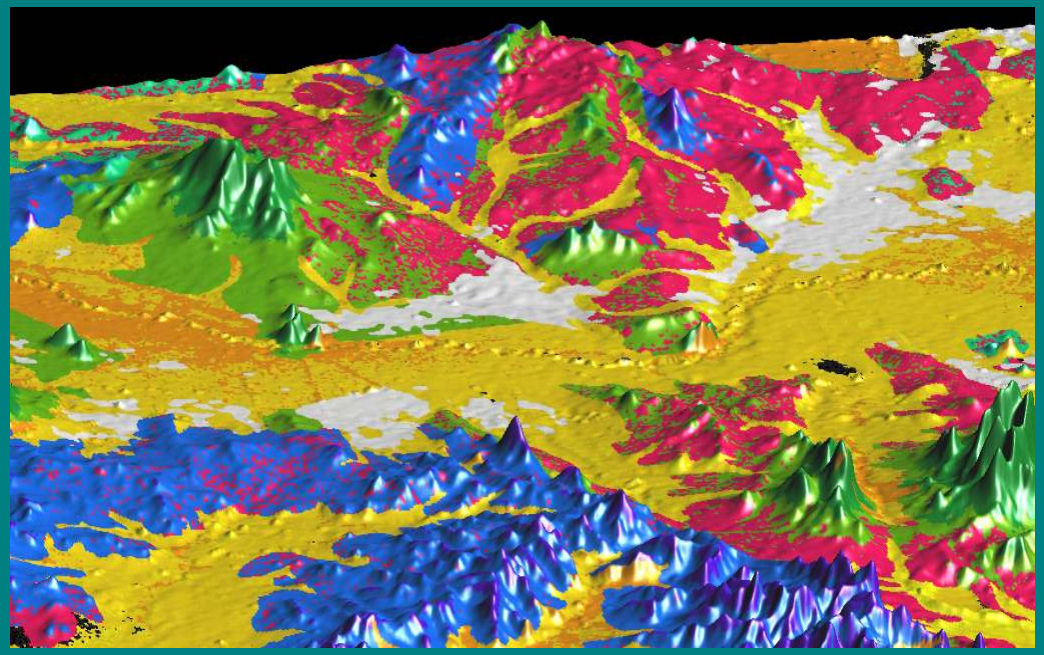
Gamma-ray remote sensing of salt source materials in the Murray-Darling Basin

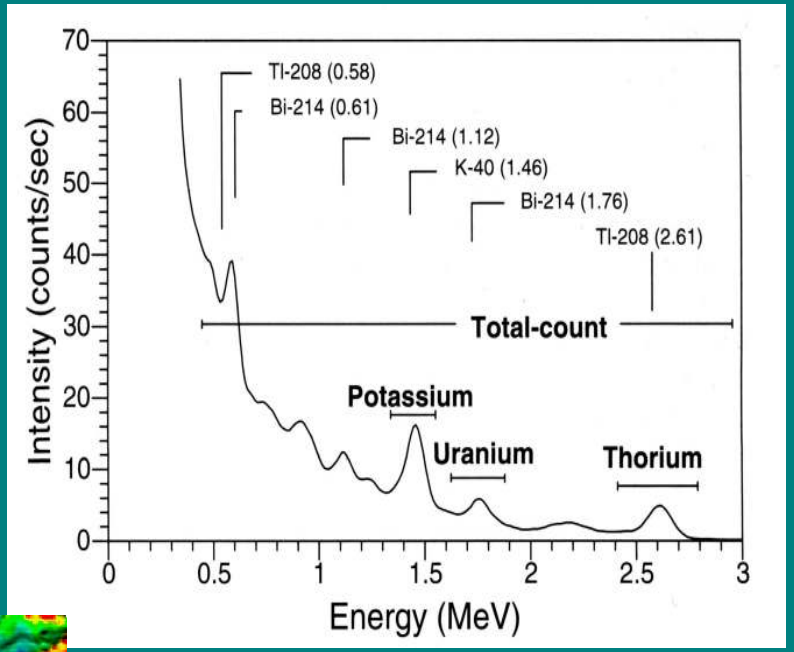


Phil Bierwirth
Defence Imagery and Geospatial Organisation (DIGO)

Airborne gamma-ray spectroscopy (GRS)

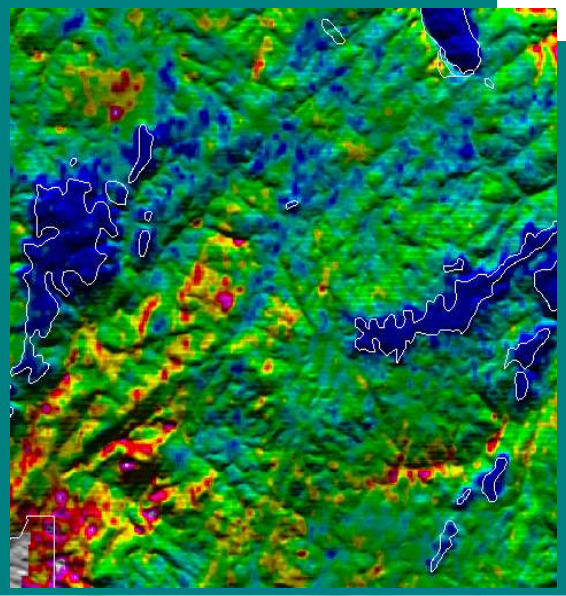
- hyperspectral in gamma-ray part of EM spectrum
- emissions from radioactive elements
- element concentrations at 50 m image resolution
- “penetrates” to 30-45cm of upper soil/rock layer
- unique data source

– gives an uninterrupted picture of soils



Landsat TM bands 3,4,5 = RGB

Airborne Potassium

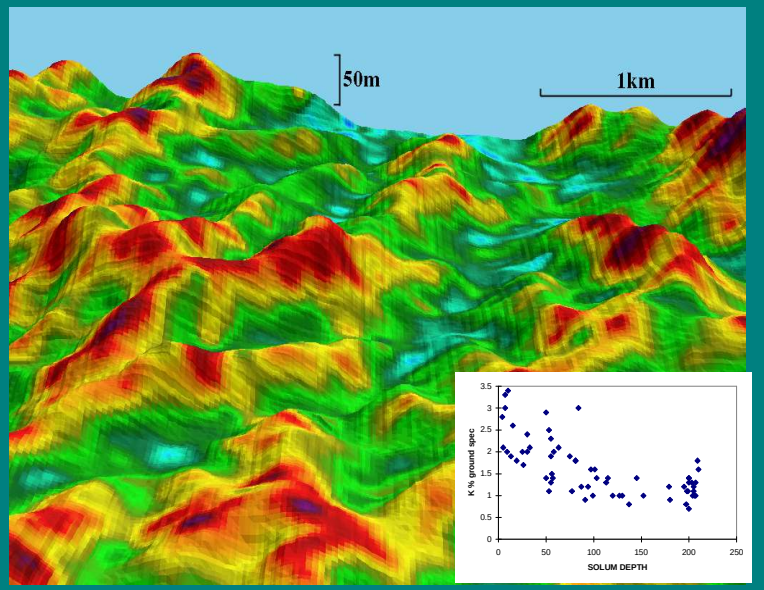


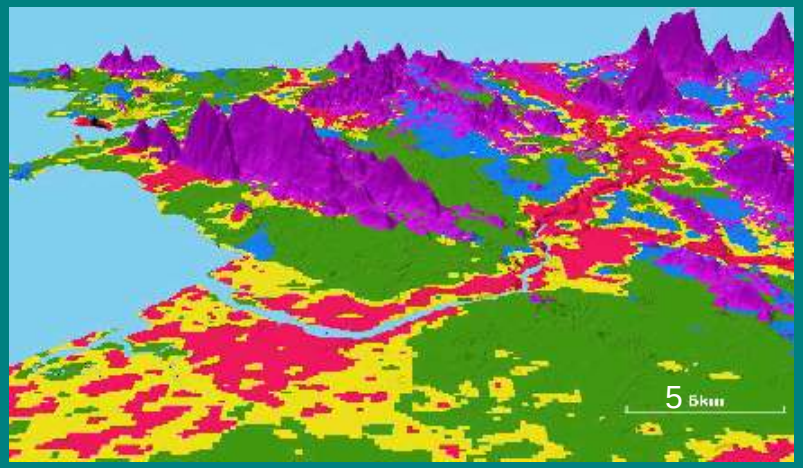
Previous work on GRS

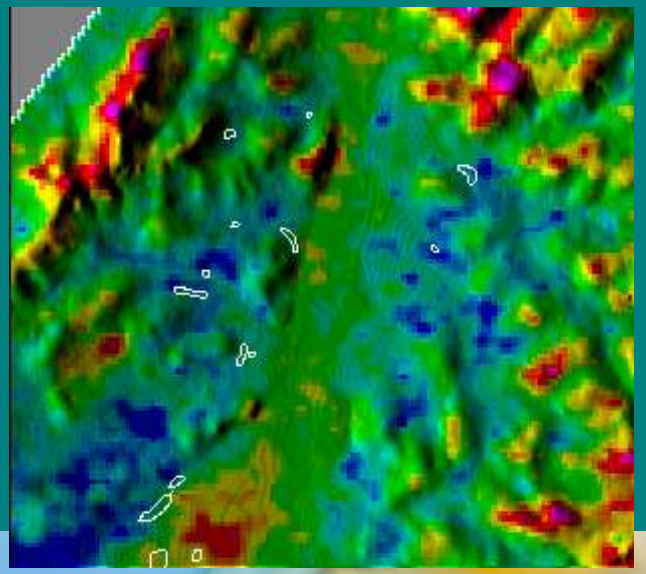
- Original AGSO project investigated use of GRS in soil and land mapping /degradation studies

- demonstrated relationship with soil properties

- needs to be interpreted with geology and landform







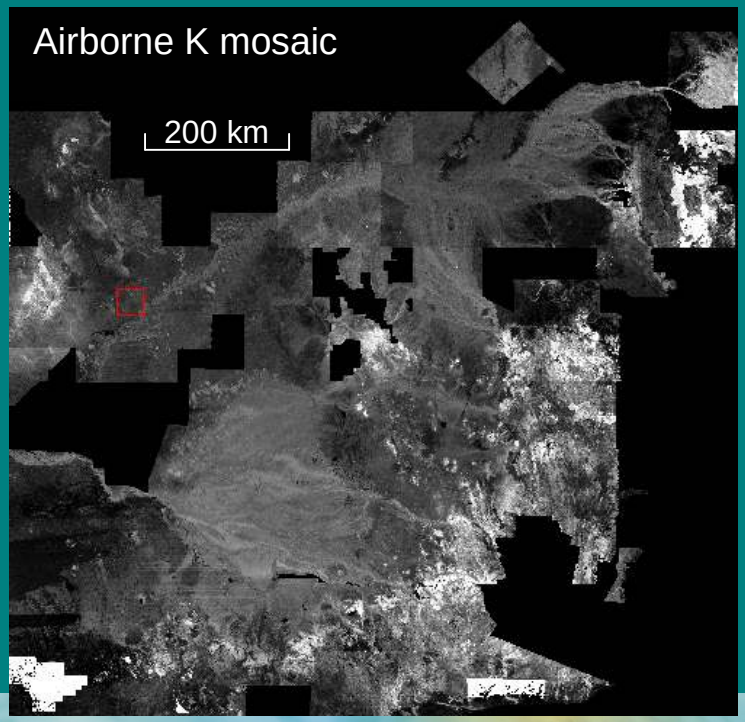
- inconclusive findings in relation to salinity due to localised and limited study areas

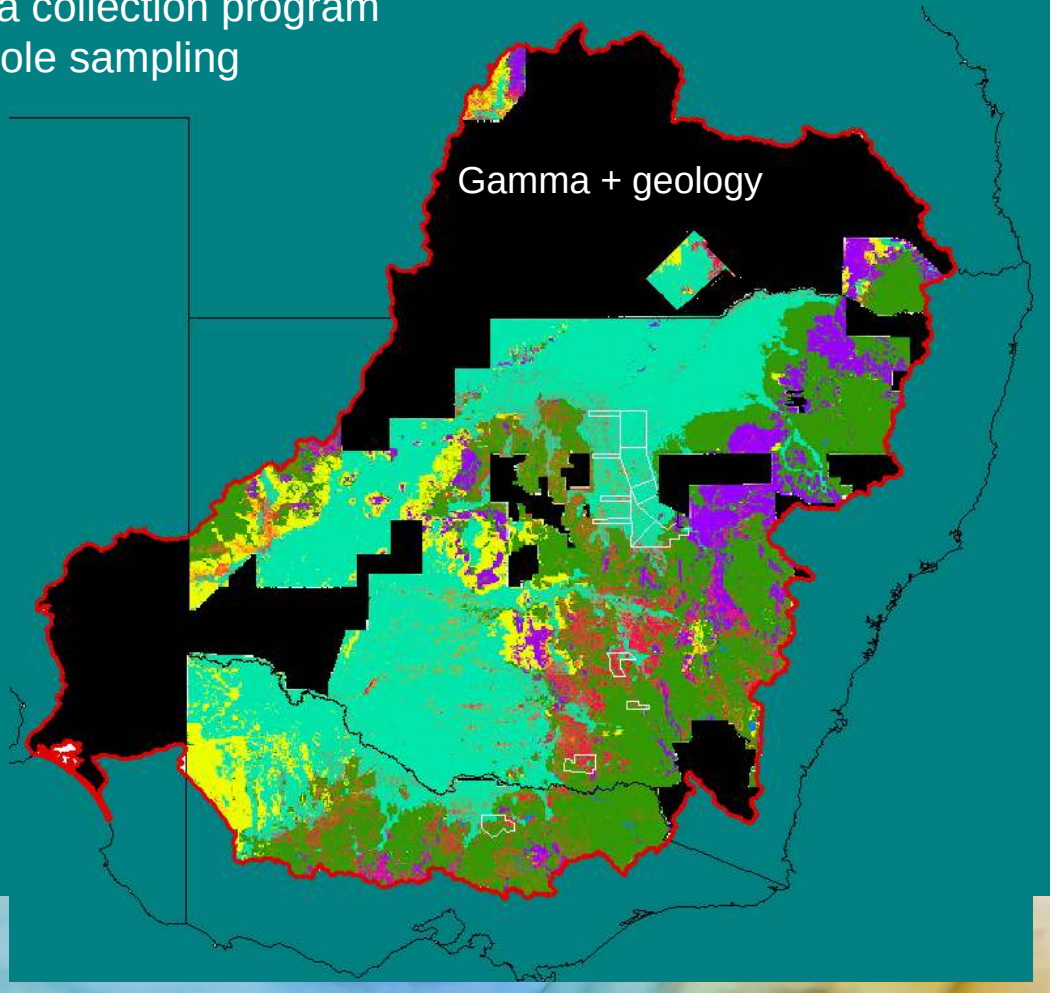
- GRS not a recognised tool (like AEM) for directly managing salinity

Revisiting the salinity – GRS relationship

Revisit because:

- new related work by other researchers
- more significant coverage of GRS
- availability of GRS data through GADDS system (Geoscience Aust)
- new supporting data through MDBC data collection program
  - airborne EM data surveys, deep borehole sampling

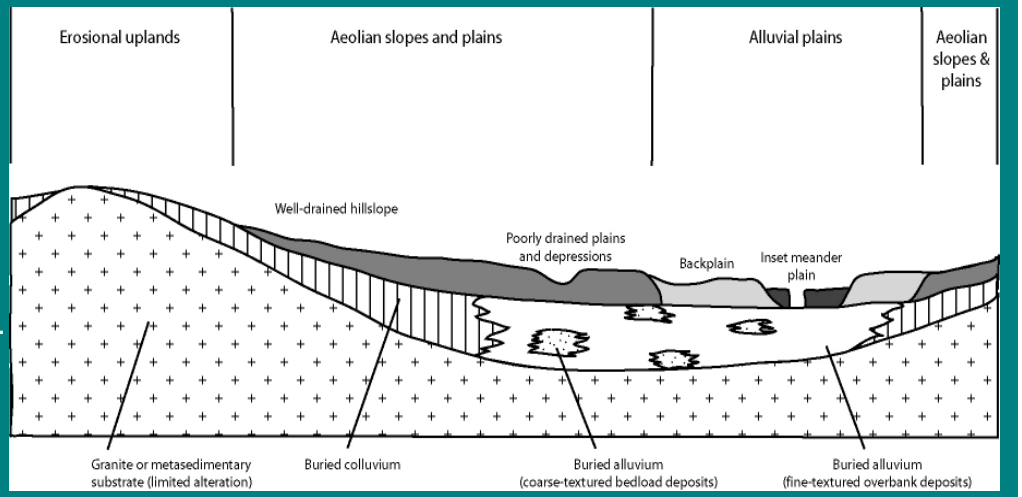


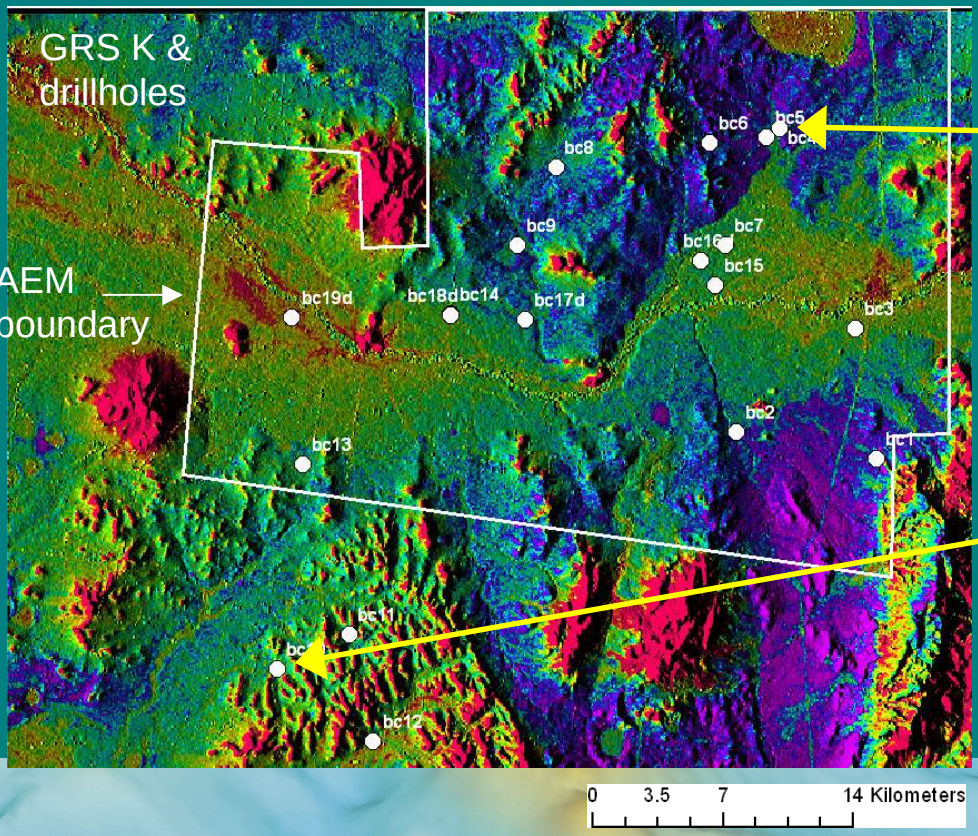


Key Study - Billabong Ck

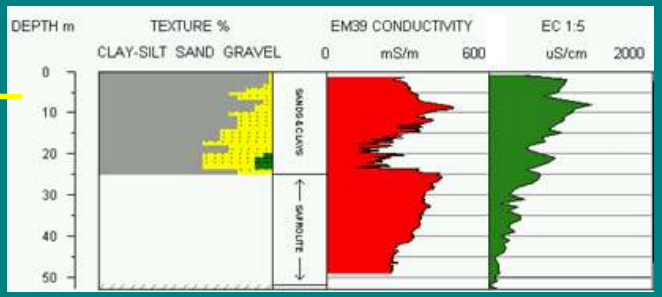
CSIRO mapping identified aeolian dust deposits (McKenzie and Gallant, 2005)

- characterized by low radiometric K and low slope
- English et al 2002 suggested aeolian (wind-blown) materials are sources of salt
- drill holes show salt is localized in CSIRO-modelled aeolian areas

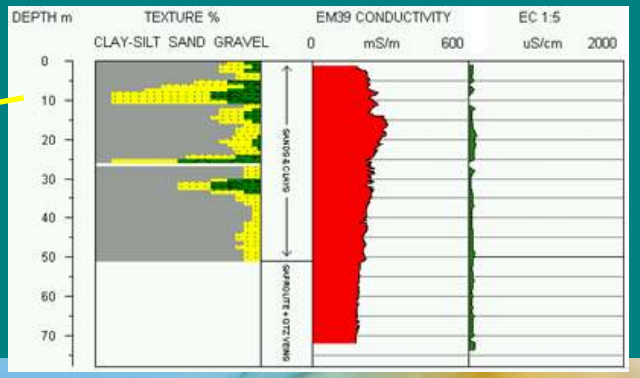




Low K, High salt



High K, Low salt

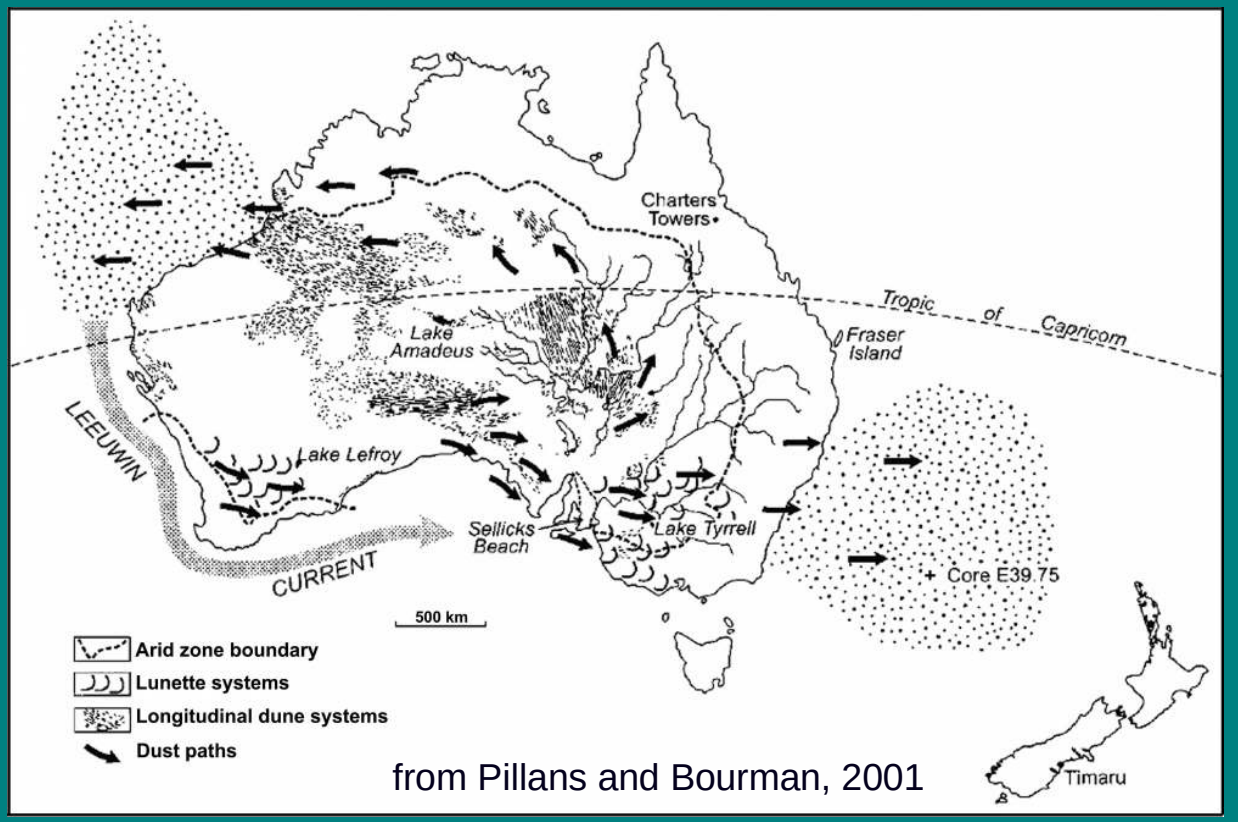


Evidence for aeolian (wind-blown) salt sources

- salts have been introduced to the landscape rather than being derived from bedrock sources.

- salt accompanying dust is “blown in” (aeolian) during arid phases

- associated deflation of salt-lakes in the Murray basin.

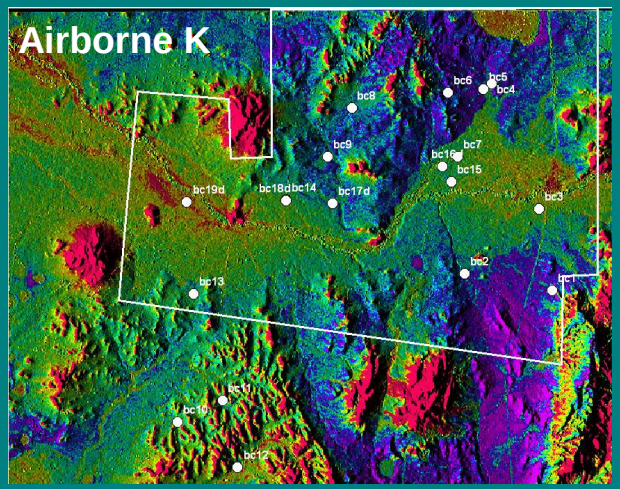


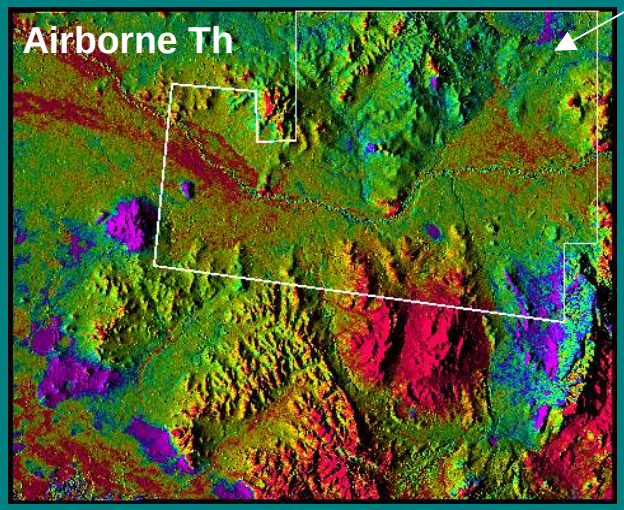
from Pillans and Bourman, 2001

Previous work has shown that:

- extensive deposits of aeolian materials in SE Australia
- aeolian deposits are significant sources of salt
- present day aeolian dust contains up to 50% salt
- aeolian materials across MDB have similar signatures

Billabong Ck - gamma element relationships with borehole salt

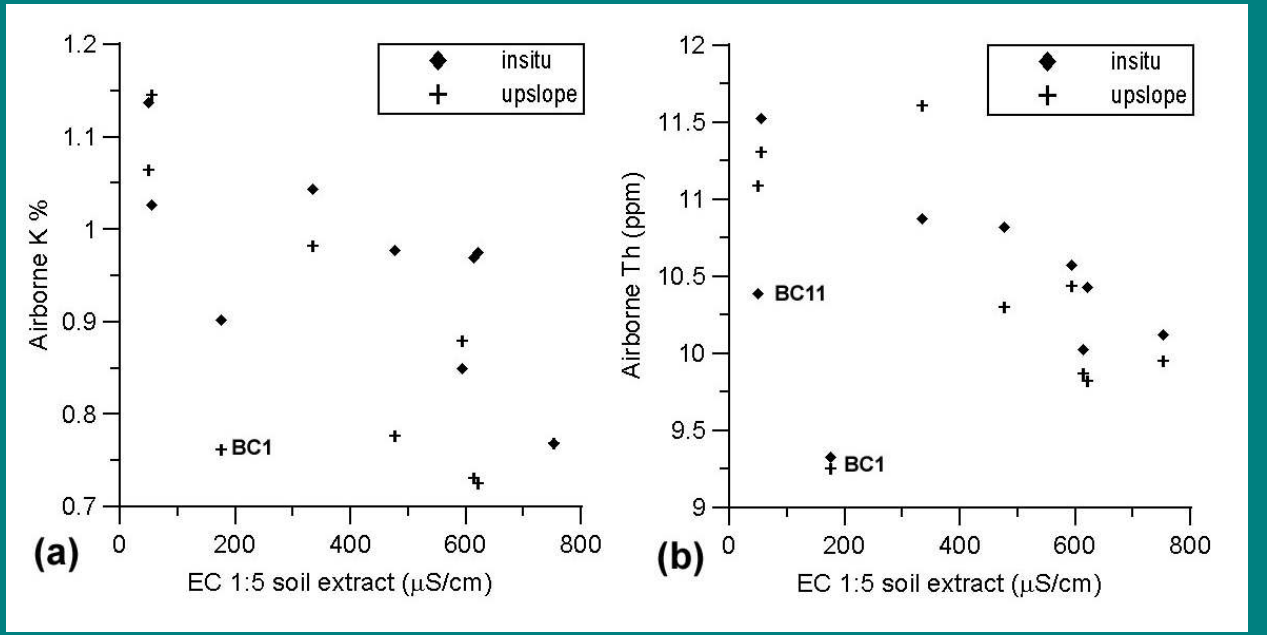




Airborne U – not used due to noisy and poorly calibrated data.

- upland boreholes indicate relationships between salt and gamma-ray signatures
- errors in comparison of airborne “footprint” measurements and borehole averages
- some overlap with geology, K with Sandstones, Th with metasediments

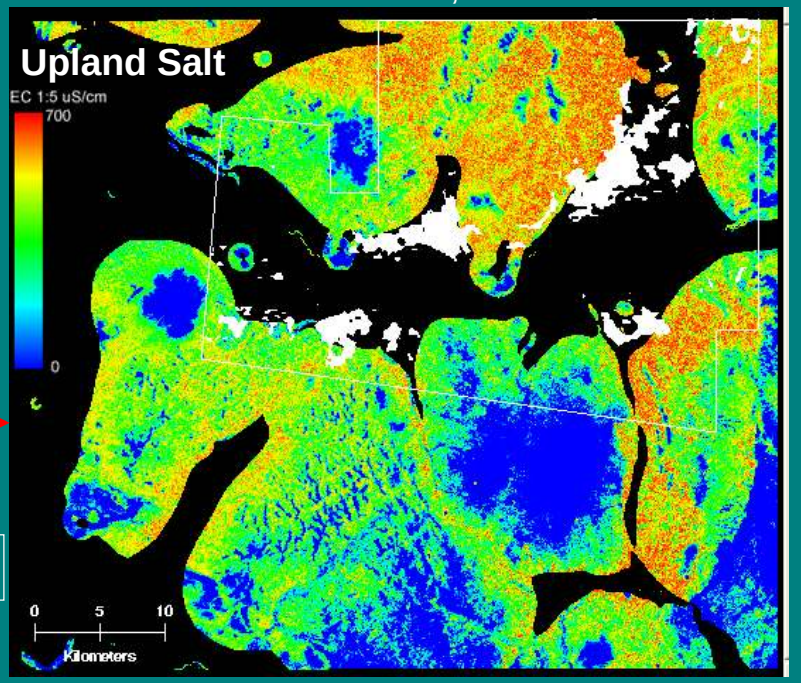
AEM study area



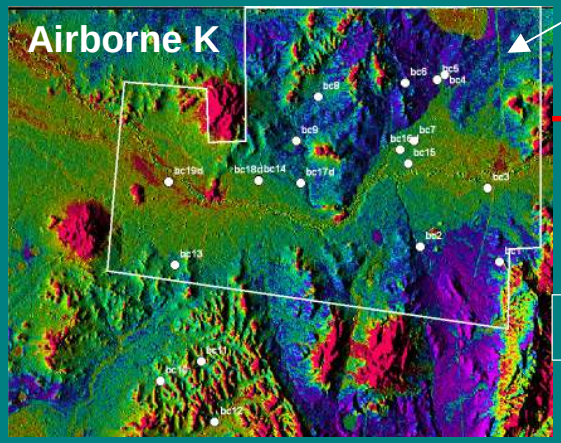
GRS upland salt source model – Billabong Ck

- Alluvial areas masked in the GRS model since no expected relationship with salt in transported sediments

Red = aeolian salt source, white = AEM 25m

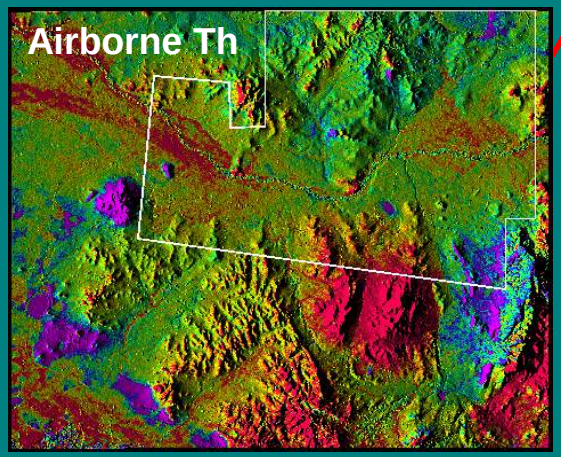


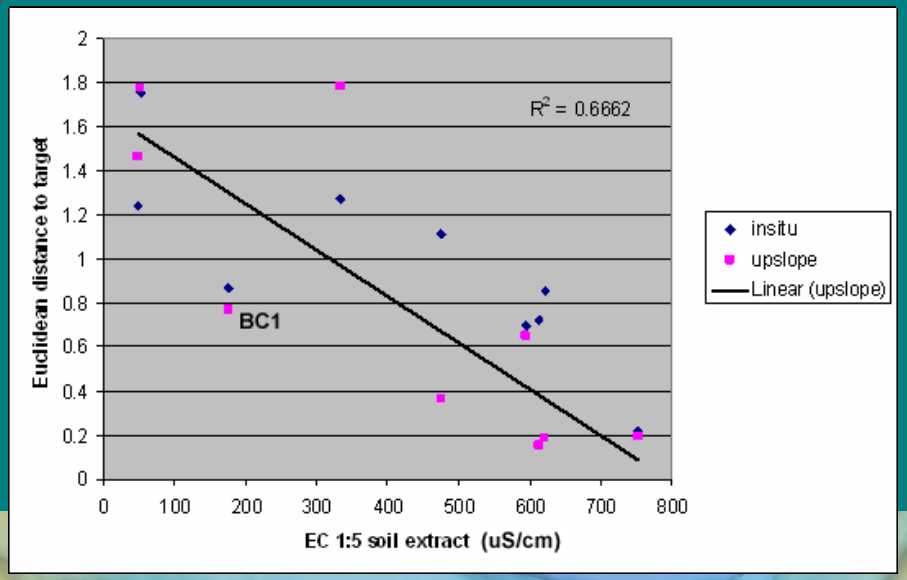
AEM study area



Euclidean Distance Model

$$E_D = \sqrt{((K_i - K_t)^2+(Th_i - Th_t)^2)}$$

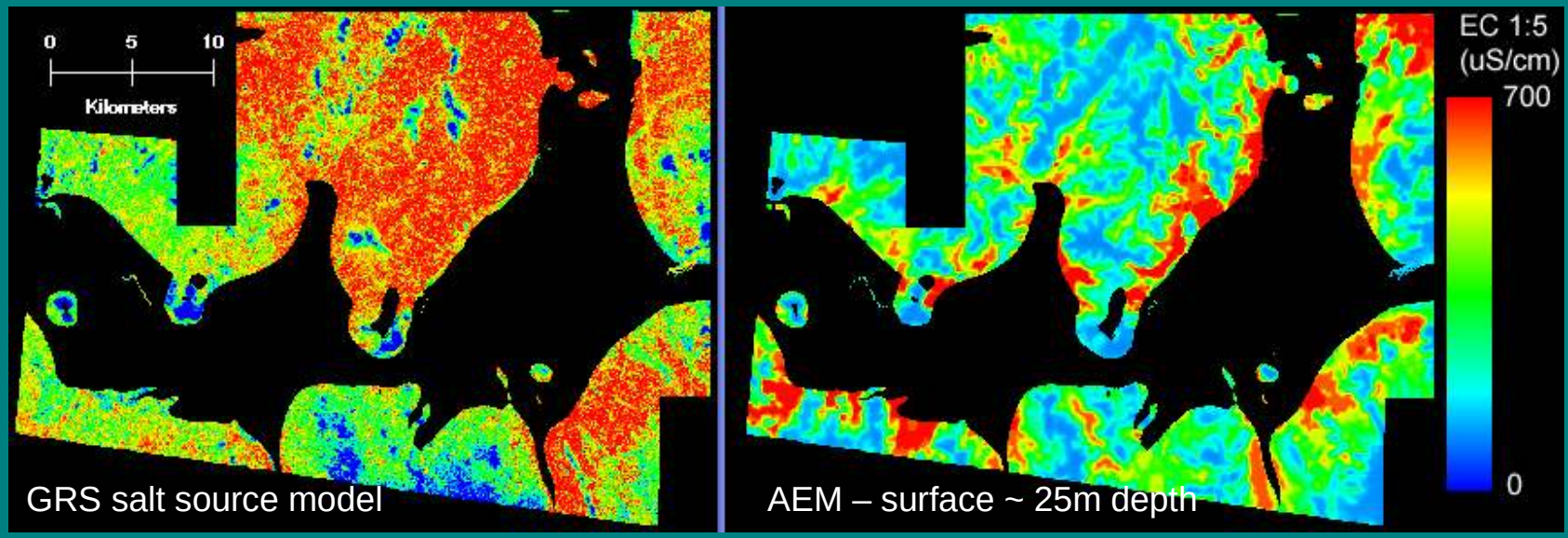


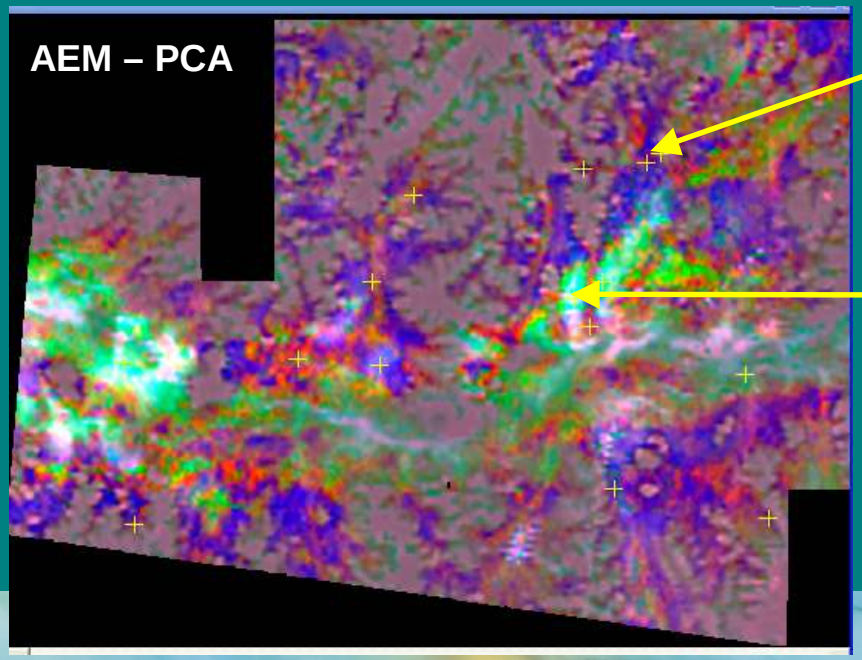


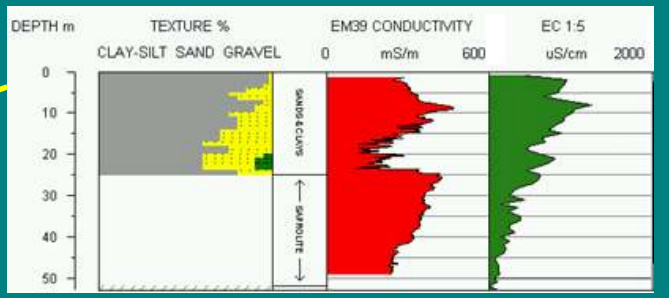
Relationship between borehole salt (EC1:5) and

Euclidean distance to target (K, Th)

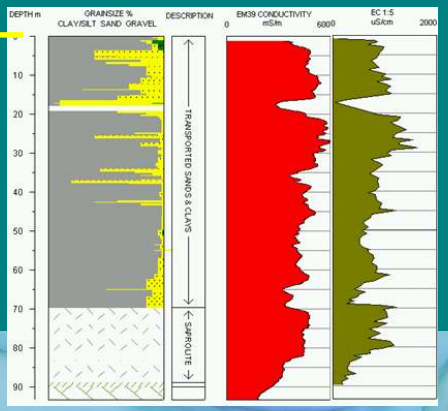
Comparison of AEM with GRS salt source model at Billabong Ck







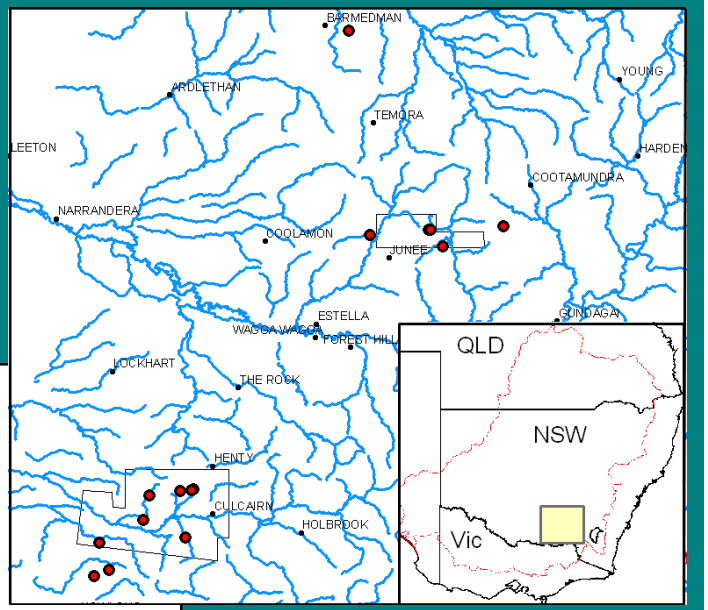
Upland -BC 5



Alluvials – BC 16

GRS model versus salt – upland boreholes from combined AEM areas

- upland boreholes selected using MRVBF (CSIRO) topographic index
- insitu versus upslope averages of model values
- upslope materials likely to influence borehole salt levels
- relationship supports gamma-ray salt-source model



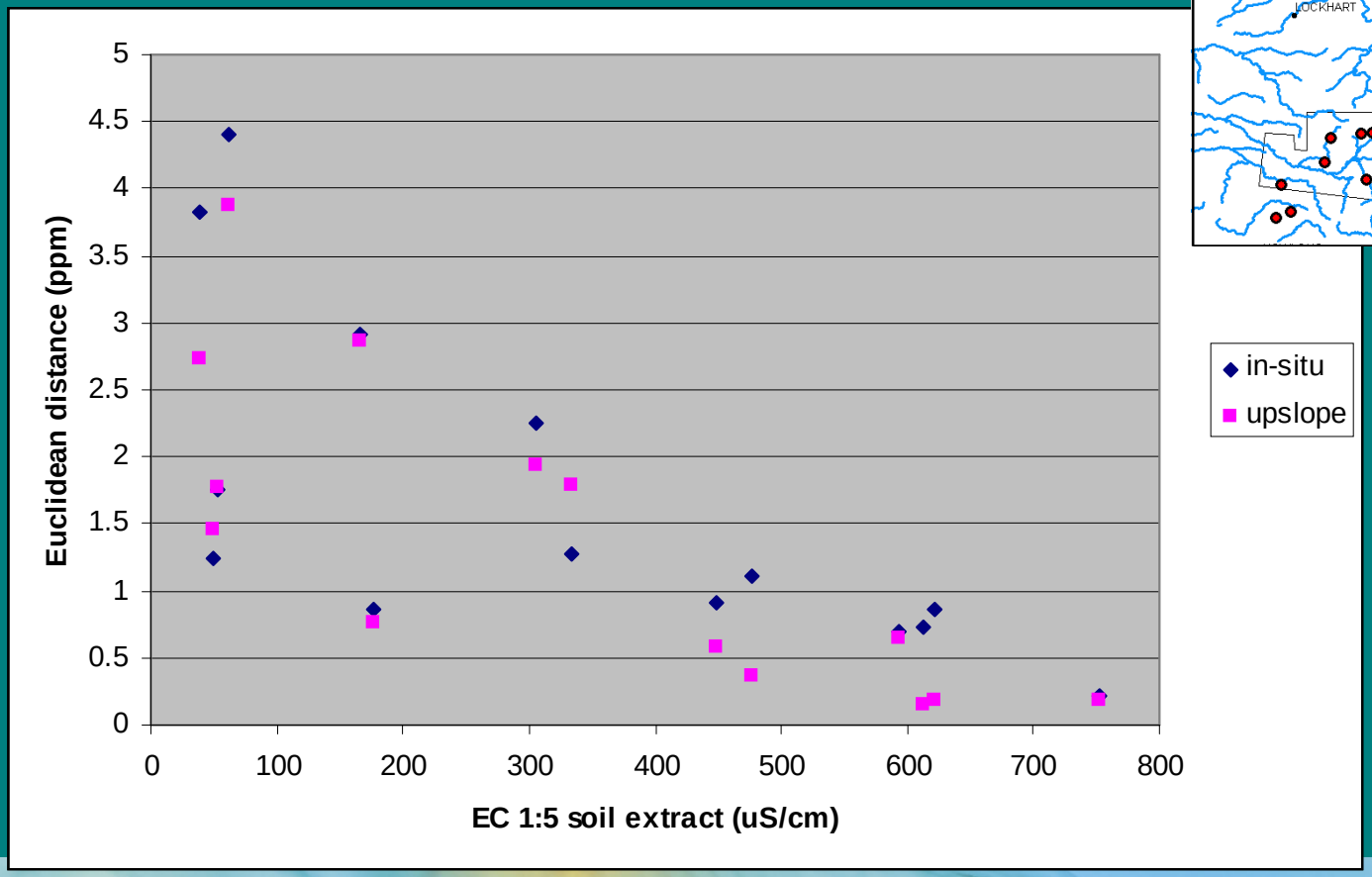
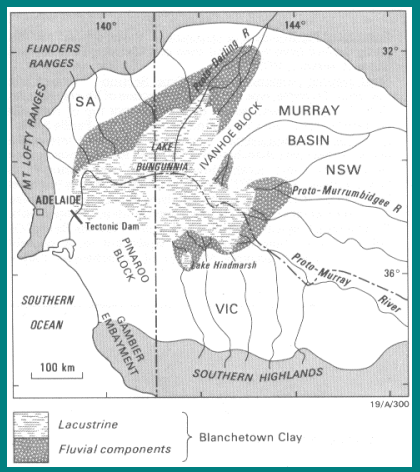


Figure: Soil EC 1:5 iin upland boreholes versus airborne GRS Euclidean distance to aeolian target signature.

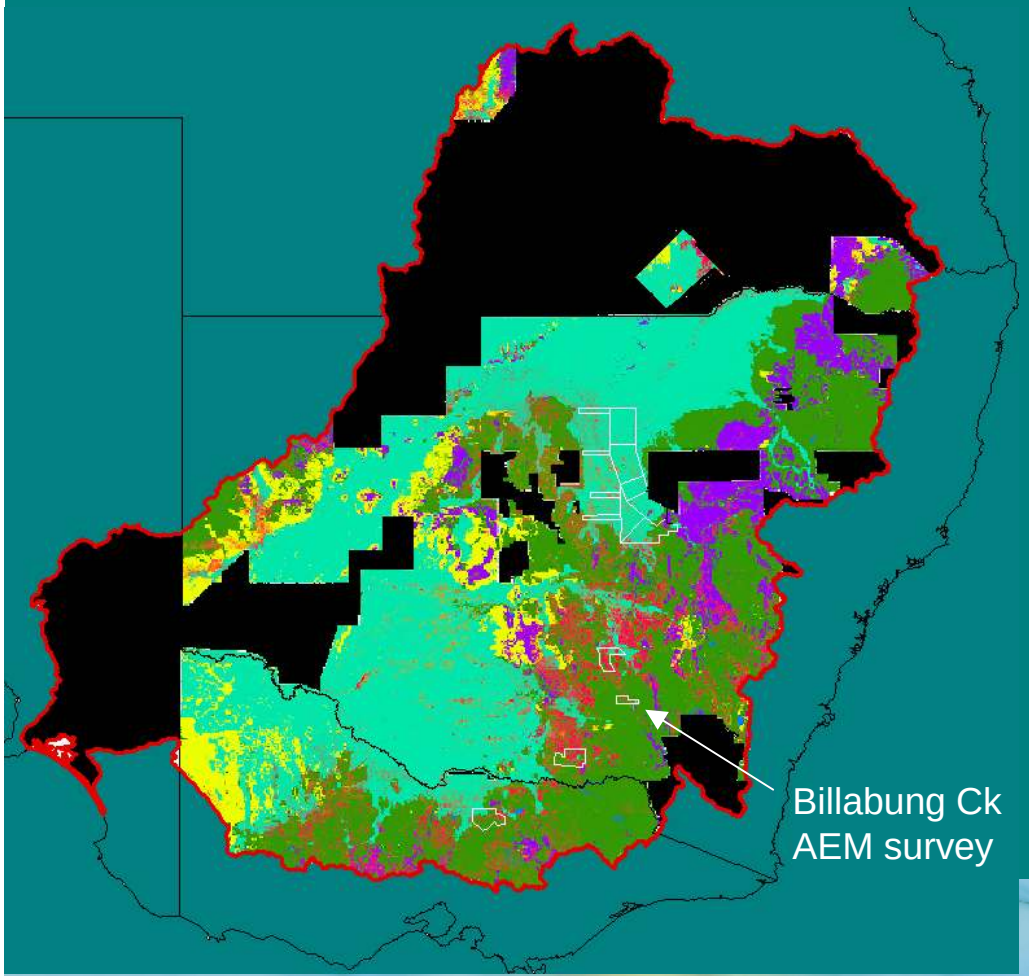
GRS salt-source model for the MDB

- Regional pattern fits with dust derived from deflation events of the ancient hypersaline (Pleistocene Lake Bungunnia and its' remnants

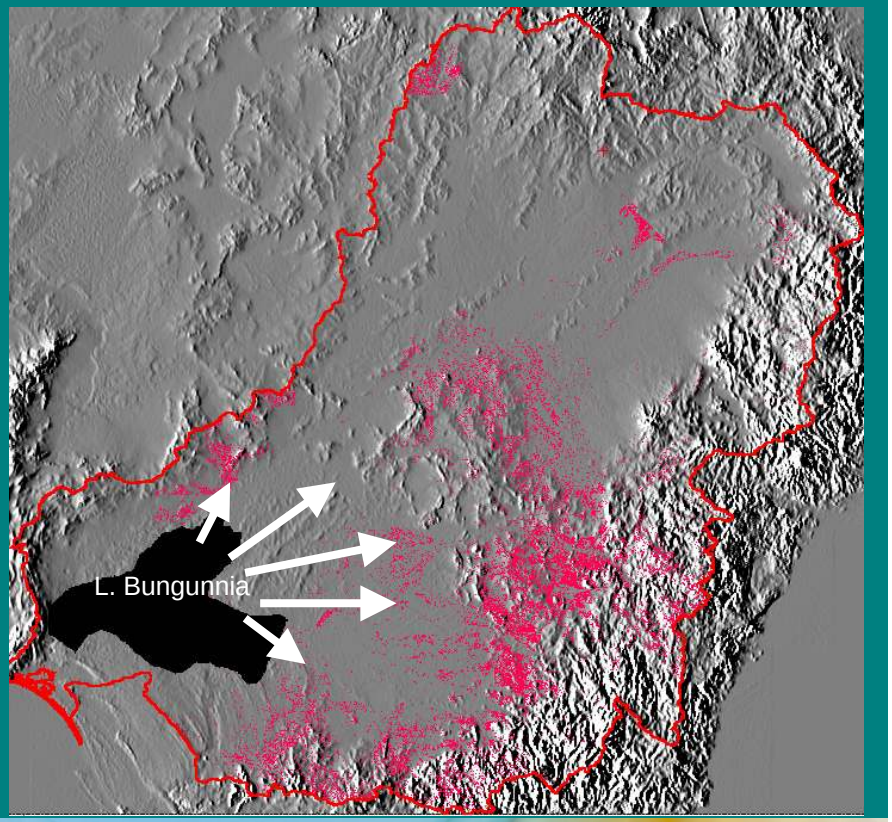


Lake Bungunnia

Brown & Stephenson (1989)

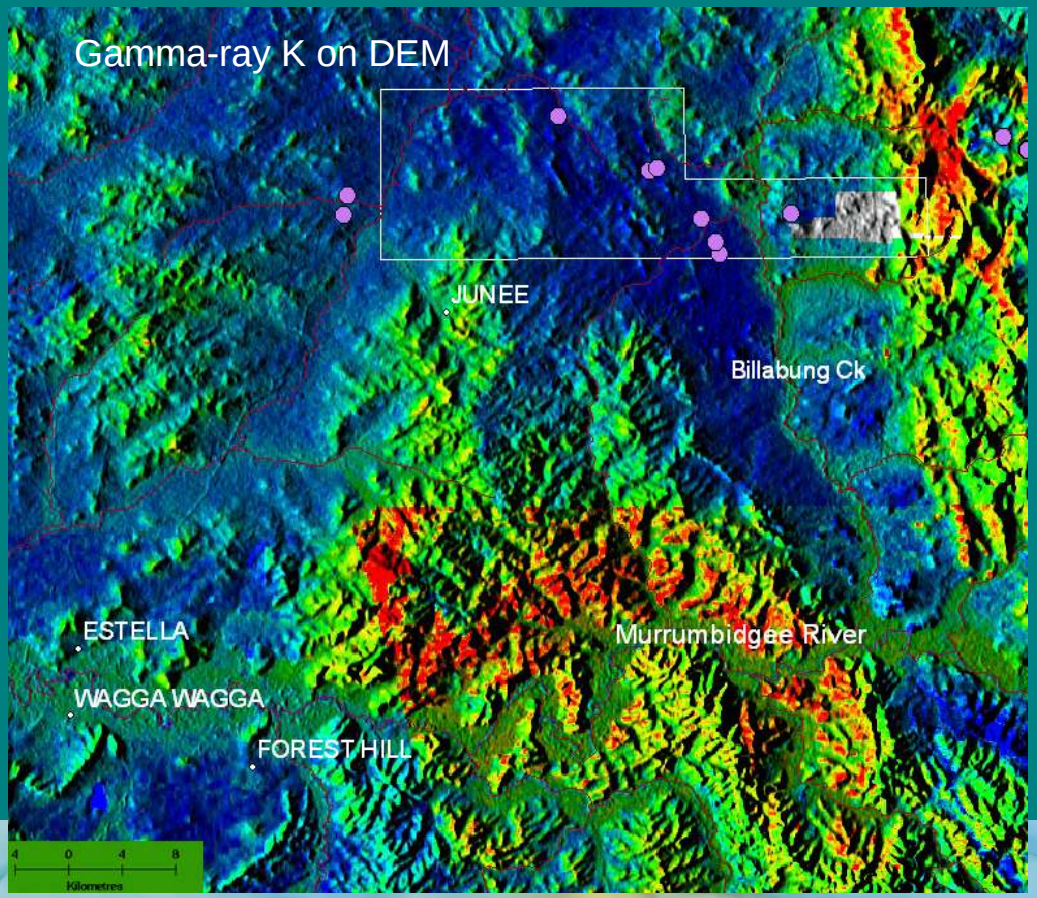


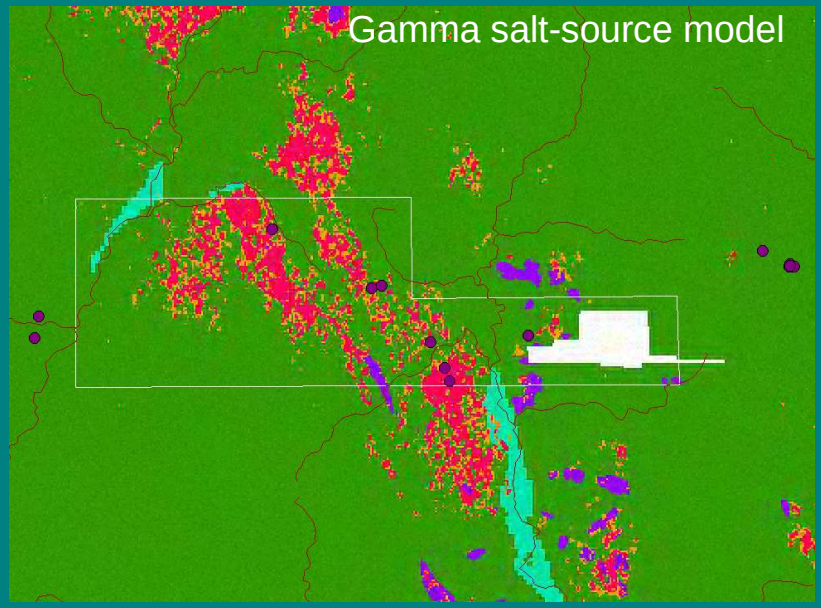
Billabung Ck AEM survey

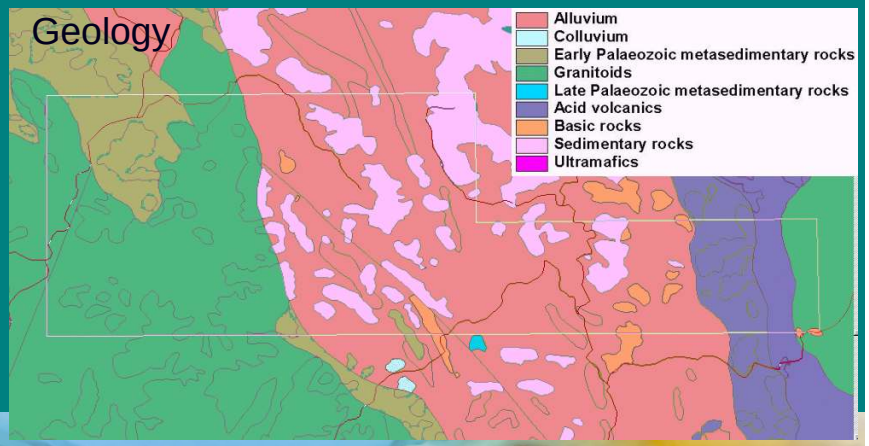


Other evidence – correlations with AEM data (Billabung Ck, NSW)

- area contributing to Murrumbidgee salt loads
- low K, low slope probably residual aeolian (mapped as alluvium)
- aeolian signature transgresses lithology
- GRS model defines salt-sources
- comparison with AEM?

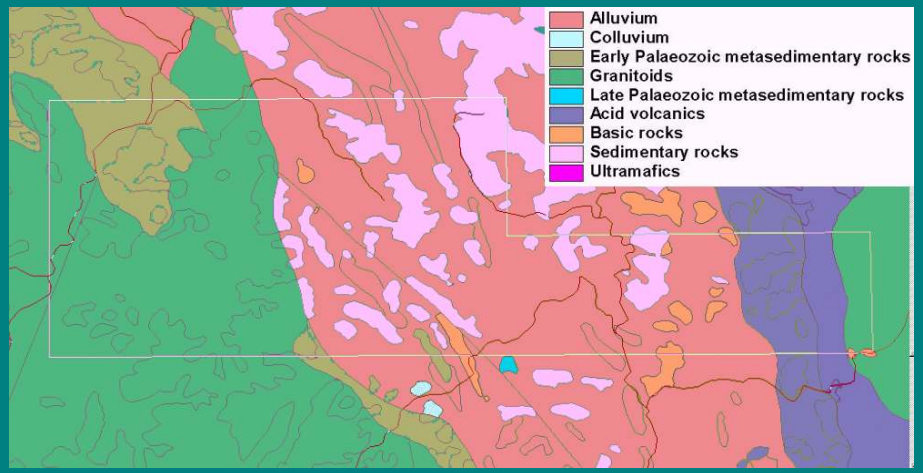


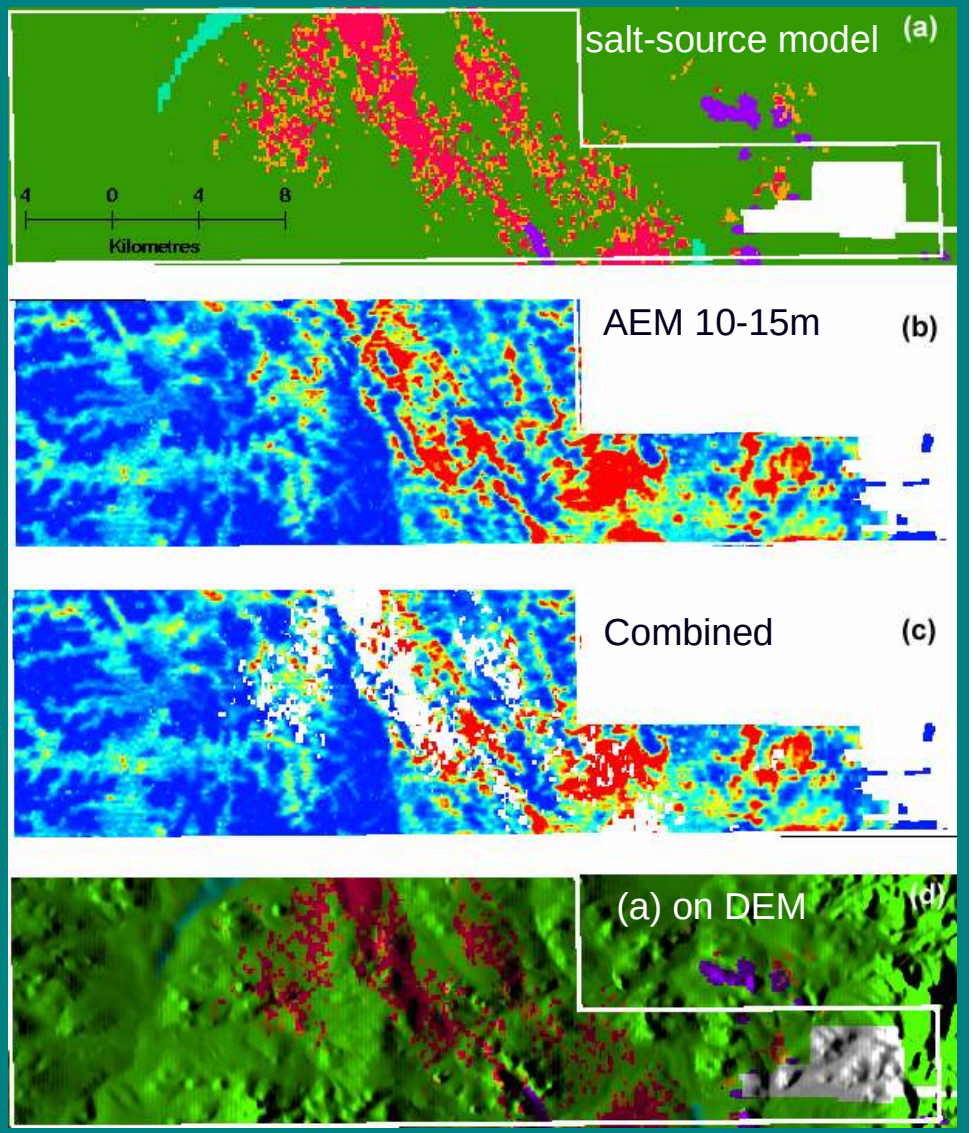




Other evidence – correlations with AEM data (Billabung Ck, NSW)

- (c) shows close match between (a) and (b) gamma-radiometrics model versus near-surface AEM layers
- deeper AEM shows salt dispersal (not shown)
- gamma model splits AEM into sources and accumulations rather than salt “stores”
- aeolian materials relate to low slope residual landscapes





Conclusions

- lines of evidence suggests GRS salt source model may be valid
- a regional tool for identifying upland salt source materials, i.e. regions for focussed management
- GRS data available and inexpensive

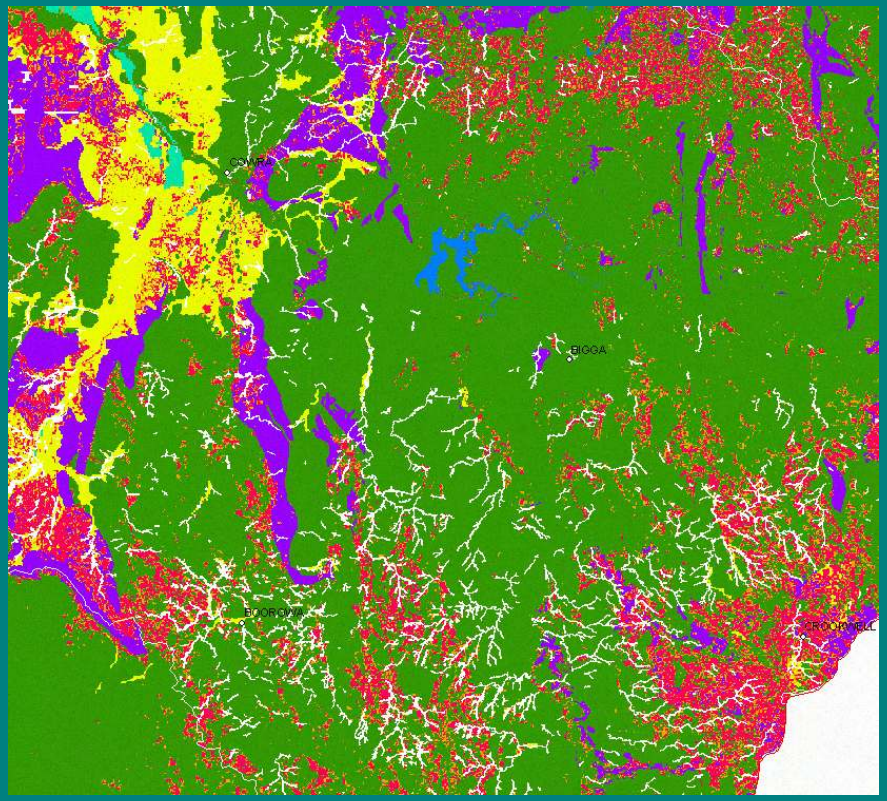


Figure: Salt scald mapping (white), Central West,NSW over salt-source model

Further work:

- calibration of airborne data sets involving ground measurements
- analysis of available ground truth data, e.g. stream salinity, drilling, soils data
- modelling potential geology-related false inclusions
- data fusion - incorporating GRS with AEM data for analysis of salt sources, stores and pathways in the landscape for more effective salinity management