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SPECIALISTS MANAGING THE EARTH

TECHNICAL SPECIFICATION - LANDFORM CONSTRUCTION FOR WILDLIFE LAKE

Penrith Lakes Development Corporation
Penrith Lakes

GEOTLCOV24000DN-AArev6
4 September 2009

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SPECIALISTS MANAGING THE EARTH

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Penrith Lakes Development Corporation
PO Box 457
CRANEBROOK NSW 2749

Attention: Colin Gibbs

Dear Sir

RE: Technical Specification for Landform Construction,

Wildlife Lake, Penrith Lakes Development

Please find attached the revised Technical Specification for Landform Construction of proposed Wildlife Lake located at the northern end of Penrith Lakes. The document history is shown below:

Date	Revision	Status/Notes
15 April 09	0	First draft issued to PLDC for clarification of concepts
24 April 09	1	Draft issued for comment. Comments received 12 May 09.
15 May 09	2	Final Draft. Comments received 1 June 09
2 June 09	3	Final for planning and approval
26 June 09	4	Final for submission
12 Aug 09	5	Final - Revised Riverbank Filter requirements per GEOTLCOV24000DF-AF dated 3 August 2009 (refer sections 7.3.7 and 10.5).
4 Sept 09	6	Includes provision for Bird Refuge in Ephemeral Wetlands (Refer section 4.1 and Sketch WLL-02B)

If you have any queries regarding this Technical Specification, please contact the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

Robert Turner

Principal Geotechnical Engineer

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1 INTRODUCTION

1.1 Proposed Construction

The proposed Wildlife Lake is located at the northern end of the Penrith Lakes Development site. Presently, the eastern part of the proposed Wildlife Lake footprint has been quarried. The western part of the footprint is yet to be quarried. Quarrying operations at Penrith Lakes cannot encroach within 40m of the crest of the high bank of the eastern side of the Nepean River. Excavation for the gravel and sand quarrying works will proceed to bedrock level east of these setbacks, leaving the existing riverbank in its natural state. Engineered Fill will be constructed against the remaining riverbank within 6 months of extraction being completed to create the lake perimeter and associated landforms.

This Technical Specification applies to earthwork construction for the landforms associated with the Wildlife Lake. The water body will have a surface area of about 100 hectares based on an operating level at RL 10m AHD. The landforms surrounding the lake will comprise Parkland. The western lake edge will be about 150m from the Nepean River. The southern shore of Wildlife Lake will be about 200m from the northern shore of the proposed Main Lake.

1.2 Background Information

The Parkland west of the Wildlife Lake will form the Riverbank Earthworks, which are designed to form a water-retaining embankment between the lake and Nepean River. The progressive landform design, which was summarised in Coffey report S20023/1-BU dated 18 March 2005, includes a requirement for a clay core and sand filter. The current design is a result of this evolutionary process. Coffey understands that the Department of Planning has approved two designs for Riverbank Core, namely:

- A 5m wide clay core constructed out of medium plasticity clay (Refer to Sketch WLL-01A).
- A 1.5m wide clay core constructed out of high plasticity clay with a surrounding Engineered Zone compacted to 98% Standard Maximum Dry Density (Refer to Sketch WLL-01B).

In both options:

- The clay core is to be compacted to 98% Standard Maximum Dry Density at a moisture range of -1% to +3% of Standard Optimum Moisture Content.
- The top of the clay core should be at least 1m above the operating water level of the adjacent lake.

The construction methods for the above options are discussed in Section 10.6.

1.3 Scope of Technical Specification

The Technical Specification is intended to be read in conjunction with Construction Drawings for the Wildlife Lake. The scope of work covered in this Technical Specification includes:

- Preparation of ground prior to placement of Engineered Fill;
- Preparation of existing excavation faces and batter slopes;
- Definition of fill materials to be used;
- Requirements for conditioning, placement and compaction of fill; and,
- Geotechnical testing and Quality Assurance.

2 PROJECT ROLES

2.1 Principal

Penrith Lakes Development Corporation (PLDC) is the Principal, and is responsible for developing the Landform Design (planning, layout, hydraulic design, environmental elements etc) for Wildlife Lake. The Principal commissions the Contractor to construct the Landform in accordance with the Landform Design and these Technical Specifications.

2.2 Superintendent

PLDC may act as, or appoint another party to act as, Superintendent to oversee and administer the earthworks construction in accordance with both the Landform Design and the Geotechnical Design, and assess compliance of the work with this Technical Specification. The Superintendent takes instruction from the Principal and advice from the Geotechnical Designer, and instructs the Contractor accordingly.

2.3 Geotechnical Designer

Coffey Geotechnics Pty Ltd is the Geotechnical Designer. At the instruction of PLDC, the Geotechnical Designer has prepared Geotechnical Design of the landform and construction specifications intended to provide geotechnical performance to meet end-use requirements. During the landform construction, the Geotechnical Designer may amend the Technical Specification and advise the Superintendent of revisions, who will at his discretion direct the Contractor accordingly.

2.4 Contractor

Appointed by PLDC, the Contractor is responsible for constructing landforms in accordance with the Construction Drawings, the Technical Specification and directions received from the Superintendent during the course of the work.

2.5 Geotechnical Inspection and Testing Authority

Coffey Information Pty Ltd is the current Geotechnical Inspection and Testing Authority (GITA) for earthworks monitoring at Penrith Lakes. Appointed by the Superintendent, the GITA will monitor landform construction for Wildlife Lake on a Level 2 basis, generally as defined in AS3798-2007, with additional “inspection” duties relating to observations of compliance with method specification procedures.

3 DEFINITIONS

3.1 Material Available for Filling

Overburden: Material derived from the in situ material that overlies in situ PRF, and that has since been redistributed across parts of the Penrith Lakes site.

Primary Raw Feed (PRF): Quarry product generally comprising sand, gravel and cobbles. Where the PRF has not yet been quarried, it is termed **In Situ PRF**

Ripped Shale Fill: Material derived from ripping of shale from the floor of designated borrow areas within the bedrock underlying the Penrith Lakes site.

Imported Fill: Approved material sourced from sites other than Penrith Lakes.

3.2 Relevant Landform Categories

In Situ Material: Any material that presently exists in the landform above bedrock level. This may include natural soil or fill placed prior to the proposed landform construction.

In Situ Riverbank: Natural ground on the eastern bank of the Nepean River that has not been disturbed by Penrith Lakes quarry excavations.

Parkland: Land within Penrith Lakes that is not intended for future urban, commercial or industrial development, including Riverbank areas.

3.3 Engineered Fill and Uncontrolled Fill

Uncontrolled Fill: Fill that is not Engineered Fill or that cannot be proven to be Engineered Fill.

Engineered Fill: Fill materials placed and compacted in a prescribed manner with the intention of achieving a certain design outcome. Engineered Fill may be placed by:

> **Density Specification:** The compaction of Engineered Fill is assessed principally on the basis of a defined frequency of in situ density testing, or
>
> **Method Specification (MS):** The compaction of Engineered Fill is achieved by a defined method of construction intended to achieve a particular fill density, but testing is usually limited to periodic calibration to monitor the adequacy of the method specification.

3.4 Relevant Categories of Engineered Fill

Lake Toe: Engineered Fill constructed to a density specification around the lake shores. Lake Toe Engineered Fill extends from bedrock level beneath the lake edges and laterally to an elevation 1m above lake operating level at batter slopes shown on Sketches WLL-01A, WLL-01B and WLL-03. In Ephemeral Wetland Cells, Lake Toe construction terminates at lake operating level (refer to Sketch WLL-02).

Wetland MS: Engineered Fill constructed to a method specification for Ephemeral Wetland cells.

Parkland MS: Engineered Fill constructed to a method specification for landforms classed as Parkland.

3.5 Construction Zones within Engineered Fill

Riverbank Core: A low permeability zone within the Engineered Fill constructed between In Situ Material along the In Situ Riverbank. The Riverbank Core extends at least 1m in elevation above Wildlife Lake operating level. Depending on the thickness of the Riverbank Core adopted, a surrounding zone termed **Engineered Fill – Core Component** may be required.

Riverbank Filter: Sand filter used to separate In Situ PRF in the In Situ Riverbank from Engineered Fill, where there is a risk of migration of fines from Engineered Fill to the In Situ PRF. Migration of fines can occur where the PRF has a low percentage of fines. The Geotechnical Designer will assess where Riverbank Filter is not required.

4 DRAWINGS & STANDARDS

4.1 Drawings

PLDC will provide Construction Drawings detailing the Landform Design pertaining to portions of work across the Penrith Lakes development. The work shall be implemented in accordance with the Construction Drawings and the Technical Specification.

To assist in the preparation of construction drawings, the following conceptual sketches outlining the Geotechnical Design are attached to this Technical Specification:

Sketches WLL-01A and 1B: Conceptual Section – Riverbank. These sketches outline the Geotechnical Design between In Situ Riverbank and Wildlife Lake for differing Riverbank Core Construction.

Sketches WLL-02A and 2B: Conceptual Section - Ephemeral Wetland Cells. These sketches outline the construction for the transition from Lake Toe construction to Parkland across the Ephemeral Wetlands, for typical construction, and for cells including bird refuges.

Sketch WLL-03: Conceptual Section between Wildlife Lake and Main Lake – This sketch shows a schematic section through proposed Weir 6 between Main Lake and the Wildlife Lake.

4.2 Standards

General specification, execution and testing of earthworks and associated site preparation works will conform to **AS3798-2007: Guidelines on Earthworks for Commercial and Residential Developments**, unless otherwise noted herein. Where inconsistency is identified between this Technical Specification and the above Australian Standard, this Technical Specification shall take precedence.

Testing of fill materials, where required, will be undertaken in accordance with the standards presented in Table 1.

Table 1 Australian Standard – Method of Testing Soils for Engineering Purposes

Field Density	AS1289.5.8.1–1995 Nuclear Gauge Direct
Standard Compaction	AS 1289 5.1.1–1993 Dry Density / Moisture Content – Standard Method
Moisture Content	AS 1289 2.1.1–1992 Standard Method
Dry Density Ratio	AS 1289 5.4.1–1994 Compaction Control Test – Dry Density Ratio – Normal Method
Particle Size Distribution	AS 1289 3.6.1–1995 Standard Method of Analysis by Sieving
Atterberg Limits	AS 1289 3.1.1–1995 Liquid Limit AS 1289 3.2.1–1995 Plastic Limit AS 1289 3.3.1–1995 Plasticity Index AS 1289 3.4.1–1995 Linear Shrinkage

5 SURVEY

5.1 Design Lines and Set-Out of Works

The landform shall be constructed to the design lines indicated on the Construction Drawings or as advised by PLDC. Design Lines including set-out points relative to ISG coordinates and elevations relative to AHD indicating the extents of the various construction zones are shown on the construction drawings or as advised by PLDC. The Contractor shall establish and maintain all necessary survey control points, markers, survey marks, recovery pegs and batter set out pegs and boards as will enable the landforms to be constructed in accordance with the Construction Drawings. The location of the survey control points will be subject to approval by the Superintendent.

5.2 Tolerances

Fill placed within the final constructed landform shall be within the tolerances listed in Table 2.

Table 2 Tolerances for Earthworks Construction

Final constructed level	Minus 0.1m to plus 0.1m of design levels; and, Within a variance of 0.1m when measured from a straight edge 6m in length; and, Graded to drain such that water does not form ponds greater than $2m^2$ in area.
Base of Wetland MS	Minus 0.2 m to plus 0.0 m
Drainage Channel Invert	Minus 0.05m to plus 0.05m; and, Graded to provide an even fall along the length of the channel.
Batter Slopes	Minus 0.0 m, plus 0.1 m.
Topsoil Thickness	Minus 0.0 m, plus 0.05 m

Note: ‘minus’ and ‘plus’ tolerances indicates below and above the specified level respectively

6 DRAINAGE AND EROSION CONTROL

6.1 Surface Erosion Control

Precautions shall be taken by the Contractor to prevent soil erosion during the execution of the Works in any stream, water pondage or reservoir. Precautions shall include, but not be limited to, the use of temporary drains, surface grading.

Erosion control measures and re-grading to facilitate drainage on excavated or filled surfaces that form part of the Works or drainage lines adjacent to the Works shall be performed in accordance with the directions of the Superintendent.

6.2 Tunnel Erosion Control

Tunnel Erosion is erosion of soil materials within a landform resulting in a void forming a tunnel or pipe.

In areas assessed as being affected by, or potentially affected by tunnel erosion, the Superintendent will direct the Contractor to blend gypsum with the soil to a depth and rate specified by the Geotechnical Designer. Within areas directed by the Superintendent, the gypsum shall be mixed with the landform soil prior to placing topsoil.

Routine addition and blending of gypsum for control of tunnel erosion shall be undertaken in areas designated by the Superintendent or as indicated on the Drawings. Supplementary addition and blending of gypsum shall be undertaken in areas designated by the Superintendent as having a higher erosion potential and for maintenance purposes.

Gypsum shall contain no less than 90% Calcium Sulphite Dihydrate, with less than 10% Calcium Carbonate or other impurities. The Contractor shall provide details and all technical data of the gypsum product proposed for use, and shall allow 7 working days for the Superintendent to evaluate the data. Approval of the material by the Superintendent will be required prior to site delivery and usage.

6.3 Temporary Drainage

The Contractor shall install and maintain temporary drains within the partially completed landform so ponding of water and/or scouring/erosion of placed fill materials do not occur. Temporary drains may take the form of channels, trenches, pipes, culvert or similar. Any drains installed within the partially completed landform in accordance with this Clause shall not interfere with completed works without the prior written approval of the Superintendent.

The Contractor shall conduct operations in such a way, and/or provide adequate drainage such that at the completion of each working day the surface is free draining and does not allow water to pond on the ground surface other than at nominated sump points. Water collected in sump points shall be removed by pumping to a location nominated by the Superintendent.

7 FILL MATERIALS

7.1 Suitable Materials

7.1.1 Overburden

Overburden obtained from borrow areas nominated by the Superintendent shall be generally free of perishable matter and after compaction shall have a maximum particle dimension of not more than 250mm, and contain particles that are not more than 1% by volume greater than 150 mm.

7.1.2 Ripped Shale Fill

Ripped Shale Fill refers to shale bedrock ripped by dozer from the floor of designated borrow areas at Penrith Lakes. The method by which the shale is ripped from the bedrock layer shall be in accordance with techniques nominated by the Contractor and approved by the Superintendent.

- Coarse Ripped Shale Fill refers to Ripped Shale Fill comprising fresh rock fragments with a maximum particle size of 350mm.
- Fine Ripped Shale Fill refers to Ripped Shale Fill comprising fresh rock fragments with a maximum particle size of 200mm that can be placed, compacted and further broken down by the use of either pad foot compactor or loaded dump truck Cat 777 minimum size.

7.1.3 Imported Fill

Imported Fill shall be classified as Virgin Excavated Natural Material (VENM). It shall be free of perishable matter and after compaction shall have a maximum particle dimension of not more than 250mm, and contains particles that are not more than 1% by volume greater than 150 mm.

7.2 Unsuitable Materials

In all landforms to be constructed, the following materials are unsuitable for use as fill in the landform:

- oversize materials;
- soil that is classified as “Silt” using the Unified Soil Classification System with nominal secondary components;
- soft or excessively wet soil;
- inclusions such as metal, timber, plastic, rubber or materials with voids (e.g. concrete pipes);
- topsoil (except in topsoil zones), organic matter or putrescible/perishable materials;
- materials that are stained, odoriferous, or otherwise contaminated;
- other materials determined by the Geotechnical Designer or Superintendent as unsuitable.

Fill materials comprising or including crushed or broken concrete shall not be used in landform construction without the written approval of the Superintendent.

Materials deemed unsuitable for use in particular landforms or zones shall not be incorporated into that construction and shall be removed to a location nominated by the Superintendent. Such materials may be used in other landform/zones provided the specified requirements for that landform/zone are met.

Material proposed for use in a particular zone that is contaminated by unsuitable material will not be accepted, and shall be removed from the Works to a place of disposal nominated by the Superintendent.

7.3 Landform Material Requirements

7.3.1 Materials for Parkland MS

Fill materials for Parkland MS shall comprise:

- Overburden that, after compaction, has a maximum particle dimension of not more than 250mm, and contains particles that are not more than 1% by volume greater than 150 mm, and/or.
- Ripped Shale Fill as defined in Section 7.1.2 of this Technical Specification, and/or.
- Imported Fill as described in Section 7.1.3 of this Technical Specification.

7.3.2 Materials for Wetland MS

Materials for Wetland MS construction shall comprise Overburden or Fine Ripped Shale Fill. Imported Fill may be approved for use by the Geotechnical Designer provided it complies with the requirements of Section 7.1.3 **and** has a Liquid Limit < 50% and Plasticity Index < 35%.

7.3.3 Materials for Lake Toe

Lake Toe materials shall comprise Overburden as defined in Section 7.1.1, unless otherwise agreed by the Superintendent and Geotechnical Designer.

7.3.4 Materials for Wave Protection

Wave Protection requirements are determined by Water Research Laboratory [1].

Wave Protection is to be constructed along the lake foreshores and submerged benches/refuges using PRF consistent with the particle size distribution range shown in Figure 1.

The thickness of Wave Protection required varies depending on:

- the anticipated wave height (which varies with location around the lake);
- the slopes of the lake edges and submerged benches;
- the elevation relative to normal lake operating level.

Between 11m AHD and 8.5m AHD, Wave Protection material shall be placed to the required thicknesses shown on the Construction Drawings.

Below 8.5m AHD, Wave Protection material may be placed to protect the lake bed during filling. The need for Wave Protection will be at the discretion of the Superintendent. Where required the thickness may vary from 100mm to 300mm.

Wave Protection material thickness refers to the loose thickness measured perpendicular to the ground surface.

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[1] *Blacka MJ and Badenhop A M, Foreshore Protection Review-Penrith Lake Wildlife Lake Technical Report 2009/09 June 2009.*

7.3.5 Materials for Riverbank Core

Riverbank core materials shall comprise medium or high plasticity clay (in accordance with the Unified Soils Classification System), or artificially stabilised soil Overburden. Clay materials shall have the following properties depending on the width of clay core constructed:

Table 3 Riverbank Core Properties

	5m wide clay core	1.5m wide clay core
Plasticity Index	greater than or equal to 25%	greater than or equal to 30%
Liquid Limit	greater than or equal to 40%	greater than or equal to 50%

The GITA will sample clay core material at a frequency of 1 sample per 2,000m^3 of material and carry out Atterberg Limits (or other tests as considered appropriate). The Superintendent will use the test results to assess conformance of the material.

7.3.6 Materials for Engineered Fill – Core Component

Where the Riverbank Core is designed for 1.5m thickness it shall be surrounded by an Engineered Fill zone (Engineered Fill – Core Component) constructed 5m either side of the centreline of the Riverbank Core. The Engineered Fill – Core Component shall comprise Overburden or approved Imported Fill.

7.3.7 Materials for Riverbank Filter

Materials forming the Riverbank Filter shall be free draining, non cohesive with non-plastic fines, and durable so as not to break down during compaction, or by the chemical action, or by wetting and drying.

There shall be two categories of Riverbank Filter materials:

- **Fine Sand Filter** shall have a particle size distribution (as determined by AS 1289 3.6.1–1995) falling between curves A and C in Figure 2.
- **Coarse Sand Filter** shall have a particle size distribution (as determined by AS 1289 3.6.1–1995) falling between curves B and C in Figure 2.

Fine Sand Filter may be used where the filter material is placed against a high face comprising well-graded PRF (ranging from cobbles and gravel to coarse sand) with no obvious voids.

Coarse Sand Filter shall be used where the PRF has voids or negligible coarse sand. If material complying with the requirements of coarse sand filter is not available, Fine Sand Filter may be used provided it is used in conjunction with an approved geofabric to limit migration of fine sand into the PRF.

The required thicknesses of Fine Sand Filter and Coarse Sand Filter shall be as specified in Section 10.5.

On each day that Riverbank Filter is being placed, the GITA will notify the Geotechnical Designer and Superintendent of the nature of the PRF. The Geotechnical Designer shall advise the Superintendent of the type of Sand Filter required. The Contractor shall not place Riverbank Filter prior to receiving instruction from the Superintendent about the type of filter material that is suitable.

The Superintendent will direct the GITA to sample filter material at a frequency of 1 sample per 2,000m^3 of fill placed, and conduct Particle Size Distribution tests (and Atterberg Limits if deemed to be appropriate). The Superintendent will use the material testing results to assess conformance with material requirements.

7.3.8 Topsoil

Topsoil shall be sourced from site or imported. Topsoil shall be reasonably free from subsoil, refuse, roots more than 20mm diameter and 300mm long, weeds, clay lumps and stones larger than 50mm.

8 GROUND PREPARATION PRIOR TO FILL PLACEMENT

Unless otherwise approved by the Superintendent in consultation with the Geotechnical Designer, ground preparation shall comply with the following. The GITA shall note the ground preparation conditions.

8.1 Dewatering

Prior to the placement of fill materials over a bedrock floor, natural ground (in situ PRF or overburden) or Uncontrolled Fill, all ponded water on the exposed surface shall be removed. Removal of ponded water may comprise sump and pump techniques. Localised earthworks, including excavation of drainage channels and sumps shall be employed to allow water to drain to dewatering points.

8.2 Clearing and Grubbing

Clearing and grubbing shall be undertaken by the Contractor to the satisfaction of the Superintendent and shall include removal, and stockpiling at a location approved by the Superintendent, of:

- Vegetation, fallen timber, stumps, roots greater than 25mm diameter;
- Unsuitable Material, including concrete, pipes, boulders, rubble, fences, minor infrastructure.

8.3 Foundation Preparation

8.3.1 Foundation Comprising Bedrock or In Situ PRF

Soft or saturated areas on the exposed ground shall be removed to expose in situ PRF or bedrock. Where, after excavation, isolated areas of soft or saturated soil covering an area of less than 20m by 20m and not in excess of 150mm thickness are present, the Contractor shall treat those soft or saturated soil materials by either:

- Blending / mixing the soft or saturated soil with PRF to obtain material that may be readily compacted; or,
- Removing the soft or saturated soil materials.

Where, in the opinion of the Superintendent, the soft or saturated soil is unsuitable for blending, or the blended material is unsuitable for compaction, the unsuitable materials shall be removed.

Where, in the opinion of the Superintendent, pit floor levels or water inflow rates make dewatering impracticable, and/or where less than 150mm of soft compressible material is present within the lower lying areas of the pit floor, PRF may be placed and compacted in layers not exceeding 450mm loose thickness to at least 0.3m above the water level. PRF shall be compacted by a minimum of four passes of a loaded dump truck of not less than 85 tonne tare weight or other approved plant. The acceptance criteria shall be a deflection of less than 10mm between subsequent passes of the plant. Fine grained sand, silt or clay soils shall not be placed into ponded water unless approved by the Geotechnical Designer.

8.3.2 Foundation Comprising In Situ Overburden or Uncontrolled Fill

Prior to the placement of fill over areas that are not excavated to bedrock or in situ PRF, soft and/or saturated materials exposed at ground surface shall be excavated and removed, or treated as outlined in Section 8.3.1.

The Contractor shall proof roll the exposed ground with a minimum 12 tonne static roller, or similar plant approved by the Superintendent. The Geotechnical Inspection and Testing Authority shall advise the Superintendent of any areas deemed to exhibit deflection in excess of 10mm under proof rolling. These shall be excavated and replaced with Engineered Fill, compacted to the requirements of the proposed overlying fill layer (i.e. the specified density or method specification and moisture content requirements for the relevant zone).

8.3.3 Preparation of Partially Constructed Landforms

Prior to the placement of fill over areas of partially constructed landform, the Contractor shall undertake surface preparation in accordance with the requirements of Section 8.3.2. Prior to placement of Engineered Fill over an existing area of Engineered Fill, the Contractor shall prepare the exposed surface such that the upper layer of existing fill is within the moisture tolerance and in situ density of the Engineered Fill to be constructed over it.

8.3.4 Preparation of Areas Affected by Sink Holes

Prior to placement of fill materials over sinkholes, the Contractor shall thoroughly mix the existing fill materials within these areas using methods approved by the Superintendent such as tyning, blading or using disc harrows to a depth equal to the depth of the sink holes in the area plus 100mm. The Contractor shall seek approval of the preparation method from the Geotechnical Designer prior to implementing the works. If mixing results in a loose soil layer greater than 400mm thickness, the Contractor shall remove excess material to provide a loose soil layer thickness not exceeding 400mm.

If in the opinion of the Superintendent additional measures are required to address the issue of sink holes in the landform, the Superintendent will direct the Contractor to add gypsum with the soil materials prior to the mixing process specified above. Where the Superintendent directs the Contractor to add and blend gypsum, 2.5% gypsum by mass shall be added to the nominated area prior to the commencement of the mixing process. The mixing process shall be carried out so that the gypsum is uniformly blended into the upper 400mm and blended using a disc plough or approved equivalent plant. If alternative plant is used or the mixing process does not produce a uniformly blended soil, then the mass of Gypsum to be blended into the soil shall be increased to 4% by mass.

The Contractor shall then compact the fill materials within the mixed layer to the appropriate compaction criteria for the landform under construction.

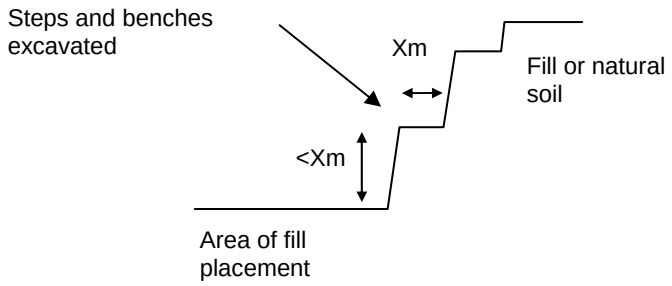
8.3.5 Preparation of Areas Affected by Erosion Gullies

Areas within the partially constructed landform identified by the Superintendent as being affected by the presence of erosion gullies deeper than 100 mm shall be prepared as follows:

- Ponded water and soft and/or saturated materials in the base of erosion gullies shall be removed in accordance with Section 8.1.
- The walls of erosion gullies shall be excavated to obtain a batter slope not steeper than 2H:1V.
- Fill shall be placed into the excavation to the layer thickness and moisture content and compacted to the requirements provided in Section 10.

8.4 Preparation of Edges of Fill Areas

Where a difference in elevation of more than 1 m is evident between adjacent fill areas, or between a fill area and natural soil, the areas shall be integrated by the excavation of a series of near vertical steps and horizontal benches. The Geotechnical Designer will assess appropriate edge treatment for particular cases. If no specific edge treatment is specified, the steps and benches should be excavated into the higher area, with steps typically less than 2m to achieve an overall gradient no steeper than 1V:1H, as shown schematically in the diagram below.



Integration of Fill Areas

9 HANDLING AND SPREADING FILL PRIOR TO COMPACTION

9.1 Fill Layers

Following Foundation Preparation, materials shall be systematically placed and spread in approximately horizontal layers of generally uniform thickness across the fill area. The maximum thickness shall not exceed the thicknesses indicated in Table 4, however, at all times the thickness of each layer shall be appropriate for the equipment being used to compact the fill and shall be adjusted accordingly.

Table 4 Fill Layer Thicknesses

Fill or Material Category	Layer Thickness	Measured
Wetland MS	250mm	Loose
Parkland MS (excluding Coarse Ripped Shale)	250 mm	Loose
Parkland MS (Coarse Ripped Shale)	400 mm	Loose
Lake Toe	400 mm	Loose
Riverbank Core (5m wide option)	200 mm	Compacted
Riverbank Core (1.5m wide option)	Depends on plant used for compaction	
Engineered Fill – Core Component	400 mm	Loose
Riverbank Filter	400 mm	Loose

The Contractor shall demonstrate methods of determining the thickness of the layers when placed prior to commencing operations. Approval shall be obtained from the Superintendent prior to the start of filling operations.

9.2 Distribution of Materials

Each load of the materials placed shall be placed to achieve good distribution of the material and avoid non-homogeneous pockets of material. Layers of material shall not differ substantially from surrounding material in the zone and the density shall be uniform throughout each compacted layer. When each layer of material has been prepared in accordance with this clause, it shall be compacted and tested.

9.3 Moisture Content of Fill

Optimum moisture content of the fill material is defined as the moisture content that is required to produce the standard maximum dry density when compacted in accordance with AS 1289 5.1.1–1993. During compaction, the moisture of material in each layer of fill shall have be within a range of Standard Optimum Moisture Content (SOMC) indicated in Table 5. The moisture content range limits may be varied at the direction of the Superintendent.

The Contractor shall take appropriate steps to maintain the fill moisture content within the specified range until the subsequent layer of fill is placed. If the Superintendent determines that there is significant delay between placing fill layers, the Contractor shall undertake surface preparation works as defined in Section 8.3.3.

Where the moisture content of any portion of any layer of fill on which a subsequent layer of fill is to be compacted falls outside the specified range, the Contractor shall moisture condition the fill (wetting or drying) to achieve the specified moisture criterion using methods approved by the Superintendent.

Table 5 Moisture Variation for Compacted Fill

Material or Fill Category	Maximum Deviation from SOMC
Fine Ripped Shale Fill	-2% to +2%
Imported Fill	-2% to +2%
Wetland MS	-3% to +3%
Parkland MS	-3% to +3%
Lake Toe	-3% to +3%
Riverbank Core	-1% to +3%
Engineered Fill – Core Component	-3% to +3%

Note: Where Fine Ripped Shale Fill or Imported Fill is used in Wetland MS or Parkland MS, adopt the more stringent moisture variation criterion.

Supplementary water to bring the moisture content to the specified amount before compaction shall be added by injection or sprinkling at the excavation site or at the location of fill placement by the use of a water truck with an approved sprinkling nozzle or other approved method of delivering water at a controlled rate to the soil.

Fill material shall be removed if, in the opinion of the Superintendent, the surface of any layer of fill material placed is too wet or there is excessive heave, shearing or rolling under the passage of construction plant due to excessive pore water pressures which will not allow satisfactory compaction and bonding of the next layer of material. The excavated material shall be allowed to dry and/or worked with suitable equipment to reduce the moisture content to the required amount and then re-compacted to the satisfaction of the Superintendent. Importation of drier material to blend with the wet fill shall not be undertaken without the prior approval of the Superintendent.

9.4 Blending of Gypsum

Where the Superintendent directs the Contractor to add and blend gypsum, 2.5% gypsum by mass shall be added to the nominated area prior to the commencement of the mixing process. Gypsum shall be spread over the surface of the area requiring treatment in a relatively uniform manner and blended using a disc plough or an approved equivalent. If alternative plant is used or the mixing process does not produce a uniformly blended soil, then the mass of Gypsum to be blended into the soil shall be increased to 4% by mass. The blending process shall be carried out so that the gypsum is uniformly blended over the entire area requiring treatment to a depth specified by the Superintendent, but no less than 300mm from the ground surface. The Contractor shall then compact the fill materials within the mixed layer to the appropriate compaction criteria for the landform under construction.

10 COMPACTION OF ENGINEERED FILL

10.1 Compaction Plant

Methods of compaction may include smooth drum compactors, pad foot compactors, scrapers, haul trucks, spreaders and other approved compaction equipment.

Vibrating compactors may only be used in nominated areas following receipt of written approval from the Superintendent.

Compaction of Fine Ripped Shale Fill shall be undertaken by CAT 825C, Komatsu WA800 and CAT 992C or other equipment approved by the Superintendent.

10.2 Contractor Responsibilities for Testing

The Contractor shall be responsible for, and shall be deemed to have included the cost of, the following into the rates for the Works:

- Preparation of test areas by (but not limited to) the use of a grader to remove near surface materials and provide a level platform for testing, as directed by the GITA;
- Delays in production which may result during testing and until test results are known;
- Delays in production that may result from tests not meeting the Specification; and
- Cost of reworking an area and additional testing resulting from tests not meeting specification.

10.3 Engineered Fill Constructed by Density Specification

10.3.1 Compaction Criteria

Table 6 indicates the Minimum Density Ratio to be achieved for Engineered Fill categories to be constructed by Density Specification.

Table 6 Compaction Criteria

Engineered Fill Category	Compaction Criterion
Lake Toe	95% SMDD
Riverbank Core	98% SMDD
Engineered Fill – Core Component	98% SMDD

SMDD = Standard Maximum Dry Density determined in accordance with AS 1289 5.4.1 – 1994.

Any part of the Engineered Fill failing to fulfil the density criterion for the Fill Category shall be reconditioned in place and re-compacted, or removed from the Works, as deemed to be appropriate by the Superintendent, and the affected area and any adjoining parts of the Works re-tested in accordance with the requirements of these Specifications.

Where a batter slope is to be constructed, the Contractor shall place and compact fill to the specifications designated for the relevant zone beyond the design line for the slope, and trim the batter slope to the design lines to ensure the specified compaction is achieved to the edge of the batter slope. Trimmed material may be reconditioned and used elsewhere in the Works. No additional payment shall be made for filling beyond the design line and trimming back.

10.3.2 Frequency of Compaction Testing

The Superintendent will provide Level 2 construction monitoring and testing services. Density testing will be undertaken at not less than the frequencies indicated below:

Table 7 Frequency of Compaction Testing

Material or Fill Category	Testing Frequency
Lake Toe	1 test per 2,500 m^3
Riverbank Core	1 test per 1,000 m^3
Engineered Fill – Core Component	1 test per 1,000 m^3

The Contractor shall report the volume of fill placed and compacted each working day within the various zones to the Superintendent in writing once every working day. The Contractor shall be responsible for coordinating compaction testing with the GITA. The Contractor should allow one working day to obtain the results of routine compaction control testing.

10.4 Engineered Fill Constructed by Method Specification

10.4.1 Intention of Method Specifications

The intention of the method specifications below is to achieve a target compaction equivalent to 95% SMDD. The Wetland MS is more stringent because this landform encroaches on the Lake Toe landform, which is intended to perform a specific design function.

Monitoring of construction by Wetland MS and Parkland MS shall be on a Level 2 basis generally as defined in AS 3798-2007. The Superintendent will co-ordinate this monitoring with the GITA.

Field density testing may be undertaken at the discretion of the GITA or Geotechnical Designer to correlate the compaction being achieved by the method specification with the target density. This value shall be used as a bench mark to calibrate the effectiveness of the method specification and not for acceptance or rejection of the works.

10.4.2 Wetland MS

Compaction of Wetland MS shall be by a minimum of:

- three passes of a loaded 85 tonne, 120 tonne or 150 tonne dump truck (or four passes if this plant is unloaded), followed by
- two passes of a Cat 825C, Komatsu WA800 or CAT 992C

One pass is defined as the passage of the wheels (wheel path) of the approved plant over the fill surface once. Wheel paths for adjacent passes shall coincide with the edge of the previous pass.

10.4.3 Parkland MS for materials other than Coarse Ripped Shale

For materials except Coarse Ripped Shale, compaction of Parkland MS shall be by a minimum of:

- three passes of a loaded 85 tonne, 120 tonne or 150 tonne dump truck; or,
- four passes of unloaded 85 tonne, 120 tonne or 150 tonne dump trucks or approved spreading equipment such as CAT 825C, Komatsu WA800 and CAT 992C or equivalent.

One pass shall be defined as the passage of the wheels (wheel path) of the approved plant over the fill surface once. Wheel paths for adjacent passes shall coincide with the edge of the previous pass.

10.4.4 Parkland MS for Coarse Ripped Shale

Where Coarse Ripped Shale Fill is used, it shall be moisture conditioned and compacted under a method specification, using vibrating pad foot rollers. Unless otherwise directed by the Superintendent each layer of material shall be compacted by a minimum of 8 passes of a vibrating pad foot roller. One pass of the roller is defined as a single traverse over a width of fill equivalent to the individual roller drum width. Complete coverage of the fill layer shall be achieved by successive overlapping of layers. The Superintendent may direct more than eight passes for any or all layers.

Vibrating Rollers shall meet the following requirements:

- The static mass of the roller drum shall be not less than 12 tonnes static mass;
- The roller shall be capable of vibrating at frequencies down to 1100 vibrations per minute;
- The centrifugal forces generated by the vibrating part of the roller shall be not less than 123kN at a frequency of 1250 vibrations per minute;
- The motor supplying the power for the vibrating part of the roller shall develop not less than 40kilowatts.

10.5 Construction of Riverbank Filter Zones

Where required, Riverbank Filter materials shall be placed and compacted progressively during the construction of Parkland MS to achieve a Riverbank Filter Zone as shown on Sketch WLL-01A and WLL-01B. The Riverbank Filter Zone shall be constructed as indicated by the Superintendent against the excavated face of the in situ Riverbank landform along the western site boundary.

The Riverbank Filter Zone shall be:

- Constructed to a level of 2m above the level of the in situ PRF materials against which the filter materials are being placed.
- At least 1.5m wide measured horizontally where Coarse Sand Filter is placed.
- At least 3m wide measured horizontally where Fine Sand Filter is placed.

Depending on the constraints of working in the vicinity of a quarry “high face”, Riverbank Filter materials may be compacted using purpose-built compaction equipment, or by tamping with the bucket of an excavator or front-end loader, or by trafficking with rubber tyres of front-end loaders, trucks, or scrapers.

10.6 Construction of Riverbank Core

Riverbank Core shall be constructed by the Contractor to achieve a low permeability zone at a location directed by the Superintendent within the Parkland MS Engineered Fill, between the Riverbank Filter and Lake Toe Engineered Fill. Riverbank Core shall be placed to an elevation 1m above the operating water level of the Wildlife Lake.

The minimum width of the core may be either 1.5m or 5.0m, depending on the material available for construction (refer to Table 3 in Section 7.3.5).

It is expected that the Riverbank Core will be constructed progressively as the surrounding landforms are constructed. The following methodology is proposed. Alternative methodologies may be submitted by the Contractor for review and approval by the Superintendent.

10.6.1 5m Width Option

During construction of Parklands MS (and Lake Toe Engineered Fill where relevant), at fill height increments (lifts) designated by the Superintendent (but not greater than 3m), the Contractor shall excavate a trench of the required width, not less than 50m long.

The trench through the first lift shall expose in situ bedrock. The trench through subsequent lifts shall penetrate 0.3m into the previous construction of Riverbank Core.

For each lift, Riverbank Core shall be placed and compacted in accordance with the layer thickness (Table 4), moisture (Table 5), compaction (Table 6) and testing requirements detailed in Section 7.1. The use of a smooth drum roller is not considered appropriate for compacting Riverbank Core.

10.6.2 1.5m Width Option

Prior to construction of the Riverbank Core, the Contractor shall construct a 10m wide Engineered Fill – Core Component within the Parkland MS landform. It is expected that this Engineered Fill zone will be constructed progressively at fill lifts designated by the Superintendent (but not greater than 3m). The Contractor would excavate a trench not less than 50m long of suitable profile to allow construction of the 10m width of Engineered Fill, and place and compact Engineered Fill – Core Component.

The Contractor would then excavate a trench 1.5m wide through the Engineered Fill – Core Component and place and compact Riverbank Core as described in Section 10.6.1 above.

If for any reason the Riverbank Core must be located close to the edge of Lake Toe Construction such that the design width of Engineered Fill – Core Component cannot be constructed, then:

- the Riverbank Core shall be increased in thickness to 2m, and;
- Lake Toe construction shall be extended laterally to abut the lakeside edge of the Riverbank Core.

10.7 Wave Protection Construction

Wave Protection shall be placed over the lake footprint and lake foreshores at the locations and to the loose thicknesses shown in the Construction Drawings. The Wave Protection Thickness design by WRL is based on loosely placed material. Compaction is not required.

10.8 Rework of Non-Complying Areas

Where tests do not meet the required density and/or moisture content criteria, the Superintendent will notify the Contractor that the area that the test represents does not meet the requirements of the Specification. Upon receipt of such advice, the Contractor shall rework the area, as required, so that the area complies with the Specifications or remove the non-complying materials from the Works.

The Contractor shall be responsible for arranging and bear the cost of retesting of non-complying areas. Retesting shall be carried out by an approved NATA registered testing authority. Retesting of non-complying areas shall include survey to either locate the non-compliant area, or to record the location of the retest.

10.9 Settlement Plates

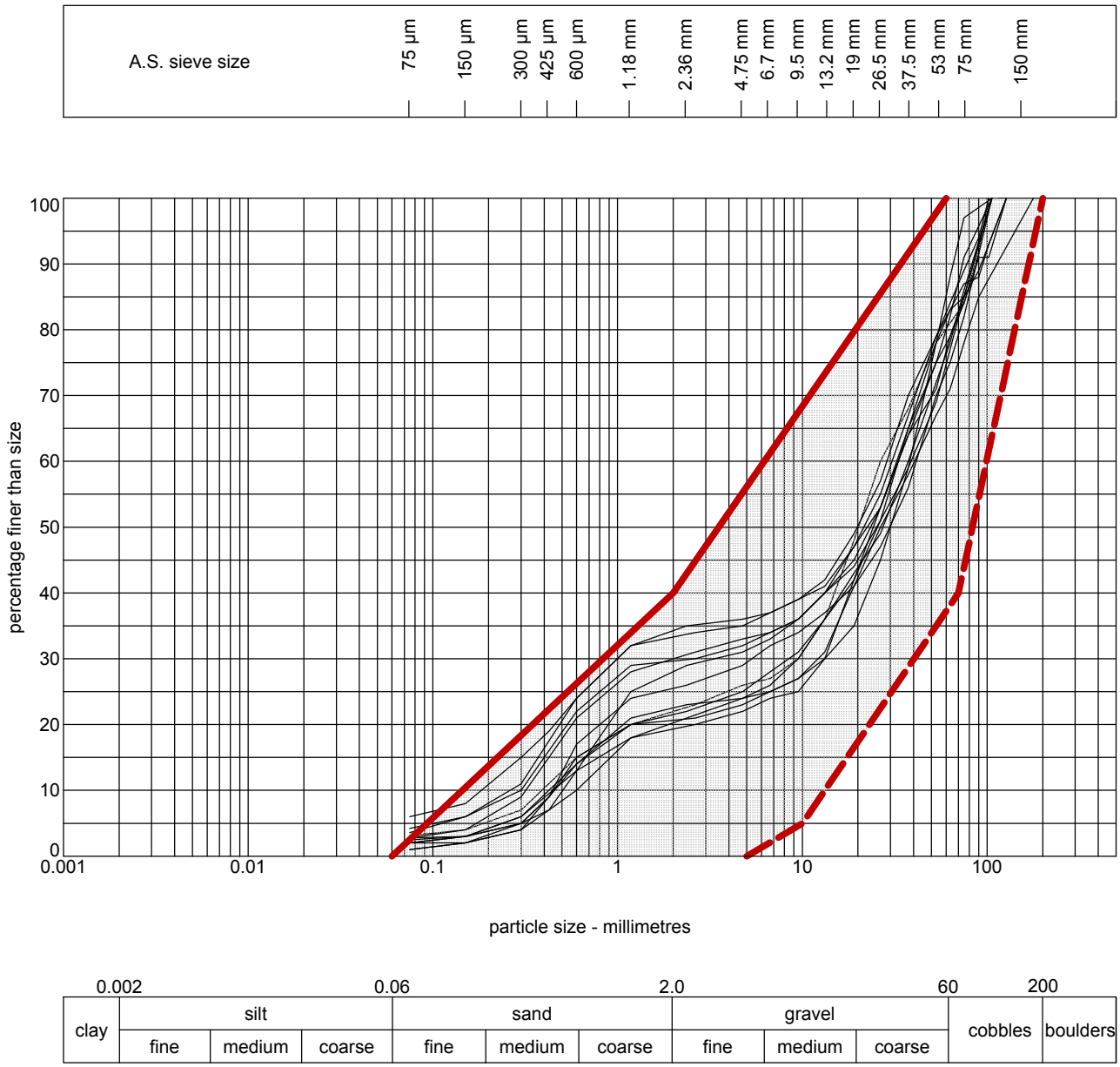
The Principal is required to install settlement plates in Parkland landforms. The Superintendent will advise the Contractor of the number and locations of settlement plates to be installed in the Wildlife Lake landform.

It shall be the responsibility of the Contractor to allow safe access for settlement plate installation and survey monitoring, and to protect the plate installations from damage or burial. The Contractor shall compact overlying fill to within, but no closer than, 0.5m of the settlement plate installations using standard compaction equipment. Any damage to settlement plates as a result of the Contractors' actions shall be rectified at the Contractors' expense that could include additional earthworks, installation of new plates, and additional survey.

10.10 Topsoil

When approval of compliance with the Specifications by the Superintendent has been provided, topsoil shall be placed over the entire area of completed landform in accordance with the landscape design. The topsoil shall be placed across the slope and in a manner that minimises compaction.

Where directed by the Superintendent approved plant such as a grader shall be used to smooth uneven areas and define drainage paths.



LEGEND

Wave Protection Design Grading Range

Typical PRF Samples (Coffey 2009, Cox & Foster 1984)

Upper Bound

Lower Bound

drawn	MFH
approved	RT
date	26/06/09
scale	As Shown
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: Penrith Lakes Development Corporation

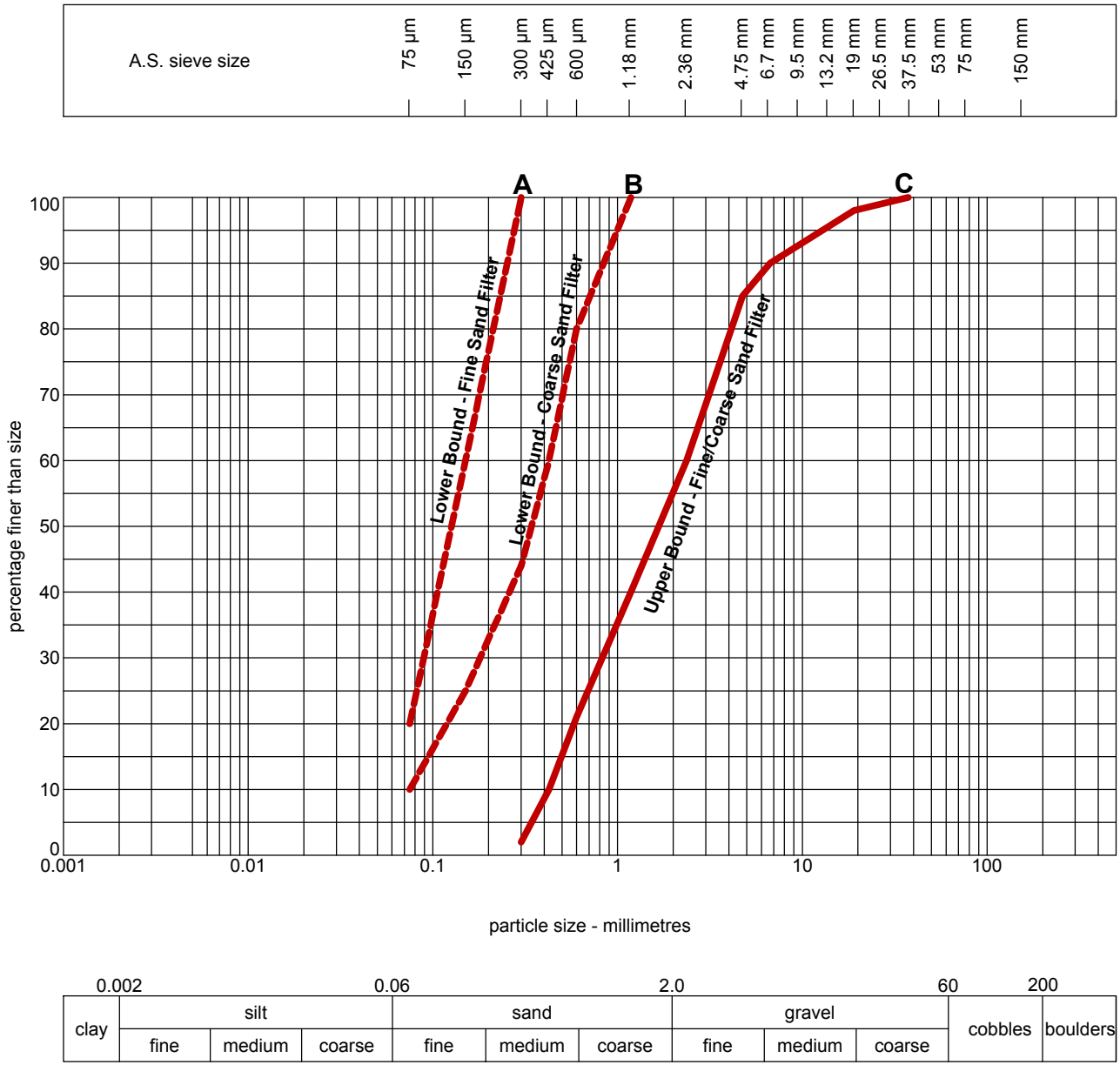
project:
Penrith Lakes - Wildlife Lake Technical Specification

title: **PARTICLE SIZE DISTRIBUTION - Wave Protection**

project no: GEOTLCOV24000DN

figure no: 1

PSD GRADING WAVE PROTECTION.GPJ 26.6.09



LEGEND

A - Lower Bound for Fine Sand Filter

B - Lower Bound for Coarse Sand Filter

C - Upper Bound for Fine/Coarse Sand Filter

drawn	MFH
approved	RT
date	18/08/09
scale	As Shown
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: Penrith Lakes Development Corporation

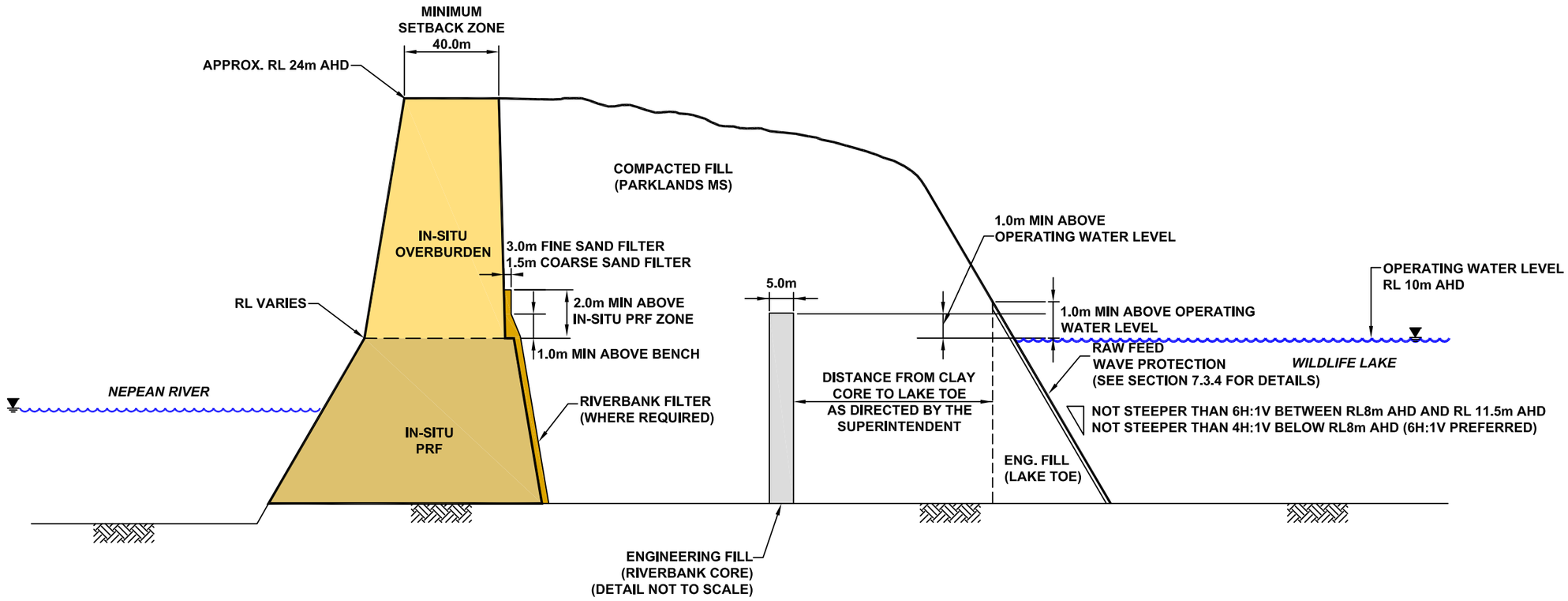
project:
Penrith Lakes - Wildlife Lake Technical Specifications

title: **PARTICLE SIZE DISTRIBUTION**

project no: GEOTLCOV24000DN

drawing no: 2

PSD GRADING UNIT H NORTH FINE SAND.GPJ 18.8.09



revision	description	drawn	approved	date
	Thickness of Riverbank Filter	AW	RMT	12/08/08

0 20 40 80 120
Horizontal Scale (metres)

0 2 4 8 12
Vertical Scale (metres)

drawn	JR/AW
approved	RMT
date	12/08/09
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

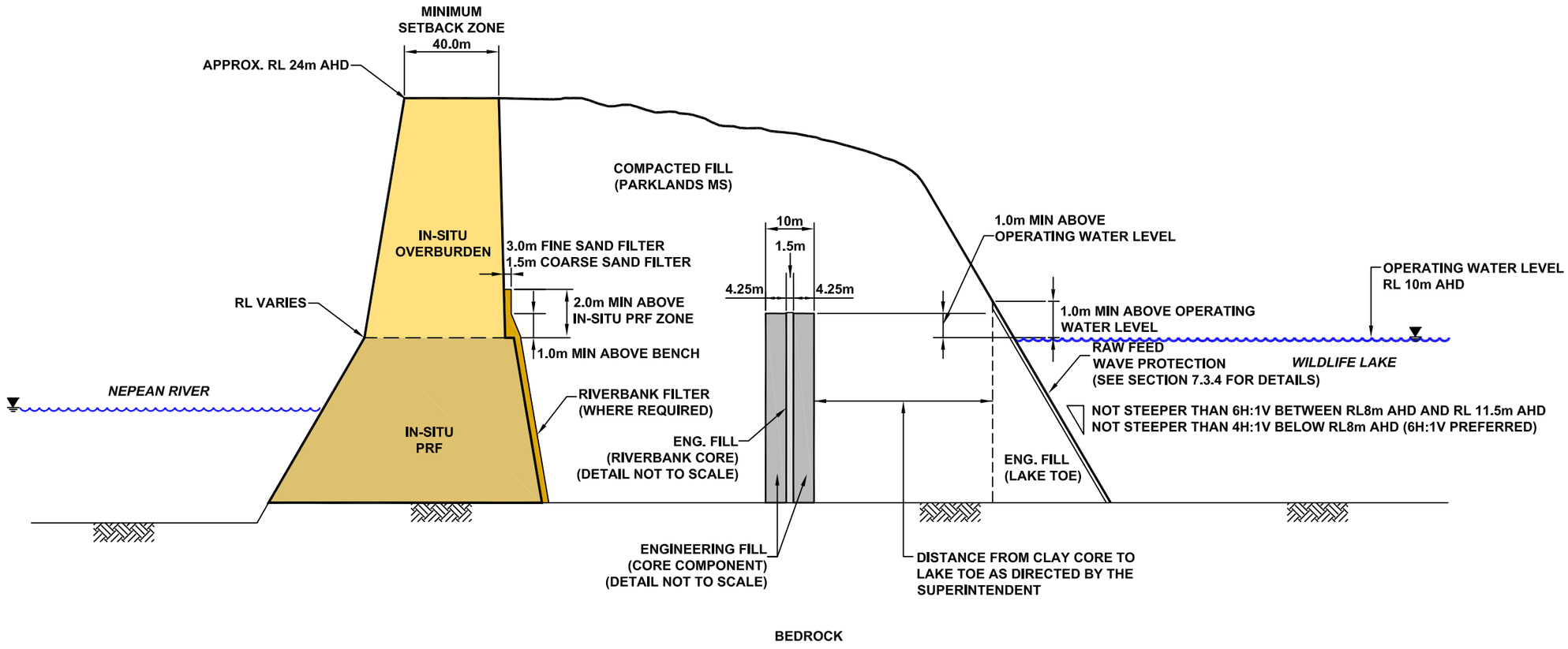
client: PENRITH LAKES DEVELOPMENT CORPORATION

project: PENRITH LAKES DEVELOPMENT
TECHNICAL SPECIFICATION
LANDFORM CONSTRUCTION FOR WILDLIFE LAKE
PENRITH LAKES, PENRITH

title: CONCEPTUAL SECTION - RIVERBANK

project no: GEOTLCOV24000DN-AA

figure no: SKETCH WLL-01A



revision	description	drawn	approved	date
	Thickness of Riverbank Filter	AW	RMT	12/08/08

0 20 40 80 120
Horizontal Scale (metres)

0 2 4 8 12
Vertical Scale (metres)

drawn	JR/AW
approved	RMT
date	12/08/09
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

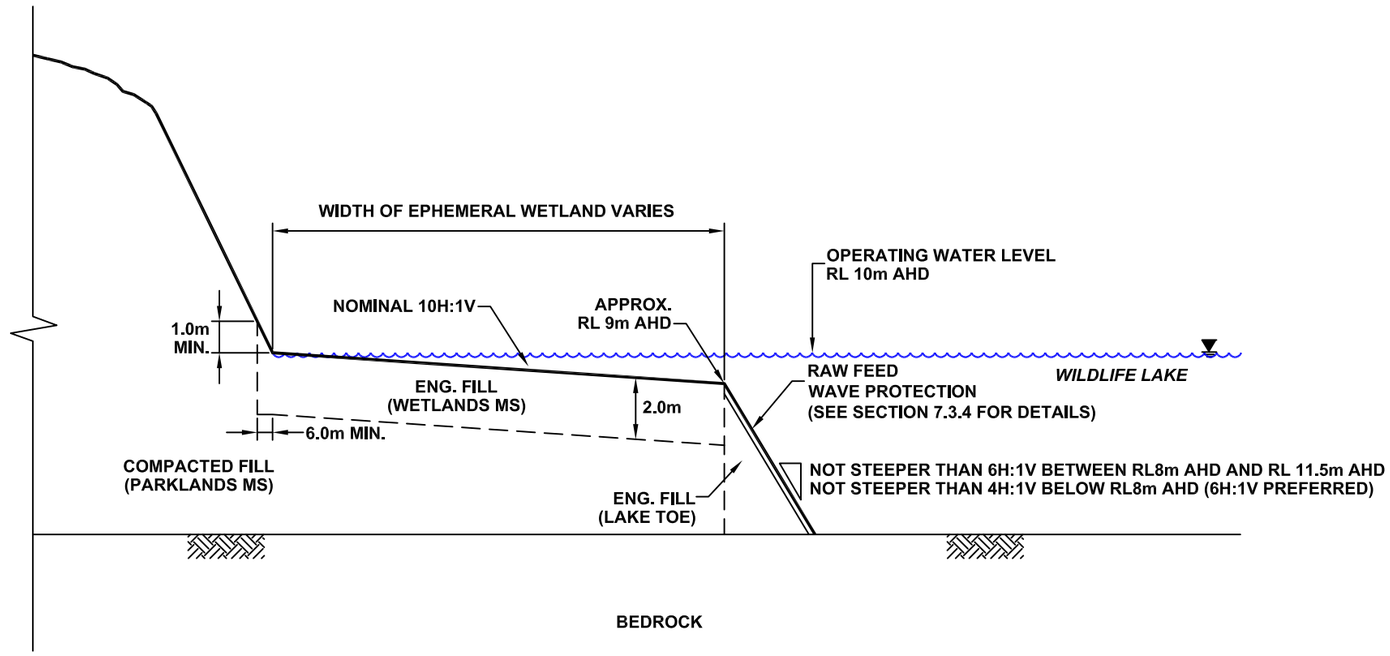
client: PENRITH LAKES DEVELOPMENT CORPORATION

project: PENRITH LAKES DEVELOPMENT
TECHNICAL SPECIFICATION
LANDFORM CONSTRUCTION FOR WILDLIFE LAKE
PENRITH LAKES, PENRITH

title: CONCEPTUAL SECTION - RIVERBANK

project no: GEOTLCOV24000DN-AA

figure no: SKETCH WLL-01B



revision	description	drawn	approved	date

0 20 40 80 120
Horizontal Scale (metres)

0 2 4 8 12
Vertical Scale (metres)

drawn	JR/AW
approved	RT
date	1/09/09
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

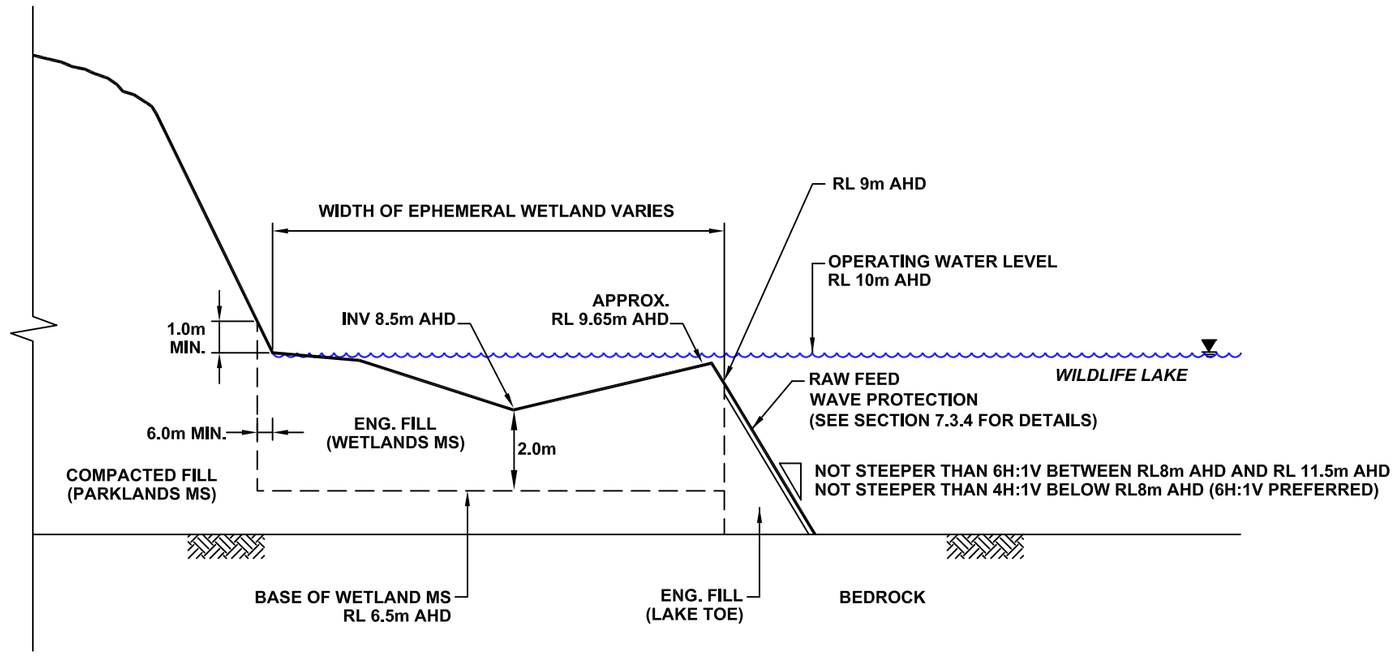
client: PENRITH LAKES DEVELOPMENT CORPORATION

project: PENRITH LAKES DEVELOPMENT
TECHNICAL SPECIFICATION
LANDFORM CONSTRUCTION FOR WILDLIFE LAKE
PENRITH LAKES, PENRITH

title: CONCEPTUAL SECTION -
EPHEMERAL WETLAND CELLS (TYPICAL)

project no: GEOTLCOV24000DN-AA

figure no: SKETCH WLL-02A



revision	description	drawn	approved	date

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Horizontal Scale (metres)

0 2 4 8 12
Vertical Scale (metres)

drawn	JR/AW
approved	RT
date	1/09/09
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

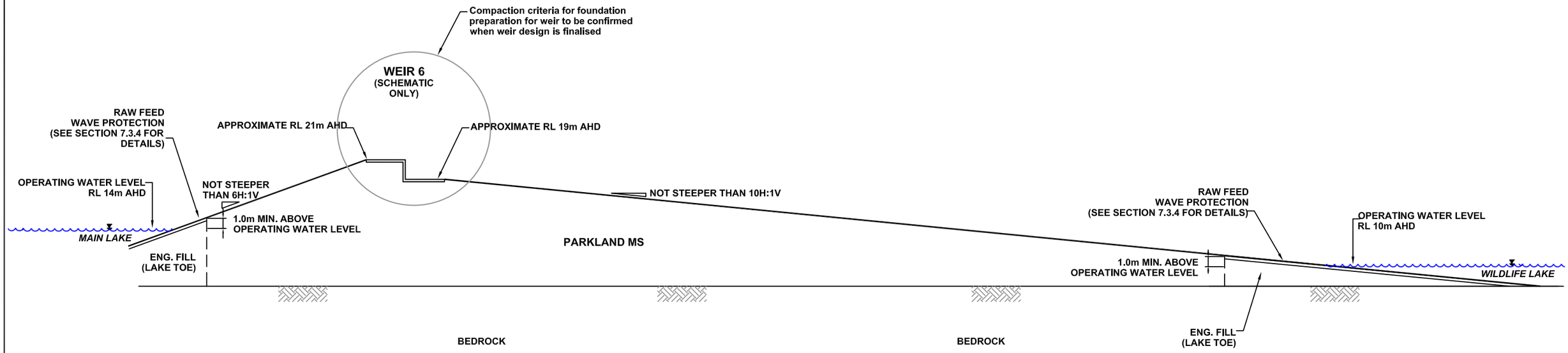
client: PENRITH LAKES DEVELOPMENT CORPORATION

project: PENRITH LAKES DEVELOPMENT
TECHNICAL SPECIFICATION
LANDFORM CONSTRUCTION FOR WILDLIFE LAKE
PENRITH LAKES, PENRITH

title: CONCEPTUAL SECTION -
EPHEMERAL WETLAND CELLS WITH BIRD REFUGE

project no: GEOTLCOV24000DN-AA

figure no: SKETCH WLL-02B



revision	description	drawn	approved	date

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Horizontal Scale (metres)

0 4 8 16 24
Vertical Scale (metres)

drawn	JR/AW
approved	RT
date	4/06/09
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: PENRITH LAKES DEVELOPMENT CORPORATION

project: PENRITH LAKES DEVELOPMENT
TECHNICAL SPECIFICATION
LANDFORM CONSTRUCTION FOR WILDLIFE LAKE
PENRITH LAKES, PENRITH

title: CONCEPTUAL SECTION - EPHEMERAL WETLAND CELLS

project no: GEOTLCOV24000DN-AA

figure no: SKETCH WLL-03

Attachment to GEOTLCOV24000DA-AA: Wild Life Lake Technical Specifications – Summary of Compaction Criteria

Engineered Fill	Suitable Materials [1]	Maximum Layer Thickness	Minimum Density Criteria	Moisture Criteria	Minimum Density Testing Frequency	GITA
Lake Toe	Overburden	400mm loose	95% SMDD	-3% to +3%	1 test per 2,500m^3	Level 2
Riverbank Core 1.5m	High Plasticity Clay	Depends on plant	98% SMDD	-1% to +3%	1 test per 1,000m^3	Level 2
Riverbank Core 5m	Medium and High Plasticity Clay	200mm compacted	98% SMDD	-1% to +3%	1 test per 1,000m^3	Level 2
Riverbank Filter	Sand and Gravelly Sand- See Table 4	400mm loose	See section 10.5	None	Not Applicable	Level 2
Engineered Fill – Core Component	Overburden	400mm loose	98% SMDD	-3% to +3%	1 test per 1,000m^3	Level 2
	Imported Fill	250mm loose	98% SMDD	-2% to +2%	1 test per 1,000m^3	Level 2
Wetland MS	Overburden	250mm loose	Method Specification See Section 10.4.2	-3% to +3%	As required to calibrate specification	Level 2
	Fine Ripped Shale	250mm loose		-2% to +2%		Level 2
	Imported Fill with LL<50%, PI<35%	250mm loose		-2% to +2%		Level 2
Parkland MS	Overburden	250mm loose	Method Specification See Section 10.4.3	-3% to +3%	As required to calibrate specification	Level 2
	Fine Ripped Shale	250mm loose		-2% to +2%		Level 2
	Imported Fill	250mm loose		-2% to +2%		Level 2
	Coarse Ripped Shale	400mm loose	Method Specification See Section 10.4.4			Level 2

Note 1 Refer to Section 7 of GEOTLCOV24000DA-AA for Material Compliance Criteria