Environmental Research &
Information Consortium Pty Ltd
(ABN) ACN (81) 055 194 771
Ph 02 4842 8182
Ph 02 6161 3716
Fax 02 4842 8183
info@eric.com.au
www.eric.com.au

General & Technical Comments of the 2004 Release:

Technical Report on Salinity Mapping Methods in the Australian Context by Brian Spies and Peter Woodgate

Brian Tunstall
June 2004

Introduction

General comments on the first section of the Spies Woodgate Report (the Report) are given first followed by a summary of errors of fact and logic. This relates to the 2004 release of the report.

Companies are named in the Report where they provide data and instruments but not where they provide services. Industry service providers are identified generically as vendors but the companies associated with specific comments in the Report are readily recognisable by the service being addressed. All comments on industry services using radiometrics to map salinity relate to ERIC. The ERIC product addressed is the SoilSelect (previously referred to as SoilMap) method for mapping soil properties including salinity using airborne radiometrics. The development of SoilSelect addressed in the Report is the SalinityMap method for directly mapping surficial salinity.

Overview

The Report addresses all issues considered important for salinity by the authors and their collaborators and discusses methods for obtaining relevant information. The key elements of the Report are:

1. The Report is positive to all methods for obtaining information on salinity except those submitted by commercial vendors, the SoilSelect and SalinityMap technologies of ERIC and the multi-band radar by GecOz.
2. Some of the measurement methods presented only provide point information and, in the absence of any discussion of methods for spatial extrapolation or interpolation, do not constitute mapping. Further information is needed before their value in salinity mapping can be assessed.
3. There is no structured analysis of the relative benefits of different methods despite the provision of information advising others how to do it. The Report represents an issues paper rather than an evaluation of the applicability of methods in addressing dryland salinity.

Despite the lack of a structured analysis of benefits it is concluded that the key requirement is for methods for managing salinity more strategically that relate to quantifying subsoil salt stores and the possibility of their being mobilised. This conclusion arises, at least in part, from the earlier suggestion in the executive summary that salt levels in the root zone are well known and there are many applicable methods for addressing this requirement.

The reasons why observations on subsurface salt stores would be more strategic than those in the root zone is unclear other than the difficulty of identifying tangible practical benefits from such subsurface observations. The June 2004 report on dryland salinity by the House of Representatives Scientific Committee, for example, provides a quote from Baden Williams that no airborne electro-magnetics (AEM) information has ever provided benefits to Landcare groups. As the report identifies dryland salinity as being associated with impacts to plants, any response based on a strategy of addressing subsoil salt stores must fail.

A number of measures are identified that provide information on subsurface conditions but it is concluded that only electro-magnetics (EM) provide the information on the level of salt store needed to identify the salinity hazard. Near surface and deep subsurface AEM measurements are promoted as being most applicable based on the assertion that the mapping requirement relates solely to quantifying the level of salt stores. While the depth of the required observations was not defined the promotion of AEM means that the salinity information starts at the 10m depth and can extend to around 150m.

The conclusion in the executive summary that surface conditions are well known is contrary to the experience, concerns and priorities of landholders and other community stakeholders. The conclusion has no factual basis. Given the absence of any analysis in the Report that evaluates the relative significance and usefulness of information in and below the root zone one is left to question how and why it is concluded that the prime requirement is to map salt stores well below the root zone.

Context

Development in science is based on logical analysis with technology being a product or outcome of scientific development. There is a need to clearly discriminate between the capabilities of technologies and the 'science' when addressing issues such as dryland salinity.

The need for discrimination between science and technology becomes most apparent when evaluating benefits. Technology characteristically delivers a product that is meant to provide benefits. The cost benefits of competing technologies can therefore readily be evaluated provided the requirement or desired outcome has been clearly defined. The benefits of research developments are usually uncertain because research involves the development of new capabilities and the potential cannot be fully evaluated until the capability exists.

The role of science in a technical evaluation arises because definition of the requirement depends on a clear understanding of how the system constraints affect the achievement of desired outcomes. The evaluation of technologies depends strongly on the detail and reliability of knowledge of how the system functions. The knowledge framework is used to identify how best to achieve community objectives and hence the relative merits of different technologies.

Some scientific considerations are addressed below to illustrate deficiencies in the knowledge framework that effectively negate the assessments in the Report.

Technical Scientific Considerations

'Evaluations' of methods in the Report are based on the assumption that the requirement is to map the salt store. That is, salinity hazard is considered to be directly related to amount of salt in the system. This raises two issues, one is whether the salt store is the sole or best measure of salinity hazard or risk and to what depth should it be measured. As the depth of measurement of the salt stores has not been defined the boundary conditions are unconstrained and there is no unique solution.

The authors assertion that salinity hazard equates directly with the level of the salt store provides the justification for their saying that AEM provides the only appropriate regional mapping method. This is despite them noting that the occurrence of adverse salinity impacts depends on the composition as well as level of salt: adverse impacts can occur at low salt levels. The solution they give arises through a definition based around the capabilities of an instrument and an assertion that surficial conditions are well known.

This use of definition to 'resolve' a salinity problem is not unique to the Report. Rising groundwater was initially given as an explanation for the cause of dryland salinity but is now considered by some as being synonymous with dryland salinity. Rising groundwater is now being used to define what dryland salinity is, hence for some, any adverse salinity not associated with rising groundwater is not dryland salinity. The circularity in the argument used to evolve this suggestion is of evidence of a high level of confusion.

On page 12 the Report states that '*It is worth noting that dryland salinity is a problem associated with increased water supply in salty landscapes.'* but the Report also discriminates between primary and secondary salinity. Primary salinity is natural and secondary salinity is land use induced. However, for the landscape to initially be salty there must be primary salinity, hence the landscape must have been subject to dryland salinity. This comment is therefore illogical except where dryland salinity is defined as only arising through the impacts of human land use when all dryland salinity becomes secondary by definition. There cannot be primary dryland salinity for this statement to be rational.

There is also an issue with the reference to *increased water supply* in relation to dryland agriculture. Water supply represents an input and dryland agricultural management does not change the water inputs. Water inputs could increase through a change in climate but the indications are that over the last 50 years the rainfall may have decreased in areas most affected by adverse salinity.

Similar illogicality occurs in identifying whether EM provides a direct or indirect measure of salinity. On Page 9, soil electrical conductivity (EC) is identified as being an indirect measure of salinity but on Page 21 EM, which only gives ECa (an apparent rather than true electrical conductivity), is given as a direct measure. Moreover, identical EM measures are given as being both direct and indirect when this is logically impossible.

Such illogicalities arise in part from the attempt to define salinity as being a single factor that directly relates to a single physical measure. The issues of concern with dryland salinity arise through loss of agricultural production and changes to natural systems in the composition of plants and animals. Salinity can affect these in a variety of ways. Some are direct, as in toxicity and osmotic reduction in water availability, while others are indirect as with changes to soil structure and health.

Toxicity effects can arise through the relative composition of salts as well as the overall level of salts. The broad osmotic effects depend on the level and composition of salts but with a strong interaction with climate. Effects on soil structure depend on the characteristics of the soil as well as the levels and composition of salts. Soils having low levels of total soluble salts but high sodium absorption ratios can be strongly adversely affected by salinity, as with the Braidwood Granites. From our knowledge of the mechanisms whereby salinity produces adverse impacts a measure of the level of salt store alone cannot reliably identify the hazard of dryland salinity.

Dryland salinity is not a single factor and hence cannot be characterised using a single measure. Moreover, no physical measurement need directly quantify the impact of any aspect of dryland salinity where dryland salinity is defined in terms of effects on plants or agricultural production. The biological aspects can preclude any simple direct connection between the system response and a single physical measure. This complexity of response is illustrated by the comment in the Report that many collaborators identified the need for a range of approaches and measurements.

The Report expends considerable effort in defining hazard and risk but in identifying the **level** of salt store as a measure of salinity hazard it breaches the definitions. Hazard is categorical in that it exists as a hazard or it does not (a binary condition of yes or no)[1]. Accumulations of salt exist in most arid and semi-arid areas of Australia hence it is axiomatic that these areas have a salinity hazard. Mapping the occurrence of a salinity hazard can be a trivial exercise[2] and the key issue relates to the assessment of risk. What is the likelihood of salinity affecting a desired outcome, and what are the magnitudes of impact by way of biophysical change and public perceptions?

Risk assessment is highly case specific. For example, while the number of days below zero provides a good measure of the incidence of frost the potential for damage to crops depends on their being at a vulnerable stage of development when a frost occurs. Predicting frost risk, which is done for crop selection and insurance purposes, should take account of the crop type and variety and its date of planting as well as the expected seasonal conditions.

Risk assessment for salinity is more complex and difficult than, for example frost, because of the spatial heterogeneity of soils and the number of factors affecting the outcome. While the physical factor of consequence for frost is temperature the risk for salinity depends on the composition as well as levels of salts and their effect on the soil as well as plants. Moreover, while temporal patterns of ambient temperature can be reasonably predicted for use in predicting frost risk the ability to predict future changes to soil salinity is very limited.

While salinity risk can be difficult to determine it is apparent that most salinity risk is associated with changes to the surface metre of soil. It is therefore difficult to comprehend how the authors conclude that the strategic need relates to mapping subsurface salt stores and hence how their conclusions have any relevance in addressing dryland salinity.

Comprehensiveness

The Report apparently covers all the methods known by and raised with the authors but is still not fully comprehensive. For example, thermal imagery is not

---

[1] There is a large diversity of opinion as to what constitutes hazard and risk that is difficult to resolve because of the development of circular arguments. The risk derives from the hazard hence they are not independent. The only clear distinction is that a hazard identifies the existence of a potential for adverse impacts due to some factor while the risk evaluates the significance of the identified hazard for defined circumstances.

[2] As the assessment of hazard depends on the land use as well as the occurrence of salt there need be no single or unique answer. Land use has generally taken natural occurrences of salinity into account hence while salt exists it does not represent a hazard to the existing land use. However, the salinity could represent a hazard if an alternate land use was considered. There is a need to clearly define the boundary conditions.

considered when the information provided by night time thermal imagery is relevant and very different from that identified in the Report for other forms of imagery. Also, it is identified that the binding of ions to clays can affect the measured levels of EC in relation to the total amount of salt present but it does not address the analogous effect of water being bound to clay. Binding of water has a reverse and potentially greater effect on soil salinity than the binding of ions.

Consequences

Use and application of the Report by consumers essentially relates to the summary information given in section 5.8 starting on Page 32. The applicability of this assessment is very limited as it is based on defining salinity hazard as being the level of salt store[3] to an undefined depth. The applicability of methods has been assessed against a single and inappropriate criterion.

The depth categories used in the evaluation do not relate well to the depth that is of most consequence to plants and hence dryland salinity. The rooting zone is defined as extending to 2m when the depths used for calculating the effective soil water storage for plants are typically around 0.6m and rarely as deep as 1m. Moreover, if the rising groundwater model is considered to be generally applicable to dryland salinity, as in the Report, then the critical depth to the water table is nominally given as being 1m. The maximum depth that should be used for the rooting zone should be 1m.

Another technical deficiency that greatly limits application of the summary information in section 5.8 is the failure to differentiate between the depth for generation of the measured signal and the depth for which the measurement provides useful information. The evaluation in the Report is based on the depth for signal generation rather than for the derived information when it is the latter that is of consequence for application. As these two depths can vary greatly the evaluation is highly misleading.

Aerial photography can be used to map lineaments for mineral exploration because the existence of subsurface structures is apparent in the surface measurement. There can be surface expressions of subsurface structures that can be detected with radiometrics and most forms of optical and radar imagery. As such structures influence patterns of subsurface water flow the information can be useful in addressing dryland salinity. Nighttime thermal imagery, not mentioned in the Report, has considerable potential because many patterns reflect variations in soil moisture and can identify preferred pathways for water flow. Radiometrics can readily provide the same form of information but with lower spatial resolution.

Radiometrics are said to be relevant to the top tens of centimeters only when interpretation of radiometric data depends on knowledge of the characteristics of the entire soil profile. While most of the signal generally derives from the surface 30cm[4] the spectral characteristics of the measured signal depend on the characteristics of the underlying subsoil. The signal generated in the surface 30cm contains information on sub-surface conditions. It is this interaction between the surface and sub-surface conditions in generating the signal that makes the radiometrics particularly

[3] While there is also an assessment of applicability to risk it derives from an assessment of hazard that has very limited applicability.

[4] The depth of the radiometric measurement has been presented in the report so as to provide a minimal value, ‘a few tens of centimeters’. Generation of the radiometric signal effectively declines exponentially with depth so that while around 70% of the signal generally derives from the surface 30 cm much of the signal usually derives from greater depths, up to around 1m.

applicable for mapping soil properties, salinity included.

This minimising of the depth of observation for radiometrics in the Report contrasts with the maximizing for AEM and magnetics. The table identifies magnetics as covering the range from the surface through bedrock when in practice the signal is dominated by deep geological formations. Magnetics contain no information from the surface and usually none from the root zone unless it represents an extension of a deeper structure. The table identifies multi-frequency AEM as providing information on the root zone (surface 2m) when the detail in the text correctly identifies that the shallowest depth for useful information is 5 to 10m with the greater depth being most realistic.

The Report also contains misconceptions and misrepresentations in addressing horizontal scales. It refers to a catchment scale when catchments can be any size and so do not have a defined or set scale. It is claimed that airborne radiometrics cannot be used for regional mapping and that the CSIRO multi-frequency AEM can when the radiometrics have been successfully applied over much larger areas than the multi-frequency AEM.

The above identifies situations where the scale of the observation and applicability of results claimed in the Report will seriously mislead consumers. It addresses some key circumstances but it is not comprehensive.

Probity

The Report is positive to all methods bar two submitted by commercial 'vendors' and were particularly negative to methods that were largely developed by me. One of these methods was deemed to be applicable for mapping soils (SoilSelect) but not to provide much useful information on salinity. This is despite the method mapping soil properties, of which salinity is one, and it having been successfully applied to salinity and soil mapping in regional as well as local (individual landholdings) studies. Comments on the other method (the very new SalinityMap) were variously in the form '*Claims about its ability to directly map near surface salinity do not have scientific foundation*.' but the authors may also consider that this comment is applicable to SoilSelect.

The comment on the limited applicability of SoilSelect results is a direct consequence of defining salinity hazard as the level of salt store (to an undefined depth but by inference greater than their 2m rooting depth) and the failure to discriminate between the mapping of soil types / soil landscapes and soil properties. The comment arises in part by the use of a definition of the requirement for salinity mapping that is adverse to the use of radiometrics and highly beneficial in promoting the use of EM and partly from a misrepresentation of the nature of the SoilSelect results. It is compounded by the unsubstantiated and incorrect statement that radiometrics cannot be used for regional mapping.

In addressing dryland salinity the soil property information from SoilSelect does provide information on the distribution of salt and therefore the salinity hazard. However, it provides additional benefits as it aids in developing understanding of system constraints and provides information needed for remediation and land management generally. The information provided by SoilSelect addresses a range of requirements and costs are much less than with the advocated multi-frequency AEM. It is therefore highly cost effective, particularly when applied to regions. Its rejection in the Report removes the main competition for the AEM mapping provided commercially by CSIRO.

The adverse comments in the Report on the SalinityMap method derive from unpublished reviews conducted by those that cannot achieve such results (either SoilSelect or SalinityMap) and the comments were taken as being correct by the authors without allowing for a right of reply. The adverse comments derive from the simplistic application of technology (a model) and can readily be dismissed through application of the scientific method. The significance of this rejection of the SalinityMap method, apart from the commercial implications, is that it effectively blocks funding for the research needed to determine how the results come about and the nature of information they provide on system function. It therefore blocks the developments required for innovation. As the SalinityMap results appear to identify surficial pathways for water movement that are important for virtually all aspects of land use and management the actions of the authors are detrimental to the commercial and environmental interests of Australia.

The denigration and rejection of a method without providing a right of reply breaches normal community and scientific standards, particularly where there are financial implications. The significance of this exclusion is greatly exacerbated by the promotion of a competing method used commercially by the organisation that employs one of the authors. The Report promotes the method provided commercially by the organisation employing one of the authors while excluding the main competition through misrepresentations and presentation of illogical and incorrect information. This abuse of position continues with the suggestion that proposals for salinity mapping work by vendors (industry) should be vetted by public organisations such as CSIRO when public organisations currently dominate in the provision of such services.

Conclusions

Overall, the errors of fact and logic and misrepresentations result in the Report misleading the consumers it is meant to inform. Application of the information and conclusions in the Report will increase costs and degrade outcomes: the result will be the reverse of what of what was intended and is being promoted.

Summary of Errors of Fact and Logic in the 2004 Report

Logical Errors

These are sequenced with the most important first. The first and second points identify a lack of understanding of dryland salinity which is critical given that dryland salinity is the focus of the report.

The bold headings identify issues or points made in the Report. Extracts from the Report are in italics.

Cause of dryland salinity

> *It is worth noting that dryland salinity is a problem associated with increased water supply in salty landscapes.*

This situation is common in Australian irrigation areas. However, water supply represents an input and, while dryland agriculture can change the partitioning of water between different components in the hydrological water balance, by definition it cannot change the inputs. Dryland salinity logically cannot arise in this way.

Conclusions in the Report are based on the assumption that the 'rising groundwater model' is completely general. It is not[5] and this invalidates many conclusions.

The level of salt store is the required measure of dryland salinity

The impact of salt on soils and plants depends on the composition as well as level of salts. The level of salt store is therefore not a reliable measure of the impact of dryland salinity. Moreover, this claim is made without any identification of the boundary conclusions. With this assertion deep salt has the same significance as salt in the surface soil which is grossly incorrect.

The false assertion that the level of salt store is the required measure of dryland salinity, the lack of definition of boundary conditions, and the application of the rising groundwater model, combine to form the basis for the conclusion that airborne EM has strategic value in addressing dryland salinity. The conclusions on airborne EM are based on an ill defined and incorrect model and so are without rational foundation. Moreover, they do not accord with experience in using airborne EM to address dryland salinity illustrated by the quote from by Baden Williams[6] that airborne EM has never provided benefit to Landcare groups.

EM is both a direct and indirect measure of salinity

This is logically impossible.

A skilled interpreter will combine as many different types of measurement as possible when producing an interpretation

A number of the methods promoted in the Report, such as Soil Landscape Mapping, use subjective interpretation of a variety of data to map patterns thought to be relevant to the product of interest. Field sampling is then used to determine the attributes such as soils associated with the mapped patterns. Soil Landscape Mapping invariably uses elevation, land cover (optical imagery) and geology to produce the reference map where land cover contains information on vegetation and land use.

---

[5] Addressed in the paper What model for dryland salinity? available on www.eric.com.au.

[6] In the House of Representatives Standing Committee on Science and Innovation report entitled Science overcoming salinity: Coordinating and extending the science to address the nation's salinity problem (available on http://www.aph.gov.au/house/committee/scin/salinity/report.htm).

With this approach the soil map is not derived independently of information on terrain, vegetation and geology. The MAPPED soils information therefore cannot be used to examine the relationship between soils and these factors as the relationships arise through definition. Moreover, the soil information should not be used in a subsequent analysis with information on these factors to produce a product such as a salinity hazard map.

Mathematical modeling can produce any desired result with a maximum of 8 variables. Some of the proposed methods use many more variables and additionally incorporate factors derived through subjective interpretation. This results in a highly confounded situation where 'an experienced interpreter' can produce any desired result. The interpretation is simply adjusted to produce the result desired for any situation. Such results do not have a foundation in science and simply reflect the subjective perceptions of the interpreter.

Many of the proposed methods breach one of the most fundamental requirements in science, the need for independence in the derivation of observations used in an analysis.

Electrical Conductivity (EC) is an indirect measure of soil salinity

The EC measure responds to ions in solution so that, provided the salts dissolve, it is a direct measure of salinity. However, the response depends on the nature of the ions and is non-linear. Conversion from EC to Total Dissolved Salts (TDS) requires knowledge of the composition of the salts.

The 1:5 soil:water suspension is designed to measure all salt with little influence of other characteristics of the soil. The saturation paste measure of EC is said to relate better to the effect of salinity on plants. It is not a reliable measure of soil salinity, rather, it is an indicator of how some believe salinity affects something of interest, namely plants.

There is currently no measure of soil salinity that goes close to identifying the way in which soil salt affects plants because of the scale of measurement. Existing measures provide an average measure for a large sample and effectively treat the soil as a homogeneous porous medium. However, results published in 1973[7] illustrate that the water draining through soils has lower salinity than the bulk of the soil. Water drains through preferred pathways such as cracks that are exploited by plant roots hence the salinity experienced by plants can be considerably lower than for the bulk of the soil. However, the situation changes as the soil dries and there is currently no knowledge of the realised temporal changes.

The effect of salt on soils and plants depends on the composition as well as level of salts. For soils the Sodium Absorption Ratio (SAR) is of particular consequence as it determines whether clays aggregate or flocculate. However, as the salinity becomes very high clays flocculate regardless of the salt composition. The salt composition also directly affects plant performance.

Soil salinity is meant to be an independent measure as this then allows evaluation of how other factors respond as soil salinity changes. For plants and for soils any such evaluation depends on the composition as well as level of salts. There is therefore NO single measure of soil salinity that can be used to characterise its impact.

[7] Peck, A. J. (1973). Chloride balance of some farmed and forested catchments in southwestern Australia. Water Resour. Res. 9: 648,57

There are different levels of salinity hazard

The detailed examination of the nature of hazard and risk in the Report implicitly identifies hazard as being categorical. It exists or it does not for a particular attribute, such as for salinity, frost or flood, but does not have a level. Risk addresses level but can only be assessed for very well defined circumstances. Hazard identifies that a potential exists while risk identifies the level of that potential for particular circumstances. Despite this the Report identifies different levels of hazard.

The rationale for the assessment of the level of hazard in the Report is undefined and obscure hence the assessment has limited value. As risk was determined from the hazard this negates the assessment of risk, quite apart from the consideration that the specific circumstances required for the risk assessments are not defined.

There can be primary and secondary dryland salinity

The term dryland salinity was originally used to differentiate it from salinity associated with irrigated agriculture and now also from urban salinity. As irrigated agriculture and urban development are land uses, dryland salinity logically arises through the impact of dryland agriculture. If dryland salinity is associated with dryland agriculture by definition there cannot be primary dryland salinity. If it is not associated with dryland agriculture then it is no different to natural salinity hence the term is redundant.

Errors of Fact and Misrepresentations

EM directly measures the level of the salt store

This is inconsistent with the position in the report that EC is an indirect measure of soil salinity. The EM measurement reflects electrical properties additional to conductivity and it responds to a number of soil factors. Empirical correlation is needed to convert the apparent conductivities (ECa) provided by EM into measures of soil salt levels. These correlations are site specific.

Airborne EM can provide information on the root zone through to bedrock

The shallowest depth given for extraction of information from airborne EM identified in the Report is 5 m which is well below the root zone.

Magnetics can provide information on the surface through to bedrock.

The value of magnetics lies in addressing deep subsurface structure and there is effectively no chance of it providing information on the surface. The chance of magnetics providing information on the surface 2m is slight unless the feature represents an extension of a deeper structure. If magnetics provided the suggested information on surficial conditions there would be no need to use EM.

Radiometrics only address the surface tens of centimeters

Most of the depth evaluations in the Report address the depth for the generation of the signal. Others identify that information can be derived from depths that do not contribute to the signal, and these are referred to as indirect. However, the evaluations do not identify that while some depths contribute to a measured signal their effect on that signal cannot be evaluated.

A more accurate explanation of the radiometric measurement is that, in a homogeneous medium, the signal generation declines exponentially with depth. The contributing depth varies with the density of the material but for soils it is generally stated that around 70% of the signal derives from the surface 30 cm.

The practical situation is that interpretation of the radiometric patterns requires examination of the subsoil as well as the surface soil with the importance of each being statistically equivalent. The radiometrics provide information on the zone most important in the plant and soil water relations where this is the prime determinant of changes that produce adverse dryland salinity.

Identification of the root zone as being 2 m deep is inappropriate as the depth of soil profiles in systems subject to dryland salinity is generally less than 1 m. As the depth of the soil profile reflects the plant and soil water relations this is the deepest indicator of rooting depth for the purpose of addressing dryland salinity. However, the plant rooting depth assumed when calculating the Available Soil Water Storage Capacity (AWHC) is generally appreciably less than the profile depth.

Radiometrics are not applicable in depositional (sedimentary) areas

The basis given for this assertion relates to signal to noise which reflects assumptions used in the traditional use of radiometrics to address geology. It is assumed that all the information derives from the K, U and Th bands and that the requirement is to distinguish minerals by their composition of these elements. The comment is based on the belief that the signal to noise is only adequate for this purpose in erosional areas.

The Total Count band, which covers the full energy spectrum and encompasses bands for K, U and TH, contains information not contained in the other bands and has a much better signal to noise ratio. A failure to use the TC band in the analysis greatly reduces the resolution that is achieved and this is compounded by basing the analysis solely on the spectral characteristics of the data. The failure of those from a geological background to use TC apparently reflects the belief that absolute count rates must be related to mineral compositions for the mapping to be useful and their analysis of the data as an unrelated set of point observations rather than as the spatially related data that they are.

The radiometric signal reflects parent material and weathering in all situations and hence can be used to map patterns of soils in depositional areas. While soils in depositional areas can comprise a mixture of parent materials these differences can be mapped by the radiometrics and are generally associated with differences in soil properties.

Provided the analytical methods achieve good resolution the practical difference between erosional and depositional areas relates to the homogeneity of parent material. As two factors primarily determine the radiometric signal, parent material and weathering, a given radiometric signal can arise for different reasons. Such ambiguity can be readily resolved when the patterns of parent material are known. It is more difficult to resolve where the soils derive from varying mixtures of parent material but the resolution can be enhanced by limiting the area encompassed by the analysis.

Soil mapping results using radiometrics only have local validity

This links with the above point and relates to the radiometric signal responding to two main factors. Reliable regional mapping depends on application of a methodology that allows separation of the effects of parent material and weathering. This is straight forward in areas where the patterns of parent material are clearly defined (identified as erosional areas in the Report) but requires more effort in depositional areas. However, the separation can be achieved and this allows the production of reliable regional results.

The simple methods currently used in geological applications do not address the issues identified above and are generally unreliable for regional mapping. This assertion is based on such results and hence reflects the limited abilities of some scientists rather than identified what can be achieved.

Salinity mapping using radiometrics is VERY indirect

The SalinityMap signature excepted, the relationship between salinity and the radiometric patterns is indirect. However, the comment applies more to all of the other mapping methods other than EM and radar. The issue is why this comment was only applied to radiometrics as it makes the presentation of information highly inconsistent between methods.

Vegetation, Soils, Land Use and Cadastre are identified as mapping techniques.

Most of the ‘techniques’ identified in the table represent the data used to derive maps of attributes such as soils and vegetation. Vegetation, Soils, Land Use and Cadastre are products derived from reference data rather than techniques used for mapping salinity.

The deleterious effect of high salinity mostly relates to the associated osmotic potential

The main effect is indirect in reducing the permeability of the soil to water and air. With direct effects it would be difficult to differentiate between the significance of osmotic and toxicity (specific ion effects) as it varies with plant species and the composition as well as level of salts.