Appendix B

Salinity Management Guidelines

Contents

The Department acknowledges Douglas Partners Pty Ltd and Sydney Environmental and Soil Laboratory, Blacktown City Council and Landcom for sections of this document taken from the Salinity Management Report for Second Ponds Creek (1998).

1 Introduction

This Salinity Management Guideline contains background information, salinity risk mapping and management recommendations to control the effects of urban dryland salinity for proposed residential development within the Camden and Liverpool Growth Centre Precincts in the South West Growth Centre.

This Management Plan is based on the findings of relevant studies undertaken for Precinct Planning, relevant guidelines and policies in relation to urban salinity management and examples of salinity management plans prepared for other western Sydney urban release areas. In particular, these guidelines adopt the approach taken in the Salinity Management Plan prepared for the Second Ponds Creek release area in north-western Sydney. This guideline includes:

- general information on the causes and effects of urban salinity;
- findings and conclusions from GeoEnviro's Geotechnical, Salinity and Acid Sulphate Soil Investigation for the Austral and Leppington North Precincts (2011).
- Recommendations, measures and general guidelines for site development and construction, covering water management, site development and buildings.

The aim of this guideline is to present practical recommendations about how to manage and, where possible, mitigate the existing saline conditions on site, so as to:

- limit any impact of salinity on roads, buildings, vegetation, underground services, water courses and storages; and
- limit the impacts of development in the precinct on the processes of salinity and the impacts of salinity on the environment.

This guideline is broadly applicable to Precincts to which the Liverpool Growth Centre Precincts DCP 2011 or Camden Growth Centre Precincts DCP 2011 applies. However, more specific assessment of salinity issues for individual Precincts may identify the need for further investigation, more stringent or different controls and management measures for salinity in some situations.

1.1 Background

1.1.1 Proposed Development

Planning for South West Growth Centre is expected to provide for up to 110,000 new homes, developing progressively over the next 25 to 30 years, together with essential facilities and open space. The Precincts will be supported by Town Centres and smaller neighbourhood centres will provide local retail and community services. Several infrastructure upgrades are planned including new road crossings and the South West Rail Link which will improve regional links to surrounding areas.

1.1.2 Salinity Risk Maps

A review of the Department of Natural Resources Map of Salinity Potential in Western Sydney (2002) indicates that much of the South West Growth Centre is prone to salinity risks to varying degrees, including significant areas that are classified as either Moderate or High Salinity Risk. The general risk assessment has been supplemented by specific salinity risk assessments for Growth Centre Precincts that have been released for Precinct Planning. A **Salinity Risk Map** in the relevant Precinct Schedule to the DCP identifies areas of salinity risk in the Precinct.

1.2 The Causes of Urban Salinity

Soils containing salts occur naturally in western Sydney due to underlying geological formations. In undisturbed areas the salts are generally stored below the plant root zone where they have minimal impact. The development of Western Sydney has disturbed the soil profile, altered hydrological processes and, in some areas, led to concentrations of salts on soil surfaces, in building materials, and waterways. Some Precincts are located within an area that is predisposed to developing salinity issues.

Although saline soils and groundwater are a natural part of the Australian landscape, land management practices are now increasingly recognised as significant contributors to the expansion of salt affected areas. In particular, urban salinity is increasingly occurring around populated areas due to clearing and site development.

Salinity occurs when salts found naturally in the soil or groundwater are mobilised. Capillary rise and evaporation concentrate the salt on, and close to, the ground surface. Urban salinity becomes a problem when the natural hydrogeological balance is disturbed by human interaction. This may occur in urban areas due to changes to the water balance, increases in the volume of water into a natural system altering subsurface groundwater flows and levels, exposure of saline soils, and removal of deep rooted vegetation reducing rates of evapotranspiration. Even small changes in sensitive areas can result in the balance being irrecoverably altered and salinisation occurring.

Some building methods may also contribute to the process of urban salinity. In particular, compacted surfaces and filling can restrict groundwater flow and result in a concentration of salt in one area. Cutting into slopes for building can result in saline soils or ground water being exposed and intercepted. The use of imported fill material may be an additional source of salt or the filling may be less permeable, preventing good drainage. These issues may also result in problems with the design and construction of roads. In particular, the building of embankments and the compaction of layers can interfere with groundwater flow. Also the inappropriate positioning, grading and construction of drains can result in surface and groundwater mixing and stagnant pools forming that evaporate leaving salt encrusted ground.

Salinity issues may also arise as the result of cumulative impacts. A common example is from the gradual removal of vegetation across a site, which can contribute to a change in the hydrological regime from reduced evapotranspiration, a consequential rise in the ground water table, and subsequent salinity problems. Where vegetation is gradually removed the water table rises as a result of a smaller volume of water being used by the plants, allowing salts to be mobilised. Of more relevance in an urban landscape is the potential for an increase in water inputs into the hydrological regime. These increased inputs commonly come from watering of gardens and playing fields, infiltration of storm water and sewage and other service leakage.

These inputs may seem minor on their own but their cumulative effects over time produce an elevated groundwater table and eventually high levels of salinity.

Figure 1 (from "Good Housekeeping to Manage Urban Salinity" by the Department of Infrastructure Planning and Natural Resources) illustrates the urban salinity process and identifies situations where salinity problems can develop due to inappropriate planning and design.

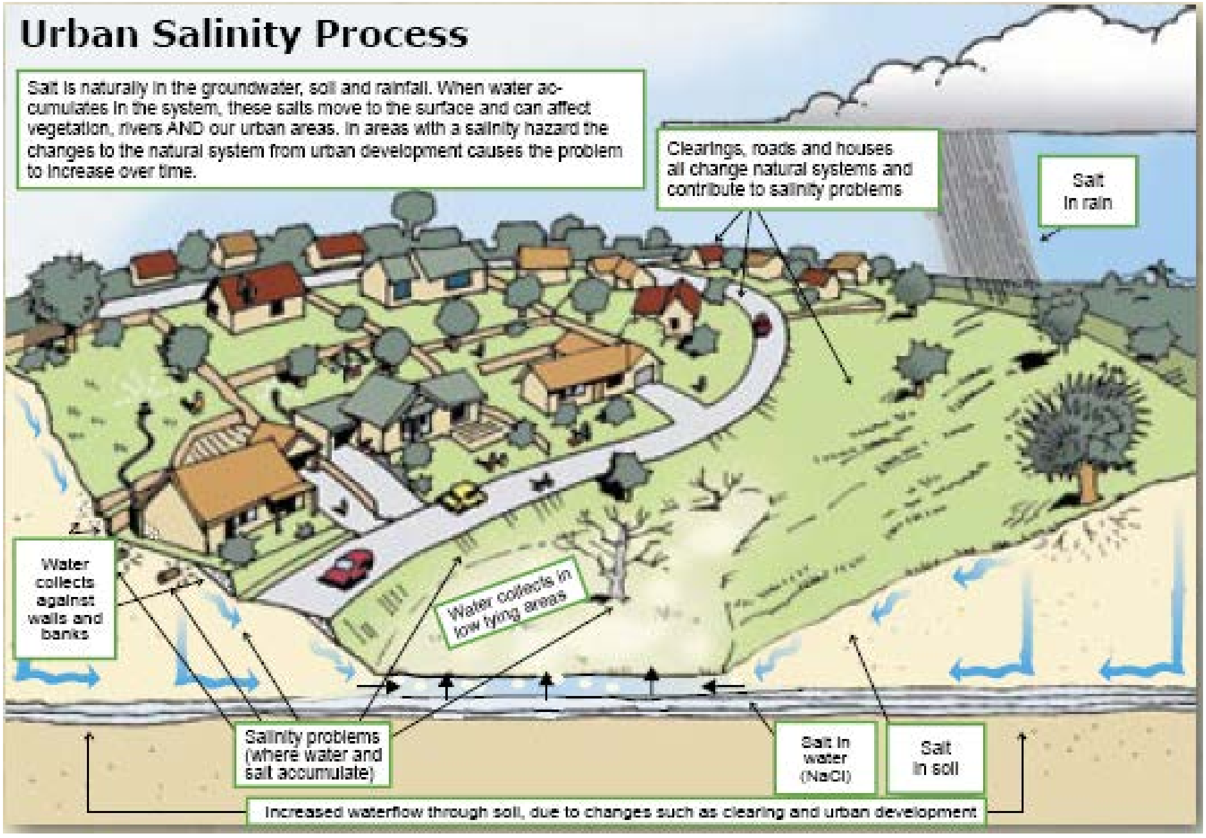

Figure 1: The Urban Salinity Process (DIPNR)

1.3 Effects of Salinity in an Urban Environment

Excess salinity in an urban environment can result in significant problems. It can manifest itself in a number of ways.

The effects of salinity can be observed in damage to building materials, infrastructure including pipework and roads and in death or poor health of vegetation. The effect of urban salinity is the result of both physical and chemical actions of the salt on concrete, bricks and metals. Salt moves into the pores of concrete and bricks and becomes concentrated when the water evaporates and can result in breakdown of materials and corrosion. Evidence of this may include crumbling, eroding or powdering of mortar or bricks, flaking of brick facing and cracking or corrosion of bricks.

High levels of salinity can result in damage to and even death of plants. Signs that vegetation is under stress from salinity include the discolouration and wilting of leaves and the death of less salt tolerant plant species. It may also be hard to establish lawns in areas that are subject to high salinity.

High levels of salinity may also affect soil structure, chemistry and productivity. This can reduce plant growth which in turn alters soil structure, chemistry and nutrient levels. As soils become more saline, plants and micro-organisms decline and soil structure deteriorates.

Water logging may also occur following a decline in nutrient levels. Over time, the alteration of soil structure can lead to the formation of gullies and other forms of soil erosion.

Salinity may also result in the corrosion of steel pipes, structural steel and reinforcement and can damage underground service pipes resulting in significant financial costs.

While limited groundwater was observed during the site investigations, these conditions may potentially change in periods of heavy downpour. Damage to pipes has the potential to exacerbate the problem by further recharging the aquifer.

Salinity can also have a significant effect on buildings and associated infrastructure where cutting and filling exposes buildings/structures to elevated salinity levels. This may include:

- degradation of bricks, concrete, road base and kerbing materials leading to expansion, cracking, strength and mass loss;
- corrosion of reinforcement and loss of structural integrity;
- rising/falling damp; and
- non-structural impacts, such as efflorescence on bricks.

These impacts can be prevented, minimised, or mitigated by the implementation of appropriate management measures as outlined in the Salinity Management Plan in **Section 3**.

2 Salinity Hazard Assessment

Salinity assessments undertaken as part of Precinct Planning are based on broad scale analysis of potential salinity risks including limited field sampling. The findings summarised in this section are indicative only of salinity conditions in the precinct. Further detailed salinity assessment investigation is only required if applicants wish to confirm site specific salinity conditions which may identify appropriate variations to these controls.

Salinity risk varies across the Growth Centres, and is often related to elevation, topography and the presence of watercourses. Saline groundwater is also an issue in most locations, although depth to ground water (below current surface level) varies considerably.

2.1 Salinity Risk Map

A **Salinity Risk Map** is included in the relevant Precinct's Schedule and is divided into:

- Low Risk Areas: The salinity of the area is considered typical of western Sydney. However, due to the broad nature of salinity assessments completed for most Growth Centre Precincts to date, the precautionary measures are to be implemented.
- Moderate or High Risk Areas: The salinity risk of the area is considered typical for creek line, floodplain or other low relief areas in western Sydney. These areas have a moderate or high risk of being affected by salinity and precautionary measures are to be implemented.

Note: *These maps are indicative only and site specific studies may be provided at the DA stage to determine salinity conditions and appropriate management measures which vary from these controls.*

3 Salinity Management Guidelines

3.1 Introduction

The Salinity Management Guidelines contain:

- general measures to consider across the Precincts, which include appropriate management strategies for the management of groundwater, site design and urban development, and measures to be taken at various stages of development; and
- strategies and measures for specific works in the Precinct.

3.2 General Measures

The following general measures apply to all development within the Liverpool or Camden Growth Centre Precincts. Where there is an inconsistency, the specific controls in the following sections take precedence. All development should be in line with the Western Sydney Salinity Code of Practice 2004.

Note that the practices for managing salinity will differ depending on the type of land use that is proposed on the site. For example, practices for land zoned Open Space and Recreation will require different approaches than practices within the Local Centre and residential zones.

Excavation and Filling

1. Excavations in excess of 1.0m should be battered to a 1 vertical to a 1 horizontal. Excavated stockpile material may either be treated immediately on site using 3% by weight of lime, otherwise capped with non-porous clay soils greater than 0.5m thick. Alternatively excavated material may be removed off-site to a landfill for treatment and disposal.

2. Gypsum should be mixed into filling containing sodic soils and cuts where sodic soils are exposed on slopes to improve soil structure and to minimise erosion potential.

3. Any material removed from the site should be carried out by a licensed contractor. This material should be sealed and contained using appropriate lining and capping material.

4. Exposure and disturbance of subsoil material must be reduced by minimising cut and fill. Time of exposure of bare ground (without vegetation) should be kept to a minimum. If extended periods of rain are forecast, the bare ground should be covered with stable fill such as ripped sandstone or stabilised with lime proportioned to 3% by weight.

5. Stormwater runoff from upstream should be diverted away from excavation areas by the use of bunding.

6. Filling areas are to be graded, revegetated and adequate surface drainage infrastructure installed as soon as practical to avoid excessive infiltration, minimise salt leaching, soil erosion and ponding of water on-site.

7. All imported fill should be verified by sampling and testing to ensure the material is non to slightly saline. Moderately to highly saline soil is not acceptable. Supporting information and documentation should be supplied verifying that the subject material complies. The addition of salts in the materials, fill or water used during construction must be limited.

8. Reversing or mixing the soil profile when undertaking cut and fill activities must be avoided. Soils must be replaced in their original order. Excavations deeper than 1m should be backfilled in the same order, alternatively this material may be treated by using lime or used in fill at depths more than 1m from finished level.

9. Batter slopes should be compacted with control of the moisture content to optimum moisture content plus 2 per cent (OMC +2%) or otherwise over-filled, compacted and then trimmed back to the final alignment to minimise infiltration through the exposed filling batters and the potential resulting flushing of salts from the filling. If the latter is to be carried out, the outer zone (3 metres) of the fill should be placed at OMC +2%.

Infrastructure and Drainage

10. Trenching for underground services should be carried out in such a manner that there is minimal rotation and vertical displacement of the original soil profile as the lower soil profile is more erodible.

11. Pipes used for stormwater drainage should be sealed to minimise the risk of leakage. Drainage, sewerage and water infrastructure is to be regularly maintained and repaired to prevent leakages.

12. Concrete of suitable strength and reinforcement cover is to be used for drainage structures and wherever contact with water and increased soil moisture is expected.

13. Watering or irrigation practices are to be managed to avoid excessive infiltration and water logging.

14. Natural drainage patterns and infiltration rates must be maintained as far as practicable. Drainage should not be designed to discharge to groundwater or salinity affected areas that is likely to cause increased water logging adjacent to the road or that concentrated surface runoff.

15. Direct runoff from paved areas into lined stormwater drains rather than along grassed channels as necessary.

16. Groundwater extraction must not occur on the site.

Stormwater

17. During construction, hay bales and other temporary erosion control devices should be placed at appropriate locations in areas where concentrated flows are expected and suitable dish drains should be constructed to retard flow and trap silt particles during heavy runoff. Temporary detention ponds in construction sites should be regularly monitored for water quality and cloudy water should be treated by flocculation with gypsum. This is critical before a storm event.

18. Surface drains should be provided along the top of batter slopes or greater than 2.5 metres height to reduce the potential for concentrated flows of water flows slopes which may cause scour. Well graded

subsoil should be provided at the base of all slopes where there are road pavements below the slope to reduce the risk of water logging.

19. Line or locate any ponds higher in the landscape to avoid recharge where proximity to the water table is likely to create groundwater mounding (refer 3.4 below).

20. Ensure an appropriate ratio of hard (impermeable) and permeable surfaces to avoid rainwater runoff infiltrating the ground in large volumes at any given location.

Vegetation

21. Native vegetation must be retained or restored on site where possible. Revegetation of the site may involve treatment of topsoil material and planting appropriate salt-tolerant water efficient plant species (trees, shrubs, and grasses).

Building Materials

22. In seepage and discharge areas or areas with a high potential sulphate, resistant building materials must be used. Sulphate resistant materials should be used for underground services, roads and paving.

23. For all building materials, the manufacturer's advice must be complied with regarding durability and correct use. Exposure of building materials to corrosive elements in soils should be minimised. Appropriate construction techniques such as suspended slab or piering to encourage ventilation and prevent soil moisture from being forced up the walls of the structure should be used.

Roads

24. Roads must have well designed sub surface drainage. A waterproof seal must be used on roads to minimise evaporation and the concentration of salt.

25. Roads and shoulder areas must be designed to drain surface water such that there is no excessive concentration of runoff or ponding which may result in water logging or additional recharge or groundwater. Road shoulders must also be sealed.

26. Materials and waters used in the construction of roads and fill embankments should be selected to contain minimal or no salt. Where it is difficult a capping layer of either topsoil or sandy materials should be placed to reduce capillary rise, act as a drainage layer and also reduce the potential for dispersive behaviour in the sodic soils.

27. Roads should not intercept known salt affected or water logged areas, and should be designed in a manner that does not impede the sub-soil flow or creates hydraulic pressure causing groundwater discharge.

28. Avoid or minimise the use of on site stormwater detention except where in accordance with a stormwater management strategy adopted for the Precinct.

Note: *Council may consider lower development densities to reduce pressure on groundwater in catchment areas, and to reduce the depth of excavation (deeper than 1m) and fill required on sloping lots.*

3.3 Residential and Other Buildings

Figure 3 presents diagrammatically a selection of salinity management tips for domestic dwellings.

Based on investigations to date, the following precautionary controls are to be implemented, unless site specific assessments are carried out to support the use of less stringent controls.

1. A high impact waterproof membrane, (not just a vapour proof membrane), should be lain under house slabs. The waterproof membrane must be extended to the outside face of the external edge beam up to the finishing ground level, as detailed in the Building Code of Australia (BCA).

2. For masonry building construction, the damp proof course must consist of polyethylene or poly-ethylene coated metal and correctly placed in accordance with BCA. Ground levels immediately adjacent to masonry walls must be kept below the damp proof course.

3. Appropriate infrastructure should be in place to manage urban water cycle and this includes all water flows such as water supply, stormwater and wastewater. Relevant design considerations are outlined in "*Evaluating Options for Water Sensitive Urban Design (WSUD) - a national guide*" Joint Steering Committee for Waster Sensitive Cities, July 2009.

4. For slab on ground construction, a layer of bedding sand at least 50mm thick should be laid under the slab to allow free drainage of water and to prevent pooling of water potentially carrying salts.

5. Concrete floor slabs must comprise of Class 32MPa concrete or sulphate resisting Type SR cement with a water cement ratio of 0.5. Similar concrete should be used for bored piers or footings.

6. Slabs must be vibrated and cured for a minimum 3 days

7. The minimum cover to reinforcement should be 30mm from a membrane in contact with the ground.

8. The minimum cover to reinforcement should be 50mm for strip footings and beams.

9. Admixtures for waterproofing and /or corrosion prevention may be used.

10. Salt tolerant masonry and mortar must be used below the damp proof course

11. Constant monitoring of water pipes to detect any leakages and the repair of damaged pipes as soon as possible after detection

12. Use Copper or non-metallic pipes instead of galvanised iron

13. Ensure any underground services are provided with adequate corrosion protection.

14. On sites where excavation and fill exceeds 1m, Council may require suspended slab or pier and beam construction as an alternative to 'slab on ground' construction. This may occur on sloping sites as this will minimise exposure to potentially corrosive soils and reduce the potential cut and fill on site which could alter subsurface flows.

15. Other measures that can be considered to improve the durability of concrete in saline environments should be considered. These include reducing the water cement ratio (hence increasing strength), minimising cracks and joins in plumbing on or near the concrete, reducing turbulence of any water flowing over the concrete and using a quality assurance supplier.

16. It is essential in all masonry buildings that a brick damp course be properly installed so that it cannot be bridged either internally or externally. This will prevent moisture moving into brick work and up the wall.

17. As there are various exposure classifications and durability ratings for the wide range of masonry available, reference should be made to the supplier in choosing suitable bricks of at least exposure quality. Water proofing agents can also be added to mortar to further restrict potential water movement.

18. Bricks that are not susceptible to damage from salt water should be used. These are generally less permeable, do not contain salts during their construction and have good internal strength so that they can withstand any stress imposed on them by any salt encrustation.

19. Design and construction to be carried out in accordance with relevant Australian Standards, Building Codes and current 'Industry Best Practice' in regard to urban salinity.

20. As indicated on **Figure 3**, service connections and stormwater runoffs should be checked to avoid leaky pipes which may affect off site areas lower down the slope and increase groundwater recharge resulting in increases in groundwater levels.

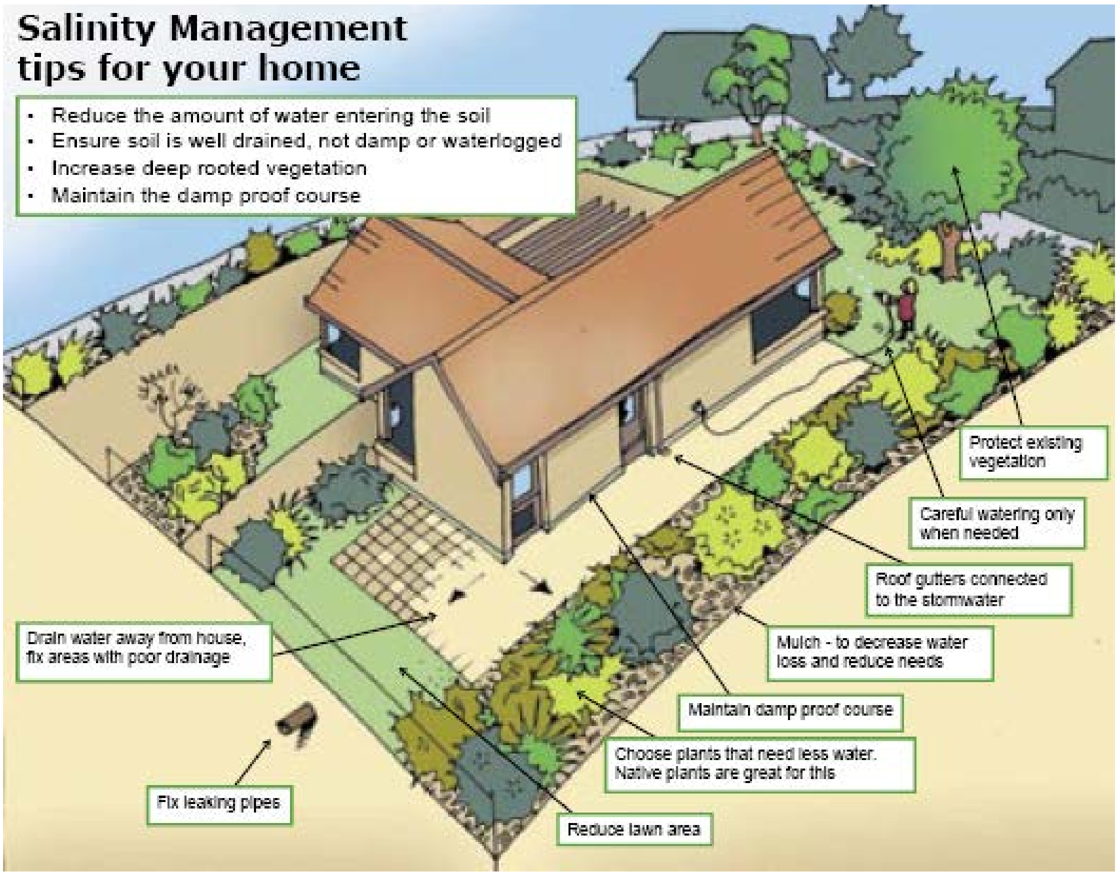

Figure 3: Salinity Management at Home (DIPNR)

3.4 Detention Ponds and Playing Fields

The following management strategies are to mitigate salinity impacts of detention ponds.

1. All excavation works should be minimised by staging the construction into small areas to prevent salinity from developing. Very saline soil is not recommended for use as building platform fill. This material may be buried beneath proposed roadways away from where underground services will be laid. Very saline soil should be placed at depths greater than 1.5m below design level and covered with non to slightly saline fill.

2. Surplus saline soil from construction works may be reused in playing fields. A revegetation scheme which includes introduction of salt tolerant plants should be in place. Amenities buildings, light poles, fences and other associated structures should be appropriately designed to reduce adverse impacts of the saline soil. A capping layer of non saline material with a minimum thickness of 1.5m may be adopted to reduce the impacts of salinity.

3. Detention ponds should be constructed to minimise build up of salts in the groundwater system via infiltration through the base of the ponds. This may be achieved by lining the ponds with synthetic HDPE liners. Clay liners may be considered if justification can be provided on the material selection process and proposed construction methodology. If using a clay lining, the possibility that on site clays may be saline should be investigated before they are used for this purpose. In these situations an impermeable geotech fabric may be preferable.

4. Sodic and dispersive soils can be managed by the addition of lime. Capping of sodic and dispersive soils within the embankments is recommended for protection against erosion.

5. Spillways should be provided in pond embankments to reduce the potential for concentrated flows of water down slopes causing scour.

6. Where mass concrete is required in or around the ponds, a minimum concrete strength of 32 MPa is recommended to limit the corrosive effects of the underlying and surrounding soils. Concrete or masonry elements of lower strength may be susceptible to long term adverse effects of the aggressive or saline soils.

7. Utilise native and deep rooted vegetation in order to minimise soil erosion and limit the rising of the water table.

3.5 Measures for Specific Assets

Table 1 summarises salinity management measures that are to be applied to the planning, design and construction of specific categories of assets in the Precincts.

Table 1: Salinity management measures for specific assets

Asset	Stage	Measure
Infrastructure and Utilities (Road Pavement, Drainage, Pipes, Structures, Pits, Substations, Duct Crossings, Sewer and Water Pipes)	Precinct Planning	▪ Consider appropriate site selection to prevent structural degradation; and ▪ Avoid low lying areas and areas near creek lines.
	DA	▪ Design and size drainage infrastructure to reduce the intensity of local and regional flooding. ▪ Ensure appropriate embankment designs. ▪ Design systems to avoid the interception of surface flow or groundwater recharge.
	DA/construction	▪ Avoid the use of materials such as clay and brass for piping. ▪ Ensure sufficient clearance to groundwater. ▪ Install appropriate subsoil drainage. ▪ Use materials of appropriate strength and cover for reinforcement. ▪ Avoid the disturbance of natural drainage patterns where possible. If this is not possible then realign drainage lines as close to natural patterns as possible.
	Post-development	▪ Maintain and repair to minimise leakages.
Landscaping and Existing Vegetation	DA/Construction/ Post Development	▪ Retain and/or establish the use of native salt-tolerant species, especially if deep rooted to minimise irrigation requirements. ▪ Line waterbodies to minimise groundwater discharge. ▪ Avoid overwatering of lawns, gardens and parklands. ▪ If possible, use 'smart' sprinkler systems or subsoil drip/capillary action systems and maintain them regularly. ▪ Carry out site specific investigations into the potential impacts of recycled water use and implement the recommendations of these studies. ▪ Ensure that existing riparian corridors are maintained.

Asset	Stage	Measure
Miscellaneous (Floor Slabs, Masonry Walls, Foundations, Carparks)	DA/Construction	▪ Ensure sufficient clearance to groundwater or install subsoil drainage. ▪ Avoid disturbance of the natural drainage pattern. ▪ Damp proof courses and vapour barriers are to be properly installed where applicable and maintained to ensure they are not breached by later additions. ▪ Use admixtures for waterproofing and corrosion prevention. ▪ On ground level, provide a sand/gravel layer of sufficient depth under the slab. ▪ Install appropriate membranes under slabs and ensure that they are extended to the outside face of the external edge beam up to the finished ground level. ▪ Use concrete of appropriate strength and cover for reinforcement. ▪ For floor slabs, ensure that concrete is of the appropriate strength and cover for reinforcement and are properly cured. The following requirements apply: ▪ minimum strength of 32MPa where the slab is at ground level ▪ cover must be at a reinforcement height of: ▪ 50mm from unprotected ground ▪ 30mm from a membrane in contact with the ground ▪ 50mm for strip footings and beams irrespective of the use of a damp proof membrane ▪ Ensure that damp proof course consists of adequate material and is correctly placed. ▪ Ensure that exposure class masonry units are used below any damp proof course, including for strip footings, and that appropriate mortar and mixing ratios are used. ▪ Select foundation type and material in according with Australian Standards with consideration of soil aggressivity. ▪ Allow for sufficient corrosion of steel or install the appropriate protective systems. ▪ Use permeable paving where practical.

Asset	Stage	Measure
Earthworks (Excavations, Cut and Fill, Re-contouring and Stockpiling)	Construction	▪ Revegetate and provide surface drainage as quickly as practical ▪ Install adequate erosion controls such as silt fences during excavation and until site stabilisation. ▪ Avoid excavation intersecting the groundwater, where possible. ▪ Ensure imported fill is non/slightly saline. ▪ Place cut materials in the original in-situ order, or if this is not possible, bury the most saline soil underneath less saline soil. ▪ Monitor runoff from stockpiles and conduct the appropriate tests to determine whether gypsum should be added. ▪ Ensure that stockpiles have adequate controls in place for erosion, covering and stabilisation.

4 References

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