Natural Resources Commission

2010 Urban Salt Conference - Key Note Address by John Williams

Hyder Consulting Pty Ltd

ABN 76 104 485 289

Level 5, 141 Walker Street
Locked Bag 6503
North Sydney NSW 2060
Australia

Tel: +61 2 8907 9000

Fax: +61 2 8907 9001

www.hyderconsulting.com

Natural Resources Commission

2010 Urban Salt Conference - Key Note Address by John Williams

Author	Brad Searle	
Checker	Denise Day	
Approver	Roland Breckwoldt	

Report No

Date 24 May 2010

CONTENTS

Paper Title – Salt in our cities - counteracting the silent flood

1 Introduction

Salinity (dryland and irrigation) is recognised as a significant problem impacting agricultural productivity and the environment in many rural areas across Australia. In response to the salinity problem the National Action Plan for Salinity and Water Quality (NAP) was developed in 2000. This resulted in investments of approximately $1.4 billion over seven years to support action by communities and land managers in 21 highly affected regions. As a result, significant research was undertaken to understand the nature and extent of dryland and irrigation salinity, and to develop solutions to respond to the problem.

Since the mid 1990s there has been increasing recognition that the full impacts of salinity are more widespread leading to significant costs and impacts in urban areas, including regional towns and the infrastructure supporting them (e.g. roads, railways) and major cities. Urban salinity is defined as the accumulation of salts in soil or water to levels that impact on human and natural assets. Urban salinity can develop in a variety of ways and is generally a combination of both dryland and irrigation salinity. Significant effort is now underway across all levels of government to better understand the severity, extent and cost of the problem across Australia.

The purpose of this paper is to outline the current significance of urban salinity, focussing on the NSW perspective in terms of the extent, severity and cost of the problem, and the implications for the management of urban salinity. The key drivers of urban salinity are discussed, as well as their spatial and temporal variability in the landscape. Finally, a range of response strategies for addressing current and future potential urban salinity impacts are highlighted.

2 A significant issue

Urban salinity is becoming increasingly recognised as a significant problem impacting on rural and urban townships. This is highlighted by the following statistics:

- The extent of urban salinity in NSW in 2001 was estimated to be 954 ha and is expected to increase to 3,646 ha by 2050 (Littleboy *et al* 2001).
- High watertables are believed to affect about 34% of state roads and 21% of national highways in south-western NSW, resulting in repair costs of $9 million annually (Littleboy *et al* 2001).
- The length of roads and railways affected by salinity in NSW is likely to increase five fold over the next 50 years (Littleboy et al 2001). Although, as discussed later in this paper, multi-decadal rainfall pattern can delay or accelerate expression of dryland salinity. In urban settings the water use patterns are however a dominate influence in salinity expression.
- In the Hawkesbury Nepean Catchment Management Authority catchment 168 ha of built up areas are currently affected by urban salinity and 60 ha in the Hunter catchment (Littleboy *et al* 2001).
- The Murray-Darling Basin (MDB) and several coastal catchments impacted by water tables less than 2 metres estimated at 180,600 ha in 2000. There is potential for this area to increase to 579,224 ha by 2020 and 1,300,807 ha by 2100 (Cross 2003).
- In the MDB 220 rural towns and cities currently display urban salinity damage (Wilson 2003).

- Salinity damage to Australian roads are estimated to be $50 - $100 million in the year 2000, increasing to $168 - $380 million by the year 2050 (Aust Roads 2007).
- The total annual cost of saline town water supplies for Dubbo, including households and industry estimated at approximately $1.47 million (Nicholson *et al* 2008)
- The total cost of salinity damage in non-irrigated rural and urban areas in the MDB is estimated to be $304.7 million per annum[1]. Of this total, urban salinity costs to local government, households and industry accounted for 67% or $204 million (Figure 1).

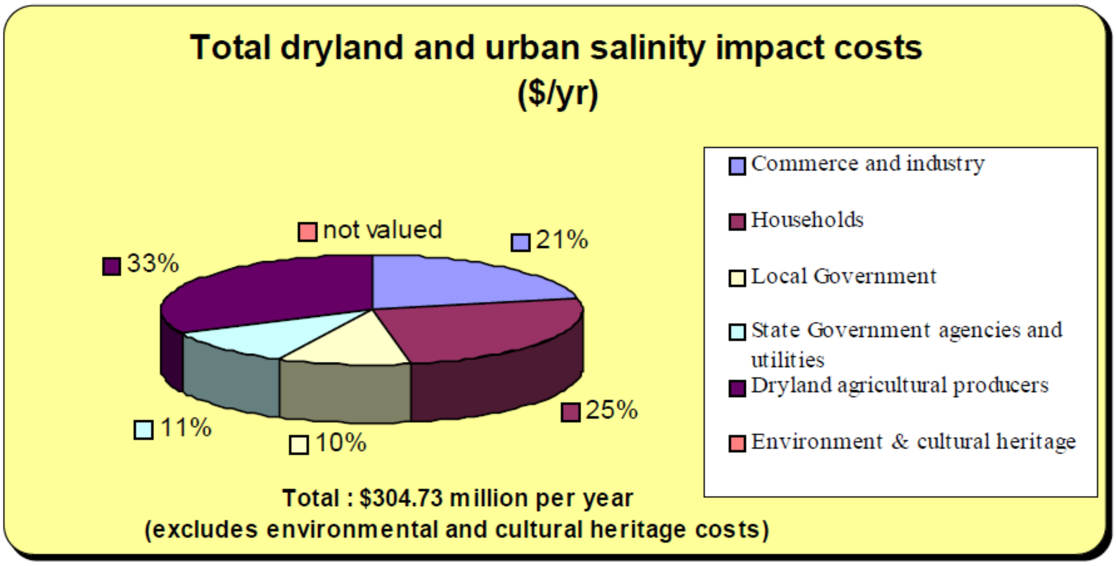


Figure 1: Total urban salinity and dryland impact costs in the MDB (Wilson 2003)

3 What is driving salinity in the urban landscape?

Current drivers

Understanding the cause of salinity in the urban context is not ‘black and white’. The interplay of physical processes such as geology, climate, soils and vegetation can all play a key role, either separately or collectively, in influencing the extent and severity of salinity. As a result, the cause of salinisation and its expression in the landscape may differ spatially and temporally, which further adds to the complexity around salinity issues. Key drivers of urban salinity are outlined below:

1) Climate

Previously the key cause of dryland and urban salinity was attributed to land use change, in particular land clearing. However, a recent study undertaken by the Department of Environment, Climate Change and Water (DECCW) in the NSW section of the MDB has shown that climate variability over the last century is likely to be the main trigger of soil salinity problems in south-eastern Australia (Rancic *et al* 2003). As evident in Figure 2 groundwater levels have risen and fallen in line with variations in rainfall, with extensive land clearing only becoming significant during wet periods.

[1] Note this figure does not include impacts of salinity on natural environment or cultural heritage.

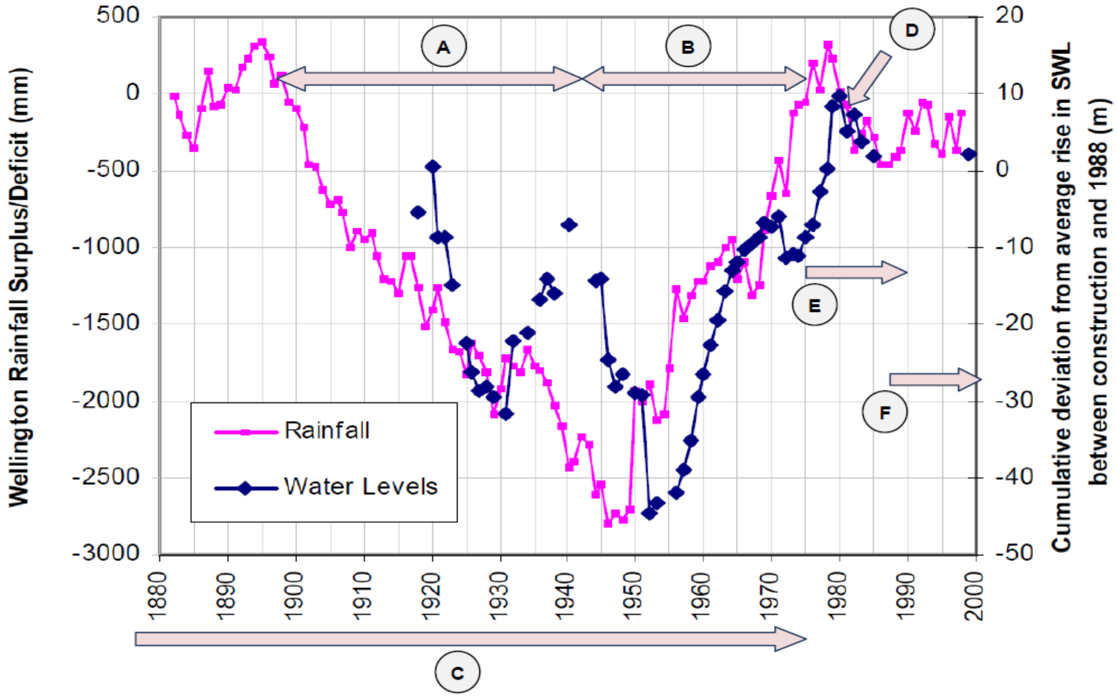


Figure 2: Relationship between rainfall and groundwater level trends for the period 1880-2000 (adapted from Rancic *et al* 2003)

Key trends which can be drawn from this graph are:

a) Extended dry period from about 1895 to 1946 (below average rainfall)

b) Wetter conditions from 1947 – 2000 (above average rainfall)

c) Extensive vegetation clearing and unsustainable land management practices from late 1800s through to the late 1900s superimposed with wetter climatic conditions cause water tables to rise, intersecting the landscape at many points

d) Extended wet period ended in 2000 with onset of drought, resulting in falling groundwater levels and areas at risk of salinity. Rainfall falls to less than 40% of pre-2000 wet period

e) Alarming increase in farmland subsequently affected by dryland salinity in the 1970s and 80s and observations of urban salinity from the 1990s onwards

f) Potential recent return to La Nina weather conditions may see a return of rising groundwater levels.

2) Geological setting of urban catchments

This has a major bearing on the development of salinity as a result of the existing circumstance or changes brought about by the development itself:

- Urban development occurring in areas that represent discharge sites, such as plains, valleys and the foot of ridges, which are prone to salinity expression (DECCW 2009).
- Development in areas with high salinity potential (e.g. existing shallow groundwater or seepage, or high risk soil types) (I&I 2003). This is relatively common given the high salt levels in Australian soils.

- Changes in hydrological flows and interactions as a result of urban development bringing about changes to natural drainage paths (e.g. a road creating a catchment constriction).

Case in point: *The possible sources of salt in Western Sydney are from the region's geology and climate. The main geological formations of Western Sydney are the Wianamatta Shales, which formed in coastal and marine environments and have a naturally high fossil (connate) salt content. Approximately 10 to 20 kilograms per year of salt are also added to each hectare of land, primarily by rainfall due to Western Sydney's proximity to the coast (Nicholson 2003).*

3) Land clearing

Large scale clearing of native vegetation since European settlement has substantially increased the amount of water entering groundwater systems leading to increased salinity (Nicholson *et al* 2008). Soil properties also play a major factor in influencing salinity development. The removal of the "elastopast" (i.e. vegetation) which in effect protects soils can promote the onset of salinity (Ackworth pers comm 2010).

Case in point: *Many of the towns in South Western Australia, as well as towns in the MDB (e.g. Narranderra), currently affected by urban salinity are likely to have been impacted by adjacent land uses in agricultural areas. In these cases townships are likely to overlay intermediate and regional groundwater flow systems.*

4) Application of water and stormwater impacts

Water plays a critical role in mobilising and transporting salt through the landscape (i.e. salts are soluble in water) (as shown in Figure 3**Error! Reference source not found.**). Salinity in urban areas is often driven by the application of large volumes of extra water to the soil as a result of watering parks and gardens. Surface water application rates and water use patterns can have a major influence on local recharge of groundwater systems. Subsequent evaporation and accumulation of this water can cause an increase in salt levels to the extent that materials such as concrete and steel are impacted through corrosion and cracking (DLWC 2002). This issue may be exacerbated by storm water management options such as retention and reuse that have the potential to result in increased recharge and salt to groundwater systems. The design of water management processes need to consider the interface between surface water management and salinity issues and build in an understanding of the landscape processes that may be impacted.

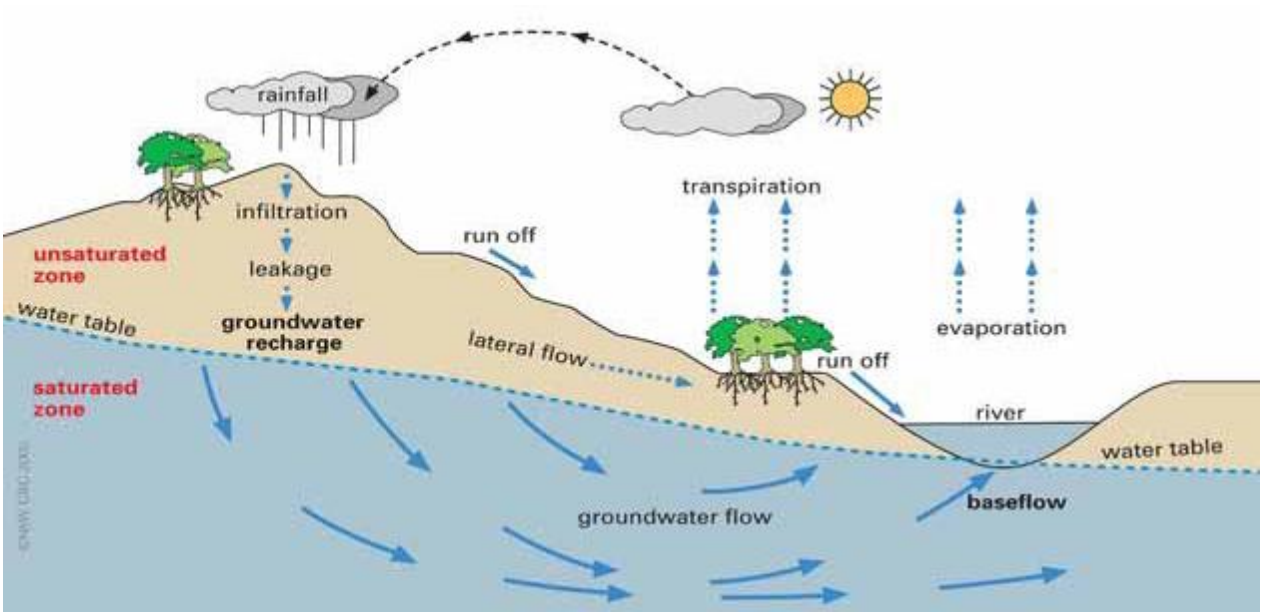


Figure 3: The hydrological cycle (Slinger and Tension 2007)

Case in point: *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.It is estimated that approximately 47% of total groundwater recharge in Wagga Wagga originates from leaking water pipes (Cross 2003).*

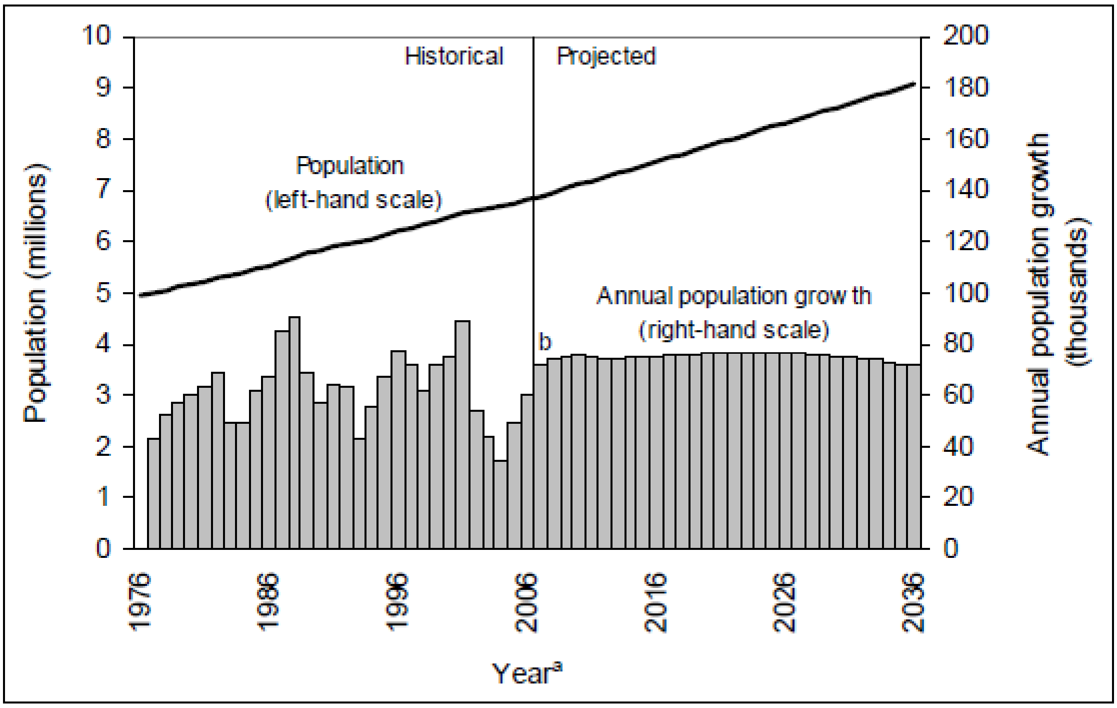
Future drivers

Population growth

Population growth will be an important driver in increasing urban salinity, particularly in greenfield development areas. The population of NSW is projected to grow to 9.1 million by 2036, an increase of 33% on the 2006 population of 6.8 million (Figure 4).

The key areas of population growth are projected to be:

- Sydney metropolitan: in particular in the South West, Sydney City and North West, with projected increases of 113%, 60% and 52%, respectively.
- Regional: Queenbeyan (up 72%), Maitland (up 71%) and Tweed (up 59%) (Department of Planning 2008).



a For population numbers (left-hand scale) 'Year' refers to the 30th June of each year; for annual population growth (right-hand scale), it denotes the 12 month period ending 30th June of the year shown.
b The projections take into account preliminary ABS population growth estimates for 2006-07.

Figure 4: Past and projected population of NSW, 1976 – 2036 (Department of Planning 2008)

Many of Sydney's existing growth centres (i.e. in the South West and North West) are already experiencing the impacts of urban salinity. Further urban development in greenfield areas highlights the importance of a co-ordinated response across State and local government in responding to issues posed by urban salinity.

Climate Change

Climate change is likely to have profound effects on the hydrological cycle through altered precipitation, evapotranspiration and soil moisture patterns. It is expected that NSW will become warmer, with an increase in maximum and minimum temperatures 'very likely' in all seasons. By 2050 winter and spring annual maximum temperatures are expected to rise by around 2–3°C across much of northern NSW (DECCW 2009). Projected changes in rainfall due to climate change indicate a likely decline in rainfall over southern Australia, mainly confined to winter and spring (Figure 5). The projections also indicate an increasing proportion of rain will fall as intense events.

It is uncertain whether reduced average annual rainfall will result in reduced recharge to groundwater (and a reduction in associated salinity expression), or whether intense rainfall events will increase recharge to groundwater.

Figure 5: Projected changes to NSW rainfall to 2050 (DECCW 2009)

Sea levels along the NSW coastline are projected to rise by up to 40 cm by 2050, and 90 cm by 2100 under climate change scenarios. This has the potential to significantly exacerbate sea water intrusion in coastal urban catchments impacting water supplies and infrastructure in these areas (Werner *et al* 2008).

4 Impacts of salinity

The impacts of salinity on urban infrastructure fall into two key groups including those caused by saline water supplies and saline water tables that have risen to close to the surface. A simplified pictorial representation of urban salinity impacts is provided in Figure 6.

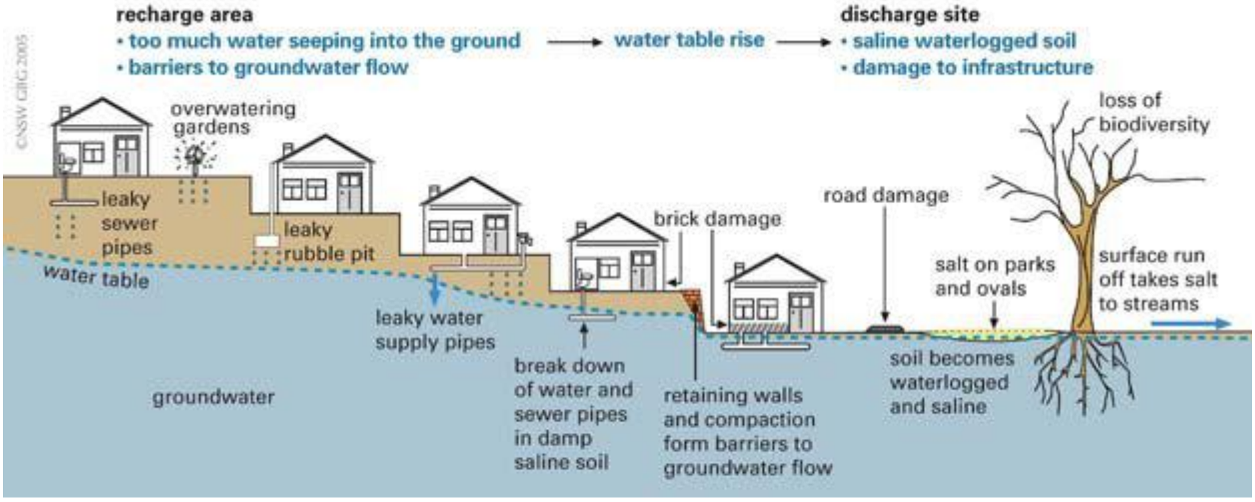


Figure 6: Drivers and impacts of urban salinity (DNR 2006)

Buildings and associated property

Salt in 'rising damp' has the potential to damage the bricks and mortar of buildings (Figure 7), domestic appliances, such as hot water systems, plumbing infrastructure and household appliances. Spennemann (1997) also found that many cultural heritage sites in the Riverina district have also been impacted by salt decay.

Infrastructure

Damage is caused to infrastructure such as roads (Figure 8), railways (Figure 9), telecommunications, power cables, gas, water and sewerage pipes through corrosion and cracking of concrete (I&I 2003). This can present increased capital and operational costs for infrastructure. For example, Wagga Wagga City Council estimated the cost of restructuring one block of salt affected urban roads at $300,000 and 1 km of highway at $700,000. Cross (2003) estimated that 78 km of railway lines were affected by rising water tables. This is projected to increase to 416 km by 2050.

Parks and gardens

High saline water tables can impact on urban lawns, gardens, street trees and sporting fields (Figure 10). In the most extreme cases impacts will render some areas no longer suitable for their intended use as a result of waterlogging and/or die off of vegetation.

The natural environment

Rising water tables and increasing salinity can impact on native vegetation values, rivers and creeks and wetlands (e.g. the Macquarie Marshes in the Murray-Darling Basin). In NSW 7000 ha of remnant vegetation and plantation forests are currently at risk from salinity which is projected to increase to 81,000 ha by 2050 (IPWEA 2002).

The above impacts can present liability issues for councils and developers. Many NSW councils now recognise the need to manage this issue to minimise potential liability. Developers may also face liability issues where they are unable to demonstrate use of materials and construction methods which are appropriate for mitigating impacts in saline sensitive areas.

Figure 7: Impacts of rising damp on property

Figure 8: Impact of salinity on road base

Figure 9: Impacts on railway

Figure 10: Saline discharge area on nature strip

(Figures 7-10 provided courtesy of Allan Nicholson, DECCW)

5 Responding to the issue

Commonwealth, state, local government and community groups have made a wide ranging portfolio of investments to counteract impacts posed by urban salinity. It is important to note that there is no 'quick fix' solution. Key responses tend to fall into two categories – salinity prevention and salinity treatment.

Some key principles which should be implemented in tackling salinity include:

- The use of best available information when responding to the problem
- The adoption of a proactive approach to salinity management
- Facilitating a co-ordinated and co-operative approach to salinity management
- Ensuring salinity is considered as a land management issue throughout the land development process.

A summary of approaches in responding to the urban salinity are outlined below.

Government Policy

In 2000 the NSW government recognised urban salinity as a significant issue when it introduced its Salinity Strategy. Some major urban salinity projects initiated under the Strategy have included:

- The Local Government Salinity Initiative (LGSI) which provides training, education and technical support to local government
- Model planning guidelines
- The establishment of specialist Salt Action teams throughout NSW.

A NSW Salinity Statement is currently being developed by DECCW which will include emphasis on urban salinity as a key issue.

Mapping, modelling and monitoring

Understanding the pathways in the hydrological cycle between groundwater recharge and discharge areas is critical for understanding the nature of the urban salinity problem. Assessing and monitoring groundwater levels, as well as mapping geology and soils, is important in assessing a site in order to identify the most appropriate and effective management responses. Some recent developments include:

- A map of the salinity potential (distribution and severity) in Western Sydney (2002) based on a practical understanding of the factors that cause salinity. The map and accompanying guidelines aim to assist land managers to assess the salinity potential for a particular area.
- The installation of monitoring bores across the Dubbo township in 1km grid in order to identify the specific areas of the catchment contributing excess water to groundwater.
- Salinity audit (2009): upland catchments of the NSW Murray-Darling Basin presents a range of information that has been compiled to assess the current status of salinity and future trends in salinity across upland areas of the NSW Murray-Darling Basin.
- The NSW Coastal Salinity Audit (DIPNR 2004).
- Water auditing of urban land use to identify areas of excess water usage.

Planning and development controls

Examples of best practice planning and development controls for tackling urban salinity include:

- Provisions in catchment plans for responding to urban salinity issues (e.g. Sydney Metropolitan CMA Catchment Action Plan).
- Local government Regional Environment Plans (REPs) - e.g. Sydney REP No 30 – St Marys.
- Local government Local Environment Plans (LEP) – identify broad levels of salinity potential and appropriate considerations and assessment of salinity requirements of developments where it is an issue (e.g. Dubbo LEP).
- Salinity policy and development control planning documentation outlining needs for detailed assessment requirements, building and design requirements for areas with salinity potential, stormwater and drainage design etc. For example, Camden, Junee and Fairfield Councils have policies and control plans in place for building in saline environments.

- *Best Practice Guidelines for Greener Subdivisions: Western Sydney* (2002) - provides a guide to the planner, designer and developer to inform how to incorporate sustainable practices in subdivision planning to ensure sustainable outcomes on the ground
- *Western Sydney Salinity Code of Practice* (2003) – management tool for local government for responding to urban salinity.
- Local government stormwater management plans, salinity management plans and water management plans.

Effective design and engineering

Effective design and engineering can play an important role in mitigation and prevention of urban salinity impacts. Some initiatives include:

- Engineering options for discharge management, including groundwater pumping systems and deep drainage systems. For example, Wagga Wagga City Council has implemented a dewatering strategy to protect the city's infrastructure, while Junnee Shire Council has installed drainage systems underneath new playing fields.
- The inclusion of requirements for building and infrastructure design in areas with high salinity potential in the Building Code of Australia (NSW provisions).
- Training courses such as *Building in a Saline Environment – An Awareness Course for NSW.*
- Department of Land and Water Conservation (2002) guide *Site Investigations for Urban Salinity* to assist in determining the impact of the development on the salt and water processes and how to tailor the design, construction and maintenance of the site to minimise undesirable impacts of salinity.

Innovation

Some recent innovative practices which improve our understanding of the hydrological cycle, particularly with regard to urban salinity include:

- A hydrogeological landscape (HGL) framework has been developed and applied to Western Sydney, Sydney Metro and Dubbo. The process allows:
    - Improved understanding of the landscape and how salinity develops
    - Assign priority, risk/hazard to a landscape in terms of land salinity, EC and salt load
    - Spatial attribution – determining the right action in the right place
    - Framework for investment, training and communication.
- The HGL framework has also been applied to Dubbo combined with DEM models, climate and groundwater level monitoring to spatially define problem areas. An output from this project is presented in Figure 11.

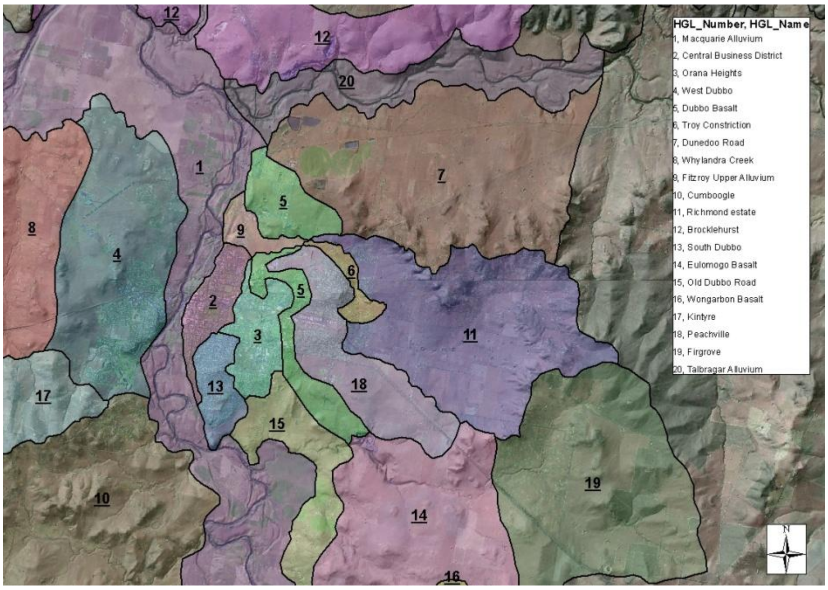


Figure 11: Output from Dubbo project (provided courtesy of Allan Nicholson, DECCW)

6 Challenges

The challenges facing the effective prevention of the urban salinity problem in NSW are:

- Salt-proofing future greenfield development areas to withstand impacts posed by saline environments. This issue is particularly important given the significant projections for growth in NSWs population by up to 33%.
- Increasing our knowledge to better understand the complex interactions between groundwater, hydrology, geology and climate. This will assist in identifying vulnerable areas and ensuring use of appropriate design and materials for developments in these areas.
- Facilitating a co-ordinated and co-operative approach to salinity management across all levels of government. It will be important to ensure salinity is considered as a land management issue throughout the land development process.
- Raising awareness of urban salinity within relevant stakeholder groups, including local government, the community, developers and builders. This includes development considerations to prevent salinity, protecting developments from salinity and the provision of ‘buyer beware’ information in relation to salinity.

7 References

Cross S (2003). *Understanding and Preventing Impacts of Salinity on Infrastructure in Rural and Urban Landscapes*.

DECCW (2009). *New South Wales state of the environment*.

Department of Planning (2008). *New South Wales State and Regional Population Projections, 2006-2036:* 2008. Release. Sydney: Department of Planning.

DLWC (2000) *NSW Salinity Strategy.*

DLWC (2002). *Guidelines to accompany map of salinity potential in Western* Sydney 2002.

DNR (2006). *Urban salinity LGSI Series*. Local Government Salinity Initiative

Institute of Public Works Engineering Australia (2002). *Local Government Salinity Management Handbook – A Resource Guide to the Public Works Professional.*

Littleboy M, Piscopo G,, Beecham R, Barnett P, Newman L and Alwood N (2001). *Dryland salinity extent and impacts. Technical report for the NLWRA*. DLWC and Centre for Resource and Environmental Studies, ANU. February 2001.

Nicholson A (2003). *Western Sydney Salinity Code of Practice. March 2003 (Amended January 2004).* ISBN 1 86271 297 2.

Ranjan P, Kundell J and Golubiewski N. (2007). *Effect of climate change and land use change on saltwater intrusion*. In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth March 15, 2007; Last revised March 16, 2007; Retrieved May 25, 2010]<http://www.eoearth.org/article/Effect_of_climate_change_and_land_use_change_on_saltwater_intrusion

Slinger, D and Tenison, K (comps) (2007). *Salinity Glove Box Guide: NSW Murray & Murrumbidgee Catchments*, NSW Department of Primary Industries.

Spennemann D (1997). *Urban salinity as a threat to cultural heritage places. A primer on the processes and effects of chloridation*.

Spennemann DHR (1997). *Urban Salinity as a Threat to Cultural Heritage Places – A Primer on the Process and Effects of Chloridation*. ISBN 187575847 X.

Werner A, Habermehl R and Laity T (2008). *An Australian Perspective of Seawater Intrusion.* 2nd International Salinity Forum. Salinity, water and society–global issues, local action.

Western Sydney Regional Organisation of Councils (2005). *Good Housekeeping to Manage Urban Salinity – for Residents in Western Sydney*.

Wilson, S (2003). *Determining the full costs of dryland salinity across the Murray-Darling Basin: Final Project Report*, Wilson Land Management Services report to the Murray-Darling Basin Commission and National Dryland Salinity Program.

Wilson, SM (2004). *Dryland and urban salinity costs across the Murray-Darling Basin. An overview and guidelines for identifying and valuing the impacts*, Murray-Darling Basin Commission, Canberra.