LOCAL GOVERNMENT

Salinity
MANAGEMENT HANDBOOK

A Resource Guide for the Public Works Professional

National DRYLAND SALINITY Program

The *Local Government Salinity Management Handbook – A Resource Guide for the Public Works Professional* is an initiative of the Institute of Public Works Engineering Australia (IPWEA).

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LOCAL GOVERNMENT SALINITY MANAGEMENT HANDBOOK
A Resource Guide for the Public Works Professional

CONTENTS

APPENDICES

FOREWORD

Salinity in the Australian landscape is a natural phenomenon. Many areas in this country have naturally high levels of soluble salt in the soil and ground water.

Although salt is a natural, historical aspect of our soils and water, it has long been recognised that our human and land use practices, particularly our agricultural development practices, have changed our landscapes and natural systems.

Effectively, these practices have significantly altered the natural balance of the water cycle. What was a slowly evolving historical process, has been accelerated to such an extent over the past 200 years that we now face a national problem of enormous significance and considerable economic cost.

The Federal Government's National Action Plan for Salinity and Water Quality, as announced by the Prime Minister, the Hon John Howard in 2000, is recognition of the seriousness of the problem. The commitment of $1.4 billion to address the problems, although unprecedented, is a mere fraction of the amount that will be ultimately required to adequately address salinity.

This Handbook has been prepared by the Institute of Public Works Engineering Australia as a resource guide for Public Works Professionals. It describes the current salinity situation in Australia suggesting mitigating measures that can be employed and proposes a role for the Public Works Professional. It is designed to be an adaptive handbook with regular reviews and, to this end, readers are encouraged to submit case studies and successful solutions to salinity problems, for incorporation in future editions.

The hidden long-term impacts from salinity on public infrastructure through reduced life spans will be enormous. This will impact on our community's assets such as roads, bridges, drainage systems, buildings and service utilities.

Engineers, public works professionals and other technical staff can contribute significantly to identifying and implementing cost-effective solutions to salinity.

The IPWEA is keen to work with government and other agencies to address this national problem and welcomes approaches where cooperative arrangements can be put in place.

Ross Moody
National President
Institute of Public Works Engineering Australia

THE ROLE OF IPWEA

The Institute of Public Works Engineering Australia (IPWEA) is a professional organisation providing member services and advocacy for those involved in planning and delivery of public works and engineering services to the community.

IPWEA is a national organisation with Divisions in each state. It represents public works engineers and other professionals in Local, State and Federal Government; it lobbies government on issues relevant to the profession; and provides specialist advice, support and services to engineers, consultants, contractors and others in the public works industry.

Many State Divisions have established a number of special interest and technical panels, for example in Environmental Management, and Competitive Provision of Services. The Divisions provide representatives on a number of state committees, and they administer special projects and grant applications such as Local Government Road Safety Projects.

IPWEA recognises the serious environmental, economic, physical and social impacts of salinity and the effect this will have on local government, landholders, communities and the wider environment (e.g. loss of native flora and fauna). It will have consequences for our public infrastructure and the future needs of public works professionals in responding to the impacts of salinity.

Local Government has an important yet somewhat neglected role to play in land management. It is responsible for land use planning; development approval; infrastructure development and maintenance; community development; environmental protection; and plays a significant role in pollution control.

So far, salinity has been largely attacked at the local level on an isolated Council basis.

It has been predicted that the greatest long-term financial impacts from salinity may not be on agriculture, but on the shortened life span of infrastructure assets such as roads, bridges, drainage systems, service utilities and buildings.

An example is the damage to roads caused by rising saline groundwater. This can reduce sealed road life expectancy by up to 75%!

Many engineers, public works professionals and other technical staff will be required to work with and identify solutions to problems associated with salinity.

While the State and Federal Governments have taken the role of formulating plans and policies, as well as providing funding and regional/local support it largely falls upon Councils to manage salinity at the local level. There is a key role for Local Government to develop and implement management and action plans tailored for their area, and importantly, involving the community and working with landholders.

IPWEA sees opportunities where it can:

- **Raise awareness of salinity** issues amongst engineers and technical staff through its national journal, regular newsletters, regional groups, conferences and publications such as this Handbook.

- **Provide training and education** through its professional development program.

- Provide a national **network base for engineers, public works professionals** and other local government staff and officials.

- **Work within the public works industry** to provide a co-ordinated response, share resources and expand networking opportunities for local government practitioners.

- **Produce further editions of this Handbook and newsletters** to update our industry on current government and regional activities and initiatives.

- Help co-ordinate Council efforts on a catchment or regional basis by acting as a **first point of contact** for technical and professional staff wishing to obtain more information.

- **Host Salinity Forums** and regional workshops.

- **Encourage resource-sharing opportunities** between councils.

- **Provide representation** on behalf of public works engineers and technical staff to provide feedback to government on salinity issues.

- **Manage** salinity research projects and/or grant applications.

Successful management of salinity will require adequate funding, access to expertise and knowledge, and sharing of 'best practice' experiences. Government agencies, whilst often having the expertise, are in many cases not effective in transferring that knowledge or expertise to local government practitioners. This needs the active involvement of an agency such as IPWEA, which knows the industry and its individual members.

Alliances and networks need to be actively formed between public works engineers and other professionals, CSIRO, scientists, government, and other organisations to support the activities of Councils and its technical staff.

The effects of salinity are serious and will significantly impact on local authorities as they face losing their rate base, increased infrastructure maintenance and replacement costs, decreased long term useability of their natural and built environment, and increased environmental obligations.

IPWEA believes that local government and the public works industry are well placed to address the environmental, physical, economic and social problems associated with salinity. IPWEA welcomes opportunities to work with other agencies to assist towards this end.

1. WHAT IS SALINITY

Salt is an inherent part of the Australian landscape. The salts originate from either the weathering of salt bearing rocks, or are deposited on the land by wind, or rain transfer from the ocean. These salts are cycled throughout a catchment on a continuous basis, accumulating in the lower parts of the landscape.

In Australia, particularly in parts of the Murray Darling Basin, much of the salt that is now expressing itself at the surface, was deposited by seas which covered much of our existing landscapes. Millions of years of salt accumulation in sedimentary rocks and the slow release of salts found in crystalline rocks has led to the development of substantial concentrations of salts at or near the Earths surface.

Salinity is therefore, a natural process in our environment. However, prior to European settlement, the processes were largely in balance – native vegetation had evolved in balance with available rainfall and existing salinity.

Human activity (specifically agricultural development) post European settlement disturbed these natural ecosystems and altered the existing hydrology. These landscape changes, which were/are dominated by annual pastures and crops, increased the amount of water that entered the landscape as deep drainage. This process greatly accelerated the mobility of salts, flushing them through the landscape and into rivers, lakes, wetlands and groundwater.

Photograph Courtesy: NSW Dept of Land and Water Conservation

Typical example of extensive land clearing in an Upland catchment area

In general, water is no longer used in the same way within the landscape, nor at the same rate. This has resulted in an accelerated pattern of leakage and in some areas caused groundwater to rise significantly.

Where irrigation of crops and pastures has been employed (particularly the "cost effective" flood irrigation of the past) percolation rates into the groundwater system are much higher.

Photograph Courtesy: NSW Agriculture

Old Man Saltbush – a salt tolerant plant which thrives in saline conditions

The end result has been rising water tables that have mobilised stored salts and brought them to or near the soil surface.

Salinity has now risen to a level that is having adverse impacts, on agricultural production, water supplies, aquatic ecosystems, biodiversity and increasingly, on rural and urban infrastructure (causing damage to roads, pipelines, foundations etc). These effects are being felt in every state of the Nation.

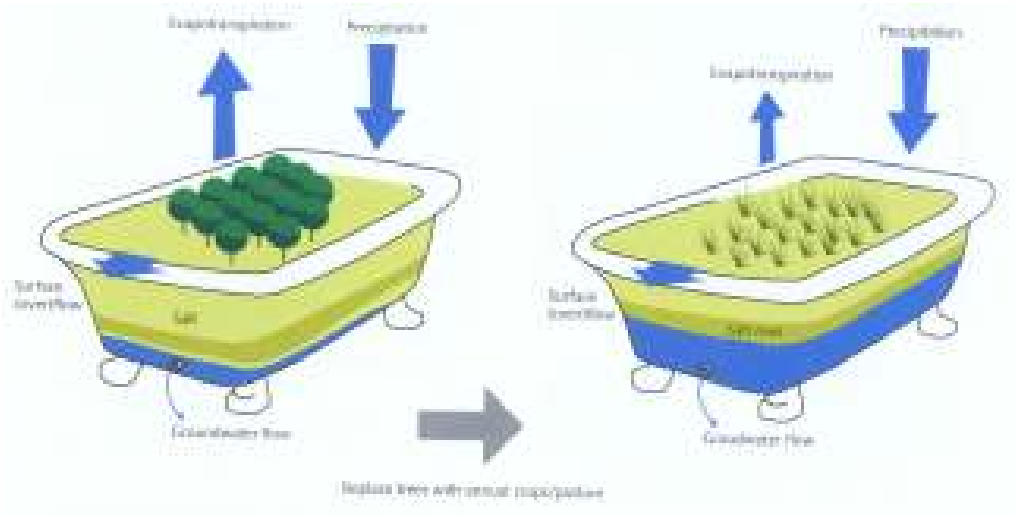
Photograph Courtesy: Elita Humphries

Salt Scalding on prime grazing land

The processes that drive salinity are long-term and are extremely difficult to slow down, let alone reverse. The root cause is inappropriate land use practices in our environment. It is now widely accepted that substantial investment and advisory and technical support is required to effectively tackle this issue at an appropriate scale.

In summary:

- Salinisation is a natural process.
- There are existing, high salt levels stored in our environment.
- Landscape use has enabled saline solutions to come to the surface.
- Salinity is a process that causes salts to concentrate at or near the soil surface.
- In a well-balanced system, the watertable usually remains at depth.
- In an altered system, an increased amount of surface water is able to move through the soil profile entering groundwater.
- Like filling a bath, as the groundwater is recharged the water table rises bringing dissolved salts with it. These salts concentrate near the surface as evaporation occurs.
- Our land use practices have accelerated the salinisation process to the extent that it is now a serious problem threatening our agricultural production, water supplies, ecosystems and biodiversity and infrastructure.
- Substantial change will be required in our natural resource management strategies to address the salinity issue and its impacts.



Courtesy: Joint Venture Agroforestry Program "Trees, Water, Salt, 2000"

The Bathtub Scenario

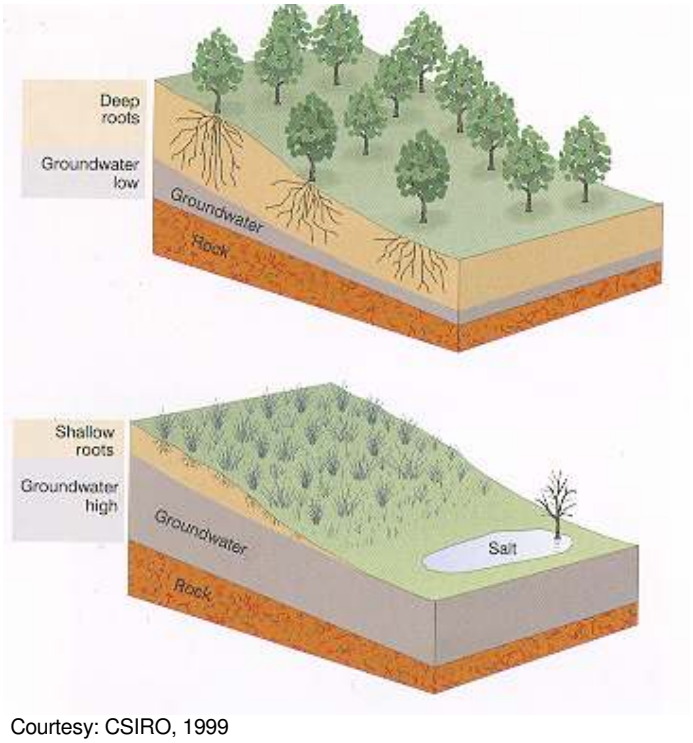
2. TYPES OF SALINITY – DEFINITIONS

It is useful to differentiate between the various forms salinity takes within our landscapes, particularly in relation to aquatic and terrestrial definitions. These fall into 5 Categories, namely, Dryland Salinity, Groundwater Salinity, Irrigation Salinity, River Salinity and Urban Salinity.

A. Dryland Salinity

Dryland salinity occurs when water tables rise to within 2 to 3 metres of the soil surface.

Clearing of native vegetation and resulting agricultural development have reduced the amount of perennial vegetation cover existing within catchments. These activities combined with urban development have initiated the process of secondary salinisation.



Courtesy: CSIRO, 1999
"Effectiveness of Current Farming Systems in the Control of Dryland Salinity"

Effect of Vegetation Clearance

At 2 to 3 metres below the surface, salt impacts are activated. This occurs as a result of capillary action, transpiration by plants and surface evaporation drawing concentrated salts to the surface.

The effects can be widespread and can also result in seepage of saline water to downslope creeks and streams.

The end result is adverse impacts to vegetation, soil structure and chemistry, increased erosion (as soil structure declines) stream bank stability and instream water quality. Productivity becomes unsustainable.

B. Groundwater Salinity

Increased "leakage" of water (rainfall and irrigation) into the groundwater has not only resulted in rising watertables, but also elevated salinity levels from the dissolution of the stored soil salts.

This is a particular problem in the Murray Darling Basin where a large store of salt has accumulated in the sedimentary Murray Groundwater Basins.

Groundwater, often almost as salty as seawater, can occur within 600 mm of the soil surface over extensive areas.

The problem in these areas is that there is practically no sub-surface outlet to the sea, resulting in a massive store of salt; seriously depleting the value of the groundwater as a re-useable asset.

There is also evidence in some parts of Australia of "leakage" of saline groundwaters into depleted fresh aquifers.

C. Irrigation Salinity

Irrigation salinity is caused by the over application of irrigation water (in some cases as much as 4 times the average rainfall); inefficient water use; poor drainage and replacement of native vegetation with plants with inappropriate water use characteristics.

The result is development of "groundwater mounds" which are bulges in the surface of the watertable, usually created by excessive recharge at that point.

Photo Courtesy: NSW Agriculture

Salinity impacts of inappropriate irrigation

D. River Salinity

River salinity is directly related to land-use practices, in that saline discharges from dryland, irrigation, groundwater and urban salinity are often to rivers, particularly at seasonally low river levels.

As salinity within a catchment increases, so too, the salinity level of catchment draining streams increases.

Photo Courtesy: NSW Agriculture

Degradation caused by high salinity levels in drainage lines of the Murray Darling Basin

Courtesy: Murray Darling Basin Commission, Salinity Audit, 1999

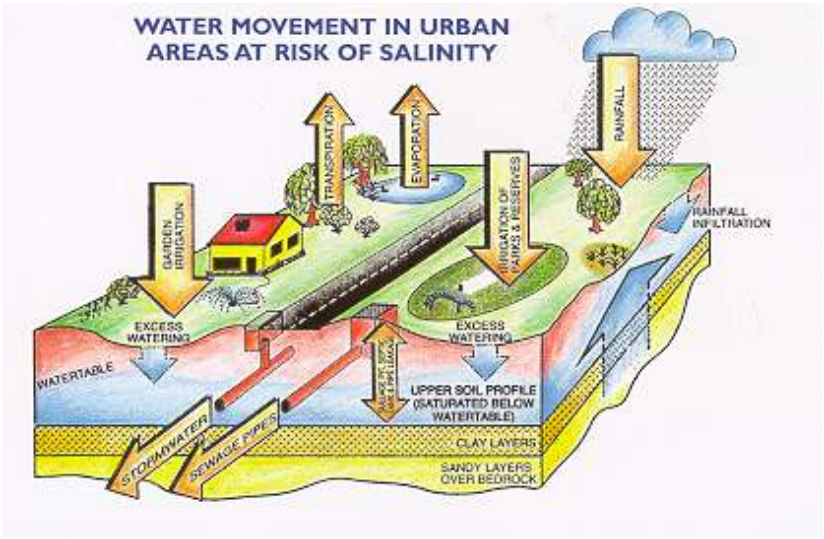
Rising River Salinity in the Murray Darling Basin

E. Urban Salinity

Salinity in towns is a result of a combination of dryland processes and over-irrigation. Towns are often located in naturally salty landscapes and urban communities are exacerbating sub-terranean salinity by:

- (over) watering of gardens, parks and sporting fields and facilities.
- degraded sub-surface infrastructure resulting in leakage from water, drainage and sewerage reticulation systems.
- interference with or modification to surface and sub-surface drainage paths.
- town layouts that can create drainage problems.

Resulting elevated saline groundwater can adversely affect and shorten the useful life of infrastructure, including buildings, roads, bridges, and pipe systems. Other impacts are to seriously damage local vegetation, sporting fields and so on.



Courtesy: NSW Salt Action "Detecting Urban Salinity"

Water Movement in an Urban Environment and Potential for Salinity Development

Summary of Salinity Impacts

- declining water quality resulting in limited applications and impacts on town water supplies, increased treatment and infrastructure costs.
- increasing water hardness.

- reduced ability to use water for industrial purposes.
- diminished agricultural diversity and productivity.
- adverse impacts on ecosystems.
- infrastructure damage.
- declining landscape amenity.
- Social and economic disruption and cost.

Examples of Urban Salinity Problems

Photographs Courtesy: NSW Salt Action Program

3. THE CURRENT SITUATION IN AUSTRALIA

a. Land Areas Affected

It is estimated that about 30 million hectares (ha) of land in Australia is affected by salinity.

A 1998 assessment of agricultural land (ref: Prime Minister's Science, Engineering and Innovation Council Report, 1998) estimated that 2.5 million hectares was affected and that this will grow to 15 million hectares in the next 50 to 100 years. This currently affected land represents 4.5% of cultivated land. The potential is for nearly 30% to be adversely affected within 50 to 100 years.

The State-by-State impact is illustrated in Table 1 below:

State	1998/2000 (ha)	2050 (ha)
WA	4 363 000	8 800 000
NSW	181 000	1 300 000
VIC	670 000	3 110 000
SA	390 000	600 000
QLD	Not assessed	3 100 000
TAS	54 000	90 000
Total	**5 658 000**	**17 000 000**

Table 1: Land Areas with a high potential to develop dryland salinity in Australia
(Source: National Land and Water Resources Audit, "Australian Dryland Salinity Assessment 2000"

The National Land and Water Resources Audit "Australian Dryland Salinity Assessment 2000", has provided the following assessment of assets at risk as a consequence of shallow water tables:

Asset	2000	2020	2050
Agricultural Land (ha)	4,650,000	6,371,000	13,660,000
Remnant and planted perennial Vegetation (ha)	631,000	777,000	2,020,000
Length of streams and lake Perimeters (km)	11,800	20,000	41,300
Rail (km)	1,600	2,060	5,100
Roads (km)	19,900	26,600	67,400
Towns (No.)	68	125	219
Important Wetlands	80	81	130

Table 2: Assets at High Risk from Shallow Watertables or with a High Salinity Hazard
(Risk is defined as watertables at 2 m or less depth and with a rising trend)

Photo Courtesy: NSW Agriculture

Struggling re-growth on a saline waterlogged site

b. Infrastructure Effects

Lifespans of road pavements are significantly reduced if groundwater levels rise to within 2 metres of the surface. Saline subgrades can also destroy the essential properties and integrity of bitumen and concrete.

Some sobering statistics relating to infrastructure impacts include:

- 34% of State roads and 21% of national highways in south western New South Wales are impacted by high watertables with damage costing $9 million per year (PMSEIC 1999).

- In Western Australia, Main Roads has estimated that over 500 kilometres of roads are adversely affected and this would probably double in 20 years (McRobert et al, 1997). The additional maintenance and reconstruction cost has been estimated at up to $100 million p.a.

- Approximately 20,000 kms of major roads and 1600 kms of railway's occur in regions considered high risk and this could grow to 52,000 kms/3600kms respectively by 2050.

- Wagga Wagga in southern NSW is one of the worst affected towns. It has been estimated that the cost of salinity induced damage to roads, footpaths, parks, sewerage pipes, housing and industry is of the order of $500,000 p.a. (Bugden 1997).

- It has been estimated that up to 30 rural towns in Western Australia will be affected by rising saline watertables by 2050. In Victoria, the estimate is that more than 60 towns will be impacted by shallow watertables.

- Increased flood risks are also a consequence of shallow watertables in Western Australia (Campbell at al, 2000) causing damage to roads, dams, fences, land and wetlands.

c. Production Losses

The National Land and Water Resources Audit of Dryland Salinity, 2000 has identified that much of the land at risk in Australia represents what many would think of as our most productive land. These areas include:

- The Temperate Semi-Arid Slopes and Plains agro-ecological regions including the sheep-wheat belt in south-west Western Australia.

- The crop-pasture zones of New South Wales, Victoria and South Australia.

- Major irrigation areas in the Murray Darling Basin.

It has been estimated that the capital value of land "lost" to date is about $700 million with a loss of production of some $130 million annually, and increasing (PMSEIC 1999). Unknown costs include on farm costs of measures to protect land and surface waters from salinity, changing to other land use practices and the increased burden on, so far unaffected, lands of increasing production to compensate for losses incurred on affected land.

d. Water Resource Impacts

It is known that salt concentrations are increasing in many streams and wetlands, particularly in the southern areas of the Murray Darling Basin. This is resulting in serious social, economic and environmental consequences particularly with respect to drinking water and irrigation supplies. The adverse impact on wetlands, particularly those of international significance, is also a major concern.

The deterioration in quality of Murray River water is indicative of the magnitude of the problem with respect to water quality.

The Salinity Audit of the Murray (MDBC 1999) suggests that unless remedial measures are implemented, the median value of salinity in the river at Morgan will increase by 25% over the next 50 years. Given that stream salinity, at Morgan exceeds World Health Organisation criteria for potable use for 10% of an average year, the impacts on South Australia's water supply are potentially untenable.

Other impacts on water resources include:

- In the upper parts of the Murray Darling Basin (the Macquarie, Namoi, Bogan, Lachlan and Castlereagh rivers) salinity levels will exceed 800 E.C (the threshold for potable supplies) within 50 years. Some rivers are expected to exceed the 1500 E.C threshold for irrigation in 100 years.

- In Western Australia, predictions indicate that the length of streams affected by salinity may double in 50 years.

- In Victoria, a potential tripling of the length of streams affected is predicted over the next 50 years.

- In South Australia, water resources in the Lower Eyre Peninsula and Kangaroo Island have been severely degraded.

e. Biodiversity Impacts

Rising water tables and increasing salinity impact on native vegetation. This is particularly evident in lower parts of the landscape. An already diminished environmental resource (as a result of large scale land clearing) is further threatened, thereby causing extreme loss of habitat (both land and water) and subsequent loss of animal species.

- In Western Australia, for example, some 1500 plant species are threatened, with up to 450 facing extinction.

- Fauna species could be reduced by up to 30% over the next 50 years.

- Approximately 80 significant wetlands are, or will be, impacted and these occur in all states of Australia. In the Murray-Darling Basin, for example, significant wetlands including the Macquarie Marshes, Great Cumbung Swamp, Avoca Marshes and Chowilla Floodplain will be adversely affected by increasing salinity levels.

The asset value of these losses and the impact on economic aspects, including tourism, are inestimable. The remnant vegetation and plantation forests considered to be at risk are summarised in Table 3 below:

State	Current	2020	2050
NSW	7,000	32,700	81,000
VIC	6,000	11,800	24,300
QLD	n/a	n/a	92,000
SA	18,000	22,000	25,000
WA	600,000	710,000	1,800,000
TOTAL	**631,000**	**776,500**	**2,022,300**

TABLE 3: REMNANT VEGETATION AND PLANTATION FORESTS AT RISK (ha)
(Source: National Land and Water Resources Audit, 2000)

f. Total Costs

The national costs resulting from salinity include:

- Capital value of land costs $700 million
- Annual infrastructure damage costs $100 million
- Annual loss of environmental assets $ 40 million
- Annual agricultural production losses $130 million

The full costs to the nation are difficult to estimate. A recent study for the Murray Darling Basin Commission in eight (8) priority catchments estimates that salinity costs farmers, local government and government agencies $251 m per year, (excluding environmental costs) as shown in Table 4 below:

Sector	Best Estimate ($m/yr)
Local Government	14.70
Business	8.70
Agencies and Utilities	16.30
Households	90.10
Environment	?
Agricultural Production	121.80
	$251.60

TABLE 4: STAKEHOLDER EQUIVALENT COSTS OF SALINITY IN THE MURRAY DARLING BASIN
(Source: National Land and Water Resources Audit: Wilson (2000))

g. Summary

Clearly, the current impacts and costs of salinity in Australia are significant. Without corrective action, the impacts could be economically, socially and environmentally devastating within 50 to 100 years. The impacts cover the broad spectrum of water quality, infrastructure costs, urban damage, agricultural production losses and biodiversity.

Substantial changes are needed in the short term to secure the future of our essential natural resources; land, water, flora and fauna.

4. WHAT ARE THE CAUSES OF SALINITY

As a general statement, salinity in Australia is a natural process that has been accelerated by inappropriate land use and water use management practices. These processes are now inextricably out of balance with the natural environment.

Typically, the specific causes are summarised below and these give an insight into the corrective measures that will be needed to address and solve this scourge on our landscape:

1. Dryland Salinity

- Clearing of native perennial vegetation
- Replacement of deep rooted native perennial vegetation with shallow rooted annual crops and pastures
    - Shallow rooted plants are less water efficient allowing leakage to groundwater, with subsequent rises in watertables
    - Groundwater rises to near the ground surface in low lying areas or on the break of slope
- Overgrazing causing a reduction in the active and growing vegetative cover of pasture resulting in reduced soil quality and associated water holding capacity

Photo Courtesy: Elita Humphries

Discharge Area Showing Early Signs of Salinisation
- including waterlogging and species change

2. Irrigation Salinity

- Excess application of irrigation water
- Replacement of native vegetation with less water efficient plants
- Results are localised rises in ground water levels, with subsequent waterlogging and salinisation of surface soils.
- Groundwater systems characterised by a lack of outlet discharges.

3. River Salinity

- Primary cause is discharge from areas affected by dryland salinity, irrigation salinity and urban salinity.
- Rising ground water levels result in saline discharges to streams.
- Increased salt availability at or near surface levels results in wash-off and leaching to streams during rainfall events.

Photo Courtesy: NSW Department of Land and Water Conservation

Drainage line affected by high salinity levels

4. Urban Salinity

- Urban salinity is a combination of dryland and irrigation salinity.
- Causes include rising watertables as a result of vegetation clearing and the application of excess water by:

* inappropriate watering of parks, gardens and sporting fields.

* excessive watering of home gardens and lawns.

* use of lawn and plant species that require large amounts of water.

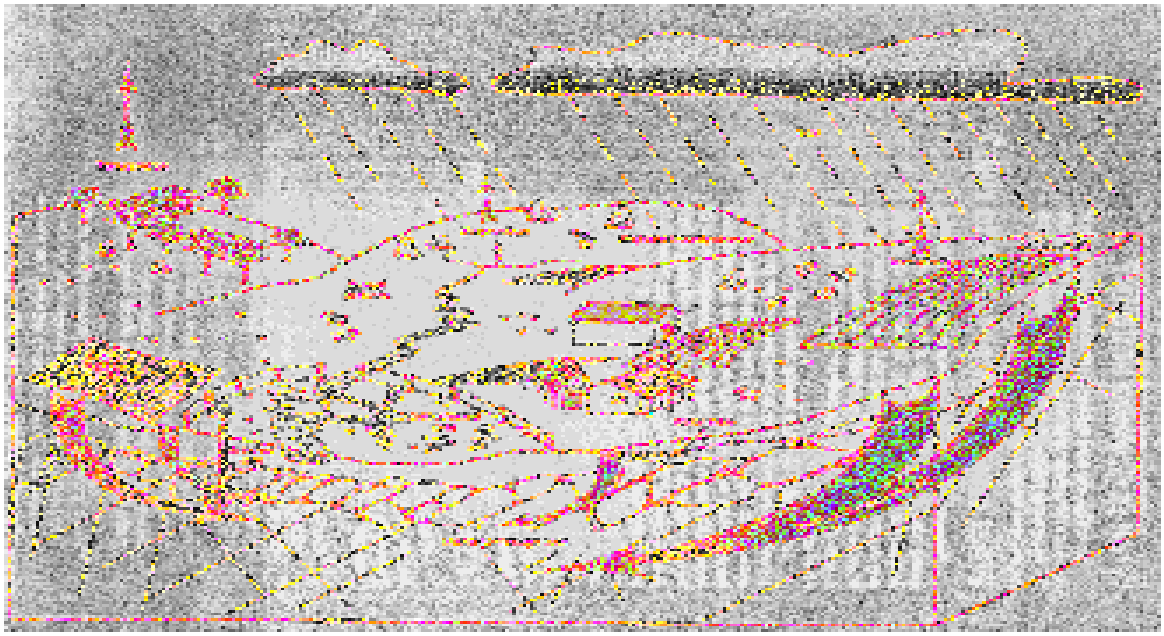
* leaking water, sewerage and drainage pipelines.

* rubble pits (as commonly installed in the 50's and 60's)

* obstruction or modification of natural surface and sub-surface drainage paths by construction of roads, bridges, railway lines and flood/drainage control structures.

* inefficient septic systems.

* tree clearing for urban development.



Courtesy: Salt Action Dryland Salinity 1-8 Series (No. 1)

Salinity and Natural Resource Management Processes

5. ROLE OF THE PUBLIC WORKS PROFESSIONAL

To combat salinity at all levels in our landscape and to implement strategies to address the problems effectively we will require partnerships at all levels of government as well as community involvement and commitment.

A brief summary of the roles of various levels of government and the community is presented below (it should be noted that roles and responsibilities under the National Action Plan are still being developed and agreed):-

a. Commonwealth Government

- Development of national strategies and priorities under the National Action Plan.
- Development of frameworks for planning, target-setting and monitoring/evaluation of actions to address salinity and water degradation.
- Large scale funding of catchment wide initiatives.
- Provide funding for research and capacity building.
- Provide funding to regional authorities to implement integrated catchment management plans.

b. State Government

- Develop State salinity strategies
- Co ordination of catchment wide targets.
- Development of effective, transparent monitoring and evaluation methodologies.
- Provision of expertise and advice via land and water resource management and environmental/conservation agencies.
- Jointly with the Commonwealth, provide funding to regional authorities to implement integrated catchment management plans, support research and capacity building.

c. Catchment Management Authorities

- Develop catchment plans and strategies.
- Develop and implement management actions.
- Develop community awareness, education and commitment.
- Be accountable for public funds and report on performance.

d. Local Government

- Assist Catchment Management Authorities in the development of Catchment Targets and Management Actions.
- Ensure salinity issues are addressed in town planning and subdivisional activity.
- Collect, collate and evaluate information of relevance to salinity management.
- Consider salinity issues in infrastructure development and management.
- Implement asset management programs with emphasis on salinity management.
- Seek/provide funding for assessment, monitoring and evaluation processes.
- Develop local area building codes with an emphasis on identifying and remediating saline impacts.
- Contribute to community awareness and education, particularly in relation to water conservation practices.

e. Land Managers

- Where possible, implement mitigation measures to offset impacts of existing, saline affected areas.
- Assess the saline impacts of new activities/projects and if adverse, implement offsetting initiatives.
- Be pro active in protecting and enhancing existing native vegetation.
- Where possible/practicable, implement water efficient solutions.
- Contribute to the knowledge base by monitoring and evaluation of projects.

f. Engineers/Town Planners/Other Professionals

"Engineers and other professionals working in agriculture and water resources have a duty of care with respect to the provision of advice on processes affecting or affected by (dryland) salinity. Those most likely to be involved are water engineers and hydrologists working as researchers, consultants and government employees. There is a major need for engineers to work closely with other scientists (hydrologists, geologists, soil scientists, plant physiologists, agricultural scientists, etc) to encourage a quantitative multi-disciplinary approach. The results of investigations need to be

discussed with landholders and communicated to the community and politicians. This will encourage implementation of new management techniques by farmers at the farm scale and communities at the catchment and regional scale" (Reproduced from: "Dryland Salinity – A Position Paper by the National Committee on Water Engineering, 2001)

In terms of the Public Works Professional the following is considered an incomplete summary of the part he/she can play in SALINITY MANAGEMENT:

- The primary role of the Public Works Professional at this time is to become INFORMED about Salinity Management, in general and specific to the area he/she is working in.

- Develop a database of expert contacts and make available to land use managers and developers.

- Develop networks and partnerships with Salinity Management experts.

- Assess groundwater levels and salinity concentrations in area of responsibility.

- Develop a local education and awareness program with emphasis on native vegetation, land and water conservation management techniques.

- Develop a "total water cycle" approach to urban water management.

- Where problems are known, develop and implement a Pilot Land Management Project.

- Implement an asset management program with emphasis on detecting and quantifying saline damage to building and infrastructure.

- Implement Active Management Initiatives (eg native revegetation projects, demonstration water conservation techniques, installation of piezometers, publish and distribute information sheets/brochures etc).

- Become involved in natural resource management and catchment management initiatives.

- Provide input to the development of building codes with specific emphasis on saline management.

- Provide input into town planning and land use planning processes particularly with respect to revegetation, vegetation retention, surface/sub-surface drainage, and infrastructure issues.

- Work with state government agencies to develop a Model LEP to guide development consents so that urban salinity problems are not exacerbated.

- Identification and mapping of recharge and discharge areas.

6. TAKING A PRO ACTIVE APPROACH - IDENTIFYING RISKS AND EMERGING PROBLEMS

Salinity as a management issue has been developing in this country for over 200 years. There are now no quick fix solutions – if we are to address these problems and ensure sustainability of our land and water resources, we need to develop a series of strategies: short term, medium term and long term.

There are three (3) clearly recognised approaches to salinity management:

(1) Do Nothing – accept the situation and adapt our land and water management approaches to make the most productive and ecologically sustainable use of salinised land.

(2) Slow or Stop the rate of salinisation and rises in groundwater levels.

(3) Reduce groundwater levels and rehabilitate salinised areas.

All three approaches will find application in our diverse landscapes.

Clearly, the objective of this Handbook is to address strategies under Categories (2) and/or (3) – our aim should always be to find realistic and affordable solutions.

A strong RECOMMENDATION for Public Works Professionals is to develop an ACTION PLAN for their area of operation and the following are some suggestions to assist in this process.

* **Salinity Audits**

- Research availability of and obtain, where possible, groundwater maps and supporting data. (State government and other agencies may have information for your area).

- Obtain information on salt concentrations of local streams and groundwater.

- Carry out area site inspections to identify areas affected by salinisation.

  Things to look for include:

  - ❖ waterlogged areas
  - ❖ crystals of salt or bare soil surfaces
  - ❖ leaf damage to plants and pastures
  - ❖ development of bare patches in open areas
  - ❖ die back of trees
  - ❖ saline discharges at break of slope
  - ❖ appearance of salt tolerant grasses in gardens and recreation areas
  - ❖ road surfaces breaking up
  - ❖ damage to structures and evidence of deterioration of bricks and mortar
  - ❖ rising damp in public and private buildings

- ❖ salt crusting on bricks, concrete and pavers
- ❖ deterioration of house foundations; reduced life of concrete slabs
- ❖ corrosion of underground services (pipes and cables)
- ❖ corrosion of metal elements; bridges and power poles etc

- A well-structured community questionnaire or a series of community meetings/workshops will provide much of the information listed above.

- Prepare a Local Area Map of Saline Affected Areas.

- Prepare a Local Area Map of Salinisation Risk Areas.

- Where possible, assign costs as Annual and Capital Replacement on the basis of existing damage/impact and potential future damage/impact.

* **Monitoring Programs**

- Assess, monitor and review water usage including residential, household and rural water use patterns.

  - *Inside Use:*

» toilet (full flush)	12litres
» bath	50-150litres
» shower	240-250litres
» dishwasher	20-90litres
» washing machine	40-265litres
» brushing teeth (tap running)	5 litres
» hand basin	8 litres
» drinking/cooking/cleaning	8 litres
DAILY INSIDE AVERAGE	205 litres (per person)

  - *Outside Use:*

» garden sprinkler	up to 1000 litres
» car washing (hose)	100-300 litres
» hosing driveway	50-100 litres
» dripping tap	150 litres
DAILY OUTSIDE AVERAGE	205litres (per person)

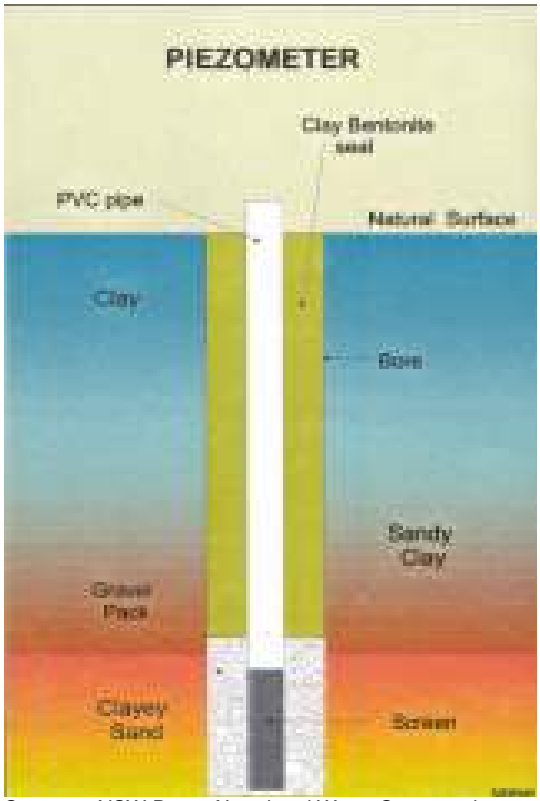
OVERALL DAILY TOTAL: 635 litres

Taken from Wagga Wagga Urban Salinity Speakers Kit

- Measure and monitor groundwater and groundwater salinity levels within your catchment.

- Locate and monitor existing bores and wells within your catchment.

- Install piezometers in strategic locations within your catchment and establish a monitoring program (This is a good way to involve your local community by recruiting residents to monitor the piezometers)



Courtesy: NSW Dept of Land and Water Conservation

Typical Piezometer Installation

- Review historical infrastructure maintenance costs, monitor, review and identify areas of unusual cost increases.

* **Asset Management Programs**

- Establish data base of assets and ascribe life expectancy, costs etc. (Many proprietary asset management programs are available; however, if funds do not permit use of these; a simplified in-house data base and recording system can be established).

- Benchmark asset maintenance recurrent costs with neighbouring areas.

- Assets that may be included in development of an Asset Management System include:

  - ❖ roads, footpaths, driveways
  - ❖ houses and buildings
  - ❖ fixed installations, like pump stations
  - ❖ water supply pipelines
  - ❖ sewerage pipelines, pump stations and facilities
  - ❖ electrical installations and substations
  - ❖ septic installations
  - ❖ gardens, lawns and sporting fields and associated facilities
  - ❖ areas of remnant vegetation
  - ❖ woodlots, forests and nurseries
  - ❖ rivers, streams, lakes and wetlands
  - ❖ cultural sites (historic and indigenous)

- Issues that may be addressed in the Asset Management Plan include:

  - ❖ total road lengths, differentiated as sealed and unsealed roads
  - ❖ total length of water, sewerage and drainage pipelines
  - ❖ definition of service level
  - ❖ life expectancy of assets
  - ❖ annual repair and maintenance expenditure (including historical data where available)
  - ❖ captial expenditure on infrastructure; including an assessment of cost increases resulting from groundwater/salinity impacts
  - ❖ financial projections of liabilities for future renewal of assets
  - ❖ outline of an improvement program
    etc

- Where possible, develop a database relating to private properties (ie residences, farms, businesses etc). This may be carried out via a ratepayer survey which could address issues like:

  - ❖ decline in farm production
  - ❖ damage to assets and facilities
  - ❖ evidence of elevated groundwater and salinity levels
  - ❖ evidence of soil erosion
  - ❖ weed invasion
  - ❖ evidence of salinity increases in residential water supply
  - ❖ corrosion of appliances, fittings and fixtures
  - ❖ loss of flora and fauna
    etc

- **Risk Management Protocols**

  Where there is evidence of saline damage in your area or where there is future potential for damage, development of a set of Risk Management Protocols in relation to infrastructure and other development is recommended.

  Issues that could be addressed in such Protocols include but are not limited to:

  - ❖ Effective underdrainage of all new roads and paths
  - ❖ Use of non-corrosive materials in subterranean and surface works
  - ❖ Insulation of pipeline materials
  - ❖ Installation of localised pump out systems to control elevated groundwater levels
  - ❖ Underdrainage, insulation and moisture protection of all footings and foundations
  - ❖ Implementation of effective tree replacement programs
  - ❖ Implementation of water conservation programs
  - ❖ Specification of salt tolerant plant species in specified areas
  - ❖ Installation of underdrainage to sporting fields & parks
  - ❖ Specifications for block and site drainage to avoid ponding
  - ❖ Develop garden management specifications and protocols including lists of appropriate deep rooted plant species
  - ❖ Specify drip irrigation systems for all new subdivisions
  - ❖ Retrofitting of interlot stormwater (roof) drainage
  - ❖ Removal of septic tanks and replacement with sewerage reticulation (where feasible)
  - ❖ Leakage identification and reduction
  - ❖ Land clearing regulations
  - ❖ Land-use and surface runoff issues

    etc

- **Strategic Management Plans**

  Utilising the information compiled via Salinity Audits, Monitoring Programs, Asset Management Programs and Risk Management Protocols, a LOCAL AREA STRATEGIC MANAGEMENT PLAN can be prepared and adopted for use in your catchment.

  This should be a community accepted document and therefore, substantial consultation will be required.

  The Strategic Management Plan should be endorsed by the local council and incorporated as a formal instrument in all planning documents.

The Strategic Management Plan should address:

- Short Term Issues (Immediate)
- Medium Term Issues (5-10 years)
- Long Term Issues (>10 years)

and should be based on best available knowledge and practice. It should also be consistent with Regional and State Strategies and related policies, procedures and practices.

The document could also include recommendations for planning controls relating to area specific issues. Examples might be:

- recommendations as to whether subdivision and subsequent as of right development can occur

- building permit conditions for types of construction or damp courses that should be used in salt affected areas

- permit conditions for septic areas to have water conservation devices in the house and garden including types of plants

- permit conditions on development plans for subdivisions which should include revegetation areas

- permit conditions relating to type of land use and (perhaps) monitoring and reporting responsibilities for landowners in order to comply with requirements for minimising or reducing the affects of salinity.

- landuse/clearing issues and conditions.

The document should be adaptive and should be reviewed and updated annually.

It is recommended that, for all developments in salinity hazard areas, councils should develop or amend their Local Environmental Plans (LEPs) and Development Control Plans (DCP's). A model LEP to guide development consents so that salinity problems are not exacerbated may be necessary. State and/or Federal Government funding may be available to assist councils in this process.

The initial development of a local area Strategic Management Plan will be invaluable in developing appropriate planning instruments.

Photo Courtesy: NSW Dept of Land and Water Conservation

Salinity Impacts on Footings/Foundations

7. REMEDIES AND MITIGATION TECHNIQUES

To manage groundwater levels and salinity impacts will require substantial changes to our current land use practices.

In essence, the primary mitigation measures will require strategies and techniques which:

- use water more effectively
- protect and enhance native vegetation
- amend agricultural practices to better suit our fragile environments and landscapes
- encourage and promote perennial vegetation cover through forestry, native vegetation retention and enhancement, pasture systems and cropping practices.
- use engineering solutions to physically stop groundwater rising
- use our salt affected land better and more efficiently
- allow residential and other development without adversely impacting our vegetation cover and drainage patterns.

Following are some strategies that can be employed to remedy and/or mitigate against the effects of salinity.

A. CATCHMENT WIDE APPROACHES

(i) Recharge Reduction

Methods to reduce recharge include:

- manage, protect and enhance areas of remnant native vegetation across entire catchments, but particularly in identified recharge areas.
    - ❖ integrate native vegetation into landscape design
- land use change (change crops and pastures; change management practices; incorporate deep-rooted vegetation)

Examples:

- ❖ introduce high water-use crops; rotation of summer/winter crops that are soil water sensitive
- ❖ introduce high water use pastures

- ❖ develop phase farming techniques (alternating crops with deep rooted lucerne or chicory)
- ❖ introduce agro-forestry systems
- ❖ sow perennial pastures where possible
- ❖ revegetate with trees/native grasses
- ❖ stock management (ensure over grazing is not practiced)
- ❖ fence off areas clearly salt affected
- ❖ practice organic farming methods

- Interception and re-use of fresh water using engineering solutions.

Examples:

- ❖ intercepting surface water using banks or surface earth drains
- ❖ intercepted water can then be put to beneficial re-use purposes (irrigation, stock watering etc)
- ❖ effective construction/maintenance of dams and channels to minimise leakage
- ❖ improve water use efficiency

Photo Courtesy: NSW Dept of Land and Water Conservation

The devastating impacts of waterlogging and salinisation

"As it is difficult to make generalisations about what will be effective for a particular catchment, it is important to consider each option within the context of local catchment and farm conditions" ("Australian Dryland Salinity Assessment 2000", National Land and Water Resources Audit).

Photo Courtesy: Bill Van Aken, CSIRO Land and Water

Extensive dryland salinity in croplands
Source: PMSEIC "Dryland Salinity and its Impact on Rural Industries and the Landscape"

(ii) Engineering Options for Discharge Management

- groundwater pumping systems
- deep drainage systems
  (it should be noted that these options only address the symptoms, not the causes of salinity)

These options will require storage or disposal facilities for the water reclaimed from groundwater.

If the water is suitable, it may be used for industries, horticulture, viticulture etc.

If saline, consideration should be given to harvesting the dry salt for re-use.

(iii) Utilisation of Saline Land and Water (Saltland Farming)

- developing salt tolerant vegetation/grasses for fodder
- saline aquaculture/fish farming
- reserving for nature conservation purposes

Photo Courtesy: E. A. Turner, G. M. Cunningham

Reclamation of saline scald by ponding
Source: Salt Action "Dryland Salinity"

- fence off salt outbreaks and exclude stock
- practice surface tillage, ripping or mounding to assist plant growth
- practice widespread mulching to reduce evaporation

B. URBAN SALINITY MANAGEMENT METHODS

- develop and implement water conservation practices
- implement effective property management practices including:
  - ❖ watering gardens, sporting fields etc only when necessary (install moisture monitors)
  - ❖ promote extensive mulching
  - ❖ select and use low water demanding plants
  - ❖ plant deep rooted plant varieties and minimise grass/lawn areas
  - ❖ beneficially re-use water where possible/practicable (wash cars on lawns; re-use pool water for irrigation)
  - ❖ ensure roof drainage systems are connected to the stormwater drainage system

- ❖ encourage collection of rainwater for garden watering.

- ensure effective underdrainage of all municipal infrastructure assets (pipes, facilities, buildings etc)

- develop and implement a community education and awareness program, focussing on:

  - ❖ impacts of urban salinity
  - ❖ water-wise issues
  - ❖ appropriate plant species and garden management advice

  Good examples of community education and awareness programs can be found at Wagga Wagga and Albury (ref: Section 9: Case Studies)

- minimise removal of native vegetation

- revegetate with appropriate native species where recharge potential exists

- develop or encourage seed propagation facilities

- ensure effective inter-property drainage systems in place

- provide information/advice on appropriate construction techniques

- consider using lime to help stabilise saline affected pavements

C. EMERGING/DEVELOPING STRATEGIES

On-going research and development of institutional support mechanisms will provide additional tools for use in the salinity battle.

Such Initiatives include:

- development of farming and land use systems that will be effective in a range of applications, including dryland salinity

- development of “large scale” landscape “demonstration” projects

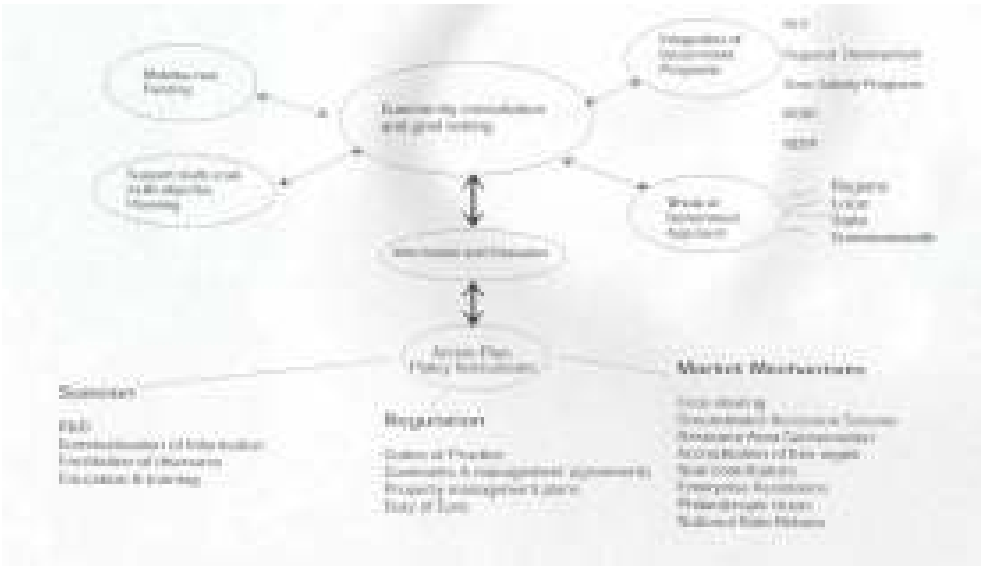
- development of regulatory and market-based solutions

- development of carbon credit trading systems

- development of salinity control credit trading schemes

- consideration of tradeable recharge permits

- consideration of strategic investment options like an Environmental Services Investment Fund
- establish benchmark biodiversity valuations
- consideration of appropriate taxation incentives
- exploration of salinity related business opportunities
- development of Codes of Practice
- development of a model LEP to guide development concerns
- development of a national approach to institutional support
- consideration/reconsideration of direct regulation mechanisms



Courtesy: The Virtual Consulting Group and Boorara Management and Consulting

A Suggested Approach to Enhancing Institutional Support
(Source: VCG "Enhancing Institutional Support for the Management of Dryland Salinity" 2000)

D. APPLICABILITY OF OPTIONS

"No one option is likely to work in isolation and most situations will require a suite of "tools" for effective salinity management.

Adaptive management and innovation have a significant role to play in maintaining productivity and profitability.

Intervention needs to be driven by asset protection plans for infrastructure, biodiversity, productive soil, water resources and combinations of these assets with realistic targets set in terms of the level of salinity management that is feasible.

An important determinant of options selected will be the benefit/cost analysis, irrespective of the scale. Not only will new farming and land use systems that suit Australian environments be required, but innovation and inclusive approaches that permit fair comparison of market and non-market values will need to be developed" ("Australian Dryland Salinity Assessment 2000", National Land and Water Audit).

8. CATCHMENT MANAGEMENT ISSUES

Under the Federal Government's National Action Plan for Salinity and Water Quality and State Integrated Catchment Management (ICM) and Salinity Strategies, a primary focus is on the development of valley/catchment based SALINITY TARGETS.

Targets will be identified and implemented through integrated REGIONAL Natural Resource Management (NRM) Plans.

In New South Wales, for example, two types of targets; END OF VALLEY SALINITY TARGETS and MANAGEMENT TARGETS, are being developed.

- **End of Valley Targets**

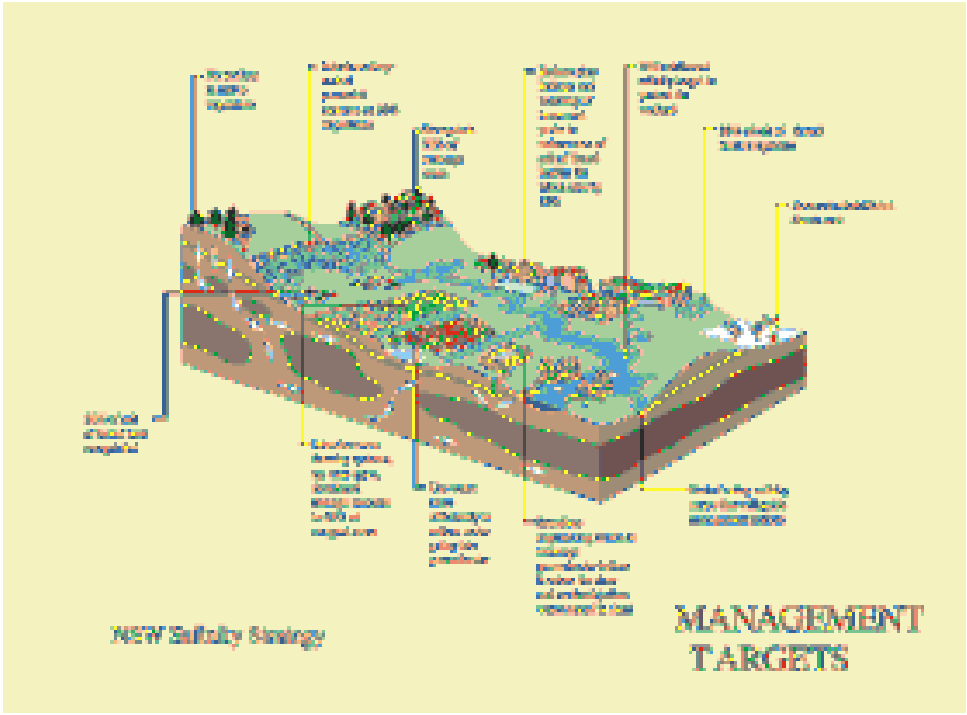
  These are river based targets determined for specific locations on the lower reaches of rivers.

  In setting these targets, consideration is being directed towards:

  - ❖ water needs of saline sensitive crops
  - ❖ drinking water quality requirements
  - ❖ protection of infrastructure
  - ❖ ecosystems and in-stream ecology
  - ❖ predicted trends in loads and concentrations
  - ❖ environmental, social and economic issues

- **Management Targets**

  An illustration of possible Catchment Management Targets is presented below:



Courtesy: NSW Dept of Land and Water Conservation

To achieve end of valley salinity targets, specific actions will need to be identified and implemented. These Management Targets may be land based (recharge and discharge areas) or river based.

A key consideration in developing Management Targets is to identify where investment of funds will achieve the most cost effective outcomes.
The Key Issues in this Target Driven Catchment Wide approach are:

- targets must be practical, achievable and measurable
- targets must satisfy the primary objective of substantial positive outcomes
- targets must be given effect through an implementation instrument, such as a Catchment Strategy or Plan
- Catchment Management Authorities are to be the enabling body and will require appropriate levels of government funding, investment strategies and empowerment to facilitate implementation of the Actions required to meet the Targets
- successful implementation will require strong and binding partnerships between all levels of government (Federal, State and Local Government), Catchment Authorities and Communities
- Local Government will play a pivotal role in implementation of Salinity Management Strategies in partnership with Catchment Authorities
- target achievement needs to be monitored and reviewed
- adaptive management strategies need to be adopted to ensure BEST POSSIBLE OUTCOMES over time
- commitments by governments, authorities, agencies and communities need to be LONG TERM.

In the short term, the objective will be to slow down or arrest the rate of increase in salinity across our landscapes. In the medium to long term, the objective must be to substantially improve the situation and ensure that land and water management strategies are in place which emphasise change in use practices and secure an acceptable level of landscape sustainability.

9. CASE STUDIES

Practitioners appreciate case studies as an illustration of what others are doing to resolve or mitigate a problem. The following are examples of actions being taken to address urban and dryland salinity, engineering options, pilot projects and other innovations.

A. Urban Salinity Actions

i) Wagga Wagga, NSW

A number of sites in Wagga Wagga are experiencing waterlogging, perched water tables and salinisation on slopes adjacent to the floodplain.

Much of Wagga Wagga is situated in a large drainage basin on heavy clay soils with a small catchment discharge point preventing water draining away readily. Groundwater levels have increased behind the restriction and built up, in some areas, to the surface causing waterlogging and salinity.

Roads, footpaths, housing and industrial buildings have been affected, causing annual costs of around $500,000 in salt-induced damage.

An “Action Plan” has been implemented, funded jointly by Salt Action, Wagga Wagga City Council and the Department of Land and Water Conservation that involves:

- Awareness Raising
- Education and Demonstration Projects
- Revegetation
- Installation of Piezometers and Dewatering Bores
- Rear Block Drainage
- On-going investigations and monitoring

For more information contact:

Debby Slinger
Department of Land and Water Conservation
Wagga Wagga

Telephone: 02) 6931 1777

ii) Central Western New South Wales

Urban Salinity Programs have been implemented at Cowra, Young, Forbes and Dubbo.

At Cowra, the Shire Council and Urban Landcare group are assessing the problems of urban salinity which are evidenced by examples of salt crusting on bricks and mature trees dying in some parks. In conjunction with the Department of Land and

Water Conservation, 35 piezometers have been installed to monitor shallow groundwater movement

At Young, 25 piezometers have been installed in the township to monitor groundwater.

Forbes Urban Landcare Group has also been addressing damage to urban infrastructure and buildings.

At Dubbo (Troy Creek), mapping techniques and placement of a network of piezometers have been employed to monitor water levels and salinity.

For more information contact:

Mr Ken Rogers or Mr John Davis
Dubbo City Council
DUBBO NSW

Telephone: 02) 6881 4270
E-mail: kenr@dubbo.nsw.gov.au

iii) Albury, NSW

A research study in 1998 indicated that some areas in Albury had unusually high groundwater salinity levels. Albury City Council in partnership with the Department of Land and Water Conservation implemented a program in 1999 to alert the community to potential problems and implement monitoring to observe watertable behaviour. Thirteen (13) piezometers have been installed and these are being monitored along with a further existing 25 bores and wells (a total of 38 sites are being monitored).

A substantial community awareness and education program is also in place.

For more information contact:

Daryl McGregor
Albury City Council
553 Kiewa Street
ALBURY NSW 2640

Telephone: 02) 6023 8220
E-mail: dmcgregor@alburycity.nsw.gov.au

iv) Corrigin, WA

In the mid 1990's, problems with waterlogging in Corrigin began to emerge. With funding from the Western Australian Government, through the Rural Towns Program, piezometers have been installed to monitor water levels and five bores pump ground water continuously into a 180 kilolitre tank for subsequent community use.

Thirty (30) towns are participating in the program, which is administered by Agriculture Western Australia.

For more information contact:

David Abe or Mark Pridhan
Agriculture Western Australia

Telephone: 08) 9368 3919

v) Pakenham Golf Course, Victoria

The Pakenham Golf Course was established on a floodplain and a substantial number of native trees were removed in the process. Surface effects of dryland salinity became evident very early on.

In conjunction with the Department of Natural Resources and Environment, the Golf Course is having substantial success by improving the soil balance using organic fertilisers, planting salt tolerant grass species and watering with effluent.

For more information contact:

Pakenham and District Golf Course
Telephone: 03) 5941 2929

vi) Western Sydney Salinity Management Project

The Western Sydney Regional Organisation of Councils, in partnership with DLWC, is working with the 13 councils of Greater Western Sydney, and the housing industry to develop a Salinity Code of Practise. The code will provide a management framework for the councils of the region to use when responding to Salinity Hazard.

With a population of over 1.6 million people, and high densities of homes and associated infrastructure in the region, Local Government is keen to be pro-active in the management of this potentially costly problem.

They are working cooperatively, with the assistance of an NHT funded Project Officer, to develop a response which identifies salinity management strategies for various stages and types of development.

This will include management strategies for development activities such as;

- pre-development investigations
- planning
- building materials and techniques
- long term land and water management practises,

and will be applicable to a range of developments, from new release areas with 1000's of blocks, to single existing houses.

The project will link many of the salinity management initiatives already occurring across Australia with the experiences of the Western Sydney Councils, in what aims to be an easily used and accessible management guide.

For more information contact: Rebecca Nicolson, WSROC ph 9671 4333 x 109, rebecca@wsroc.com.au

B. Dryland Salinity

i) Gordon and Irene Stopp's McNamara Property Cropping and Grazing Property Keith, South Australia

Of the 1500 hectares of pasture on the property, some 400 hectares are salt affected. Under the property management plan developed by the Stopp's, the salt affected areas have been fenced off, most of the flats sown with puccinellia, the higher country sown with lucerne and primrose and veldt grass sown on sandy dunes.

Source: Dryland Salinity – the Farmer's Guide
NSW Agriculture

Contact: Bruce Munday
NDSP Communication Coordinator (SA)

ii) Boyd and Julie Henson's Cattle Property Silkwood, South East Queensland

Salt areas on this porous red soil property were very evident in 1991. The strategy employed to address the problems include tree plantings on the edges of salt affected areas (mix of natives); plantings of hoop pines in rows with blue grass as an experiment between tree rows and future plantings of salt tolerant pastures in scald areas.
For more information contact:

Bob Baldwin
Queensland Department of Natural Resources

iii) North Central Farm Forestry Development Project, Bendigo, Victoria

In an area where forestry was considered unsuitable because of the low rainfall (less than 600 mm p.a.), this project, which commenced in 1987, has successfully changed this view with the added benefits of reduced salinity and increased biodiversity. A complete farm forestry implementation package has been developed, using NHT Funding. The package includes development of a farm forestry strategy, feasibility

study, extension program, education, training and implementation.

To date, 500 hectares of cleared farming land has been planted to forestry (red ironbark, sugar gum, weeping myall, river she-oak and willow wattle), and the target is 10,000 hectares by 2006.

For more information contact:

North Central Catchment Management Authority
Telephone: 03) 5444 6750

iv) Philip and Diane Down's Property
Meningie, South Australia

This dryland dairy property is located in the Coorong District, a landlocked catchment where recharge reduction is an important salinity management initiative. A Local Action Plan has been developed with the aim of reducing recharge by 50% over the period 1994 – 2004.

Central to the strategy is sustainable farming with reliance being placed on substantial lucerne plantings, with a 24 metre wide strip of mixed, local, native vegetation strips along the edges of every renovated paddock. The native vegetation plantings have multiple benefits – recharge control, windbreaks and enhanced biodiversity.

For more information contact:

Bruce Munday
Clear Connections
Telephone: 08) 8538 7075

v) Russell and Linda White's Property, at Simpson, Victoria and Irene and Chris Callaghan's Property, at Gerangamete, Victoria

Both properties are dairy farms, located in Victoria and are involved in an NHT funded project directed at Agroforestry for Salinity Control.

Piezometer records have been kept since 1993. Over that period about 15-20% of the farms have been revegetated.

Chris says that although he has taken areas out of production, he has actually increased production. This is not just from uptake of water, but from added shelter for stock and pasture from shelter belts as well as the projected returns from harvested timber.

Both properties are in very high rainfall areas.

For more information, contact:

Agriculture Victoria
Centre for Land Protection Research
Bendigo VIC 3550

Mr David Heislers
Telephone: 03) 5430 4319

For other projects in Victoria, particularly in Colac Otway Shire contact:

Ms Wendy Briggs
Colac Otway Shire
Telephone: 03) 5232 9414

C. Engineering Options

i) NDSP Project

Under the National Dryland Salinity Program, a project is underway to "Assess the Efficiency of Engineering Options for the Management of Dryland Salinity". The objective is to develop a tool to help salinity managers identify effective options for particular regions. Twenty-four (24) case studies are being compiled to summarise successful and unsuccessful examples of engineered initiatives.

For more information contact:

Chris McAuley
Sinclair Knight Merz
Telephone: 03) 9248 3370

ii) Robert and Helen Nixon Property Kalannie, Western Australia

A third of this grain and sheep property had the potential to go saline. Groundwater pumping has reclaimed about 200 hectares. The first step in the reclamation program was a cost-benefit analysis, followed by installation of 52 groundwater monitoring bores, three water extraction bores and about 10 kilometres of pipelines. The bores yield 450 kilolitres per day. Apart from the reclaimed land, benefits have included increased production with potential to harvest and sell salt.

For more information contact:

Georgina Wilson
Agriculture Western Australia
Telephone: 08) 9368 3889

D. Pilot Projects and Innovations

i) In the Lachlan, Macquarie and Castlereigh Catchments in NSW, a pilot project will develop ways to overcome social and economic barriers to land management change.

In the Liverpool Plains of NSW a pilot project will trial a range of market and investment mechanisms, including:

- An environmental management system to accredit farm produce grown using best practice salinity management
- A tender system where land managers can bid for grants to help them protect and manage their properties to maximise salinity prevention, salinity abatement and biodiversity.
- Strategic funding approaches to finance small community projects.

In the Wagga area, a pilot project will examine joint solutions for salinity, biodiversity and water quality.
For more information contact:

The Department of Land and Water Conservation
PO Box 3720
PARRAMATTA NSW 2124
Telephone: 02) 9895 7465

ii) Leakage Studies

a) Liverpool Plains, NSW

A joint study by CSIRO and NSW Agriculture has been conducted to assess alternative land use systems, using APSM (Agricultural Production Systems Simulator). The modelling program simulates alternative farming systems including their water balance and crop production.

b) Burkes Flat, Avoca River, Victoria

The Victorian Department of Natural Resources and Environment has undertaken extensive mapping of areas of leakage to groundwater and groundwater discharge areas.

Catchment treatment, involving native tree plantations, establishment of perennial pastures and planting of salt tolerant grasses was then undertaken.

Without these treatments, it is estimated that the salinised area would have increased by 25%.

c) Walpeup (Victoria) and Hillston (NSW)

A joint project between NSW Agriculture, Agriculture Victoria and CSIRO studied leakage rates under fallow and non-fallow systems in the Mallee and at Hillston.

Results at Walpeup indicated that by removing the fallow and including mustard into a wheat-pea crop rotation, long term average leakage was reduced by between 25% and 40%.

For more information on a), b), and c) contact:

CSIRO Land and Water
CANBERRA ACT 2600

d) West Wyalong/Junee, NSW

In the West Wyalong/Junee region of NSW, a major project involving more than 60 scientists from 14 research organisations is developing systems to locate water resources, salt stores and pathways.
For more information contact:

Dr Richard Cresswell
Bureau of Rural Sciences

e) Airborne Geophysics

Under the National Action Plan for Salinity and Water Quality a Commonwealth Government Airborne Geophysics Survey has commenced in two selected catchments in Western Australia. The program is intended to extend to other states in the future.

It is anticipated that this technology will become increasingly more valuable as a tool for assessing large scale dryland salinity risks.

For more information contact:

Dr Richard George
Agriculture Western Australia
Telephone: 08) 9780 6100

Photo Courtesy: Bill Van Aken, CSIRO Land and Water

Extensive dryland salinity showing impacts on infrastructure
Source: PMSEIC "Dryland Salinity and its Impact on Rural Industries and the Landscape"

APPENDIX A: LIST OF CONTACTS

National

National Land and Water Resource Audit
C/o Land and Water Australia
91 Northbourne Avenue
TURNER ACT 2612

Telephone: 02) 6257 9516
E-mail: info@nlwra.gov.au
Home page: www.nlwra.gov.au

National Dryland Salinity Program
Richard Price, National Manager
GPO Box 2182
CANBERRA ACT 2601

Telephone: 02) 6263 6002
E-mail: richard.price@lwa.gov.au
Website: www.ndsp.gov.au

For further information related to the National Dryland Salinity Program (NDSP), contact your nearest NDSP Communication Co-ordinator:

National
Kim Mitchell
Currie Communications
Telephone: 03) 9696 5899
Facimile: 03) 9696 6285
Email: kim@curriecom.com.au

Queensland
Mark Warnick
Department of Natural Resources and Mines
Telephone: 07) 3896 9645
Facimile: 07) 3896 9625
E-mail: warnickmf@dnr.qld.gov.au

New South Wales
Lisa Gray
Department of Land and Water Conservation
Telephone: 02) 9228 6111
Facimile: 02) 9228 6464
E-mail: lgray@dlwc.nsw.gov.au

Victoria
Jo Curkpatrick
Span Communication Pty Ltd
PO Box 2054, Hotham Hill VIC 3051
Telephone: 03) 9328 5301
Facimile: 03) 9328 5302
Email: jocurk@enternet.com.au

South Australia
Bruce Munday
Clear Connections
PO Box 375, Mt Torrens SA 5244
Telephone: 08) 8538 7075
Facimile: 08) 8538 7075
Email: bcmunday@senet.com.au

Western Australia
Georgina Wilson
Agriculture Western Australia, Locked Box 4, Bentley Delivery Centre WA 6983
Telephone: 08) 9368 3889
Facimile: 08) 9474 2018
Email: gwilson@agric.wa.gov.au

TOOLS – TOOLS for Dryland Salinity, a program of the NDSP. The TOOLS program provides FACT SHEETS on identifying, managing and preventing dryland salinity.

OPUS – Options for the Productive Use of Saline Lands – a program of the NDSP

State Contacts of the NDSP

Queensland
Ian Gordon
07) 3896 9471
ian.j.gordon@dnr.qld.gov.au

New South Wales
Peter Barker
02) 6971 4101
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South Australia
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Western Australia
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Grains R&D Corporation
John Harvey
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National Land & Water Resources Audit
Adrian Webb
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adrianwe@msn.com.au

Rural Industries R&D Corporation
Tony Byrne
02) 6272 5472
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CSIRO
Tom Hatton
Telephone: 08) 9333 6208
E-mail: tom.hatton@per.clw.csiro.au

The Murray-Darling Basin Commission
GPO Box 409, CANBERRA ACT 2601
Telephone: 02) 6279 0141
Facimile: 02) 6248 8053

Western Australia

Land Management Society
PO Box 242, COMO WA 6152
Telephone: 08) 9450 6862
Website: www.space.net.au/~imsinfo

Agriculture Western Australia
3 Baron-Hay Court, SOUTH PERTH WA 6151
Telephone: 08) 9368 3333
Website: www.agric.wa.gov.au

Department of Conservation and Land Management
Hackett Drive, CRAWLEY WA 6009
Telephone: 08) 9442 0300
Website: www.calm.wa.gov.au

New South Wales

NSW Agriculture
161 Kite Street, ORANGE NSW 2800
Telephone: 02) 6391 3100
Website: www.agric.nsw.gov.au

Department of Land and Water Conservation
23-33 Bridge Street, SYDNEY NSW 2000
GPO Box 39, SYDNEY NSW 2001
Telephone: 02) 9228 6111
Website: www.dlwc.nsw.gov.au

Victoria

Department of Natural Resources and Environment
8 Nicholson Street, EAST MELBOURNE VIC 3002
Telephone: 03) 9637 8000
Website: www.nre.vic.gov.au

Northern Territory

Department of Primary Industries and Fisheries
Berrimah Farm, Makagon Road, BERRIMAH NT 0828
GPO Box 990 DARWIN NT 0801
Telephone: 08) 8999 2311
Website: www.nt.gov.au/dpif

Queensland

Department of Natural Resources
GPO Box 2545, BRISBANE QLD 4001
Telephone: 07) 3896 3111
Website: www.dnr.qld.gov.au

Department of Primary industries
80 Ann Street, BRISBANE QLD 4000
Telephone: 07) 3404 6999 or (local) 13 25 23
Website: www.dpi.qld.gov.au

South Australia

Department of Primary Industries and Resources
101 Grenfell Street, ADELAIDE SA 5000
GPO BOX 1671, ADELAIDE SA 5001
Telephone: 08) 8463 3384
Website: www.pir.sa.gov.au

Department for Water Resources
GPO Box 1047 ADELAIDE SA 5001
Telephone: 08) 8204 9137
Website: www.sacentral.sa.gov.au/environment/water

Department of Environment and Heritage
GPO Box 1047 ADELAIDE SA 5001
Telephone: 08) 8204 9000
Website: sacentral.sa.gov.au/environment/

Tasmania

Department of Primary Industries, Water and Environment
GPO Box 44A
HOBART TAS 7001
Telephone: 03) 6233 8011
Website: www.dpiwe.tas.gov.au

State and Natural Resource Management Agencies

Western Australia
Agriculture Western Australia
Information and Media Services
Telephone: 08) 9368 3333

New South Wales
Department of Land and Water Conservation
Information Centre
Telephone: 02) 9895 6211

Victoria
Department of Natural Resources and Environment
Information Centre
Telephone: 03) 9637 8080

South Australia
Department of Primary Industry and Resources
Information Centre
Telephone: 08) 8226 0307

Land and Water Resources Research and Development Corporation.
GPO Box 2182
CANBERRA ACT 1998

Telephone: 02) 6257 3379
Facimile: 02) 6257 3420
Website: http://www.lwrrdc.gov.au/nsdp/index.html

APPENDIX B: FUNDING SOURCES

Readers should contact the relevant Departments/Agencies in their State to determine what funding opportunities for mitigation works/education and awareness programs may be available (Refer Section 12 for a List of Contacts).

On a National basis, funding may be available under the following programs:

National Action Plan for Salinity and Water Quality

Funding for the 21 Priority Regions is expected to be available in 2002-03.

The Natural Heritage Trust
Environment Australia
GPO Box 787
CANBERRA ACT 2601

Telephone: 1800 065 823
Web Site: www.nht.gov.au

Bushcare
NRM Branch
Environment Australia
GPO Box 787
Canberra ACT 2601

Telephone: 1800 671 717
Facsimile: 02) 6250 0286

National Landcare Program
The NLP Contact Officer
Natural Heritage Trust Administration Section
Natural Resource Management Division
Agriculture, Fisheries and Forestry – Australia
GPO Box 858
Canberra ACT 2601

Telephone: 02) 6271 5474
Facsimile: 02) 6272 5618

National Rivercare Program
The National Rivercare Program Manager
Natural Resource Management Policy Division
Agriculture, Fisheries and Forestry – Australia
GPO Box 858
Canberra ACT 2601

Telephone: 02) 6272 3932

Farm Forestry Program
Forests Division
Agriculture, Fisheries and Forestry – Australia
GPO Box 858
Canberra ACT 2601

Telephone: 02) 6271 6380
Facsimile: 02) 6272 4875

National Wetlands Program
Wetlands Section
Environment Australia
GPO Box 787
Canberra ACT 2601

Telephone: 02) 6274 2289
Facsimile: 02) 6274 2735

Waterwatch
Wetlands Section
Environment Australia
GPO Box 787
Canberra ACT 2601

Telephone: 02) 6274 2797
Facsimile: 02) 6274 2735

Murray-Darling 2001
The Director
Murray Darling Basin Section
Water and Regional Branch
Natural Resource Management Policy Division
Department of Agriculture, Fisheries and Forestry – Australia
GPO Box 858
Canberra ACT 2601

Telephone: 02) 6272 5502
Facsimile: 02) 6271 6448

Private Investment options, particularly for the establishment of plantations or alternative agricultural pursuits, should also be considered.

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Wilson S.M. 2000b, *The cost of dryland salinity to non-agricultural stakeholders in selected Victorian and New South Wales catchments – interim report,* Part 1, a Wilson Land Management Services report prepared for the Murray-Darling Basin Commission and the National Dryland Salinity Program, Canberra.

State Strategies

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APPENDIX D: GLOSSARY OF TERMS

Agro-forestry: Land management practice in which farmers cultivate trees in addition to their other agricultural activities.

Alluvial: Deposited by rivers in low-lying areas and flood plains.

Aquatic ecosystem: All living and non-living elements of a water-based environment and the relationship between them.

Aquifer: A layer of rock which holds and allows water to move through it, and from which water can be extracted. Confined aquifers have a layer of rock above them that are impermeable to water.

Biodiversity: The variety of life forms, the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form.

Bore: A hole of uniform diameter (usually 150 mm to 160 mm) drilled vertically into the ground to tap an aquifer. It contains a pipe through which groundwater can be pumped or can flow to the surface by artesian pressure.

Break of slope: The line across a landscape at which the surface slope is reduced and where the hydraulic conductivity of the underlying material or the hydraulic gradient decreases.

Catchment: The area of land drained by a river and its tributaries.

Deep drainage: Where water drains from below the root-zone into underlying aquifer systems.

Development Control Plan: A plan prepared by a local council which contains detailed guidelines that must be considered when carrying out new development.

Discharge area: An area where groundwater seeps to the surface or waterway.

Drain: A channel for the purpose of interception and removal of excess surface or sub-surface water to a stable outlet.

Drainage paths: Naturally defined pathways through which run-off flows. Generally used to describe drainage depressions, gullies, drainage lines, creeks and rivers.

Ecologically Sustainable Development: Using, conserving and enhancing the community's natural resources so that ecological processes on which life depends are maintained and the total quality of life, now and in the future, can be increased.

Ecosystem: Communities of organisms and their physical environment interacting as a unit.

Electrical conductivity: The most widely used and convenient method of measuring the salinity of water is by electrical conductivity. One measure of electrical conductivity is 'micro-Siemens per centimetre'. The shorthand expression for this is the 'electrical conductivity unit', 'EC unit' or just 'EC'.

End of valley salinity target: A "big picture" target or goal that is an overall indication of our desired salinity conditions and also how much salt we are aiming for at the end of major catchments.

Evaporation basin: a shallow pond into which saline water is discharged to evaporate, leaving a residue of salt.

Geomorphology: Science of describing and interpreting landform patterns and processes of landscape formation.

Geophysics: The science of studying the earth's physical properties such as magnetism, conductivity and density.

Groundwater: water beneath the surface held in or moving through saturated layers of soil, sediment or rock.

Groundwater mound: A bulge in the surface of the watertable, usually created by excessive recharge at that point.

Hard water: Water containing high concentrations of calcium and magnesium salts. Hard water makes soap difficult to lather and may cause scaling or corrosion in water pipes, boilers, water heaters and other appliances, and industrial equipment.

Hydrogeology: The study of water in or moving through soils and rock formations and the transport of materials that are either in suspension or dissolved in the water.

Hydrological equilibrium: When the water cycle is in balance and there is no long-term trend in groundwater levels. That is, groundwater recharge and discharge are balanced over time.

Landscape: An area of land and its physical features. A term we use to describe an area that has common features.

Local Environmental Plan: A plan prepared by a local council which contains guidelines and environmental standards that must be considered when carrying out new development. It is not as detailed as a Development Control Plan, and in cases of conflict, an LEP overrides a DCP. In most (but not all) cases, the LEP must be consistent with any relevant Regional Environmental Plans and State Environmental Planning Policies.

Local provenance vegetation: Native plant varieties of local/regional origin.

Management actions: What we need to do on the ground to achieve management targets.

Management targets: What we need to have in the landscape to get desired salinity conditions locally and to achieve end of valley salinity targets. They will often be land-based (biophysical).

Native vegetation: Plants species originating in Australia.

Natural resources: The assets of land, water, plants, animals and air.

Perched aquifer/watertable: A watertable above the main watertable level where impermeable soil or rock prevents the water from percolating through to the main groundwater body.

Perennial: Plant that lives for several years (annuals live for only one growing season).

Permeability: The capacity of a substance (for example, soil or rock) to allow water to pass through it. Sand, for example, is said to have high permeability.

Piezometer: a piezometer is a sealed PVC bore (20-40 mm diameter) that measures groundwater levels. The depth of the piezometer corresponds to the depth at which water in encountered.

Recharge: A component of rainfall that drains below the root zone of vegetation and joins the groundwater.

Recharge area: The area where water can enter and move downward to the groundwater. Recharge areas are usually permeable in the upper slopes and are often on shallow soils.

Regional Environmental Plan: A plan that deals with matters that are significant for environmental planning in a region.

Remnant vegetation: Vegetation remaining after an area has been cleared.

Residual salt: Salt that is left in the landscape after the water has evaporated or receded.

Riparian zone: the area close to a river, stream or watercourse.

Risk: An estimation of the expected amount of harm that will occur to an asset.

Root zone: The area below the ground surface occupied by plant roots.

Salinisation: The process by which land becomes salt-affected or salinised.

Salinised land: Land affected by salinity.

Salinity: refers to the presence and amount of dissolved salts (mainly sodium chloride) and some other salts containing calcium and magnesium in soil and water.

Salt concentration: Level of salts on the land surface or in soil, rocks or water.

Salt interception scheme: Usually works comprising a system of pumps and drainage that reduce the level of the groundwater by pumping it into evaporation basins or elsewhere, thereby intercepting salt before it enters a river or reaches the soil surface.

Salt load: The amount of salt carried in water flow in rivers, groundwater or off the soil surface, in a given time period.

Salt scald: A bare patch of earth where the surface soil has been removed by erosion or damaged by salinity, making it hard to revegetate. Salt may form crystals on the surface.

Salt, salts: Salt causing salinity is actually a mixture of several types of chemical 'salts'. These include common salt (table salt or sodium chloride) and other salts that cause hardness in water (potassium, magnesium salts).

Salt-tolerant crops: Crops that grow well in salty soils.

Seepage: The process by which water percolates downwards and/or laterally through the soil, often emerging at ground level lower down the slope.

Soil profile: A vertical section of earth from the soil surface to parent rock material, that shows the different soils' horizons.

Subsoil: The layers of soil below the topsoil.

Sustainability: Managing our natural resources in a way that maintains their environmental, economic and cultural values, so that they continue to be available in the long-term.

Top soil: The surface or upper level of soil.

Waterlogging: Waterlogging occurs when the watertable rises into the root zone. It results in anaerobic (absence of free oxygen) conditions which reduce plant growth and may kill plants.

Watertable: The watertable is the upper surface of groundwater. The soil profile is fully saturated below the watertable and unsaturated above it.

APPENDIX E: FACT SHEETS

It is recommended that users of this Handbook subscribe to the National Dryland Salinity Program (NDSP) and Salt Action to obtain Fact/Information Sheets, which can be filed under this Section for reference.

Relevant websites are:

NDSP: http://www.ndsp.gov.au/10_NDSP_projects
Salt Action: http://www.ndsp.gov.au/15_publications

FAX BACK SHEET FAX TO: 02 9283 5255

The Local Government Salinity Management Handbook has been produced by the Institute of Public Works Engineering Australia as a resource guide for public works professionals.

It is intended to be an adaptive handbook with regular reviews and, to this end, readers are encouraged to submit case studies and successful solutions to salinity problems for incorporation in future editions.

Please forward comments, case studies, details of errors or omissions, or other suggestions for inclusion in future editions to:

Chris Champion
Chief Executive Officer
Institute of Public Works Engineering Australia
Level 12, 447 Kent Street
SYDNEY NSW 2000

Or e-mail your suggestions to: ipwea@ipwea.org.au

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