Our ability to effectively manage dryland salinity depends upon our understanding of its causes, location and behaviour in any landscape. Accurate mapping of the saline landscape and the hydrogeological pathways that control the movement of salt is critical.

The Natural Resource Management Ministerial Council commissioned a review of salinity mapping methods in the Australian context in 2003 to provide an authoritative assessment to inform governments, regions and other users about appropriate options for mapping salinity. The report has been reviewed and endorsed by the Academies of Science and Technological Sciences & Engineering.

Peter will discuss the findings of the review, which assessed the technical capabilities and costs of 31 salinity mapping methods and found that no single method could meet all user needs. The best approach being to use several methods structured into a program tailored to specific circumstances. Airborne electromagnetics was found to be the only broad acre mapping techniques currently available for remote sensing of salt loads below the soil surface. The review also identified limitations of the method, such as access to skilled people.

Bio Peter Woodgate

• In June 2003, Peter was appointed CEO of the newly created Cooperative Research Centre for Spatial Information, currently located at the University of Melbourne. This is an unincorporated joint venture with 56 partners including research institutions, Federal and State agencies and a consortium of companies. The partners, together with the Australian Government, have provided $78 million over seven years to foster world class research and to help create new wealth in Australia through the better use of spatial information and its related technologies.

• Peter has previously working as the CEO of RMIT’s Geospatial Science Initiative. He has particularly research interests in greenhouse issues, forest management, dryland salinity, remote sensing and the use of innovation to stimulate industry development.
REVIEWS OF SALINITY MAPPING METHODS IN THE AUSTRALIAN CONTEXT

for the
NATURAL RESOURCE MANAGEMENT STANDING COMMITTEE
through
LAND AND WATER AUSTRALIA
and the
NATIONAL DRYLAND SALINITY PROGRAM

By Brian Spies and Peter Woodgate
PURPOSE OF REVIEW

To establish an up-to-date position statement of the use, range and effectiveness of technologies for mapping salinity in Australia’s Landscapes.

TARGET AUDIENCE

A range of potential investors in mapping, including catchment and regional natural resource managers, State, Territory and Commonwealth government agencies, scientists, and vendors of mapping methods and systems.
OUTPUTS

1. User Guide
2. Technical Report
3. Recommendations
THE REVIEW PROCESS

- Initiated jointly by DAFF, DEH and Queensland
- Proposal put to the Board of the NDSP
- Ministerial Standing Committee agreement to fund
- Consultancy let
- NDSP Steering Committee formed
- Call for public submissions (5 July 2003)
- 36 submissions received, 2500 pages + cd’s and maps
- Early draft reviewed by 24 Joint Academy experts at a workshop (Sept 2003)
- Further revision
- Joint Academies Public Forum at the Dome (Oct 2003)
- Further revision
- Five person panel selected by Joint Academies undertakes final review (Dec 2003 – Jan 2004)
- Hardcopy publication available (Feb 2004)
- Graphic editor preparing camera ready versions (now)
SCOPE OF REVIEW

Mapping Methods for Dryland Salinity

- Summary of method and description of mapping products
- Prior use and evaluations (if any)
- Scale and survey design (and level of detail)
- Data requirements, processing, interpretation and mapping products
- Prepare a fitness for purpose statement, and indicate likelihood of success (User Friendly Guide)
- Hazard and risk where appropriate
- Integration with other techniques, optimum suite of methods
- Costs
SIGNIFICANT ELEMENTS OF REVIEW

1. Clear definition of hazard and risk
2. Expanded treatment of risk management
3. Coverage of 31 classes of mapping methods
4. Identification of scale and depth of each mapping system
5. Investment analysis for users
6. Up-dated list of information sets required for full risk assessment
HAZARD AND RISK

HAZARD

• Is anything that can potentially cause harm to an asset.
• Salinity is a hazard.
• Assets include; agriculture production, biodiversity, built assets.
• (Threat is considered to have the same definition as hazard for this review).

RISK

• The probability that a hazard will cause harm to an asset at some estimated time in the future.
• ‘Assets’ include agriculture, infrastructure, water quality and biodiversity.
• Measured in terms of impact x likelihood.
• Can also consider the vulnerability (degree of susceptibility, eg tolerance to salinity of a crop) and exposure (expected timing).
• Cost-benefit analyses should take into account total cost and total benefit – many of which may be intangible and geographically remote.
SCALES OF USER

1. Farm scale
   - paddock level

2. Community scale
   - around 10 – 20 farms in a catchment

3. Catchment management groups
   - catchment or region
FACTORS AFFECTING GROUNDWATER MOVEMENT
(govern the rate, location and destination of groundwater)

- Climate; long term rainfall, drought
- Weather; local rainfall
- Land-use; including land clearing, farming
- Terrain; landscape, topography
- Regolith properties; affect permeability
- Soils; different permeabilities, different salinity susceptibilities
- Ancestral or prior stream systems
- Impermeable features of the regolith; basement highs
- Geological faults and dykes
- Vegetation
- Groundwater itself

... All contribute to our ability to model salinity risk
STRUCTURE OF REPORT – KEY ELEMENTS

Review of 31 individual (and integrated) mapping methods

1. Analytical and Point Based Measurement (2)
   (e.g., laboratory, field-based electrical conductivity of soils)

2. Surface mapping (11) – root zone
   (e.g., visual inspection, air photos, radiometrics, satellite)

3. Shallow sub-surface mapping (2) – to 2m depth
   (e.g., electromagnetics, ground-probing radar)
4. Sub-surface mapping (9) - > 2m depth local scale
   (e.g., deeper-probing EM, borehole logging, ground-magnetics)

5. Sub-surface mapping (2) - > 2 depth regional scale
   (e.g., airborne EM, airborne magnetics)

6. Predictive Risk Assessment Methods (4)
   (e.g., Composite Index Methods, Trend-based Methods)
FIVE STEP PLAN FOR ASSESSING THE NEED FOR NEW INFORMATION

1. Determine the value of the asset at risk
2. Assess the current level of knowledge about dryland salinity in the area of interest
3. Consider whether the mapping techniques you are proposing to use are suitable for the specific environment
4. Identify areas where no useful remedial action is possible
5. Assess costs and benefits of this approach and then act
# SUMMARY OF MAPPING METHODS

<table>
<thead>
<tr>
<th>Mapping method</th>
<th>Application to Hazard Mapping</th>
<th>Contribution to Risk Assessment</th>
<th>Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIELD AND LABORATORY</strong></td>
<td></td>
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<tr>
<td>1. VISUAL INSPECTION</td>
<td>Yes - through direct observation of salt scalds or by observing stressed vegetation.</td>
<td>No direct contribution other than as a method for spot checking some attributes required for risk assessment such as vegetation type, soils, geology and landuse.</td>
<td>Subject to the ordinary cost of labour.</td>
<td>Useful technique for mapping small areas (paddocks). Essential as a checking method for maps prepared from satellites, aircraft or systematic vehicle-based EM surveys.</td>
</tr>
</tbody>
</table>

| **SURFACE-BASED METHODS** | | | | |
| 4. SHALLOW-PROBING EM CONDUCTIVITY METERS (Geonics EM38, Geophex GEM2) | A popular method for mapping spatial variations in conductivity in the root zone at farm scale Strong correlation with salinity. | Useful in mapping near-surface variability and salt load. | Starts at about $1500 per day. Cover about 50 ha per day | Some depth information from varying coil orientation. Subject to changes in moisture and clay content. Should be calibrated at key locations. |
MAPPING LANDSCAPE AND SALINITY – KEY CONCLUSIONS

1. No single technique is optimal for all mapping salinity hazard or risk assessment.
2. Undertake preliminary analyses based on existing information first.
3. Airborne and satellite techniques can delineate surface and near-surface salt scalds and track progression over time.
4. Airborne geophysical techniques (Eg electromagnetics) can map salt load at depth as well as hydrological pathways.
5. Ground truth and calibration is essential for all techniques.
6. Effective use of mapping techniques requires trained personnel and expert knowledge.
7. Need 3-D understanding of landscape and hydrological processes.
8. Combination of mapping techniques of most value.
RECOMMENDATIONS

1. Regular evaluation of new mapping techniques

2. Improve general understanding of hazard and risk

3. Salt versus water; priorities need to be set

4. Management of data; ‘collect once and use many times’

5. Guidelines and standards for EM surveys need to be kept
ACKNOWLEDGEMENTS

• All 36 Organisations and individuals who made submissions.

• **STEERING COMMITTEE:**
  (Drawn from the Operations Committee of the National Dryland Salinity Program)

  Dr Sharon Davis (Chair) – MDBC
  Dr Richard George – Dept of Agriculture, WA
  Dr Mirko Stauffacher – CSIRO Land & Water

• **Land and Water Australia:**
  Dr Richard Price
  Ms Melanie King

• **Advisors:**
  Mr Simon Veitch (DAFF)
  Ms Annette Bleys (DEH)

• **Joint Academies Reviewers:**
  Prof Kurt Lambrick (Chair)    Dr Ian Rae
  Dr Andy Green                Prof John Lovering
  Dr John Ive

• **Report compilation assistance:** Ms Jane Inall (CRC SI)
> 2000 yrs of flat maps- Time for new 3D paradigm
Schematic diagram of a fixed wing AEM system
LAKE TOOLIBIN, WESTERN AUSTRALIA
LAKE TOOLIBIN MAGNETICS AND ELECTROMAGNETICS
Visualization of model outcomes

Realistic effect on virtual environment

3D models of sub-surface process

Bushfire affected trees

Salt affected grasses

Salt affected grasses
INDEPENDENCE OF REVIEW

• Declarations of prior interests and conflicts of interest by members of the Project Team and the Steering Committee

• Arms length role of Steering Committee

• Independent review by Academies (Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering)
  - Scoping workshop peer review
  - Theme reviews
  - National public forum review
THANK YOU