Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Remediation Action Plan

Proposed School
Lot 100, DP1261496 Maitland Street, Muswellbrook, NSW

Prepared for
Pacific Brook Christian School Ltd

Project 91601.02
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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1. Introduction

1.1 General

This Remediation Action Plan (RAP) has been prepared for a proposed school at Lot 100, DP1261496 Maitland Street, Muswellbrook, NSW. The work was commissioned in an email dated 27 August 2019 by Chris Baldry of Pacific Brook Christian School Ltd and was undertaken with reference to Douglas Partners Pty Ltd (DP) proposal NCL190535 dated 27 August 2019.

It is understood that the development of the site will comprise a school facility (primary and/or secondary school). It is noted that detailed design plans were not available at the time of writing this report.

This RAP specifically addresses the localised PAH soil contamination identified in asphalt fill materials in the Detailed Site Investigation (DSI) (DP Report 91601.00.R.001.Rev0 dated 23 July 2019). The PAH contamination exceeded the relevant NEPM 2018 guidelines for the proposed landuse. Remediation was therefore recommended to render the site suitable for the intended use. The asphalt was observed in discrete lenses in Pit 106 located within the gravel path, as shown on Drawing 1.

This RAP has been developed based on the results of previous assessments undertaken at the site, including a DSI by DP in July 2019 and a preliminary contamination assessment (PCA) by JK Environments (2019) (JK). The RAP has been prepared with reference to the NSW EPA 'Guidelines for Consultants Reporting on Contaminated Sites' (2011) and NEPM (2013).

It should be noted this RAP addresses soil contamination and does not refer to the recommendations of the hazardous building materials (HBM) survey by DP in July 2019, which have been reported separately.

1.2 Objectives

The objective of the RAP is to remediate the site in an acceptable manner, with minimal environmental impact, to a condition suitable for the proposed school development.

This RAP provides the clean-up objectives, remediation acceptance criteria (RAC), principles, methods and procedures by which the remediation and validation of the site will be achieved. The action plan is not intended as a specification for contract.

2. Site Details

2.1 Site Identification

The site is identified as Lot 100 DP 1261496, Maitland Street, Muswellbrook, New South Wales, as shown in Drawing 1.

The site comprises a triangular area of approximately 2.35 hectares and has a frontage of approximately 334 m to Maitland Street.

At the time of the investigation the site was vacant and generally comprised several empty buildings in connection with the previous site use (plant nursery), gravel and asphalt paths, gravel garden beds and grass covering.

The site is bound by Maitland Street to the south west, residential developments immediately to the south east with a service station located further to the south east (approximately 60 m), a golf course to the west and north.

The site is currently zoned RU3 – Forestry and is within Muswellbrook Shire Council.

Refer to Drawing 1, Appendix A, for site features.

2.2 Background

2.2.1 Preliminary Contamination Assessment

The PCA undertaken by JK in April 2019 comprised a site history review, drilling of 20 boreholes, sampling and laboratory testing. The results of the investigation identified following:

- Fill materials were identified in all bores form 0.1 m to 0.8 m which comprised a mixture of clayey silt, sandy gravel and gravel materials;
- Natural materials were encountered in all bores beneath the filling and typically comprised silty clay materials;
- Groundwater was not encountered during the previous investigation, however minor seepage was encountered in the southern portion of the site at a depth of 0.8 m which may have been attributed to site infrastructure (ie site irrigation) as opposed to natural groundwater;
- It was noted that no odours or staining were observed in the filling or natural materials during the investigation;
- Results of laboratory testing indicated minor exceedances of PAHs and hydrocarbons above human health and ecological criteria in regard to the proposed landuse.

JK indicated that the environmental / ecological risks associated with the identified hydrocarbon concentrations were negligible.

JK concluded that "the site can be made suitable for the proposed primary school or secondary school development subject to further investigation, risk assessment, and (if required) remediation / validation".

The PCA also outlined the following data gaps:

- The sampling density was approximately 57% of the minimum sampling density recommended for hotspot identification, as outlined in the NSW EPA Sampling Design Guidelines (1995) for a site area of approximately 25 000 m^2. A minimum of 15 additional sampling locations would be required to meet the guidelines for a Stage 2 DSI. It is recommended that further investigation is undertaken from test pits to provide a better visual assessment of the soil;
- Groundwater sampling was outside the scope of the preliminary assessment. The potential for on-site activities to have resulted in significant groundwater contamination is considered to be relatively low (based on the site observations and soil analysis results). However, an investigation will be required to assess the potential for contamination impacts associated with the service station to the south-east of the site;
- Chemical storage within the Hazchem sheds has the potential to leach through concrete slabs through historical leaks or spills. Additional sampling would be required around the edges of building slabs and within the building footprint to better characterise these areas; and
- The potential presence of hazardous building materials within the existing buildings.

2.2.2 Detailed Site Investigation (Contamination)

The DSI conducted by DP in July 2019 identified the following:

- Presence of shallow filling within majority of test pits / bores;
- Presence of ash within the upper fill materials in Pits 103, 107 and 111;
- Presence of asphalt lenses in Pit 106 exceeding landuse criteria;
- Fill materials generally met the criteria for classification as 'General Solid Waste' (GSW) based on total concentrations. It is noted leachability testing was not conducted on the samples that exceeded GSW to confirm waste classification. Experience with similar materials indicate such contaminants generally have a low propensity to leach. Therefore, classification as GSW is considered likely, however should be confirmed with additional testing (refer to Section 6);
- Elevated PAH, associated with asphalt lenses within the upper fill materials of the gravel path (Pit 106). This may be associated with a former asphalt seal layer within the path;
- Testing of localised fibro fragments encountered onsite and surrounding soils indicated the absence of asbestos containing materials (ACM);
- General absence of impacts from the nearby petrol station to groundwater quality along the south-east site boundary.

In summary, development of the site will require localised remediation of PAH impacted soils associated with the asphalt lenses within the gravel path. The extent of impact has also not been confirmed (refer to Section 6, Additional Investigation), however, it is likely to be associated with the gravel path within the site.

The site is considered to be suitable for the proposed development, subject to localised remediation of contamination and regulatory approvals.

2.3 Current Site Condition

Site conditions observed during the site walkover on 1 July 2019 are summarised below as follows:

- The site was vacant and contained several site structures as follows:
  - A residential property in the central northern portion of the site (Figure 1);
  - Administration buildings in the south central portion of the site;
  - A glasshouse in the south eastern portion of the site (Figure 2);
  - Two Hazchem sheds in the south eastern portion of the site (Figures 3); and
  - Several awning and shed structures and a large water tank were also located across the site (Figures 3 and 4).

The south eastern portion of the site was fenced and housed the majority of the buildings which were made of weatherboard cladding or metal sheeting along with metal sheet roofing. The south eastern areas also comprised several mature trees along and adjacent to the site boundaries and internal gravel paths and gravel areas covered in weed matting presumably used as display beds when the previous nursery was in operation, the undeveloped areas in the south eastern portion were grassed (Figure 5).

The north western portion of the site was unfenced and appeared to be undeveloped comprising abundant mature trees and vegetative ground cover (Figure 6).

At the time of the inspection the majority of the accessible buildings (sheds, Hazchem and glasshouse) were mostly vacant. The two Hazchem buildings contained remnants of previous chemical storage (ie containers of pesticides etc) (Figure 7).

The concrete flooring and concrete surrounds within the Hazchem buildings did not comprised gross staining or evidence of chemicals leaking from the buildings.

Fibrous cement fragments were also encountered in south eastern portion of the site adjacent to the northern boundary (Figure 8).

Figure 1: Residential building in the central portion of the site, looking south east

Figure 2: Glasshouse in the south eastern portion of the site, looking north

Figure 3: Hazchem buildings in the background and on the right and awning / shed on the left, looking south east

Figure 4: Large water tank on the right and gravel beds lined with weed matting on left, looking south west

Figure 5: Grassed covered areas, internal gravel paths and gravel / weed matting areas, looking north west

Figure 6: Dense grass covered area with abundant mature trees in the undeveloped north western portion of the site, looking south

Figure 7: Stored chemical containers within the Hazchem building

Figure 8: Fibrous cement fragments encountered adjacent to the northern boundary in the south eastern portion of the site, looking north

3. Proposed Development

The proposed development of the site will comprise a school facility (primary and/or secondary school). It is noted no detailed design plans were available at the time of this RAP.

4. Extent of Remediation

Based on the results of the previous investigation, the extent of remediation is generally limited to localised lenses of asphalt, identified in Pit 106 between 0.25 m to 0.28 m and from 0.35 m to 0.37 m depth (ie two asphalt lenses 0.2 to 0.3 m thick). The asphalt lenses observed in Pit 106 are indicated in Figure 9. The test pit log for Pit 106 is contained in Appendix A.

Figure 9: Pit 106 excavation with asphalt layers identified

The extent of the asphalt is unknown, however the lateral extent is expected to be associated with the construction of the gravel paths, indicated on Drawing 1.

Additional investigations, outlined in Section 6, should be conducted prior to remediation to better assess the extent of soil remediation required.

It is noted that the asphalt materials were not encountered by DP in Pit 107 excavated within the gravel path. The underlying asphalt lenses, therefore, may not be present or continuous throughout the entire gravel path area. For the purposes of preparing this RAP, and in the absence of additional investigations, it is assumed the lateral extent of the asphalt lenses are confined to the gravel pathway, and the depths are as observed in Pit 106. Based on the conditions encountered in Pit 106, the estimated dimensions of the gravel path (ie approximately 307 m long and 4 m wide), discussions with a Remediation Contractor (RC) and consideration of practical excavation / segregation depths, an approximate volume of 250 m^3 has been estimated for the removal of impacted soils.

5. Soil Remediation Strategy

A range of possible options were considered for the soil remediation strategy. These were:

- No Action;
- On-site management of contaminated soils;
- On-site treatment and re-use;
- Off-site disposal of contaminated material to a licensed landfill.

Each of the possible strategy options will have an associated cost and timing impact that will need to be carefully considered by the client.

The following is an overview of each strategy and how DP considers they may be applicable to the contamination identified at the site.

No Action
The 'No Action' option involves no active remediation response to the contamination identified on the subject site and would rely on natural attenuation processes. This option was considered not appropriate as it does not actively address, remediate, alleviate, and/or manage the long and short-term human health and environmental risk of the contamination already identified on-site.

On-Site Management of Contaminated Soils
On-site management of contaminated soils involves placement / retention of the contaminated soils within the site area such that the proposed development is constructed over the contaminated soils, minimising the potential for access to the contaminated soils. The management of contaminated soils at the site requires the preparation and implementation of a long-term Environmental Management Plan (EMP) at the site, which outlines the procedures used to render the site suitable for the proposed development. The EMP also provides the procedures for managing contaminated soils should access to the soils be required following construction. On-site management of contaminated materials also requires that a notice be on the relevant Planning Certificate.

On-site management via capping would require additional investigation to assess the extent of impacts, together with leachability testing to confirm that the contaminants of concern can be appropriately managed and contained within the site. On-site capping would need to be integrated with the proposed development, which would incur additional cost to the development during design and construction, including the installation of a marker layer and clean capping material in landscape areas (where required). On-site management would also require regulatory approval prior to development. Council are also likely to require a Statutory Site Audit due to the sensitive landuse and long term management requirements for remediation. It is noted that the identified contamination is likely to be localised.

On-site management of contaminated soils was not considered to be the most appropriate remediation strategy for the proposed development due to the proposed sensitive landuse (school), the localised extent of contamination, and the liability for long-term management via an EMP.

On-Site Treatment of Contaminated Soils
On-site treatment of contaminated soils involves a physical or chemical process that would allow retention of remediated soils on site for beneficial re-use, or retention of contaminated soils combined with on-site management of soils.

On-site treatment of the identified hydrocarbon (asphalt) contaminated soils is not likely to be viable due to the localised nature of the contamination.

Off-Site Disposal of Contaminated Material to a Licensed Landfill
Off-site disposal of hydrocarbon (asphalt) impacted soils is proposed as the preferred remediation strategy as it is expected to render the site suitable for the proposed development with minimal long term restrictions placed on the subject site, considering the localised nature of the identified impacts.

This strategy will not require long-term management of site contamination nor notification on the Planning Certificate for the site.

6. Additional Investigation

Additional investigation is recommended to further assess the extent of PAH contamination prior to commencing remediation. The additional investigation should include:

- Excavation of test pits to better assess the extent of impacted material (area and depth);
- Laboratory testing (including leachability) of selected samples to confirm waste classification; and
- Confirm the volume of impacted soil requiring remediation.

7. General Remediation Procedure

The objective of the RAP is to provide procedures to remediate the site in an acceptable manner, with minimal environmental impact, to a condition suitable for the proposed school development.

The following general remediation procedure (following additional investigation - Section 6), provides for off-site disposal of contaminated material as follows:

- Inception meeting with the project manager and remediation contractor to discuss remediation requirements;
- Excavation and segregation of the upper layer of ‘clean’ fill materials;
- Removal/segregation and off-site disposal of asphalt contaminated materials by an appropriately licensed remediation contractor (RC), following waste classification and clearance / validation by a suitably qualified consultant. It is anticipated the waste classification confirmed during the additional investigation (refer to Section 6) would allow for direct loading of the contaminated materials and disposal;
- Preparation of a soil stockpiling area for temporary storage (if required);
- Visual inspection and stripping of contaminated material where identified within the site (ie asphalt lenses etc);
- Collection of validation samples in the above areas to confirm the removal of contaminated materials;
- Replacement of the upper layer of ‘clean’ fill materials;
- Classification of imported materials for on-site use, to allow for reinstatement of current site levels;
- Inclusion of the results of remediation in the validation report for the site.

8. Remediation Goals and Acceptance Criteria

The proposed Remediation Acceptance Criteria (RAC) for soils remaining on-site with respect to the proposed landuse and identified contaminants are provided in Tables 1 to 3 below. On the basis of the findings of the previous investigation, the general contaminants of concern are hydrocarbons (specifically PAH).

It is considered that the validation analysis should focus on the identified areas of concern and their associated contaminants. In order to provide for contingency situations, however, RAC are also established for other contaminants. This should, however, only be used as and when required (ie if signs of such contaminants are observed, suspected or found).

The analytical results from validation testing will be assessed against the following as provided in NEPC (2013) and CRC Care (2011).

Although the investigation levels are not intended to be used as clean up levels, they establish concentrations above which further appropriate investigation (eg Tier 2) should be undertaken. If the concentrations of contaminants in the remaining soils (ie following remediation) are within the investigation levels, it is considered that the site would be suitable for the intended landuse.

Table 1: RAC – HIL A / EIL A (Contaminants of Concern)

Analyte		HIL A	EIL A
PAH	Benzo(a)pyrene TEQ[1]	3	-
	Total PAH	300	-
	Naphthalene	-	170

Notes to Table 1:

1 Sum of carcinogenic PAH

Table 2: RAC Health Screening Levels (HSLs) for Vapour Intrusion (mg/kg)

Analyte		HSL A Clay (0-<1 m / 1-<2 m)	Intrusive Maintenance Worker Clay 0-<2 m	Direct Contact HSL A
TRH	$C_6 – C_{10}$ (less BTEX) [F1]	50/90	NL	4400
	$>C_{10}-C_{16}$ (less Naphthalene) [F2]	280/NL	NL	3300
	$>C_{16}-C_{34}$	NC	NC	4500
	$>C_{34}-C_{40}$	NC	NC	6300
BTEX	Benzene	0.7/1	350	100
	Toluene	480/NL	NL	14000
	Ethyl Benzene	NL/NL	NL	4500
	Xylene	110/310	NL	12000
PAH	Naphthalene	5/NL	NL	1400

Notes to Table 2:

The soil saturation concentration (Csat) is defined as the soil concentration at which the porewater phase cannot dissolve any more of an individual chemical. The soil vapour that is in equilibrium with the porewater will be at its maximum. If the derived soil HSL exceeds Csat, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

Table 3: RAC Management Limits for TRH Fractions in Soil

TRH Fraction	Soil Texture	Management Limit Residential, Parkland and Public Open Space (mg/kg)
C_6-C_9	Coarse	700
	Fine	800
$>C_{10}-C_{16}$	Coarse	1,000
	Fine	1,000
$>C_{16}-C_{34}$	Coarse	2,500
	Fine	3,500
$>C_{34}-C_{40}$	Coarse	10,000
	Fine	10,000

Table 4: RAC Ecological Screening Levels (ESLs) in mg/kg

Analyte		Urban Residential and Public Open Space – Fine Soils	Comments
TRH	$C_6 – C_{10}$ (less BTEX) [F1]	180*	All ESLs are low reliability apart from those marked with * which are moderate reliability
	$>C_{10}-C_{16}$ [F2]	120*	
	$>C_{16}-C_{34}$ [F3]	1,300	
	$>C_{34}-C_{40}$ [F4]	5,600	
BTEX	Benzene	65	
	Toluene	105	
	Ethyl Benzene	125	
	Xylenes	45	
PAH	Benzo(a)pyrene	0.7	

Table 5: RAC for other contaminants, in mg/kg Unless Otherwise Indicated

Analyte		HIL A	EIL A
Heavy Metals	**Arsenic**	100	100
	Cadmium	20	-
	Chromium	100	410
	Copper	6000	110
	Lead	300	1100
	Mercury (inorganic)	40	-
	Nickel	400	35
	Zinc	7400	310
	Manganese	3800	-
OCP/ OPP	**Aldrin + Dieldrin**	6	-
	Chlordane	50	-
	DDT+DDE+DDD	240	180 (DDT only)
	Endosulfan	270	-
	Endrin	10	-
	Heptachlor	6	-
	Methoxychlor	300	-
	Chlorpyrifos	160	-
PCBS[2]		1	-

Notes to Table 5:

1 Sum of carcinogenic PAH

2 Non dioxin-like PCBs only

In addition to the above analytical criteria, the soil should be assessed based on the basis of aesthetic considerations. The soil should be free from odours and deleterious materials. Odour will be assessed on the basis of olfactory observations made by the environmental consultant.

Conformance with the RAC will be attained when either all validation samples meet the specified RAC, or, as a minimum for chemical contamination, the 95% UCL mean concentration value of each contaminant in the materials remaining on-site (validation samples) are below the respective RAC level, and no individual exceedance is greater than 2.5 times the RAC.

In addition to the above, imported fill used to reinstate site excavations or raise site levels (if required) should be classified as Virgin Excavated Natural Material (VENM) or Excavated Natural material (ENM) or should be classified under a relevant resource recovery order (RRO / RRE) and should be accompanied by a certificate from the supplier, otherwise detailed assessment (including analysis of representative samples) will be required prior to use on-site.

Landfill disposal criteria for contaminants, in accordance with NSW EPA Waste Classification Guidelines, are presented in Tables 6 and 7 below.

Table 6: Landfill Disposal Criteria – Total Concentrations

CONTAMINANT THRESHOLD VALUES FOR CLASSIFYING WASTE BY CHEMICAL ASSESSMENT WITHOUT DOING THE LEACHING TEST [1]			
Contaminant	**Maximum Values of *Total Concentration* for Classification without TCLP**		**CAS Registry Number**
	General Solid Waste CT1 (mg/kg)	**Restricted Solid Waste CT2 (mg/kg)**	
Benzene	10	40	71-43-2
Toluene	288	1152	108-88-3
Ethyl Benzene	600	2400	100-41-4
Xylenes (total)	1000	4000	1330-20-7
C_6-C_9 petroleum hydrocarbons	650	2600	-
C_{10}-C_{36} petroleum hydrocarbons	10,000	40,000	-
Lead	100	400	-
Arsenic	100	400	-
Cadmium	20	80	-
Chromium (total)	100	400	-
Mercury	4	16	-
Nickel	40	160	-
Polycyclic Aromatic Hydrocarbons (total)	N/A	N/A	-
Benzo(a)pyrene	0.8	3.2	50-32-8
Organochlorine Pesticides [2]	<50	<50	
Organophosphorus Pesticides [3]	250	1000	

Notes to Table 6:

1 Adopted from Table 1 – NSWEPA 2014
2 Classified as part of Scheduled Chemicals group
3 Classified as part of 'Moderately Harmful Pesticides' group

N/A – Not Applicable (refer to Table 6)

Table 7: Landfill Disposal Criteria – Leachable and Total Concentrations

LEACHABLE CONCENTRATION (TCLP) AND TOTAL CONCENTRATION (SCC) FOR CLASSIFYING WASTE BY CHEMICAL ASSESSMENT [1]					
Contaminant	Maximum Values for *Leachable Concentration* and Total Concentration when used together				CAS Registry Number
	General Solid Waste		Restricted Solid Waste		
	Leachable Concentration TCLP1 (mg/L)	Total Concentration SCC1 (mg/kg)	Leachable Concentration TCLP2 (mg/L)	Total Concentration SCC2 (mg/kg)	
Benzene	0.5	18	2	72	71-43-2
Toluene	14.4	518	57.6	2073	108-88-3
Ethyl Benzene	30	1080	120	4320	100-41-4
Xylenes (total)	50	1800	200	7200	1330-20-7
C6-C9 petroleum hydrocarbons [2]	N/A [2]	650	N/A [2]	2600	-
C10-C36 petroleum hydrocarbons [2]	N/A [2]	10000	N/A [2]	40000	-
Lead	5	1500	20	6000	-
Arsenic	5	500	20	2000	-
Cadmium	1	100	4	400	-
Chromium (total)	5	1900	20	7600	-
Mercury	0.2	50	0.8	200	-
Nickel	2	1050	8	4200	-
Polycyclic Aromatic Hydrocarbons (total)	N/A	200	N/A	800	-
Benzo(a)pyrene	0.04	10	0.16	23	50-32-8
Organochlorine Pesticides [3]		<50		<50	
Organophosphorus Pesticides [4]		250		1000	

Notes to Table 7:

1 Adopted from Table 2 – NSW EPA 2014
2 Petroleum hydrocarbons are assessed only by total concentration (SCC1 or SCC2)
3 Classified as part of Scheduled Chemicals group
4 Classified as part of 'Moderately Harmful Pesticides' group

N/A – Not applicable

On the basis of previous assessment, contaminant concentrations within the impacted area were generally classified as General Solid Waste (GSW) from a chemical contamination perspective and no leachability testing was conducted on the samples that exceeded GSW to confirm waste classification. It is noted NSW EPA have pre-classified asphalt as GSW and experience indicates such materials generally have a low propensity to leach. Therefore, the classification of impacted soils as GSW is considered likely, however, this should be confirmed during the additional investigation (refer to Section 6).

9. Remediation Roles and Responsibilities

In order to achieve the goals of the remediation/earthworks programme, the roles and tasks identified for the contractor and consultants are presented in Table 8.

Table 8: Remediation Roles and Responsibilities

Task	Description	Responsibility
1. Additional Investigation		
(i) Additional Subsurface Investigation	Additional test pits and testing to better assess the extent of contamination and confirm waste classification	Consultant
2. Preliminaries		
(i) Engage Remediation Contractor		client
(ii) Inception Meeting	Meeting between relevant parties (project manager, remediation contractor, consultant) to discuss tasks and responsibilities	client
(iii) Preparation of Safety and Environmental Management Plans		Remediation Contractor
(iv) Site Inductions	Safety and environmental induction for all site workers	Remediation Contractor
(v) Set up environmental control measures		Remediation Contractor
3. Remediation of Identified Impacts		
(i) Mark out areas of identified contamination		Consultant
(ii) Set up stockpile areas for upper layer of “clean” fill materials	Preparation of stockpiling areas for temporary storage of ‘clean’ fill materials	Remediation Contractor
(iii) Remediation of asphalt impacted soil	Removal / segregation and off-site disposal of asphalt impacted soil/fill material, in accordance with relevant statutory and regulatory requirements	Remediation Contractor
(iv) Handling of fill materials	Excavations, stockpiles, segregation, placement, compaction, and disposal of unsuitable fill materials	Remediation Contractor
(v) Inspection of remediation works	Full time inspection associated with excavation, segregation and disposal of asphalt impacted soils	Consultant
(vi) Validation of remediated areas	Inspection and testing of remediated areas to validate the removal of contamination	Consultant
(vii) Classification of soils for off-site disposal	Contamination sampling and testing for waste classification for disposal of soils to a licensed landfill (if additional classification is required)	Consultant
(viii) Disposal of contaminated materials	Disposal of soils/materials to an appropriately licensed landfill	Remediation Contractor
Task	**Description**	**Responsibility**
(ix) Classification of imported fill materials (where required)	Review of documentation, or assessment of materials via inspection and testing to confirm VENM or ENM status or RRO / RRE	Consultant/remediation contractor

Table 8: Remediation Roles and Responsibilities (cont)

Task	Description	Responsibility
4. Reporting		
(i) Submit tip dockets and tracking information for reporting purposes		Remediation Contractor
(ii) Preparation of a validation report		Consultant

Prior to the commencement of remediation works, a site meeting between the project manager remediation contractor and DP should be held to confirm the above responsibilities and procedures in accordance with this remediation action plan.

Details of remediation methodologies are presented in the following sections.

10. Remediation

10.1 Methodology

The following general procedures are recommended for the remediation and validation of asphalt impacted soils following the additional investigation (Section 6):

- Contractor to progressively excavate affected soils from affected areas under full-time inspection by DP;
- Contaminated material will be excavated/chased until visual evidence indicates the absence of such materials;
- DP to validate excavated areas as discussed in Section 10.3;
- Remediation Contractor to dispose of the excavated soils to an appropriately licensed landfill, following confirmation of waste classification of the soils.

Procedures for stockpiling of excavated soil/fill materials are discussed in Section 10.2 below.

The objective will be to minimise the volume of soils requiring excavation and off-site disposal for remediation.

10.2 Stockpiling of Contaminated Soils (if required)

Should temporary storage be required, impacted soil should be placed on site in a specified area, prepared by the contractor as follows:

- Nominate stockpile area on-site, away from the possible excavation of contaminated soil, and as far as practicable from adjacent residences or other sensitive landuses;
- Provision should be made to allow for expansion of the stockpile area should this be required during the course of the works;

- Install relevant controls (such as blocking any drainage pits if present) within the stockpile area to minimise the risk of leachate from contaminated soil entering the stormwater system;
- Surround the stockpile with erosion/sediment control measures (eg silt fence, clean soil bund or similar);
- Stockpile contaminated material over plastic sheeting (where required);
- Barricade the perimeter of the stockpiled material.

10.3 Validation of Excavations/Stripped Surfaces

The following procedure is recommended for validation of identified areas of PAH contaminated soils following stripping / removal:

- The stripped surface should be inspected by DP to confirm the visual absence of potentially contaminated materials / soils;
- Validation samples for chemical testing will be collected by DP at 10 m intervals along the excavated gravel path, or at a sampling density of at least a 10 m x 10 m grid over the stripped area, with a minimum of two samples per stripped area;
- Chemical analysis will be conducted by DP at a NATA registered laboratory on samples collected to validate the removal of materials containing PAH contamination;
- Validation samples should also be collected from the surface of former temporary stockpile areas following removal of impacted soils (if conducted).

The above analysis will be utilised to compare contaminant levels to the RAC in the validated areas.

If validation results exceed the RAC, further removal (additional scraping/excavation) will be required, followed by additional validation sampling and analysis, until the RAC are met. Note that at least seven working days are required for laboratory analysis. Excavation of contaminated material will be limited to the extent of site boundaries.

10.4 Fill Stockpile Classification and Disposal/Re-use Options

Segregated fill stockpiles containing potentially contaminated materials should be classified in accordance with NSW EPA (2014) for disposal purposes.

It is understood that one of the objectives of the additional site investigation prior to the commencement of remediation (refer to Section 6) is to confirm waste classification of impacted materials to allow direct excavation and disposal during remediation (ie minimise requirement for double handling and delays during remediation).

In the event, however, that soils not already classified during previous assessment are to be disposed off-site, representative samples should be collected by DP from the segregated fill stockpiles, and analysed for the potential chemical contaminants as discussed in Section 11.3. The frequency of samples will depend on the size and composition/characteristics of the stockpile. A minimum frequency of one sample per 25 m^3 should be initially considered.

The results of analysis will be utilised to confirm options for off-site disposal, or re-use at the site, as follows:

- Satisfies RAC:
  - Re-use on site, subject to geotechnical suitability as engineered fill;
  - Dispose off-site to a licensed landfill.
- Satisfies RAC and off-site re-use criteria:
  - Re-use on site, subject to geotechnical suitability as engineered fill;
  - Dispose off-site to a licensed landfill;
  - Re-use off-site, subject to geotechnical suitability and classification as VENM, ENM or classified under a relevant RRO.
- Exceeds RAC but satisfies landfill disposal guidelines (NSW EPA, 2014):
  - Dispose off-site to a licensed landfill.
- Exceeds RAC and exceeds landfill disposal guidelines:
  - Develop on-site remediation strategy and continue until guidelines are satisfied;
  - Carry out appropriate immobilisation for off-site disposal to licensed landfill (subject to regulatory approvals).

10.5 Loading and Transport of Contaminated Materials

Transport of contaminated material off the site should be via a clearly demarcated haul route and this route exclusively should be used for entry and egress of vehicles used to haul identified contaminated materials within and away from the site.

Removal of waste materials from the site should only be carried out by a licensed contractor holding appropriate licences, consents and approvals from NSW EPA and/or other Authorities to transport and dispose the waste materials according to the classification guidelines.

Details of all contaminated materials removed from the site should be documented by the contractor with copies of weighbridge slips, trip tickets and consignment disposal confirmation (where appropriate). Such information should be provided to DP for reporting purposes. A site log/tracking sheets should be maintained by the remediation contractor for stockpiles (numbered locations), to enable the tracking of disposed loads against on-site origin and location of the materials and corresponding (validation) sample numbers.

Measures should be implemented to minimise the potential for contaminated material to be spilled onto public roadways or tracked off-site on vehicle wheels. Such measures could include the deployment of a vehicle washing/cleaning facility, which should be placed at a location before the egress point of the site. The facility should be able to handle all vehicles and plant operating on site (if required). Residue from the cleaning facility will be deemed contaminated unless shown by validation to be below RAC criteria.

The proposed waste transport route should be notified to the local Council and truck dispatch should be logged and recorded by the contractor for each load leaving the site. The waste tracking procedure should be confirmed by DP.

11. Sample Collection and Analysis

Sampling will be directly from the exposed surface of excavation, or, in the case of stockpiles, from various depths between the surface and the base. Sampling data should be recorded to comply with routine Chain of Custody requirements.

The general sampling, handling, transport and tracking procedures comprises:

- The use of stainless steel sampling equipment;
- The use of disposable gloves for each sampling event;
- Washing of all sampling equipment in contact with the sample, in a 3% solution of phosphate free detergent (Decon 90) then rinsing with distilled water prior to each sample being collected;
- Transfer of the sample immediately into new glass jars;
- Collection of 10% replicate samples for QA/QC purposes;
- Collection of replicate soil samples in zip-lock plastic bags for PID screening;
- Labelling of the sample containers with individual and unique identification including Project Number and Sample Number;
- Placement of the containers into a chilled, enclosed and secure container for transport to the laboratory; and
- Use of chain of custody documentation so that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to hand-over to the laboratory.

11.1 Sample Holding Times

Maximum sample holding times are as follows:

- PAH - 14 days;
- Metals - 6 months (if required);
- TRH/BTEX - 7 days.

All samples must be collected in appropriate containers, and stored and transported at 4°C.

11.2 Validation Sample Analysis

11.2.1 Asphalt Impacted Soils

Validation of asphalt impacted soils should include PAH analysis and Total Recoverable Hydrocarbons (TRH) and silica, and PAH.

Analysis on selected soil samples during the additional subsurface investigation (Section 6), prior to the commencement of remediation, should include PAH and TRH, for waste classification purposes. Additional leachability testing and possible coal tar identification testing may also be required to confirm waste classification. The suite of tests required for waste classification will be confirmed during the additional investigation, depending on the subsurface conditions encountered. Waste classification should be conducted with reference to the relevant NSW EPA guidelines.

If additional waste classification of impacted soils is required for off-site disposal, the soils should be analysed for the following general suite:

- Total Recoverable hydrocarbons (TRH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Polychlorinated Biphenyls;
- Organochlorine and Organophosphorus Pesticides;
- Heavy Metals (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc).

The analytical programme will be reviewed following excavation, segregation and sampling. Leachability (TCLP) analysis may be required for stockpile samples if total contaminant levels are found to exceed 'General Solid Waste' criteria.

11.2.2 Imported Fill

Any materials which are imported onto the site (eg to backfill excavations) should be classified as VENM, ENM or conform with a relevant RRO / RRE, and an appropriate report must be made available to the environmental consultant prior to the importation of the material.

In the absence of confirming the source and suitability of imported fill for use on site, the VENM or ENM material should be assessed with reference to the ENM Order and Exemption 2014 and analysed for the following:

- Total Recoverable hydrocarbons (TRH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Organochlorine pesticides (OCP);
- Polychlorinated Biphenyls (PCB);
- Heavy Metals (Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Mercury, and Zinc);

- pH, Electrical Conductivity; and
- Rubber, plastic, bitumen, paper, cloth, paint and wood (NSW RTA Test Method T276).

Materials imported to site in accordance with a relevant resource recovery order should be assessed under the relevant order prior to importation.

12. Quality Assurance Plan

12.1 Field Quality Assurance

Sampling accuracy and precision should be maintained through the analysis of 10% field duplicate / replicate samples.

Appropriate sampling procedures should be undertaken to minimise potential for cross contamination, for example:

- Standard operating procedures are followed;
- Site safety plans are developed prior to commencement of works;
- Replicate field samples are collected and analysed;
- Samples are stored under secure, temperature controlled conditions;
- Chain of custody documentation is employed for the handling, transport and delivery of samples to the selected laboratory.

12.2 Laboratory Quality Assurance and Quality Control

DP's preferred laboratory routinely undertakes in-house QA/QC procedures involving the routine testing of:

- Reagent blanks;
- Spike recovery analysis;
- Laboratory duplicate analysis;
- Analysis of control standards;
- Calibration standards and blanks;
- Statistical analysis of QC data.

12.3 Achievement of Data Quality Indicators

Based on the analysis of quality control samples, ie duplicates / replicates and in-house laboratory QA/QC procedures, the following data quality indicators will be required to be achieved:

- Conformance with specified holding times;
- Accuracy of spiked samples within the laboratory's acceptable range (typically 70% to 130% for inorganic contaminants and greater for some organic contaminants);
- Field and laboratory duplicates and replicates samples will have a precision average of +/- 50% relative percent difference (RPD). Elevated RPDs may be present due to heterogeneity of materials; and
- Field duplicates/replicates will be collected at a frequency of 10% of all samples.

Based on a fulfilment of the data quality indicators, an assessment of the overall data quality will be presented in the final validation report.

12.4 Validation Reporting

A validation report will be prepared by DP with reference to the NSW EPA Contaminated Sites Guidelines for Consultants Reporting on Contaminated Sites (2011) and other appropriate guidance documentation, and be submitted to the client at the completion of the remediation works programme.

The validation report should include details of the total volume of contaminated materials removed from site, indicate the final disposal destination of the materials removed from site, present detailed analytical results, and provide comment on the suitability of the site for residential landuse following remediation.

13. Work Health and Safety

13.1 Introduction

All site work must be undertaken in a controlled and safe manner with due regard to potential hazards, training and safe work practices. The work should comply with WHS policies specified by the relevant Authorities. It is recommended that the contractor prepare a project-specific environmental management and WHS plan to supplement the measures presented in this RAP.

13.2 Personnel and Responsibilities

Before undertaking works on site, all personnel will be advised of the officer responsible for implementing health and safety procedures. All personnel should read and understand the WHS Plan prior to commencing site works. Contractors employed at the site will be responsible for ensuring that their employees are aware of, and comply with the requirements of the safety plan.

The contractor is responsible for all on-site activities including handling of fill materials – excavation, stockpiling, segregation, placement of fill, etc.

13.3 Hazards at the Site

13.3.1 Chemical Hazards

Chemical compounds or substances that may be present on site include hydrocarbon contaminated soils.

The possible risks to site personnel associated with the above analytes include:

- Ingestion of contaminated soil or water;
- Dermal contact with contaminated soil or water;
- Inhalation of dusts or aerosols containing contaminants.

13.3.2 Physical Hazards

Potential hazards associated with the works may include but not limited to the following:

- Heat exposure;
- Excavations;
- Buried services;
- Noise;
- Dust;
- Electrical equipment;
- Heavy equipment and truck operation.

13.4 Safe Work Practices

Personnel will endeavour, wherever possible, to avoid direct contact with potentially contaminated material. Surface or groundwater should not be ingested or swallowed, and direct skin contact with soil and water should be avoided.

Subject to the site controller's requirements, all personnel on site will be required to wear the following protection at all times:

- Steel-capped boots and high visibility clothing;
- Safety glasses or safety goggles with side shields meeting AS 1337:1992 requirements (as necessary);
- Hard hat meeting AS 1801:1997 requirements;

- Hearing protection meeting AS 1270:2002 requirements when working around machinery or plant equipment if noise levels exceed exposure standards.

13.5 Asbestos

In the event that personnel are required to work in areas of potential contact with asbestos containing materials, the following additional protection may be required subject to the prevailing conditions:

- Disposable coveralls to prevent contact with asbestos materials;
- Particulate respirator (Class P2) or equivalent.

Excavation, handling, stockpiling, transport etc of materials containing asbestos should be undertaken by a licensed contractor in accordance with relevant regulatory requirements.

13.6 Emergency Response Plan

An essential component of the WHS Plan will involve development of an Emergency Response Plan for all aspects of site works. This will include provisions for the safety of personnel working on site in the event of an emergency situation. Any emergency will be reported immediately to the site office and/or the Site Safety Officer, and the appropriate emergency assistance should be sought by telephoning 000.

The works contractor will be responsible for ensuring that site personnel are aware of the emergency services available and appropriate contact details. A Site Safety Officer must be available on-site during remediation works.

14. Environmental Management Plan

14.1 Introduction

The contractor should undertake the work with due regard to the minimisation of environmental effects and to meet regulatory and statutory requirements.

The contractor should have in place an Environmental Management Plan (EMP) so that work on the site complies with, but not limited to, the requirements of the following legislation:

- Protection of the Environment Operations Act;
- Contaminated Land Management Act;
- Dangerous Goods Act;
- Construction Safety Act;
- Work Health and Safety Act (WorkCover);
- Council Development Approval Conditions.

The contractor should also be responsible that the site works comply with the following conditions:

- Wastes generated at the site are disposed in an appropriate manner;
- Fugitive dust leaving the confines of the site is minimised;
- No water containing any suspended matter or contaminants leaves the site in a manner which could pollute the environment;
- Vehicles should be cleaned and secured so that no mud, soil or water are deposited on any public roadways or adjacent areas;
- Noise and vibration levels at the site boundaries comply with the legislative requirements.

In order to achieve a minimisation of environmental effects, the following measures are recommended, and should be adopted by the appointed contractor.

14.2 Traffic Management

All vehicular traffic should use only routes approved by Council, to and from the selected landfill where off-site disposal is undertaken. All loads should be tarpaulin covered and lightly wetted to minimise the potential for materials or dust to be dropped or deposited outside or within the site.

Each vehicle exiting the site should be inspected for cleanliness before being logged out as clean (wheels and chassis), or hosed down into a wheel wash or wash down bay until designated as clean.

Wheel wash silt residues should be collected periodically and either returned to the excavation area or included in the remediation stockpile. Such material will be treated as contaminated unless analysis proves otherwise.

14.3 Excavations

Records of all excavations and stockpile locations should be maintained. A site diary should also be maintained by the contractor to record daily progress, abnormal occurrences, incidents, and truck movements.

All excavations should be made with due regard to the stability of adjacent footings and structures. It will be the contractor's responsibility to provide adequate battering, shoring and/or underpinning to protect adjacent structures (if required).

No person should be permitted to enter an unsupported excavation where it is more than 1.5 m deep or where it is considered to be unstable, irrespective of depth.

14.4 Stormwater Management and Control

Appropriate measures should be taken to minimise the potential for potentially contaminated water to leave the site. Such measures could include:

- Appropriate construction of the remediation stockpile area (if required), with regular checks for integrity and repairs if/when required;
- Construction of diversion bunds to divert stormwater from contaminated areas and remediation stockpiles; and
- Provision of sediment traps including geotextiles or hay bales.

Discharge of any waters should meet the consent conditions from the appropriate authority. This should be verified by sampling and analyses undertaken by the contractor. For example, if excavations fill with water during validation works (ie due to rainfall), the water will require analysis to determine appropriate options for discharge (ie disposal to stormwater, sewer or collection by a licensed contractor).

14.5 Control of Dust and Odour

Control of dust and odour during the course of the remediation works should be maintained by the contractor and may include, but not necessarily be limited to, the following:

- The use of a water cart, as and when appropriate, to eliminate windblown dust;
- Use of sprays / sprinklers to prevent dust blow from stockpiles;
- Covering of stockpiles with plastic sheeting or geotextile membranes;
- Restriction of stockpile heights to 2 m above surrounding site level;
- Ceasing works during periods of inclement weather such as high winds or heavy rain;
- Regular checking of the fugitive dust and odour issues. Undertake immediate remediation measures to rectify any cases of excessive dust or odour.

14.6 Noise Control

Noise and vibration will be restricted to reasonable levels. All plant and machinery used on site should not breach statutory noise levels. Working hours will be restricted to those specified by Council.

14.7 Long-Term Site Management

Based on the proposed remediation methodology, it is noted that a long-term site management plan is not required following satisfactory completion of remediation of identified contamination and validation of the remediated locations.

15. Contingency Plan

As a contingency, if unexpected conditions with respect to contamination are encountered during site development (such as filling, presence of anthropogenic materials including building rubble, fragments of suspected ACM, buried structures or unexpected contaminated soil, contaminants, evidenced by staining, odours or free product), the following general approach should be adopted:

- Upon discovery of an unexpected find, works will cease in that area, the Site Manager is to be notified and the affected area will be demarcated (closed off);
- The location of the unexpected find should be surveyed;
- The Site Manager is to notify an appropriately qualified Environmental Consultant (ie DP);
- The environmental consultant will inspect the area and make an assessment of the significance of the find in terms of the potential impact to human health and the environment;
- Provision of advice from the environmental consultant regarding the recommended course of action (ie extent and methods of remediation, as required);
- Implementation of the agreed management / remedial strategy in accordance with the relevant sections of the RAP.

16. Conclusion

This RAP provides the clean-up objectives, remediation acceptance criteria (RAC), principles, methods and procedures by which the remediation and validation of the site will be achieved.

Following additional investigations recommended in Section 6 and prior to commencement of remediation and construction works, it is recommended that a site inception meeting is held between the developer, remediation contractor and consultant to discuss the remediation and validation process and to identify the tasks and responsibilities for the remediation of the site to a condition suitable for the proposed residential development.

17. References

CRC CARE (2011), *Technical Report No 10, Health screening levels for petroleum hydrocarbons in soil and groundwater*, Cooperative Research Centre for Contamination Assessment and Remediation of the Environment September 2011.

DP (2019), *Detailed Site Investigation (Contamination), Lot 62, Maitland Street, Muswellbrook, NSW, NSW*, Douglas Partners Pty Ltd, Report 91601.00.R.001.Rev0.

JK (2019), *Preliminary Contamination Assessment, Lot 62, Maitland Street, Muswellbrook, NSW*, J K Environments.

NEPM (2013), *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013*, National Environment Protection Council.

NSW EPA (2011), *Guidelines for Consultants Reporting on Contaminated Sites*, NSW Environment Protection Authority.

NSW EPA (2014), *Waste Classification Guidelines, Part 1: Classifying Waste*, NSW Environment Protection Authority.

18. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Lot 100, DP1261496 Maitland Street, Muswellbrook, NSW in accordance with DP's proposal NCL190535 dated 27 August 2019 and acceptance received from Pacific Brook Christian School Ltd dated 27 August 2019. The work was carried out under an agreed Professional Services Contract Agreement. This report is provided for the exclusive use of Pacific Brook Christian School Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Although the sampling plan adopted for the previous investigations are considered appropriate to achieve the stated project objectives, there are necessarily parts of the site that have not been sampled and analysed. This is either due to undetected variations in ground conditions or to parts of the site being inaccessible and not available for inspection/sampling (ie due to concrete pavements). It is therefore considered possible that HBM, including asbestos, may be present in unobserved or untested parts of the site, between and beyond sampling locations, and hence no warranty can be given that asbestos is not present.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Symbols & Abbreviations

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

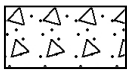
Symbols & Abbreviations

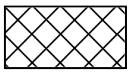
Graphic Symbols for Soil and Rock

General

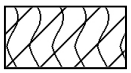

Asphalt

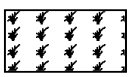

Road base

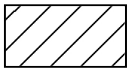

Concrete

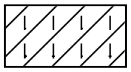

Filling

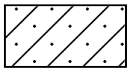
Soils


Topsoil

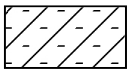

Peat

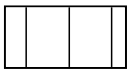

Clay

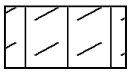

Silty clay

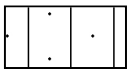

Sandy clay

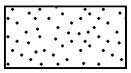

Gravelly clay

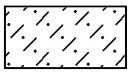

Shaly clay

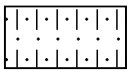

Silt


Clayey silt


Sandy silt

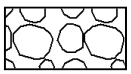

Sand

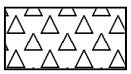

Clayey sand


Silty sand


Gravel

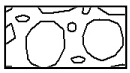

Sandy gravel


Cobbles, boulders

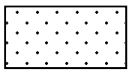

Talus

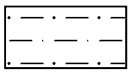
Sedimentary Rocks

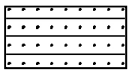

Boulder conglomerate

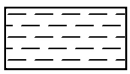

Conglomerate


Conglomeratic sandstone

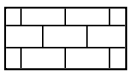

Sandstone


Siltstone

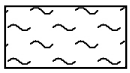

Laminite

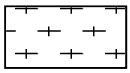

Mudstone, claystone, shale

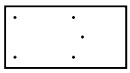

Coal


Limestone

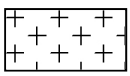
Metamorphic Rocks

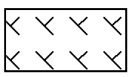

Slate, phyllite, schist

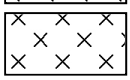

Gneiss

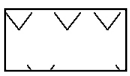

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

TEST PIT LOG

CLIENT: Pacific Brook Christian School
PROJECT: Detailed Site Investigation
LOCATION: Lot 100 DP1261496, Maitland Street, Muswellbrook

SURFACE LEVEL: --
EASTING: 301930
NORTHING: 6426981

PIT No: 106
PROJECT No: 91601.00
DATE: 1/7/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		FILLING - Generally comprising brown gravelly silty sand filling with clay, dry		D	0.1	E	PID<1		
		From 0.25m to 0.28m asphalt lens		D	0.26	E	PID<1		
		From 0.35m to 0.37m asphalt lens							
	0.4	CLAYEY SILT - Medium to low plasticity pale grey and brown w<PL		D	0.5	E	PID<1		
	0.6	SILTY CLAY - Medium plasticity, dark brown, w>PL							
	1								1
	1.2	Pit discontinued at 1.2m, limit of investigtion		D	1.2	E	PID<1		
	2								2

5 10 15 20

RIG: 6.5 tonne excavator with 450mm bucket teeth

LOGGED: Sebastian

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Site Location

0 10 20 30 40 m

Legend

- Groundwater Location
- Test Pit Location
- Approximate Site Boundary
- Previous Borehole Locations (JKEnvironments)
- Approximate Location of Gravel Path

Drawing adapted from Nearmap Image dated 13.1.2019.
Test locations are approximate only and were located using hand-held GPS.

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Pacific Brook Christian School Ltd	
OFFICE:	Newcastle	DRAWN BY: PLH
SCALE:	1:1500 @ A3	DATE: 29.August.2019

TITLE: **Test Location Plan**
Remediation Action Plan
Lot 100 DP1261496, Maitland Street, Muswellbrook NSW

N

PROJECT No:	91601.00
DRAWING No:	1
REVISION:	0