity on biodiversity projects as it is an indirect method that does not necessarily produce salinity maps, and its coverage is very limited. As well, ground-based EM methods have not been used to map salinity heavily timbered areas.

There is a large range of projects that are producing information that is essentially describing salinity risk. The output from these projects is, again, of little use for the assessment of the impacts of salinity on biodiversity as they produce lumped risk assessments at landscape or sub-catchment levels. Salinity risk at anything but the local scale is not a good indicator of the spatial distribution of salinity outbreaks.

The report recommends that the NPWS Salinity and Biodiversity project work closely with the DLWC Salinity Outbreak Mapping project to ensure that the resolution and scale of the outputs are relevant, and that the timing of the outputs is appropriate to the NPWS project. As well, some discussion should commence regarding the task of assessing salinity in woodlands, especially in key areas.

The report recommends that guidelines/standards for salinity mapping be generated so there is an agreed approach to what is mapped and how it is mapped, along similar lines to soil mapping standards.

The report recommends that there be some discussion by relevant people about what is mapped in salinity mapping projects and how this is done keeping in mind the needs of the users of the maps/data. For example, there needs to be discussion about what needs to be done to provide adequate data for investigating salinity impacts on biodiversity.

ACKNOWLEDGEMENTS

We would like to thank all of those people who contributed to this report, particularly those who made a concerted effort to respond to the questionnaires that we sent out. It is the information provided by the questionnaire responses that make up the main body of this report.

We are particularly grateful to the efforts of Alan Nicholson (Central West and Lachlan Region, DLWC) and Stuart Lucas (Murray Region, DLWC) for discussions and providing us with information beyond the scope of the questionnaires.

Thanks also go to Paul Houlder of NRIC, BRS, AFFA for background information about natural resource metadata.

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CONTENTS

1 INTRODUCTION

The aim of this report is to collect, collate and document information about past and present projects undertaking mapping, modelling and prediction of locations of dryland salinity, including salinity hazard mapping.

This work forms part of a broader National Parks and Wildlife Service (NPWS) project that is looking at the impacts of salinity on biodiversity. The broader project aims to provide information about:

- Landscape scale risks to terrestrial biodiversity from salinity, including risks to threatened ecological communities and National Parks and Nature Reserves; and

- The site effects of salinity on biodiversity, including effects of salinity on vegetation condition.

The broader project will also investigate impacts of current salinity affected lands on biodiversity, as well as provide guidelines for targeting investment in management strategies to ameliorate impacts of salinity on terrestrial biodiversity.

In order to achieve these objectives, the broader project requires a range of input data that describes the spatial distribution of land that is affected by dryland salinity. This report deals with the suitability to the project of the range of data that has been produced as part of all known dryland salinity investigations across Central and South West New South Wales.

It is clear from the objectives of the broader project that there are a range of specific requirements that can be used to focus the assessment of the wide-ranging data and information being collected and produced as part of salinity mapping and modelling in NSW.

For this project, data should be related to dryland salinity and not to irrigation induced salinisation. As well, the data should relate to land salinisation and not to any form of river salinisation, as the project is dealing with salinity impacts on terrestrial ecosystems.

As well, some distinction needs to be made in this project about whether the information sought should relate to actual dryland salinity outbreaks, or to areas that are at risk of developing salinity outbreaks. This issue importantly introduces the concept of time. To be able to produce meaningful assessments of the risk of biodiversity to salinity degradation, there has to be some form of future extent of the salinity problem. Predictive modelling methods are the only approach to understanding this future extent.

However, there is a range of predictive methods that might be assessed as representing future salinisation. Gilfedder and Walker (2001) reviewed many approaches to dryland salinity risk assessment and found “there was no

readily accepted and adopted approach for the consistent prediction of dryland salinity at a regional scale". They further concluded, "suitable approaches need to incorporate:

- Appropriate and consistent landscape disaggregation;
- Robust methods for assessing salinity risk within each landscape element; and
- An ability to provide long-term predictions of salinity risk."

Central to the use of outputs to infer areas at risk of salinisation are the issues of the spatial and temporal scale of the predictions. For any prediction to be of use for the assessment of biodiversity impacts from salinisation, the spatial scale of the salinity risk prediction needs to be at least the same as the functional biodiversity unit of interest. As well, the temporal nature of the prediction needs to be explicitly stated.

In some instances where mapped salinity outbreak data is not available, models of depth to groundwater have been used to infer those areas where salinisation may be currently occurring.

1.1 Project Objectives

1. To collect, collate and document information about past and present projects undertaking mapping, modelling and prediction of locations of dryland salinity, including salinity hazard mapping, in inland New South Wales (Central West, Lachlan, Murrumbidgee and Murray Catchments).

2. To document names and contact details of data managers, and locations and contact details for reports, GIS data (including metadata) and other information about locations and predicted locations of dryland salinity, including salinity hazard mapping, in inland New South Wales.

3. Where possible, to obtain GIS data and other information on locations and predicted locations of dryland salinity (including salinity hazard mapping) in inland New South Wales from past and current projects, including reports, GIS information and associated metadata.

4. The primary emphasis of the project is on salinity discharge areas. Information on mapping and prediction of recharge areas should be collated and documented, where possible.

1.2 Data Issues

Both dryland salinity data and data related to biodiversity are spatial in nature. Therefore, if they are to be used together, it is important to ensure that the scale and resolution characteristics of both data sets are the same, or as close to being the same as is possible. Scale is an attribute that relates to the spatial representation of the mapped data, and resolution is the attribute of

the data that relates to the spatial dimension of the mapped unit (that is, salt outbreaks of a certain minimum size are represented on a map – similar to a detection limit). For instance, salinity outbreak data may be represented at a scale of 1:250,00 and have a resolution of 100 square metres.

Comments are made (where possible) about each of these attributes as they relate to each of the data sets discussed below.

There are two main salinity data sets that are required to study the effects of salinity on biodiversity across the landscape. The first is the *current* extent of all dryland salinity sites at an appropriate resolution and scale. Maps of the current extent of salinised areas can be derived from a range of techniques. Essentially they fall into three main methods used – extent that is directly observed; extent that is inferred via an indirect method (that is, a method that maps a surrogate variable that relates to salinity) either via direct measurement of a related variable; or via modelling of a related variable. Thus, it is possible in some areas to have maps of the current extent of salinity outbreak that were derived via a modelling exercise (also known as modelled current extent).

The second data set required is the *future* extent of salinity outbreaks. Data sets such as these are based on some form of predictive analysis, usually based around a modelling approach.

There has been a great deal of work over the past decade related to the production of salinity risk or hazard maps. These have been produced in response to the desire to understand the future size of the dryland salinity problem. Because of their nature, these analyses generally cover large areas (they are large scale) and have extremely low resolution (the base unit of analysis is usually some form of landscape element – a soil landscape or a land system). Further more, they only ever purport to represent regions having a high salinity risk/hazard at some time in the future as opposed to actual salt outbreaks at a specified time in the future.

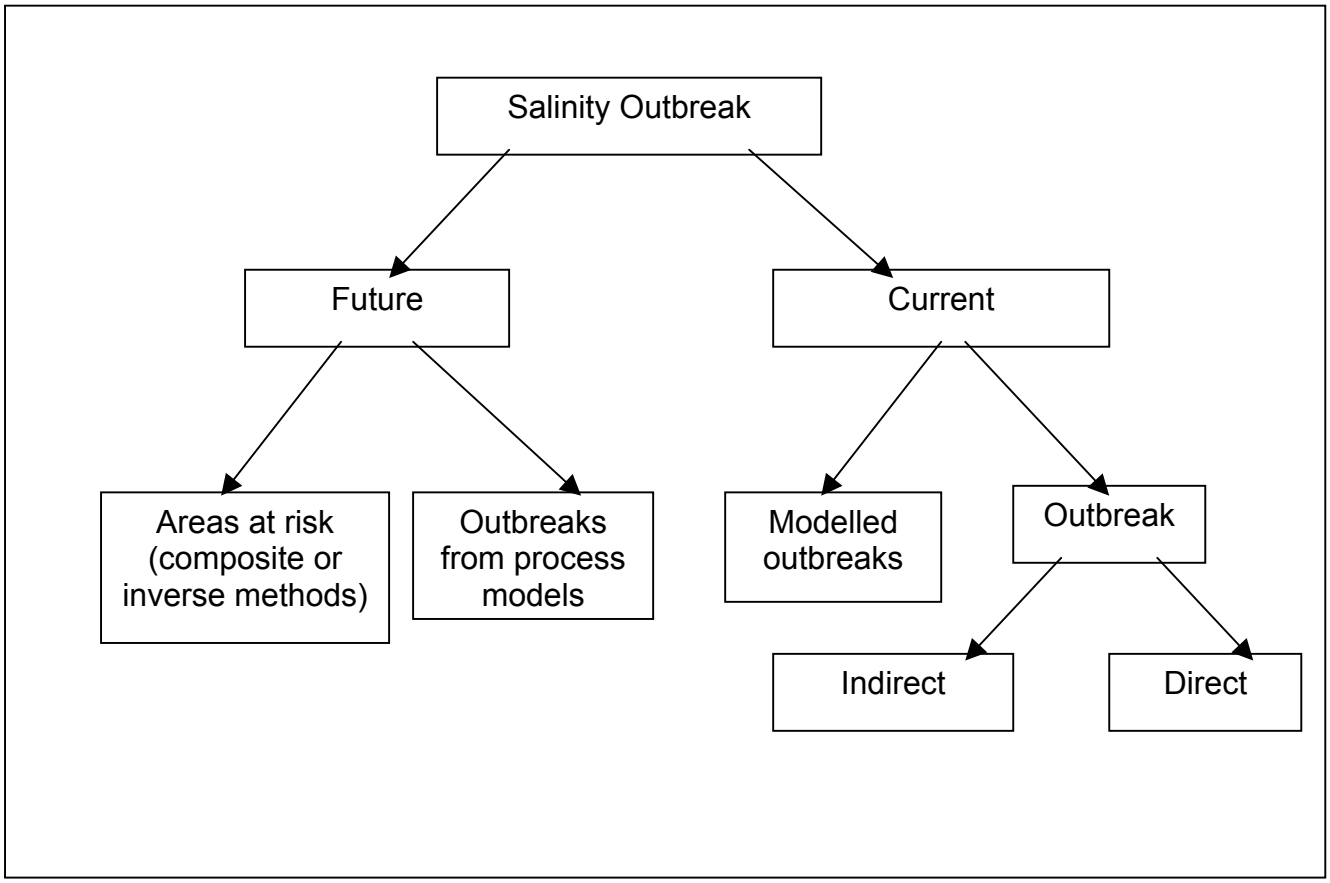

Figure 1: Diagram showing relationship between different datasets

Based on Figure 1, there are five basic types of salinity outbreak data – directly measured current outbreaks; indirectly measured current outbreaks; areas of modelled (current) outbreaks; future areas at risk generated by composite or strongly inverse techniques; and future areas of outbreaks generated by process models. Each of the direct or indirect current outbreak data sets may also involve the use of modelling (as opposed to direct observation). The scale at which the analysis is undertaken will influence the suitability of the five.

A range of different approaches and methods are listed in Table 1 below.

1.3 The Salinisation Process

The following section provides a brief background describing the salinisation process. In particular, it outlines the key elements of the degradation problem so that the data required to map the problem can be fully understood.

Degradation due to dryland salinity is the result of an increased discharge of salt to due to the mobilisation of salt via a changed hydrologic balance. Thus, both an increase in the flux of water flowing through a system and a source of salt that can be mobilised are required before degradation can occur.

The changed water flux is usually due to an increase in recharge, as a result of a change in vegetation from a higher to a lower water using system. The

resultant discharge can manifest in either of two ways – firstly as an increased discharge to the land surface (which can result in land salinisation), and secondly, as an increased discharge to surface water bodies (streams, creeks and lakes).

Dryland salinity is often referred to as a groundwater problem. This is because groundwater is the main process agent that drives the problem.

It is important to reinforce that both the hydrologic change and a source of salt are fundamental to the problem. Both are necessary for the problem to occur, and neither is sufficient by itself.

In terms of the objectives of this report, it is critical to differentiate the variables that underlie any process model that is used to infer the extent of salinity outbreaks, or that define a possible risk of salinisation. Mapping salt stores by themselves, or recharge characteristics, is not sufficient to define the problem. It is where the interaction of these two results in an increased flux that the problem arises.

Table 1. Salinity Mapping/ Modelling Techniques (reproduced courtesy of Alan Nicholson, DLWC, Wellington)

Technique	Method	Usual Scale	Utility
1. Known Site mapping	Air photo interpretation, known site locations, records. Spatial mapping of area onto map sheet	1:50,000 or 1:100,000 map sheet	Uses air photos, and depends on up to date scenes. Most reliable of techniques
2. Remote sensing- TM, SPOT	Utilisation of satellite data that is manipulated to enhance salt sites.	Satellite scenes. Minimum is 1:20,000 usually 1:25,000	Inaccurate method. Requires calibration, and ground truthing.
3. Electro Magnetic Survey- Ground based	Use of EM 31/38/34 to determine apparent EC. Indirect Method that is usually mechanised by use of a 4WD bike and GPS.	Small scale (Urban) and up to 20,000 ha on 200m gird. Coloured maps of apparent salinity hazard produced.	Very effective and useful tool for salinity mapping in more open areas (problems of mobility in denser vegetation). Needs to be ground-truthed. Most used method.
4.Geophysical techniques- Radiometrics/ Airborne EM/ Magnetics/ Resistivity	Traditional minerals exploration tools that aid as layers in interpretation of salinity sites.	1:250,000 usually for airborne methods, but can be used on site survey.	Techniques do not map salinity, but aid in the geological interpretation of a saline site
5. FLAG Modelling	Catchment shape interpretation method. Requires considerable computing power. Interprets DEM data.	Large catchment (river basin) down to urban areas. Usually 1:250,000	Shows the area of likely accumulation of water due to catchment shape. This is not a salt map, but can be used as a layer in interpretation.
6. Weights of Evidence	GIS technique, that statistically relates factors such as geology, shape etc to known sites, and makes predictions as to likelihood of salinity	Has been conducted at NSW scale, and also 1:100,000 scale	Heavily weighted by known site data, which needs to be accurate. Can give some idea of area of salinity.
7. Risk Analysis – regional scale	GIS additive approach. Relies on expert panel approach on factors such as landuse, soils, geology, salt store etc	River basin scale eg Macquarie River Catchment.	Useful as a planning and priority setting tool.
8. Soils Landscape Mapping	Association of the soil landscape likely to produce salinity, represented in a priority mapping process	1:250,000 soils mapping	Indicative data only
9. Groundwater Rise maps	Mapping of groundwater levels within 2 m of surface to determine salinity consequence.	1:100,000 map sheets	Relies on good spatial spread of bores to produce maps. This is usually not available, except in high groundwater demand areas.
10. Modelling Tools ❑ Catsalt ❑ Flowtube ❑ G factor	Modelling tools used for salinity modelling. Can be used to compare catchments, using modelled outputs. All use varying degrees of assumptions.	Large basin scale models	Need large amounts of data to enable calibration and to run models. Changing modelling environment as models and approaches improve.

2 METHODS

2.1 The Questionnaire

In order to obtain accurate and up-to-date information on salinity mapping, modelling and prediction, a questionnaire was developed and sent out to key staff in local, State and Commonwealth government and research agencies (Questionnaire - Appendix 1; List of Respondents - Appendix 2).

The questionnaire was designed to acquire information on the nature of the work undertaken in Central and South West NSW, the properties of the data gathered and the accessibility of the data for use elsewhere. In particular, it was designed so that it would simplify the process for obtaining the digital spatial information associated with dryland salinity mapping.

The questionnaire responses were recorded (in some cases summarised) into an Excel spreadsheet (for information on obtaining the Excel spreadsheet see Appendix 3). The individual responses in the Excel spreadsheet were then returned to the respondents, who initially provided the information, for verification and approval to make this information public. Information was also obtained from the CANRI (Community Access to Natural Resource Information) website.

This report provides a summary of the salinity mapping, modelling and prediction information in NSW made known to us through this questionnaire process.

It is recommended that the information contained in the Excel spreadsheet be used as a guide for obtaining further information regarding salinity data. The quality and detail of the responses is variable. This partly reflects the variety of institutions and project staff that were contacted and partly reflects the nature of the professional relationship between the ‘questioner’ and the ‘respondent’.

2.2 Classification of Results from Questionnaire

The results of the questionnaire are collated into types of salinity mapping/modelling within the framework developed in the Section 1.2:

1. Direct current outbreak methods – direct measurements taken from the ground, airphotos or maps;
2. Indirect current outbreak methods – salinity data derived from other methods such as remote sensing and geophysical surveys, using surrogates; and
3. Current modelled outbreak methods – information derived from modelling techniques which utilise data from 1) and 2).
4. Future outbreak methods

This subdivision of information allows some generic conclusions to be drawn regarding data usefulness for the broader salinity-biodiversity studies.

2.3 Application of a Data Quality and Usefulness Measure to the Results

The data supplied by respondents, via the questionnaire, has two types of quality measure attached to it. The first relates to the *integrity* of the method used to generate the data (was the method best practice and was it applied in the correct manner by appropriate people). The second relates to *usefulness* of the salinity data when applied to biodiversity studies looking at the impacts of salinity. Criteria for assessing the quality of the data may include: spatial scale, resolution, nature of project objectives, relevance of input data to the proposed method requirements, etc.

It was an intention to develop a general categorisation for this project, combining the two quality measures from above and applying them to the various datasets submitted via the questionnaire. However, there was insufficient information gathered upon which to base an objective assessment of the various datasets. This in part is due to the lack of consistent metadata statements associated with the various methods/datasets.

A preliminary categorisation was developed in relation to the requirements of understanding the impact of salinisation on biodiversity, and is presented below for completeness. The categories attempt to deal with both the quality of the data and the usefulness to a biodiversity analysis.

Category A:

- Is at the appropriate scale relative to the associated biodiversity data;
- Is a direct measurement of the variable to be input into a later analysis;
- Has the same spatial and temporal distribution as for the desired biodiversity analysis;
- Has been produced by best practice methods with adequate quality controls.

Category B:

- Has some of the attributes above, but not all. That is, it may be a surrogate variable that has been inferred, or be of a restricted spatial nature, or be at a scale that introduces uncertainty into a later analysis/comparison.

Category C:

- Has only one of the attributes above.

The categorisation was not applied to the specific datasets. Rather a more general assessment of the types of data was made in relation to these categories in the Discussion section.

3 RESULTS

3.1 Direct Methods

The following section details results of salinity outbreak mapping by DLWC in Central and South West NSW. No other agency undertakes mapping using direct methods.

DLWC have recently undertaken, and are undertaking, a comprehensive approach to salinity mapping under the Dryland Salinity Outbreaks project. The scope of the Dryland Salinity Outbreak Project is defined as: "Identification of outbreaks of dryland salinity caused by rising groundwater. The data set does not include outbreaks caused by irrigation practices or of saline scalds in western NSW where saline subsoils are exposed when the top layer of soils is removed" (K. Emery, pers. comm.). The area to be covered is from the Great Dividing Range, west, to the start of the Plains and also includes a limited number of coastal catchments. It is NOT a complete statewide data set.

This project aims to update and replace all existing regional and local data sets that record outbreaks of dryland salinity, and is due to be completed by 2006. It is essentially a revision of an earlier data set collated in 2000 and based on data from 1983 – 1992, that is now out-of-date in some areas. Details of the general technical approach used for this mapping is summarised in Section 3.1.1.1. The project is being managed by Keith Emery, DLWC, Sydney.

The Outbreaks mapping relies heavily on airphoto interpretation. The mapper identifies salinity outbreaks from airphotos using an implicit landscape process conceptual model. These outbreaks are assessed against local knowledge and then a subset is ground-truthed to partially verify the distribution. The resultant map is then digitally stored.

Class 015 – Areas with developing salinity problems. Salt tolerant grasses and brushes are present on the majority of the site. Scalds if any are less than a square metre.

Class 025 – Areas well advanced with salinity problems. Scalded areas up to several square metres in size occur between clumps of salt tolerant grasses and/or bushes. The area is dominated by salt tolerant species and the bare areas represent no more than 5-25% of the surface area of the site.

Class 045 – Areas severely affected with salinity problems. The majority of the site is scalded and bare of vegetation with salt crystals appearing at the surface and occasional clumps of salt tolerant grasses and/or bushes present.

Class 055 – Salinity outbreaks present in gullies of minor intensity. Outbreaks usually occur in the floor of the gully.

Class 065 – Salinity Outbreaks present in gullies of moderate intensity. Outbreaks usually occur in the floor of the gully.

Class 075 – Salinity outbreaks present in gullies of severe intensity. Outbreaks usually occur in the floor of the gully.

Class 085 – Salinity outbreaks present in gullies of extreme intensity. Outbreaks usually occur in the floor of the gully.

Class 013 – Areas affected by waterlogging. Areas that are seasonally or predominantly water logged and although there may be one species of salt tolerant plant present (eg. Cumbungi or Typha sp), no scalding, salt efflorescence or broad scale occurrence of salt tolerant plants are present.

The mapping system also includes some data from indirect methods that are given here (rather than in Section 3.2) for the sake of consistency:

Class 014 – Areas surveyed with an Electromagnetic Induction (EMI) sensor (EM31, EM38 or EM34) that record high levels of conductivity (pink in colour on output maps) when compared to other areas within the survey site. More information about EMI techniques is available in Section 3.2. In some sites, soil testing has been undertaken to confirm the presence of salts, but in other situations no soils testing has been undertaken. As a consequence, the information is only of a provisional nature concerning potential salt stores and needs to be treated with caution as it could simply indicate the presence of clay layers.

The mapping appears to have a resolution of between 100 sq. m. (10 m by 10m) and 625 sq. m. (25m by 25m) (pers. comm. A. Nicholson and A. Wooldridge). The mapping may include some salinity outbreaks in woodland areas, but only where these are known prior to the mapping. There is no guarantee that all areas of salt outbreaks have been mapped as part of the methodology.

Work on this project is being undertaken on an individual catchment basis. Therefore, the following summary of the progress of this work, within Central and South West NSW, has been documented according to the individual catchments.

3.1.1 Murrumbidgee Catchment

3.1.1.1 Salinity Outbreak Mapping in the Murrumbidgee Catchment

Comprehensive dryland salinity outbreak mapping in the Murrumbidgee Catchment has recently been completed and published in a report:

Howarth, C. September 2001. *Salinity Mapping in the Murrumbidgee Catchment 2001.* Department of Land and Water Conservation in NSW. ISBN 0 7347 5239 3

There are two accompanying maps:

Howarth, C. September 2001. *Murrumbidgee Catchment Management Board Dryland and Irrigation Salinity – 2001 (1:600 000 map scale).* Department of Land and Water Conservation in NSW.

Howarth, C. September 2001. *Murrumbidgee Catchment Management Board – Treated Saline Areas (1:600 000 map scale).* Department of Land and Water Conservation in NSW.

The aim of the report was to provide spatial information on the status of salinity outbreaks in the Murrumbidgee Valley in 2001. The project initially combined, into one map, all the different digital data sets of dryland salinity stored on the Murrumbidgee Region's GIS. EM data sets were included as an additional guide to salinised sites. A second map, using FLAG (see Section 3.3.1), was derived to indicate where other salinised sites might be located in the catchment. These two maps were then distributed to district staff for air photo and field verification of salinised outbreaks. The final map of salinity outbreaks utilises the class system/coding, defined in Section 3.1 of this report, to describe the different types of outbreaks (see Appendix A in Howarth, C., 2001). A map was also derived of saline areas treated with land management works.

A copy of the metadata statement associated with this report can be found in Appendix 4.1 of this report (from Appendix B in Howarth, C., 2001). It includes reference to all of the earlier studies in the catchment that contributed to this current project.

The study included areas of woodland.

A large proportion of the earlier studies included sixteen Land and Water Management Studies undertaken within the Murrumbidgee Catchment. Fourteen of these are small-scale studies of 1:25 000 scale. The other two, the Mid- Murrumbidgee and the Upper Murrumbidgee, are composites of the 1:25 000 multi-attribute mapping. All of these studies involved multi-attribute mapping using aerial photography. Attributes mapped are: slope, terrain, land use, regrowth, timber and density, erosion rocks and soils. Salinity outbreaks are a coded category within the erosion attribute mapping. The sixteen Murrumbidgee Land and Water Management study areas are listed in Appendix 4.2 and their associated metadata can be accessed through CANRI, the NSW Community Access to Natural Resource Information database (www.canri.nsw.gov.au).

The Salinity Mapping in the Murrumbidgee Catchment project/report is being promoted as the format for the reporting of DLWC Dryland Salinity Outbreak mapping projects in the other catchments in NSW. The data is in digital format and will eventually be loaded onto the CANRI Web Site for public access.

3.1.1.2 Other Information Relevant to Salinity Mapping in the Murrumbidgee Catchment

A list of publications on salinity, relevant to the Yass region, is in Appendix 5. None of the titles specifically mention outbreak mapping but there may be relevant information in some of the reports (see CALM, 1991; CALM, 1992, and Nicoll and Scown, 1993)

3.1.2 Central West/Lachlan Catchments

3.1.2.1 Salinity Outbreak Mapping in the Central West/Lachlan Catchments

Dryland Salinity Outbreak Mapping in the Central West/Lachlan catchments is due to be completed by September 2003. This work is currently being undertaken by the DLWC Salt Team in these catchments and is following a format similar to the Murrumbidgee mapping (see Section 3.1.1.1). A metadata statement is not yet available. Table 2 provides a summary of the 1:50,000 scale map sheets included in the study and the status of the work to date. The methods employed to derive the outbreaks are described above in section 3.1.

Table 2: 2002 Work Program for Dryland Salinity Outbreak Mapping in the Central West

Map Name	Map Number	Status	Completed
Grenfell	n8530s_2002	Scanned/Tagged	yes
Gooloogong	n8530n_2002	Scanned/Tagged	yes
Cudal	n8631s_2002	Scanned/Tagged	yes
Forbes	n8531s_2002	Scanned/Tagged	yes
Euchareena	n8732s_2002	Scanned/Tagged	yes
Dunedoo	n8733n_2002	Scanned/Tagged	yes
Canowindra	n8630n_2002	Scanned/Tagged	yes
Bendick Murrell	n8529n_2002	Scanned/Tagged	yes
Goolma	n8733s_2002	Scanned/Tagged	yes
Mogriguy	n8633n_2002	Scanned/Tagged	yes
Burrendong	n8732n_2002	Scanned/Tagged	yes
Cowra	n8630s_2002	Scanned/Tagged	yes
Young	n8529s_2002	Scanned/Tagged	yes
Leadville	n8833n4_2002	Scanned/Tagged	yes
Durridgere	n8833s1_2002	Scanned/Tagged	yes
Cassilis	n8833n1_2002	Scanned/Tagged	yes
Narragamba	n8833s4_2002	Scanned/Tagged	yes
Gulgong	n8833n3_2002	Scanned/Tagged	yes
Munghorn	n8833s2_2002	Scanned/Tagged	yes
Home Rule	n8833s3_2002	Scanned/Tagged	yes
Botobolar	n8832n1_2002	Scanned/Tagged	yes
Mudgee	n8832n4_2002	Scanned/Tagged	yes
Broombee	n8832s4_2002	Scanned/Tagged	yes

Lue	n8832s1_2002	Scanned/Tagged	yes
Windeyer	n8832n3_2002	Scanned/Tagged	yes
Tunnabidgee	n8832s3_2002	Scanned/Tagged	yes
Ilford	n8832s2_2002	Scanned/Tagged	yes
Kandos	n8832n2_2002	Scanned/Tagged	yes
Koorawatha	n8629n_2002	Scanned/Tagged	yes
Bigga	n8729n_2002	Scanned/Tagged	yes
Crookwell	n8729s_2002	Scanned/Tagged	yes
Dalton	n8728n_2002	Scanned/Tagged	yes
Gunning	n8728s_2002	Scanned/Tagged	yes
Hill End	n8731n_2002	started	
Parkes	n8531n_2002	Scanned/Tagged	yes
Molong	n8631n_2002	Scanned/Tagged	yes
Alectown	n8532s_2002	Scanned/Tagged	yes
Peak Hill	n8532n_2002	Scanned/Tagged	yes
Boorowa	n8629s_2002	Not started	
Binnaway	n8734n_2002	Scanned/Tagged	yes

In 1999, the DLWC Salt Team mapped known sites in the northern region of the Central West/Lachlan catchment on 1:100, 000 sheets. Kevin Styles (contractor) is currently checking the work done in the north and Nik Henry (DLWC, Cowra) is focussing on the southern region. The verified data will be included in the Outbreak Mapping project. Map sheets completed include 1:100, 000: Coonabarabran, Mendooran, Coolah, Gulgong, Euchareena, Wellington, Dubbo, Cobbora, Molong, Parkes.

3.1.2.2 Previous Mapping Work Undertaken in the Central West/Lachlan Catchments

1992 Land Degradation Mapping of NSW

Land degradation in most of eastern half of NSW was mapped using 1988 air photography. This mapping forms the base line data set for DLWC. It includes salinity mapping at 1:50k, and 1:100k output sheets. This data set is not listed on CANRI, the NSW Community Access to Natural Resource Information database (www.canri.nsw.gov.au).

3.1.3 Murray Catchment

The Dryland Salinity Outbreak Project mapping is due to start in the Murray Catchment in July 2002.

Previous salinity outbreak mapping data can be derived from ten Salt Action funded Land and Water Management Studies undertaken within the Murray Catchment. These are small-scale studies of 1:25 000 scale multi-attribute mapping using aerial photography. Attributes mapped are: slope, terrain, landuse, regrowth, timber and density, erosion rocks and soils. Salinity outbreaks are a coded category within the erosion attribute mapping.

The ten Murray Land and Water Management study areas are listed in Appendix 4.3 and their associated metadata can be accessed through CANRI.

3.1.4 Statewide Mapping

No statewide mapping of dryland salinity outbreaks exists.

In 1999 a map was prepared for the Salinity Summit at Dubbo, NSW by Georgina Ashton, NSW DLWC. This was a compilation of existing information on salinity outbreaks and included data from the Land and Water Management Studies mentioned in Sections 3.1.1.1 and 3.1.3. The metadata for this map can be located on CANRI using ANZLIC Unique ID: ANZNS0359000148. A brief summary of this metadata statement is in Appendix 4.3.

Although it was presented as a 'State' map, the data only covers the eastern third of NSW. The map is reliable only at the scale produced – which was approximately 1:2 000 000. It is not for use at larger scales. The Central West data input was provisional and is now known to be incorrect (pers.comm., K. Emery).

3.2 Indirect Methods

The most common indirect method used to map salinity relies on the measurement of the electrical conductivity of the ground via the use of Electromagnetic Induction techniques (EMI or EM). Results from this method are sometimes integrated with results from direct methods/salinity mapping.

The EM techniques can either be ground-based or airborne. The assumption with both these techniques is that a high EM reading is caused by the presence of salt in the volume of soil being measured. This is sometimes represented as a salt map, rather than an apparent bulk electrical conductivity. Even if the correlation between electrical conductivity and salt content is high, it is still necessary to establish that a large salt store is in fact manifest as a salinity problem.

Both ground-based and airborne EM techniques collect data as measurements along lines. All surveys will quote the line spacing of the primary data capture. This raw data is then usually gridded and contoured to give a spatial coverage. The choice of the contouring software is critical to the nature of the final output. For instance, some simple contouring software used in the early days of the technique would interpolate across areas where there was no raw data, thus giving the impression of complete coverage.

Another indirect method of salinity mapping utilises the measurement of shallow groundwater levels (Section 3.2.3).

3.2.1 Ground-based EM Surveys

The most common methods of geophysical survey used in the regions of NSW are the ground-based electro-magnetic induction (EMI) surveys. EMI surveys are used to determine apparent EC of the near-surface layer with the aim of identifying salinity hazard in areas where surface outbreak may not have yet manifest. There are a range of instruments, EM-38/31/34 and EM39 that work on similar principles. The differences in these methods relate to the distance between the two coils, which affects the depth of measurement, and the frequency of the generated signal.

Ground-based EM techniques seem to be targeted at agricultural/grazing lands, with a view to managing productivity. The surveys do not generally include timbered areas (at a tree density of more than about 50 stems per hectare. It is assumed that this relates to those areas where it is difficult to traverse with motor bike-mounted equipment.

EM-38 is the smallest unit and can be operated by one person. It tends to measure depths to approximately 1m. EM-31 can also be operated by one person but has a greater distance between coils (it is a long rod shape) and measures 3-6 m depth. EM-34 is the largest model and requires 2 operators. It can measure from 7.5 to 60 m depth. Finally, EM-39 is used for down borehole measurements.

These methods are best suited to small-scale studies and are undertaken on a grid-based format. It is a very effective, efficient and useful tool for salinity mapping and surveys can be done on 4WD bike with GPS. Further information about the use of EMI techniques can be obtained in a CSIRO publication:

> Nicoll, C., 1993. *Land Assessment Using Electromagnetic Induction – A Guide to the use of Electromagnetic Induction Techniques in the Analysis of Landscapes Affected by Dryland Salinity,* CSIRO Division of Water Resources, LWRRDC, Canberra.

Output is commonly as coloured map of “apparent salinity hazard”. Some controversy exists over degree of correlation between apparent EC and salinity hazard as apparent EC can be affected by water moisture content, clay content (solid matter) and salt content. For this reason, ground-truthing needs to be included as part of the process.

Data received from DLWC regional offices is in the form of small, separate individual studies, often undertaken for Landcare groups, etc. A report exists for each study. Access to this data and reports is variable and depends on the initial agreement/contract that DLWC had with the contractor. It is suggested that it is best to use this data as part of a larger integrated multi-attribute study.

The following is a summary of the studies available in the South-West Slopes region:

3.2.1.1 Murrumbidgee

A project was undertaken by DLWC called “Electromagnetic Surveys for Catchment Planning” that involved 16 surveys covering a total of 12,300 ha.

Reports associated with each survey are held by DLWC. Appendix 5 contains a listing of EM surveys carried out in the Murrumbidgee Catchment for the period 1990-99.

EM surveys in the Murrumbidgee catchment have been integrated into the salinity mapping by C. Howarth (2002).

3.2.1.2 Murray Catchment

The listing of EM surveys in Appendix 5 also includes surveys undertaken in the Murray Catchment.

Some ground EM work has been undertaken as part of the CSIRO Heartlands Project in Billabong Creek Catchment (see more information on the Heartlands Project in Section 3.3.5). A small EM34 survey, as well as downhole EM39, was done at Simmons Creek (English et al., 2002 (draft)) and Ten Miles Creek to support the development of a hydrogeological conceptual model for future groundwater modelling in the region. The output of this data is in hard copy, not digital format.

3.2.1.3 Lachlan

Forty-six EM surveys have been undertaken in the Upper Lachlan Catchment – 43 three of them are EM 31 and three are EM38 surveys. Most of these surveys have associated reports. Hard copy maps and reports are available (contact details on Excel spreadsheet – see Appendix 3). Metadata statements have been derived for some of the coverages. The following is a listing of the studies undertaken since 1997:

Bangaroo EM31 – property and group scales
Woodstock EM31 - property and group scales
The Islands EM31 - property scale
Frogmore EM31 - property scale
Garland EM31 - property and group scales
Narrawa EM31 - property and group scales
Belubula EM31 – property scale
Bevendale EM31 - property and group scales
Breakfast Creek EM31 – property scale
Boomey EM31 - property and group scales
Carcoar SGS site EM31 – property scale
Cranbury EM31 - property and group scales
Darby’s Falls Park EM31 – property scale
Kangaroo Flat EM31 – property scale
Lake Cargelligo EM31 – property scale

Murringo EM31 – property and group scales
Torrington EM31 – property scale
Walli Limestone EM31 – property scale
Woodsflat EM31 – property and group scales
Cowabbie Creek EM31 - property and group scales
Aloolak EM31 – urban scale
Avoca EM31 – property scale
Pattersons Lane EM31 – urban scales
Treasures Vineyard EM31 – property scale
Kiola Vineyard EM31 – property scale
Temora CSIRO site EM31 – property scale
Warrendgong TARGET catchment EM31 – property and group scale
North Darra IDMP EM31 – property scale
Coorumbeen IDMP EM31 – property scale
River View West IDMP EM31 – property scale
St Mary's ADI development EM31 – urban scales
The Rocks EM31 – property scale
Charlotte Vale EM31 – property scale
Kallena and the ACT EM31- property scale
Canowindra EM31 – property scale
Cowra Shire Council EM31 – urban scale
DLWC CNR in Cowra EM31 – property and group scales
Cudal EM31 – property and group scales
Cudgell Creek EM31 – property and group scales
Tyagong and Brundah Creeks EM31 – property and group scales
Dairy Park EM31 – property scale
Mamagong and Tumbleton Creek EM31 – property and group scales
Lachlan Farm Forestry Sites EM38 – property scales
Mamildra EM38 – property scale
Forbes Sale Yards EM38 – urban scale.

3.2.1.4 Central West

The Central West has an EM mapping component of the Central West Community Support Project where EM31 surveys are undertaken for Landcare groups in order to provide priority appraisal to direct salinity action. Each of the following surveys has an associated report and these reports are confidential to the client (unlike the freely available EM survey information in the Lachlan Catchment). There are no metadata statements associated with this work. This list covers surveys undertaken in the past 6 years.

Arthurville
Barbigal
Barneys Reef
Belgravia
Bingman- Rylstone
Bodangora
Burgoon

Boomey Lane
Boomley Valley
Butheroo – Mendooran
Camboon- Rylstone
Comobella
Cooks Myalls
Cundunbul _ Stage 1
Cundumbul – Stage2
Dennykymine
Dubbo – Troy Gully
Dubbo- Consultancy for Developers- 10
Dunville Loop
Easterfield
Eurimbla
Hervey Ranges- Stage 1
Hervey Ranges- Stage2
Merry Glen
Myrangle- Cumnock
Mudgee- 4 surveys around urban area
Narangerie
Nubrygyn
Saddle Back
Saxa
Scenic Road
Snake Gully
Spicers Creek
Suntop
Ten Mile Creek – Alectown
Toongi
Windmill Creek
Yahoo Peaks
Yeoval
Bakers Swamp

3.2.2 Airborne Electromagnetic Surveys

In the South-West Slopes region, Billabong Creek was selected as a site for Airborne EM data capture (2002). The Murray Darling Basin Commission (MDBC) are the official custodians of this data under project D2018 – Airborne Geophysics (MDBC contact details in Appendix 2 and on Excel spreadsheet – see Appendix 3). Geoscience Australia also hold the data. The Airborne EM study includes the acquisition of digital elevation, magnetics and, in some smaller areas, radiometric data. The data will be utilized with other data in multi-attribute studies being undertaken by the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (Geoscience Australia as part of CRC LEME) and CSIRO (see Section 3.3.7).

At this stage it is uncertain what other area/s in NSW Airborne EM will be flown and if that will include other parts of Central and South West NSW.

Geoscience Australia (GA, formerly AGSO), as part of CRC LEME, use Airborne EM and drilling data to study depositional landscapes and Airborne Radiometrics with terrain analysis/DEM's to study erosional landscapes.

ASTER data (thermal and visible bands) is also utilized in these studies. The ASTER data is used to map waterlogged areas. The methodology used is to map green vegetation during the summer months when everything else is dry.

Information and accessibility to this data varies. It is recommended that contact be made directly with the Project Manager for further details (contact details in Excel spreadsheet - see Appendix 3). More detailed information on the technical specifications can be obtained from other contacts listed in the spreadsheet referred to in Appendix 3.

3.2.3 Borehole Groundwater Level Mapping

In some regions, areas underlain by shallow watertables (usually within 2 m of the ground surface) are considered to be at risk of salinisation. Maps, based on mapping borehole groundwater levels, are sometimes used as salt outbreak maps.

Shallow groundwater level mapping has been undertaken by DWLC in Tarcutta Creek catchment (D. Pepper, pers. comm.). This mapping is to be used as part of an economic analysis in this catchment. The mapping is based on salinity mapping and some groundwater levels.

In some studies, (NSW component of the National Land and Water Resources Audit - NLWRA) the depth to watertable is used to generate process models based on landscape position to infer the current distribution of salt outbreaks. These maps may be referred to as modelled current salinity outbreaks. By their very nature, they must be viewed as highly speculative. A copy of the metadata for the NSW Dryland Salinity Assessment 2000, which utilised this approach, is in Appendix 4.4.

3.3 Modelled Current Outbreaks and Future Areas at Risk

There are a variety of projects being undertaken at various institutions that involve the modelling and prediction of salinity. Some of these methods utilize data acquired in the aforementioned sections and some do not.

3.3.1 FLAG

DLWC now possess a geo-spatial data set derived by the FLAG model (Fuzzy Landscape Analysis GIS). FLAG is a CSIRO developed spatial model (Dowling, 2000) that uses topographic information in the form of a Digital Elevation Model (DEM) to rapidly assess soil wetness in landscapes. This is without the direct use of process models. The wetness index is based on topography that reflects the same processes that lead to salinisation and water logging, including rainfall, vegetation, soils, geology and geomorphology. (Watson, 2002)

FLAG has been used in regional basin-wide salinity hazard mapping exercises (see Murray Salinity Report (Watson, 2002) and Murrumbidgee Salinity Mapping Report (Howarth, 2001) for regional applications) and in CATSALT models.

A report by Summerell et al. (2002, draft) includes maps (GIS output coverages) of the Murray, Murrumbidgee, Lachlan and Macquarie catchments wetness indices.

Additional information on the FLAG technique was to be provided by DLWC, but was not available at the time of printing. For further information on FLAG, contact G. Summerell, CNR-DLWC (see Appendix 2 for contact details).

3.3.2 CATSALT

CATSALT focuses on salt storage and salt movement in the landscape and its relationship to landuse change and hydrology. The following section on CATSALT has been extracted from Watson, 2002, paraphrased from Beale, 2001.

CATSALT is a suite of models integrated into a comprehensive modelling framework, which can be used to assess the cumulative impact of landuse changes made across catchments. A core functionality of CATSALT is the calculation of historical salt loads and the provision of such information at a micro, macro and intermediate scale……It also serves as an input to more comprehensive decision support models including economic and social analysis.

Additional information on the CATSALT technique was to be provided by DLWC, but was not available at the time of printing. The information presented above was summarised from published reports. For further information on CATSALT, contact G. Beale, CNR-DLWC (see Appendix 2 for contact details).

3.3.3 Murray Catchment Salinity Study

A recent report (Watson, A., 2002), titled “NSW Murray Catchment Salinity Report”, provides detailed information on the application of a GIS based model to determine the salinity risk of the sub-catchments of the Eastern Murray evaluation area. The model utilized the primary datasets DEM, sub-catchment boundaries, geology and soils and land use (included erosion/land use mapping) to create three derived datasets:

- Sub-catchment wetness – using the FLAG model
- Salt source potential – based on geology and soils data; and
- Effective perennial cover – using land use data to determine leakage to groundwater systems

The wetness hazard and leakage hazard layers were assigned scores, respectively, and then summed to determine the salinity risk for each sub-catchment in the Eastern Murray. A salinity risk map was then produced. Salt source potential was considered separately. This work is providing a geographical focus for land management action and research directions.

The output of this work is at a sub-catchment scale – ie a salinity risk class has been assigned for whole sub-catchments. The output data is not useful for detailed, spatially explicit projects.

3.3.4 Salinity Risk Assessment of the Central West Catchment

In a similar study to the one mentioned above, Humphries (2000) produced a risk assessment of the Macquarie, Castlereagh and Bogan River Catchments. This study also relied upon a composite index approach using GIS coverages. The resolution of the output was at sub-catchment level and was therefore not spatially explicit, e.g. the risk for the Bell River sub-catchment was assessed.

It is understood that similar work was done for the Lachlan Catchment, but the report was not sighted for this study.

3.3.5 DiSHMoP – UCAN

DiSHMoP, the Dryland Salinity Hazard Mitigation Program, is a program run by L. Moore at University of Canberra. It is a “student-centered learning program” where students produce regolith landform maps as a land management tool for DLWC and Landcare. Salinity affected woodlands are included in the studies. DiSHMoP are moving into characterization of vegetation linked with landforms in the Central West region.

With respect to salinity outbreaks, the work can be used to assist in inferring and modelling salinity outbreaks – but is not directly about mapping salinity outbreaks. The regolith maps value-add to EM surveys to assist in developing land management strategies. The regolith mapping projects are usually at small upland catchment scale, 30-200 km2, and are mapped at 1:10 000 to 1:15 000 with the output at 1:25 000.

A reference list of the projects undertaken in 2001 and 2002 is in Appendix 7. The data is currently available through DLWC or the relevant Landcare group. They are in the process of being published as CRC LEME reports.

3.3.6 CRC LEME Salt Mapping Consortium

Geoscience Australia (GA), as part of the CRC LEME Salt Mapping Consortium, undertake multi-attribute analysis of a range of geoscience and salinity data in the service of modelling and improving the understanding of salinity processes and salinity hazard.

Geoscience Australia is in the final stages of completing their report on the Gilmore project. This work involved a multi-disciplinary approach to mapping

salinity systems and groundwater processes and is considered to be a model providing the scientific underpinning for further work in uplands areas. Earlier publications on this work can be found in AusGeo News and "Victoria Undercover – Benalla 2002" (Phillips and Ely, 2002). GA's final Gilmore report is due out by the end of this year.

GA's strength and focus is in the interpretation of airborne EM and radiometrics and relating that data to regolith in the landscape. They look at erosional and depositional terrains and attempt to better understand the processes leading to deep and shallow salinity. Essentially, they are mapping salt - where it is and where it moves in the landscape - and they utilize a range of sophisticated mapping/modelling techniques to do this, including 3-D mapping.

BRS and GA are working together on the Billabong Creek area (MDBC funded). Billabong Creek was recently flown for airborne EM and this data will feed into other salinity work being done by these two institutions. GA will be following a format similar to the Gilmore study. BRS is studying the relationship between geology, topography, groundwater systems and climate. A range of data is used in these studies, many of it derived from local/DLWC data sources. The data includes AEM, bore data, stream sampling, DEM, geology, regolith, topography and climate data. Analysis involves a variety of known mapping and modelling techniques.

3.3.7 CSIRO Heartlands Project

The Heartlands Project involves four focus catchment projects where catchment-scale water balance modelling is utilized to develop management options. Two of these focus catchments are located in the South West Slopes region: Billabong Creek, Murray Catchment Management Region and Kyeamba Creek, Murrumbidgee Catchment. Billabong Creek is due to have more work undertaken on it as the study will include the recently flown Airborne EM data.

Using existing data, direct measurement and inference, a conceptual hydrogeological model is developed that can then be used for quantitative hydrological/hydrogeological modelling. Some soil mapping has been included as part of the study. New work aims at modelling the link between the groundwater and the surface systems. The overall aim is to assist in making recommendations for land use change that are spatially explicit, to monitor environmental outcomes and to support ongoing adaptive management processes.

The draft report (English et al., 2002) on the hydrogeological conceptual model derived for Simmons Creek (in the Billabong Creek Catchment) is complete. A ground EM survey was undertaken for that study. The Ten Miles Creek study (also in Billabong Creek Catchment) is in progress.

3.3.8 Other CSIRO Modelling Work in the South West Slopes Region

Work undertaken by CSIRO and BRS, modelling the future extent, hazard and risk of salinisation in the Billabong Creek Catchment, using spatially explicit Flowtube, was published in 2001 as part of the National Land and Water Resources Audit Theme 2 – Project 3 on Catchment Groundwater Modelling and Water Balance. The work contains predictive modelled output on rising water levels down selected flow paths in the Billabong Creek catchment.

The reference is:

Baker, P. et al., 2001. *Assessment of Salinity Management Options for Upper Billabong Creek Catchment, NSW: Groundwater and Farming Systems Water Balance Modelling*, Report for the NLWRA, Canberra.

This report can be located on the National Land and Water Resources Audit website at www.nlwra.gov.au.

3.3.9 Soil Landscape Mapping – DLWC

The DLWC Soil Survey Unit is analysing multi-attribute data from soil landscape mapping that includes mapping, inferring and modelling salinity outbreaks. The process involves the integration of soils data and information for the assessment of recharge and discharge areas. They are also working on the assessment of salinity hazard and soils at risk.

On a technical level, the projects involve identifying leached soils with low PAWC, high K_{sat} and soils that are acidic. It is assumed that these attributes together are more likely to characterise a soil that allows high level of deep drainage. Sodic soils are assumed to be associated with past locations of discharge sites and saline saturated soils. A range of geophysical techniques is also used including EM and radiometrics.

Work is currently in progress.

3.3.10 DLWC - Salinity Hazard – Weights of Evidence Method

CANRI documents the metadata for a statewide Salinity Hazard Map compiled by J. Bradd using the Weights of Evidence Method (Bradd et al., 1997 and CANRI metadata statement: 1999). There is a lack of information about the specific input data utilized in this mapping/modelling procedure and the positional and attribute accuracy is defined as ‘very broad scale with borders not very accurate’.

Separate smaller studies were carried out on the Boorowa River (upper Lachlan) (Evans and Bradd, 2001(unpub)). and Little River (Mid-Macquarie) Catchments. These studies employed the same techniques as the statewide approach, but used more detailed data.

4 DISCUSSION

4.1 Direct Methods

The Dryland Salinity Outbreak Project is considered by the authors to be the only direct method identified during the course of this study.

The mapping of salinised sites has a history of being patchy and of variable quality and scale. The Dryland Salinity Outbreak project is aimed at addressing this problem by instigating a more comprehensive approach to salinity mapping. At this stage of reporting we have insufficient information to be able to comment on the degree of coordination and standardisation of mapping methods between the catchments. This is an area that requires further investigation.

The method employed in the outbreak mapping relies heavily on an implicit conceptual model of landscape behaviour to salinisation processes. The process will work best in landscapes where this model is understood, but may perform poorly in landscapes that are new to the mapper. It is therefore critical that appropriately experienced people undertake this style of work.

The results from the survey questionnaire show that there is a large amount of data being collected in the areas of interest related to dryland salinity. The data ranges from the collection of very detailed information at the paddock scale, to projects producing inferred information at regional scale. It is salutary, however, to realise that there have been no projects collecting comprehensive data at a regional scale. The corollary of this is that there are no data sets that satisfy the data requirements for determining impacts of salinity on terrestrial biodiversity, particularly woodland health.

4.2 Indirect Methods

There is also a range of programs that are part of the dryland salinity effort that use indirect methods. These are not generally relevant to biodiversity. In some instances data sets have been collected/generated that relate to salinity hazard/risk, while others are concentrating on mapping or inferring recharge zones.

In particular, there is a large effort going into the collection of EM data at both a local and regional scale. Some of this data is being proposed as salinity mapping *per se*. It is our view that this may be misleading. EM mapping is a valuable tool to map the salt stores in affected landscapes. From Section 1.3 it can be seen that knowledge of the hydrologic imbalance is required as well as knowledge of the distribution of salt stores.

4.3 Data Quality and Usefulness

Some simple (and somewhat subjective) observations about the data and approaches can be made, in terms of the data quality and usefulness (see

Section 2.3 for the criteria). These observations are based on both the quality of the data and its relevance to determining impacts of salinity on biodiversity.

The majority of projects, as described above via the questionnaire responses, would be classed as Category B data for the purposes of this report. That is, they are either of a restricted spatial nature, are measuring surrogate variables that are not relevant to biodiversity assessments or are producing outputs that are spatially lumped, i.e. at sub-catchment scale. At this point in time, there would appear to be no Category A data sets, as defined in Section 2.3, for this report, being produced except possibly for components of the Dryland Salinity Outbreak Project. However, it is not possible to concisely describe the usefulness of the outputs of this project until more detail has been released on a Statewide or regional basis.

It is extremely difficult for this study, based on the scant information available, to make any judgement on whether individual projects are being undertaken according to best practice using appropriately skilled people. This is not meant to denigrate the efforts of those people working on the projects reported here. Rather it is a comment on the disconnected and piecemeal approach to salinity mapping by a range of organisations across the area of study.

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from this study.

- Generally, there is a piecemeal and disconnected approach to salinity mapping in the four catchments surveyed. The work is being carried out by many organisations and agencies and appears to not necessarily be producing the outputs that are required for comprehensive natural resources management.
- This study recommends that guidelines/standards for salinity mapping be generated so that there is an agreed approach to what is mapped and how it is mapped, along similar lines to soil mapping standards. This could be achieved by a workshop involving relevant people working in the field. Such a workshop should address current standards of salinity mapping and what is needed to produce useful datasets of current and predicted areas (including woodlands and other remnant native vegetation areas) likely to be affected by salinity in order to investigate the impacts of salinity on biodiversity.
- Much effort has been invested in the collection of both ground-based and airborne EM data. Some of these products are being marketed as salt maps. This data is of little use to investigating impacts of salinity on biodiversity as it is an indirect method that does not necessarily produce salinity maps, and its coverage is very limited. As well, ground-based EM methods have not been used to map in heavily timbered areas.
- There are no broad scale data that show the current distribution of salinity outbreaks that is of direct relevance to investigating impacts of salinity on biodiversity. Information is currently being collected by a Statewide project on Dryland Salinity Outbreak Mapping. However, it is understood that no data is likely to be collected specifically for woodland areas as part of this project, and the time to complete the project is still sometime into the future.
- There is a large range of projects that are producing information that is essentially describing salinity risk. The output from these projects is, again, of little use for the assessment of the impacts of salinity on biodiversity as they produce lumped risk assessments at landscape or sub-catchment levels. Salinity risk at anything but the local scale is not a good indicator of the spatial distribution of salinity outbreaks.
- It is recommended that the NPWS Salinity and Biodiversity project work closely with the DLWC Salinity Outbreak Mapping project to ensure that the resolution and scale of the outputs are relevant, and that the timing of the outputs is appropriate to the NPWS project. As well, some discussion should commence regarding the task of assessing salinity in woodlands, especially in key areas.
- This study recommends that there be discussion by relevant people about what is mapped in salinity mapping projects and how this is done, keeping in mind the needs of the users of the maps/data. This should include having regard for what needs to be done to provide

adequate data for those investigating the impacts of salinity on biodiversity.

6 REFERENCES

A listing of publications on salinity, relevant to the Yass region, is in Appendix 5.

A reference list of the DiSHMoP (University of Canberra) projects 2001-2002 is in Appendix 7.

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APPENDIX 1: SURVEY QUESTIONNAIRE

Questionnaire for Salinity Mapping and Modelling, Data Collation and Documentation

INTRODUCTION

This questionnaire has been designed to collect, collate and document information about past and present projects undertaking mapping, modelling and prediction of locations of dryland salinity, including salinity hazard mapping, in inland New South Wales (Central West, Lachlan, Murrumbidgee and Murray Catchments). The primary emphasis is on salinity discharge areas but information on mapping and prediction of recharge areas is also requested. This questionnaire relates only to dryland salinity (as opposed to irrigation salinity) and does not include any river salinisation.

This work is being undertaken by Salient Solutions Australia Pty Ltd (Ray Evans, Patty Please) for New South Wales National Parks and Wildlife Service as part of a broader project to look at links between biodiversity and salinity. A copy of the resultant report to NPWS will be available on request on completion of the project.

Please fill out one questionnaire for each salinity mapping, modelling or EM project. We would appreciate the return of this questionnaire by **Tuesday, 28 May 2002.**

. email to patplease@netspeed.com.au ,
. fax it to 02-6255-8192 or
. send it by mail to Patty Please, 28 Banfield St., Downer, ACT, 2602.

If you have any queries, please contact Ray Evans on 6255-8901 or Patty Please on 02-6255-6697.

1. Have you undertaken or are you undertaking any work that relates to: (tick boxes)

   a. Mapping of salinity outbreaks ☐
      Were salinity affected woodlands included in the outbreak mapping Y / N
   b. Inferring salinity outbreaks ☐
   c. Modelling salinity outbreaks ☐

d. Acquisition of EM data – ground or airborne ☐

e. Defining future extent, hazard or risk ☐

2. Title of Project:

3. Current Contact Officer for work:

4. Aims/goals of project:

5. Location or extent of area covered, including a map if possible:

6. Reference/Name of Report detailing the work:

7. Could you provide more details of the project via email or fax (circle one)?

Yes No

Your email address
Your fax number
_____

8. Detailed information on **SALINITY** Data

The following information was collected for (circle one):

Modelling Mapping or Inference EM

a. What was the methodology?

b. Who undertook the analysis?

c. When was it undertaken?

d. What data was used?

e. What was the scale of input and output (modelling)?
What was the scale of data capture (mapping)?
What was the detail of data capture (EM)?

f. What was the area to which the data was extrapolated (modelling)?

g. If output data was made digital, how and what system (see below for providing GIS specifications)?

9. Are the results available to people outside your organisation and who should be contacted to obtain it ? How would we go about obtaining this data (including licence agreements)?

10. Is there a metadata statement (attach a copy if possible – example of metadata statement at end of questionnaire)?

Is the metadata accessible through the Australian Spatial Data Directory www.auslig.gov.au/asdd?

What is the ANZLIC Unique Identifier for the metadata on the ASDD?

11. If no metadata statement, is there any known quality statement attached to the data?

12. For GIS Coverages: Please define the following specifications/requirements:

a) Sender (name, organisation, contact details)

b) Owner (name, organisation, contact details)

c) Shape files or image files or grids?

d) Scale and resolution of mapping

e) Any background info about the origin, age, reliability etc of input data

f) Any restrictions on usage

g) Projection info
   (1) Projection
   (2) Datum
   (3) Map units
   (4) Spheroid
   (5) 1st standard parallel
   (6) 2nd standard parallel
   (7) central meridian
   (8) latitude of projection's origin
   (9) False easting (metres)
   (10)False northing (metres)

EXAMPLE OF METADATA FOR A DATASET

Title

Custodian

Jurisdiction
Australia

Contact Address

Contact Organisation

Contact Position

Mail Address
-

Suburb/Place/Locality

State

Country

Postcode

Telephone

Facsimile

Electronic Mail Address

Description

Abstract
**********DATASET
ABSTRACT********

****
****

Searchwords

Geographic Extent
109.0594 -42.7320
156.7982 -42.7320
156.7982 -8.6766
109.0594 -8.6766

National

Scale 1 : 250000

Description of DOUBLE precision coverage nap_updatev2

FEATURE CLASSES

Feature Class	Subclass	Number of Features	Attribute data (bytes)	Spatial Index?	Topology?
ARCS		13102	32		
POLYGONS		5943	128		Yes
NODES		12997			

SECONDARY FEATURES

Tics	9
Arc Segments	457813
Polygon Labels	5942

TOLERANCES

Fuzzy = 0.000 V Dangle = 0.000 V

COVERAGE BOUNDARY

Continue?
Xmin = -2181045.418 Xmax = 1824999.194
Ymin = -4965713.603 Ymax = -1189958.679

STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

COORDINATE SYSTEM DESCRIPTION

Projection LAMBERT
Units METERS Spheroid AUSTRALIANNATIONAL
Parameters:

1st standard parallel	-18 0 0.000
2nd standard parallel	-36 0 0.000
central meridian	135 0 0.00
latitude of projection's origin	0 0 0.000
false easting (meters)	0.00000
false northing (meters)	0.00000

Dataset Currency

Beginning Currency Date
Not Known

Ending Currency Date
Current

Dataset Status

```
-------------
 Status
In Progress

Maintenance and Update Frequency
As required
```

Access

```
------
Stored Dataset Format
DIGITAL Arc/Info 8.0.2 under SunOS

Available Format Types
DIGITAL - ARC/INFO

Access Constraints
Partially Restricted .
```

Data Quality

```
------------
 Positional Accuracy
100 m to 1 km

 Attribute Accuracy
High

 Logical Consistency
Full

Completeness
Full

Metadata Date
11-FEB-2002

Further Information
```

Lineage

```
********************************DATASET
LINEAGE********************************

**************************************************************************
***********
```

Attribute Metadata

```
------------------

Table Name
Item Name
SYMBOL
Item Definition
Description

Table Name
Item Name
Item Definition
100,100,C,0
Description

Table Name
Item Name
```

```
Item Definition
Description
```

APPENDIX 2: LIST OF RESPONDENTS

Name	Org	Locality	Region Catchment	Ph:	Email
Alan Nicholson	DLWC	Wellington	Central West & Lachlan	02 6845 2488	anicholson@dlwc.nsw.gov.au
Andrew Wooldridge	DLWC	Cowra	Lachlan	02 6341 1600	awooldridge@dlwc.nsw.gov.au
John Franklin	DLWC	Yass	Murrumbidgee	02 6226 1433	jfranklin@dlwc.nsw.gov.au
Chris Howarth	DLWC	Cootamundra	Murrumbidgee	02 6942 4977	chowarth@dlwc.nsw.gov.au
Darice Pepper	DLWC	Leeton	Murrumbidgee	02 6953 0700	dpepper@dlwc.nsw.gov.au
Prem Kumar	DLWC	Leeton	Murrumbidgee	Answered by D. Pepper	pkumar@dlwc.nsw.gov.au
Rod Sewell	DLWC	Wagga	Murrumbidgee/ Murray EM	02 6293 0446	rsewell@dlwc.nsw.gov.au
Stuart Lucas	DLWC	Albury	Murray	02 6043 0126	slucas@dlwc.nsw.gov.au
Tony Watson	DLWC	Albury	Murray	02 6043 0115	twatson@dlwc.nsw.gov.au
Geoff Beale	CNR DLWC	Wagga	CATSALT	02 6971 4102	gbeale@dlwc.nsw.gov.au
Greg Summerell	CNR DLWC	Wagga	FLAG	02 6971-4121	gsummerell@dlwc.nsw.gov.au
Keith Emery	DLWC	Sydney	State Outbreak mapping	02 9895 6161	kemery@dlwc.nsw.gov.au
Greg Chapman	DLWC	Parramatta	State Soil Landscape	02 9895 6172	gchapman@dlwc.nsw.gov.au
Peter Baker Dom Galloway	BRS	Canberra	NAP/EM	02 6272 5609 02 6272 4562	peter.baker@brs.gov.au dom.galloway@brs.gov.au
Paul Nanninga	MDBC	Canberra	MDB data	02 6279 0124	paul.nanninga@mdbc.gov.au
Ken Lawrie Colin Pain John Wilford	AGSO/ GA	Canberra	LEME data	02 6249 9847 02 6249 9469	ken.lawrie@ga.gov.au colin.pain@ga.gov.au john.wilford@ga.gov.au
Leah Moore	Uni Canb	Canberra	Regolith data	02 6201 5296	lmoore@scides.canberra.edu.au
Hamish Cresswell	CSIRO	Canberra	Heartlands	02 6246 5933	hamish.cresswell@csiro.au
Mirko Stauffacher Pauline English	CSIRO	Canberra	Heartlands – Billabong Catchment	02 6246 5814 02 6246 5858	mirko.stauffacher@csiro.au pauline.english@csiro.au
Peter Golding	NRIC	Canberra	NAP/EM anything else	Done by P. Baker, BRS	peter.golding@brs.gov.au
No Name	ASDD-AUSLI	Canberra	Metadata		www.auslig.gov.au/asdd

APPENDIX 3: SUMMARY OF QUESTIONNAIRE RESPONSES

The questionnaire responses were summarized in an Excel Spreadsheet. Some of the responses from individuals were combined with information from others – i.e. the information from John Franklin on the Yass region was dealt with in Chris Howarth's response on mapping in the Murrumbidgee region. Some other information was awaiting approval at the time this report was due for completion. For that reason, some information was not included

The respondents listed in the spreadsheet have given their approval for the information to be made available to the public.

The spreadsheet is available as a pdf file. For full copy contact sue.briggs@csiro.au

APPENDIX 4: METADATA STATEMENTS

Metadata statements provide a standardised description of geospatial datasets. Metadata statements for New South Wales natural resource data can be searched for at:

www.auslig.gov.au/asdd (asdd - Australian Spatial Data Directory) or www.canri.nsw.gov.au (canri – Community Access Natural Resource Information).

Appendix 4.1 Metadata Statement: Updated Salinity Outbreak Mapping for the Murrumbidgee Valley (from C. Howarth, 2001 – Appendix B)

Category	Element	Description
Data set	Title	Salinity Mapping for the Murrumbidgee Catchment, 2001
	Custodian	Regional Director, Murrumbidgee Region NSW Department of Land & Water Conservation (DLWC) Wagga Wagga NSW Australia 2650
	Jurisdiction	New South Wales, Australia
Description	Abstract	Spatial mapping of where salinity outbreaks occur in the Murrumbidgee Valley and assessments of treated saline sites.
	Search Word(s)	Salinity, Salinity Outbreaks, Dryland Salinity, Irrigation Salinity
	Geographical Extent Name(s)	Limited to the Murrumbidgee Valley, inclusive of the following 1:100 000 map sheets **Fully Completed 1:100 00 Map Sheets** **Gunbar 7929 Kooroongal 8029 Griffith 8129** **Ardlethan 8229 Coleambally 8028 Yanco 8128** **Narrandera 8228 Coolamon 8328 Junee 8428 Cootamundra 8528** **Wagga 8327 Tarcutta 8427 Tumut 8527** **Brindabella 8627** Partly Completed 1:100 000 Map Sheets **Muckerumba 7930 Merriwagga 8030 Ungarie 8230** **Wyalong 8330 Barmedman 8329 Young 8529 Tantangara 8626 Boorowa 8629 Urana 8127 Lockhart 8227** **Walbundrie 8226 Holbrook 8326 Rosewood 8426** **Yarrangobilly 8526 Berridale 8625 Cooma 8725** **Yass 8628 Cobargo 8825 Araluen 8826** **Bombala 8724 Kosciusko 8525 Rankin Springs 8130**
	Geographica	Polygon and Line Features

Category	Element	Description
	l Extent	
Data Currency	Beginning Date	December 2000
	Ending Date	September 2001
Data Set Status	Progress	Completed
	Maintenance & Update Frequency	On going as required for recording of new or overlooked saline areas. Updating every three to five years for the recording of treated saline outbreaks.
Access	Stored Data Format	Genamap binary format
	Available Format Type	Genamap export; ARC Info shape file
	Access Constraint	Unrestricted
Data Quality	Lineage	The data source is an existing series of salinity maps prepared by DLWC for the MCMB area, combined with updating of new and treated areas of salinity not previously mapped. Existing data sets used in the mapping are:- ▪ AJ and E Series, 1989-91 (Source; Landuse and Erosion Mapping) ▪ Binalong, 1998* ▪ Burkes Creek, 1992-93* ▪ Coolac (draft), 2000* ▪ Cootamundra (draft),1999* ▪ Cunjegong, 1998* ▪ Downside,1992* ▪ Houlaghans Creek, 1992* ▪ Jindalee/Muttama, 2000* ▪ Junee 1, 1998* ▪ Junee 2 (draft), 2000* ▪ Kyeamba, 1996 (Source; Salinity Update Mapping) ▪ Reedy Creek, 2000 (Source; Salinity Update Mapping) ▪ Salt Clay Creek,1998* ▪ Sandy Creek, 1992* ▪ Spring Creek,1999* ▪ Strontian Road, 1992/93* ▪ Tarcutta Creek, 2000* ▪ Tarcutta and Rosewood, 1:100,000 sheets, 2000 (Source; Salinity Update Mapping) ▪ Wagga Wagga, 1996-97* ▪ Wantiool Creek, 1995* ▪ Wattle Creek, 1994* ▪ Yass, Salinity Abatement Demonstration, 1992* ▪ Yass Valley, 1992* ▪ Young (draft), 2000 (Source; Land Use Mapping) *Denotes Multi-Attribute Mapping as the source Mapping was done using air photo interpretation to determine spatial boundaries, combined with field checking and field testing of water and/or soil

Category	Element	Description
		samples to determine salinity levels of the areas identified from the air photos. Areas of treated saline outbreaks were identified either by air photo interpretation or field checking. New line work for updating the base maps was drawn on 1:25,000 or 1:50,000 topographic maps, whereas the published scale for the Updated Salinity Map is 1:600,000.
	Positional Accuracy	50 metres for the original DLWC mapping.
	Attribute Accuracy	All attributes described at the primary level, with only treated saline sites being described to a secondary level.
	Logical Consistency	All lines and polygons are tagged. Topological consistency is performed as part of the quality assurance procedures using Genamap.
	Completeness	Complete
Contact Information	Contact Organisation	New South Wales Department of Land & Water Conservation
	Contact Position	Regional Director, Murrumbidgee Region
	Mail Address	P.O. Box 10 Wagga Wagga NSW 2650
	Locality	Wagga Wagga
	State or Locality 2	NEW SOUTH WALES
	Country	AUSTRALIA
	Postcode	2650
	Telephone	02 6923 0400
	Facsimile	02 6921 7308
	Electronic Mail Address	Wford@dlwc.nsw.gov.au
Metadata Date	Metadata Date	23rd October 2001
Current List of Salinity Outbreak Codes Used in the Data Set, Primary Level		
Polygons		
015		Saline Plant Indicator Species
025		Scalded Saline Land
045		Sheet and Rill Eroded Saline Land
115		Saline Plant Indicator Plant Species (Irrigation areas)
125		Scalded Saline Land (Irrigation areas)
145		Sheet and Rill Eroded Saline Land (Irrigation areas)
Line Features		
055		Minor Gully Erosion with Salting
065		Moderate Gully Erosion with Salting

Category	Element	Description
075		Severe Gully Erosion with Salting
085		Extreme Gully Erosion with Salting
Prefixes Used with Salinity Outbreak Codes to Describe Data Sources Used		
aj		Data from original Land Use and Erosion Survey (AJ series), 1988 to 1991.
z		Data from various Multi Attribute Mapping Projects
sl		Updated Mapping for the Tarcutta and Rosewood 1;100 000 Sheets, 2000 by S Lucus. A suffix was also added to these codes only, which described the age of the salinity outbreak; a: 2-5 years old, b: 5-20 years old, c: >20 years old
k		Data from Kyeamba Mapping
y		Data from Young 1:50 000 Map sheet, Water Management Fund Project, 1999.
su		Updated Salinity Outbreak Mapping, 2001.
Current List of Salinity Treatment Codes Used in the Data Set, Secondary Level		
A		Fencing Only
B		Fencing with Salt Tolerant Pasture
C		Fencing with Salt Tolerant Trees and Shrubs
D		Fencing with Salt Tolerant Trees, Shrubs and Pastures
E		Fencing with Salt Bush Only
F		Fencing with Salt Tolerant Trees , Shrubs, Pasture and Salt Bush
G		Salt Tolerant Pasture
H		Drainage or De Watering Systems
I		Drainage or De Watering Systems with Salt Tolerant Vegetation

Appendix 4.2 Metadata Statements for Murrumbidgee and Murray Land and Water Management Studies

Metadata statements exist for sixteen Land and Water Management Studies undertaken in the Murrumbidgee Catchment. These were multi-attribute mapping projects where salinity mapping was undertaken as part of the erosion mapping. The salinity outbreak information from these studies has been incorporated into, and usurped, by the Salinity Mapping in the Murrumbidgee Catchment report (C. Howarth, 2001).

Information about the Land and Water Management datasets can easily be located on the CANRI or ASDD websites by searching under the names listed below. (web addresses in introductory paragraph of Appendix 4).

Binalong
Bredbo Landcare Area
Cunjegong
Downside
Houlaghans Creek
Junee Urban
Kyeamba Valley
Mid-Murrumbidgee (composite)
Salt Clay
Sandy Creek
Strontian Road Landcare Group
Upper Burkes Creek
Upper Murrumbidgee (composite)
Wantiool Landcare Group
Wattle Creek
Yass Valley

Metadata statements for the ten Land and Water Management Studies undertaken in the Murray Catchment (NSW) can also be located on the CANRI or ASDD website. The names of the studies are:

Bungowannah Landcare
Burrumbuttock Creek
Little Billabong – Holbrook
Long Plain Creek
Majors Creek
Mullengandra
Sawyers Creek
Thugga Lane
Upper Murray/Billabong
Yarra Yarra

Appendix 4.3 Metadata Statement for NSW Erosion – Landuse Survey

(compiled by G. Ashton, 1999 for Dubbo Salinity Symposium)

This Erosion – Landuse dataset is a compilation across large parts of NSW of other datasets (including the Murrumbidgee and Murray Land and Water Management Studies listed in Appendix 4.2). It is not a 'statewide survey' as data does not exist for the whole state. It is for use at approximately 1:2 000 000 scale.

The metadata statement for this survey can be located on CANRI or ASDD using ANZLIC Unique Identifier ANZNS0359000148.

Appendix 4.4 Metadata Statement for NSW Dryland Salinity Assessment 2000

DATASET

Unique Identifier
ANZCW1202000023

Custodian
Department of Land and Water Conservation (DLWC)

Jurisdiction
New South Wales

DESCRIPTION
Abstract
The data shows areas of dryland salinity risk in 2000, 2020 and 2050 in the Murray-Darling Basin within NSW and coastal NSW catchments.

Areas of risk are based on groundwater levels and air photo interpretation. The merged data, at a nominal scale of 1:250 000, show actual areas where dryland salinity or watertables less than 2 metres have been measured. For the extent map, every delineated area is underpinned by either air photo data or by one or more groundwater bores. Therefore, the area at risk is regarded as conservative due to limitations in the spatial coverage of air photo and bore data. A number of techniques to spatially extrapolate these data to infer potential areas at risk were trialed but were considered scientifically or statistically inadequate. Estimates of impacts are based on areas at risk having groundwater levels of less than 2 m. An impact assessment based on groundwater less than 5 m and rising was considered inappropriate. Total areas affected with groundwater less than 5 m and rising have been presented, but only for improved consistency with other States.

Coastal catchments are not represented in the prediction for 2050 due to the paucity of groundwater data on which to make the estimates.

Search Word	Qualifier
GEOSCIENCES Geomorphology	Monitoring
SOIL	Monitoring
SOIL Chemistry	Monitoring
SOIL Physics	Monitoring

Bounding Coordinates
North: -28
South: -38
East: 154
West: 141

DATA CURRENCY
Beginning Date
01-Jan-1980

Ending Date
23-Oct-2000

DATASET STATUS
Progress
Complete

Maintenance & Update Frequency
Not Planned

ACCESS
Stored Data Format
DIGITAL - Arc/INFO grid

Access Constraints
All products derived from these data must include the disclaimer: The Commonwealth and all suppliers of data used to derive the maps of "NEW SOUTH WALES - DRYLAND SALINITY ASSESSMENT 2000" do not warrant the accuracy or completeness of information in this product. Any person using or relying upon such information does so on the basis that the Commonwealth and data suppliers shall bear no responsibility or liability whatsoever for any errors, faults, defects or omissions in the information.

DATA QUALITY
Lineage
To derive a current watertable map, bore data from 1980 to 2000 were considered, a total of 7036 bores.

Groundwater level data were used to estimate its rate of rise. Bore data was collated from several sources including the Department's Corporate Groundwater Data System and regional data sets supplied by Regional Hydrogeologists.

The number of bores eventually collated included bores with 2 temporal (2-point) and 3 or more temporal water level data (3-point). Groundwater and salinity data from a series of reconnaissance surveys in the late 1980's and early 90's formed the basis of these data.

Those bores where a third temporal data value existed were limited predominantly to the Central West Region with the Macquarie and Lachlan Catchments containing some 88% of those bores measured with the third point being collected a short time before the commencement of this project (ie late 1999). Rate of rise has been estimated from water levels measured during these reconnaissance surveys and water-levels measured at the time of bore construction.

For many parts of NSW, current saline outbreaks have been mapped from aerial photography. The data collected from 1990s aerial photography was digitised, compiled and joined into single coverage. Although the data represents an incomplete spatial coverage of NSW, it contains data for many areas of NSW where dryland salinity is considered a major issue.

For graphical display of maps, the data were aggregated to occurrences within 1 km grid cells.

To calculate watertable maps for 2020 and 2050, rates of watertable rise were required. Data from each of the 1273 monitored bores was analysed to estimate the average annual rate of rise (ie. cm per year). Rates of rise were compiled for each groundwater flow system in each of the eastern Murray-Darling Basin catchments.

The detailed methodology for this assessment is at:

http:://audit.ea.gov.au/ANRA/land//docs/state/NSW/NSW_DrylandSalinity_summary.html

Positional Accuracy

The method of analysis ensures that each identified area is underpinned by actual data. However, we realise that both the production bore data and air photo data are spatially incomplete. There are some areas where data is severely lacking. Consequently, we have confidence in those areas we have identified as current risk, but there will be other areas within NSW where there is currently saline outbreaks and shallow watertables occurring. But since no data set comprehensively covers all areas of NSW, some areas will have been missed in the analyses. Therefore, the results should be viewed as minimum or conservative values.

The strengths of the adopted approach are:

- Each delineated area identified in the analyses is underpinned by measured data; either bore data or from aerial photography,
- no spatial extrapolation to artificially infer other areas of shallow watertables was undertaken,
- depth to watertable, rather than watertable elevation was considered for all bore analyses,
- approach is conservative, in that it only focuses on areas where we have measured data and ignores areas where we have no data, and
- method reflects the quality and quantity of available data; we did not push the analyses beyond the accuracy of available data.

The limitations of the adopted approach are:

- The extent of dryland salinity and shallow watertables identified is limited by the spatial extent of data available for this project,
- Effects of topography were unable to be quantified, and
- There is a potential to produce larger areas of flat watertables in areas where the network of bores with similar depths to watertable is sparse.

Attribute Accuracy
Extent00 - predicted salinity extent 2000 - DLWC API mapping of salinity outbreaks for 1990's DLWC depth to watertable modelling results

Extent20 - predicted salinity extent 2020 - DLWC API mapping of salinity outbreaks for 1990's DLWC depth to watertable modelling results

Extent50 - predicted salinity extent 2050 - DLWC API mapping of salinity outbreaks for 1990's DLWC depth to watertable modelling results

Logical Consistency
Not documented

Completeness
The coverage is only for the Murray-Darling Basin within NSW and coastal NSW catchments

CONTACT INFORMATION
National Land and Water Resources Audit (NLWRA)
Technical Director
GPO 2182
Canberra
ACT
Australia
2601

Telephone
02 6257 3067
Facsimile

02 6257 9518
Electronic Mail Address
atlas@nlwra.gov.au

METADATA DATE
23 October 2000

APPENDIX 5: SUMMARY OF GROUND—BASED EM SURVEYS 1990-99 MURRUMBIDGEE CATCHMENT

Total of all E.M 31 Surveys completed =. 54088 hectares

No.	1989/90	No.	1990/91	No.	1991/92	No.	1992/93	No.	1993/94	No.	1994/95	No.	1995/96	No.	1996/99
1	420	1	394	1	176	1	3702	1	960	1	100	1	430	1	200
1	68	1	50	1	203	1	253	1	200	1	1612	1	1650	1	800
1	307	1	360	1	400	1	367	1	350	1	86	1	2800	1	50
1	1236	1	450	1	332	1	733	1	388	1	1	1	2600	1	900
1	144	1	423	1	354	1	161	1	568	1	199			1	2200
1	145	1	149	1	263	1	598	1	625	1	525			1	1000
1	200	1	50	1	348	1	678	1	7	1	1758				
	200	1	261	1	267	1	96	1	440	1	2868				
		1	207	1	1957	1	112	1	450	1	2676			1	1500
		1	101	1	127	1	275	1	127						
		1	117	1	118	1	500	1	1112						
		1	1175	1	165			1	349						
		1	61	1	4436			1	149						
				1	165			1	380						
								1	88						
								1	53						
								1	370						
								1	67						
								1	45						
								1	101						
7	2720	13	3798	14	9311	11	7475	20	6829	9	9825	4	7480	7	6650

Data supplied by Rod Sewell, Murrumbidgee Region, DLWC

APPENDIX 6: BIBLIOGRAPHY OF SALINITY PUBLICATIONS IN THE YASS RIVER VALLEY

This list is not complete but contains references that may be useful to the project work on impacts of salinity on biodiversity, linked to this report.

CALM, 1991. *Yass Dryland Salinity Abatement Demonstration Program* – Final Report for the National Afforestation Program.

Summary: The objectives of this program were to establish and maintain hardwood species as a sustainable land usage; to rehabilitate degraded rural lands, particularly those affected by dryland salinity; to investigate and monitor dryland salinity sources within the demonstration area; and to reduce sedimentation and pollution of rural water resources. A subcatchment within the Yass Water supply was selected as the demonstration area. This included the creek catchment of Dicks, Williams and Sawpit Creeks. The Demonstration Area contained 687 ha of dryland salinity. The dryland salinity within the catchment is a major source of pollution and sedimentation to the Yass River System, the Yass Water Supply, and the Murray-Darling Basin.

CALM, 1992. *Yass Dryland Salinity Abatement Demonstration Program* – Final Report for the National Soil Conservation Program.

Summary: The objectives of this program were to demonstrate to landholders, and the community in general, the economic benefits of controlling dryland salinity. Further to this, other aims were to arrest the extension of dryland salinity and rehabilitate salt-affected lands, demonstrate cost effective salinity control methods, and to establish a range of appropriate techniques to control dryland salinity in the Yass Valley and other similar areas within the Murray-Darling Basin. The Demonstration Area was the same as described above.

Kater, A., Yass Area Network of Landcare Groups, 1998. *Salinity Assessment Mapping Kit – Yass Valley Sub-Catchment.*

A coloured guide sheet, including photos and descriptions for determining whether you have a salt problem, determining how bad your salt problem is, mapping your results, and where to get help with projects.

Murray-Darling Basin Commission, Oct. 1995 and Nov. 1996. *Dryland Research Forum – Murray-Darling Basin Commission Investigations andEducation Program Proceedings*, and

Murray-Darling Basin Commission, Oct. 1997 and Nov. 1998. *Dryland Forum – Strategic Investigations and Education Program*.

Investigations conducted by the Dryland Program of the Murray-Darling Basin Initiative, including projects on issues such as dryland salinity; land use; nutrient management; basin-wide data sets; and development of improved farming and grazing systems.

Nicoll, C. and Scown, J., 1993. *Dryland Salinity in the Yass River Catchment – Processes and Management.* CALM.

Final technical report for the Natural Resources Management Strategy (i.e. Yass Dryland salinity Abatement Program).

Starr, B. *Soil Erosion, Phosphorus and Dryland Salinity in the Upper Murrumbidgee: Past Change and Current Findings*, Upper Murrumbidgee Catchment Coordinating Committee (UMCCC).

Wagner, R., *Dryland Salinity In The South East Region*, Soil Conservation Service (SCS) of NSW.

General salinity information, factors which influence salinity development, and observations of rehabilitation and regeneration of saline sites.

APPENDIX 7: DISHMOP REFERENCE LIST 2001-2002

Moore C. L., Agar B. and Harvey K. (2001) Cudgell's Creek Regolith-Landform Map (1:25,000 scale) Dryland Salinity Hazard Mitigation Program (DSHMP), University of Canberra, Canberra.

Moore C. L., Austin B., Coslett D., Gorecki V., Harvey K., Haddrill P., Kent M., Peachey H., Ratchford A. and Southwell P. (2001) Warrendale Regolith-Landform Map (1:10,000 scale) Dryland Salinity Hazard Mitigation Program (DSHMP), University of Canberra, Canberra.

Moore C. L., Austin B., Coslett D., Gorecki V., Harvey K., Haddrill P., Kent M., Peachey H., Ratchford A. and Southwell P. (2001) Warrendale Preliminary Geology Map (1:10,000 scale). Dryland Salinity Hazard Mitigation Program (DSHMP), University of Canberra, Canberra.

Southwell P. (2001) Upper Tyagong Creek Regolith-Landform Map (1:20,000 scale) Dryland Salinity Hazard Mitigation Program (DSHMP), University of Canberra, Canberra.

Southwell P. (2001) Upper Tyagong Creek Geology Map (1:20,000 scale) Dryland Salinity Hazard Mitigation Program (DSHMP), University of Canberra, Canberra.

Ratchford A. and C. L. Moore (2002) Regolith-Landform Mapping at Hovell's Creek, Central West NSW: Dryland Salinity Hazard Mitigation in High-Relief Granitic Landscapes. In Press W. (ed) *Geoscience 2002: Expanding Horizons.* Geological Society of Australia.

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