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Y06/103

Dr Tom Parry
Commissioner
Natural Resources Commission
GPO Box 4206
SYDNEY NSW 2001

31 JAN 2006

Dear Dr Parry

I refer to my previous letter of 17 November 2005 seeking advice on an amendment to the Environment Outcomes Assessment Methodology that had been proposed by the Department of Natural Resources. The proposed amendments recommended by my Department consisted of a number of changes to Chapter 4, which deals with salinity assessment.

I understand that the Natural Resources Commission has raised a number of issues concerning the proposal. Following discussions with the Commission, the Department of Natural Resources has provided me with a revised chapter (Attachment A) for the Environment Outcomes Assessment Methodology (EOAM) and further information (Attachment B) in the form of a discussion paper regarding the "fit for purpose" of the Salt Store map.

The approval of the new 9 class salt store map will also improve the Land and Soil Capability Tool. Editorial changes are also required in the related table contained in Appendix B of the EOAM (See also Attachment A).

As such, I would request that the Commission consider this revised chapter, and disregard that attached to my earlier correspondence.

In accordance with clause 25(1)(c) of the *Native Vegetation Regulation 2005*, I seek your advice in the form of a formal recommendation to me. I would be grateful if you could provide your advice as soon as possible.

Thank you for your assistance in this matter.

Yours sincerely

IAN MACDONALD MLC

Tag B
4 Salinity Assessment

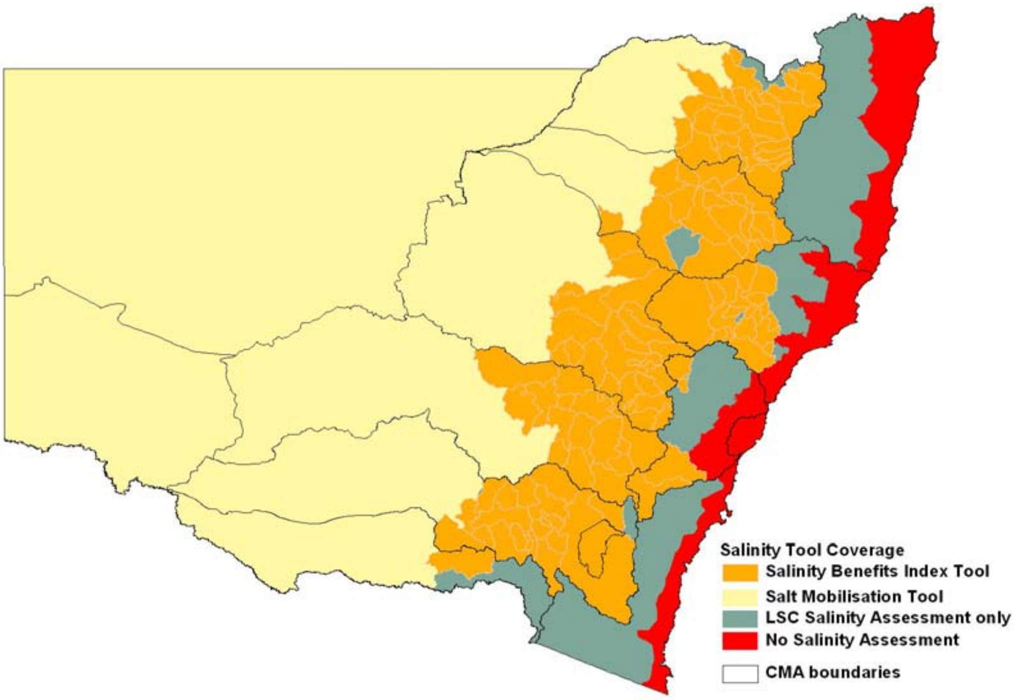
4.1 Introduction

This Environmental Outcomes Assessment Methodology defines the circumstances in which broadscale clearing is to be regarded as improving or maintaining environmental outcomes for salinity under the *Native Vegetation Act 2003* including for the purposes of agreeing to a Property Vegetation Plan.

The assessment of the impacts of clearing on salinity, and the calculation of offsets, varies with location in NSW of the proposal:

- in upland areas of the Murray-Darling Basin, most of the Hunter catchment and a few coastal catchments, where dryland salinity has been identified as a significant hazard, the procedure involves calculating a Salinity Benefits Index, which is a measure of the change in stream salinity from current levels arising from a change in land cover. Chapter Section 4.4 describes the procedure for applying the improve or maintain test to clearing proposals and evaluating offsets using the Salinity Benefits Index;
- in the western part of NSW, where the geomorphic province is best described as "plains" but can also include some upland areas, the hydrologic processes and connectivity of salt stores with the surface drainage network are not adequately represented by the Salinity Benefits Index modelling approach. Here, the assessment procedure involves calculating a Salt Mobilisation Index which is a measure of the change in salt mobilised following a change in land use or cover (Department Infrastructure Planning and Natural Resources, 2005). Chapter Section 4.5 outlines the procedure for applying the improve or maintain test to clearing proposals in these areas;
- on the coastal slopes and tablelands an assessment of salinity is undertaken using only the Land and Soil Capability Tool (LSC); and
- on the coastal plains, a salinity assessment is not required because the dryland salinity hazard is low.

Figure 4.1 Map showing where each salinity assessment procedure is used



4.2 Assessing salinity hazard

The Land and Soil Capability Tool provides a preliminary assessment of clearing and offset proposals to check whether they are likely to improve or maintain environmental outcomes for dryland salinity.

A salinity hazard assessment is undertaken for all Catchment Hazard Areas where the clearing of native vegetation is proposed, excluding most of the Coastal Plains Catchment Hazard Areas. The one Coastal Plains exception is the Hawkesbury-Nepean Coastal Plain, where a preliminary assessment of salinity hazard is required.

The criteria used by the Land and Soil Capability Tool to assess salinity hazard depend on the Catchment Hazard Area in which the assessment is undertaken and include:

- evidence of salinity outbreaks in the Land and Soil Capability zone;
- evidence of salinity outbreaks down-slope from the Land and Soil Capability zone;
- whether the Land and Soil Capability zone is in a known high salt store area;
- permeability of the soil; and
- condition of existing native vegetation.

The criteria (and relationships between the criteria) used by the Land and Soil Capability Tool to determine the Land and Soil Capability Class are shown in Table 4.1 for all Slopes and Tablelands Catchment Hazard Areas and the Hawkesbury-Nepean Coastal Plain Catchment Hazard Area, and in Table 4.2 for the Inland Plains Catchment Hazard Area.

If a preliminary salinity hazard assessment by the Land and Soil Capability Tool results in Land and Soil Capability Class 3 to 6, in the case of a clearing proposal, or Land and Soil Capability Class 3 to 8 in the case of an offset proposal, then:

- where the Salinity Benefits Index Tool is available for the Catchment Hazard Area, this Tool must be run to determine the salinity offset requirement, if any; or
- where the Salinity Benefits Index Tool is not available for the Catchment Hazard Area, and the Salt Mobilisation Tool is available, then the Salt Mobilisation Tool must be run to determine the salinity offset requirements.

Table 4.1 Criteria for determining Land and Soil Capability Class for Salinity Hazard for all Slopes and Tablelands Catchment Hazard Areas and the Hawkesbury - Nepean Coastal Plains Catchment Hazard Area.

Evidence of salinity outbreaks in the Land and Soil Capability Zone	Evidence of salinity outbreaks downslope from the Land and Soil Capability Zone	Salt Store Class	Land and Soil Capability Class
No salt outbreaks	**No salt outbreaks**	**Very Low; Very Low to Low**	**1**
		Low; Low to Moderate	**2**
		Moderate	**3-6**
		Moderate to High; High	**7**
		High to Very High; Very High	**8**
	Salt outbreaks observed but not extensive and no severe scalding	**Very Low; Very Low to Low; Low; Low to Moderate; Moderate**	**3-6**
		Moderate to High; High	**7**
		High to Very High; Very High	**8**
	Salt outbreaks extensive and severe scalding	**Any**	**7-8**
Salt outbreaks observed but not extensive and no severe scalding	**No salt outbreaks**	**Very Low; Very Low to Low; Low; Low to Moderate; Moderate**	**3-6**
		Moderate to High; High	**7**
		High to Very High; Very High	**8**
	Salt outbreaks observed but not extensive and no severe scalding	**Very Low; Very Low to Low; Low; Low to Moderate; Moderate**	**3-6**
		Moderate to High; High	**7**
		High to Very High; Very High	**8**
	Salt outbreaks extensive and severe scalding	**Not Required**	**7-8**
Salt outbreaks extensive and severe scalding	**Not Required**	**Not Required**	**7-8**

Table 4.2 Criteria for determining Land and Soil Capability Class for Salinity Hazard for the Inland Plains Catchment Hazard Area.

Evidence of salinity outbreaks in the Land and Soil Capability Zone	Salt Store Class	Soil Permeability Class [1]	Low Condition Vegetation [2]	Land and Soil Capability Class
No salt outbreaks	**Very Low; Very Low to Low**	**Low**	**Yes**	**1**
			No	**1**
		Moderate	**Yes**	**1**
			No	**2**
		High	**Yes**	**2**
			No	**3**
	Low; Low to Moderate	**Low**	**Yes**	**1**
			No	**2**
		Moderate	**Yes**	**2**
			No	**3**
		High	**Yes**	**3**
			No	**4**
	Moderate	**Low**	**Yes**	**2**
			No	**3**
		Moderate	**Yes**	**3**
			No	**4**
		High	**Yes**	**4**
			No	**5**
	Moderate to High; High	**Low**	**Yes**	**3**
			No	**4**
		Moderate	**Yes**	**4**
			No	**5**
		High	**Yes**	**5**
			No	**6**
	High to Very High; Very High	**Low**	**Yes**	**4**
			No	**5**
		Moderate	**Yes**	**5**
			No	**6**
		High	**Yes**	**6**
			No	**7**
Salt outbreaks and/or scalding	**Very Low; Very Low to Low**	**Low**	**Yes**	**3**
			No	**3**
		Moderate	**Yes**	**3**
			No	**3**
		High	**Yes**	**3**
			No	**4**
	Low; Low to Moderate	**Low**	**Yes**	**3**
			No	**3**
		Moderate	**Yes**	**3**
			No	**4**
		High	**Yes**	**4**
			No	**4**
	Moderate	**Low**	**Yes**	**3**
			No	**4**
		Moderate	**Yes**	**4**
			No	**4**
		High	**Yes**	**4**
			No	**5**
	Moderate to High; High	**Low**	**Yes**	**4**
			No	**4**
		Moderate	**Yes**	**4**
			No	**5**
		High	**Yes**	**5**
			No	**6**
	High to Very High; Very High	**Low**	**Yes**	**4**
			No	**5**
		Moderate	**Yes**	**5**
			No	**6**
		High	**Yes**	**6**
			No	**7**

[1] **Defined in Section 4.5.4**
[2] **Defined in Section 4.3.7**

4.3 Definitions

4.3.1 Streamflow

Streamflow is the total volume of water in a stream channel, for a specified time. It is measured at gauging stations and therefore is only known for discrete locations. In this model, streamflow (expressed in megalitres/year) is reported as an average annual value for the period 1975-2000.

Streamflow is separated into two flow components: quickflow and baseflow:

- Quickflow is the component of streamflow that is generated quickly during a rainfall event. It is sourced from surface runoff and lateral shallow subsurface runoff (i.e. pathways of water movement that are at or close to the ground surface). Quickflow is assumed to be a function of rainfall, soil, topography and land use.
- Baseflow is the component of streamflow that travels more slowly from the catchment to the stream and tends to sustain flow in a channel between rainfall events. It is sourced from rainfall that has infiltrated deep into the soil profile to recharge groundwater. This pathway of flow is typically slower than surface runoff pathways. Baseflow is assumed to be a function of rainfall, soil and land use.

4.3.2 Recharge

Recharge refers to the component of rainfall that infiltrates (percolates) down through the soil, beyond the root zone of the vegetation cover and into the groundwater aquifer. Rates of recharge tend to be slow. Where recharge water is discharged from a groundwater aquifer into a stream, it contributes to baseflow.

4.3.3 Surface Runoff

We use the term surface runoff to refer to the component of rainfall that flows at or relatively close to the ground surface and which, when it reaches a stream channel, contributes to the quickflow component of streamflow. It includes flow across the land surface and lateral shallow subsurface flow.

4.3.4 Salt Load

Salt load is the quantity of salt carried by a stream, over a specified time. It is a function of the salinity of streamflow and the volume of streamflow:

Salt Load (M) = Streamflow (V) * Salinity (M/V)

4.3.5 Stream Salinity

Stream salinity is the concentration of salt in a volume of water – in other words, the mass of salt per unit volume of water:

$$Salinity = \frac{Salt(M)}{Water(V)}$$

4.3.6 Local Reference Point

The local reference point is the nearest downstream gauging station from the list approved by the Minister. The list can be found in Tables 4.7 to 4.10 in Chapter Section 4.6.

4.3.7 Low Condition Vegetation

For the purposes of the salinity assessments:

Native woody vegetation is in low condition if:

- the over-storey percent foliage cover is less than 50% of the over storey percent foliage cover benchmark for that vegetation type; and
- the percent ground cover tends(or is on average) less than 50%.

Native grassland, shrubland, wetland or herb field is in low condition if:

- the percent ground cover tends (or is on average) less than 50%.

Groundcover can comprise non-native species, including weeds, as the interest from a salinity perspective is in water use by the vegetation cover. This represents a slight variation on the definition of 'low condition' used in biodiversity assessments.

4.3.8 Paddock Trees

Paddock trees refer to "native vegetation with an over-storey projected foliage cover less than 25% of the lower benchmark for the vegetation community and where the ground layer is either exotic crop, ploughed fallow or almost exclusively perennial or annual exotic pasture (90% plus of the cover is exotic species)".

4.4 Using the Salinity Benefits Index Tool

At any given point along a stream network, stream salinity provides an integrated signature of the salinity processes operating in the area contributing to that point. The salinity benefits index value is used to determine whether the improve or maintain condition for a proposal to clear native vegetation is met and, if not met, the minimum level of offset (expressed in terms of the salinity benefits index) required to meet the improve or maintain test. The rationale for, and calculation of, the Salinity Benefits Index are described in Chapter Sections 4.4.4 and 4.4.5.

4.4.1 Clearing Areas

Clearing is deemed to improve or maintain instream salinity conditions if there is no increase in the long-term average stream salinity. The following general rules are used to interpret the Salinity Benefits Index (SBI) for clearing:

- If **SBI > 0**, then the proposal improves stream salinity outcomes and there is no requirement for salinity offsets;
- If **SBI = 0**, indicates that at the reference location there is no net change in average annual stream salinity, and there is no requirement for salinity offsets;
- If **SBI < 0**, then the proposal does not improve or maintain stream salinity outcomes. The proposal can only occur if actions are undertaken elsewhere on the property to offset the negative salinity impact.

4.4.2 Offset Areas

If offsets are required to mitigate against salinity impacts from a proposal to clear native vegetation, then the following rules are used to interpret the offset salinity benefits index relative to the clearing Salinity Benefits Index (SBI):

- If $\mathbf{SBI_{offset} \geq 0}$ and $\mathbf{SBI_{offset} \geq (SBI_{clearing}}$ ignoring its minus sign**)**, then the cumulative impact of the clearing and offset actions improve salinity outcomes;
- If $\mathbf{SBI_{offset} \geq 0}$ and $\mathbf{SBI_{offset} < (SBI_{clearing}}$ ignoring its minus sign**)**, then the proposed offset provides a partial offset to the clearing impact, but the net outcome is that stream salinity is not improved or maintained. Additional or alternative salinity offsets are required;
- If $\mathbf{SBI_{offset} < 0}$, then no salinity benefit is gained and the proposed offset does not improve or maintain stream salinity outcomes.

To obtain consistent and meaningful results the Salinity Benefits Indices for the impacts of a clearing proposal and any proposed offsets must be evaluated at the same reference point.

Offsets must be located:

- on the 'same property' as that where the clearing is proposed, and
- in catchments of the same stream order (Strahler system) or lower, and
- in the same SBI catchment as that of the clearing proposal.

The 'same property' assumes a contiguous block of land, but this definition can be expanded at the discretion of the CMA to include a property that is fragmented, so long as the clearing and offset sites are within the same local catchment, groundwater flow system or salinity hazard area. In circumstances where group PVP proposals are considered, the 'same property' refers to all properties making up the group bid, but with offset areas still subject to the other constraints listed above.

4.4.3 Reference Location

Salinity Benefits Index values are evaluated at the Local Reference Point (see Tables 4.7 to 4.10 in Chapter Section 4.6). It is assumed that:

- where the Salinity Benefits Index is negative at the reference location, the offset will negate any adverse impact such that there is no change in average stream salinity anywhere along the stream length;
- where the local Salinity Benefits Index is positive at the reference location (hence not requiring a salinity offset), any negative impact that might occur downstream of this point will be negligible, reflecting the increasing attenuation of impacts with distance downstream of the area of change.

4.4.4 Conceptual Framework for the Salinity Benefits Index Tool

It is assumed that if:

the quantities of water and salt flowing past a given point in a stream; and

the physical characteristics, which influence catchment water and salt yields (e.g. rainfall, topography, soil properties, salt stores, land cover), of the area contributing to that point;

are known, then the water and salt loads at the measurement point can be apportioned to different parts of the catchment based on hydrologic principles and salt storage patterns.

In other words, every part of a contributing catchment can be defined in terms of its contribution to catchment water yield and salt export.

The approach adopted assumes that:

- there are two salt stores within the system: a soil salt store and a groundwater salt store;
- the salt from the soil salt store is mobilised by surface runoff and contributes to the salt load in quickflow;
- the salt from the groundwater salt store is mobilised by recharge and contributes to the salt load in baseflow;
- changing land cover can affect quickflow and baseflow in different proportions; and
- that soil and groundwater salinities are unaffected by land cover change.

Therefore, to capture the different pathways for salt mobilisation and differences in the way that quickflow and baseflow are impacted by a land cover change, streamflow is separated into two flow components. Source area maps represent the spatial variability of each component. For example, the source area map for quickflow describes the relative significance of every part of a catchment in terms of its contribution to quickflow. These source area maps are inputs to the Salinity Benefits Index Tool, which sits behind the PVP Developer software.

Because quickflow and baseflow are influenced by land cover, when a land cover change is made, the source area distributions also change. The differences between the current condition and new condition source area distributions are used to calculate new quickflow and baseflow volumes. The changes in quickflow and baseflow cause changes in their respective salt loads, and these new flows and salt loads are used to calculate a Salinity Benefits Index.

4.4.5 Calculating the Salinity Benefits Index

The Salinity Benefits Index is a measure of the relative change in stream salinity from current salinity levels at a specific location, caused by changes in land cover and/or management.

A Salinity Benefits Index value is calculated as follows:

$$SBI = \frac{\frac{Salt_{current}}{Water_{current}} - \frac{Salt_{new}}{Water_{new}}}{\frac{Salt_{current}}{Water_{current}}} = \frac{Salinity_{current} - Salinity_{new}}{Salinity_{current}} * 1000$$

Where the subscript *current* refers to the mean annual salt load, water and salinity under current land cover conditions and subscript *new* refers to these same terms under the proposed land cover changes (Herron *et al*., 2004). This equation says that the Salinity Benefits Index is the proportional change in stream salinity from current conditions caused by the land cover change.

The Salinity Benefits Index is evaluated at a reference point and applies to that reference point only. A reference point is a location downstream of the area of proposed clearing or other land use/management change at which measured streamflow and salinity data are available (i.e. a gauging station). The period 1975-2000 serves as the standard benchmark period for all catchment salinity assessments in the Murray-Darling Basin Salinity Management Strategy (MDBMC, 2003), and has therefore been used for deriving mean annual streamflow and salt load estimates for use in the Salinity Tool in the PVP Developer.

4.4.6 Defining Current Land Use Conditions

Streamflow

Streamflow is monitored in New South Wales' rivers by a network of gauging stations. A subset of these gauging stations is used to delineate the catchments used in the Salinity Benefits Index Tool for calculating the Salinity Benefits Index (see Tables 4.7 to 4.10 in Chapter Section 4.6). The selected gauging stations have good flow records and provide data, which is also used in NSW for surface water resources management planning.

The daily streamflow record for each gauging station is split into quickflow and baseflow components, using a digital filter approach. This is a standard hydrologic procedure for separating long term continuous records (Lyne & Hollick, 1979).

Salt Loads

Stream salinities are also measured at the gauging stations, although the record is generally shorter than for streamflow monitoring. Relationships between stream salinity and flow have been developed for each catchment based on the available data and these relationships are used to generate continuous time-series data of salinity, from which salt loads can be calculated. Salt load is split into quickflow and baseflow salt loads using the approach in CATSALT v1.5 (Tuteja et al., 2003; Vaze et al., 2004).

Spatial Data

A catchment is represented as a grid composed of square pixels (or cells) with sides of 25 metres. To represent the spatial pattern of a particular catchment attribute, whether it is elevation, groundwater salinity, recharge or some other attribute, each pixel within a grid is assigned a numerical value representing the attribute value in that part of the catchment. Different catchment attributes, represented as individual grids, are combined to produce weighted surfaces, reflecting the contributions from each pixel to total quickflow, baseflow and associated salt loads.

The weighted surface is a source area map in which the magnitude of the value assigned to each pixel of a catchment reflects its contribution to the total. Table 4.3 lists the individual grid layers used to generate weighted surfaces for quickflow, baseflow, quickflow salt load and baseflow salt load.

The proportional contribution, P_i, that cell i makes to some catchment total (eg. baseflow) is a function of the value of that cell, w_i, in the weighted grid relative to the sum of all the cell values (Σ = sum of) within the weighted grid, Σw_i:

$$P_i = \frac{w_i}{\sum w_i}$$

When P_i is multiplied by, for example, the mean annual baseflow for the catchment, the result is the volume of water contributed by pixel i to the total at the catchment outlet.

Table 4.3 The catchment attributes combined to produce weighted surfaces for quickflow, baseflow, quickflow salt load and baseflow salt load.

Quickflow	Baseflow	Quickflow Salt Load	Baseflow Salt Load
Digital Elevation Model(DEM) →* Compound topographic index (CTI)	Climate → Recharge	Soil Salinity	Groundwater salinity
Climate → Runoff	Soils → Recharge	Salt Outbreaks	Baseflow
Soils → Runoff		DEM → Flowpath length	
Land Cover	Land Cover	DEM → slope	
		Quickflow	

*** The → symbol indicates a processing step from the first attribute to a derived attribute.**

Factors Influencing Quickflow and Baseflow

- *Rainfall* – influences the amount of water entering the system. Everything else being equal, a pixel with a high mean annual rainfall will be a more significant source of quickflow than one with low rainfall. Modelled rainfall grids (five kilometre grid resolution) are derived by interpolating between points where rainfall has been measured (Hutchinson, 1995);
- *Soils* – different soils have different physical properties, which influence how readily they store and transmit water. The best available mapped soils data are used to define the spatial pattern of soils across each catchment. Soil hydraulic properties are assigned to each of the different soil types, based on measured data and, where measured data is not available, standard modelling techniques for deriving soil hydraulic properties;
- *Runoff* – the soil hydraulic properties and rainfall data are in the generation of a state-wide runoff grid. Water balance modelling was undertaken for every unique combination of climate zone and soil type occurring in the state to calculate average annual runoff (in mm). The spatial variability in runoff, as influenced by climate and soil type (i.e. no vegetation cover) is represented in the resultant runoff grid;
- *Recharge* – the soil hydraulic properties and rainfall data are in the generation of a state-wide recharge grid. Water balance modelling was undertaken for every unique combination of climate zone and soil type occurring in the state to calculate average annual recharge (in mm). The spatial variability in recharge, as influenced by climate and soil type (i.e. no vegetation cover) is represented in the resultant recharge grid;
- *Topographic position* – influences the re-distribution of catchment water between rainfall events. Locations with large contributing areas and low local gradients tend to accumulate catchment water. As a result they are more likely to generate quickflow (i.e. shed water quickly) when it rains because their relatively high moisture content prevents more rain from infiltrating. They also tend to be near the stream so delivery of runoff to the stream occurs quickly. Locations with low contributing areas and/or steep gradients tend to drain relatively quickly, which means that on average they tend to be relatively dry. When it rains, more rain can infiltrate. These areas tend to be distant from streams, and are less significant sources of quickflow. A modelled index, the compound topographic index (CTI of Beven and Kirkby (1979)) is used to reflect this characteristic;
- *Land cover* – influences the evapotranspiration term of the catchment water balance and the partitioning between overland flow and infiltrated runoff. Perennial vegetation types use more water through a year via evapotranspiration than annual vegetation types, which are active for only part of the year (Zhang *et al*., 2001). In general, trees use more water than perennial grass systems because they tend to have deeper root networks, and can access water stored deeper in the soil profile. Where there is no vegetation cover, the transfer of rainfall back to the atmosphere is by evaporation from the soil and this is restricted to a fairly shallow depth. These differences between vegetation types and cover influence the quantity of rainfall, which is available for quickflow and baseflow.

A water balance model is also used to calculate the weight assigned to each land cover class to reflect its influence on recharge and runoff. A bare soil condition is set as the reference condition and assigned a weighting of one (1). Since plant cover has the effect of reducing runoff and recharge, relative to bare soil, the land cover weightings are between zero (0) and one (1), where zero (0) is no runoff or recharge and one (1) is the same runoff or recharge as bare soil.

In the SBI Tool, the land cover/use layer maps to a look-up table which contains the land use weightings for runoff and recharge for every land cover/use type. These weightings vary from catchment to catchment.

Weighted Quickflow Surface

A weighted quickflow surface, QF_w, is generated by combining the runoff grid (based on soil-rainfall data) with the CTI surface and the weighted land use surface for quickflow (LU_{qf}):

$$QF_w = Runoff * CTI * LU_{qf}$$

Weighted Baseflow Surface

A weighted baseflow surface, BF_w, is generated by combining the recharge grid (based on soil-rainfall data) and the weighted land use surface for baseflow (LU_{bf}):

$$BF_w = Recharge * LU_{bf}$$

Factors Influencing Salt Load

- *Soil Salinity* – reflects the concentration of salt in the soil and available for mobilisation by quickflow. Everything else being equal, areas of high salinity are assumed to be more significant source areas of salt than areas of low salinity. Soil salinity spatial units are based on mapped soil type or geology, salt outbreak areas and landscape position. Estimates of soil salinity for each spatial unit are based on measured data and generalisations from point data to the wider area. Soil salinity is adjusted by topographic factors to account for landscape connectivity. In other words, each pixel is weighted to reflect the concentration of salt that the quickflow generated on the pixel would acquire in its journey to the stream. If a pixel is close to the stream, its weighting will be less than a pixel that is far away from the stream network, everything else being equal. Furthermore, if quickflow from two pixels must travel the same distance to the stream, but the pathway for one pixel is through very saline cells, while the other pathway is through relatively non-saline cells, the pixel with the more saline pathway will have the higher weighting;
- *Groundwater salinity* – reflects the concentration of salt in groundwater and contributing to baseflow salt loads. Areas with high groundwater salinities are assumed to be more significant source areas of salt than areas of low groundwater salinity. Groundwater salinity spatial units are defined on the basis of groundwater flow systems mapping, and each unit is assigned a salinity value based on measured data and extrapolation from measured data to the wider area.

Weighted Quickflow Salt Load Surface

As quickflow salt load is a function of soil salinity and volume of quickflow, the weighted quickflow salt load grid, S_{QFw}, is generated by combining the weighted quickflow grid with the weighted soil salinity grid, $SoilEC_w$:

$$S_{QFw} = QF_w * SoilEC_w$$

Weighted Baseflow Salt Load Surface

As baseflow salt load is a function of groundwater salinity and volume of baseflow, the weighted baseflow salt load grid, S_{BFw}, is generated by combining the weighted baseflow grid with the groundwater salinity grid, $GWEC_w$:

$$S_{BFw} = BF_w * GWEC$$

4.4.7 Land Cover Change

Once the distribution of catchment exports is defined for current land use conditions, different land use changes can be modelled and the change in mean annual salt loads and streamflow estimated.

The land cover term is the only variable in the model. All of the other catchment characteristics are assumed to not change. When land cover is changed, the amount of rainfall that returns to the atmosphere changes, as do the amounts of rainfall that become runoff (quickflow) and recharge (baseflow).

If an area of annual crops is converted to woodland, runoff and recharge is reduced. In the model, the weightings for cropping, which might be around 0.7 or 0.8, are changed to the appropriate land cover weightings for woodland, which are more like 0.2 or 0.3. This causes the weighted quickflow and baseflow surfaces to change – in this instance the sum of the weighted grids for quickflow and baseflow under the proposed land use change are lower than under the current conditions. The sum of the weighted grid under the new condition is compared to that for the current condition. The ratio, which in this case will be less than 1, is multiplied by the mean annual quickflow (baseflow) to obtain a new mean annual quickflow (baseflow).

A change in quickflow and baseflow volumes influences the export of salt from the affected area and the weighted quickflow salt load and baseflow salt surfaces also change. Using the same approach, the new salt load for the land cover change is calculated.

The new exports are calculated as follows:

Quickflow

$$QF^{new} = \frac{\sum QF_w^{new}}{\sum QF_w} * QF_{ann}$$

Baseflow

$$BF^{new} = \frac{\sum BF_w^{new}}{\sum BF_w} * BF_{ann}$$

Quickflow Salt Load

$$S_{QF}^{new} = \frac{\sum S_{QFw}^{new}}{\sum S_{QFw}} * S_{QF}^{ann}$$

Baseflow Salt Load

$$S_{BF}^{new} = \frac{\sum S_{BFw}^{new}}{\sum S_{BFw}} * S_{BF}^{ann}$$

Where *QF* is quickflow, *BF* is baseflow, *S* is salt load and *new* denotes parameters for the new land use scenario. These equations compare the sum of all the cells in the weighted grid for the new land use scenario to that of the current land use for each flow and salt component and multiply the ratio by the current mean annual quickflow, QF_{ann}, baseflow, BF_{ann}, quickflow salt load, S_{QF}^{ann} and baseflow salt load, S_{BF}^{ann}, respectively. Thus, using information about current exports and the best available hydrologic and salt storage data, estimates of the impacts of land use changes on average annual streamflow and salt load are derived.

Finally, the salinity benefits index is calculated by:

- summing together quickflow and baseflow for current conditions and for the new conditions to produce total streamflows for current and new conditions;

- summing together the quickflow and baseflow salt loads for current conditions and the new conditions to produce current and new total salt loads;
- putting these values into the salinity benefits index equation; and
- rounding to the nearest whole (integer) number.

4.5 Using the Salt Mobilisation Tool

In the western parts of NSW, where landscapes tend to be flat and the connectivity between salt stores, hydrologic pathways and the stream network is not well understood, it is assumed that land cover changes which reduce average annual recharge benefit the environment through reducing the mobilisation of salt in the landscape.

The Salt Mobilisation Tool is used to calculate a Salt Mobilisation Index (SMI) for each site where clearing or offsets is proposed. The Salt Mobilisation Index is a measure of potential salt mobilisation as a function of recharge and salt store. The Salt Mobilisation Index is used to determine whether the improve or maintain condition for a proposal to clear native vegetation is met and, if not met, the minimum level of offset required to meet the improve or maintain test. The rationale for, and calculation of, the Salt Mobilisation Index are described in Chapter Sections 4.5.3 and 4.5.4.

4.5.1 Clearing Areas

Clearing is deemed to improve or maintain salinity outcomes if there is no increase in local recharge, hence salt mobilisation. The following general rules are used to interpret the Salt Mobilisation Index (SMI) for clearing:

- If **SMI** $\geq$ **0**, then the proposal is deemed to improve or maintain salinity outcomes and there is no requirement for salinity offsets;
- If **SMI < 0**, then the proposal is deemed to not improve or maintain salinity outcomes. The proposal can only occur if actions are undertaken elsewhere on the property to offset the negative salinity impact.

The majority of proposals to clear native vegetation in western NSW are likely to cause an increase in local recharge, and will typically require offsets. The steps for calculating the salt mobilisation offset requirement are described in Chapter Sections 4.5.2 and 4.5.4.

4.5.2 Offset Areas

If offsets are required to produce a net no salt mobilisation outcome from a proposal to clear native vegetation, then the following rules are used to interpret the offset Salt Mobilisation Index relative to the clearing Salt Mobilisation Index (SMI):

- If $\mathbf{SMI_{offset} > 0}$ and $\mathbf{SMI_{offset} > (SMI_{clearing}}$ ignoring its minus sign**)**, then the cumulative impact of the clearing and offset actions is deemed to improve or maintain salinity outcomes;
- If $\mathbf{SMI_{offset} > 0}$ and $\mathbf{SMI_{offset} < (SMI_{clearing}}$ ignoring its minus sign**)**, then the proposed offset provides a partial offset to the clearing impact, but the net outcome is that some salt is mobilised and the improve or maintain test is not met. Additional or alternative salinity offsets are required;
- If $\mathbf{SMI_{offset} < 0}$, then the offset proposal is likely to increase salt mobilisation, hence provides no offset. The improve or maintain test is not met for salinity outcomes.

Offsets must be located:

- on the 'same property' as that where the clearing is proposed, and
- in catchments of the same stream order (Strahler system) or lower~~, and~~
- ~~in the same SBI catchment as that of the clearing proposal.~~

The 'same property' assumes a contiguous block of land, but this definition can be expanded at the discretion of the Catchment Management Authority to include a property that is fragmented, so long as the clearing and offset sites are within the same local catchment, groundwater flow system or salinity hazard area. In circumstances where group PVP proposals are considered, the 'same property' refers to all properties making up the group bid, but with offset areas still subject to the other constraints listed above.

4.5.3 Conceptual Framework for the Salt Mobilisation Tool

The approach adopted for assessing salinity impacts in relatively flat, floodplain environments is based on a very different assumption from the upland areas, where the assessment is based around the impacts on stream salinity. Here, the assumption is simply that reducing the mobilisation of salt stored in the ground is beneficial to the environment. Reducing salt mobilisation can be achieved through land cover changes that increase plant water uptake and, hence, reduce recharge. With respect to the clearing of native vegetation, unless the clearing involves the replacement of native grasses with some higher water use vegetation cover such as trees, the impacts will always be negative and require a salinity offset.

The Salt Mobilisation Tool uses current land cover, proposed land cover, salt store class, soil permeability class and the area of the clearing and offset sites to determine whether salinity outcomes are improved or maintained.

4.5.4 Calculating the Salt Mobilisation Offset requirement

The Salt Mobilisation Index is a function of the change in recharge caused by the proposed land cover change and the salt store weighting for the area. A limited set of recharge estimates has been defined to cover the range of land covers and soil types of the Inland Plains.

Each land cover available for selection in the tool has been classified into one of five classes according to its water use characteristics. In general, deep-rooted, perennial vegetation covers are on average higher water users than shallow-rooted or annual vegetation systems and the rating reflects this. Table 4.4 gives the water use efficiency rating that has been assigned to a range of different land cover options in western NSW.

For the native vegetation classes, it is assumed that water use will be less efficient where vegetation is in a "low condition" than where it is in a relatively undisturbed condition. Chapter Section 4.3.7 provides the definition of "low condition" for salinity purposes. Note that this definition differs somewhat from the biodiversity definition of low condition, since from a water use perspective a groundcover dominated by weeds can be as efficient as the natural groundcover. In other words, it is not the composition of the groundcover, so much as the extent of coverage, which is significant in terms of water use. In Table 4.4, each of the native vegetation classes has a water use efficiency classification reflecting the two conditions.

Paddock trees are assumed to be native vegetation remaining in areas of cropping or pasture (Chapter Section 4.3.8 for definition). The Salt Mobilisation Tool treats the clearing of paddock trees as having no impact on recharge, hence salt mobilisation. Thus clearing of paddock trees is deemed to maintain environmental outcomes.

Table 4.4 Vegetation covers classified into water use efficiency classes.

Vegetation Class	*Water Use Efficiency Class*	
	Not Low Condition	*Low Condition*
Arid and semi-arid shrublands[1]	*Very High*	*High*
Semi arid woodlands[1]	*Very High*	*High*
Sclerophyll grassy woodlands[1]	*Very High*	*High*
Dry sclerophyll shrub/grass forest[1]	*Very High*	*High*
Dry sclerophyll shrub forest[1]	*Very High*	*High*
Forested Wetlands[1]	*Very High*	*High*
Grasslands (native)[1]	*High*	*Moderate*
Horticulture (with DIMP[2])	*High*	*N/A*
High water use pasture (e.g. lucerne)	*High*	*N/A*
Response cropping	*High*	*N/A*
Pasture with paddock trees	*High*	*N/A*
No till cropping / Deep-rooted perennial pasture rotation	*High*	*N/A*
Continuous no till cropping	*High*	*N/A*
No till winter cropping	*Moderate*	*N/A*
Crops with paddock trees	*Moderate*	*N/A*
Summer-winter cropping	*Moderate*	*N/A*
Pasture (e.g. annual grasses/medic)	*Moderate*	*N/A*
Winter cropping (with conventional fallow)	*Low*	*N/A*
Annual pasture (e.g. oats)	*Low*	*N/A*
Horticulture (with no DIMP[2])	*Very Low*	*N/A*

[1] **Based on Keith vegetation formations relevant to western NSW and non-native vegetation types relevant to western NSW.**

[2] **DIMP is drainage and irrigation management plan (DIMP).**

Soil permeability classes are defined on the basis of their clay and sand content:

- low: light, medium and heavy clays;
- moderate: loams, clay loams;
- high: sandy loams, loamy sands, sands.

Sandy soils tend to have lower water holding capacities and higher conductivities than clay-rich soils, hence, everything else being equal, areas characterised by sandy soils have higher recharge rates.

The combined effects of soil permeability and water use efficiency on recharge are summarised in Table 4.5. Recharge estimates are based on values reported in the literature for areas with average annual rainfalls less than about 500 mm. It is the accuracy of the relative differences between classes, rather than that of the absolute values, which is significant for the calculations undertaken here.

Table 4.5 Estimates of average annual recharge (mm) in western NSW.

Soil Permeability Class	**Vegetation Water Use Efficiency Class**				
	Very Low	Low	Moderate	High	Very High
High	100	60	20	5	0.5
Moderate	60	30	10	3	0.1
Low	20	10	5	1	0.1

These values (in mm) are used to calculate the impact of changing land cover on recharge, *R*, on both the clearing and offset sites, as follows:

$$\Delta R_{clearing} = \left(R^{NV}_{clearing} - R^{proposed}_{clearing}\right) * A_{clearing}$$

$$\Delta R_{offset} = \left(R^{current}_{offset} - R^{proposed}_{offset}\right) * A_{offset}$$

where ΔR is the change in average annual recharge (mm) from changing land cover, multiplied by the area, A, of clearing. The subscripts and superscripts *offset*, *clearing*, *current*, *proposed* and *NV* refer to the offset site, clearing site, current vegetation cover, proposed vegetation cover and native vegetation, respectively. The formulation of the equation is such that a change to lower water use vegetation will result in a negative ΔR, whereas a change to higher water use vegetation will result in a positive ΔR.

The change in recharge from the land cover change is multiplied by the salt store weighting, S_w, (Table 4.6) for the site to produce an index of salt mobilisation.

$$SMI = \Delta R * S_w$$

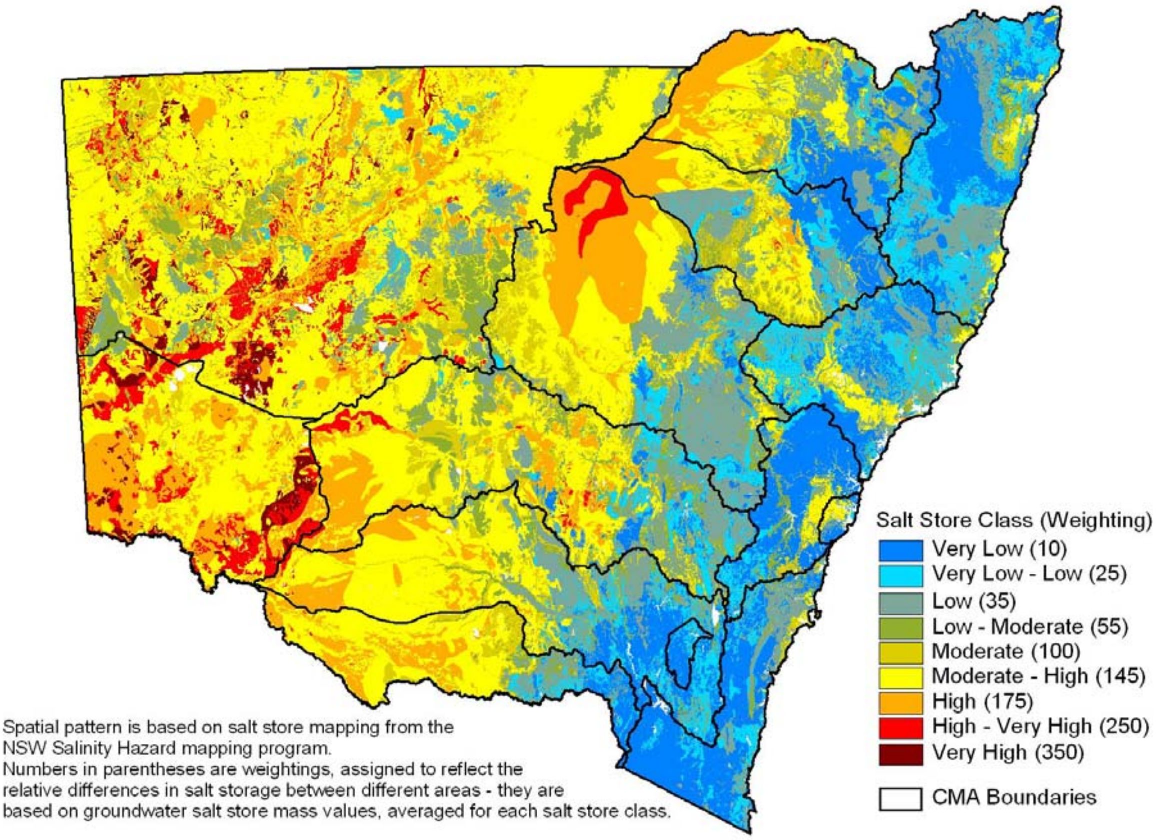
With respect to a proposal to clear native vegetation, a negative SMI value on the clearing site will indicate the need for a salt mobilisation offset and the magnitude of the SMI will indicate how large an offset is required.

Table 4.6 Salt store classes and their model weighting.

Salt Store Class	Weighting, S_w
Very High	350
High – Very High	250
High	175
Moderate - High	145
Moderate	100
Low - Moderate	55
Low	35
Very Low - Low	25
Very Low	10

Salt weightings have been assigned to a salt store map of New South Wales (Figure 4.2), which was produced as part of the Salinity Hazard Mapping project (Department of Natural Resources). The salt store map represents the spatial pattern of salt storage in the groundwater, regolith and soil, taken together. The PVP Mapper version has been classified into 9 classes (Table 4.6) and the weightings assigned to each class are based on the range of salinity values from groundwater data. Weightings have been used in preference to actual salinity values because of uncertainties in the soil, regolith and groundwater salt store data.

Figure 4.2 Map showing salt store class and weightings.



4.6 Catchments covered by the Salinity Benefits Index tool

Table 4.7 Border Rivers/Gwydir and Namoi

Stream Gauge Number	Description of Location	Stream Gauge Number	Description of Location
Border Rivers		**Namoi**	
416003	Tenterfield Creek	419001	Namoi River @ Gunnedah
416006	Severn River @ Ashford	419005	Namoi River @ North Cuerindi
416008	Beardy River @ Haystack No 4	419006	Peel River @ Carrol Gap
416010	Macintyre River @ Wallangra	419007	Namoi River @ Keepit Dam
416012	Macintyre River @ Holdfast	419012	Namoi River @ Boggabri
416020	Ottleys Creek @ Coolatai	419015	Peel River @ Piallamore
416021	Frazers Creek @ Ashford	419016	Cockburn River
416026	Reedy Creek	419020	Manilla River @ Briabri
416032	Mole River @ Donaldson	419022	Namoi River @ Manilla Railway Bridge
416039	Severn River @ Strathbogie	419024	Peel River @ Paradise Weir
Gwydir		419027	Mooki River
418001	Gwydir River @ Pallamallawa	419029	Halls Creek
418005	Copes Creek	419032	Coxs Creek
418012	Gwydir River @ Pinegrove	419035	Goonoo Goonoo Creek
418013	Gwydir River @ Gravesend Bridge	419036	Duncans Creek
418015	Horton River	419043	Manilla River @ Tarpoly Weir
418016	Warialda Creek	419045	Peel River @ Chaffey Dam
418017	Myall Creek	419051	Maules Creek
418018	Keera Creek		
418021	Laura Creek		
418022	Georges Creek		
418023	Moredun Creek		
418025	Halls Creek		
418026	Gwydir River @ Copeton Dam		
418029	Gwydir River @ Stonybatter		
418032	Tycannah Creek		
418033	Bakers Creek		

Table 4.8 Murrumbidgee and Murray

Stream Gauge Number	Description of Location	Stream Gauge Number	Description of Location
Murrumbidgee			
410001	Murrumbidgee River @ Wagga Wagga	410048	Kyeamba Creek
410004	Murrumbidgee River @ Gundagai	410057	Goobarragandra River
410025	Jugiong Creek	410059	Gilmore Creek
410026	Yass River	410061	Adelong Creek
410038	Adjungbilly Creek	410071	Brungle Creek
410039	Tumut River @ Brungle Bridge	410073	Tumut River @ Oddy's Bridge
410043	Hillas Creek	410087	Bullenbung Creek
410044	Muttama Creek	410103	Houlaghans Creek
410045	Billabung Creek		
410047	Tarcutta Creek	**Murray**	
		410091	Billabong Creek @ Walbundrie

Table 4.9 Castlereagh, Macquarie and Lachlan

Stream Gauge Number	Description of Location	Stream Gauge Number	Description of Location
Macquarie		**Castlereagh**	
421001	Macquarie River @ Dubbo	420004	Castlereagh River @ Mendooran
421007	Macquarie River @ Bathurst	420007	Castlereagh River @ Binnaway
421018	Bell River		
421019	Cudgegong River @ Yamble Bridge	**Lachlan**	
421025	Macquarie River @ Bruinbun	412002	Lachlan River @ Cowra
421026	Turon River	412004	Lachlan River @ Forbes
421035	Fish River	412009	Belubula River @ Canowindra
421040	Macquarie River d/s Burrendong Dam	412028	Abercrombie River
421041	Crudine Creek	412029	Boorowa River
421042	Talbragar River	412030	Mandagery Creek
421048	Little River	412043	Goobang Creek
421052	Lewis Creek	412050	Crookwell River
421053	Queen Charlottes Creek	412055	Belubula River @ Bangaroo Bridge
421058	Wyaldra Creek	412057	Lachlan River @ Nanami
421059	Buckinbah Creek	412065	Lachlan River @ Narrawa
421066	Pyramul Creek	412067	Lachlan River @ Wyangala Dam
421072	Winburndale Creek	412072	Back Creek
421073	Meroo Creek	412077	Belubula River @ Carcoar
421079	Cudgegong River @ Windamere Dam Site	412080	Flyers Creek
421101	Campbells River	412092	Coombing Creek

Table 4.10 Hunter and Hawkesbury (Capertee, Wollondilly and Wolgan)

Stream Gauge Number	Description of Location	Stream Gauge Number	Description of Location
Hunter		**Hunter**	
210055	Hunter River @ Denman	210002	Hunter River @ Muswellbrook Br
210044	Glennies Creek @ Middle Falbrook	210052	Pages River @ Gundy Recorder
210090	Martindale Creek near Martindale		
210089	Black Creek @ Rothbury	**Capertee**	
210088	Dart Brook @ Aberdeen No.2	212018	Capertee River @ Glen Davis
210087	Doyles Creek @ Doyles Creek	**Wolgan**	
210071	Glendon Brook @ Glendon Brook	212028	Wolgan River @ Newnes
210040	Wybong Creek @ Wybong	**Wollondilly**	
210031	Goulburn River @ Sandy Hollow	212270	Wollondilly River @ Jooriland
210014	Rouchel Brook @ Rouchel Brook (The Vale)	212271	Wollondilly River @ Golden Valley
210064	Hunter River (Singleton-Greta)		

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Appendix B. Management Actions Specified by the Clearing Module of the LSC Tool for Assessed Land Degradation Hazards to Pass the Improve or Maintain Test.

Hazard	Class	Management Action
Salinity	3	Run the Salinity Benefits Index Tool to ensure no net disbenefit
Salinity	3	Run the Salt Mobilisation Tool to ensure no net disbenefit
Salinity	4	Run the Salinity Benefits Index Tool to ensure no net disbenefit
Salinity	4	Run the Salt Mobilisation Tool to ensure no net disbenefit
Salinity	5	Run the Salinity Benefits Index Tool to ensure no net disbenefit
Salinity	5	Run the Salt Mobilisation Tool to ensure no net disbenefit
Salinity	6	Run the Salinity Benefits Index Tool to ensure no net disbenefit
Salinity	6	Run the Salt Mobilisation Tool to ensure no net disbenefit
Water Erosion	3	Use conservation farming practices &/or erosion control earthworks
Water Erosion	3	If cropping: no burning of stubble, use controlled traffic, minimal cultivation, adequate fertiliser, direct seeding
Water Erosion	3	If cropping very long slopes in the Border Rivers / Gwydir, Namoi or Central West CMAs: use strip cropping
Water Erosion	3	If grazing: use suitable pasture rotations & manage grazing to maintain groundcover and pasture composition
Water Erosion	3	If cropping or grazing: use soil ameliorants where required (gypsum, lime)
Water Erosion	4	If cropping: use conservation farming practices
Water Erosion	4	If cropping: no burning of stubble, use controlled traffic, minimal cultivation, adequate fertiliser, direct seeding
Water Erosion	4	If grazing: use suitable pasture rotations & adequate fertiliser & manage grazing to maintain groundcover and pasture composition
Water Erosion	4	If cropping or grazing: use soil ameliorants where required (gypsum, lime)
Water Erosion	5	No cultivation or cropping
Water Erosion	5	If grazing: use suitable pasture rotations & adequate fertiliser & manage grazing to maintain groundcover and pasture composition
Water Erosion	5	Use earthworks to control erosion and intercept sediment
Water Erosion	6	No cultivation or cropping
Water Erosion	6	If clearing or thinning in the Coastal Tablelands and Slopes: no soil disturbance and no removal of cut or fallen timber
Water Erosion	6	If grazing: use controlled grazing, suitable pasture rotations, adequate fertiliser & maintain groundcover

Wind Erosion	3	Use conservation farming practices
Wind Erosion	3	If cropping: no burning of stubble, maintain 50% groundcover, minimal cultivation with reduced speed of implements, adequate fertiliser, direct seeding
Wind Erosion	3	If grazing: use controlled grazing, minimal cultivation to establish pasture and suitable pasture rotations
Wind Erosion	3	If cropping or grazing: install wind breaks
Wind Erosion	4	Use conservation farming practices
Wind Erosion	4	If cropping: limited to 3 years in 10
Wind Erosion	4	If cropping: no burning of stubble, maintain 50% groundcover, minimal cultivation with reduced speed of implements, adequate fertiliser, direct seeding
Wind Erosion	4	If grazing: use controlled grazing, minimal cultivation to establish pasture and suitable pasture rotations
Wind Erosion	4	If cropping or grazing: install wind breaks
Wind Erosion	5	No cultivation or cropping
Wind Erosion	5	If grazing: manage pasture to maintain groundcover, including use of adequate fertiliser
Wind Erosion	6	No cultivation or cropping
Wind Erosion	6	If grazing: manage to maintain groundcover, including use of adequate fertiliser
Soil Structure Decline	3	Use conservation farming practices
Soil Structure Decline	3	If cropping: no stubble burning (retain and incorporate stubble), and use controlled traffic, minimal cultivation, direct seeding, adequate fertiliser, adequate soil ameliorant (lime), & recommended rotation and length of pasture phases
Soil Structure Decline	3	If grazing: use controlled grazing, manage pasture to maintain groundcover and biomass to protect soil structure, adequate soil ameliorant (lime)
Soil Structure Decline	4	Use conservation farming practices
Soil Structure Decline	4	If cropping: limited to 3 years in 10
Soil Structure Decline	4	If cropping: no stubble burning (maintain 50% groundcover), controlled traffic, reduced speed of cultivation, minimal cultivation, direct seeding, adequate fertiliser, adequate soil ameliorant (lime)
Soil Structure Decline	4	If grazing: use controlled grazing, suitable pasture rotations, manage pasture to maintain groundcover and biomass to protect soil structure, use adequate fertiliser & soil ameliorant (lime)
Soil Structure Decline	5	No cultivation or cropping
Soil Structure Decline	5	If grazing: manage pasture to maintain groundcover and biomass to protect soil structure, use adequate fertiliser & soil ameliorant (lime)
Soil Structure Decline	6	No cultivation or cropping
Soil Structure Decline	6	If grazing: manage pasture to maintain groundcover and biomass to protect soil structure, use adequate fertiliser &

		soil ameliorant (lime)
Shallow & Rocky Soils	4	No cropping
Shallow & Rocky Soils	4	If grazing: manage pasture to maintain ground cover, including use of adequate fertiliser
Shallow & Rocky Soils	5	No cultivation or cropping
Shallow & Rocky Soils	5	If grazing: manage pasture to maintain ground cover, including use of adequate fertiliser
Shallow & Rocky Soils	6	No cultivation or cropping
Shallow & Rocky Soils	6	If grazing: manage pasture to maintain ground cover, including use of adequate fertiliser
Acid Sulfate Soils	3	No soil disturbance or drainage deeper than 3 metres
Acid Sulfate Soils	4	No soil disturbance or drainage deeper than 1 metre
Acid Sulfate Soils	5	No soil disturbance or drainage deeper than 0.5 metre
Earth Mass Movement	3	No concentration of surface or subsurface water flow
Earth Mass Movement	3	No excavation batters >2.5 metres without geotechnical design & batter angles <3:1
Earth Mass Movement	3	Maintain groundcover to maximise water use & bind soil
Earth Mass Movement	6	No concentration of surface or subsurface water flow
Earth Mass Movement	6	No excavation batters >1.5 metres without geotechnical design & batter angles <3:1
Earth Mass Movement	6	Subsurface drainage required
Earth Mass Movement	6	Maintain groundcover, especially deep-rooted plants, to maximise water use & bind soil

Tag C

DNR –Science and Information Discussion Paper

Fit for purpose considerations of the salt store map in the PVP Developer

Issues:

1. Whether the salt stores map in the PVP Developer is fit for purpose for application in the:
   - Land and Soil Capability (LSC) assessment of salinity hazard; and
   - Salt Mobilisation Tool.
2. Does the salt stores map require any improvements for use in the PVP Developer?

Background:

The salt stores map used in the PVP Developer was derived from datasets originally developed as part of a Salinity Hazard Mapping project. The salinity hazard methodology evolved from a multi-agency technical workshop that involved staff from DNR and DPI and CSIRO. It was agreed to compile the best available data across New South Wales, develop an agreed analytical framework and apply it across the State, identify data sources and their inherent weaknesses, establish a Project Steering Committee to oversee the development of the salinity hazard map and obtain regional endorsement of the final product and all underpinning spatial datasets including the salt stores map. With this process, the products that were developed in the Salinity Hazard Mapping project have been underpinned by substantial consultation to ensure that best available data were used, and that all analytical procedures were the most appropriate given current data availability.

An overview of the methodology used to develop the original salt store map and its inherent strengths and limitations is provided in Appendix A. In summary, the strengths of the salt stores map are:

- Datasets were compiled using an agreed methodology that was consistent across NSW and compatible with the available data;
- There is good consistency with other departmental data and mapping products;
- A salt stores map based on a class system (low, low-medium, medium, medium-high and high) was achieved; and
- Data gaps in mapping salt stored within the soil, regolith and groundwater in NSW were clearly identified.

The limitations of the original salt store map include:

- Salt store is represented in classes (low to high) and not as absolute values, due to data constraints;
- Salt store maps for the soil, regolith and groundwater were derived separately and then combined into a total salt store map. Classes between each of the component salt stores cannot be compared directly. For example, a Class 2 for the regolith salt store is not equivalent to a Class 2 for groundwater salt store with respect to salt mass. However, within each component each class has the same relative significance everywhere; and
- The salt store map is based on a mix of quantitative and qualitative data. This is solely due to data availability issues. The analysis used reduced the complexity of the final product to deliver a map that is consistent across the state which, of necessity, means it is constrained by the lowest quality of data available.

Comments:

There are a number of key considerations in the use of the salt store map in the PVP Developer:

1. The salt store map in the PVP Developer is used to determine the Land and Soil Capability (LSC) class for salinity hazard across the state. The LSC salinity hazard assessment considers regional, catchment and local scales as part of the assessment. It uses actual evidence of on-site and downslope salinity at a local scale. This is coupled with a qualitative assessment of the regional salt store obtained from the salt store map. The salt store map is used to classify the regional salt store in the LSC tool and contains suitable information at an appropriate scale for this level of assessment. Such an assessment does not require an absolute value of salt store mass. The LSC salinity hazard assessment methodology will need to be modified to reflect the incorporation of a 9 class salt store map, but the modification is minor and will not affect the application of the LSC tool.

2. In the western plains of NSW, the salt store map is used with the Salt Mobilisation Tool to evaluate potential salinity impacts of clearing activities and requirements for offsets, and predict salinity impacts of incentive funding bids. Use of the salt store map and a simple, rule-based model to estimate salt mobilisation in western areas is consistent with the scale and quality of available data in western NSW and with the importance of dryland salinity as a management issue.

3. Significant improvements have now been made to the salt stores map for use in the PVP Developer in two ways:
    - Re-analysis was undertaken to derive the new 9 class map to better represent spatial variability in salt store classes as the original 5 class map did not provide sufficient spatial variation for the Salt Mobilisation Index tool; and
    - Weightings used to reflect the relative differences in salt store between salt store classes were re-derived to better reflect these relative differences. A representative salt weighting for each of the 9 classes was derived based on groundwater salt store mass. That is, the new weightings are physically based whereas the original 1 to 5 weightings have no physical basis. In using the groundwater salt mass to assign weightings to the 9 salt store class map, it is assumed that groundwater integrates across all 3 salt stores and provides a reasonable range of variation for the combined salt store map. In the absence of salt store masses for the soil and regolith components of the salt store profile, the groundwater salt store represents the best source of data for weighting the different salt store classes and provides a sound basis for evaluating relative differences in salinity impacts between salt store classes for a given change in land use or management.

4. Under the proposed changes, the Salt Mobilisation Tool will use the new salt store weightings from the 9-class salt store map to represent the relative significance of different salt store classes. The Salt Mobilisation Tool assumes that an increase in salt mobilisation resulting from increased recharge volume after clearing can be offset by an equal reduction in salt mobilisation via a suitable reduction in recharge volume at an offset site. Where the clearing and offset sites are both located in the same salt store class the relativities between weightings for the different salt store classes will not come into consideration because there is no relative difference in salt store between the two sites. It is anticipated that in most cases, the clearing and offset sites will be in close proximity to each other and within the same salt store class. However, where the clearing and offset sites are located in different salt store classes the weighting factors derived from the groundwater salt store map to classify salt stores into 9 classes are used to reflect the relative difference in salt

mobilisation between classes. These weightings provide the most robust data available on these relativities.

5. The new salt store map proposed for the PVP Developer classifies salt store into 9 classes from very low to very high. While a map of absolute salt stores (e.g. tonnes per hectare) is not needed for the PVP Developer, if the decision was made to produce a map that expresses salt store in absolute quantities across NSW then this would be a massive undertaking with respect to data collection, data capture and analysis. As an example, $7 million of NAP funding has been allocated to BRS to undertake such mapping in one small area of NSW over a 3 year period.

Recommendations:

1. That the salt stores map should be recognised as fit for purpose for use the LSC Tool in the PVP Developer (Based on comment 1 above).
2. That the salt stores map should be recognised as fit for purpose for use the Salt Mobilisation Tool in the PVP Developer (Based on comments 2-4 above).

Appendix A. Methodology for the development of the salt stores map

The methodology is summarised in the following flow diagram (Figure A1). The process to develop the salt stores map can be summarised into 4 major steps. Each of these steps, along with their inherent strengths and limitations is summarised in Table A1. Table A1 also provides some recommendations for future improvements to the salt stores map.

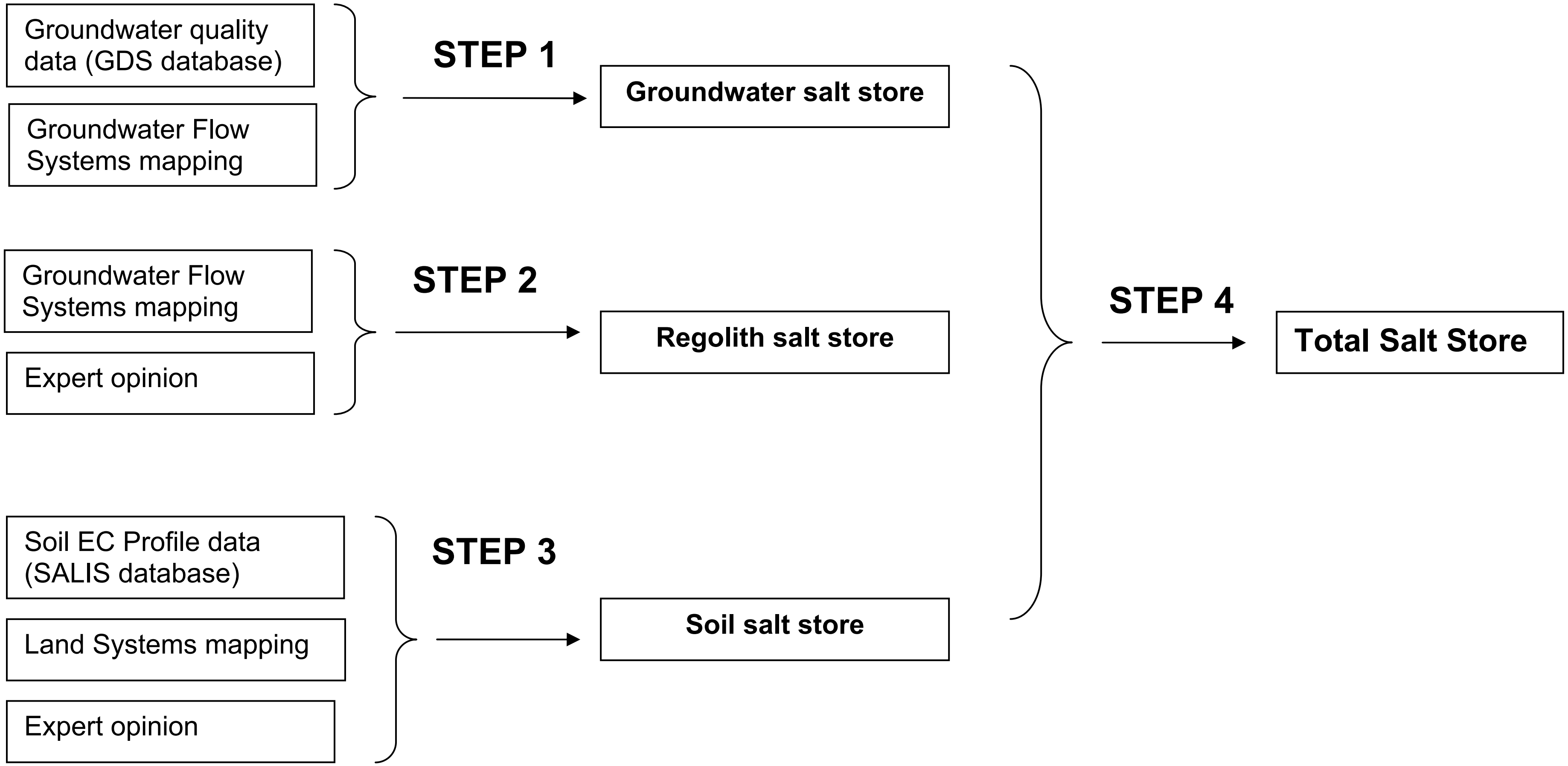

Figure A1: Methodology for the development of the salt stores map

Table A1
Summary of the salt stores map

Step	Description	Strengths	Limitations
1	Groundwater salt store (tonnes per hectare) was derived from an empirical model that assessed the volume of groundwater in the saturated zone, and multiplied it by the salt concentration of the shallowest groundwater. Aquifer thickness was set so that the salt store mass was representative of the upper parts of the saturated zone. A log transformation was required due to the highly skewed distribution of groundwater salinity. Data were then classified into an equal interval spread to produce a 1 to 5 ranking (low to high).	• Compilation of data from a variety of existing spatial and point datasets • Class values can be equated to an absolute quantity of salt (tonnes per hectare). • Log transformation and equal interval classification of values were done once for the entire state, so values are directly comparable across the entire coverage.	• The logarithmic transformation assumes that the distribution of groundwater salinity across NSW is log-linear which is not necessarily the case.
2	The regolith salt store is the amount of salt stored below the soil but above the watertable. While the regolith can store substantial amounts of salt, it will have little impact on salinity outbreaks unless mobilised by increased recharge. Regolith salt store information was derived from spatial data compiled as part of the Groundwater Vulnerability Mapping program	• Good consistency with existing groundwater vulnerability maps that identify locations where risk of groundwater contamination is greatest. • Groundwater vulnerability maps are based on an assessment of depth to watertable, recharge, aquifer conditions, overlying soil conditions, and topography. While qualitative in many areas, it is a compilation of best available data using consistent techniques.	• There is very little data available to provide quantitative estimates of the salt mass stored in the regolith. • Knowledge of regolith types and their three-dimensional distribution at any scale across the State is extremely limited. • Approach used was heavily dependent on expert opinion due to paucity of data • Class values cannot be equated to an absolute quantity of salt.
3	The SALIS point data and land systems mapping data were combined with the best (or most confident) data value used. The DNR Soils and Land Information System (SALIS), contains point-source soil profile salinity data across NSW. It was used to provide qualitative and quantitative soil salinity data. SALIS data were complemented by soils data from the DNR Soil Landscape Mapping program, with gaps filled by the Northcote and Skene saline and sodicity map. The derived salt store was ranked one a 1 to 5 scale.	• Compilation of data from a variety of existing spatial and point datasets	• Class values cannot be equated to an absolute quantity of salt.

Step	Description	Strengths	Limitations
4	The salt store map consists of three components: salt stored in the soil (usually within 1 or 2 metres of the surface), salt stored in the regolith (deeper than the soil, but above the watertable) and salt stored below the watertable. It was not possible to express salt store as a quantity, due to the reliance on qualitative data. A ranked index of salt store for each of the three layers was combined to provide a total salt store index ranging from 1 to 5 (low to high).	• The spatial variation exhibited in the maps is considered appropriate for application to catchment, regional and state-wide assessments.	• The spatial variation exhibited in the maps is too coarse for application to sub-catchment and property-scale assessments. • The original 5 class map developed in the salinity hazard project does not provide sufficient spatial variation for use in the Salt Mobilisation Index tool. This limitation was overcome be re-analysing the data into 9 classes using a more robust classification system. • Class values cannot be equated to an absolute quantity of salt, although this is not important for the PVP Developer. • Direct comparisons between component salt stores cannot be made because the methods for classification into 5 classes remain variable (a mix of quantitative and qualitative) and data dependent.

Potential improvements

1. Better quantification of the components of the landscape salt store, especially the regolith and groundwater salt stores. The current salt store maps have been derived from the data currently accessible within New South Wales government. Other data sets from Federal Agencies, Universities, Research Providers and potentially mineral exploration bore logs would improve the salt store maps, but would require significant resources and collaborative linkages.

2. Airborne geophysics coupled with an extensive drilling program. Costs of obtaining airborne data are high, but research has been undertaken to look at the potential to reduce costs of data collection by widening the spacing between flight lines and reducing the bore hole frequency. An advantage of the AEM profile is that the salt store for the entire depth profile can be determined, which means a single system of data acquisition is used, rather than differing systems for soil, regolith and groundwater strata. However, while AEM data can help to build a profile of salt storage across the landscape, considerably more research is required to understand the hydrologic connectivity between salt stores, the surface drainage network and dryland salinity outbreaks.