LANDHOLDER FACTSHEET:

Assessing the risk of salinity from water affecting activities on Kangaroo Island

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The potential for the development of salt land is a limitation to sustainable land use on Kangaroo Island. Small saline patches and salt lagoons have existed naturally in some districts, but the spread of saline seepage associated with agricultural development and rising water tables continues to have a detrimental impact on both productive farmland and the natural environment.

The Kangaroo Island Natural Resources Management Plan, states that '*water affecting activities must not cause or exacerbate unnatural waterlogging, dryland salinity or rising water tables'*. The proposed assessment tool can be used by landholders to undertake a level of self-assessment before formally applying to the KI NRM Board.

CAUSES OF DRYLAND SALINITY ON KI

Cyclic salt has been blown in from the sea, and deposited on Kangaroo Island with rain for thousands of years. This salt is still being deposited at rates between 2 to 300 kg per hectare per year on the coast to about 100 kg per hectare per year in the middle of the Island. Most of this salt is washed out of the catchment to the sea each year with surface runoff; hence "cyclic" in nature. However, under the original native vegetation, a small amount has accumulated each year in the relatively deep (up to 25m) unconsolidated profiles of the plateau region of the Island. Over time this accumulated salt has become a significant amount.

Dryland salinity on the Island is caused by the clearing of deep-rooted, perennial native vegetation and its replacement with shallow-rooted crops and pastures, which use less water. The resultant rising water table dissolves the accumulated cyclic salts in the profile and where the saline groundwater comes to the surface it creates saline land and surface water. Groundwater movement reflects surface run-off and flows toward the lower lying areas in the landscape. Where the groundwater flow is restricted and cannot be contained in the soil profile it breaks the surface producing saline seeps.

After clearing there is a relatively rapid (within 2 years) hydraulic response with the appearance of saturated areas and hillside springs. The solute response, which is the mobilization of the accumulated cyclic salt, is slower and saline seeps may take 5 to 10 years to appear.

WHAT ACTIVITIES REQUIRE A PERMIT

Water Affecting Activities (WAA) that require a permit include:

- the erection, construction, modification, enlargement or removal of a dam, wall or other structure that will collect or divert water
- the erection, construction or placement of any building or structure in a watercourse or lake or on the floodplain of a watercourse
- depositing or placing an object or solid material in a watercourse, lake or flood plain
- destroying vegetation growing in a watercourse or lake or growing on the floodplain of a watercourse
- excavating or removing rock, sand or soil from a watercourse, lake or floodplain.

WHAT IS THE PROCESS

The permit application process involves the following steps:

- Obtain a permit application form. (Download from www.kinrm.sa.gov.au or collect a hard copy from the Board, 35 Dauncey St Kingscote)
- Complete the application form. (Include details such as land title details, plans/photograph's of the proposed activity, site location and consultants/engineers reports where required)

- Lodge the application with the prescribed fee
- A site assessment may be undertaken by an officer from the Board
- Permit notification and conditions. (The Board will notify you of the decision in writing).

HOW DOES THE ASSESSMENT TOOL WORKS

This assessment tool classifies the risk of salinity into three categories; permits that are:

- approved without further investigation
- approved subject to meeting specific salinity mitigation conditions
- refused on the grounds of salinity risk concerns unless additional information is received which addresses these concerns.

THE SALINITY RISK ASSSESSMENT TOOL

Approval of a Water Affecting Activity (WAA) is based on the level of risk associated with the activity. If it is high risk, then the WAA will not be approved, unless the risk can be reduced through appropriate management techniques. The level of risk is determined through the use of a simple matrix.

A SIMPLE RISK MATRIX

Risk is a function of likelihood and consequence, where likelihood is the chance of an adverse impact occurring, and consequence is the result of the impact. For instance, construction of a large dam in an area where groundwater is shallow is likely to lead to increased waterlogging and salinity at the site, and the consequences may include death of surrounding terrestrial vegetation and increased salinity in the stream ecosystem.

Table 1 illustrates where the product of likelihood x consequence generates a risk score between 1 and 25. This risk can then be categorised according to the score, for example into low risk (1 to 6), moderate risk (7 to 12) and high risk (13 to 25).

RISK = likelihood x consequence	**LIKELIHOOD**				
CONSEQUENCE	*1 Rare*	*2 Unlikely*	*3 Possible*	*4 Likely*	*5 Almost certain*
1 Insignificant	**1**	**2**	**3**	**4**	**5**
2 Minor	**2**	**4**	**6**	**8**	**10**
3 Moderate	**3**	**6**	**9**	**12**	**15**
4 Considerable	**4**	**8**	**12**	**16**	**20**
5 Severe	**5**	**10**	**15**	**20**	**25**

Table 1. Simple Risk Matrix

Key:

Low
Moderate
High

DETERMINING THE LIKELIHOOD SCORE

The KI Salinity Risk Potential GIS Layer provides an indication of the likelihood of an adverse salinity impact happening from WAA as it maps the potential for further salinity to occur should groundwater rise. On site assessment is required to determine the accuracy of the designated salinity risk.

THE DWLBC SALINITY RISK POTENTIAL GIS LAYER

The KI Salinity Risk Potential Map (Figure 1) provides at a broad scale, a representation of salinity risk, should significant groundwater rise (0.5m) occur. Copies of the map are available from the NRM Office, Kingscote.

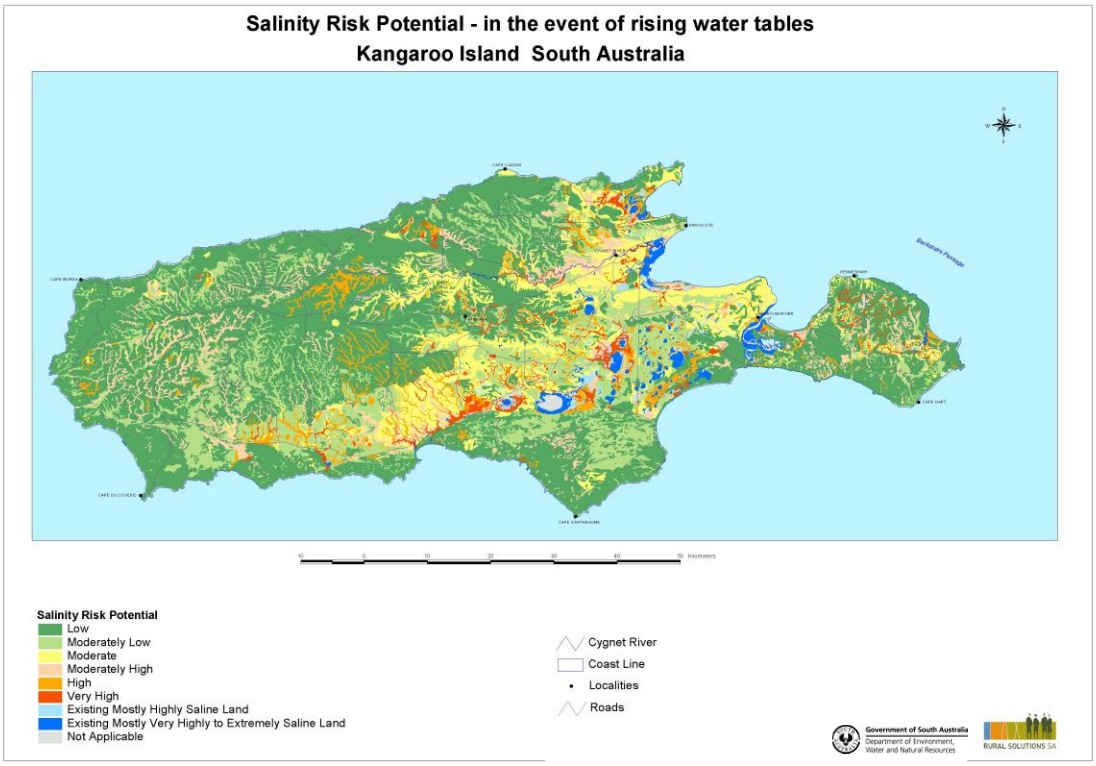


Figure 1. Salinity risk potential map (copes of this map at a larger scale are available from the DEWNR Office, Kingscote)

KI Salinity Risk GIS Layer (map) Classes 1 to 8	Likelihood score for the salinity risk matrix 1 to 5
Class 1 low	**1** (rare)
Class 2 moderately low	**2** (unlikely)
Class 3 moderate	**3** (possible)
Class 4 moderately high	**3** (possible)
Class 5 high	**4** (likely)
Class 6 very high	**4** (likely)
Class 7 existing mostly high	**5** (almost certain)
Class 8 existing mostly very high	**5** (almost certain)

Table 2. Developing likelihood scores for the Salinity Risk Matrix

DETERMINING THE CONSEQUENCE SCORE

This is a more subjective process, requiring ranking of the various WAA in terms of their relative potential impacts (i.e. the WAA may increase water table levels or impede groundwater flow, leading to increased soil and/or water salinity, and waterlogging).

WAA hazard	Consequence score for the salinity risk matrix
Larger dames 15 ML+	**5** (severe)
Larger dams 15 ML+ were the base of the dam is at least 1m above the water table at the end of summer.	**4** (considerable)
Smaller dams 5 – 15 ML	**4** (considerable)
Creek crossings	**3** (moderate)
Vegetation removal	**3** (moderate)
Obstructions	**2** (minor)
Excavation	**2** (minor)

Table 3. Developing consequence scores for the salinity risk matrix

DETERMING THE SALINITY RISK SCORE

The consequence and likelihood scores are then used to determine the salinity risk and an initial assessment of the application for a permit (approve or refuse) can be made on this basis (Table 4).

WAA example	Consequence score	Likelihood score	Salinity risk score	Initial permit assessment – example responses
Small dam located in Class 4 on the KI Salt Risk Map	4 considerable	3 possible	12 **moderate**	Approve subject to management conditions being met
Large dam, base of dam within 1m of water table in Class 5 on the KI Salt Risk Map	5 severe	4 likely	20 **high**	Refuse unless requested information addresses the issues
Creek crossing in Class 3 on the KI Salt Risk Map	3 moderate	2 unlikely	6 **low**	Approve with no conditions
Vegetation removal in Class 7 on the KI Salt Risk Map	3 moderate	5 almost certain	15 **high**	Refuse unless requested information addresses the issues

Table 4. Using the salinity matrix to generate the initial permit assessment response

WHAT TO DO IF THE SALINITY RISK SCORE IS TOO HIGH

It may be possible to reduce the salinity risk score by either reducing the consequence or the likelihood of the WAA producing an adverse impact.

A) REDUCING THE CONSEQUENCE SCORE

The only way to reduce the consequence score is to change the scope of the WAA proposal. For instance, the capacity of a proposed dam can be reduced or the dam can be sited off-stream, a pipe can be placed in the base of the dam wall or the number of culverts in a creek crossing can be increased.

B) REDUCING THE LIKELIHOOD SCORE

As the KI Salinity Risk Potential GIS Layer was generated for use at the regional scale and not the property scale, on-site inspection for salinity is recommended. This includes taking soil and water samples for salinity tests, determining how deep the water table is and looking for indicator plants. Such testing will confirm the existing mapped salinity risk potential class, or lead to an upgrading or downgrading of the classification.

WHAT TESTS ARE REQUIRED AND HOW TO TAKE THEM

A) Water

Water samples should be collected in a clean container and tested for conductivity using a lab approved calibrated salinity meter. Due to inherent limitations with the KI Salt Risk Map, it is proposed as a minimum that site photos, water and surface soil salinity readings should be submitted with the initial application to help determine the initial Salt Risk Map Likelihood score

For creek crossings and removal of vegetation, surface water should be collected from creeks/waterways both above and below the location of the proposed activity. Samples need to be collected during summer (i.e. base flows not winter rains).

For dams, samples should be collected from creeks/waterways both above and below the location of the dam as well as samples of any ground water (if present). Ground water samples can be collected when exploratory backhoe or augers holes are dug to test for clay suitability. For dams with a high salt risk rating score (>15) depth to groundwater table plus salinity needs to be recorded in late summer/early Autumn and mid-Winter.

Remember the water table is a subdued reflection of surface topography i.e. as you go up the hill, the water table is deeper and thus the risk of salinity decreases.

Refer to Appendix 2 for interpretation of results.

B) Soil

Soil samples need to be collected and analysed by an accredited lab for EC and texture to determine the soils ECe.

For creek crossings and removal of vegetation, a representative soil sample (of at least 25 cores in the surrounding area) at 0-10cm deep plus samples from the clay layer need to be collected during late summer/early autumn.

For dams, top-soil samples should be collected as well as samples at depth (clay horizons). Samples of the sub soil layers (from each distinct horizon layer – or a collective sample every 1m) should be collected as the holes are dug for clay suitability. Samples also need to be collected from at least 1m below the base of the dam. (Even with a well-constructed dam, the clay will be saturated and the hydraulic pressure will lead to the rise of the water table in that area, hence any salts in the area will be mobilised and brought to the surface).

Do not locate dams in areas with shallow saline water tables, ensure the base of the dam is at least 1m above the water table at the end of summer.

Refer to Appendix 1 for interpretation of results.

C) Indicator plants

Record if any of the species below are in the near vicinity of the proposed activity:

- Hordeum marinum (Sea Barley Grass)
- Halosarcia sps (Samphire)
- Paspalum paspaloides (Swamp couch)
- Juncus acutus (Spiny Rush)
- Melaleuca halmaturorum (Kangaroo Island Paperbark)
- Polypogon monspeliensis (Annual Beard-grass)

D) SITE PHOTOGRAPHS

Take several photos to provide an indication of surrounding topography, vegetation types, natural drainage conditions; and provide a record for any future site inspection or monitoring.

MANAGEMENT REQUIRED TO REDUCE SALINITY RISKS

Effective management relies on the sound construction of the dam or creek crossing. The information provided below relates only to reducing the risk of salinisation. It is not a full list of criteria required for the construction.

A) DAMS

The key risk factor with the construction and siting of dams, with respect to salinity, is the raising of the hydraulic head of surrounding ground water systems giving potential for ground water to come to surface. Leaking dams can exacerbate seepage areas.

Steps to reduce the risk of salinisation:

Factor	Desirable	Undesirable	Potential issues	How to test
Clay %	A minimum clay content of 30-40%.	Gravel or sand seams Rock	Without sufficient clay content, soil pores will leak	Hand ribbon texture length 40mm >30% clay, 50mm>40% clay
Dispersion	Low to moderate dispersion. Some dispersion enables fine clay particles to mobilise when wet to seal soil pores	Non-dispersive clays can behave like gravel with high permeability. Highly dispersive clays can lead to dam wall failure	Highly dispersive soils (ESP >15) are prone to tunnelling. Good compaction of mod-highly dispersive soils at the correct moisture content can reduce the risk.	Observe a crumb of dry soil placed in fresh water. Dry soils with no or low spontaneous dispersion, but disperse after working when moist (shaken in a jar of water) are most suitable. Dry soils that spontaneously disperse are prone to failure Soils that do not disperse, even after shaking, will be difficult to make water tight. Recommended Lab analyses – Exchangeable Sodium Percentage (ESP)
Linear Shrinkage	Less than 15%	More than 15%	Low linear shrinkage reduces the risk of shrinkage cracks and dam leakage	Work the soil into a wet state, (with a texture similar to whipped cream), make a 200mm long mould (using a 12mm diameter split PVC tube) allow soil to dry and measure % shrinkage
Organic Matter	Negligible organic matter	>0.5% organic matter	Organic material is considered unstable for dam construction	No tree branches, roots, organic or other perishable materials should be placed in the embankment Tree roots should be removed and holes plugged with impervious clay. Dam banks must be kept free of trees and shrubs (tree roots can puncture dam walls causing leaks)
Permeability	Less than 0.0036mm/hr		Potential for dam leakage	Cut the bottom off a plastic drink bottle. Fill the neck and part of the main bottle with clay to be used in dam construction. Fill the remainder of the bottle with water. Fix the bottle to a stand with the neck pointing downwards. Leave for 24 hrs, if no water leaks through the clay should be water tight.

Table 5. Testing clay suitability for dam construction

However water tight dams can still exert a hydraulic head effect hence the requirements for:

- Foundation of the dam should be above the highest seasonal ground water table height
- Placement of a pipe in the base of the dam to allow for removal of saline base flows in winter
- Ensure the dam is well compacted during construction:
    - Dam embankment should be constructed from soil that is sufficiently moist to be pliable without crumbling but not so wet as to be sticky (roll a small ball of clay into a ‘rod’ between your hand and a smooth hard surface. If you can roll to the thickness of a pencil (7mm) soil moisture is near optimum, if it crumbles it’s too dry, if it sticks to hand it’s too wet).
    - The thickness of the clay to line the dam should be up to 2.5m or more especially at the dam wall. Add the clay in 200mm layers compacting each layer before adding the next.

B) CREEK CROSSINGS

Note: in the wording of Water Affecting Activities the terminology refers to the erection, construction or placement of any building or structure in a watercourse or lake or on the floodplain of a watercourse. The information below relates specifically to creek crossings as they are deemed to be the most likely form of obstruction placed in a watercourse, however the guidelines will relate to any structure.

The key risk factor with the construction and siting of creek crossings, with respect to salinity, is the potential to disrupt the natural water flows. Pooling of water above a structure has the potential to cause saline water pools as water is left to evaporate rather than drain naturally away.

Steps to reduce the risk of salinisation:

- Set the floor of the culvert at or below the creek bed to avoid creek pooling
- Ensure culverts are kept clear of debris
- Refer also to steps below for vegetation removal

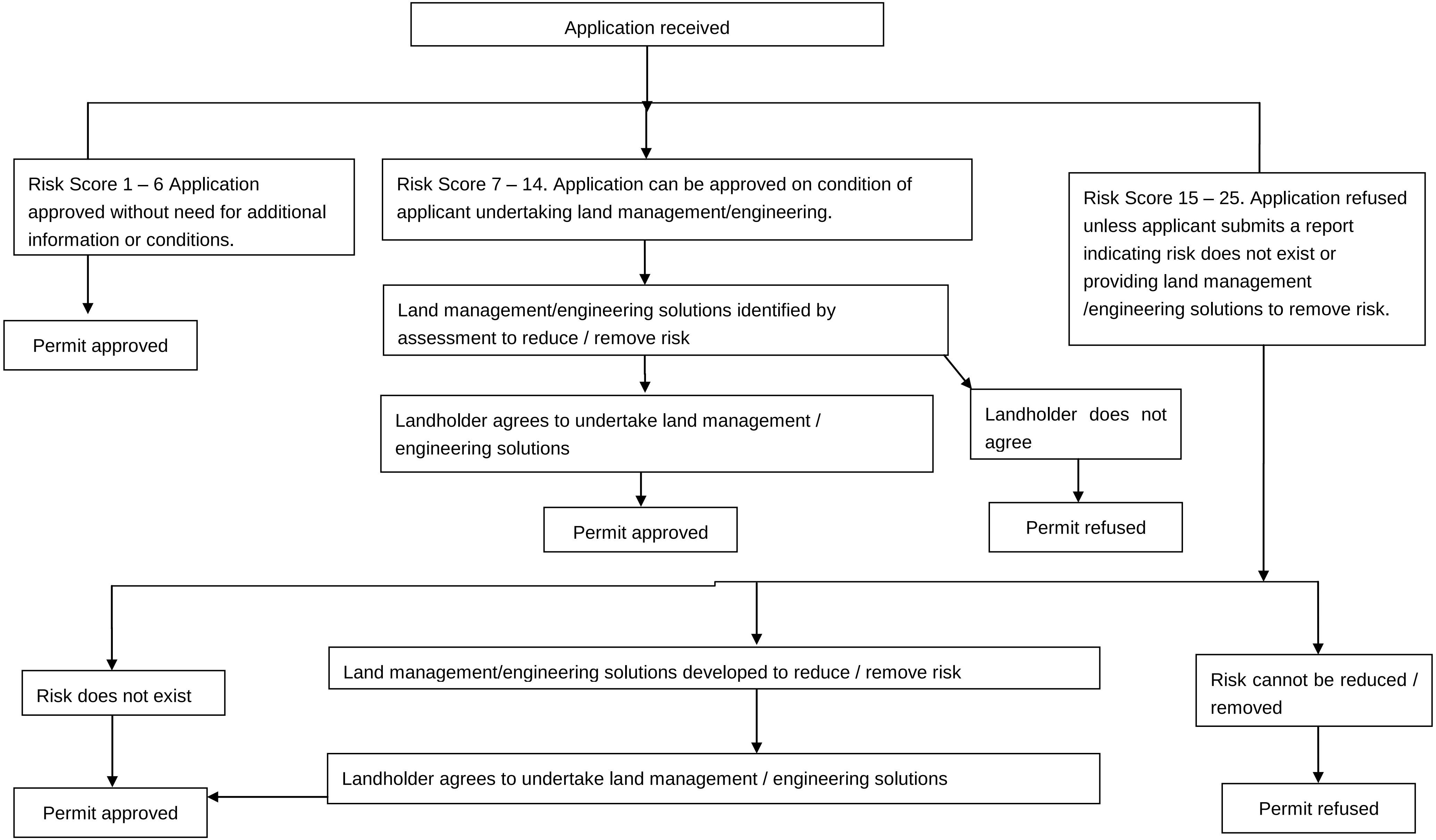
C) VEGETATION REMOVAL

Water table recharge occurs over all the catchment, but removal of vegetation will result in a decrease in evapotranspiration and direct evaporation from the canopy and these processes are critical, ensuring water tables do not rise. The clearance process may also increase the risk of soil erosion. Once top soil is lost, salinity may occur where the exposed sub soils have a higher salt content and further evaporation will concentrate the stored salt.

Steps to reduce the risk of erosion which may exacerbate salinization;

- Ensure no or limited soil disturbance during the clearing process
    - Where possible, remove trees by cutting at ground level and painting the stumps to prevent regrowth
    - Dig shallow drains to divert any water flows away from the site until it is stabilised
- Maintain ground cover
    - Fence the area to reduce grazing pressure
    - Use of weed mats or mulch to cover the bare areas
    - Re-establish cover i.e. perennial grass such as kikuyu, or use of quick growing native plants and ground covers

FLOW DIAGRAM OF THE PROCESS

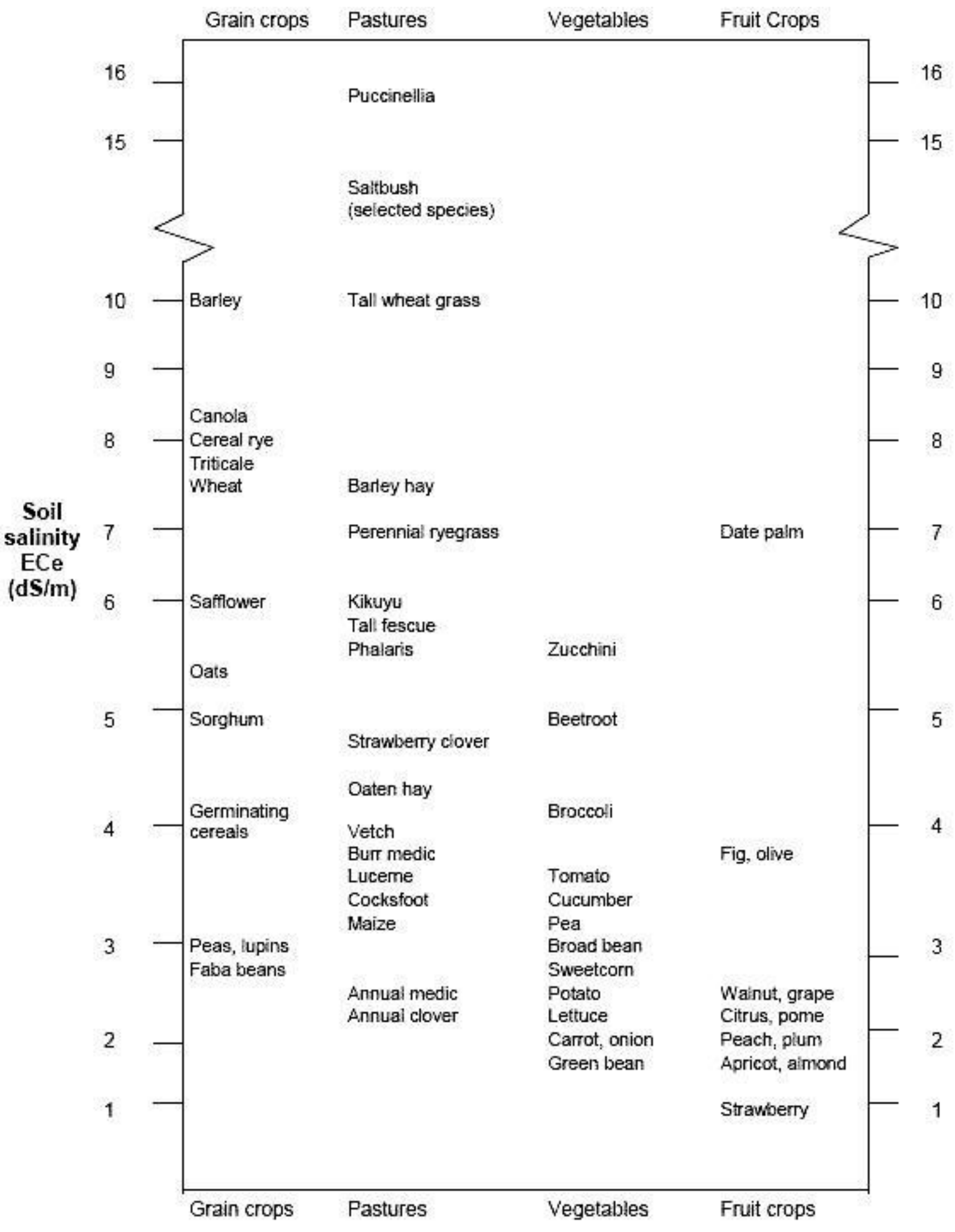


APPENDIX 1- RELATIVE TOLERANCE OF PLANTS TO SOIL SALINITY

HOW TO USE THIS CHART

Convert the EC (1:5) extract figure to "ECe (est.)" using the texture conversion indicated below. Plant names are positioned at the soil salinity figure which will cause a 10% yield reduction.

Soil texture	**Conversion figure (ie EC x conversion figure = ECe**
Sand – clayey sand	14
Sandy loam – clay loam	9.5
Clay to heavy clay	6.5



APPENDIX 2- RELATIVE TOLERANCE OF PLANTS TO WATER SALINITY

Many factors determine whether water of a certain quality will be satisfactory for a particular plant. The table below should be used as a guide only.

- Saline water progressively reduces growth and yield long before visual symptoms (e.g. margin leaf burn) are apparent
- The water salinity limits assume the worst soil drainage conditions ie it is likely higher levels of salt could be tolerated on well drained soils.
- Salty water should not be sprayed onto foliage, especially during the heat of the day.
- When using salty water it is most important to keep the soil moist ie adequate water supplies must be available to avoid a "wet and dry" watering cycle where soil salinity increases dramatically as the soil dries out. Avoid frequent light watering's, rather apply enough water, at each watering, to leach accumulated salts below the roots of the plants.

GUIDE TO SALINITY TOLERANCES FOR IRRIGATED PLANTS

Salinity (mS/cm)	**Crops, Pastures and Lawn Grasses**	**Flowers and Shrubs Ornamentals**	**Fruit**	VEGETABLES
0.47		Violets	Loquat	
1.09-1.25	Bent grass	Aster, begonia, fuchsia, rose, azalea, camellia, gladiolus, zinnia, bauhinia, dahlia, poinsettia, magnolia, gardenia	Avocado, walnut, blackberry, strawberry, cherry, passionfruit	French beans, peas
1.33–1.56	Field peas and beans, Broad bean Flax	Bougainvillea, hibiscus, carnation, Vinca, coprosma	Apple, almond, apricot, grapefruit, lemon, orange, peach, pear, plum, raspberry	Beans, capsicum, potato, celery, radish, lettuce
1.87-2.11	Clover*, bluegrass, rye grass, Groundnut	Chrysanthemum, oleander, stock	Fig, grape, olive, pomegranate, quince, mulberry	Broccoli, onions, carrot, cauliflower, gherkins, sweetcorn, cantaloupe, potatoes, cucumber
2.73	Rice (paddy)			Artichoke, tomato
3.13–3.28	Berseem clover*, corn, millet, soy bean, sudax, lucerne, safflower			Asparagus, cabbage, beetroot, spinach
4.37	Phalaris*, sorghum, sunflower			
4.69	Tall fescue			
5.00	Fescue*, perennial rye grass*, Sudangrass*			
5.78	Barley, Cereals (wheat)*, cotton, sugar beet	Boobialla, Swamp yate, Ficus sps		
7.81	Santa Anna couch, Buffalo grass			
Up to 23.6	Kikuyu, Puccinellia, Saltbush, Salt water couch, Paspalum	Canary Palm, Salt River Gum, Tamarisks, Salt Sheoaks	Date Palm	

*relative yield for salinity figures is approximately 75%