Appendix 7: Soils Report

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Arrow Energy Pty Ltd
25-Mar-2021

Surat Low Pressure Header (LPH) Pipeline Soil Assessment

Phase 1 - Desktop Assessment

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1.0 Introduction

1.1 General

AECOM Australia Pty Ltd (AECOM) was appointed by Arrow Energy Pty Ltd (Arrow) to undertake a desktop soil assessment along the proposed pipeline for the Surat Low Pressure Header (Surat LPH) between the David Inlet Processing Facility (located in Daandine area) and the Tipton Facility, to support Arrow's application under the *Regional Planning Interests Act 2014* (RPI Act).

1.2 Objective

The key objectives of the desktop soil assessment along the Surat LPH pipeline were to:

- Assess various soil types along the Surat LPH;
- Assess key issues including soil degradation, loss of productivity and subsidence related to the identified soil types; and
- Provide strategies to manage these identified soil issues during construction.

2.0 Project Description

2.1 Site Identification

The proposed Surat LPH (herein referred to as "the alignment") is approximately 44 km in length, located between the David Inlet Processing Facility (IPF), Harry IPF and the Tipton Central Gas Processing Facility (CGPF), shown in **Figure 1**. The function of the proposed Surat LPH is to:

1. Convey gas from the well systems gathering to compression infrastructure.
2. Convey produced water to the water treatment system.

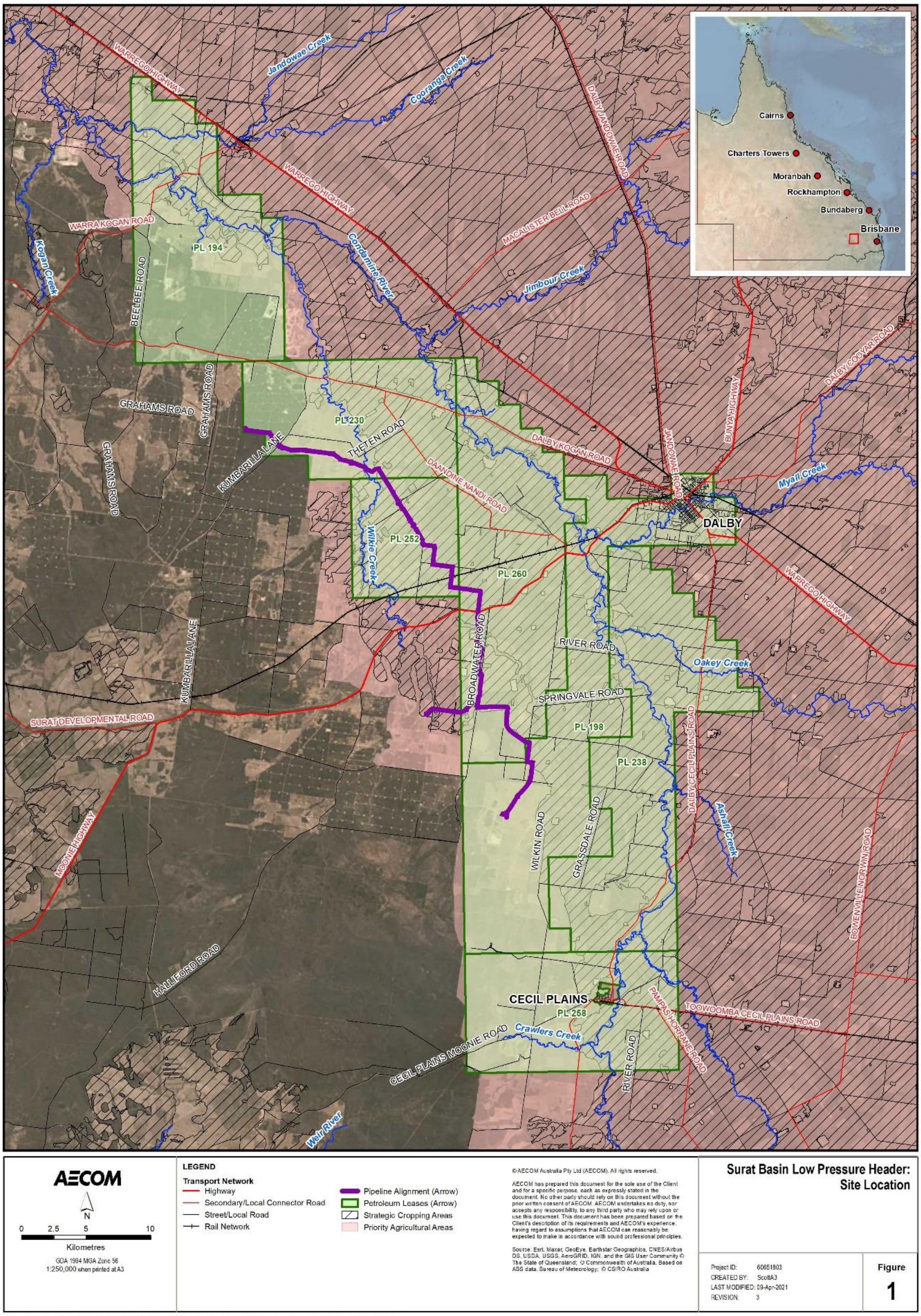
2.2 Right of Way (ROW) Layout

The alignment will be a common easement, containing water/gas pipelines and fibre optic/power cables within a right of way (ROW). The dimensions of a the ROW will be approximately 50 metres (m) wide, with dedicated areas for storage, workspaces, traffic and the pipeline trench (**Plate 1**).

As per information provided by Arrow, the pipelines will be installed by conventional trenching with a trenching machine. Conventional trenching involves an open trench between 1-2 m wide and approximately 2.0 m deep to install, inspect or maintain piping, conduits or cables. After installation, the trench is backfilled with the original material and the surface is restored.

Where the pipelines are required to be installed below existing roads or infrastructure, other trenchless technologies such as thrustbore may be used.

Figure 1 Surat Basin Low Pressure Header: Site Location



The key steps in the pipeline construction are given below, and a generic pipeline ROW layout is provided in **Plate 1**:

- Detailed survey of the ROW and construction areas.
- Establishing temporary access tracks if necessary.
- Installing temporary gates and fences as required.
- Clearing vegetation, where required, and grading the ROW to prepare a safe construction working area (on average the ROW will be 50 m in width).
- Separating and stockpiling topsoil and subsoil to protect and preserve topsoil.
- Crossing watercourses, roads and existing buried pipelines by open cut, boring or alternate trenchless technology (e.g. Horizontal Directional Drilling [HDD] methods) depending upon the type and nature of the crossing.
- Delivering pipe sections along the ROW.
- Welding the low-pressure high-density polyethylene (HDPE) pipe sections together to form ‘a string’.
- Creating a trench in which to lay the pipeline. The trench is excavated by a trenching machine and may include the use of rock saws, excavators, rock hammers or blasting in hard rock terrain.
- Lowering the pipeline strings into the trench and placing padding (e.g. screened trench subsoil) around the pipe to protect the pipe from external damage.
- Returning the subsoil and topsoil to their original horizons.
- Testing the integrity of the pipeline by pneumatic testing or filling it with water and pressurising it to above the maximum allowable operating pressure (i.e. hydrostatic pressure testing).
- Cleaning up, restoring and progressively rehabilitating the construction ROW and all temporary and permanent tracks, gates and fences.
- Installation of multiple pipelines in a single ROW is sequential. The first pipeline is installed, and the trench backfilled before the next pipeline installation commences.

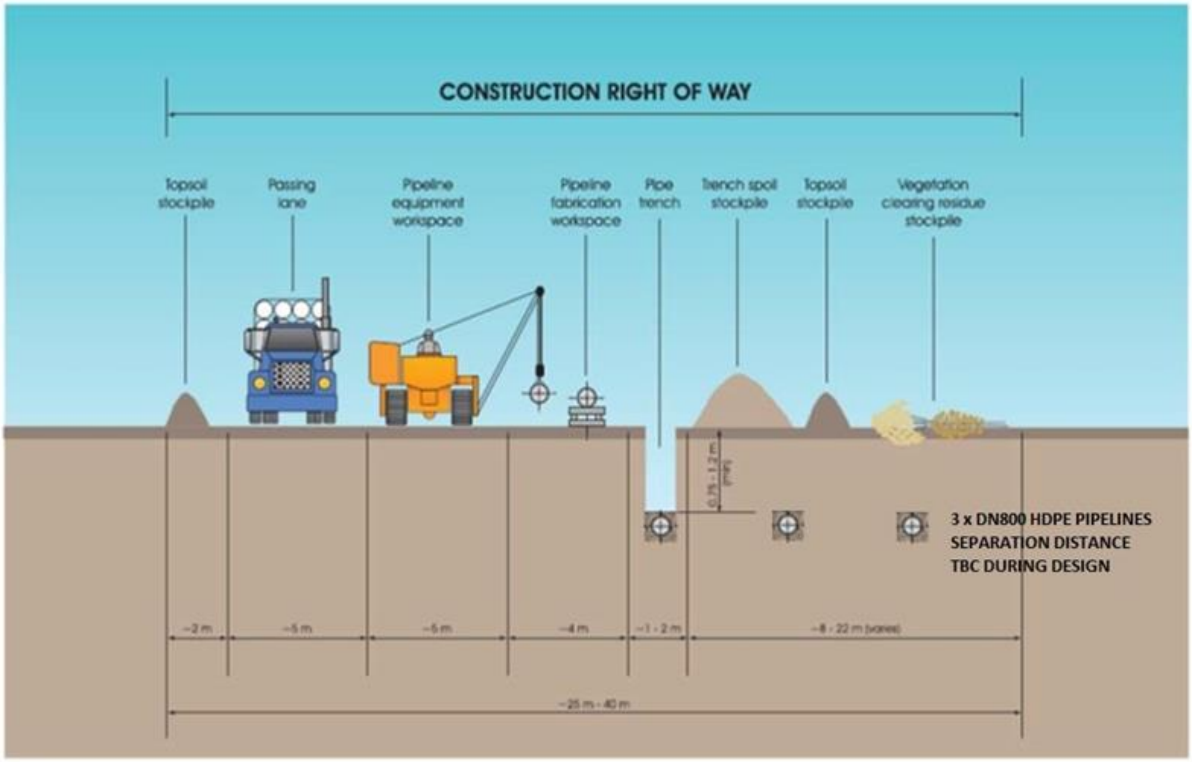


Plate 1 Typical Pipeline ROW Layout

3.0 Scope of Works

The scope of works for undertaking the desktop soil assessment includes:

- Desktop review encompassing:
  - Review of available mapping and publications sourced from the Queensland Government Open Data Portal and Queensland Spatial Catalogue.
  - Review of available data provided by Arrow relevant to the Surat LPH.
- Preparation of this desktop soil assessment report, including recommendations for each soil type including soil stripping, stockpile storage, returning topsoil and subsoil to trench, addition of ameliorants and/or fertilizers (if needed), compaction strategies, erosion controls, post-construction inspection and maintenance regimes.

4.0 Methodology

The methodology for the desktop soil assessment is summarised in this section.

4.1 Relevant Legislation and Guidelines

The key legislation applicable to the works undertaken as part of this desktop soil assessment is the RPI Act, administered by the Department of Infrastructure, Local Government and Planning (DILGP). The Act restricts the carrying out of resource of regulated activities where the activity is not exempt from the provisions of the RPI Act, or a RIDA has not been granted.

The Act identifies four ARIs, including: a priority agricultural area (PAA); a priority living area (PLA); the strategic cropping area (SCA); and a strategic environmental area (SEA). The alignment (the resource activity) intersects PPA and SCA.

- PAA: an area which includes one or more areas used for a priority agricultural land uses (PALU), identified in the relevant regional plan. PALUs may include certain types of agriculture, plantations, and/or intensive horticulture. In the case of the alignment, the PALUs are identified in the Darling Downs Regional Plan.
- SCA: defined as an area mapped as potential Strategic Cropping Land (SCL) on the Department of Natural Resources, Mines and Energy (DNRME) trigger map. The SCL is likely to be highly suitable for cropping due to a combination of the soil, climate, and landscape features.

This desktop soil assessment has been prepared in accordance with Australian legislations, Standards and Guidelines and Arrow's Standard Operating Procedures (SOP) for Surat and Bowen Basins including:

- *RPI Act, Statutory Guideline 02/14, Carrying out resource activities in a Priority Agricultural Area, State of Queensland, Department of State Development, Manufacturing, Infrastructure and Planning, August 2019*
- *RPI Act, Statutory Guideline 03/14 Carrying out resource activities in a Strategic Cropping Area, State of Queensland, Department of State Development, Manufacturing, Infrastructure and Planning, August 2019*
- *Environmental Authority EA0002659 Non-Scheduled Petroleum Activity Petroleum Pipeline Licence -PPL2052, dated 5 February 2021*
- *Environmental Authority EPPG00972513, dated 14 January 2021*
- *Guidelines for Soil Survey along Linear Features, Soil Science Australia, 2015*
- *Arrow Land Disturbance Procedures (ORG-ARW-HSM-PRO-00146)*
- *Scope of Work (SoW), Soil Assessment Report – Surat Low Pressure Header (LPH) pipeline dated 21 December 2020.*

4.2 Desktop Review

The purpose of the desktop review was to obtain background information on potential soil types and landscapes likely to occur within the alignment, information on the underlying geology and topography of the project site and understand potential PAA and SCA limitations.

The Surat LPH study area of the desktop assessment is represented by a 1 km buffer applied to the proposed pipeline route and is presented in the desktop mapping and interpretations.

4.2.1 Publicly available data

The desktop review involved a search of publicly available soil data, sourced from the Queensland Government Open Data Portal and Queensland Spatial Catalogue, including:

- Priority Agricultural Area mapping (DSDMIP, 2013).
- Strategic Cropping Land trigger map (DNRME, 2020).
- Central Darling Downs Land Management Manual (Harris *et al.*, 1999).

- Australian Soil Resource Information System (ASRIS) Atlas of Australian Soils (Northcote *et al.*, 1960-1968).

This information was used to develop a map of soils and physical limitations along the alignment.

4.2.2 Arrow provided data

Arrow provided the following data to assist in validating the potential soil types and landscapes likely to occur within the Surat LPH study area, including:

- Existing and/or historical soil field and laboratory data.
- Master crossing list.
- Standard pipeline construction, rehabilitation requirements and procedures.
- Typical Construction Erosion and Sediment Control Plans.
- Relevant Environmental Authorities (EA).

4.3 Suitably Qualified Person

AECOM confirms that the desktop review and interpretation of available data, has been undertaken directly or under the supervision of a suitably qualified person (SQP). Copies of curriculum vitae have been provided in **Appendix A**.

5.0 Desktop Review

5.1 Topography and geomorphology

5.1.1 Regional physiography

The Surat LPH study area is located wholly within the Condamine Central Lowlands physiographic region (**Figure 2**). The region is described as a low-lying area of undulating siltstone hills with alluvial sediments on the floodplains of the Condamine River and highly weather bedrock on the slopes (CSIRO, 2011).

5.1.2 Topography

Regionally, there is a north-south topographic high of the Taroom Hills and an east-west topographic high of the Great Dividing Range. Two major drainage systems separate these topographic highs: the Condamine River and Wilkie Creek, both draining towards the north-west.

Based on the Queensland Globe relative elevation mapping, the surface elevation across the Surat LPH study area ranges between approximately 330 m Australian Height Datum (mAHD) and 370m AHD. Majority of the LPH alignment [kilometre point (KP) 14 to KP44] in the central area is relatively flat at approximately 330 m AHD. The highest elevation of 370m AHD is observed in north near David IPF. The area in south (from KP0 to KP14) has relative elevation of approximately 350m AHD, with 340m AHD near Harry IPF lateral line. The relative elevations are consistent with the area being located on the Condamine Lowlands and floodplains of the Condamine River (**Figure 2**).

The surface slope occurring throughout the LPH study area is presented in **Figure 3**. The digital elevation model (DEM) for the LPH study area was sourced from the 1 second Shuttle Radar Topographic Mission (SRTM) DEM-S (smoothed) v1.0 (coverage of Queensland, supplied by Geoscience Australia). The DEM-S is supplied in generic GRID format, so no further conversion was necessary. The DEM-S was also used to create the Hillshade Terrain used as a background detail.

The Slope DEM was created from the DEM-S GRID and the Slope calculation tool from the Spatial Analysis toolset, available in ArcGIS. Output measurement was set to PERCENT_RISE, also referred to as percent slope. Based on the calculations, the slope within majority of the LPH study area range from near level (<1%) to 3%, with only minor patches of land with slope >3%.

5.2 Surface geology

The surface geology (presented in **Figure 4**) beneath the Surat LPH study area is a part of the extensive Surat and Clarence Moreton Basins. Based on the Queensland detailed surface geology mapping (DNRME, 2018), the sequency of sedimentary rocks (Kumbarilla Beds [JKk] and Springbok Sandstone [Jis]) within the Basins are overlain by surficial Cenozoic sediments (undifferentiated alluvium and the Condamine Alluvium). These alluvium units are described as unconsolidated [Qs], poorly consolidated [TQ] and semi-consolidated [Qa] sediments typically comprised of sand, silt and clay (DNRME, 2019).

The alignment is primarily underlain by the Condamine Alluvium. The Condamine Alluvium is an extensive accumulation of Tertiary to Quaternary age alluvial sediments, forming a broad (greater than 20 km wide) alluvial plain, extending from Millmerran to Chinchilla. The thickness ranges from less than 10 m to more than 120 m in the floodplain near Dalby (DNRME, 2019). The sediments are dominated by coarse grained gravels and sands, interbedded with clays. The coarse-grained alluvium is associated with higher transmissibility and are the primary source of groundwater.

Figure 2 Regional Physiography- Central Lowlands Province

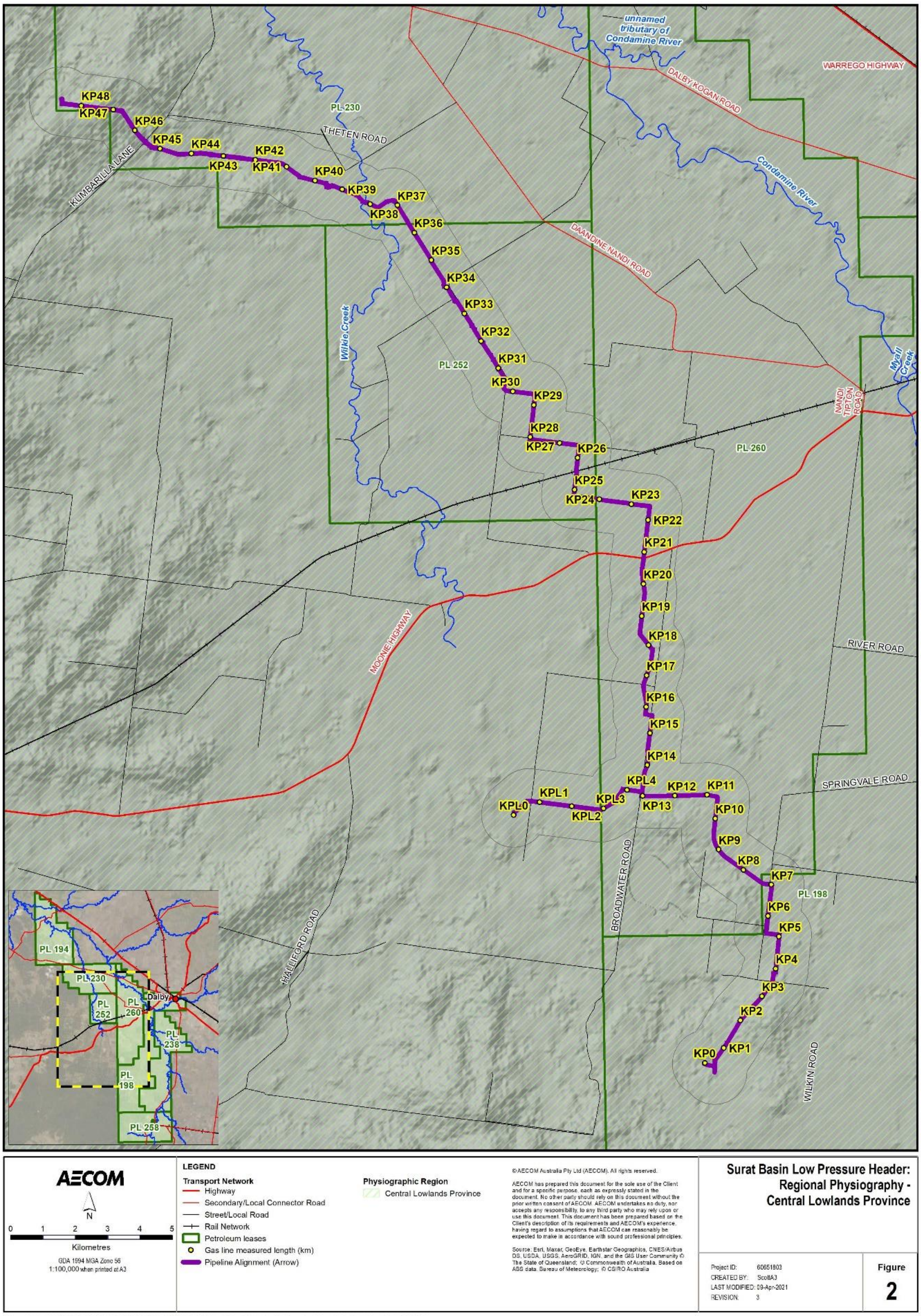


Figure 3 Slope Class and Slope Range (%)

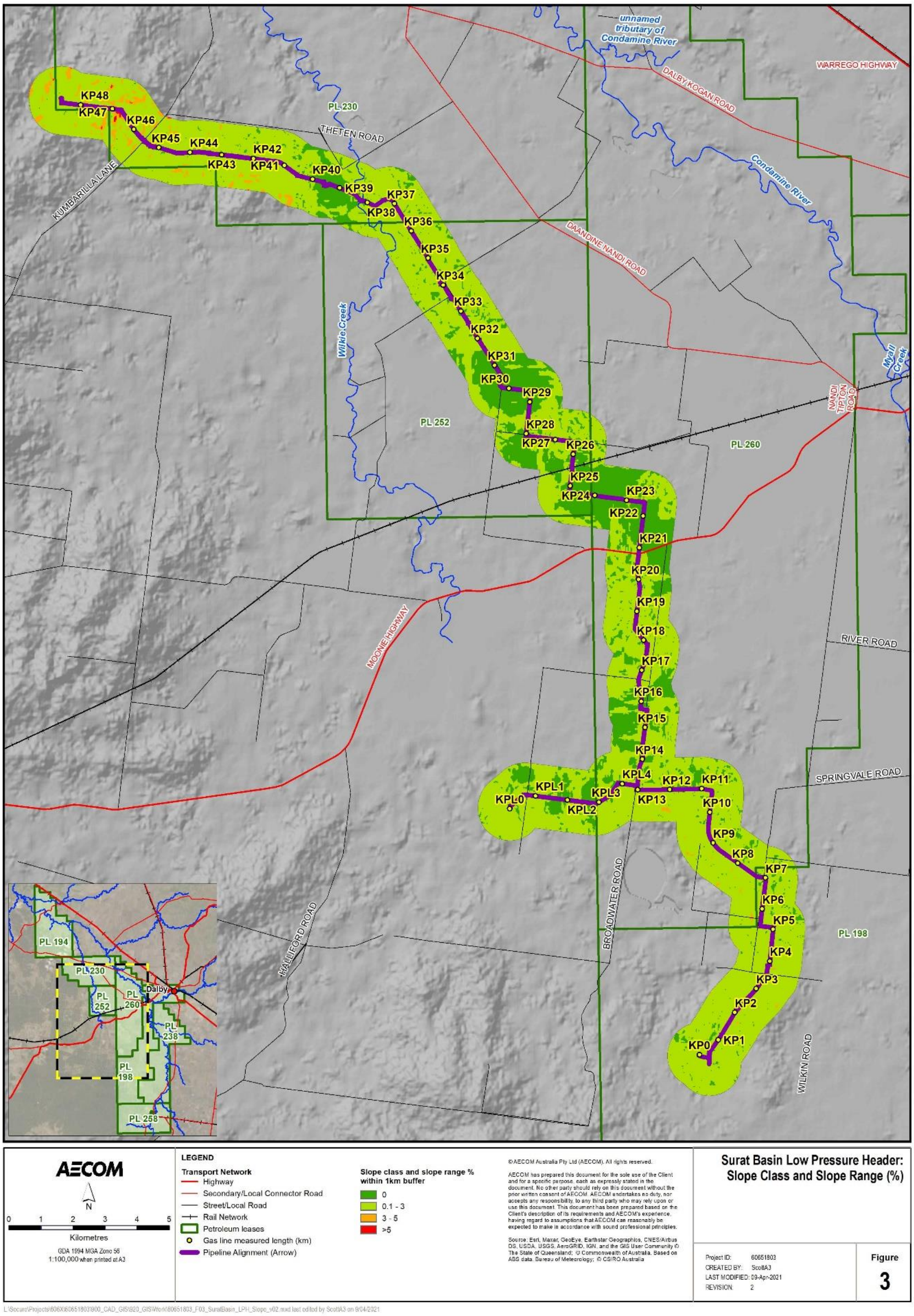
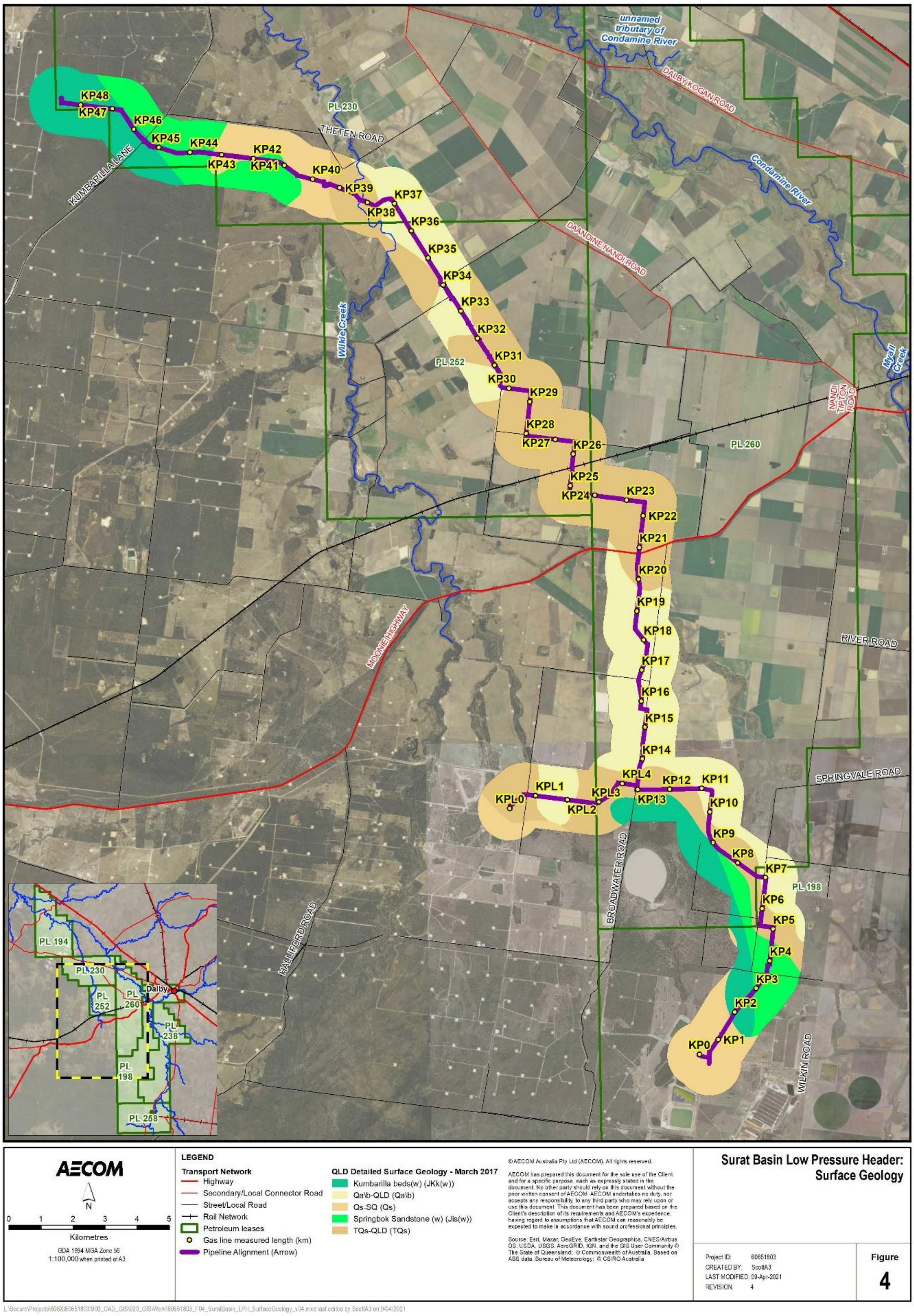


Figure 4 Surface Geology



5.3 Atlas Soil Landscape Units

The relevant soil landscape units have been sourced from the ASRIS Atlas of Australia Soil (Northcote *et al.*, 1960-1968) (herein referred to as 'the Atlas'), which was compiled by CSIRO to provide a nationally consistent description of Australian soils. Mapped units are published at a scale of 1:2,000,000, but the original 10 map compilation was at scales from 1:250,000 to 1:500,000. This scale mapping is commonly used for desktop studies.

The soil landscape units identified in the Atlas provide a description of the physical environmental, displaying the occurrence and distribution of geological regimes, landscape units and associated soil types within 1 km of the alignment. Soil landscape units are reoccurring soil mapping units with shared geology, landform, soil and vegetation associations. More than one soil type can occur within a landscape unit, represented with a dominate and several subdominant types.

The Atlas indicates six (6) soil landscape units[1] intersect the alignment, which are summarised in **Table 1**, and presented graphically in **Figure 5**.

The dominant soil type of each landscape unit is presented alongside the corresponding Australian Soil Classicisation (ASC) soil order and Principle Profile Form (PPF), to aid in the interpretation of the soil encountered along the alignment and based on Ashton & Mackenzie (2001). The ASC is the relevant national classification descriptor achieved using the Isbell (2002) system. The hierarchical scheme allows soils to be named and communicated in an orderly manner.

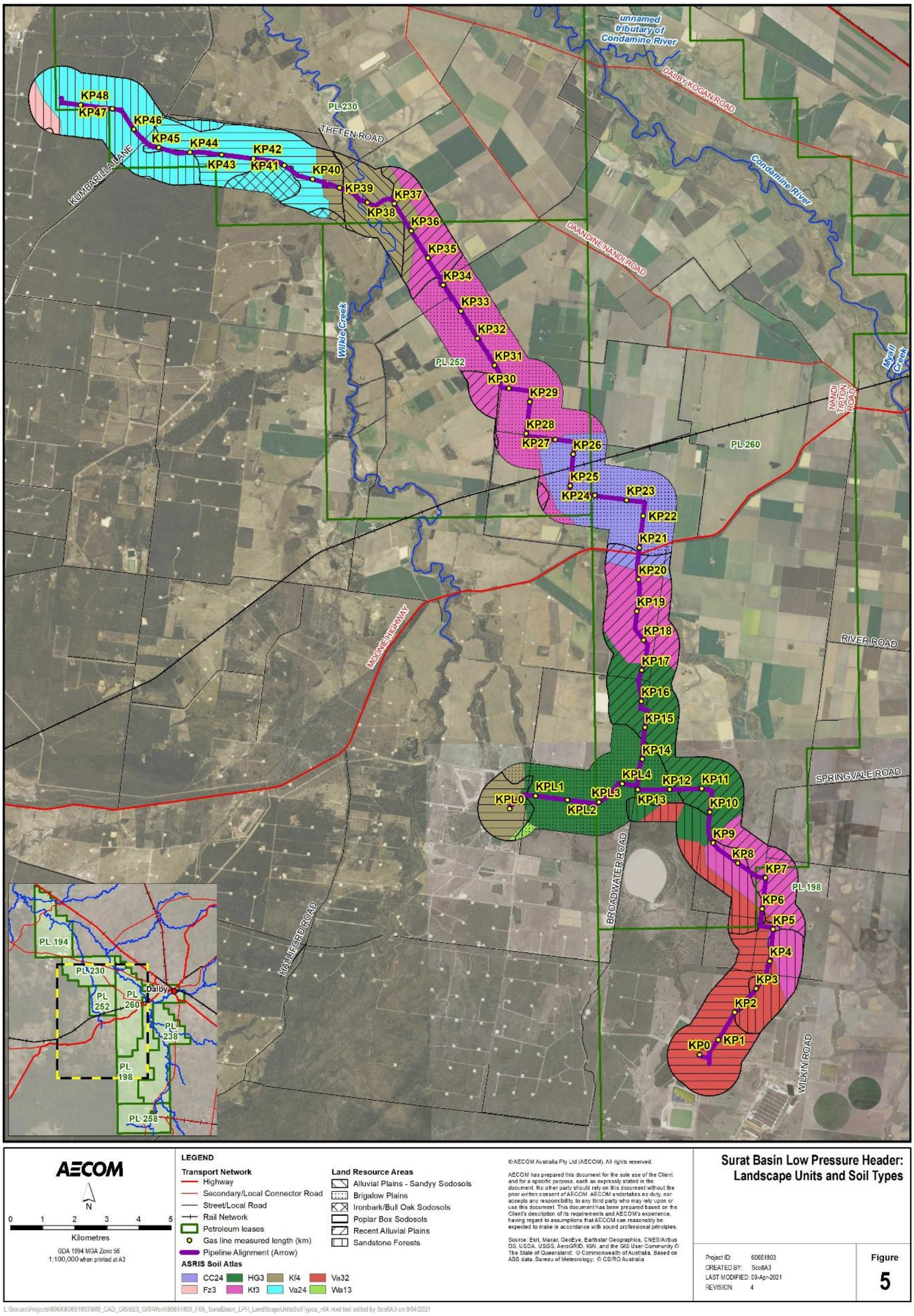
Table 1 Soil Landscapes which intersect the Surat LPH alignment

Soil landscape units	Landform description	Dominant soil type[1]	Dominant Principle Profile Form[2]	Dominant ASC Group[3]
CC24	Plain	Dominant soils are grey cracking clays with some dark cracking clays	Ug5.24, Ug5.28, Ug5.16	Vertosol
HG3	Plain associated with old riverine terrace formation	Hard alkaline dark soils	Dd1.33, Dd1.43	Sodosol
Kf3	Plain with very low sandy rises and banks separated by flats and depressions	Dominant soils are dark cracking clays	Ug5.16	Vertosol
Kf4	River terraces and adjoining plains	Dominant soils are dark cracking clays	Ug5.16	Vertosol
Va24	Gently undulating plains	Hard alkaline and neutral yellow mottled soils	Dy3.43, Dy3.42, Dy2.43, Dy2.42	Sodosol
Va32	Low convex hills with some mounds of lateritised rock	Dominant soils are hard alkaline yellow mottled soils	Dy3.43	Sodosol

Notes:
1. ASRIS Atlas of Australian Soils (Northcote et al., 1960-1968)
2. Principal Profile Form (Northcote, 1974)
3. Dominant Australian Soil Classification (Isbell, 2002)

[1] Two additional soil landscape units (Wa13 and Fz3) were located within the 1 km buffer of the Surat LPH; however, as these do not intersect the pipeline alignment, they have not been included in this soil assessment.

Figure 5 Soil Landscape Units



5.4 Land Resource Areas: Central Darling Downs

Due to the broad scale of the Atlas (1:2,000,000), a review of the Land Resource Areas (LRA) mapping was used to further assess the soil types across the alignment.

LRAs have been determined from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), and are based on the combination of geology, landscape features (slope/relief), vegetation and groups of soils. LRA maps are not designed to strictly identify soils in a particular map unit but predict their probable occurrence.

LRA identified to intersect the Surat LPH alignment are presented in **Table 2.**

Land suitability for each LRA was also provided by Harris *et al.* (1999), which restricts limited cropping land to the sandy Sodosols of the alluvial plains. The remaining LRAs units have agricultural potential as cropping land (broadacre and horticulture) and pasture (sown and native pastures).

Typical soil characteristics should a generally good correlation with the soil landscape units mapped in the Atlas (Northcote *et al.*, 1960-1968), with the alignment likely to encounter cracking clays as well as bleached sands over cracking clays.

The typical soil types likely to be encountered in each LRA, along with generic soil properties, are detailed in the following subsections.

Table 2 Identified LRAs in the Central Darling Downs (Harris *et al.*, 1999)

LRA	Landform description	Major soils	Estimated ASC	Agricultural land classification	Typical vegetations	Generic physical and chemical soil properties				
						Soil (m)	pH	Dispersion[1]	Sodicity[2]	Salinity[3]
Recent alluvial plains (1a): Condamine	Board level plains of mixed basaltic and sandstone alluvium	Black and grey cracking clays with bleached sands or loams over brown or black clays	Vertosol	A1 – crop land: broadacre and horticulture	Poplar box or Queensland blue gum open woodlands, or grasslands	Surface soil: 0-0.15	8.7	Low	Non-sodic	Very low
						Upper subsoil: 0.15-0.6	9.1	Medium	Sodic	Medium
						Lower subsoil: 0.6-1.4	8.1	Medium	Strongly sodic	High to Very high
Alluvial plains – sandy Sodosols (4a): Leyburn	Level alluvial plains and stream terraces	Bleached sands over brown or black clays	Sodosol	B – limited crop land	Poplar box and Moreton Bay ash woodland with wilga	Surface soil: 0-0.20	7.0	Medium	Non-sodic	Very low
						Upper subsoil: 0.2-0.6	6.1	Medium	Sodic	Very low
						Lower subsoil: 0.6-1.1	7.7	High	Strongly sodic	High to medium
Brigalow plains (5a/5b): Kupunn	Flat plains, with gently undulating clays plains with shallow to deep gilgai	Grey self-mulching cracking clays	Vertosol	A1 – crop land: broadacre and horticulture	Brigalow, belah forest with wilga with some black tea tree	Surface soil: 0-0.05	8.5	Low	Non-sodic	Low
						Upper subsoil: 0.05-1.2	9.0	Low to medium	Sodic	Low
						Lower subsoil: 1.2-1.5	4.3	High	Strongly sodic	High
Poplar box Sodosols (9a): Downfall	Gently undulating plains on sandstone	Bleached sands and loams over brown and grey clays	Sodosol	C1 – pasture land: sown pastures	Poplar box and gum topped box open woodland	Surface soil: 0-0.15	6.5	Medium	Non-sodic	Low
						Upper subsoil: 0.15-0.5	7.4	Medium	Sodic	Very low

LRA	Landform description	Major soils	Estimated ASC	Agricultural land classification	Typical vegetations	Generic physical and chemical soil properties				
						Soil (m)	pH	Dispersion[1]	Sodicity[2]	Salinity[3]
						Lower subsoil: 0.5-0.14	9.0	High	Strongly sodic	High
Ironbark bulloak sodosols (10a): Braemar	Gently undulating plains on sandstone	Bleached sands to loams over mottled, grey or yellow clays	Sodosol	C2 – pasture land: native pastures	Narrow-leaved ironbark, bull oak, cypress pine, rusty gum and poplar box open forest	Surface soil: 0-0.30	5.6	Low	Sodic	Low
						Upper subsoil: 0.3-0.6	6.6	High	Strongly sodic	High
						Lower subsoil: 0.6-1.2	5.0	High	Strongly sodic	Very high to extreme
Sandstone forests (12a): Weranga	Rises and undulating plains on sandstone; often lateritised	Bleached sands to loams over mottled, grey, or yellow clays	Sodosol	C2 – pasture land: native pastures	Narrow-leaved ironbark, bull oak, cypress pine, rusty gum and poplar box open forest	Surface soil: 0-0.06	6.3	Low	Non-sodic	Very low
						Upper subsoil: 0.06-0.4	6.4	Low	Strongly sodic	Medium
						Lower subsoil: 0.4+	7.1	High	Strongly sodic	High

Notes:
1. Clay dispersion is measured as a dispersion ratio (Baker and Eldershaw, 1993)
2. Sodicity is calculated as the percentage of exchangeable sodium (ESP) (Baker and Eldershaw, 1993)
3. Salinity is estimated from the measurement of the electrical conductivity in a 1:5 suspension of soil to water (Shaw, 1988)

5.4.1 Recent alluvial plains (1a)

Common soils within this LRA are deep to very deep (0.8 to 1.8 m) coarse, self-mulching cracking clays on recent alluvial plains on mixed basalt/sandstone alluvia. Soil are distributed along the active floodplain of the Condamine River and tributaries, including river terraces, streambanks, old river channels and plains.

Generic soil features include a medium to heavy clay, self-mulching surface soils, which are moderate to coarse and granular. The surface is often non-sodic and can sometimes be lightly crusted. The subsoil is commonly sodic to strongly sodic with medium to very high salinity. The profiles have an alkaline trend, consistent with depth.

The land is suitable for dryland/irrigated cropping and grazing of native pastures, depending on the risk presented by inundation and erosion.

Native vegetation has mostly been cleared but contains fringing woodland to open forests of river gum, Queensland blue gum and some acacia species.

5.4.2 Alluvial plains – sandy Sodosols (4a)

Soils within this LRA are typically deep texture contrast soils with a shallow, hard setting, bleached loamy sand to clay loam surface, over yellowish brown and brown clay subsoils. Soils are located on flat plains and very gentle slopes (<1%) valley floors of mixed sandstone and traprock alluvium.

Generally, surface soils are thin with a sharp change between the surface and subsurface. The hard-setting, loamy sands to clay loams are underlain by a bleached upper profile with occasional gravels. The subsoil is commonly comprised of blocky or columnar structured clays, which are strongly sodic from 0.05 m and highly saline from 0.05 to 0.9 m. Deeper soils are strongly sodic and have moderate to high salinity. The profiles have a slight alkaline trend with depth.

The land use is best suited to grazing natives and is not considered suitable for cropping, due to its low plant available water capacity (PAWC) (0.05 mm), strong sodicity, high salinity and relatively impermeable subsoils. The soils are susceptible to wind and water erosion if the surface is left unprotected.

Native vegetation has mostly been cleared but contains poplar box grassy woodlands with wilga, or poplar box, gum topped box within open forests.

5.4.3 Brigalow plains (5a/5b)

Typical soils associated with this LRA are deep to very deep (0.1-0.16 m), self-mulching grey cracking clays with shallow gilgai on the brigalow claysheet. Soils are located on flat to very gently sloping undulating brigalow clay plains north of Warra and around Kupunn, west of Dalby.

Generic soil features include an angular blocky surface structure, which is strongly alkaline. The subsoil is often a structured clay, with mild alkalinity in the upper subsoils, tending to strongly acidic deeper in the profile. The subsoil is both strongly sodic and saline.

The land is suitable for continual grain and cotton cropping, only limited by strongly sodic and saline subsoils. The soils are susceptible to erosive flooding.

Native vegetation has mostly been cleared but contains brigalow, belah, wilgas scrub and black tea tree in low lying areas.

5.4.4 Poplar box Sodosols (9a)

The texture contrast soils within this LRA typically have a hard setting surface over clay subsoil. Soils are located on flat plains and very gently sloping (<1%) valley floors of mixed sandstone and basaltic alluvium.

Surface soils are generally described as a sandy loam to clay loam, hard setting with a bleached subsurface layer. The clay subsoil is commonly comprised of coarse blocky or prismatic structure clays, which are sodic to strongly sodic and moderately saline. The profiles have a slight alkaline trend with depth.

The land use is best suited to grazing natives, governed by moderate PAWC (0.1-0.15 mm), surface deterioration following continuous cultivation and potential for hard surface crust formation. Potentially susceptible to overland flooding and wind erosion if under intensive cultivation and dry.

Native vegetation has mostly been cleared but contains poplar box grassy woodlands with wilga, occasional bull oak and grey box. Rough-barked apple and Moreton Bay Ash also occur where the surface soils are sandier.

5.4.5 Ironbark bulloak sodosols (10a)

The texture contrast soils within this LRA typically have a bleached surface overlying mottled clay subsoil. Soils are located on gently undulating sandstone plains, mainly west of the Condamine River on the Kumbarilla Ridge.

Generic soil features include a sharp texture change between the surface and subsoil. The surface is often a massive sandy loam to clay loam, with a thin layer of bleaching occurring above the impermeable subsoil. The subsoil is commonly formed of strongly columnar clays, with varying degrees of mottling. Subsoils are also strongly sodic and have highly saline deep subsoil. The profiles have a slightly alkaline trend, consistent with depth.

The land use is best left in the native state for the purpose of timber production and nature conservation due to several limitations, including low fertility, low PAWC, impermeable subsoil and being extremely susceptible to both erosion and waterlogging.

Native vegetation has been partially cleared and contains shrubby woodland of poplar box with bull oak and narrow-leaved ironbark.

5.4.6 Sandstone forests (12a)

Common soils within this LRA are texture contrast soils with a bleached sandy surface over a mottled subsoil. Soil are distributed along the gently undulating sandstone plains, mainly to the west of the Condamine River on the Kumbarilla Ridge.

Generic soil features include sharp contrast between the surface and subsurface. The surface is often described as a bleached, hard setting loam to sandy loam. The clay subsoil is often mottle and impermeable, as well as being strongly sodic and highly saline. The profiles have an alkaline trend, consistent with depth.

The land use is best left in the native state for the purpose of timber production and nature conservation due to several limitations, including low fertility, low PAWC, impermeable subsoil and being extremely susceptible to both erosion and waterlogging.

Native vegetation has been partially cleared and contains open forest of bull oak or bull oak and cypress pine with associated narrow-leaved ironbark, rusty gum and occasional paperbark tea tree.

Summary

Based on available chemical and physical data from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999) (**Table 2**), most soils along the alignment are expected to have an alkaline upper subsoil (pH 8.0 to 10.0) over acidic lower subsoil (4.0 to 6.0), as a result of developing over clay sheets or sedimentary rocks.

The soils along the alignment are sodic or strongly sodic and have medium to very high levels of salinity in the subsoil. Levels of salinity were generally low in the surface soils, increasing to medium to extreme in the subsoil.

A summary of identified LRA within the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), cross-referenced with the Atlas soil landscape units and associated ASC soil classification is presented in **Table 3**.

Based on the available Atlas and LRA mapping, the study area is dominated by the following two soil types:

- Self-mulching cracking clays, such as Vertosols – 54%; and
- Texture contrast soils, such as Sodosols – 46%.

Table 3 Summary of the Surat LPH soil units and resource areas

LRA	Soil landscape units (ASRIS)	Dominant ASC	Approximate LPH reference points	Total length (km)	Mapped LPH
Recent alluvial plains (1a)	Kf3	Vertosol	KP6 to KP7 KP17 to KP20 KP34 to KP36	6	11%
	HG3	Sodosol	KP10 to KP12 KP15 to KP17	4	7%
	CC24	Vertosol	KP20 to KP21	1	2%
	Kf4	Vertosol	KP36 to KP37	1	2%
Alluvial plains – sandy Sodosols (4a)	Kf4	Vertosol	KP37 to KP39	2	4%
Brigalow plains (5a/5b)	HG3	Sodosol	KPL1 to KPL4 KP12 to KP15	7	13%
	CC24	Vertosol	KP 21 to KP27	6	11%
	Kf3	Vertosol	KP27 to KP34	7	13%
Poplar box Sodosols (9a)	Va32	Sodosol	KP0 to KP2	2	4%
	Kf4	Vertosol	KP39 to KP40	1	2%
	Va24	Sodosol	KP40 to KP45	5	9%
Sandstone forests (12a)	Va32	Sodosol	KP2 to KP4 KP5 to KP6	3	6%
	Kf3	Vertosol	KP4 to KP5 KP7 to KP10	4	7%
	Va24	Sodosol	KP45 to KP49	4	7%
Ironbark bulloak sodosols (10a)	Kf4	Vertosol	KP40 to KP41	1	2%

6.0 Disturbance Management

The major limiting factors for the soils encountered along the Surat LPH alignment are soil structure and texture, along with subsoil salinity and sodicity issues. The proposed management options for these issues are presented in these sections.

6.1 Topsoil suitability and management

The generic soil properties from Harris *et al.* (1999), were reviewed against the criteria set out in the *Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley* (Elliott and Veness, 1981) to determine the suitability of available soil material for reuse as topsoil. The estimated depth of primary growth media was estimated using the plant available water capacity. These estimates should be reviewed following a detailed pre-characterisation assessment of soils along the alignment to assist in identifying rooting depth and nutrient deficiencies.

The major limiting factors for the soils encountered along the alignment are soil structure and texture, along with subsoil salinity and sodicity issues, as detailed in **Table 4**.

Table 4 Guide to estimated stripping depths

<table>
<tr><th>LRA</th><th>Estimated primary growth media (m)</th><th>Limiting factors</th></tr>
<tr><td>Recent Alluvial Plains (1a)</td><td>0.15-0.2</td><td>Soils have a narrow moisture range for effective workability, which can be improved by adding a sandier textured material.</td></tr>
<tr><td>Alluvial Plains – Sandy Sodosols (4a)</td><td>0.05</td><td>Sodic and relatively impermeable subsoils susceptible to gully and tunnel erosion if exposed. Gypsum can be added to improve the subsoil material and limit dispersion and erosion.</td></tr>
<tr><td>Brigalow Plains (5a/5b)</td><td>0.2-0.25</td><td>Gypsum can be incorporated into the subsoil material to limit dispersion and erosion.</td></tr>
<tr><td>Poplar box Sodosols (9a)</td><td>0.1-0.15</td><td>Addition of a clayey material and gypsum can improve soil structure and reduce sodicity issues.</td></tr>
<tr><td>Ironbark Bull Oak Sodosols (10a)</td><td><0.05</td><td rowspan="2">Sodic and relatively impermeable subsoils susceptible to gully and tunnel erosion if exposed. Gypsum can be added to improve the subsoil material and limit dispersion and erosion.</td></tr>
<tr><td>Sandstone Forests (12a)</td><td><0.05</td></tr>
</table>

6.2 Soil stripping and stockpiling/storage

The Surat LPH alignment largely crosses existing agricultural land, with only a small portion which is timbered (approximately 4.9 km) located within the Braemar State Forest on the northern side of Kumbarilla Road. Where clearing is required, timber should be cleared and retained for chipping or habitat recreation. Chipping can provide a useful soil amendment to improve the physical properties of sandy material and limit weed growth.

Suitable topsoil should be stripped for the width of the pipeline trench and access track plus (nominally) 1 m each side of the trench. The estimated primary growth media depths provided in **Table 4** can be used as a guide.

Topsoil and subsoil (which may have dispersive or sodic subsoil horizons) should be stockpiled separately to avoid mixing. Topsoil management should be undertaken in line with the requirements listed in Arrow's *Land Disturbance Procedure* (ORG-ARW-HSM-PRO-000146).

Stockpiles are not recommended to exceed 3 m in height, to minimise degradation through physical, biological and chemical processes. Based on the typical ROW construction, stockpiling is expected to be undertaken in section along the length of the trench to maintain access/egress. The stockpile should not be compacted to minimise surface runoff and facilitate infiltration.

Stockpiles should be in place for the minimum duration practicable to safely install the infrastructure, which is understood to be typically less than three months. Where practicable work will be staged to not extend over a wet season. In situations where this is unavoidable, quick vegetation such as pasture species and mulches should be used to minimise surface erosion.

Consideration should be made for drainage flow direction and diversions in place to prevent stockpile erosion. Appropriate erosion and sediment control measures should be documented prior to works commencing.

6.3 Returning topsoil/spoil to the trench

Excavated soils should be returned to the trench in the soil pre-disturbance soil profile. Topsoil that has been stripped can be re-spread as part of stabilisation and rehabilitation activities.

Sodic soils are expected to be encountered along the alignment and should be blended with appropriate soil ameliorants (gypsum and organic matter) during the rehabilitation process to reduce the potential for soil dispersion. Sampling and analysis of soil prior to reuse is recommended to assist in identifying nutrient deficiencies and ameliorant requirements. The use of such ameliorants should also be discussed with landholders prior to application.

The disturbance area should be re-shaped into a stable landform with consideration for surface drainage lines.

6.3.1 Compaction Strategies

The backfilling and compaction of the trench is also dependant on the use of appropriate equipment suited for compacting soil in trenches, ensuring the soil is moisture conditioned (i.e. if the soil is too wet or dry to compact) adding moisture based on the inherent moisture content. The soils are generally placed in thin layers (maybe 300 to 400 mm), adding moisture conditioning, if needed, followed by thorough tampering with the bucket (or a roller attachment for the excavator). The site specific compaction strategies are informed by the geotechnical assessment and pipeline construction design.

Compaction of surface layers within the ROW disturbance areas should be undertaken in a way to improve the water infiltration capacity and aeration along the contour, prior to the re-shaping and re-spreading of topsoil and revegetation.

6.4 Reinstatement and erosion controls

The different soil types traversed by the alignment have variable erodibility characteristics, determined primarily by soil structure, texture and sodicity. An overview of the erodibility ratings associated with each soil type is provided in **Table 5**, based on typical Queensland soils described in the DTMR Road Drainage Manual (DTMR, 2019).

An estimate of the long-term soil loss from both sheet and rill erosion can be calculated using the Revised Universal Soil Loss Equation (RUSLE) (IECA, 2008). This issue is less of a concern in the LPH project area due to the flat terrain, including many lasers levelled paddocks.

Erosion and sediment controls should be identified, documented and implemented as part of soil preparation works. These documents should remain in place until stabilisation of the disturbance area is achieved.

Table 5 Typical Erodibility Ratings

Soil type and ASC	Description of erodibility characteristics	Erodibility rating
Uniform sands and sandy loams – *Rudosols and Tenosols*	Incoherent sand, loamy and sand and clayey sand and coherent sandy loam with single grained massive structure.	Moderate (3)

Soil type and ASC	Description of erodibility characteristics	Erodibility rating
Uniform loams and clay loams – Massive – *Kandosol* Structured – Rudosols, *Tenosols and Dermosols*	Coherent loams, sandy clay loams and clay loams with massive to strong structure.	Very Low (1)
Uniform non-cracking clays - *Dermosols*	Light to heavy clays with strong structure: • fine aggregates • coarse aggregates	Very Low (1) Low (2) to Moderate (3)
Uniform cracking clays – *Vertosols*	Light medium to heavy clays that shrink and crack open when dry and swell when wet, gilgai micro relief common.	Low (2) to moderate (3)
Sandy gradational soils – *Kandosols*	Texture gradually increases from a sandy surface to sandy clay loam or sandy light clay with depth; single grain to massive structure.	Moderate (3)
Loamy gradational soils – *Dermosols and Kandosols*	Texture gradually increases from a loamy surface to sandy clay loam or clay with depth; massive to strong structure.	Low (2)
Texture contrast soils (non-dispersive) – *Chromosols*	Sandy or loamy surface abruptly overlaying non-dispersive and generally friable clay subsoil.	Moderate (3)
Texture contrast soils (dispersive) – *Chromosols and Sodosols*	Sandy or loamy surface abruptly overlying a hard, dispersive clay subsoil with: • ESP ≥6 and/or Ca:Mg <15 • ESP ≥15 and/or Ca:Mg <0.1	High (4) Very High (5)

6.5 Construction inspection and maintenance regimes

The disturbance area should continue to be visually monitored until such time that the site is considered effectively stabilised or rehabilitated, in line with Arrow's rehabilitation criteria. To help in adequate rehabilitation, the quantity of ameliorants needed (if any) for topsoil and subsoil based on pre-construction land use are generally calculated based on site specific laboratory analysis.

After completion of pipeline installation, cropped areas should be stabilised to combat erodible / dispersive surface soils (below topsoil) and then topped with a topsoil dressing to match the thickness and quality of the surrounding topsoils of undisturbed areas, as a minimum. Ideally, topsoils stripped during pipeline installation would have been stockpiled and reused in the same location and to the same thicknesses to match the original soil profile as closely as was practical. Inspection and maintenance should include assessment of surface stabilisation (e.g. – lack of erosion of the topsoil / crop-supporting layer and the health of surface vegetation) in accordance with Arrow's rehabilitation criteria.

Waterway crossings might require specific inspection and maintenance regimes, which should be considered at the time of conceptualising and designing each crossing.

7.0 Conclusions

The proposed Surat LPH alignment intersects two ARIs namely PALU and SCA and as such require a RIDA application to be submitted under the RPI Act.

Based on the desktop review of the geology, landscape features, vegetation and groups of soils, a total of eight landscape units (with only six units intercepting the LPH route) and six land resource areas were identified within the 1 km study area of the Surat LPH.

The alignment is located between the Condamine River and Wilkie Creek, described as the Condamine Lowlands. The area contains low-lying siltstone hills with alluvial sediments on the floodplains of the Condamine River and highly weather bedrocks on the slopes. The low-lying area has an elevation ranging from 330 to 370 m AHD. Based on the data, the slope within the majority of the LPH study area range from near level <1% to 3%, with only minor patches of land with slope >3%.

The surface geology is a part of the Surat and Clarence Moreton Basins, dominated by alluvial sediments overlying sedimentary rocks. The Condamine Alluvial sediments are extensive and can range in thickness from 10 m to more than 120 m in the floodplain near Dalby.

Based on the existing mapping (a scale of 1:2,000,000), the soils within the study area were dominated by self-mulching cracking clays (i.e Vertosol) and texture contrast soils (i.e. Sodosol). The available mapping reviewed as part of the desktop review are not designed to strictly identify soils in a particular map unit but predict their probable occurrence.

Based on available chemical and physical data from the Central Darling Downs Land Management Manual (Harris *et al.*, 1999), most soils along the alignment are expected to have alkaline upper subsoil (pH 8.0 to 10.0) over acidic lower subsoil (4.0 to 6.0), as a result of developing over clay sheets or sedimentary rocks. The soils along the alignment are sodic or strongly sodic and have medium to very high levels of salinity in the subsoil. Levels of salinity were generally low in the surface soils, increasing to medium to extreme in the subsoil.

The major limiting factors for the soils encountered along the alignment are soil structure and texture, along with subsoil salinity and sodicity issues. Most issues are likely able to be controlled by suitable soil handling, construction management practices and application of appropriate spoil ameliorants (gypsum and organic matter).

8.0 Recommendations

It is recommended that a detailed soil investigation be undertaken to refine the assessment of soils identified along the alignment, with the objective of ensuring that the adopted control measures are reflective of site-specific soil conditions.

Further soil investigations are recommended to be completed prior to any earth works commencing within the ROW and be detailed within a Sampling Analysis and Quality Plan (SAQP), developed by an SQP.

9.0 References

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10.0 Limitations

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Appendix A

Curriculum Vitae

Appendix A Curriculum Vitae

Simon Muniandy
ANZ Upstream Oil and Gas Market Sector Lead

Qualifications
Bachelor of Science (Hons, Geology)

Career History

Areas of Experience

- Conventional and Unconventional Oil and Gas
- Programme and Project Management
- Contamination Assessment and Remediation
- Geology, hydrogeology, & geochemistry
- Operations Management

Career Summary
Simon is the ANZ Upstream Oil and Gas Market Sector Lead and Technical Director with more than 20 years' experience in the geoscience/environmental industry, with projects across Australia, Pacific Islands, Papua New Guinea and S.E. Asia. Simon has a leading role the Oil and Gas market sector responsible for the delivery of AECOM projects to the onshore upstream oil and gas industry across ANZ.

Simon has extensive experience in the oil and gas and mining industry specifically in the risk management of environmental liabilities related to the acquisition, operation, decommissioning and demolition of facilities associated with all aspects of these industries.

Simon has managed the design, implementation and execution of a range of environmental projects including decommissioning and remediation of fuel terminals, marine, aviation and retail facilities. Simon also has extensive experience in upstream unconventional oil and gas, including development approvals and associated environmental assessments, baseline monitoring, water/brine management related to treatment and storage infrastructure, surface water discharge and aquifer storage. Simon has also been responsible for the design, management and execution of a $20M (Office of Groundwater Impact Assessment) groundwater monitoring bore program for Santos.

Due to his achievements associated with the OGIA drilling project, Simon was awarded the URS Pyramid Award for project management in 2014.

Simon has been able to apply his oil and gas industry experience to work collaboratively to achieve his Client's objectives and develop business for AECOM across technical disciplines and geographies.

Detailed Experience

ANZ Upstream Oil and Gas Market Sector Lead
Queensland Office, AECOM Australia Pty Ltd
Simon is responsible for the delivery of upstream oil and gas projects across ANZ. His responsibilities include; health and safety, cost control, contract management, scheduling and resourcing to enable the flawless execution of AECOM projects for our oil and gas clients. Whilst Simon's remit is across all AECOM technical services, he reports to Asia Pacfic Environment Managing Director

Work Group Manager Geoscience and Remediation Services, Queensland
Queensland Office, AECOM Australia Pty Ltd
As Work Group Manager, Simon is responsible for the leadership and management of the Geoscience and Remediation Services group consisting of approximately 30 staff. Simon is accountable for the group's financial performance, technical direction, business development and the technical delivery of a wide range services including:

- Contaminated land assessments and remediation
- Hydrogeological assessments and modelling
- Geochemistry
- Soil Science
- Geophysics
- Geology

Client Management
Santos & Caltex - National Client Account Manager, AECOM Australia Pty Ltd
Simon was AECOM's national client account manager for Santos & Caltex, responsible for the successful delivery of all AECOM projects nationally and throughout the Pacific. Simon provides Santos & Caltex with a single point of contact for contract or issues critical to project delivery. Simon also is Principal in Charge for a range of Coal Seam Gas (Coal Bed Methane) groundwater and environmental projects including; the management of associated water, infrastructure decommissioning, remediation and environmental assessments. His responsibilities as the National Client Account Manager include:

- Contracts negotiation and reporting;
- Financial management;
- Project support and technical review;
- Stakeholder management;
- Strategy Planning, Budgeting and Forecasting;
- Health and Safety Management and Leadership.

Project Management
Project Manager, ExxonMobil Environmental Services - Major Projects, Mobil Oil Australia, Australia, PNG, Indonesia
Simon was the Project Manager responsible for the management of ExxonMobil's environmental liabilities associated with the operation and/or decommissioning of major facilities in Australia. Critical to the successful execution of projects was the ability to evaluate risk and prioritise a large number of sites across the portfolio, then effectively manage the environmental risk and commercial objectives for each site.

Simon has successfully completed multi-million dollar site assessment and remediation projects across Australia with a number of projects receiving recognition for flawless execution across health and safety (zero recordable incidents), on schedule and under budget. Simon was responsible for the following portfolios:

- Non-Operating Distribution Terminals and Pipelines (National);
- Aviation Terminals (National);
- Marine Fuel Terminals (Queensland);
- PNG LNG Office and Housing;
- Oil Field Divestment – Aceh, Indonesia

His responsibilities as a project manager with ExxonMobil Environmental Services included:

Duties:

- Management of environmental risks and liabilities;
- Management of consultants and contractors on major projects (>$15M AUD).
- Technical review and stewardship of environmental assessment and remediation.

Skills:

- Contractor Management;
- Cost and budget controls;
- Health and safety stewardship;
- Technical expertise including soil and groundwater remediation, and risk assessment;
- Risk management;

- Communication of project risks and analysis to stakeholders including senior management.

Oil and Gas

Project Director, Shallow Groundwater Assessment, QGC
Design and construction of 44 groundwater monitoring bores in the Surat Basin Aquifers targeted: Springbok Sandstone and Walloon Coal Measures. The groundwater monitoring program to assess CGS impacts on groundwater and potential groundwater dependant ecosystems. A small mobile drill rig to install shallow groundwater well, compliant with the Code of Practice and API specifications. The project received an QGC Wells team award for excellence.

Project Manager, Spring Gully and Taloona Evaporation Pond Assessment and Remediation
Assessment of an 83ha and 10ha brine storage and evaporation ponds, and development and design of a remedial strategy to protect nearby sensitive receptors. The multidisciplinary delivery team has produced the first remediation and approvals plan of this type in the CGS industry in QLD.

Principal in Charge, Water Facilities Upgrade Project Scotia – Design Phase, Brisbane Team, Queensland
In 2012 URS designed and subcontracted the construction and supervised the filed assembly and oversaw commissioning of a managed aquifer recharge (MAR) water injection system. URS was commissioned to design and oversee construction of the injection equipment and manage the design of the reverse osmosis plant. URS had previously successfully installed the injection bore and had performed hydrogeological testing to ensure that the aquifer had the capacity to accept the required injection volume and rate.

Principal in Charge, Deep Monitoring Program, Queensland
URS engaged a combination of large oil and gas service providers (Halliburton, Weatherford, GE Oil & Gas) and smaller scale drilling and services companies to design a turnkey approach for developing, managing and executing large scale groundwater drilling projects for Coal Seam Gas (CSG) operators.

The 16-well campaign based in Roma, targeted zones of the Springbok and Hutton sandstones to depths of up to 1,150 mBGL. In order to manage potential influxes from gas bearing units (Walloon Coal Measures), a full BOP stack (annular, double rams) was been employed, and all auxiliary gear on site (mud systems, generators, pumps) were intrinsic safety rated.

URS was responsible for the planning, procurement, management and delivery of a groundwater well installation campaign targeting aquifers in close proximity to, and underlying economics CSG reserves. Our technical team, comprising experienced project managers, field hydrogeologists, site supervisors, drilling and completions engineers enable the delivery of reliable groundwater monitoring infrastructure which is designed, drilled and completed to CSG standards.

Principal in Charge, Old Bogandilla, Emu Park Wells, Queensland
URS was commissioned to design, procure and manage the installation of a 1500m deep monitoring well at Old Bogandilla site and a 1600m deep brine injection monitoring well at Emu Park site, located near Roma QLD. The project was completed on budget without any recordable health and safety incidents.

Principal in Charge, Roma MAR Pumping Tests, Queensland
During the construction phase of the Roma Managed Aquifer Recharge Project (MAR), URS was commissioned to perform pumping tests on the Roma MAR injection bores. The objective to gain a better understanding of the hydraulic parameters of target aquifers and to determine the bore efficiency of each injection bore.

Principal in Charge, MAR Numerical Model, Queensland
The project included, update of the numerical model for injection which URS had previously designed, review baseline assessments of all private bores within the Roma MAR injection impact zone, provide recommendations on remedial actions which may be required due to injection.

Principal in Charge, Regional Bore Inventory- Data Review, Queensland
In order to comply with the Queensland Department of Environment Resource Management, Baseline Assessment Guidelines for Roma Regional Bore Inventory, the Client required data collected by their field staff to be reviewed by a third party. URS attended 10% of the baseline assessments being conducted by the Client RBI team and reviewed all information presented in the baseline assessment reports completed by the Client RBI team, enabling sign off by the regulator.

Principal in Charge, Landholder Bore Investigations, Queensland
The Client was required to conduct down-hole surveys of landholder bores in the Fairview field. The surveys will be used to establish which formation the well is screened in, review the construction of the bore and the integrity of the casing, and to determine their suitability for use as ongoing groundwater monitoring points. URS was commissioned to manage the down-hole survey of the bores and perform the data analysis of the survey data. Use of existing bores for monitoring purposes gave a large cost saving to the client.

Project Manager, Regional Bore Inventory - Roma Fairview Arcadia Valley, Queensland
The aim of the project was to collect accurate, verifiable and representative information on the private bores within and surrounding the clients' petroleum leases or Authorities to Prospect (ATPs). The baseline assessments were required to assist with any potential make good agreements with landholders and the assessment was a requirement of the Queensland Water Act 2000. The baseline assessment included all water bores within and potentially surrounding coal seam gas tenures, including water bores not formally registered or notified to the Department of Environment and Resource Management.

Project Manager, Narrabri Surface Water Monitoring, New South Wales
Development and completion of a baseline surface water monitoring program for the Clients Narrabri operations. Scope of work incudes; site familiarisation and orientation, desktop analysis and site selection, map preparation, detailed catchment characterisation, monthly field visits, sampling, preparation of post monitoring memorandums, tracking and review of laboratory data, reporting and data analysis.

Project Manager, Narrabri Environmental Monitoring, New South Wales
Field groundwater and environmental monitoring for the Narrabri operations team including, collection of 22 groundwater samples, collection of 16 raw CSG groundwater samples and collection of 5 surface water samples, and tracking and review of lab data.

Project Manager, Screening Study – Hydraulic Connectivity Studies
Assessment of telemetry bores for suitability of aquifer hydraulic assessment. There were 70 private bores that have been equipped with telemetry to monitor groundwater levels within the bores. During the regular operation of these bores by the landholder, water level data is collected on the drawdown and recovery within the wells. This information alongside flow rates and information available through various sources can be used to determine localised aquifer hydraulics. The desktop assessment through interrogation of all available information was to identify which of the approximate 70 bores have the suitability for further analysis for hydraulic assessment, based on; Groundwater level pumping and recovery data, pumping rate is constant, and availability of well flow rate or volume of water extracted.

Project Manager, Scotia MAR – Injection Equipment Modification and Implementation, Queensland
URS was commissioned to investigate the modification of existing Managed Aquifer Recharge equipment used for permanent use in a separate scheme. The study lead to a full redesign of the existing system and project management of the design of a separate reverse osmosis plant.

Environmental Studies

Principal in Charge GE Project Eldridge - Due Diligence Assessment
URS was commissioned by GE to perform Due Diligence assessment for the sale of 5 chemical sites across eastern Australia. The project required that URS complete the entire project; desk top, intrusive assessment and reporting) within two weeks. GE were able to successfully complete the transaction based on the timeliness and quality of the URS reports.

Principal in Charge – Santos Moonie to Brisbane Pipeline Assessment and Decommissioning Plans
URS were appointed as the environmental consultants to assess and manage the environmental impacts and decommission planning for the entire 300km Moonie Brisbane crude oil pipeline. Through an extensive review of operational records, URS were able to rank each section of the pipeline for the risk of impacts and tailored an assessment process for each risk level (high, medium low,). On the basis of the assessment URS identified a limited number of impacted site requiring remediation or further risk assessment, ensuring management of Santos risk into the future.

In preparation for the potential decommissioning of the pipeline URS prepared an abandonment plan recommending the most cost effective and safest options for decommissioning the pipeline along its entire length including; agricultural regions, urban residential regions, road and rail crossings, and creek crossings. On the basis of the plan Santos were able to select the best decommission techniques for all section of the pipeline.

Team Leader/Principal in Charge, Various environmental projects, Mobil/Shell/Caltex/BP, Australia, Pacific Islands, S.E. Asia
Simon has successfully filled a number of key roles (project manager, technical reviewer, Principal in Charge) on contaminated site assessment and remediation projects for the oil majors. Simon has acted as a team leader for URS contaminated site projects in Victoria, Northern Territory and Queensland where his tasks included the management and technical review of multiple projects to ensure the technical delivery of project for our Clients.

Project Manager, Department of Planning and Infrastructure, Northern Territory
Simon was the project manager for the remediation and ongoing assessment of the Darwin Waterfront Redevelopment. The project management included the development and completion of remedial work plans for each of the construction areas, independent environmental consultant supervision of construction and remedial works, ongoing groundwater monitoring of the site, assessment of former navy fuel storage tanks,

bio-remediation of hydrocarbon contaminated soil, groundwater modelling of the site, trial installation of groundwater interception drains and assessment of 800,000m^3 of imported fill.

Project Manager, Soil and groundwater contamination assessment Leederville Pty Ltd, Cranbourne South, Victoria
Soil and groundwater contamination assessment of former pastoral grazing land rezoned for residential development. Simon had involvement in the planning and conduct of the field component, project management, reporting and also remediation and validation of impacted areas. Following the final assessment report the auditor was able to provide the client with a Certificate of Statutory Environmental Audit for the site.

Project Manager, Confidential Client, Ansett Facilities, Tullamarine, Victoria
A potential purchaser of the Ansett maintenance facilities at Tullamarine required a due diligence environmental site assessment performed prior to purchase. Involvement included managing field activities on two sites simultaneously, three drill rigs and three field staff. Installation of eight groundwater wells to depths of up to 50 m and approximately 60 soil boreholes. Simon was also involved in the groundwater modelling and production of detailed lithological cross-sections and reporting.

Project Manager, Groundwater Assessment, Orica Engineering Pty Ltd, Yarraville, Victoria
A large chemical plant adjacent to the Yarra River required a detailed groundwater assessment prior to the divestment of part of the site. Simon's involvement included installing aquifer specific wells across the three significant aquifers at the site, utilising sophisticated drilling and well installation techniques. Simon also project managed the groundwater monitoring component, involving analysis of non-standard, organic, analytes.

Project Manager, Mirvac Victoria Pty Ltd, The Heath, Heatherton, Victoria
The project involved a groundwater nitrate investigation, assessment of extent and rate of migration of groundwater nitrate plume extending beneath former market garden area. This included the review of possible remediation technologies for groundwater nitrate.

Project Manager, Auspine Pty Ltd, Kalangadoo, Tarpeena, SA and Scotsdale, Tasmania
Simon was the project manager for timber processing and treatment plants, requiring on-going monitoring of groundwater to assess for potential site use impacts on groundwater. Involvement also included groundwater sampling, reporting and peer review.

Project Manager, Australand Apartments Pty Ltd, Abbotsford, Victoria
Australand were developing a former textile mill on the banks of the Yarra River in Abbotsford, Melbourne. The site requires a statement or certificate of environmental audit prior to the completion of the residential development. Involvement included project management of field staff for the installation of 11 groundwater bores, groundwater flow modelling, conceptual geological and groundwater modelling and reporting. Issues in completing to fieldwork included, drilling on an asbestos contaminated site, liaison with CFMEU representatives, OH&S consultants, local council and residents.

Project Manager, Beverford Pty Ltd, Sheep Dip Assessment, Swan Hill, New South Wales
Two former sheep dips are located in a proposed residential subdivision area. Simon's involvement included project management, initial site inspections, sampling and cement stabilisation trials for remediation and disposal of arsenic contaminated soil.

Geotechnical Investigations
Project Manager, Henty Goldmine West Coast, Tasmania
Henty was developing a major extension to the underground workings involving a long drive requiring two vent shaft for ventilation and emergency exists. Involvement included geotechnical logging the pilot hole for Vent Shaft 2, consisting of over 600 m of diamond core. Simons' involvement also extended to point load testing of core samples, organising mine geologists and field staff.

Project Manager, Temco Pty Ltd, Bell Bay, Tasmania
An additional wastewater storage dam was required by a major industry. Simon's involvement included geotechnical investigations of soil and installations of groundwater wells providing information for the dam design.

Project Manager, Comalco Pty Ltd, Bell Bay, Tasmania
A major erosion gully had developed below a historical landfill on the Tamar River causing and increase risk of a landslip occurring. Simon's involvement included soil and groundwater sampling, groundwater and landfill leachate modelling, land slip modelling using SLIP software, reporting, risk assessment and further investigation recommendations.

Project Manager, Leightons Pty Ltd, Melbourne, Victoria
A major petroleum company proposed to develop a large tank farm adjacent to West Swanson Dock. The initial assessment involved geotechnical and environmental components. Simon's involvement included geotechnical logging of 30 - 40 m deep, cored boreholes.

Project Manager, Hydro Tasmania Pty Ltd, Meander Dam, Meander, Tasmania
Soil mapping and sampling to locate sufficient quality and quantity of clay to construct an earth dam wall. Issues included working in remote areas and logistics.

Project Manager, Eastern Treatment Plant, Tertiary Treatment Plant Investigation, Melbourne, Victoria
Excavation of approximately 20 testpits and the construction of three groundwater piezometers to provided geotechnical information for the design of the tertiary treatment plant. Testpits were excavated to a depth of 4 m and bag and bulk samples were collected, in-situ consistency was measured and lithologies logged. Bulk samples were used for standard compaction tests and bag samples were used for particle size analysis and Atterburg limits. Three deeper boreholes were advanced with SPTs performed and U63 collected during drilling. Piezometers were then installed to investigate groundwater levels in the area. Simon's involvement included the reporting of this project which establishing background geology and hydrogeology, summarising field results, laboratory results and allowable soil bearing pressures.

Project Manager, John Mullen Partners, Aldi Food Stores, Melbourne, Victoria
The project involved a joint geotechnical and environmental investigation of numerous proposed Aldi Food stores in Melbourne. Simon's involvement in these projects ranged from fieldwork to project management. The geotechnical component consisted of a limited number of testpits, usually one at each corner of the proposed building and one or two in the vicinity of the proposed car park and CBR testing and limited reporting on allowable bearing pressures for footings and reporting CBR results for pavement design.

Project Manager, Melbourne Water, Mains Water Supply Pipeline, Melton, Victoria
The project involved the geotechnical investigation of a small section of a proposed mains water supply pipeline, where the proposed route went beneath a railway. Simon's involvement included drilling two auger and cored bores on either side of the railway, the installation of piezometers in each bore and surveying the borehole levels. The core was logged, specifically weathering, fracture density and hardness. This information was reported and supplied to the contractor for excavation design.

Project Manager, Melbourne Water, Bridge Investigation, Koo wee rup, Victoria
A geotechnical investigation of a small bridge crossing was required for this project. Simon's involvement included drilling two boreholes, conducting SPTs and collection U63 tubes during drilling and the installation of piezometers. Reporting consisted of regional and local geological and hydrogeological conditions, field and laboratory results and discussion of soil bearing capacities.

Project Manager, Nillumbik City Council, Bridge Investigation, Diamond Creek, Melbourne, Victoria
The project involved a geotechnical investigation of a small foot bridge. Simon's involvement included drilling two boreholes, conducting SPTs and collection U63 tubes during drilling, the installation of piezometers and performing DCPs. Reporting consisted of regional and local geological and hydrogeological conditions, field and laboratory results and discussion of soil bearing capacities. In addition, the project involved liaison with anthropologists and representatives of the local aboriginal tribe.

Project Manager, Radfords Abattoir Pty Ltd, Effluent Lagoon Liner Investigation, Warragul
As a part of a wastewater irrigation project a geotechnical investigation of a proposed effluent storage lagoon site was performed. Simon's involvement ranged from project management to fieldwork. A number of testpits were excavated and bulk samples collected for compaction and tri-axial permeability testing at a range of compaction and moisture conditions. Based on the results of the fieldwork and laboratory results, recommendations were made as to the suitability of the material for uses as a lagoon liner and the required compaction and moisture conditions for the construction of the liner.

Mining
Exploration Geologist Duketon, Western Australia
Exploration geology experience involved a broad range of field, office and managerial tasks. Simon was involved in fieldwork including design and implementation soil sampling program, regional and local scale geological mapping, regolith mapping and geomorphology mapping, groundwater level mapping and supervision of test bore installation for dewatering, supervision and logging of RC, RAB, and diamond core drilling. Office work consisted of database management, GIS management including plan and section production, ore body modelling and wire-framing and geological interpretation and drilling program design. Managerial work consisted of logistical organisation, coordinating drill-rigs and other associated heavy machinery, field technicians, and surveyors.

Wastewater Projects
Exploration Geologist Kraft Foods Ltd, Mil Lel, Mt Gambier, South Australia
The project involved wastewater irrigation assessment and monitoring. High strength, industrial wastewater has been irrigated onto pasture for a number of years. Environmental Protection Act (EPA) required as a part of the licence agreement, the annual monitoring of soils

and biennial monitoring of groundwater, to be reported annually. Simon's involvement included project management, fieldwork and reporting. The report summarises the data, interpolates trends and makes recommendations for reducing adverse environmental impacts. The report is reviewed by an independent reviewer for South Australian EPA.

Exploration Geologist, Starwood Pty Ltd, Bell Bay, Tasmania
Wastewater irrigation assessment for a wood processing plant proposing to reuse the wastewater generated from the plant. The Department of Primary Industries, Water and Environment (DPIWE) required a detailed assessment of the soil and groundwater characteristics of the proposed irrigation site before irrigation could commence. The assessment included soil mapping and sampling, groundwater well installation and sampling, infiltration, permeability and water holding capacity testing. Simon was involved in project manager, fieldwork and reporting.

Exploration Geologist, North West Rendering Pty Ltd, Devonport, Tasmania
Wastewater irrigation and effluent lagoon assessment for a proposed rendering plant site in northern Tasmania. The assessment consisted of soil mapping, soil sampling, infiltration and permeability testing and a lagoon condition assessment. Simon had involvement in project management, soil sampling, permeability and infiltration tests, and reporting.

Exploration Geologist, Sandhurst Development Joint Venture Pty Ltd, Carrum Downs, Victoria
A large residential and golf-course development is utilising treated effluent from the Eastern Treatment Plant for irrigation purposes. Prior to irrigating the effluent EPA require baseline groundwater quality data. The project consisted of the installation and sampling of groundwater monitoring wells and the decommissioning of old irrigation wells. Simon was involved in project management and reporting.

Exploration Geologist, Melbourne Water, Werribee Golf Course and Equestrian Centre, Werribee, Victoria
Western Treatment Plant is providing the Werribee golf course and equestrian centre with treated effluent for irrigation. Prior to irrigating the effluent *EPA* require baseline groundwater quality data. The project consisted of the installation and sampling of groundwater monitoring wells. Simon was involved in project management and reporting.

Exploration Geologist, Coliban Water, Envirosafe 2001, Victoria
Conducting site selection and site assessment for wastewater treatment projects in seven regional Victorian towns, involving GIS assessment, detailed soil and groundwater assessments, permeability testing, salinity susceptibility and agronomic recommendations. The work was performed in conjunction with geotechnical and anthropological assessments.

Exploration Geologist, Wagga Wagga City Council, Wagga Wagga, Victoria
A new industrial area located to the north of Wagga Wagga required a new large effluent treatment system. Simon's involvement included geophysical interpretation and field soil mapping to determine the suitability of proposed effluent irrigation sites.

Exploration Geologist, Oztek Rendering Plant Wadonga, Victoria
As a part of a works approval application for the rendering plant, Oztek required the installation of a groundwater monitoring network surrounding the effluent treatment lagoons and irrigation area. Simon's involvement included, project management and data interpretation and reporting of results to EPA for the works approval.

Exploration Geologist, Epsom Racecourse Redevelopment, Cheltenham, Victoria
The project required the redevelopment of the Epsom racecourse required the relocation of a significant remnant wetland, requiring a detailed soil and groundwater assessment of the existing wetland and the proposed relocation position. This included analysis of bulk density, permeability and major chemical constituents of the soil.

Training
Santos Eastern Queensland, NSW and Cooper Basin Level 1 & 2 inductions

URS Project Manager Certification - 2012

First Aid International Training - 2012

ExxonMobil Stakeholder Engagement Training - 2011

ExxonMobil LPS Training 2007 (annually updated through 2012)

40hr URS Health and Safety Training - 2004

URS Project Management Training (2 days) - 2004

ExxonMobil Incident Investigation Training - 2005

Fundamentals of Groundwater Science, Technology and Management - 2002

Defensive driving and FWD course - 1999

Mining and Resource Contractors Safety and Training Association (MARCSTA) - 3 day training course - 1999

Remote Area Survival Course - 1999

Professional History

2012 - Present
AECOM Services Pty Ltd (formerly URS Australia Pty

Ltd), Brisbane
Principal Geologist

2008 - 2011
Mobil Oil Australia
Contractor

2004 - 2008
URS Australia Pty Ltd, Melbourne
Associate Environmental Scientist

2003 - 2004
Coffey Geosciences Pty Ltd, Victoria
Victorian Environmental Manager

2001 - 2003
Coffey Geosciences Pty Ltd
Environmental Scientist

2000
Van de Graaff and Associates Pty Ltd
Soil Scientist

1999
Johnson's Well Mining
Exploration Geologist

Navjot Kaur
Technical Lead - Acid Sulfate Soils, Principal Soil Scientist

Qualifications
Certified Professional Soil Scientist (CPSS) 2016 to present
MSc (Hons) Agronomy, Punjab Agriculture University, Punjab, India
BSc (Hons) Agriculture Science, Punjab Agriculture University, Punjab, India

Affiliations
Member of Australian Society of Soil Science
Member of Australian Land and Groundwater Association

Awards
URS International Pyramid Award of Excellence - Health and Safety 2011

URS International Pyramid Award of Excellence - Health and Safety 2009

URS 4sight Health and Safety Excellence Award - 2008

University Merit scholarship and awarded merit certificate in Both BSc and MSc

Career History
Navjot Kaur is an Environmental professional with technical background and competent knowledge of soil science and more than 17 years' experience in working with natural resource sector with respect to environmental management. At AECOM she is placed as Principal Soil Scientist with the Geoscience and Remediation Services team.

Her project experience includes environmental impact statement (EIS) assessments from soils perspective including land and soil classification as per Australian Soil Classification (ASC) system; Land Suitability, Land Use, Good Quality Agriculture Land (GQAL) and Strategic Cropping Land (SCL) assessment; Identification and management of acid sulfate soils (ASS); Land Rehabilitation including assessment of potential impacts of problem soils and mitigation measures, erosion and sediment control, topsoil reuse and management

She was also involved in various contaminated site assessments involving Phase I and Phase II site investigations including soil and groundwater sampling, Quantitative and Qualitative Risk Assessment for human health and environmental receptors and Remediation works including development of sampling and analysis plans (SAP), remedial action plans (RAP) and site management plans (SMP).

Her project management experience includes scope development, cost estimation, project administration, budget management, cost control, project completion sub-contractor administration, bid/tender evaluation, procurement and invoicing. She was also involved in supervision of junior staff and sub-contractors

She also has extensive experience with various data management software (gINT, ESDAT, EQUIS) and MS office for graphs, logs, presentations, statistics and report preparation.

Detailed Experience

Navjot's range of experience includes conducting environmental management works on oil & gas, mining, commercial and industrial sites undertaking the following:

- Environmental Impact Assessment
  - Soil and Land Classification based on Australian Soil Classification System
  - Land Suitability, Strategic Cropping Land (SCL) and Topsoil assessment
  - Identification and management of Acid Sulfate Soils (ASS)
  - Site reinstatement and rehabilitation
- Environmental Sites Assessment and Remediation:
  - Environment and Human health risk assessment and mitigation
  - Soil, soil gas, surface water and groundwater investigations
  - Remediation of hydrocarbon, metals, salts and solvent impacted sites
- Environmental Compliance:
  - Environmental Management Plans (EMP) development and implementation
  - Environmental audits (internal and 3rd party) and approvals/ license documents
  - Incident response, monitoring, sampling, mitigation, and reporting
- Water Management:
  - Dewatering programs and groundwater treatment systems
  - Bore drilling and well installation; compliance monitoring and sampling
- Waste Management:
  - Contaminated/ hazardous and non-hazardous waste management and transport
  - Drilling waste management including drilling muds disposal
- Health, Safety & Environment:
  - Development and implementation of project specific health and safety plans
  - Conduct inductions, risk assessments, incident investigation, auditing
- Data management, Interpretation and Report Writing
  - Data management software (gINT, ESDAT, EQUIS) and MS office for graphs, logs, statistics and report preparation
- Project Management:
  - scope development, cost estimation, project administration, budget management, cost control and project completion
  - Contractor administration, bid/tender evaluation, procurement and invoicing
  - Supervision of junior staff and contractors

Key Projects at AECOM:

- Acid Sulfate Soils intrusive investigation and development of ASSMP for Cross River Rail – Rail Integration System (RIS) – Lead Acid Sulfate Soils Specialist - Co-ordination of fieldwork, data analysis, interpretation and Reporting
- Frac Ponds Decommissioning and Rehabilitation, QGC, Technical Lead and Project Manager. Co-ordination of fieldwork, data analysis, interpretation and Reporting
- Acid Sulfate Soil assessment for road upgrade works at Walkerston Bypass, Mackay, Project – Desktop assessment, data analysis and reporting as per Qld Guidelines
- Contaminated land and Acid Sulfate Soil assessment for underground rail tunnel in Brisbane – Desktop assessment
- Acid Sulfate Soil assessment for road upgrade works at Port Alma Road, Bajool, Project – Desktop assessment, data analysis and reporting as per Qld Guidelines
- Stage 1 and Stage 2 Contamination Investigation across the whole RAAF Base Amberley – Desktop, fieldwork, data analysis and reporting
- Stage 1 and Stage 2 Contamination Investigation across the whole Gallipoli Barracks Enoggera – Desktop, fieldwork, data analysis and reporting
- Stage 2 Contamination Investigation across the whole Jennings Defence Base – Desktop, fieldwork, data analysis and reporting
- Soil Assessment for PFAS and other Contaminants for Growler Project, RAAF

Amberley - Desktop assessment, data analysis and reporting

- Coastal Acid Sulfate Soil assessment (CASS) for North East Link (NELA) Project – Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Land Capability Assessment for onsite Effluent Disposal at a site in Melbourne. It included assessment of topsoil and subsoil and water balance calculations.
- Coastal Acid Sulfate Soil assessment (CASS) for Melbourne Metro Project – Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Stage C Groundwater Assessment – AACO Base, Oakey – Reporting
- Groundwater Radioactive Assessment - Defence Science and Technology Group, Fishermans' bend – Fieldwork and reporting
- Exxon Mobil Altona Refinery Sediment Assessment - project management and reporting
- Coastal Acid Sulfate Soil assessment (CASS) for Edithvale and Bonbeach Level Crossing Removal (LXRA) Projects - Desktop assessment, data analysis and reporting as per Victorian Guidelines
- Project manager, Soil sampling at Oakey Base for PFC assessment in Soils for disposal
- Project manager, Soil sampling at Oakey Civil Terminal for PFC assessment in Soils for disposal
- Santos Remediation Project at Roma – Project team, fieldwork and reporting
- Oakey Groundwater Investigation, AACO base Oakey – Project team, fieldwork and reporting
- Growler Project, RAAF Base Amberley Additional Soil Characterization including assessing soils for PFC contamination
- C-17 Project RAAF Base Amberley Additional Soil Characterization including assessing soils for PFC contamination
- Contamination Investigation for Acid storage dam, Incitec Pivot, Phosphate Hill
- Origin Energy, Deep Drilling for groundwater monitoring wells at Ironbark.
- LendLease – RNA Showgrounds Development Project – Contaminated land and ASS investigation and management – Team member
- Part of the Team for Origin Energy CSG Dams Remediation Project SELECT Phase
- Defence – RAAF Base Amberley, Phase 1 and site contamination Investigation, C17, Growler, Battlefield airlifter etc. – fieldwork and reporting
- Caltex Gold Coast Airport, JUHI and PRA Remediation including ASS management
- UPSS Inspections at various sites for Goodman Pty Ltd – Project Team, fieldwork and reporting
- Deputy Project manager (DPM) for BP contaminated land investigation at Charters Towers.
- Caltex Sites Groundwater Investigation at North Queensland - DPM
- Origin Energy former gasworks sites Bundaberg, QLD Project Team, fieldwork and reporting.
- Origin Energy former gasworks sites, Maryborough, QLD Project Team, fieldwork and reporting.
- Remediation Plans for Origin Energy former gasworks sites at Warwick and Bundaberg, QLD Team lead.
- Part of the Team for Origin Energy CSG Dams Remediation Project Phase 2.
- Origin Energy Asbestos Investigation Project – Project Team, fieldwork and reporting.
- Caltex UPSS 2014, reporting for select sites.
- Phase I Environmental Investigation at different sites for Goodyear Pty Ltd – Project Team, fieldwork and reporting
- Soils and topography as part of the EIS for a major underground combined Bus and Train (BAT) tunnel project in Brisbane – Team lead.

Historical Projects:

- Groundwater monitoring sampling and report writing for key Shell retail and distribution sites in and across Brisbane – Project team
- Groundwater investigation including halogenated compounds for an Industrial site

(BOC), fieldwork and report preparation – Project team

- Environmental Site assessment (Phase I and Phase II) – Project Manager/Site Supervisor.
- Posted on secondment for an year with a major CSG project (Santos), Data manager for Quality control and assurance of environmental data
- CSG Pipeline Construction (Origin Energy via East Coast Pipeline) – Project Manager, SCL and Topsoil Assessment.
- Disposal Options for Drilling Muds for CSG industry (Origin energy) – Project Team, Desktop review, field trials.
- CSG Gas fields EIS – Project Team, Soil survey and land assessment.
- Major underground tunnel project – Team lead, ASS investigation and management.
- Site closure for Box cut mine – Team Lead, Dewatering, Soil treatment and re-interment.
- Soils and groundwater remediation including ASS soils management at a major fuel distribution centre (ExxonMobil) – Project Team
- ASS soils investigation for various projects at Brisbane Airport including fieldwork – Project team
- Marine sediment sampling program associated with the proposed LNG (Liquefied Natural Gas) plant in the Port of Gladstone (Santos)
- Marine Sediment analysis involving a proposed dredge area for the removal of the subsea section of a decommissioned pipeline bundle (Caltex Refineries Pty Ltd)

Conferences
Soil Science Conference, Canberra, 2018

Mine Closure, Brisbane 2012

Training

- AECOM Certified Project Manager
- Acid Sulfate Soils; Identification, Assessment and Management, Three day short Course
- Nature and Distribution of Queensland Soils as per Australian System of Classification, Two Day Training
- Software Training gINT, Three day training
- Software Training ESDAT, one day training
- How to Write Effective Reports, one day training at Australian Institute of Management (AIM)
- 40 Hour Health and Safety Training (HAZWOPER)
- 30215 QLD Construction Industry Safety Induction (Blue Card)
- PMASUP236A Operate Vehicle in the Field 4WD,
- Santos Environment Health and Safety Induction Rev 7.3 including gas Certificate
- Senior First Aid and CPR training
- Australian Institute of Petroleum Permit System
- MOBIL Loss Prevention System Training
- Shell Coles Express Online Induction A and B
- Shell Approved Retail and Distribution Permit Holder Training
- Working in Electrified Territory (WET), Safely Accessing the Rail Corridor (SARC), Fatigue Management, Category 3 Medical
- Rail Industry Worker (RIW) card

Other Languages
Punjabi, Hindi

Professional History

2020 - Present
AECOM
Principal Soil Scientist – Technical Lead Acid Sulfate Soils

2016 - 2020
AECOM
Senior Soil Scientist - RCE

2014 - 2016
AECOM
Professional Environmental Scientist - RCE

2008 - 2013
URS Australia Pvt Ltd
Soil Scientist

2005 - 2008
Simmonds and Bristow Pvt Ltd
Scientist

2003 - 2004
Sydney Environmental & Soil Laboratory Pvt Ltd
Analyst