PRACTICAL MEASURES WITHIN ROAD RESERVES TO AVOID DEVELOPMENT OF CATCHMENT SALINITY PROBLEMS

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ABSTRACT

Road Design and Asset Management Professionals typically give careful consideration to surface water issues associated with road design and construction. However they are often not as well informed about the nature and influence of groundwater flow processes on roads or of the influence of roads on those flow processes. This can result in road construction initiating or exacerbating land and water salinity issues or shallow water tables.

This paper recommends initiatives that pervade into the general specification of road reserve creation and management across Australia. The initiatives comprise succinct planning, design and management specifications or requirements that will reduce the risk that works will encourage the progressive development of shallow water tables and land and water salinisation. Requirements and criteria for design and maintenance are to be included in the AUS-SPEC contract document set. Examples are provided in the paper and industry wide assistance for future action is sought.

AUS-SPEC is proposed as one effective medium to communicate widely to the general practising professional without specialist knowledge of salinity problems in catchments. AUS-SPEC is licensed to over 199 Councils in all states and is targeting the achievement of a uniform base set of contract documentation for public works in Local Government across Australia. The initiatives proposed involve amendments to specification sections that deal with stormwater drainage, sub-surface drainage, control of erosion and sedimentation and landscaping.

1. Introduction

Road reserves are strips of land designated for the provision of roads. The road reserve typically has a road pavement and some provision for drainage. It includes verge areas and a buffer zone inside the typically fenced boundaries which mark the adjoining "titled" land. Road reserves are dedicated to provide mobility to communities and they do not consider environmental effects as primary issues. Most road reserves were dedicated prior to requirements for environmental impact studies.

An aerial survey of any rural area in Australia will indicate that there is little chance of a valuable net result from environmental protection measures in the paddocks and bush blocks if care is not taken within the road reserves which criss-cross the terrain, often in cuttings and embankments that intercept both surface and subsurface water drainage.

Road reserve management is the responsibility of State and Local Government. The design, construction and maintenance of roads and road reserves is typically managed by professionals who need to balance the needs of traffic, pedestrians, and cyclists, using the road with the amenity afforded the neighbouring landowners, and also environmental preservation issues.

An environmental issues list for a road reserve professional will include:

1. Noise pollution
2. Air pollution
3. Surface water quality downstream

4. Preservation of indigenous flora and fauna
5. Groundwater quality downstream
6. Preservation of soil health in the reserve and immediately adjacent land
7. Erosion and sedimentation in the reserve and on immediately adjacent land and receiving streams.

The purpose of this summit is to address salinity development and its detrimental economic and environmental consequences. Salinity development entails the abnormal concentration of salts in surface soils and shallow substrata as a result of high groundwater and evaporation processes. Salinity at this level is deleterious to the soil health and productivity and can contaminate runoff so as to transfer the problem to further areas. In this regard issues 3, 4, 5 and 6 above need the attention of the "Road Reserve Manager".

Works carried out in the road reserve to enhance the level of service provided to the community or address other issues on the list above may have detrimental effects in deteriorating water quality downstream or effecting the nature and health of the local soils.

Works related to both construction and maintenance are controlled by specifications which define both design and construction procedures or outcomes. Specifications are relevant to both work contracted out by the "Road Reserve Manager" (RRM) and also work supervised by the RRM utilising available resources directly under his/her control. The intention of this discussion is to review the AUS-SPEC construction and maintenance specifications in the context of avoiding salinity damage. Improvements that can be identified will benefit the community and will be able to be incorporated in AUS-SPEC and other specification sets.

This paper is considered to broaden the scope of issues considered in Works specification for road reserves.

2. Terrain and Climate Effects

Decisions on road alignments when new roads are built typically consider terrain and climate effects in terms of the geometry of the alignment, the cost of construction and the effectiveness of surface drainage.

Works specifications for road reserves are typically adopted independently of the local terrain and climate. Unfortunately the terrain and climate have a pronounced effect on the volume and rate of flow of both surface and subsurface waters which intercept a road reserve. Accordingly the issues of surface water quality and subsurface water quality are influenced.

Specifications currently focus on road quality as it affects performance and maintenance costs as well as erosion and sediment control, and effective surface water transmission across the road reserve. In some terrain conditions the preventative measures to limit erosion and sedimentation may aggravate salinity problems.

Areas prone to salinity problems on the basis of climate topography and geology have been mapped and can be identified for special specification reference by State and Local Government. Local terrain and geomorphology can be classified described so as to alert road designers and specifiers when there is a higher than usual risk of developing salinity problems. Specification services like AUS-SPEC, and those provided by State Government Authorities like the Roads and Traffic Authority, can provide precautionary clauses for design and construction specifications for such areas.

Figure 1 illustrates the classic flat land scenario which many road professionals identify as a drainage problem and also in recent years a salinity problem. The road designer, as always, is traditionally attempting to balance three predominant issues:

1. The cost of earthworks when flat terrain over extended distances means embankments require fill material imported from outside the intended construction area.
2. Adequate support for the pavement layers to provide for traffic over a designated design life when subgrade strengths are poor, especially when damp.
3. Effective drainage of the road pavement run off and cross country run off to minimise dampening of the subgrade.

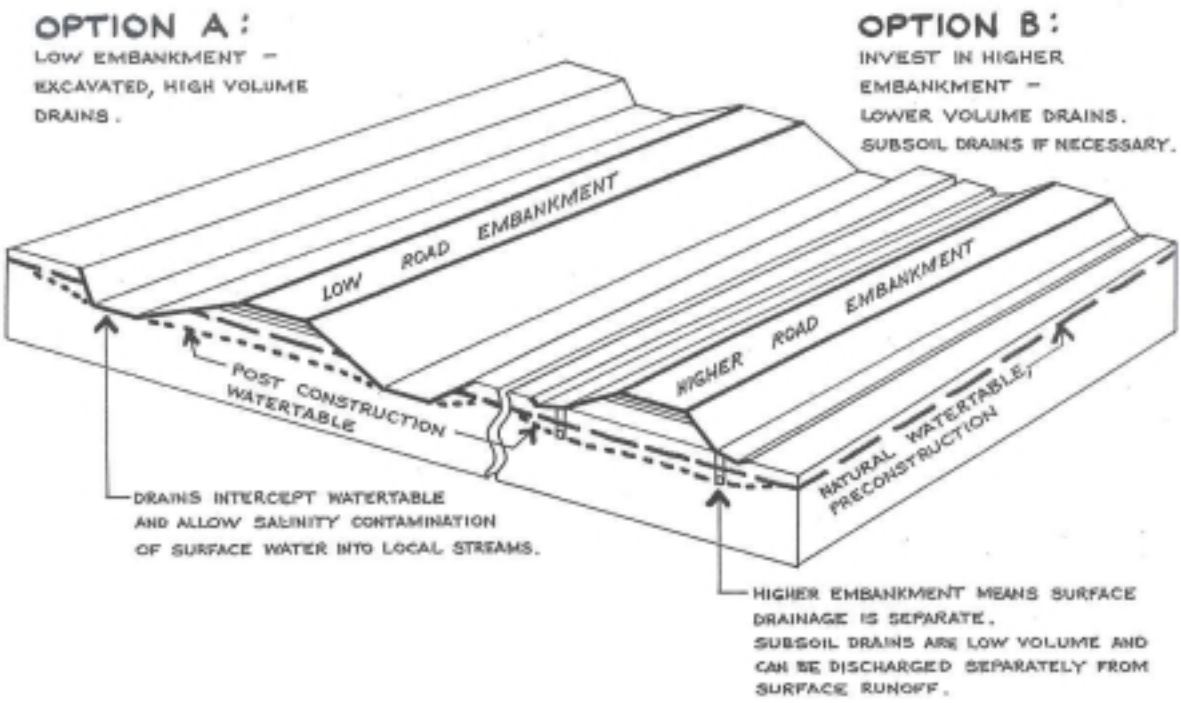

Figure 1: Drainage Configurations in Flat Terrain

The figure shows the traditional design solution (Option A) which addresses the predominant issues but ignores the propensity for this configuration to progressively lead to salinity damage to the road reserve which is considered at this stage practically irreversible. Unfortunately the contaminated water in the drains is typically "turned out" into adjacent pasture when rainfall allows sufficient head in the flat terrain. This discharge spreads in the flat country risking salt contamination in further acres that constitute productive land.

Option B in Figure 1 recommends ideally that embankment heights are increased to provide "adequate cover" of the weaker and damper subgrade. The cost of the imported material needs to be balanced with the lost value of adjacent road reserve and productive land deteriorated due to poor soil health caused by salinity effects. The required embankment cover may be reduced by use of better embankment material or improving the embankment material by stabilisation processes and these processes need to be considered.

In many cases the water table will still require local lowering by provision of subsoil drains as indicated. In terms of salinity treatment it is important to ensure that the subsoil drains do drain effectively and separately from the surface runoff captured in the shallower table drains. It may be necessary to concentrate and encapsulate the salt from the subsoil drainage into separate "pits" for containment and periodic removal. Should discharge of the contents of these "pits" to streams be

considered reference to appropriate Environment Protection authorities in the relevent State would be required to determine acceptable resultant salinity levels in the streams.

Figure 2 illustrates the rolling hill and tableland terrain where salinity issues should be addressed but are often unexpected and not considered. Figure 3 illustrates some of the likely effects of road embankment construction in the inappropriate zone of terrain. The basic philosophy again is to avoid the mixing of groundwater and surface water, and the interruption or delay of groundwater discharge. Similarly surface water that mixes with groundwater increases the height of the watertable and is likely to result in upward salinity migration. Once the watertable is within approximately 2 metres of the surface salt tends to be concentrated by evaporation of the groundwater as water from deeper strata is drawn to replace losses in an upward hydraulic gradient

The ability of the "aquifer" below the water table to transmit any recharge (surface infiltration to the aquifer) downstream beyond any flow restriction constitutes the basic test for an emerging salinity problem. This can be remembered as:

Recharge > Transmission = PROBLEM

Unfortunately it is far too costly to use quantified hydrological studies to identify these situations. Avoidance is the recommended strategy.

Avoid Zone 2 in Figure 2 where there is a greater lateral flow component to groundwater movement
Avoid interference with the "aquifer" by excavation or unwarranted compaction in Zone 2 which will reduce transmission (see Figure 3).

Avoid drains for surface water that are deep enough to result in recharge from surface drainage concentration (see Figure 1).

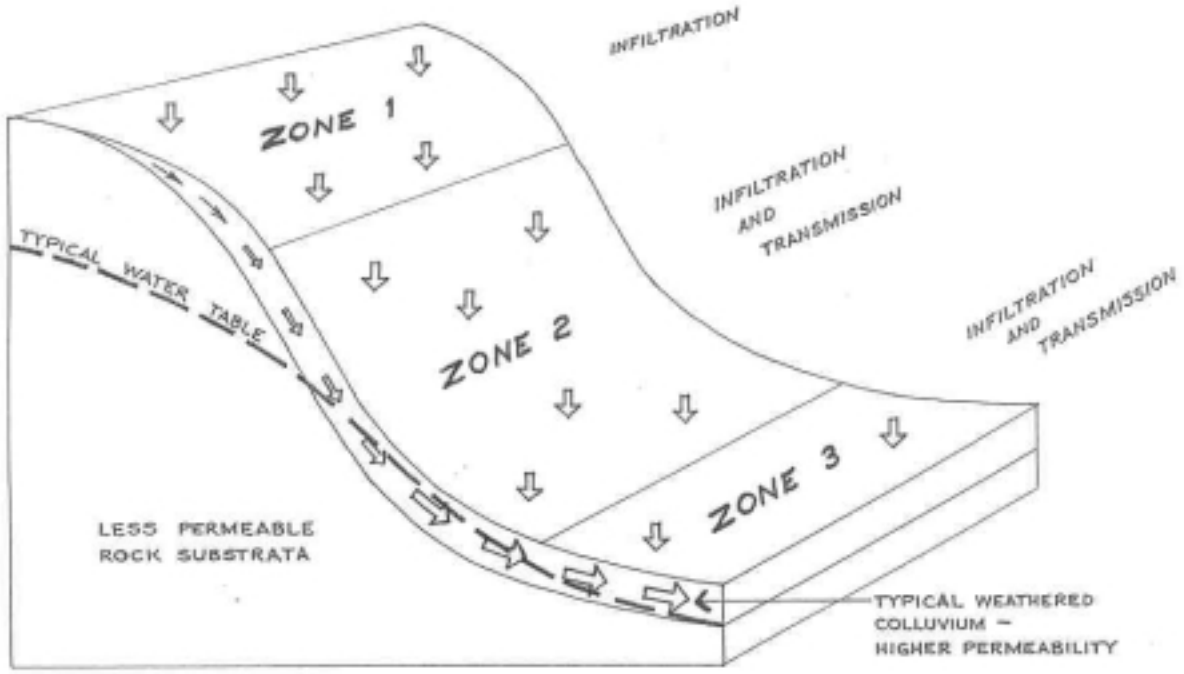

Figure 2: Groundwater Issues in Hilly Terrain

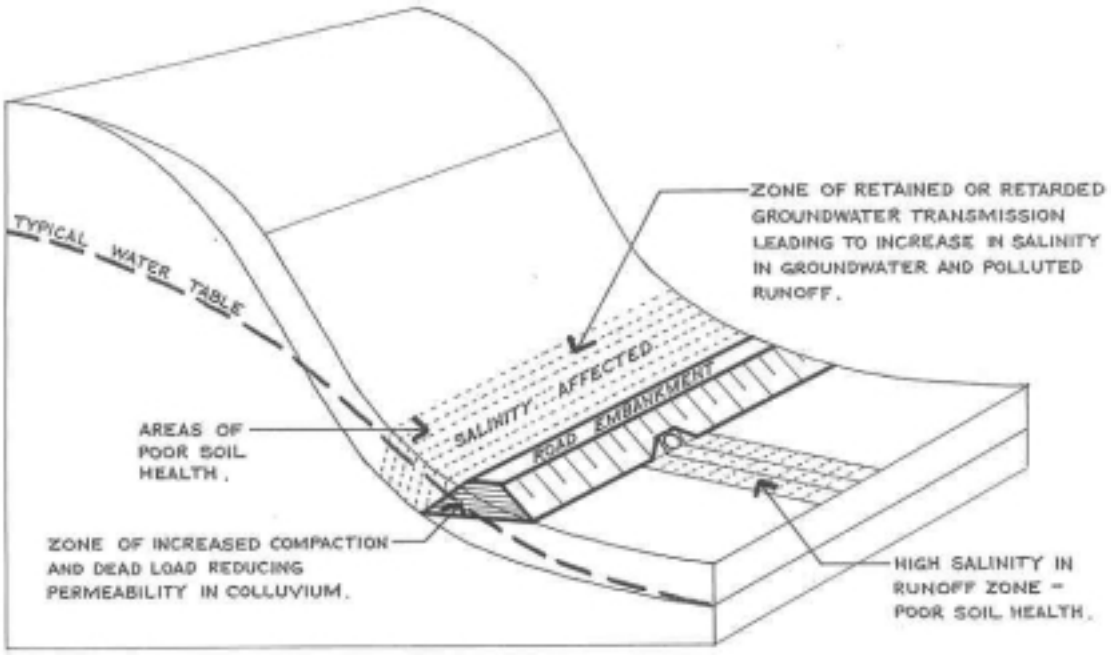

Figure 3: Salinity Issues for Critical Road Positions

When designing Works for road reserves in areas prone to salinity problems, the following "DESIGN DON'TS" apply:

- DON'T design road alignments to intercept known salt affected areas;
- DON'T discharge surface drainage immediately upstream of groundwater discharge areas or salt affected land;
- DON'T site sedimentation/detention basins in the immediate vicinity of groundwater discharge areas;
- DON'T design drainage that excessively concentrates surface runoff.

In undertaking Works in road reserves in areas prone to salinity problems, the following "CONSTRUCTION DON'TS" apply:

- DON'T exceed the design dimensions for surface drainage without consideration of subsurface drainage and reference to the Designer;
- DON'T expect vegetation, which is planted to stabilise erodible soil and capture sediment load from surface drains, to flourish if the drainage is contaminated with salt upstream.

3. Surface Drainage

Design and construction of provisions for surface drainage in road reserves tend to follow the same guidelines as those proposed to control other water pollution. Given that recognition of the salinity problems of some terrain and climate factors are dealt with as in the previous section, there is no apparent conflict in designing surface drainage to reduce water pollution generally.

There are some basic rules of design that need to be addressed which may not have been adequately emphasised in the past. They are as follows:

1. Collect and transmit natural runoff such that it is not mixed with road surface run off which is to be considered contaminated.
2. Do not allow surface drainage to enter the subsurface drain system.

In the context of reducing salinity problems the following "DESIGN DON'TS" apply:

- DON'T consider that treatments such as detention basins, sedimentation basins, bio-retention zones and grassed swale drains assist in reducing salinity problems. They only address non soluble particulate pollution.
- DON'T design detention basins, sedimentation basins, bio-retention zones, without ensuring that the installations do not leak and recharge the water table thereby exacerbating the salinity problem downstream.

4. Subsurface Drainage

Works in road reserves sometimes require subsurface drainage. Usually the reasons for subsurface drainage comprise one or more of those listed below:

- Lower moisture in subgrade materials to improve bearing strength.
- Lower moisture in subgrade materials to control consolidation (settlement) during the service life of the road.
- Protect pavement materials from deterioration due to moisture.

In areas with a track-record of salinity problems subsurface drainage may be prescribed to keep the watertable lower in the strata so as to avoid progressive deterioration of the health of topsoil and upper layers due to salinity levels increased by rising and/or fluctuating water tables.

The basic design approach should be to lower the watertable only in the vicinity of the road embankment and only to the extent required to meet the requirements determined for the design and for the construction process.

In reducing salinity problem potential whilst meeting the design requirements, the following "DESIGN DON'TS" are suggested in relation to design of subsurface drainage systems:

- DON'T excessively "transport" water entrapped in subsurface drains. Endeavour to outlet the subsurface drain in the same sub catchment and on the downstream side of the embankment rather than overloading the natural ground drainage on the upstream side of the embankment.
- DON'T allow natural surface run off and/or road pavement run off to enter and mix in with the subsurface drainage.
- DON'T plan to discharge salt contaminated groundwater to streams

Some "CONSTRUCTION DON'TS" which assist in reducing salinity effects from subsurface drainage include:

- DON'T allow extensive batter areas on the side of road embankments to act as "sponges" in absorbing runoff, and particularly contaminated road pavement runoff. Reduce permeability by material selection, compaction, stabilisation or appropriate rapid vegetation.
- DON'T reduce the number of subsurface drain outlets for reasons of cost or convenience.

5. Vegetation

Vegetation establishment can assist in the mitigation of salinity and water quality hazards associated with construction and operation of roads. While features such as grassed swales and bio-retention zones may be used to good effect in reduce suspended sediment and other adsorbed contaminant loadings in road run-off, they offer little value in mitigating salinity hazards.

Establishment of deep-rooted, perennial vegetation is one of the key recommendations in almost all of the dryland salinity control strategies that have been developed in Australia. Trees, shrubs and deep-rooted perennial pastures are used to reduce the leakage of water to groundwater systems and thereby slowing or reversing rising water table trends in salt-affected catchments. The perennial nature of such vegetation allows it to use water when it is available and the deep roots allow it to create a "buffer" of dry soil to prevent or reduce infiltration to the water table during periods where rainfall exceeds evaporative demand. Native trees, such as the eucalypts, wattles and casuarinas, are widely used in this role. Native and introduced perennial grasses and fodder plants are also used in agricultural settings.

The characteristics of deep-rooted, perennial vegetation can be used to good effect in the mitigation of salinity hazards associated with roads. Belts of trees and shrubs may be used in landscape settings such as that depicted in Figure 3 to remove soil water or groundwater whose movement downslope is impeded by road embankments. They may also be used in a similar "dewatering" role downslope of the road, at locations where road run-off or overland flows from upslope of the road are dispersed onto land adjoining the road reserve and might otherwise create a point source of groundwater recharge.

The effectiveness of trees and shrubs in this role should not be overestimated, particularly when they are young. Establishment at or before the time of road construction may be required to ensure that the vegetation has developed to an extent that it has sufficient water use capacity to fulfil this role. Multiple row belts and relatively close spacings are recommended. Indigenous species would generally be preferred, however if the sites are likely to be particularly water-logged, other, more tolerant species may be required. State government natural resource management agencies, Greening Australia and some nurseries can provide advice on species selection.

Vegetation will have a much more limited role in mitigating the effects of salinity in valley floor or plains environments where water tables are already relatively shallow (e.g. Figure 1). In some settings, densely planted belts of trees may be able to lower the water table in the vicinity of roads in similar way to sub-surface drainage. However, plantations may not be able to sustain such a function in the long-term if the groundwater is saline and would need to be established in a way that avoids plants being exposed to prolonged water-logging when young.

Vegetation may be established to stabilise soils or improve landscape values in highly saline environments, however they are unlikely to mitigate other impacts. There is a wide range of Australian native species that are suited to such environments. Vegetation cannot be used to remove salinity from affected areas.

Salinity hazards in some road settings relate to the management of the catchment through which the road passes. If salinity hazards cannot be avoided through planning or design, it may be useful, over the long-term, to adopt a catchment management approach to salinity mitigation. The road authority may need to cooperate with landholders in catchment upslope of the road reserve to achieve a long-term change in the management of the catchment. Again, establishment of deep-rooted perennial vegetation – trees or pastures – across the majority of the catchment would be recommended. This may reduce water table recharge at its source and in the long-term reduce reliance on engineering measures and off-site effects associated with drainage of saline groundwater.

Some vegetation “DESIGN DOs" to improve salinity levels are as follows:

- DO select appropriate indigenous or native species for plantings in association with road reserve works.
- DO design plantations to be of sufficient size and density to be effective in their proposed role.

Some vegetation “CONSTRUCTION DOs" to improve salinity levels are as follows:

- DO use best practice in establishing plantations to ensure rapid early growth
- DO establish vegetation at an early stage in road construction activities to ensure it becomes effective as early as possible.

6. Identified Road Reserve Salinity Actions

The discussion above based on industry experience and some limited literature search suggests that education of Designers involved in road design and road rehabilitation design will be the best pre-emptive action in reducing both this generation’s and the next generation’s salinity based deterioration of land quality and water quality.

In this regard this paper and even this summit can only start the process. Adjustments to design practice will most effectively be made via Specifications and Training Procedures. AUS-SPEC and similar specification services are an obvious target for improvement to salinity design considerations.

AUS-SPEC comprises a series of specification and contract documentation products which have been developed principally for Local Government under a Joint Venture between the Institute of Public Works Engineering Australia and Sinclair Knight Merz. The products are sold as electronic documents under license. They are reviewed and updated on an ongoing basis and seek to enable a much more uniform standard of infrastructure delivery, rehabilitation and maintenance across Australia. Over 195 Councils hold AUS-SPEC licenses currently across all states of Australia. AUS-SPEC cites requirements and testing methods from Australian Standards wherever appropriate. AUS-SPEC is referred to in several university undergraduate programmes. A website and update bulletin board is provided by AUS-SPEC as well as a subscription for annual document updates.

AUS-SPEC is perceived to be an obvious platform, though not the only platform, from which to launch information to improve design and construction practice within the road reserves.

AUS-SPEC is using this summit to announce its intention to redraft some key sections of AUS-SPEC #1 and AUS-SPEC #2 to draw attention to salinity prevention measures and possible clashes with current industry practice focussed on other environmental and sustainability issues at sites sensitive to salinity damage. Primary drafting will be the responsibility of the AUS-SPEC author team, however, suggestions from attendees at this summit and other industry stakeholders will be appreciated. The changes will not be major or voluminous but will hopefully be very effective.

In AUS-SPEC #1 Development Specification Series – Design, the editorial insertions will alert the reader and engineer/designer in Section DQS – Quality Assurance Requirements for Design, Section D7 – Erosion Control and Stormwater Management, and Section D6 – Site Regrading. The amendments will alert the designer of the possible deleterious effects of some design practices for salinity sensitive areas ensuring alternative design options are considered with a view to providing a road reserve that reduces rather than contributes to any salinity increment in groundwater and upper soil profile.

In AUS-SPEC #1 Development Specification Series – Construction, the editorial insertions will require specific consideration of salinity problem prevention in general execution of the works under

Environmental Requirements in the Specification C101 – General as well as the following specification parts:-

- C211 Control of Erosion and Sedimentation
- C212 Clearing and Grubbing
- C220 Stormwater Drainage – General
- C230 Subsurface Drainage – General
- C273 Landscaping

AUS-SPEC #2 – Roadworks Specifications will receive similar editorial treatment to AUS-SPEC #1.

7. Industry Collaboration

This is an industry-wide action that also requires landowners and land users to take complementary action. AUS-SPEC will ensure that the additional wording inserted and any diagrammatical work developed will be freely available for use in other specifications. The scripts will be made available on the AUS-SPEC web page that can be accessed via the IPWEA web page and SKM Consulting web page.

Industry wide input is sought during August-September to enable finalisation and web publishing in November 2001.

8. Conclusion

This paper has been confined to discussion of the level of awareness of salinity issues across the road infrastructure industry, the identification of areas where practice can be improved, and the identification of an initiative to encourage best practice.

It is argued that road designers and constructors do not typically have knowledge of the emerging salinity problems in most states of Australia. Practice can be improved dramatically and in the short term by inserting amendments in design and construction specifications. The authors have a commitment from the AUS-SPEC Joint Venture to prepare such insertions for the AUS-SPEC documents after requesting submissions and input from the industry.

Rather than detailed requirements that need to be site specific, the insertions will take the nature of warnings and policies. In the interest of dissemination the scripted insertions will be published on the AUS-SPEC website as available, for usage in other document sets.

References

AUS-SPEC Joint Venture (1996 ongoing) AUS-SPEC Contract Document Series.
Institute of Public Works Engineering Australia and Sinclair Knight Merz.
WEB SITE http://www.ipwea.org.au/AUS-SPEC