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REPORT
ON
LAND CAPABILITY ASSESSMENT

PROPOSED DEVELOPMENT
WESTERN SYDNEY PARKLANDS

Prepared for
LANDCOM

PROJECT 40465
JANUARY 2006

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EXECUTIVE SUMMARY

This report presents the results of a land capability assessment of the Western Sydney Parklands site, near Doonside, which is proposed for re-zoning for urban (residential and employment) development and public open space. The area of study falls within the Blacktown Local Government Area and is located northwest of Prospect Reservoir. For the purposes of this investigation, the site has been broken up into four distinct areas defined as follows:

- Parcel 2 – Rooty Hill: Residential Release (12 ha);
- Parcel 3 – Doonside: Residential Release (88 ha);
- Parcel 4 – West Huntingwood: Employment Lands (55 ha); and
- Parklands Precinct 2, incorporating the former Telstra site, and undeveloped land adjacent to Eastern Creek (493 ha).

The objective of the study was to determine the suitability of the site for urban development, primarily with regard to site stability, soil erosion potential, soil salinity, soil contamination and minerals potential to assist in the conceptual planning process.

The investigation comprised site history searches, inspection, non-intrusive (electromagnetic) and intrusive (test pitting) investigation followed by laboratory testing of selected samples for physical and chemical characteristics, engineering analysis and reporting.

Most of the site has been cleared and developed for grazing and agriculture but includes remnant concentrations of tree and shrub cover.

The site includes two soil landscapes; South Creek Soil Landscape and the Blacktown Soil Landscape. The soils are underlain at depths generally of about 1 – 3 m by Bringelly Shale comprising shale, carbonaceous claystone, laminite and some minor coal and sandstone bands.

A detailed groundwater study was not undertaken in the site area. However, recent groundwater investigations undertaken in the Blacktown area and previous studies of areas underlain by the Wianamatta Group indicate that the shales have a very low intrinsic permeability and that the groundwater is typically brackish to saline, the water being generally unsuitable for livestock or irrigation.

Laboratory testing has indicated that the clay soils would be susceptible to shrinkage and swelling movements with changes in soil moisture content and that the soils are slightly dispersive to non-dispersive.

No areas of previous instability or potential landslip were identified.

Erosion gullies and localised sheet and rill erosion were also noted in areas of previous surface disturbance for infrastructure and where salinity scalding has occurred. It is considered that the erosion hazard within the site would be within usually accepted bounds that may be managed by good engineering and land management practices.

Testing indicates that moderately saline conditions can be expected throughout the study area, with only minor occurrences of very saline or highly saline conditions generally located within or adjacent to drainage depressions. Given the salinity potential identified the conceptual planning of the development should include minimising water infiltration, planting of deep rooted vegetation, minimising cut and fill operations which inappropriately alter natural drainage patterns, the adoption and implementation of appropriate sediment and erosion controls prior to commencement of construction and the selection of construction materials suitable for use in a saline environment.

A Phase 1 environmental soil assessment was undertaken in Parcel 2 – Rooty Hill, and Parcel 4 – West Huntingwood. The results of this assessment indicate that the sites had been used primarily for agricultural (including market gardening) and residential purposes. Based on the results of an extensive site history review and walkover inspection each lot was given a classification of High, Medium or Low risk of contamination. Each risk category was assigned an investigation methodology to be undertaken as a second phase investigation.

Harvest Scientific Services were commissioned to undertake a preliminary minerals assessment of the site. The site has been identified as being underlain by coal bed measures, which also contain coal bed methane. Both of these resources are outside of the relevant extractive industries planned expansion areas, and as such are not considered likely to be used in the recent future, if ever. Another potential mineral resource within the site is clay and shale for brick making. It is suggested that the use of this resource could be considered before releasing the land for other uses.

The subsurface profiles at most locations are as would be expected for Class M (moderately reactive) and Class H (highly reactive) sites. Lots proposed in areas with shallow groundwater would be classified as Class P sites and as such, design and construction would need to be in accordance with accepted practice.

Soil and water management is an integral part of the development process and should adopt a preventative rather than a reactive approach to the site limitations so that the work can proceed without undue pollution of receiving streams. Following consent, a detailed soil and water management plan will be required and will need to be incorporated into the engineering design of the development. The soil and water management plan shall address: methods for minimising water pollution due to erosion of soils or the development of saline conditions; reducing or managing salinity to provide acceptable conditions for building and revegetation works; minimisation of soil erosion during and after construction; and maximisation of the re-use of materials on site.

Further investigation will be required as conceptual design/planning progresses together with routine inspections and earthworks monitoring during construction and detailed geotechnical investigations on a stage-by-stage basis. Section 12 of this report details the specific further work required.

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CCK
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REPORT ON LAND CAPABILITY ASSESSMENT
WESTERN SYDNEY PARKLANDS
DOONSIDE

1. INTRODUCTION

This report presents the results of a land capability assessment undertaken of the Western Sydney Parklands site (near Doonside) which is proposed for re-zoning for urban (residential and employment) development and public open space. The site boundaries are indicated on Drawing 1 and other relevant drawings which accompany this report (Appendix A). The work was commissioned by Landcom on behalf of the Department of Infrastructure Planning and Natural Resources (DIPNR) owners of the site and was undertaken in liaison with APP Corporation, lead consultant.

The area of study is within the Blacktown Local Government Area and located northwest of Prospect Reservoir. For the purposes of the assessment, the site has been divided into four distinct areas, defined as follows:

- Parcel 2 – Rooty Hill: Residential Release (12 ha);
- Parcel 3 – Doonside: Residential Release (88 ha);
- Parcel 4 – West Huntingwood: Employment Lands (55 ha); and
- Parklands Precinct 2 - incorporating the former Telstra site, and undeveloped land adjacent Eastern Creek (493 ha).

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It is understood that re-zoning of the land in Parcels 2 and 3 to facilitate residential development is proposed and that Parcel 4 will be rezoned to accommodate commercial/industrial premises.

Precinct 2 is part of the 5500 ha corridor of open space known as the Western Sydney Parklands. The objective of the land capability study was to determine the suitability of the site for urban development, primarily with regard to site stability, erosion potential, soil salinity potential, soil contamination and minerals potential.

The investigation comprised site history searches, site inspections, non-intrusive and intrusive site investigation followed by laboratory testing of selected samples, engineering analysis, mapping and reporting.

This report contains details of all work undertaken and results together with comments relating to land capability, engineering design and construction practice. Whilst pertinent results of field work, laboratory testing and associated subconsultant reports are included in the text, further details are provided in the following Appendices:

A Drawings
B Photograph Plates
C Electromagnetic Survey - Field and Processing Methods
D Test Pit Logs
E Laboratory Test Results
F Phase 1 Contamination Assessment Report (Project 40465-1, 40465-2)
G Harvest Scientific, Minerals Assessment
H CSIRO Publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance*

2. SITE DESCRIPTION

The site is approximately 650 ha in plan area, and was generally cleared and vegetated with dense long grass at the time of the inspection. Remnant stands of trees surrounded Eastern Creek, portions of the western flood plain and a large part of the northern eastern and south-western sectors of the site. Low lying areas were vegetated with salt resistant vegetation, including Bulrushes and Spiny Rushes.

In addition to salt resistant vegetation, salt scalds and eroded soils were also present across the site. Many salt scalds show salt efflorescence at the surface.

Topographical relief across the site was slight. The western portion of the site from Eastern Creek was flat, except for the northern portion which rose to meet the flanks of The Rooty Hill. The eastern portion was gently undulating, associated with bedrock rise. There were only two significant drainage lines in the eastern portion, Bungaribee Creek and an unnamed drainage depression to the south. The entire site drained to Eastern Creek. Due to the slight relief and low permeability of the soils, much of the low-lying parts of the site were inundated. Relatively light rain periods resulted in extensive surface ponding across the site.

The central portion of the site was unoccupied, whilst Parcel 2 and Parcel 4 had a low density of rented properties. Properties in Parcel 2 were small (low density) residential. Parcel 4 lots were generally rural in nature with some grazing land.

Significant disturbance had taken place in the western potion of the site associated with construction of the M7 Western Sydney Orbital, and construction of an AGL gas pipeline.

Various topographical features of the site are shown in the colour photographs included as Appendix B.

3. PREVIOUS STUDIES

Several previous studies have been undertaken at the sites, though there appears to have been an emphasis on the Parcel 3 and the Parklands Precinct areas. The following documents have been reviewed whilst preparing this report:

- HLA Enviro-Sciences, *Site Audit Report: Former Telstra OTC Eastern Road Doonside*, 26 March 2001.
- Ian Perkins Consultancy Services, *Land and Vegetation Management Plan for three sections of the Western Sydney Regional Parklands,* 23 February 2004.
- URS, *Western Sydney Regional Parklands Management Vision & Concept Plan Options*, March 2004.
- Whelans, *Doonside Land and Acquisition Report*, December 2004.
- Whelans, *Huntingwood and Eastern Creek Land and Acquisition Report*, December 2004.
- Whelans, *Rooty Hill Land and Acquisition Report*, December 2004.

The following summarises the relevant information from the above documents:

Contamination: Historic contamination has been addressed within the former Telstra site up to March 2001 by the unreviewed Australian Site Assessment reports covered by the HLA Audit Report. The audit report notes that the site "*has been remediated and validated to a level that renders it suitable for residential land use with access to soil."* (Ref 1) The HLA audit report also requires the development and implementation of a Management Plan to address "*the unlikely event that contamination is found with site development earthworks".* This plan is to be approved by an NSW EPA accredited auditor. (Ref 1)

The Perkins Report (February 2004) notes that since the audit report, fly-tipping of waste has been an issue on the site. Parcels 2 and 4 have not been the subjects of previous environmental investigations (Ref 2).

Slope Stability: Preliminary slope mapping has been undertaken in the URS report (March 2004) (Ref 3). This information provides a baseline but was not a constraints map, as no criteria were assigned to the various map areas.

Erosion and Sedimentation Hazard: Soil mapping has been undertaken on the site. It appears however, that this mapping has been prepared by referencing the published soils maps. No field investigations or test pitting was previously undertaken to confirm the expected soil landscapes (Ref 2).

Soil Salinity: The Perkins Report (Ref 2) identifies salinity indicators across the site. These were not mapped.

4. PROPOSED DEVELOPMENT

It is understood that the majority of the subject site is proposed for inclusion in the greater parcel of land known as the Western Sydney Parklands; a 5500 ha corridor aligned in the north-south direction. Parcel 2, Parcel 3 and Parcel 4 (known collectively as the interface lands), will be the subject of urban development with Parcels 2 and 3 being residential developments, and Parcel 4 proposed for Employment Lands.

The following sections provide general comment on development constraints relevant to geotechnical factors, soil chemistry, environmental contaminants, mining and alternative potential land uses to assist in the conceptual planning of the proposed development. It is noted that further investigations will need to be undertaken as the planning, design and construction of the subdivision proceeds.

5. REGIONAL SOIL LANDSCAPE, GEOLOGY AND HYDROGEOLOGY

5.1 Soil Landscapes

Reference to the 1:100 000 Soil Landscapes of the Penrith Sheet (Ref 4) indicates that the site includes two soil landscapes which are summarised below and for which the distribution is given in Drawing 2:

Blacktown Soil Landscape - present over most of the eastern and the north-western sections of the site and is characterised by a topography of *"gently undulating rises on Wianamatta Group Shale, with local relief to 30 m and slopes usually less than 5%"*. This is a residual landscape and comprises up to four soil horizons that range from shallow red-brown hard-setting sandy clay soils on crests and upper slopes to deep brown to yellow sand and clay soils overlying grey plastic mottled clay on mid- to lower slopes. These soils are typically of low fertility, are moderately reactive and have a generally low wet bearing strength.

South Creek Soil Landscape – present over most of the western and central sections of the site and is characterised by a topography of *"flat to gently sloping alluvial plain with occasional terraces".* This is a fluvial landscape and includes often very deep layered sediments. Where pedogenesis has occurred, developed soils include sandy to sandy clay loams, clay loams and brown clays. These soils are typically of low fertility, may be of moderate reactivity and are subject to waterlogging.

5.2 Geology

Reference to the Penrith 1:100 000 Geological Series Sheet (Ref 5) indicates that the site is underlain by Bringelly Shale of the Wianamatta Group of Triassic age. This formation typically comprises shale, carbonaceous claystone, laminite and some minor coal bands. These rock units typically weather to form clays of medium and high plasticity. The bedrock is mantled by Quaternary alluvium within valley floors of the Eastern Creek and Bungarribee Creek system (Drawing 3). The geological sheet also indicates that the site is intersected by the south-easterly trending Penrith Basin Syncline.

Hydrogeology

McNally (2005) describes the general hydrogeological framework relevant to Western Sydney, including the subject site, where the shale terrain is known for saline groundwater (due to connate salt in shales of marine origin or to windblown sea salt) and the salt accumulates by evapo-transpiration (mostly in the B-horizon of residual soils). In areas of urban development, this can lead to damage to building foundations, lower course brickwork, road surfaces and underground services, where these impact on the saline zone or where the salts are mobilised by changing groundwater levels.

Seasonal water level changes of 1 - 2 m can occur in a shallow regolith aquifer or a deeper shale aquifer due to natural causes, however urban development should be carried out with a view to maintaining the natural water balance (between surface infiltration, runoff, lateral throughflow in the regolith, and evapo-transpiration) so that long term rises do not occur in the saline groundwater level.

The Department of Infrastructure Planning and Natural Resources (DIPNR) infers a “high salinity potential” in the lower slopes and drainage areas of Eastern Creek, on their map entitled “Salinity Potential in Western Sydney 2002”. These DIPNR inferences are based on soil types, surface levels and general groundwater considerations but are not in general ground-truthed, hence it is not generally known if actual soil salinities are consistent with the potential salinities of DIPNR.

Whilst a detailed groundwater study was not undertaken as part of the current scope, recent groundwater investigations undertaken by DP in the Blacktown area and previous studies of areas underlain by the Wianamatta Group and Quaternary river alluvium indicate that:

- the shales have a very low intrinsic permeability and groundwater flow is likely to be dominated by fracture flow with resulting typically low yields (< 1 L/s) in bores;
- the groundwater in the Wianamatta Group is typically brackish to saline with total dissolved solids (TDS) in the range 4000 – 5000 mg/L (but with cases of TDS up to 31, 750 mg/L being reported), the dominant ions being sodium and chloride and the water being generally unsuitable for livestock or irrigation.
- groundwater flow in unconsolidated Quaternary deposits is likely to be by porous flow in sandy horizon, typically fresh (TDS < 500 mg/L) and dominated by sodium and bicarbonate ions.

6. SCOPE OF WORKS

From the brief provided by APP, DP identified the following scope of works for the site. For clarity, the scope of works undertaken for the assessment was divided up based upon the individual areas of the site. The level of assessment on each area of land is different and is described in the sections below.

6.1 Whole Site

An assessment of stability, erosion and sedimentation potential covering the entire 650 ha study site was undertaken and incorporated the following steps:

- Collection and review of background information, predominantly from Council files and aerial photographs.
- Field mapping by a senior engineering geologist, to confirm soil landscape mapping, identify potential unstable areas and to nominate locations for additional subsurface investigation.
- Undertaking service location utilising the Dial Before You Dig service;

- Excavation of 50 test pits across the site with a rubber-tyred backhoe to profile the subsurface strata. The pits incorporated the collection of regular soil samples to assist in strata identification and for possible laboratory testing to determine soil plasticity, erosion potential, and salinity.
- The surface levels shown on the test pit logs were interpolated to the nearest 0.5 m from 1 m contour intervals on the basemap provided by the project surveyors.
- Geotechnical testing of selected samples for plasticity (5 Samples) and erosivity characteristics (20 Samples).
- Production of constraint maps showing areas of landslip risk as well as areas of potential erosion and sedimentation hazard.

The salinity investigation comprised the following components:

- A review of all previous documents pertaining to site salinity.
- A site walkover by an experienced hydrogeologist to identify areas of salinity potential based on landform, indicator species and other visual indicators. All areas identified were GPS plotted on a GIS database, logged and photographed.
- Electromagnetic profiling for measurement of in-situ apparent conductivities of the surface and shallow subsurface soils (further detailed in Appendix C),
- Ground-truthing of apparent (insitu) conductivities using soil sampling and laboratory measurement of salinities from collected soil samples.
- Identification of sites for later installation of groundwater bores for salinity (groundwater) monitoring.
- Production of a salinity hazard map for the site.

The provision of an assessment for minerals potential was undertaken by a sub-consultant, Harvest Scientific Pty Ltd, with the reports included as Appendices to this report.

The investigation included an assessment of clay, shale and sandstone as well as coal and coal-bed methane resources.

6.2 Parcel 2 and Parcel 4

Two Phase 1 Contamination Assessments were undertaken, which included the following:

- Site walkover inspection by an environmental engineer.
- A search through the NSW EPA Land Information records to confirm that there are no statutory notices current on any parts of the release area under the *Contaminated Land Management Act* (1997).
- A review of historical aerial photography for the area through the Land Information Section of the Department of Infrastructure, Planning and Natural Resources (DIPNR).
- A review of previous site ownership records including land title records archived at the Land Titles Office.
- Interviews with past and present local residents and land owners (where possible) to obtain anecdotal information regarding the potential nature and extent contaminating activities (including filling) across the site.
- Inspection of test pits excavated as part of the stability assessment.

At the conclusion of the Phase 1 assessments a contamination risk rating was assigned to each existing lot (high, medium or low). This formed the basis for recommendations regarding the need for further environmental investigation.

6.3 Parcel 3 and Parklands Precinct

Contamination assessments were based upon the following:

- a thorough review of all previous documents pertaining to site contamination.
- a site walkover by an experienced Environmental Engineer to identify areas of additional contamination across the site.
- Identification of illegal tipping sites which were GPS plotted on a GIS database, logged and photographed.

6.4 Horizontal and Vertical Control

The coordinates of the field tests and other pertinent features were determined by use of a GPS receiver. This enabled positioning of features in relation to digital aerial photographs and basemaps for generation of the drawings within this report. GPS location allowed for accuracy within 3 m, which was considered sufficient accuracy for the location of field tests. Where greater accuracy was required (ie location of EM31 readings) differential GPS (DGPS) was used. A Trimble DGPS backpack mounted system was used which provided sub-metre accuracy.

All field measurements and mapping for this project have been carried out using the Geodetic Datum of Australia 1994 (GDA94) and the Map Grid of Australia 1994 (MGA94), Zone 56. Digital mapping has been carried out in a Geographic Information System (GIS) environment using MapInfo software. All reduced levels are given in relation to Australian Height Datum (AHD).

7. FIELD WORK RESULTS

7.1 Site Observations

7.1.1 Geotechnical

The principal geotechnical observations made during inspections of the site on 26 August and 16 September 2005 are summarised below and further detailed in Drawing 5:

- rock outcrop was limited to a single exposure of fine grained sandstone within a midslope location in a road cut of Eastern Road within the north-western section of the site (Drawing 5).
- the bedrock is mantled by extensive alluvial deposits about Eastern Creek, Bungarribee Creek and associated minor un-named tributary gullies. Within the flatter footslope sections, the alluvium boundary is commonly indistinct and grades into residual soil profiles.

- gully erosion locally entrenches the alluvium infilled bases of creek lines (Drawing 5). Erosion depths ranged from 0.3 m to 2.5 m.
- erosion along the courses of Eastern Creek and Bungarribee Creek is generally limited to the immediate banks and stream bases. The erosion is discontinuous and appears to generally occur during flood flows. Most of the banks are densely penetrated by tree roots and grasses which protect against erosion and associated slumping of undercut sections.
- salt scalding and efflorescence are present along two small side gullies within the north-eastern section of the site (Locations 1 – 4 and 9) and along the edges of waterlogged areas (Locations 13 and 15) in the east-central section of the site.
- areas of possible surface ponding are present upslope of road embankments (Locations 21 and 22) within the south-eastern section of the site.
- The soils have been exposed in many localised areas, mainly for the provision of access tracks, during the past landuse.

7.1.2 Environmental

Environmental inspections were undertaken as three independent assessments, namely:

- Stage 1 Preliminary Inspection of Parcel 2 – Rooty Hill,
- Stage 1 Preliminary Inspection of Parcel 4 – West Huntingwood,
- Surface Contamination Mapping of the Parklands Precinct to update the earlier HLA Audit report.

Inspection of the subject site was made on six occasions between 8 and 28 September 2005. As before, locations of features were logged using a GPS unit according to the GDA 94-MGA 94 format. These were transferred to GIS environment and logged, Drawings 9 - 11 show contamination observations.

Parcel 2 – Rooty Hill

The principal observations made during the inspection included:

- A number of soil stockpiles, building rubble and dumped material located at the northern most portion of the site. This dumping may be associated with the construction of the M7 Western Sydney Orbital.
- Dumped waste close to the creek line in the north-eastern portion of the site, including car bodies, building rubble and other scrap metal. (E300753, N6260947)
- General rubbish and waste in the western portion of the creek, mainly due to stormwater outlets, as opposed to actual dumping.
- Dumped fibrous material on the southern creek bank (possible asbestos). (E300826, N6260985).
- Earth stockpile resulting from fly-tipping (E300983, N6260919)
- Dumped scrap and rubbish Western Portion of the site (surrounding E301120, N6260771).
- Demolished house, (floor slab still in place) fibreboard sheeting on ground surface, possible asbestos. (E301120, N6260771).
- Several (possibly asbestos) fibreboard structures were noted during the investigation (As indicated on Drawing 9.)
- Septic tanks were in use across the site.

The identified areas of environmental concern (AEC) are indicated in Drawing 9.

Parcel 4 – West Huntingwood

- A number of soil stockpiles, building rubble and dumped material located at the south-eastern portion of the site.
- A service station located in the north-eastern portion of the site.
- Six (possibly asbestos) fibreboard structures across the site in various states of repair (some partially demolished)

- Farm machinery and several empty 1000 L plastic tanks were located on a concrete pavement in front of a farm shed.
- The whole area is used for horse grazing and training. A training track which may have used imported fill lies just beyond the site boundary.
- Septic tanks were in use across the site.

The identified areas of environmental concern (AEC) are indicated in Drawing 10.

Parklands Precinct and Parcel 3 - Doonside

The principal observations made during the inspection included:

- Numerous dumped soil stockpiles, building rubble and scrap metal from illegal dumping in the northern portion of the site, near to the intersection of Doonside Road and Eastern Road. (E302870, N6261170)
- Numerous car bodies, concrete blocks and general scrap metal dumped in depressions near illicit motorbike track in the central portion of the site. (E302710, N6260930)
- Building rubble and soil stockpiles in the central portion of Parcel three. (E302660, N6260790)
- Asbestos piping and dumped soil near road way loop between gates on Parcel 3. (E303036, N6260699)
- Numerous dumped stockpiles and rubbish including asbestos on the path between Eastern Road and the telecommunications tower (E302315, N626148)
- Dumped rubbish beneath power lines in the northern portion of the site (E302242, N6261356).
- Soil stockpile near demolished building at hill crest in central southern portion of the site. (E302517, N6259519)

The identified areas of environmental concern (AEC) are indicated in Drawing 11.

7.2 Subsurface Investigation

Details of the subsurface conditions encountered are given on the test pit logs in Appendix D which should be read in conjunction with the accompanying notes defining classification methods and descriptive terms.

Relatively uniform conditions were noted underlying the site, with the succession of strata broadly summarised as follows:

SILTY CLAY:	typically dry, brown clayey silt, silt and silty clay to depths of 0.1 – 0.4 m;
CLAY:	stiff to hard (but generally very stiff to hard) silty clay, clay, gravely clay to depths of 0.55 – 3 m;
BEDROCK:	variably extremely low to very low strength shale, extremely low to low strength sandstone and siltstone below depths of 0.65 – 3 m.

Depth of clay was generally found to be greatest in the lower slopes and Eastern Creek flood plain. Hill top locations revealed only very shallow residual soils before encountering bedrock.

No free groundwater was encountered within the pits during excavation. It is noted however that the test pits were immediately backfilled following excavation which precluded long term monitoring of groundwater levels. Further, it is anticipated that some groundwater would have been present within the limits of excavation at some of the locations and as such, longer term seepage inflow should be anticipated.

8. LABORATORY RESULTS

Selected samples from the test pits were tested in the laboratory for measurement of field moisture content, Atterberg limits, Emerson Class Number and Electrical Conductivity in a 1:5 soil:water extract.

The detailed test report sheets are given in Appendix E. The results indicate that the soils tested are of an intermediate to high plasticity, with field moisture contents in the range of 14% dry to 7% wet of the plastic limit (which is roughly equivalent to the standard optimum moisture content). As such, the clays would be moderately to highly susceptible to shrinkage and swelling movements with changes in soil moisture content. The results of the Emerson crumb tests indicate that the soils tested are slightly to non-dispersive.

The mechanical and chemical testing data is summarised in Tables 3 and 4. Discussion of the results and implications for the proposed development are given in Section 9.3.3.

Table 1 - Results of Laboratory Testing (Mechanical Properties)

Pit No.	Depth (m)	FMC (%)	PL (%)	LL (%)	PI (%)	ECN
3	0.6	19.1	17	59	42	4
7	0.5	-	-	-	-	4
17	0.5	-	-	-	-	4
21	1.0	-	-	-	-	4
22	1.0	23.3	20	83	63	4
24	0.8	-	-	-	-	4
25	0.4	-	-	-	-	4
27	0.4	-	-	-	-	4
35	0.8	20.5	34	58	24	4
36	0.8	-	-	-	-	4
39	0.5	-	-	-	-	4
40	0.4	11.3	14	30	16	4
41	0.5	-	-	-	-	4
42	0.3	-	-	-	-	4
44	1.0	19	12	41	29	4
46	1.0	13.7	17	63	46	4
50	1.3	-	-	-	-	4

Where FMC = Field moisture content
PL = Plastic limit
LL = Liquid limit
PI = Plasticity index
ECN = Emerson Class No.

Table 2 – Results of Laboratory Testing (Salinity)

TP	Depth (m)	$EC_{1:5}$ (dS/m)	Moisture (%)	M (Texture)	EC_e (dS/m)	TP	Depth (m)	$EC_{1:5}$ (dS/m)	Moisture (%)	M (Texture)	EC_e (dS/m)
1	0.6	0.54	24	7	3.78	30	0.7	1.1	17	7	7.7
2	0.6	0.56	15	7	3.92	31	0.5	0.03	16	7	0.21
2	0.6	0.56		7	3.92	32	0.6	0.61	14	7	4.27
3	0.6	0.57	14	8.5	4.845	32	0.6	0.61		7	4.27
4	0.6	0.066	8.8	7	0.462	33	0.1	0.038	9.8	8.5	0.323
5	0.4	0.11	6.5	7	0.77	33	0.8	0.91	13	7	6.37
7	0.5	0.28	11	7	1.96	33	1.6	1.7	12	7	11.9
8	0.5	0.29	15	7	2.03	33	2	1.2	13	7	8.4
9	0.6	0.78	11	7	5.46	34	0.4	0.23	10	7	1.61
10	0.5	0.077	17	7	0.539	35	0.2	0.034	7	7	0.238
11	0.2	0.17	22	7	1.19	35	0.4	0.33	15	7	2.31
11	0.5	0.56	15	7	3.92	35	0.4	0.33		7	2.31
11	0.8	1.6	14	7	11.2	35	0.6	0.79	17	7	5.53
11	0.8	1.6		7	11.2	35	0.8	0.73	16	7	5.11
11	1.1	0.72	9.8	14	10.08	35	1	0.89	15	7	6.23
11	1.9	0.64	11	10	6.4	35	2	0.78	11	7	5.46
12	0.5	0.28	15	7	1.96	36	0.8	0.056	14	7	0.392
13	0.4	0.48	13	7	3.36	37	0.8	0.33	8.8	7	2.31
14	0.5	0.11	14	8.5	0.935	38	0.4	0.22	13	7	1.54
15	0.6	0.049	8.9	7	0.343	39	0.5	0.097	11	7	0.679
16	0.7	0.039	12	7	0.273	40	0.2	0.066	16	7	0.462
17	0.5	0.24	10	7	1.68	40	0.4	0.091	4.7	7	0.637
18	1	0.46	16	7	3.22	40	1.2	0.073	5.8	7	0.511
19	0.4	0.023	12	7	0.161	40	1.2	0.06		7	0.42
20	0.2	0.05	18	8.5	0.425	40	2.8	0.055	5.4	7	0.385
20	0.4	0.071	20	9	0.639	41	0.5	0.052	9.1	8.5	0.442
20	0.7	0.29	28	7	2.03	42	0.3	0.048	14	7	0.336
20	1.6	0.42	18	7	2.94	43	0.5	0.15	13	7	1.05
21	1	0.3	8.8	7	2.1	44	0.2	0.14	18	7	0.98
21	1	0.26		7	1.82	44	1	0.32	12	7	2.24
22	1	0.26	12	7	1.82	44	1.8	0.13	13	7	0.91
23	0.4	0.03	11	7	0.21	44	2.4	0.32	12	7	2.24
24	0.8	0.26	8.5	7	1.82	45	1	1.3	14	7	9.1
25	0.4	0.037	8.2	7	0.259	46	1	0.18	13	7	1.26
26	0.8	0.54	13	7	3.78	47	0.5	0.33	12	7	2.31
27	0.4	0.57	8.7	7	3.99	48	0.6	0.99	16	7	6.93
28	0.6	0.14	9.9	7	0.98	49	0.4	0.5	14	7	3.5
29	0.7	0.22	3.1	7	1.54	50	0.3	0.21	14	7	1.47

Where $EC_{1:5}$ = Electrical conductivity M = Soil texture factor (Ref. 8)
EC_e = Electrical conductivity of a saturated extract
Bold values indicate saline conditions.

9. SALINITY DATA: ANALYSIS AND PRESENTATION

Soil salinity is often assessed with respect to electrical conductivity of a 1:5 soil:water extract (EC 1:5). This value can be converted to ECe (electrical conductivity of a saturated extract) by multiplication with a factor dependent of soil texture ranging from 6 for shale to 17 for sand (Ref. 8).

Based on the requirements of DIPNR's Booklet (Ref 8, 2003) *Salinity Investigations* soil salinity is classified as follows:

Table 3 - Soil Salinity Classification

Class	ECe (dS/m)	Implication
Non Saline	<2	Salinity effects mostly negligible
Slightly Saline	2 – 4	Yields of sensitive crops effected
Moderately Saline	4 – 8	Yields of many crops effected
Very Saline	8 – 16	Only tolerate crops yield satisfactorily
Highly Saline	>16	Only a few very tolerant crops yield satisfactorily

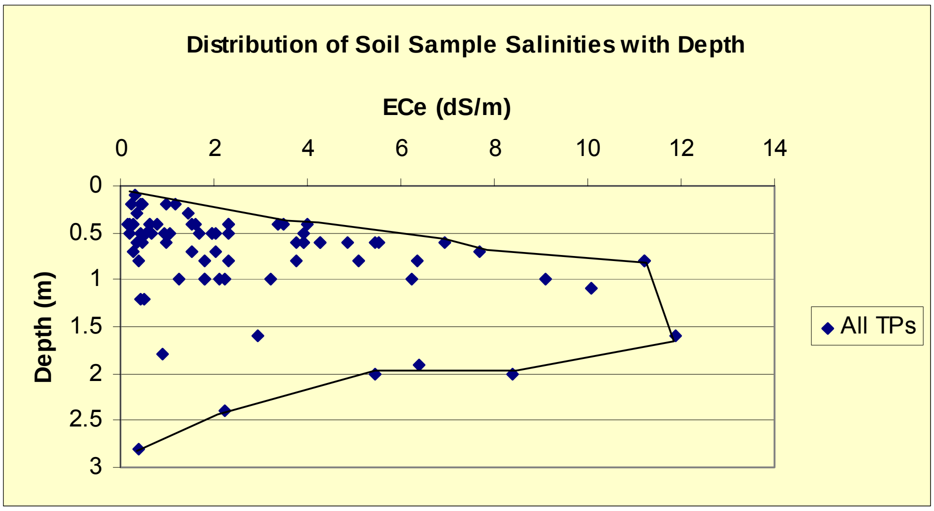
The salinity measurements on test pit samples from the Western Sydney Parklands are distributed throughout the salinity classes as shown below.

Table 4 - Ranges of Test Pit Sample Salinities

Class	ECe (dS/m)	% of measurements
Non Saline	<2	51
Slightly Saline	2 – 4	25
Moderately Saline	4 – 8	16
Very Saline	8 – 16	8
Highly Saline	>16	0

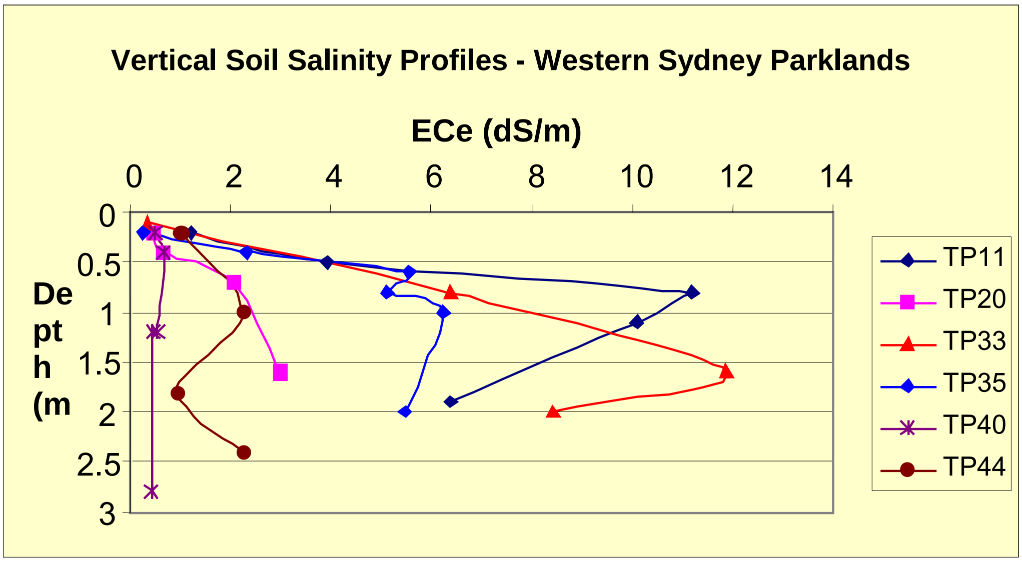
The implication of these results, to the extent that the 76 test pit samples are representative of the study area, is that non-saline to moderately saline conditions can be expected throughout the study area, with only minor occurrences of very saline conditions. These results are, however, dominated by salinity measurements within the upper 1 m of soils, as indicated by the salinity-depth scattergram shown in Figure 1, showing all measurements from all test pits, together with an overall envelope.

Figure 1 - Distribution of Soil Sample Salinities with Depth



At six locations (selected on the basis of initial apparent conductivity results to cover the full range of salinities within the area), test pits were sampled at several depths to a maximum of 2.8 m below ground surface. This enabled the construction of vertical soil salinity profiles (see Figure 2).

Figure 2 - Vertical Soil Salinity Profiles



From these profiles it is inferred that where soils become moderately or very saline, these salinities are reached in the 0.5 – 2.0 m depth zone, corresponding in general to the B soil horizon. A number of test pits were sampled at the top of this horizon, however the distribution of salinities derived from test pit samples alone is expected to slightly underestimate salinities throughout the greater depth range of urban development.

9.1 Processing and Interpretation of Electromagnetic Data

On completion of EM31 profiling, field data were corrected for the conductivity response of the quad bike and were filtered with a moving average operator to reduce the noise induced by irregular quad bike motion (changes in height of the coils above the ground conductor). Details of these corrections and subsequent processing steps are presented in Appendix C.

The histogram and table below show that of the 42 000 corrected and filtered apparent conductivity measurements over the study area, 57% fall in the non-saline to slightly saline classes of Chhabra (1996), with 39% in the moderately saline class and 4% in the very to extremely saline classes.

Figure 3: Distribution of Salinities from EM 31 Profiling

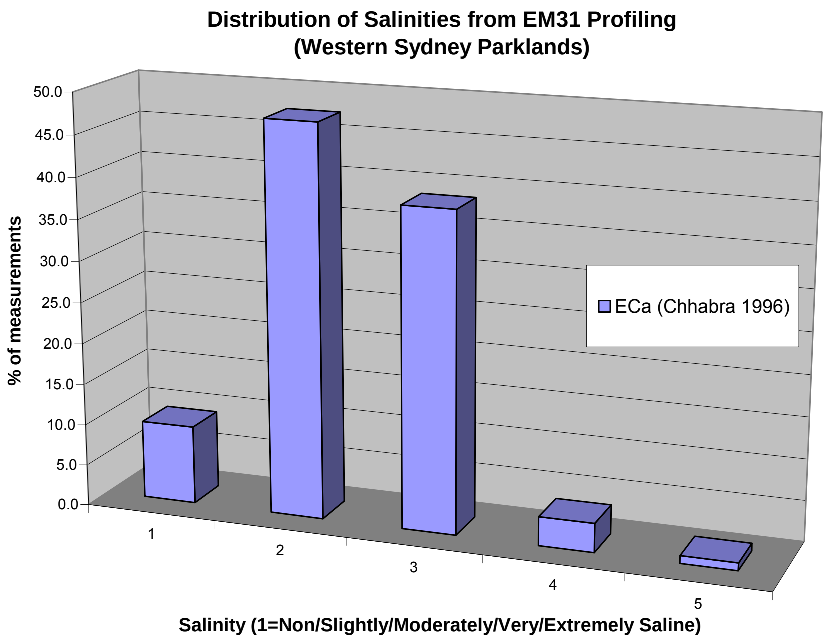


Table 5 - Distribution of Salinities from EM 31 Profiling

ECa Range (mS/m)	<50	50-100	100-150	150-200	>200
Salinity Class (Chhabra 1996)	Non-saline	Slightly saline	Moderately saline	Very saline	Extremely saline
%ECa data	10	47	39	3	1

Apparent conductivity data was added to the GIS database for interpolation of apparent conductivities onto a regular grid throughout the area surveyed. Drawing 6 presents the apparent conductivity image with a continuous colour spectral scale in mS/m. Areas of most interest are those coloured orange to red. Using the classifications of Chhabra (1996), these colours may indicate moderately saline to extremely saline ground conditions. It should be noted however that some of the highest apparent conductivities were unrelated to soil salinities, being measured immediately adjacent to steel fencing materials in the east of Parcel 3.

To achieve a consistent classification from both test pit samples and EM profiling data, a form of calibration of the latter was carried out as described in Appendix C.

A linear regression on the EC_e/EC_a scattergram provided a factor of 2.55 by which to multiply apparent conductivities (in dS/m) to estimate EC_e values throughout the EM31 data set.

The factor was applied to all data, which was then re-gridded for presentation as an apparent salinity image (Drawing 7) with a continuous colour spectral scale in dS/m, based on the Richards (1954, Ref 9) classification scheme. The histogram and table below show that of the re-scaled data points, 97% fall in the non-saline to slightly saline classes of Richards, and 3% fall in the moderately saline class.

Figure 4: Distribution of Salinities

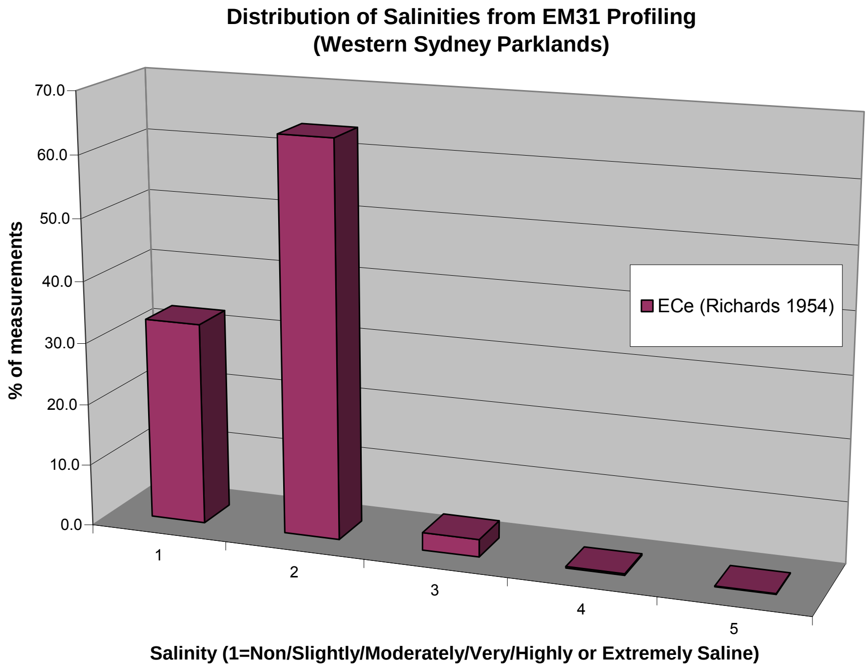


Table 6 - Distribution of Salinities

ECe Range (mS/m)	<2	2-4	4-8	8-16	>16
Salinity Class (Richards 1954)	Non-saline	Slightly saline	Moderately saline	Very saline	Highly saline
%ECe data	33	64	3	~0	~0

Contours were added to the image, corresponding to the 4 dS/m boundary of the salinity classes of Richards, providing a direct subdivision of the study area into non-saline to slightly saline classes versus moderately saline to very saline classes.

It can be seen that areas inferred to be moderately saline or greater occur as a small subset of the EC_a classes, generally to the east of Eastern Creek, or along the western site boundary within 500 m north and 500 m south of the Great Western Highway.

10. DISCUSSION

10.1 Slope Instability

No evidence of hillslope instability (landslip) has been observed within the site.

The steepest section of the site lies immediately to the north of Eastern Road within the north-western section of the site. The section has previously been developed for rural and residential use and has obscured any surface evidence of soil creep (if present). Other than erosion-triggered localised slumping from the low height banks of Eastern Creek and Bungarribee Creek, there does not appear to be a significant risk of stream bank instability. It is considered that hillslope and stream bank instability do not impose significant constraints on the proposed site development.

A stability hazard map has not been prepared as no stability hazard was apparent within the site.

10.2 Erosion Potential

Water erosion hazard forms a landscape limitation for the South Creek Soil Landscapes (Ref. 4). Soils of the Blacktown Soil Landscape are typically of moderate erodibility (K values of 0.02 – 0.04). The more sodic or saline soils of the Blacktown soil landscape can have high erodibility and the erosion hazard for this landscape is estimated as moderate to very high (Ref. 4).

It is considered that the erosion hazard within the areas proposed for residential and industrial would be within usually accepted limits which could be managed by good engineering and land management practices.

The site inspections identified several shallow gullies entrenching recent alluvial deposits within stream courses and the residual soil profiles. Localised areas of sheet erosion are also noted in areas of previous surface disturbance.

It is anticipated that the treatment of the existing gullies as part of an overall site development would include:

- filling using select materials (i.e. non–dispersive or erodible) placed under controlled conditions;
- provision of temporary surface cover (e.g. pegged matting) during the period of gully floor revegetation;
- channel lining in sections of rapid change in gully floor grade;
- piping of flow where appropriate;
- the re-establishment of a zone of tree cover along gully banks.

10.3 Soil Salinity

10.3.1 Assessment of Salinity Risks

Three means of assessment of soil salinity were adopted:

- Visible indicators of salinity mapped during a geological inspection;
- EC_e measurements of soil samples from test pits; and
- EC_e estimates derived from 42,000 EM31 apparent conductivity measurements at 2.5 m sample spacings on an approximate 100 m x 100 m grid over the investigation area.

It is considered that no single means of assessment is sufficient due to spatial sampling and other limitations. However, a joint assessment can provide a practical means of defining areas where there is a risk that urban development will be affected by soil salinity, or will adversely affect the salinity of the environment.

Drawing 8 presents the topographic contours overlain with:

- locations of visible salinity indicators;
- test pit locations (with moderate and high salinity locations classified by colour); and
- 4 dS/m apparent EC_e contours (enclosing zones of moderate or greater apparent salinity).

On the basis of these factors, areas of moderate or greater salinity risk have been inferred and outlined. When considering the results, it should be noted that high apparent salinities to the east of Pits 11, 12 and 13 result from steel fences and are not included in risk assessment.

Within the areas identified in Drawing 8, it is recommended that strategies be employed for the management of moderate or greater salinity.

10.3.2 Salinity Management Strategies

In general the salinity study indicates that the high salinity potential inferred by DIPNR (2003, Ref 10) for the lower slopes and drainage areas of Eastern Creek is not realised, with only moderate salinity expected in limited areas, generally east of Eastern Creek.

Elsewhere within the investigation area, non-saline to slightly saline conditions predominate. Efforts should be made however throughout the area to prevent or restrict changes to the water balance that will result in rises in groundwater levels, bringing more saline water closer to the ground surface. As a precaution, development must be planned to mitigate against the effects of any potential salinisation that could occur.

These efforts need to be directed at all levels of the development process including:

- site design, vegetation and landscaping;
- commercial building and infrastructure construction.

In general, the following strategies are directed at:

- maintaining the natural water balance;
- maintaining good drainage;
- avoiding disturbance or exposure of sensitive soils;
- retaining or increasing appropriate native vegetation in strategic areas;
- implementing building controls and engineering responses where appropriate.

10.3.3 Site Design, Vegetation and Landscaping

Planning for the development of the site requires careful management with a view to controlling drainage and infiltration of both surface waters and groundwater to prevent rises in groundwater levels and minimise the potential for erosion.

Precautionary measures to reduce the potential for salinity problems include:

- Avoiding water ponding in low-lying areas along shallow creeks, floodways, in ponds, depressions, or behind fill embankments or near trenches on the uphill sides of roads. This can lead to water logging of the soils, evaporative concentration of salts, and eventual breakdown in soil structure resulting in accelerated erosion.

- Roads and the shoulder areas should also be designed to be well drained, particularly with regard to drainage of surface water. There should not be excessive concentrations of runoff or ponding that would lead to waterlogging of the pavement or additional recharge to the groundwater. Road shoulders should be included in the sealing program.

- Surface drains should generally be provided along the top of batter slopes of greater than 2.5 m height to reduce the potential for concentrated flows of water down slopes possibly causing scour. Well graded subsoil drainage should be provided at the base of all slopes where there are road pavements below the slope to reduce the risk of waterlogging.

- With regard to regrading within the development footprint, a minimum surface slope of 1V:40H is suggested in order to improve surface drainage and reduce ponding and waterlogging, which can lead to evaporation and salinisation. Consideration should also be given to regrading (steepening) of natural slopes outside the development footprint, where this will improve overall drainage without creating additional erosion hazards.

- Where possible, materials and waters used in the construction of roads and fill embankments should be selected to contain minimal or no salt. This may be difficult for cuts and fills in lower areas where saline soils are exposed in cut or excavated then placed as filling. Under these circumstances and where salinisation could be a problem, a capping layer of either topsoil or sandy materials should be placed to reduce capillary rise, which will also act as a drainage layer and reduce the potential for dispersive behaviour in any sodic soils.

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

- Salt tolerant grasses and trees should be considered if re-planting close to creeks and in areas of moderate and greater salinity to reduce soil erosion and maintain the existing evapotranspiration and groundwater levels. Reference should be made to an experienced landscape planner or agronomist.

10.3.4 Commercial Building and Infrastructure Construction

The extent of measures adopted during construction, in particular the concrete, masonry and steel requirements, should depend on the level of salinity, aggressivity or corrosivity at the site.

Soil from specific building sites or services alignments which are impacted by Salinity Risk (as shown on Drawing 8) should be sampled, tested and classified for soil salinity, aggressivity and corrosivity to the proposed depth of excavation. Additional investigation should include analysis of pH, electrical conductivity, TDS, sodicity, and sulphates and chlorides. At least one groundwater bore per risk area must be installed. This investigation will identify any highly saline sites not identified in this preliminary study.

If any potentially highly saline or aggressive areas are identified in the above investigations, higher than normal strength concrete or sulphate resistant cement may need to be considered in order to reduce the risk reinforcement corrosion in concrete slabs. A minimum of 65 mm of concrete cover on slab reinforcement, appropriate compaction and curing of concrete are also suggested to produce a dense, low-permeability concrete.

In general, for the construction of buildings or infrastructure (buried services) in areas of Salinity Risk (as shown on Drawing 8), the following are suggested:

- Use of a thick layer of sand (say 100 mm minimum) followed by a membrane of thick plastic is recommended under the concrete slab to act as a moisture barrier and drainage layer to restrict capillary rise under the slab.

- As an alternative to slab on ground construction, suspended slab or pier and beam construction should be considered, particularly on sloping sites as this will minimise exposure to potentially aggressive/corrosive soils and reduce the potential cut and fill on site which could alter subsurface flows.

- Other measures that can be considered to improve the durability of concrete in saline environments 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.

- It is essential that in all masonry buildings that a brick damp course be installed so that it cannot be bridged either internally or externally. This will prevent moisture moving into brickwork.

- 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 an appropriate exposure quality. Water proofing agents can also be added to mortar to further restrict potential water movement.

- In areas of elevated salinity, 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.

- Consideration could be given to use of infrastructure service lines (that will be deeper than say 1.2 m), to promote subsurface drainage by incorporating slotted drainage pipes fitting into the stormwater pits in lower areas where pipe invert levels are within about 1 m of existing groundwater levels.

- 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.

- Where moderately saline conditions are mapped and site-specific tests confirm aggressive/corrosive conditions, consideration should be given to use of higher grade (more resistant) materials in all underground service lines.

10.4 Soil Contamination Potential

Phase 1 environmental assessments were undertaken by DP on Parcel 2 Rooty Hill and Parcel 4: West Huntingwood, details of which are given in separate reports (Project 40465-1, 40465-2) which are provided in Appendix F.

In summary, the site history and walkover inspections indicated that the sites had been used primarily for rural, intensive agricultural and residential purposes. Uses included poultry farming and market gardening, which may have resulted in widespread contamination. Numerous fibreboard structures were noted on site which may have resulted in asbestos contamination.

Due to the early subdivision of the lots and large number of lots on each site (25 and 23 for Parcels 2 and 4 respectively), assessment was made on a lot-by-lot basis. Based on the results of the site walk-over and site history investigations, each lot was assigned a contamination risk factor as shown in Table 7 and Table 8.

Any further contamination-based work on Parcel 2 and Parcel 4 must be undertaken in accordance with all of the recommendations made in the individual Stage 1 Environmental Assessments (Project 40465-1 and 40465-2, respectively).

The following sections summarise the contamination related findings for each of the relevant Parcels.

10.4.1 Parcel 2 – Rooty Hill

Based on the results of the site walk over and site history investigations each lot was assigned a contamination risk factor of high, medium or low. Taking into account the proposed residential reuse of the land suitable management strategies were developed based on the contamination risk.

Table 7 - Risk Categories: Parcel 2

Low Risk		Medium Risk		High Risk	
Lot 7, DP 806052	1.03 ha	Lot 54, DP 8995	0.32 ha	Lot 11, DP 806052	0.13 ha
Lot 8, DP 806052	0.34 ha	Lot 57, DP 8995	0.32 ha	Lot 12, DP 806052	0.47 ha
Lot 9, DP 806052	Inc with 9	Lot 30, DP 8995	2.4 ha	Lot 13, DP 806052	0.47 ha
Lot 53, DP 8995	0.32 ha	Lot 31, DP 8995	Inc with 30	Lot 14, DP 806052	Inc with
Lot 34, DP 8995	0.48 ha	Lot 32, DP 8995	Inc with 30	Lot 55, DP 8995	0.32 ha
Lot 35, DP 8995	0.48 ha	Lot 33, DP 8995	Inc with 30	Lot 56, DP 8995	0.32 ha
Lot 45, DP 8995	0.48 ha	Lot 36, DP 8995	1.9 ha		
Lot 46, DP 8995	0.48 ha	Lot 43, DP 8995	0.48 ha		
		Lot 44, DP 8995	0.48 ha		
		Lot 5, DP 806052	0.63 ha		
		Lot 6, DP 806052	Inc with 5		
		Lot 10, DP 806052	0.46 ha		
Total 8 lots (3.61 ha)		Total 12 lots (6.99 ha)		Total 6 lots (1.71 ha)	
Percentage of Lots 31%		Percentage of Lots 46%		Percentage of Lots 23%	
Percentage of Area 29 %		Percentage of Area 57%		Percentage of Area 14 %	

Inc with – Included with lot number listed as a total area.

Taking into account the proposed residential reuse of the land, the following management strategies are recommended:

Low Risk: Low risk sites will be sampled on a grid basis at a rate of 6 test locations per hectare. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. Samples will be analysed for the full EPA suite of contaminants.

Medium Risk: Medium risk sites will be sampled on a judgemental basis at a rate of 6 test locations per hectare. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. Samples will be analysed for the full EPA suite of contaminants including asbestos.

High Risk: lots designated high risk will be subjected to full EPA density sampling across the site as well as judgemental sampling in areas around identified AEC. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. Samples will be analysed for the full EPA suite of contaminants including asbestos.

10.4.2 Parcel 4 – West Huntingwood

Based on the results of the site walk over and site history investigations each lot was assigned a contamination risk factor of high, medium or low. Taking into account the proposed residential reuse of the land suitable management strategies were developed based on the contamination risk.

Table 8 - Risk Categories: Parcel 4

Low Risk		Medium Risk		High Risk	
Lot 4, DP 327540	0.75 ha	Lot 99 DP1030393	1.4 ha	Lot 1, DP 802277	4.4 ha
Lot 5, DP 327540	0.75 ha	Lot 100 DP1030393	Inc with	Lot 7, DP 913820	4.0 ha
Lot 5, DP 913789	3.9 ha	Lot 101 DP1030393	1.1 ha		
Lot 8A DP 391499	2.0 ha	Lot 1, DP976165			
Lot 8B DP 391499	2.0 ha	Lot 4, DP976165	3.8 ha		
Lot 2, DP244378	9.6 ha	Lot 17, DP 666798	2.0 ha		
Lot 1, DP 171732	3.8 ha	Lot 1, DP 916147	2.0 ha		
		Lot 1, DP 915115	4.0 ha		
		Lot B DP 108398	1.8 ha		
		Lot4A DP 378122	2.1 ha		
		Lot B, DP 371678	3.7 ha		
		Lot C, DP 371678	1.9 ha		
		Lot AX, DP 374284	0.94 ha		
		Lot AY, DP 374284	0.93 ha		
Total 7 lots (22.9 ha)		Total 14 lots (10.3 ha)		Total 2 lots (8.4 ha)	
Percentage of Lots 30%		Percentage of Lots 61%		Percentage of Lots 9%	
Percentage of Area 55%		Percentage of Area 25%		Percentage of Area 20%	

inc with – Included with lot number listed as a total area.

Based on the findings of this Phase 1 Environmental Site Assessment, each lot has been classified as high, medium or low risk. Taking into account the proposed commercial reuse of the land, the following management strategies are recommended:

Low Risk: Low risk sites will be sampled on a grid basis at a rate of 4 test locations per hectare. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. 50% of samples will be analysed for the full EPA suite of contaminants, and the remainder will be analysed for heavy metals and OC/OP Pesticides.

Medium Risk: Medium risk sites will be sampled on a judgemental basis at a rate of 4 test locations per hectare. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. Samples will be analysed for the full EPA suite of contaminants including asbestos.

High Risk: lots designated high risk will be subjected to full EPA density sampling across the site as well as judgemental sampling in areas around identified AEC. Investigations would involve the excavation of test pits and sample collection at regular depth intervals. Samples will be analysed for the full EPA suite of contaminants including asbestos.

10.4.3 Parklands Precinct and Parcel 3 (Doonside)

This site has been signed off for residential reuse (and less sensitive, ie parks and open space) under a separate audit report. Current assessment examined only contaminating activities since the finalisation of the previous report. Numerous stockpiles of building rubble were noted in the site walkover as documented within. Clean up of the site will therefore be required prior to redevelopment. The amount of dumping on site should not present a constraint to development.

Logged stockpiles and waste dumps will require removal to a suitably licensed waste facility and validation testing prior to site development.

10.5 Preliminary Minerals Assessment

Harvest Scientific Services were commissioned to undertake a preliminary minerals assessment of the site. The results of this work are given in detail in the report (Reference 200624) included in Appendix G. A summary of the principal findings is given below.

The site is underlain by the Illawarra Coal Measures which provide a commercially viable resource elsewhere in the Sydney Basin. However, these coal seams are located deep below the site (in the order of 600 m), and it is highly unlikely that they would become commercially viable. It is understood that there are no proposals (by BHP-Billiton) or others to mine coal in this area within the next 30 years or so, and the lack of exploration in the area suggests that there is a low level of interest in it as a potential resource.

Similarly, resources of coal-bed methane are present within the underlying coal seams but are currently not subject to plans for extraction. The feasibility of extraction however, would depend upon detailed exploration and analysis which take into consideration economic, environmental and technical aspects. The potential for petroleum extraction, has also received some attention in the Western Sydney area, again, it is highly unlikely that viable quantities are present beneath the site.

Another potential mineral resource within the site is in clay and shale for brick making. The Bringelly Shale that underlies the site is used elsewhere in Western Sydney as a source of material for this industry. Furthermore, the site is located close to brick manufacturing plants and a ready market for the finished product. It is suggested that the use of this resource could be considered before releasing the land for other uses. Volcanic material with potential value as concrete aggregate may also be present near Parcel 2, but is not considered to be present on site in viable quantities.

10.6 General Development Considerations

10.6.1 Site Classification

Classification of residential lots within the site should comply with the requirements of AS 2870 – 1996 *"Residential Slabs and Footings"* (Ref. 11). Based on the limited work for the current investigation, the subsurface profiles at most locations are as would be expected for Class M (moderately reactive) and Class H (highly reactive) sites.

The investigation has indicated the presence of ironstone gravel and saturated silt at 1 m depth within Pit 11 (in the vicinity of a watercourse), and as such, would also result in a P classification. Notwithstanding this, residential construction would be relatively straightforward utilising the underlying stiff clays or weathered rock for foundation support. However, as stiff clays/rock was below termination depths of Pit 11, additional investigation should be undertaken at the appropriate time to determine depths to a suitable founding strata.

10.6.2 Footings

All footing systems should be designed and constructed in accordance with AS 2870 – 1996 (Ref. 11) for the appropriate classification. Conventional high level footing systems would be appropriate for M or H sites. Suitable foundation systems for Class P lots could include (depending on the depth of suitable founding stratum and the presence of groundwater) backhoe excavated blockdowns, pier and beam, screw piles or possibly driven timber piles founding on the underlying stiff clays or weathered rock.

10.6.3 Site Preparation and Earthworks

Site preparation for the construction of residential structures should include the removal of topsoils and other deleterious materials from the proposed building areas.

In areas that require filling, the stripped surfaces should be proof rolled in the presence of a geotechnical engineer. Any areas exhibiting significant deflections under proof rolling should be appropriately treated by over-excavation and replacement with low plasticity filling placed in near horizontal layers no thicker than 250 mm compacted thickness. Each layer should be compacted to a minimum dry density ratio of 98% relative to standard compaction with placement moisture contents maintained within 2% of standard optimum. The upper 0.5 m in areas of pavement construction should achieve a minimum dry density ratio of 100% relative to standard compaction.

All batters should be constructed no steeper than 3:1 (horizontal:vertical) and appropriately vegetated to reduce the effects of erosion.

To validate site classifications, sufficient field inspections and in-situ testing of future earthworks should be undertaken in order to satisfy the requirements of a Level 1 inspection and testing service as defined in AS 3798 – 1996 (Ref. 12).

Earthworks required for pavement construction will need to be based on batters formed no steeper than 3:1 (H:V) in the residual clays. All batters should be suitable protected against erosion with toe and spoon drains constructed as a means of controlling surface flows on the batters.

10.6.4 Site Maintenance and Drainage

The developed residential lots should be maintained in accordance with the CSIRO publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance"*, a copy of which is included in Appendix H. Whilst it must be accepted that minor cracking in most structures is inevitable, the guide describes suggested site maintenance practices aimed at minimising foundation movement to keep cracking within acceptable limits.

Adequate surface drainage should be installed and maintained at the site. All collected stormwater, groundwater and roof runoff should be discharged into the stormwater disposal system.

10.6.5 Pavements

Preliminary Thickness Designs:

Table 9 summarises a range of pavement thickness designs based on the procedures given in APRG – SR 21 (Ref. 13) for varying traffic loadings and subgrade CBR values.

Table 9 – Preliminary Pavement Thickness Design

Traffic Loading (ESA)	Total Pavement Thickness (mm)			
	CBR <3%	CBR 3%	CBR 4%	CBR 5%
5×10^4	440 (590)	440	370	320
1×10^5	470 (625)	470	395	340
1×10^6	550 (700)	550	470	390

Bracketed figures in Table 9 indicate total boxing depth, taking into account 150 mm of subgrade replacement with granular material with CBR ≥ 20%

The pavement should be placed and compacted in layers no thicker than 150 mm with control exercised over placement moisture contents. If layer thicknesses greater than 150 mm are proposed, it may be necessary to test the top and bottom of the layer to ensure that the minimum level of compaction has been achieved through the layer.

Suggested material quality and compaction requirements are given in Table 10.

Table 10 – Materials and Compaction

Layer	Material Quality	Minimum Compaction
Wearing Course	To conform to APRG requirements	To conform to APRG requirements
Base Course	To conform to APRG requirements Soaked CBR ≥ 80%, PI ≤ 6% or Council requirements	Minimum dry density ratio of 98% Modified (AS 1289 Test 5.2.1)
Sub-base Course	To conform to APRG requirements Soaked CBR ≥ 50%, PI ≤ 12% or Council requirements	Minimum dry density ratio of 95% Modified (AS 1289 Test 5.2.1)
Subgrade		Minimum dry density ratio of 100% Standard (AS 1289 Test 5.1.1)

Where PI = plasticity index

Whilst the use of lesser quality pavement materials than that detailed in Table 10 may be feasible, some compromise in either performance and/or pavement life must be anticipated and accepted. It is also suggested that advice be sought from Council if lesser quality pavement materials are proposed.

Drainage: Adequate surface and subsoil drainage should be installed and maintained to protect the pavement and subgrade. The subsoil drains should be located at a minimum of 0.5 m depth below the excavation level. Guidelines on the arrangement of subsoil drainage are given on Page 20 of ARRB – SR41 (Ref. 14).

11. SUMMARY OF LAND CAPABILITY FOR SITE DEVELOPMENT

No evidence of hillslope instability was observed within the site. It is considered that hillslope and stream bank instability do not impose significant constraints on the proposed site development.

The presence of erosive soils on site should not present significant constraints to development provided they are well managed during earthworks and site preparation stages. Gully erosion already present on site should be remediated during site works as discussed earlier in Section 10.2.

Salinity Risk across the site is generally low with some areas of salinity risk noted. Development within identified Risk Areas should be undertaken in accordance with the guidance given in Sections 10.3.2 to 10.3.4.

Soil contamination risk across the site is generally low. However, a range of further investigations in Parcel 2 and 4 will be required to assess the actual degree of contamination present on site. That said, it is not anticipated that soil contamination will present a constraint to development and any areas of contamination identified, once remediated, will be suitable for the proposed land use. Illegal dumping of waste material and soil across Parcel 3 and the Parklands Precinct will require removal to a suitably licensed waste facility and validation testing prior to site development.

The presence of an economic coal resource underlying the site indicates that future coal mining activity may form a constraint to development. The likelihood of mining is very low, and at current knowledge of mining activity within the region it is anticipated that it would not occur for in excess of 30 years, if ever.

12. FURTHER INVESTIGATION

Further investigation will be required as conceptual design/planning progresses together with additional work during the construction phase. Specific investigation would include (but not necessarily limited to):

- Removal of dumped material and validation from Parcel 3 and Parklands Precinct.
- Preparation of a Contamination Management Plan in accordance with the HLA audit report
- Detailed environmental investigation (comprising subsurface sampling and laboratory testing) in the nominated areas of environmental concern, primarily in those areas which lie within the proposed "development footprint". The purpose of this work would be to quantify the level of contamination (if any) and delineate contaminated areas in order to facilitate the preparation of remediation action plans (RAP).
- Remediation and validation monitoring of areas subject to an RAP, to render such areas appropriate for the proposed land use, from the contamination viewpoint.
- Additional investigation should be undertaken in development areas which are impacted by salinity risk. Investigations should include installation of at least one permanent monitoring bore per risk area, as well as analysis of soil and water pH, electrical conductivity, TDS, sodicity, and sulphates and chlorides.
- Installation of groundwater bores well in advance of construction and monitoring/sampling/analysis before, during and after construction, to assess changes in soil water quality as a result of the development. The bores would be strategically located at exit points from the site into the Eastern Creek system.
- Routine inspections and earthworks monitoring during construction.
- Detailed geotechnical investigations on a stage-by-stage basis for determination of pavement thickness designs and lot classifications.

13. LIMITATIONS OF THIS REPORT

DP's assessment is necessarily based upon the result of a site history search and limited site inspection that was set out in the original proposal. Neither DP, nor any other reputable consultant, can provide unqualified warranties nor does DP assume any liability for site conditions not observed, or accessible during the time of the investigations.

Despite all reasonable care and diligence, site characteristics may change at any time in response to variations in natural conditions, chemical reactions and other events, e.g. groundwater movement and or spillages of contaminating substances. These changes may occur subsequent to DP's investigations and assessment.

This report and associated documentation have been prepared for the use of Landcom and DIPNR, owners of the site. The report was prepared in accordance with a specific scope of works. It is the responsibility of any third parties to investigate fully to their satisfaction if any information prepared by DP is suitable for their specific objective.

Before passing on to a third party any information or a report prepared by DP, the Client is to inform fully the third party of the objective and the scope, and all limitations and conditions, under which the reports were prepared.

Any reliance assumed by third parties on this report outside of the stated scope shall be at such parties' own risk. Any ensuing liability resulting from this use of the report by third parties cannot be transferred to DP.

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