3

The nature of the salinity problem

3.1 This chapter provides an overview of:

- the nature of the salinity problem (paragraphs 3.2–3.45); and
- alternative scientific perspectives presented in the evidence for the sources of salt, salinity processes, the extent of the salinity problem and the veracity of some public sector research and audits (paragraphs 3.46–3.80).

An overview of the nature of the salinity problem

3.2 The following section summarises the consensus explanation of the salinity problem—salinisation processes, the types of salinity, management options, and the extent, impacts and costs of salinisation. This account of the salinity problem underpins the programs to address salinity which were detailed in the previous chapter.

Salinisation processes, types of salinity and management options

3.3 Salts are naturally present in much of the Australian landscape. While these salts have a number of sources, it is generally held that the primary source comes from historic rainfall or 'cyclic salt'.[1] Salt (sodium chloride) has been carried inland from the sea by wind and deposited in rainfall over the millennia and then accumulated in the regolith, which is 'the soil,

1 Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME), *Exhibit no. 128, Salination models*, p. 1. Glenelg Hopkins Catchment Management Authority, *Exhibit no. 20, Salinity Plan: Final Draft*, p. 7: 'Salt is carried inland from the sea by wind and deposited in rainfall. Some rain (containing salt) runs off the land surface, flowing into creeks and eventually back out to sea. For this reason it is often called cyclic salt.'

sediments, and weathered bedrock, that lie between fresh air and fresh bedrock.'[2] A proportion of the salt in the landscape has also resulted from mineral dissolution: that is, where salts present in rocks are released by weathering.

3.4 Salt is distributed widely across the arid and semi-arid landscapes of Australia and is known to be stored in patchy, complex patterns reflecting earlier geological events. Salt stores extend:

> in a huge arc from northern Australia, south by the Great Dividing Range, then broadening and sweeping south-west across the Murray-Darling Basin to take in the Riverina and Mallee regions of NSW, Victoria and South Australia. In Western Australia, massive amounts of salt are stored in an arc that sweeps south and east across the semi-arid and arid landscapes of south-western Australia.[3]

3.5 Naturally occurring salinity, such as coastal marine plains and salt lakes in central Australia, is referred to as *primary salinity* and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) estimates that there are approximately 29 million hectares of naturally saline land in Australia.[4]

3.6 As the continent is very flat, most rivers and groundwater systems are sluggish and have little capacity to drain the continent of salt. In addition, native vegetation has become effective at using Australia's low and highly variable rainfall, resulting in low amounts of runoff to rivers and deep drainage to groundwater.[5]

3.7 Consequently, enormous quantities of salt have accumulated in the Australian landscape over geological time. In Western Australia for example, 'a typical Wheatbelt hectare down to 40 metres contains between 170 and 950 tonnes of stored salt.'[6] Salt levels have been measured at up to 15 000 tonnes per hectare in Western Australia.[7]

3.8 Native vegetation, which in semi-arid areas is dominated by trees or woody shrubs, adapted to Australia's natural conditions. Perennial

2 CRC LEME, *Submission no. 64,* p. 1.

3 Land and Water Australia (LWA), *Exhibit no. 71, Australian Dryland Salinity Assessment 2000,* p. 44.

4 *ibid.,* p. xiv; CSIRO, *Exhibit no. 83, Groundwater Flow Systems Framework,* p. 1.

5 *ibid.* Groundwater is 'all the free water below the earth's surface' or, more precisely, the water in the saturated pores of soil or rock below the watertable.

6 CRC LEME, *Exhibit no. 128, loc. cit.*

7 Mr Tim Sparks (Western Australian Department of the Environment), *Exhibit no. 111, Salinity: A New Balance,* p. 22.

vegetation, with its relatively deep roots, uses most of the water entering the soil and the 'leakage' of water past the root zone into the deeper soil and groundwater is usually minimised. Over time, an equilibrium or balance is achieved where the amount of leakage beneath the root zone is approximately the same as the amount of water that drains or discharges from the landscape.[8]

3.9 Changes in land use since European settlement have significantly altered the hydrology of the Australian landscape. In particular, there has been large scale clearing of native vegetation which has been replaced with shallow-rooted annual crops and pastures. This has substantially increased the amount of water entering groundwater systems:

> These increased amounts of water now entering the groundwater [known as 'recharge'] under current agricultural production systems greatly exceed the capacity of the groundwater systems to discharge the additional water to the rivers and streams. As the input to the groundwater exceeds the output, the water table [the top of the groundwater layer] must rise. As it rises, more water is discharged to the land surface as seepage surfaces (usually at lower positions in the landscape). Whenever this groundwater contains salt or intercepts salt stored in the landscape, salt is mobilised to these seepage faces, and hence to the lands surface, rivers and streams.[9]

3.10 As saline groundwater evaporates, salt is left, causing land salinisation. The salt can then increase surface water salinity when it is moved by rain into waterways and river systems. Water leaking beyond the root zone may also move laterally through soils and discharge into streams, rather than enter the groundwater.[10]

3.11 Salinity caused by changes to the groundwater balance induced by human activity is referred to as *secondary salinity*. Two main types of secondary salinisation are generally recognised in Australia. The clearing of native vegetation and its replacement with crops and pastures causes *dryland salinity*. In this type, the concentration of soluble salts near the soil surface of non-irrigated lands is sufficient to reduce plant growth and produce other deleterious effects. *Irrigation salinity* occurs when excess surface water is added to the land, thus raising groundwater levels. Irrigation

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8 CSIRO, *Exhibit no. 80, Dryland Salinisation: A Challenge for Land and Water Management in the Australian Landscape*, p. 462.

9 CSIRO, *Exhibit no. 82, Effectiveness of Current Farming Systems in the Control of Dryland Salinity*, p. 3.

10 *ibid.*, p. 4.

salinity may also be caused where the irrigation water itself contains high levels of salt.[11]

3.12 The consensus position is that in both types of secondary salinity the fundamental hydrologic process is the same—changing land use (irrigation, land clearing and the replacement of perennial deep-rooted native vegetation with shallow-rooted annual crops and pastures used in agriculture) alters the water balance, allowing excess water to enter the groundwater, thereby mobilising salt, which then rises to the land surface.

3.13 The salinisation process described here is known to operate at a number of different scales in the landscape:

> Salinisation can occur in situations controlled by local processes such as shallow groundwater on a hill slope stretching over less than a kilometre, where seepage zones develop as the slope flattens near the stream. Or salinisation can occur in extensive situations where processes operate over large areas such as regional groundwater basins stretching hundreds of kilometres, where salt emerges on the lower parts of the basin and the floodplains.[12]

3.14 The original cause of the water entering the watertable may therefore be distant from where the effects of salinity appear. Salinity can occur on-site (farm scale), elsewhere in the catchment or outside the catchment (downstream). There may also be long response times in groundwater levels and time lags between the original cause of salinity and the appearance of its effects in the landscape—'often 100 years or more'.[13]

3.15 The original causes of salinisation and its expression in the landscape may therefore be both spatially and temporally distant from each other, which adds considerably to the complexity of the salinity problem, and means that 'salinity is likely to increase even with immediate, widespread action.'[14]

3.16 The National Land and Water Resources Audit's (NLWRA) *Australian Dryland Salinity Assessment 2000* maintains that there are four management options available in addressing salinity:

- prevention, or protecting regions at risk from salinity;

11 LWA, *Exhibit no. 71, op. cit.*, p. xiv. A third type of salinity, referred to as urban salinity, results from a combination of dryland salinity processes and over-watering of urban areas.

12 *ibid.*, pp. 45-46.

13 *ibid.*, p. vi.

14 *ibid.*

- treating the causes of salinity by managing the amount of recharge to prevent or reduce the rate of groundwater rise;
- ameliorating symptoms by intercepting and storing salt, and managing saline discharge, adapting to more saline land and water conditions; and
- adaptation, or learning to live with salt, by developing alternative uses of saline land and water resources.[15]

3.17 Due to regional variations in hydrogeology, soil characteristics and climate, the most appropriate salinity management response will vary depending on the landscape characteristics of the particular region. One or a combination of the approaches listed above may be deployed depending on the conditions of the particular region or catchment.

3.18 The most widely promoted management response to salinity is 'to restore the original water balance (or best approximation) to ensure catchments are not leaking water in ways that mobilise salt'—that is, to reduce recharge into the groundwater.[16]

3.19 Options for the management of recharge include:

- retention of native vegetation;
- growing trees, which have the capacity to use large quantities of water, through evaporation of rainfall intercepted by the tree canopy and through extraction and transpiration of soil moisture (for example, blue gums and oil mallees);
- deep rooted perennial fodder crops, which use more water than annual pastures and lower watertables (for example, lucerne and tagasaste); and
- modified cropping, including raised bed, alley and phase cropping.[17]

3.20 Controlling salinity by reducing recharge is said to require a major shift towards the water balance which exists in native ecosystems. For Dr John Williams, Dr Glen Walker and Dr Tom Hatton from CSIRO:

> The cause of salinity can only be brought under control by the development of new industries and land uses based on deep-rooted perennial plants that are commercial, able to generate attractive farm incomes and control the leakage beneath the root

15 *ibid*., p. 48.
16 CSIRO, *Exhibit no. 80, op. cit*., p. 470.
17 Glenelg Hopkins Catchment Management Authority, *Exhibit no. 20,* op. cit., pp. 11-15.

> zone at levels similar to native vegetation. This is a most demanding task and will require a long-term, well-focused and funded strategy of research and development and on-farm innovation.[18]

3.21 The importance of engineering options as a means to mitigate salinisation is also emphasised by these authors:

> Given the immediacy of salinity risk and the impact of salinity on important built environments (eg. 80 towns) and natural assets (eg. key Ramsar wetlands), no solution involving recharge control will afford timely protection, and Australia will have to look to engineering approaches to protect these assets … large areas that are already affected, such as the regional valley systems in Western Australia, are in such an advanced state of salinisation that no form of recharge control is likely to maintain current farming enterprises.[19]

3.22 Engineering works intercept salt and redirect surface or groundwater. These options include surface, subsurface and deep open drains, and pumping of saline groundwater (for example, into evaporation basins) to lower watertables.[20]

3.23 Options to manage saline discharge, particularly saline land, include:

- saline agronomy, including salt tolerant pasture and fodder crops (for example, tall wheat grass, balansa clover, saltbush and bluebush);
- development of alternative industries, including commercial use of saline water in aquaculture, energy production, mineral harvesting and desalinisation; and
- use of trees around the margins of discharge zones, which can use the groundwater and lower saline watertables.[21]

3.24 It was suggested to the Committee that a 'triage' approach needs to be adopted towards salinity management, involving three overarching objectives of avoidance / prevention, mitigating the symptoms or adapting to live with salinity:

18 CSIRO, *Exhibit no. 80, op. cit*., p. 470.

19 *ibid*.

20 Glenelg Hopkins Catchment Management Authority, *Exhibit no. 20, Salinity Plan: Final Draft*, pp. 11-15.

21 *ibid*., p. 17. Also see: Grains Research and Development Corporation (GRDC), *Exhibit no. 79, Economic Evaluation of Salinity Management Options in Cropping Regions of Australia*, pp. 27-45.

> We tend to have introduced, within this ground water flow system concept, a thing called the triage approach. The triage approach … says that there are some places where farmers are going to be able to take action on the salinity problem that they already have and they might be able to fix that problem over a number of years, there are other places where they might be able to take some action now and head off an emerging problem, and there are other systems where the problem is so intractable and has so much momentum that it makes sense to actually live with that problem by finding more salt tolerant farming systems or new saline industries within them. So when it comes to individual farmers that have an emerging problem or an existing problem, it is that level of analysis that we have to go through: in the first instance, is this a problem that can be fixed or is this a problem that we are going to have to live with? That may well govern the decision about whether they go ultimately for a change from annual pastures to lucerne or perennial pastures or something else or whether their best option is to invest in saltbush or something like that.[22]

3.25 During its inspections the Committee observed several of the management options described here being deployed or trialled, either separately or in combination:

- In Western Australia, the Committee observed:
  - ⇒ engineering and vegetation solutions for salinity affecting water supplies in the East Collie catchment, including groundwater pumping at Maxon Farm (depicted in photograph 3.1);[23]
  - ⇒ surface water management, groundwater pumping and remnant vegetation protection at Lake Toolibin;[24]
  - ⇒ farmer-initiated vegetation projects in the Beaufort River flats, including raised-bed cropping and trials of new pastures species;[25]

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22 Mr Philip Dyson (Phil Dyson and Associates Pty Ltd), *Transcript of Evidence*, 31 October 2003, p.7. Also see: CSIRO, *Submission no. 42*, p. 1; Western Australian Salinity Research and Development Technical Committee (WA SRDTC), *Submission no. 54*, p. 2; Murray-Darling Basin Commission (MDBC), *Submission no. 51*, p. 7.

23 Mr Tim Sparks (Western Australian Department of the Environment), *Exhibit no. 93, Collie Salinity Update – November 2003*; *Exhibit no. 95, A Fresh Future for Water: Salinity situation statement for the Collie River Catchment – a summary*, p. 3.

24 Mr Ken Wallace (Western Australian Department of Conservation and Land Management), *Exhibit no. 98, Water balance and salinity trend, Toolibin catchment, Western Australia*; *Exhibit no. 99, The Toolibin Lake Recovery Project*; *Exhibit no. 100, Recovering Lake Toolibin*.

25 Mr Jon Glauert (Western Australian Department of Agriculture), *Exhibit no. 92, NRM on Beaufort Flats, Woodanilling*, pp. 1, 2.

- ⇒ deep open drainage systems being evaluated in Dumbleyung (depicted in photograph 3.2);[26]
- ⇒ groundwater pumping to protect the town of Katanning;
- ⇒ a demonstration plant for the use of mallee eucalypts in the concurrent production of eucalyptus oil, activated carbon and electricity in Narrogin (depicted in photograph 6.1 in chapter six);[27] and
- ⇒ strategies, including surface water and groundwater management, for the protection of the Yenyening Lakes system.[28]

- In Victoria, the Committee observed the Muckatah surface water management system and engineering works to protect Kinnaird's Wetland.
- In New South Wales, the Committee inspected the Wagga Wagga Council's efforts to address urban salinity, including use of a bore field to pump groundwater and targeted revegetation. Outside the town, the Committee observed other works, funded under the NAP and supported by the New South Wales Southern Salt Action Team, in the Kyeamba Valley.[29]

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26 Mr Nick Cox (Western Australian Department of the Environment), *Exhibit no. 96, Dumbleyung Water Management Strategy: Benyon Road Deep Drainage*; Mr Tim Sparks (Western Australian Department of the Environment), *Exhibit no. 97, Dumbleyung Water Management Strategy*. Approximately 10 000 km of drains have been installed in the broad valleys of the Western Australian Wheat Belt over the past 25 years. The major risks of Wheat Belt drainage include: the downstream impacts of the effluent, including on biodiversity; increased acidity; and an increased risk in flood impacts. The Dumbleyung site has been partly funded under the NHT.

27 Mr John Bartle (Western Australian Department of Conservation and Land Management), *Exhibit no. 87, Development of mallee as a large-scale crop for the wheatbelt of WA*, p. 1.

28 Mr Peter Muirden (Western Australian Department of the Environment), *Exhibit no. 102, Yenyening Lakes Management Strategy: 2002 – 2012*.

29 Ms Deb Slinger (New South Wales Department of Agriculture), *Exhibit no. 110, Kyeamba Valley Targeted Salinity and Water Quality Control Program*.

Photograph 3.1 Chair of the Committee, Mr Gary Nairn MP (left), inspecting a groundwater pump at Maxon farm in the East Collie catchment, Western Australia

Photograph 3.2 Deep drainage systems being trialled at Dumbleyung, Western Australia

3.26 In terms of salinity management practices adopted by landholders, the Australian Bureau of Statistics (ABS) *Land Management and Salinity Survey*, conducted in May 2002, found that salinity management actions have been implemented on nearly 30 000 farms. The most common of these are:

- use of salt tolerant crops, pastures and fodder crops (including lucerne and other deep rooted perennial plants), over 3.2 million hectares (on 23 700 farms);
- earthworks (levees, banks, shallow and deep open drains, and subsurface drains) over 208 000 km (19 300 farms);
- trees on 776 000 hectares (11 000 farms); and
- fencing of 466 000 hectares (9 460 farms).

In addition, over 7 000 irrigated farms have made changes to irrigation practices for salinity management purposes.[30]

3.27 Salinity presents a highly complex problem to manage for reasons that include:

- the time it takes to implement the scale of land use changes necessary to alter the water balance;
- in some regions, farmers do not have practical and viable management options; and
- even where management options are implemented, there are time lags before groundwater systems show responses to change, which may be several decades or longer.[31]

The extent, impacts and costs of salinisation

3.28 The *Australian Dryland Salinity Assessment 2000* estimated that 'approximately 5.7 million hectares of Australia's agricultural and pastoral zone have a high potential for developing dryland salinity through shallow watertables' and that unless effective solutions are implemented, this area is predicted to increase to 17 million hectares by 2050.[32] Table 3.1 summarises the Assessment's estimates of dryland salinity potential for each state and territory.

30 ABS, *Salinity on Australian Farms*, cat. no. 4615.0, ABS, Canberra, 2002.

31 LWA, *Exhibit no. 71, op. cit.*, p. 46.

32 *ibid.*, p. 6.

Table 3.1: Areas, measured in hectares (ha), with a high potential to develop dryland salinity in Australia

State/Territory[33]	1998/2000	2050
NSW	181 000	1 300 000
Victoria	670 000	3 110 000
Queensland	not assessed	3 100 000
South Australia	390 000	600 000
Western Australia	4 363 000	8 800 000
Tasmania	54 000	90 000
Total	**5 658 000**	**17 000 000**

Source National Land and Water Resources Audit, *Australian Dryland Salinity Assessment 2000*, NLWRA, Canberra, 2001, p. 6.

3.29 Western Australia has by far the largest area of dryland salinity, with 1.8 million hectares already affected—amounting to over 70 per cent of the nation's currently affected land area of 2.5 million hectares.[34]

3.30 The Western Australian Salinity Research and Development Technical Committee (WA SRDTC) explained that the main reason salinity is such a large problem in Western Australia is that:

> We have large thicknesses of clay based regolith from the weathering of the granites that is able to absorb a lot of the salt coming in rainfall. We have very poor drainage or flushing out of the system, but we also have a very thick layer of clay which is able to accumulate very large quantities of salt.
>
> After clearing, it is that salt which is actually mobilised. One of the reasons why Western Australia has developed a salt problem far earlier than a lot of the other states is that our drainage has been so poor and we have had a long geological history where we could build up such a large, thick, weathered zone. Our environment was just teetering. Some of the valleys were already going saline progressively, when they went in and started clearing. The clearing released a lot of extra water into the system and we have had quite early onsets of salinity.[35]

33 The Northern Territory and the Australian Capital Territory were not included as the dryland salinity problem was considered to be minor.

34 Prime Minister's Science, Engineering and Innovation Council (PMSEIC), *Dryland Salinity and its Impacts on Rural Industries and the Landscape*, Australian Government Department of Education, Science and Training (DEST), Canberra, 1999, p. 6, viewed 22 January 2004, <www.dest.gov.au/science/pmseic/documents/salinity.pdf>.

35 Dr Don McFarlane (WA SRDTC), *Transcript of Evidence*, 12 November 2003, p. 48.

3.31 Increasingly in Western Australia inland forms of acid sulfate soils are occurring in agricultural areas. These acidic soils appear to be forming in response to rising watertables and land salinisation. Draining these soils could potentially cause significant environmental problems.[36] The Western Australian Farmers' Federation submitted:

> Once you start drainage, though, there are areas where you will start to bring in acid water, through iron sulfides in the soil. That is a far greater problem than salinity, but there are solutions ... I think this is where science can play a role.[37]

3.32 In other evidence of the extent of salinisation, the ABS' *Salinity on Australian Farms* report found that:

- 19 500 farms and two million hectares of agricultural land were reported by farmers as showing signs of salinity;
- of the agricultural land showing signs of salinity, 800 000 hectares cannot be used for agricultural production; and
- the state most affected by salinity is Western Australia, with 7 000 farms and 1.2 million hectares showing signs of salinity.[38]

3.33 The major impacts of salinisation include:

- declining river quality and salinisation of previously fresh rivers, which affect the quality of drinking and irrigation water, and damage the habitats of aquatic fauna in wetland, stream and riparian systems;
- the loss of productive land—when groundwaters are close enough to the surface to discharge or concentrate salts, total loss of crop and pasture production follows;
- damage to farm equipment, roads, buildings and other public infrastructure;
- damage to urban infrastructure;
- damage to conservation reserves, bio-biodiversity and remnant vegetation; and

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36 Government of Western Australia (Department of Environmental Protection), *Acid Sulfate Soils in Western Australia*, viewed 11 May 2004, <www.environ.wa.gov.au/article.asp?id=16&catid=69&pubid=2570>.

37 Mr Collin Nicholl (Western Australian Farmers' Federation), *Transcript of Evidence*, 13 November 2003, p. 3.

38 ABS, *op. cit.*, p. 2. The report's findings were based on a sample of 20 000 farm establishments and covered agricultural land only (460 million hectares), representing approximately 60 per cent of land use in Australia.

- increased flood risk.[39]

3.34 The magnitude of the predicted impacts is indicated by the following:

- dryland salinity potentially threatens production from 4.6 million hectares of agricultural land and this is expected to increase to 13.6 million hectares within 50 years;[40]
- some 80 rural towns are currently showing signs of salinity-induced damage;[41]
- approximately 80 important wetlands have been affected or are at risk of salinity across all states;[42]
- in Western Australia, salinity could cause the extinction of 450 species of native flora and reduce fauna species by 30 per cent in affected areas over the next 50 years;[43] and
- with predicted increases in salinity in the River Murray, within 20 years Adelaide's drinking water will fail World Health Organization salinity standards in two days out of five.[44]

3.35 Table 3.2 summarises the nation's assets in areas at high risk of shallow watertables or with a high salinity hazard.

Table 3.2 Summary of assets in areas at high risk from shallow watertables or with a high salinity hazard

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 perimeter (km)	11 800	20 000	41 300
Rail (km)	1 600	2 060	5 100
Roads (km)	19 900	26 600	67 400
Towns (number)	68	125	219
Important wetlands (number)	80	81	130

Source National Land and Water Resources Audit, *Australian Dryland Salinity Assessment 2000*, NLWRA, Canberra, 2001, p. 8 (*Exhibit no. 71*, from *Land and Water Australia*).

39 LWA, *Exhibit no. 71*, *op. cit.*, pp. 8-13; PMSEIC, *op. cit.*, p. 7.

40 LWA, *Exhibit no. 71*, *op. cit.*, p. 11.

41 PMSEIC, *loc. cit.*

42 *ibid.*, p. 7.

43 LWA, *Exhibit no. 71*, *op. cit.*, pp. 13, 38.

44 Council of Australian Governments (COAG), *A National Action Plan for Salinity and Water Quality*, Australian Government Departments of Agriculture, Fisheries and Forestry (DAFF) and the Environment and Heritage (DEH), Canberra, 2000, p. 5.

3.36 The Committee observed first-hand the impacts of salinity during its inspections in New South Wales and Victoria, but particularly in the Western Australian Wheat Belt. The Committee witnessed the devastation of former fresh water lakes and vast tracts of farming land.

3.37 The effect of salinity in urban areas was just as striking. The Committee observed saline groundwater filling the basement of a business in the centre of the Katanning township, despite groundwater pumping, and the destruction wreaked by salt on private dwellings and public infrastructure.

3.38 Innovative actions had been taken in an attempt to save Katanning's infrastructure, including raising the level of the town's oval and pumping saline groundwater away from key areas. The Committee heard about the efforts of CSIRO, in partnership with the Western Australian Department of Agriculture, to establish Katanning as a demonstration town for interventions to address rural town salinity. There are proposals to trial desalinisation technologies and, potentially, save the cost of having to pipe fresh water to Katanning and other Wheat Belt towns.

3.39 The Committee also observed clear evidence of the damage caused by rising saline groundwater to buildings in Wagga Wagga, including 'tide marks' from rising damp, salt efflorescence (white staining) and the breakdown of mortar and brickwork caused by the growth of salt crystals. These effects are illustrated in photograph 3.4.

Photograph 3.4 Members of the Committee inspecting urban salinity damage in Wagga Wagga

3.40 The costs attributable to salinity are difficult to estimate and to separate from costs attributable to other forms of natural resource degradation. Nonetheless, salinity costs are considered to be substantial. The Prime Minister's Science, Engineering and Innovation Council report, *Dryland Salinity and its Impacts on Rural Industries and the Landscape*, estimated that the capital value of land lost to salinity is approximately $700 million, and the value of lost production is $130 million per year, and increasing.[45]

3.41 The Murray-Darling Basin Commission has estimated that the cost of dryland salinity in eight tributary valleys of the Basin is approximately $247 million per year and the cost to consumptive users of River Murray water totals $47 million per year.[46]

3.42 The NLWRA estimated that the total annual costs of dryland salinity in Western Australia is $664 million per year.[47] The loss in profits for the agricultural sector in Western Australia has been estimated at between $80 and $260 million per year.[48]

3.43 Significant costs are imposed on local governments and residents of affected towns. In Wagga Wagga, the Council reported that if nothing were done to address urban salinity, the damage to infrastructure in Wagga alone would be in the order of $180 million over 30 years, with some residents already spending '$10 000 to $20 000 on repair work' for their homes.[49]

3.44 Other evidence suggested while salinity is costly, it is not the most costly resource degradation issue confronting the nation.[50]

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45 PMSEIC, *op. cit.*, p. 5.

46 MDBC, *Exhibit no. 37*, *Basin Salinity Management Strategy 2001-2015*, p. 1.

47 LWA, *Exhibit no. 71*, p. 38.

48 Joint statement by the Western Australian Minister for the Environment, The Hon. Dr Judy Edwards MLA and the Western Australian Minister for Agriculture, Forestry and Fisheries, The Hon. Kim Chance MLC, 'Half a million dollars for Wheatbelt salinity options', issued 21 March 2004. Media statement available online, viewed 15 April 2004, <www.ministers.wa.gov.au / main.cfm?MinId=07&Section=0051>.

49 Mr Bryan Short (Wagga Wagga City Council), *Transcript of Evidence*, 30 October 2003, pp. 28, 23.

50 Mr John Ive, *Exhibit no. 124, Managing Dryland Salinity: From paddock to web*, p. 5. Citing a report prepared for the National Farmers' Federation and the Australian Conservation Foundation in 2000, Mr Ive stated that dryland salinity ranks fourth in terms of the relative costs of different forms of natural resource degradation. The cost of dryland salinity was estimated at $2250 per year for every agricultural holding in Australia, behind (1) environmental decline at $4800, (2) water quality at $3600 and (3) acid soils at $2400. However, the cost of irrigation salinity was ranked separately, in seventh place, at $520 per year for each agricultural holding in Australia. Combined, irrigation and dryland salinity would rank as the third most costly form of resource degradation by this estimate.

3.45 The explanation of the sources of salt (principally sodium chloride from historic rainfall—'cyclic salt') and the basic salinisation process (rising watertables due to water imbalance in a catchment) summarised above have been embraced in state and Australian government strategies to address salinity. For example, information associated with the NAP explains that the accumulation of salt has largely originated from oceanic salt deposited in rainfall, and that 'salinity increases are usually caused by a rise in the level of underground water-tables bringing naturally occurring salt to the surface.'[51]

Alternative scientific perspectives

3.46 The overview presented in the previous section summarises the conventional explanation of the salinity problem. Submitters stated that 'there is little dispute over the causes of dryland salinity', that 'our conceptual understanding of salinisation processes is good' and that 'we know enough about salinity's causes and effects to commence some action now.'[52] However, some evidence provided alternative perspectives on:

- the sources of salt in the landscape;
- salinisation processes; and
- the extent of the salinity problem and the veracity of some public science.

The sources of salt in the landscape

3.47 Associate Professor Robert Creelman and Dr Jerzy Jankowski submitted that there ought to be more comprehensive research into the sources of

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51 DAFF and DEH, *Australia's Salinity Problem*, Commonwealth of Australia, Canberra, 2001, p. 1, viewed 4 march 2004, <www.napswq.gov.au/publications/factsheets/salinity.html>; DAFF and DEH, *Putting Salinity on the Map*, Commonwealth of Australia, Canberra, 2001, p. 2, viewed 4 march 2004, <www.napswq.gov.au/publications/pubs/put-sal-map.pdf>.
Also see state strategies, for example:
New South Wales Department of Land and Water Conservation, *Taking on the Challenge: NSW Salinity Strategy*, Government of New South Wales, Sydney, 2000, p. 10, viewed 4 March 2004, <www.dlwc.nsw.gov.au/care/salinity/pdf/all_about_salinity.pdf>;
Western Australian State Salinity Council, *The Salinity Strategy*, Government of Western Australia, Perth, 2000, p. 14, viewed 28 January 2004, <www.salinity.org.au/management/pdfs/salinity-strategy.pdf>;
Primary Industries and Resources SA and the Soil Conservation Council of South Australia, *South Australian Dryland Salinity Strategy*, Government of South Australia, Adelaide, 2001, p. 7, viewed 23 February 2004, <www.saltcontrolsa.com/pdfs/sadss_72.pdf>.

52 GRDC, *Submission no. 29*, p. 2; CSIRO, *Submission no. 42*, p. 1; WA SRDTC, *Submission no. 54*, p. 1. See also: Centre for Salinity Assessment and Management (CSAM), *Submission no. 19*, p. 3.

salt, the origins of salinity and the mechanisms responsible for the development of saline groundwaters.[53] It was argued that:

> The causes of salinity are complex, and although the rising water table model may be the answer in certain areas, and the source of the salt cyclical salts, these ideas are not universally applicable.[54]

3.48 In particular, Associate Professor Creelman suggested that the dominant model has neglected 'the role of rock weathering and the complexities of water-rock interaction—hydrogeochemistry'.[55] For example, it was argued that:

> the efflorescent salts seen on the ground surface in dryland salinity sites are not only sodium chloride (NaCl), but sodium-bicarbonate, magnesium-sulphate, calcium-sulphate and very complex salts … The undue emphasis and assumption that all white efflorescence is NaCl, and all saline groundwaters are sodium-chloride rich, is misleading. Cyclical salts cannot explain why some waters are magnesium rich, in fact magnesium dominated; this is the product of water-rock interaction and rock weathering.[56]

3.49 The contrary position was argued by the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME), which maintained that while 'it is true that salt can have a number of primary sources … historic rainfall is the overwhelming contributor.'[57] However, Associate Professor Creelman conceded that the dominant model is appropriate in Western Australia, but stated that '[i]n south-eastern Australia is it is another story altogether.'[58]

3.50 Identifying the source of the salt is said to be important because misinterpreting the salt source could lead to the incorrect selection of management options:

> [T]he management options being applied … are simplistic. They are simplistic because there is an undue emphasis in Australia on the role of cyclical salts as the source of all salinity. This has

53 Associate Professor Robert Creelman and Dr Jerzy Jankowski, *Exhibit no. 19*, *Review of the Science of Salinity – It's Time*, p. 1.

54 Associate Professor Robert Creelman, *Submission no. 16*, p. 2.

55 *ibid*.

56 Associate Professor Robert Creelman and Dr Jerzy Jankowski, *Exhibit no. 19, op. cit.* pp. 3-4.

57 CRC LEME, *Exhibit no. 128, op. cit*., p. 3.

58 Associate Professor Robert Creelman, *Transcript of Evidence*, 29 October 2003, p. 28.

> probably come about because there are insufficient players in the scientific debate.[59]

A consequence of this perspective is said to be that, in some cases, 'salinity may not be related to water table changes'.[60]

3.51 Similarly, Dr Jerzy Jankowski argued that:

> If we understand the source [of the salt], we will also understand the origin of the salinity, and the solution to the problem and management of options will be much better.[61]

3.52 Moreover, Associate Professor Creelman asserted that the scientific community is now 'steadily entrenching itself in what are warring camps', essentially between '[t]hose who adhere to orthodox models of water table rises, aeolian [salt in dust carried by the wind] and other cyclic salts—the surficial camp' and '[t]hose who contend that salt has many inputs, including connate salt (salt in ancient sediments) and salt from rock weathering—the whole earth camp.'[62]

3.53 To address these issues, it was recommended that:

- academic debate be widened to incorporate the contributions of all relevant disciplines, particularly geology, geochemistry and hydrogeochemistry, and a proposal for a conference involving all fields of science was supported;[63]
- greater collaboration and sharing of information between scientists and between research organisations, including smaller research groups, be encouraged;[64]
- greater support be given to basic research into the source(s) of salt and the origins of salinity;[65] and
- funding for basic salinity science be broadened through the establishment of a specific Australian Salinity Research Program, modelled on the Australian Research Council, industry based granting

59 Associate Professor Robert Creelman and Dr Jerzy Jankowski, *Exhibit no. 19, op. cit.* pp. 1-2.

60 *ibid.*, p. 3.

61 Dr Jerzy Jankowski, *Transcript of Evidence*, 29 October 2003, pp. 34-35; Dr Jerzy Jankowski, *Submission no. 60,* p. 2.

62 Associate Professor Robert Creelman, *Submission no. 16*, pp. 2-3.

63 *ibid.*, p. 2; Dr Jerzy Jankowski, *Transcript of Evidence*, 29 October 2003, p. 37.

64 Dr Jerzy Jankowski, *Submission no. 60,* p. 3.

65 *ibid.*, pp. 2-3.

groups such as the Australian Coal Association Research Program, or a special Cooperative Research Centre.[66]

Salinisation processes

3.54 In contrast to the conventional explanation of the principle salinisation process (the hydrologic imbalance or 'rising groundwater' model), two submitters proposed an alternative mechanism based exclusively on increased lateral flows of water through the soil, caused by land use impacts that degrade soil structure.

3.55 Natural Resource Intelligence (NRI) disputed the conventional rising groundwater explanation of the salinisation process. Four reasons were posited for the alleged failure to identify the correct salinisation mechanism:

> One issue relates to the inability to directly measure the factor deemed responsible, namely the rate of recharge (percolation) to groundwater systems. Another relates to very limited knowledge of the functioning of natural systems and a third to the definition of groundwater. The fourth is the limited attention paid to the effects of land use impacts on soils and the consequences of these impacts for the hydrology of systems.[67]

3.56 As an alternative explanation of the cause of dryland salinity, NRI proposed that:

> salinity is generally associated with a decline in soil structure that is largely caused by a decline in soil organic matter. The decline in soil structure increases the near surface lateral flow of water in the soil, and also increases the salinity of the water moving through the soil. Adverse salinity arises where this water accumulates at lower parts of the landscape and is concentrated through evaporation.[68]

3.57 In this model, tree clearing may exacerbate salinity but it is not the cause. Rather, 'rising groundwater levels and adverse salinity are symptoms of land degradation', which may be caused by other land use impacts such as grazing.[69]

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66 Associate Professor Robert Creelman, *Submission no. 16*, p. 3; *Transcript of Evidence*, 29 October 2003, p. 32; and Dr Jerzy Jankowski, *Submission no. 60*, p. 2.

67 NRI, *Submission no. 32*, p. 4.

68 *ibid.*, p. 5; Mr Brian Tunstall, (NRI), E*xhibit no. 23, Scenario for Dryland Salinity*.

69 *ibid.*

3.58 Similarly, Orbtek submitted that the traditional 'groundwater rising model is fundamentally flawed, unscientific and inappropriate in developing land use management options.'[70] It was claimed that 'salinity is a minor symptom of a much larger land use and soil health issue' and asserted that salinity is 'clearly an outcome of increased lateral flows … due to land use impacts that degrade soil structure, eg. loss of organic matter in the case of dryland salinity.'[71]

3.59 Salinity is therefore said to be caused by soil degradation 'primarily due to unsustainable land use practices rather than from land clearing per se'.[72] As argued by NRI, the underlying salinisation mechanism is said to be a decline in soil structure:

> This change in soil health decreases deep percolation of water and increases lateral flows of water through preferred pathways of geological fractures and old / ancient prior stream systems.[73]

3.60 Using gamma-ray mapping technology, Orbtek found there was 'no evidence to support the groundwater rising model as it failed on all mapping applications and the only model that stood any test was a lateral flow model.'[74] Specifically, Orbtek claimed its mapping technology determined that, along salt pathways:

> Lateral flows can concentrate and saturate areas with salt and water and this process is often perceived as groundwater rising in these areas.[75]

3.61 The implications of these conclusions are said to be significant: 'The traditional solutions of treating salinity with groundwater management and engineering actions are fundamentally flawed.'[76]

3.62 Consequently, NRI recommended that programs be directed towards addressing the 'degradation of soil structure initially associated with a decline in organic matter', and hence at remediation of the soil structure.[77] Similarly, Orbtek concluded that salinity should be addressed, in part, by 'restoration of soil structure decline through the retention and recycling of

70 Orbtek Pty Ltd, *Submission no. 3*, p. 1.
71 *ibid.*, pp. 2, 8.
72 *ibid.*, p. 2.
73 *ibid.*
74 *ibid.*, p. 8.
75 *ibid.*, p. 2.
76 *ibid.*, p. 8.
77 NRI, *Submission no. 32*, p. 5.

organic matter in agricultural lands', and 'better understanding of the location, function and status of salt pathways.'[78]

3.63 More generally, NRI also recommended that salinity 'program structures should not be rigidly based on uncertain assumptions' and allow for 'independent assessment on the ground to develop approaches and methods that effectively address the specific local circumstances.'[79]

3.64 The Committee notes that debates on precisely this theme of alternative salinisation models have occurred on SALTLIST, an email-based forum hosted by the *National Dryland Salinity Program*, most recently during January and February 2004. The participants in this discussion included those proposing the lateral flow / soil processes model as an alternative to the commonly accepted model of rising groundwater. The debate underscored the complexity of salinisation processes, but some agreement was reached around the proposition that the rising groundwater model is not the only process that can lead to salinisation.[80] Nonetheless, CSIRO disputed the soils model as a salinisation process.[81]

3.65 While the Committee is not in a position to adjudicate between salinisation models, it notes that if alternative models of salinisation processes are valid, these may have implications for salinity management practices.

3.66 The Committee is concerned that those contributing to the scientific understanding of basic salinity processes have adequate opportunity for their perspectives to be presented and examined appropriately. Given the impacts and costs of salinisation, the nation cannot afford inter and intra disciplinary debates that degenerate into 'warring camps'. The Committee believes that further research must cover the differing views and techniques, and analyses should include a certain element of on-ground verification and testing.

3.67 The Committee acknowledges that a situation of perfect knowledge about underlying processes in all catchments is unlikely to ever be achieved, and therefore urges that salinity programs have a sensitivity to the regional variation in salinisation processes.

78 Orbtek Pty Ltd, *Submission no. 3*, p. 8.

79 NRI, *Submission no. 32*, pp. 2, 6.

80 Mr Paul Raper (SALTLIST), email posting, 2 February 2004, <Bruce@clearconnections.com.au>.

81 Dr Mirko Stauffacher and Dr John Williams (CSIRO), *Transcript of Evidence*, 7 November 2003, pp. 91-92.

The extent of the salinity problem and the veracity of some public sector research

3.68 Some submitters questioned the accuracy of research by some public sector research agencies and national audits relating to the current extent and predicted increases of salinity.[82]

3.69 The Institute of Public Affairs (IPA) disputed claims, said to have been made by CSIRO, that salinity is increasing in the Murray River. Drawing on data requested from the MDBC, the IPA found that average salinity levels in the Murray at Morgan have been dropping over the last 20 years and that water quality is improving. The MDBC concurred with these findings.[83]

3.70 It was also argued that the *Australian Dryland Salinity Assessment 2000* 'does not distinguish between current and predicted salinity problems' and does not give an indication of the current extent of salinity:

> When we are told water quality is deteriorating and dryland salinity is a worsening problem we should be provided with basic trend lines that give us a clear indication of the current and recent past situation. Indeed it is imperative that we have an indication of current trends. How else are we to understand whether or not our investment in salinity mitigation works over the last two decades have been effective?[84]

3.71 The IPA argued that the reason public sector science agencies misrepresent available information is to 'maintain the illusion of a crisis', notwithstanding evidence to the contrary, so that they can maintain their funding base and control the research agenda.[85]

3.72 Murray Irrigation also questioned the involvement of CSIRO in the Wentworth Group and urged that 'researchers need to maintain their

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82 The Committee notes that related issues were raised in the interim report of the House of Representatives Standing Committee on Agriculture, Fisheries and Forestry's inquiry into *Future Water Supplies for Australia's Rural Industries and Communities*. The report noted evidence which questioned the science underpinning the Living Murray initiative. It recommended that a comprehensive program of data collection and monitoring be completed and an audit of the Murray-Darling Basin's water resources be conducted, prior to authorisation for increased flows to the River Murray. The report is available at the Committee's web site, viewed 12 April 2004, <www.aph.gov.au/house/committee/primind/wateringq/interimrpt/wireport.pdf>.

83 IPA, *Submission no. 41*, pp. 4-5.

84 *ibid*., pp. 1, 2.

85 *ibid*., p. 1.

integrity by remaining apolitical' so that 'community confidence in the independence and professionalism of the organisation' is maintained.[86]

3.73 Similarly, Orbtek argued that:

> environmental decline predicted from some saline areas has never eventuated. For example, the Jemalong / Wyldes Plains area was predicted by CSIRO scientists in 1993 to have significant salinity degradation increases by 2020, but in 2003 there is little or no sign of further degradation. During the past 15 years salinity has been promoted as the worst environmental problem facing Australia, but this message has been a monumental beat-up by public scientists with a vested interest in access to public funds for research.[87]

3.74 In order to remove the alleged control over public funds for salinity research from 'public scientists and bureaucrats', Orbtek recommended encouraging greater industry involvement in salinity science. However, Orbtek also argued that new science in industry should not necessarily be subject to peer review by public scientists prior to application for participation in publicly funded programs.[88]

3.75 The IPA urged that public research agencies make basic information on the current extent and trends with respect to dryland and river salinity readily available, and recommended that there be greater reliance on measured statistics:

> [F]actual information needs to be based on measured statistics rather than computer generated predictions from simulation or decision support models. Information from models is useful, but must complement rather than replace measured statistics.[89]

3.76 The Chinchilla Shire Council also questioned the accuracy of salinity hazard maps, particularly of the Condamine Catchment in which the Shire is located. The Council argued that only small, localised outbreaks of salinity have been observed, contrary to the salinity maps which portray a high salinity hazard over much of the land. The Council concluded that:

> the research to date and the scientific knowledge being applied to the subject is not adequate to determine the significance of the

86 Murray Irrigation Ltd., *Submission no. 27*, p. 5.

87 Orbtek Pty Ltd, *Submission no. 3*, pp. 1-2.

88 *ibid.*, pp. 1, 13.

89 IPA, *op. cit.*, p. 2.

> salinity problem and/or is incorrectly being applied to promote solutions which do not have scientific backing.[90]

3.77 The Council insisted that the outbreaks in the Catchment require local solutions (such as planting lucerne or groundwater pumping), rather than the imposition of tree clearing limits.[91]

3.78 In a related argument, Mr Rex Wagner rejected the claim that salinisation may be driven by rising regional groundwater systems and argued that the projected spread of dryland salinity is not occurring. Instead, he argued that 'much past and current research supports' a localised model of salinisation:

> Salinisation is localised, restricted to particular soils and landforms, restricted in its spread, episodic in its development, and responsive to mitigation measures within its own local catchment or recharge area.[92]

3.79 CSIRO has readily conceded that small scale salinisation processes occur which do not fit easily into catchment-wide models.[93]

3.80 Again, the Committee does not propose to definitively adjudicate on these debates, but notes the concerns of submitters that statements by research agencies and audits of the extent and trends in salinisation be objective and as accurate as possible. There is a need to guard against fostering a sense of crisis where this is not warranted. This issue also points to the adequacy of the science base and the management of data, which are addressed in chapters six and seven respectively.

Conclusions

The nature of the salinity problem and alternative scientific perspectives

3.81 The Committee concludes that a consensus explanation of the salinity problem has developed which explains secondary, or human-induced, salinity as having resulted from changes to the hydrology of the Australian landscape caused by changed land use following European

90 Chinchilla Shire Council, *Submission no. 47*, p. 2.

91 *ibid.*, p. 8.

92 Mr Rex Wagner, *Submission no. 7*, p. 1.

93 Dr John Williams (CSIRO), *Transcript of Evidence*, 7 November 2003, p. 94.

settlement. In this model, land clearing and the use of shallow-rooted annual crops and pastures alters the water balance in catchments, allowing excess water to enter the groundwater, thereby mobilising salt, which then rises to the land surface.[94]

3.82 The Committee is profoundly concerned that while the precise extent of salinisation is unclear, 5.7 million hectares of agricultural and pastoral land are currently estimated to have a high potential for developing salinity. Landholders have observed that two million hectares of agricultural land are currently showing signs of salinity. More than 70 per cent of the nation's salinity problem occurs in one state—Western Australia.

3.83 The current and predicted impact of salinity on infrastructure, water quality, productive land, bio-diversity, remnant vegetation and conservation reserves is significant. The costs imposed on landholders, governments and residents of rural towns are considerable.

3.84 The Committee recognises that salinity presents a highly complex problem to address, and that its management may require a triage approach based on three overarching objectives of:

- avoidance / prevention;
- mitigating symptoms; and
- adapting to live with salinity.

3.85 The consensus explanation of the basic salinisation process and sources of salt (considered to be predominantly cyclic salt) have been criticised and alternative models proposed. Concerns have also been raised about the paucity of basic information on the current extent and trends with respect to salinity. The veracity of some statements issued by national science agencies and programs have been questioned.

3.86 Although the Committee does not wish to definitively adjudicate on these debates, it urges that all contributors to the scientific understanding of basic salinity processes and the sources of salt have adequate opportunity for their perspectives to be presented and examined, and that scientific disciplines addressing salinity not degenerate into 'warring camps'.

94 Dr Mirko Stauffacher (CSIRO), *Transcript of Evidence*, 7 November 2003, p. 91.