Dampier to Bunbury Natural Gas Pipeline Stage 5 Expansion – Acid Sulphate Soil and Hydrogeologic Desktop Study

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Strategen

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1. Introduction

Construction of the Stage 5 Looping of the DBNGP requires clearing and grading, excavation, pipe-laying, backfilling, hydrotesting, rehabilitation and commissioning activities to be undertaken adjacent to the existing DBNGP pipeline in eleven looped sections distributed between Karratha and Wagerup (Figure 1). As part of the approvals process for the project, the proponent must demonstrate suitable knowledge and management of environmental issues associated with the proposed construction works.

Parsons Brinckerhoff (PB) was engaged by Strategen in May 2006 to undertake a desktop assessment to predict the likelihood of encountering acid sulphate soils, shallow groundwater, wetlands and river systems along the proposed Dampier to Bunbury Pipeline (DBNGP) Stage 5 expansion route. The results of this desktop assessment will be used to develop an investigation strategy along the pipeline route to enable preparation of suitable acid sulphate soil and dewatering management plans.

This desktop assessment encompasses the length of the pipeline from KP 22 to KP 1,483, with the exception of those areas of the DBNGP constructed as part of Stage 4, resulting in the assessment of a total of 1,257 km.

1.1 Distribution of Acid Sulphate Soils in Western Australia

Acid sulphate soil is the common name for soil that contains iron sulphide or sulphide oxidation products. When acid sulphate soils are exposed to air and water, the iron sulphides can oxidise to produce sulphuric acid, iron precipitates and groundwater with elevated concentrations of dissolved metals such as aluminium, iron and arsenic. Although these materials are typically benign when undisturbed in their natural environment, the dewatering, excavation and/or stockpiling of acid sulphate soils may promote the occurrence of the aforementioned adverse environmental impacts.

Acid sulphate soils are widespread around coastal regions of Western Australia, and may also be locally associated with freshwater wetlands and saline sulphate rich groundwater in some agricultural areas. Through regional mapping projects, shallow acid sulphate soils are known to be present in the following general locations in Western Australia (DoEC, 2006):

- Riverine, estuarine and coastal lowland areas such as mangroves, brackish lakes, tidal flats, salt marshed, salt pans, swamps and seasonally inundated plains;
- Wetland areas;
- Saline inland areas;
- Locally between the Moore River and Dunsborough on the Swan Coastal Plain; and
- On the Scott Coastal Plain at elevations up to 40 metres above sea level.

2. Assessment Methodology

2.1 Desktop methodology

Despite knowledge on the general areas characteristic of acid sulphate soils, detailed risk maps in Western Australia have only been produced for the Swan Coastal Plain and for the Albany-Torbay region (DoEC, 2006).

Desktop assessment of regionally available information has been undertaken to use key indicators of acid sulphate soils to identify the likelihood of occurrence outside the regionally mapped areas (Loops 0-8), and to confirm the risk of DBNGP specific activities disturbing acid sulphate soils and shallow groundwater in those areas previously mapped (Loops 9 and 10).

2.2 Data sources

The following data sources were used as part of the desktop investigation for Loops 0-8:

- Geotechnical Characteristics of the Pipeline Corridor (Dames & Moore, 1999) including flight observations, broad soil types and geology
- Department of Environment WIN Database for depth to groundwater
- Department of Environment Statewide River Water Quality Assessment (2004) for surface water quality.
- Shuttle Radar Topography Mission (SRTM) for Digital Elevation Model (DEM) and water bodies
- AGSO National Geoscience Dataset for regional regolith mapping
- Integrated dataset of Agricultural Land Cover Change (ALCC95), Forests of Australia 2003, 1996/97 Land Use of Australia, and the National Vegetation Information System 2000 (NVIS00) for regional vegetation cover.

The following data sources were reviewed as part of the desktop investigation for Loops 9 and 10:

- WAPC Bulletin 64 - South Metropolitan Region Scheme Acid Sulphate Soil Map
- Perth Metropolitan Region 1:50,000 Environmental Geology Series Maps – Serpentine, Muchea, Perth, Rockingham Sheets.
- Geological Maps of Australia Series, 1: 250,000, Perth , Pinjarra and Collie Sheets.
- WRC, Perth Groundwater Atlas

2.3 Risk assignment

Data from each of the aforementioned sources was mapped along the pipeline route. The potential for occurrence of acid sulphate soils occurring within the proposed excavation footprint was assessed through the use of key indicators such as geology, wetlands, depth to groundwater, and vegetation and classified as HIGH (almost certain), MEDIUM (likely), MEDIUM TO LOW (possible in isolated circumstances), and LOW (unlikely).

The following general principles (DoEC, 2006) regarding the occurrence of acid sulphate soil occurrence was used to rank the key indicators. Acid sulphate soils can be found in:

- Areas depicted on geology and/or geomorphological maps as geologically recent (e.g. shallow tidal flats or tidal lakes, coastal alluvial valleys, wetlands, floodplains, waterlogged areas, swamps);
- Areas identified in geological descriptions or maps as bearing acid sulphide minerals, former marine or estuarine shales and sediments, recent sand units, iron cemented orgaind rich sands (coffee rock), coal deposits, or mineral sand deposits;
- Areas known to contain peat or a build-up of organic material;
- Areas where the highest known watertable level is within 3 m of the surface; and
- Areas depicted in vegetation mapping as mangroves, wetland dependent vegetation (e.g. Melealuca spp.), or salt/acid dependent vegetation (e.g. Casuarina spp.)

Due to the geomorphological setting of most of the looped segments, risk rankings of MEDIUM or HIGH based on geological information required supporting information from a secondary source (wetland, vegetation, water table) to result in a MEDIUM or HIGH ranking.

The risk ranking matrix used for Loops 0-8 is summarised in Table 2.1. The risk ranking matrix used for Loops 9 and 10 in summarised in Table 2.2.

Table 2.1 Acid Sulphate Soil Risk Classification Criteria – Loops 0 to 8

ASS RISK RANKING	GEOLOGY/LITHOLOGY				VEGETATION, WETLANDS AND WATER BODIES		DEPTH TO GROUNDWATER
	Regolith	Geology	Soil Types	Flight Observations	Vegetation	Water Bodies	mBGL
LOW	MODERATELY WEATHERED BEDROCK	DURICRUST (CALCRETE/ SILICRETE/ UNDIFFERENTIATED) SEDIMENTARY ROCKS (MESOZOIC) SEDIMENTARY ROCKS (PALEOZOIC) GRANITIC ROCKS (ARCHEAN-PROTEROZOIC)	DUPLEX SOILS RED AND YELLOW EARTHS HARD SETTING LOAMY SANDS WITH RED CLAYEY SUB SOILS	SHALLOW ROCK ROCK FROM WITHIN TRENCH LATERITE	NATIVE GRASSLANDS NATIVE SHRUBS AND HEATHS CROPS NATIVE FORESTS AND WOODLANDS	NONE CREEKS – fresh to brackish RIVERS – fresh to brackish WATER BODIES – fresh to brackish	>10
MEDIUM TO LOW	TERRESTRIAL SEDIMENTS ALLUVIAL SEDIMENTS AEOLIAN SANDS	QUATERNARY DEPOSITS DURICRUST (FERRUGINOUS)	EARTHY SANDS LEACHED SANDS	SOIL COVER	NATIVE GRASSLANDS NATIVE SHRUBS AND HEATHS CROPS NATIVE FORESTS AND WOODLANDS	RIVERS –saline WATER BODIES –saline	5-10
MEDIUM	TERRESTRIAL SEDIMENTS ALLUVIAL SEDIMENTS AEOLIAN SANDS	QUATERNARY DEPOSITS DURICRUST (FERRUGINOUS)	EARTHY SANDS LEACHED SANDS	SOIL COVER	MALALEUCAS, EUCALYTUS	SEASONAL WETLANDS	0-5
HIGH	LACUSTRINE SEDIMENTS	QUATERNARY DEPOSITS in low-lying, wetland areas	LEACHED SANDS in low lying areas. CRACKING CLAYS, UNDERLAIN IN AREAS BY HARD PAN AREAS	SOIL COVER	MALALEUCAS, EUCALYTUS	WETLANDS	0 – 5

Table 2.2: Acid Sulphate Soil Risk Classification Criteria – Loops 9 and 10

ASS Risk Ranking	WAPC AA Risk Map	Geology	Wetland Classification	Depth to Groundwater
LOW	LOW TO NO RISK	LIMESTONE, SAND of residual origin	NONE	>10 m
MEDIUM to LOW	MODERATE TO LOW RISK	SAND of eolian origin, SILT	MULTIPLE USE	5-10 m
MEDIUM	MODERATE TO LOW RISK	SAND of eolian origin, SILT	MULTIPLE USE	<5 m
HIGH	HIGH RISK	SILT of lacustrine origin	RESOURCE ENHANCED or CONSERVATION CATEGORY	<5 m

2.4 Proposed investigation methodology

Although this preliminary desktop investigation will allow areas of acid sulphate soils to be identified to a relatively high level of confidence, field sampling and validation are likely to be required by the Department of Environment (DoE) to meet current guidelines in areas that are classified as having a medium to high risk of being characterised acid sulphate soils.

A level of intrusive investigation was assigned based on the risk of acid sulphate soils being present along the pipeline route. The level of intrusive investigation, based on the acid sulphate soil risk classification, for the preliminary acid sulphate soil investigation was defined as follows:

LOW: Site walkover at time of development. Where ground truthing indicates a deviation from the predicted occurrence, field analysis of pH_F and pH_{FOX} (pH after oxidation) at a rate of 1:200 m^3 will be undertaken.

LOW TO MEDIUM: Site walkover and minor field pH testing at time of development. Field analysis of pH_F and pH_{FOX} (pH after oxidation) at a rate of 1:200 m^3 of excavated soil will be undertaken at the time of investigation.

MEDIUM: Soil bores will be installed at a frequency of 1 soil bore per 200 m to 1 bore per 500 m. Field analysis of pH_F and pH_{FOX} (pH after oxidation) at 0.25 m intervals will be undertaken. The highest risk soil sample from each bore will be sent for laboratory analysis by the Chromium Reducible Sulphur Suite (S_{CR}) and 1 in every 10 bores will be laboratory analysed for S_{CR} at 0.5 m intervals through the bore profile

HIGH: Soil bores will be installed at a frequency of 1 soil bore per 100 m or one bore per area, whichever is greater. Field analysis of pH_F and pH_{FOX} (pH after oxidation) at 0.25 m intervals will be undertaken. The highest risk soil sample from each bore will be sent for laboratory analysis for S_{CR} and 1 in every 5 bores or a minimum of 1 bore per area will be laboratory analysed for S_{CR} at 0.5 m intervals through the bore profile.

3. Loop 0

Loop 0 comprises a distance of 92 km (KP 22 to KP 114). As part of the environmental approval process a total of 116 km has been assessed (KP 22 to KP 138) between Baynton and Fortescue. The site is located at an elevation of approximately 7 – 74 mAHD at the edge of a historical floodplain.

Appendix A depicts occurrence of the geological, wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 0 pipeline route and these parameters are tabulated in Appendix L.

3.1 Geologic Setting

Regionally the area comprises a basement of Archaen granite and volcanics overlain by massive deposits of Proterozoic sediments.

Most of the surface is covered by alluvium and colluvium sands and/or clays. Soils along the former floodplain are characterised by cracking clays that were former marine sediments. In the Karratha area, these soils have been previously identified as containing 4 to 5% sulphides. Hard setting loamy soils with red clayey subsoils predominate at higher elevations.

3.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from at least 6 groundwater monitor bores located predominantly within 1 km radius of the pipeline. An additional 20 groundwater monitor bores are also located in the area, however information on depth to groundwater at those sites was not available for the majority of these bores.

Depth to groundwater along the pipeline route is generally predicted to be shallow (0-10 mbgs) although increases (10 – 20 mbgs) at the southern end of Loop 0 where the pipeline route rises off the floodplain.

3.3 Water Bodies and Wetlands

The Maitland River, Yanyare River, Fortescue River and four unnamed rivers cross Loop 0. No information is currently available on the quality of these rivers, however, based on the elevation of the river crossings and their distance from the coast, the Maitland River and Yanyare Rivers at the area of crossing are likely to be saline. At the pipeline intercept, the Fortescue River is likely to be fresh water. In addition to the shallow groundwater system, these water bodies can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

3.4 Acid Sulphate Soil Classification

Approximately 15 km of HIGH risk soils were identified at the northern end of Loop 0. HIGH risk soils are generally associated with cracking clays with stoney residuals of basement rocks, underlain by hard pan layers soil type and a depth to groundwater less than 5 m below ground surface (mbgs).

An additional 30 km of MEDIUM risk soils were identified in association with cracking clays where the depth to ground water is predicted to be greater than 5 mbgs.

A 1 km interval of MEDIUM TO LOW risk soils was identified in association with hard setting loamy soils with red clay sub soils in areas that are in close proximity to the river. The river in this area is located at a high elevation (44 mAHD) and has seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered possible but low.

Approximately 70 km of LOW risk soils were identified at the higher elevations along Loop 0. Low risk soils are associated with hard rock exposures, laterite/ silcrete/calcrete OR hard setting loamy soils with red clay sub soils in areas where depth to ground water greater than 10 mbgs.

The acid sulphate soil risk ranking is illustrated in Appendix A4.

3.5 Proposed ASS and Hydrogeologic Investigation

Table 3.1 summarises the proposed soil and groundwater sample and analysis plan for Loop 0. A soil bore depth of 3 m has been assumed for all bores, however, soil bores will need to be installed to 1 m below the proposed depth of pipeline excavation.

Groundwater monitor bores are proposed to be installed to a depth of 5 m at 2 km intervals in those areas where groundwater is encountered.

Table 3.1 Summary Sampling and Analysis Plan

ASS Risk Ranking	No. Kilometers	No. Proposed Soil Bores	No. Proposed Monitor Bores	No. Proposed Field Tests	No. Proposed S_{CR} Analysis
LOW	70	0	0	0	0
MEDIUM to LOW	1	0	0	0	0
MEDIUM	30	150	15	1950	105
HIGH	15	150	7	1950	210

1 Soil bores are assumed to be installed to 3 metres below ground level

2 This includes the entire length of Stage 5 loop 0 required for assessment for the environmental approvals process (116 km).

4. Loop 1

Loop 1 comprises a distance of 123 km (KP 149 to KP 272). As part of the environmental approval process a total of 124 km has been assessed (KP 149 to KP 273) between approximately Robe River and Ashburton River. The site is located at an elevation of approximately 45 to 89 mAHD at the edge of a historical floodplain.

Appendix B depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 1 pipeline route and these parameters are tabulated in Appendix M.

4.1 Geologic Setting

Regionally the area comprises a basement of Archaen granite and volcanics overlain by massive deposits of Proterozoic sediments.

Most of the surface is covered by alluvium and colluvium sands / clays. Hard setting loamy soils with red clayey subsoils are typically found in the northern sections of the Loop 1, while red yellow earths, fine earthy fabric underlain by laterite are located within the southern section.

4.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from at least 12 groundwater monitor bores located predominantly within 1 km radius of the pipeline. An additional 25 groundwater monitor bores are also located in the area, however information on depth to groundwater at those sites was not available for the majority of these bores.

Depth to groundwater along the pipeline route is generally predicted to be relatively shallow between 5 to 10 mbgs for the northern portion of Loop 1 and then increases to (10 to 50 mbgs) at the southern portion of Loop 1 correlating with an increase in elevation.

4.3 Water Bodies and Wetlands

The Robe River and Cane River cross Loop 1. No information is currently available on the quality of these rivers, however, based on the elevation of the river crossings and their distance from the coast, they are likely to be fresh to brackish ephermeral rivers. These can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

4.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH or MEDIUM risk along Loop 1.

Approximately 14.5 km of MEDIUM TO LOW risk soils were identified along Loop 1. MEDIUM TO LOW risk is generally associated with hard setting loamy soils with red clay sub soils or red and yellow earths, fine earthy fabric underlain by laterite in places in areas where depth to groundwater is between 3 – 10 mbgs. Elevation in these areas is high 45 to 89 mAHD and in areas where the rivers intercept the pipeline, flows are seasonal and high. Therefore, the likelihood of deposition of sulphides is considered low.

Approximately 109.5 km of LOW risk soils were identified along Loop 1. LOW risk areas are generally associated with shallow rock, laterite/ silcrete/calcrete or hard setting loamy soils and red yellow earths in areas where depth to ground water greater than 10 mbgs.

The acid sulphate soil risk ranking is illustrated in Appendix B4.

4.5 Proposed ASS and Hydrogeologic Investigation

Due to the absence of HIGH and MEDIUM risk soils along Loop 1, preconstruction field verification will not be undertaken for this loop.

5. Loop 2

Loop 2 comprises a distance of 97 km (KP 304 to KP 401). As part of the environmental approval process a total of 107 km has been assessed (KP 304 to KP 411). The area of assessment start approximately 20 km north east of Yannarie and ends approximately 77 km south west of Lyndon. The site is located at an elevation of approximately 88 to 204 mAHD.

Appendix C depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 2 pipeline route and these parameters are tabulated in Appendix N.

5.1 Geologic setting

Regionally the area comprises a basement of Archaen granite and volcanics overlain by massive deposits of Proterozoic sediments.

Most of the surface is covered by alluvium and colluvium sands. Soil types are predominantly red and yellow earths with a fine earthy fabric underlain by laterite in places.

5.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from 10 groundwater monitor bores, however information on depth to groundwater at those sites was not available for a large number of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 10 mbgs).

5.3 Water Bodies and Wetlands

The Yannarie River crosses Loop 2 and the Lyndon River is located within 7 km to the west of Loop 2. No information is currently available on the quality of these rivers, however, based on the elevation of the river crossings and their distance from the coast, they are likely to be fresh to brackish ephermeral rivers. The Yannarie River can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

5.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH or MEDIUM risk along Loop 2.

A 1 km interval of MEDIUM TO LOW risk was identified in association with red and yellow earths in areas within close proximity from the Yannarie River. This river is located at a high elevation (88 to 204 mAHD) and has seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered low.

Approximately 106 km of LOW RISK areas were identified along Loop 2. LOW risk soils are associated with shallow rock, hard rock exposures or red yellow earths in areas where depth to ground water greater than 10 mbgs.

The acid sulphate soil risk ranking is illustrated in Appendix C4.

5.5 Acid Sulphate Soil Classification

Due to the absence of HIGH and MEDIUM risk soils along Loop 2, preconstruction field verification will not be undertaken for this loop.

6. Loop 3

Loop 3 comprises a distance of 113 km (KP 434 to KP 547). As part of the environmental approval process a total of 114 km has been assessed (KP 434 to KP 548) between Minilya River and Coyerbooroo. The site is located at an elevation of approximately 167 to 264 mAHD within the Carnarvon Basin.

Appendix D depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 3 pipeline route and these parameters are tabulated in Appendix O.

6.1 Geologic Setting

Regionally the site is located within a sedimentary basin with locally exposed rocks of Permian to recent age.

Most of the surface is covered by Quaternary colluvium and alluvium sands. Soil types are described as hard red duplex soils with sandy textures. These are underlain by a variety of materials including weathered rock, laterite, calcrete, silcrete and re-brown hardpan.

6.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from 9 groundwater monitor bores, however information on depth to groundwater at those sites was not available for a large number of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep between 10 and 40 mbgs).

6.3 Water Bodies and Wetlands

The Minilya River, Newman Creek and Lyons River cross Loop 3. No information is currently available on the quality of these rivers, however, based on the elevation of the river crossings and their distance from the coast, they are likely to be fresh to brackish ephermeral rivers / creeks. The Minilya River, Newman Creek and Lyons River can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

6.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH or MEDIUM risk along Loop 3.

A 3 km interval of MEDIUM TO LOW risk was identified in association with hard red duplex soils within close proximity to the Minilya River, Newman Creek and Lyons River. These rivers are located at a high elevation (167 to 264 mAHD) and have seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered low.

Approximately 111 km of LOW risk soils were identified along Loop 3. LOW risk is generally associated with shallow rock, laterite / silcrete / calcrete or hard red duplex soils in areas where depth to ground water greater than 10 mbgs and located greater than 500 m from a river.

The acid sulphate soil risk ranking is illustrated in Appendix D4.

6.5 Proposed ASS and Hydrogeologic Investigation

Due to the absence of HIGH and MEDIUM risk soils along Loop 3, preconstruction field verification will not be undertaken for this loop.

7. Loop 4

Loop 4 comprises a distance of 99 km (KP 572 to KP 671). As part of the environmental approval process a total of 114 km has been assessed (KP 572 to KP 686) between Gascoyne Junction and Yalardy. The site is located in the Gascoyne at an elevation of approximately 149 to 226 mAHD.

Appendix E depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 4 pipeline route and these parameters are tabulated in Appendix P.

7.1 Geologic Setting

Regionally the site is characterised by Palaeozoic sandstones. Most of the surface is covered by aluvium and colluvium sands.

Soil types encountered along the northern section of Loop 4 are described as hard red duplex soils with sandy textures. These are underlain by a variety of materials including weathered rock, laterite, calcrete, silcrete and red-brown hardpan. Soil types in the southern portion of Loop 4 are generally earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone.

7.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from 3 groundwater monitor bores, however information on depth to groundwater at those sites was not available for some of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 75 mbgs).

7.3 Water Bodies and Wetlands

An unnamed lake, Jacobs Gulley and Wooramel River cross Loop 4 and Gascoyne River is located within 2 km to the north of Loop 4. The Gascoyne River has been classified as fresh water quality. No information is currently available on the quality of the other rivers / lake, however, based on the elevation of the water body crossings and their distance from the coast, they are likely to be ephemeral fresh to brackish rivers / lakes. The Gascoyne, unnamed lake, Jacobs Gulley and Wooramel River can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

7.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH and MEDIUM risk along Loop 4.

A 4.5 km interval of MEDIUM TO LOW risk soils were identified in association with earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone in areas within close proximity (500m) to a river, lake or gulley. The rivers / gulley in this area are located at a high elevation (149 to 226 mAHD) and have seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered low. The lake in this area is also located at a high elevation (149 to 226 mAHD) and the likelihood of deposition of sulphides is also considered low.

Approximately 109.5 km of LOW risk soils were identified along Loop 4. Low risk soils are associated with risk with shallow rock and hard rock exposures OR hard red duplex soils and earthy sands in areas where depth to ground water greater than 10 mbgs and/or located greater than 500m from a river.

The acid sulphate soil risk ranking is illustrated in Appendix E4.

7.5 Proposed ASS and Hydrogeologic Investigation

Due to the absence of HIGH and MEDIUM risk soils along Loop 4, preconstruction field verification will not be undertaken for this loop.

8. Loop 5

Loop 5 comprises a distance of 119 km (KP 706.5 to KP 825). As part of the environmental approval process a total of 120 km has been assessed (KP 706 to KP 826). Loop 5 is located between Talisker and 24 km west Lower Yallaloonga. The site is located in the Gascoyne at an elevation of approximately 197 to 276 mAHD.

Appendix F depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 5 pipeline route and these parameters are tabulated in Appendix Q.

8.1 Geologic Setting

Regionally the site is characterised by Permian sandstones.

Most of the surface is covered by aluvium and colluvium sands. Soil types can be described as earthy sands, often underlain by ironstone gravels, laterite or indurated, mottled, or pallid zone.

8.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from 7 groundwater monitor bores, however information on depth to groundwater at those sites was not available for some of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 90 mbgs).

8.3 Water Bodies and Wetlands

Two unnamed lakes intercept Loop 5. No information is known on the quality of the water within the lakes. A series of lakes is also located within a 5 km radius of the pipeline in this area. All lakes in the vicinity of Loop 5 are likely to be ephemeral. The unnamed lakes can be considered a sensitive receptor to any impacts resulting from the disturbance of acid sulphate soils.

8.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH or MEDIUM risk along Loop 5.

A 1km interval of MEDIUM TO LOW risk soils was identified in association with earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone in areas within close proximity to a lake. The lakes in this area are located at a high elevation (197 to 276 mAHD) and the likelihood of deposition of sulphides is considered low.

Approximately 119 km of LOW risk soils were identified along Loop 5. LOW risk is generally associated with shallow rock or earthy sands in areas where depth to ground water greater than 10 mbgs and/or not within close proximity (500m) to a lake.

The acid sulphate soil risk ranking is illustrated in Appendix F4.

8.5 Acid Sulphate Soil Classification

Due to the absence of HIGH and MEDIUM risk soils along Loop 5, preconstruction field verification will not be undertaken for this loop.

9. Loop 6

Loop 6 comprises a distance of 130.5 km (KP 836 to KP 966.5). As part of the environmental approval process a total of 132 km has been assessed (KP 836 to KP 968). Loop 6 is located between approximately Coolcalalaya and Murderunggnoo town sites. The site is located in the Gascoyne and mid west region at an elevation of approximately 156 to 310 mAHD.

Appendix G depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 6 pipeline route and these parameters are tabulated in Appendix R.

9.1 Geologic Setting

Regionally the site is characterised by alluvial and colluvial sands overlying Palaeozoic sandstones. Laterite duricrust overlying Mesozoic sandstones are encountered towards the southern end of Loop 6.

Soil types along Loop 6 are described as earthy sands, often underlain by ironstone gravels, laterite or an indurated, mottled or pallid zone.

9.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from the 35 groundwater monitor bores located along Loop 6, however information on depth to groundwater at those sites was not available for the some of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 60 mbgs).

9.3 Water Bodies and Wetlands

The Murchinson River (classified fresh water) and Greenough River (classified brackish water) intercept Loop 6. The Murchinson and Greenough Rivers can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

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9.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH to MEDIUM risk along Loop 6.

A 0.5 km interval of MEDIUM TO LOW risk soils was identified in association with earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone in areas intercepting the Greenough River. This river is located at a high elevation (156 to 310 mAHD. and has seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered low.

Approximately 131.5 km of LOW risk areas were identified along Loop 6. LOW risk areas are generally associated with shallow rock, laterite/silcrete/calcrete and hard rock exposures OR earthy sands in areas where depth to ground water greater than 10 mbgs and/or located greater than 500m from a river.

The acid sulphate soil risk ranking is illustrated in Appendix G4.

9.5 Proposed ASS and Hydrogeologic Investigation

Due to the absence of HIGH and MEDIUM risk soils along Loop 6, preconstruction field verification will not be undertaken for this loop.

10. Loop 7

Loop 7 comprises a distance of 118.5 km (KP 972 to KP 1,090.5). As part of the environmental approval process a total of 143 km has been assessed (KP 972 to KP 1,115). Loop 7 is located between Ambania and extends to 6.5 km south of Eneabba town site. The site is located on the Dandaragan Scarp in the MidWest region at an elevation of approximately 42 to 261 mAHD.

Appendix H depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 7 pipeline route and these parameters are tabulated in Appendix S.

10.1 Geologic Setting

Regionally the site is characterised by Laterite duricrust overlying Mesozoic sandstones and siltstones. Some of the surface is covered by alluvium and colluvium sands.

Soil types along Loop 6 are described as earthy sands, often underlain by ironstone gravels, laterite or an indurated, mottled or pallid zone.

10.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from at least 8 groundwater monitor bores located predominantly within 1 km radius of the line the line. An additional 39 groundwater monitor bores are also located in the area, however information on depth to groundwater at those sites was not available for the majority of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 20 mbgs).

10.3 Water Bodies and Wetlands

An unnamed lake and the Irwin River (classified fresh to brackish water) intercept Loop 7. The unnamed lake and Irwin River can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

10.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH risk along Loop 7.

A 0.3 km interval of MEDIUM risk soils were identified in association with an area of pipeline intercepting the Irwin River. The Irwin River coal measures are potentially exposed in this area. Coal measures contain sulphides that have the potential to generate acid sulphate soils.

A 3 km interval of MEDIUM to LOW risk was identified in association with earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone in area within 500 m of an unnamed lake and Irwin River. The lake in this area is located at a high elevation (~66 mAHD.) and the likelihood of deposition of sulphides is considered low. The Irwin River is also located at a high elevation (~67 mAHD.) and has seasonal high flows. Therefore, the likelihood of deposition of sulphides is considered low.

Approximately 140 km of LOW risk soils were identified along Loop 7. LOW risk is generally associated with laterite/silcrete/calcrete OR earthy sands in areas where depth to ground water greater than 10 mbgs and/or located greater than 500m from a river / lake.

The acid sulphate soil risk ranking is illustrated in Appendix H4.

10.5 Proposed ASS and Hydrogeologic Investigation

Table 10.1 summarises the preliminary acid sulphate soil sample and analysis plan for Loop 7. A soil bore depth of 3 m has been assumed for all bores, however, soil bores will need to be installed to 1 m below the proposed depth of pipeline excavation.

Table 10.1 Summary Sampling and Analysis Plan

ASS Risk Ranking	No. Kilometers	No. Proposed Soil Bores	No. Proposed Monitor Bores	No. Proposed Field Tests	No. Proposed S_{CR} Analysis
LOW	140	0	0	0	0
MEDIUM to LOW	3	0	0	0	0
MEDIUM	0.3	2	0	26	7
HIGH	0	0	0	0	0

1 Soil bores are assumed to be installed to 3 metres below ground level

2 This includes the entire length of Stage 5, loop 7 required for assessment for the environmental approvals process (143 km).

11. Loop 8

Loop 8 comprises a distance of 97 km (KP 1,160 to KP 1,257). As part of the environmental approval process a total of 98 km has been assessed (KP 1,160 to KP 1,258). Loop 8 starts 31 km east of Jurien Bay and ends near Moore River National Park at an elevation of 83 to 290 mAHD.

Appendix I depicts the occurrence of the geological wetland, vegetation and water table characteristics encountered along the Stage 5 Loop 8 pipeline route and these parameters are tabulated in Appendix T.

11.1 Geologic Setting

The site is located on the Dandaragan Plateau and enters the Perth Basin at the southern end of the loop. Regionally the site is characterised by Quaternary sands (coluvium and alluvium) overlying Mesozoic sandstones.

Soil types along Loop 8 are described as earthy sands, often underlain by ironstone gravels, laterite or an indurated, mottled or pallid zone.

11.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from data from at least 9 groundwater monitor bores located predominantly within 1 km radius of the line the line. An additional 41 groundwater monitor bores are also located in the area, however information on depth to groundwater at those sites was not available for the majority of these bores.

Depth to groundwater along the pipeline route is generally predicted to be deep (greater than 20 mbgs).

11.3 Water Bodies and Wetlands

The Moore River and Moore River wetland area cross Loop 8. The Moore River is classified of brackish water quality. The Moore River and surrounding wetland can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

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11.4 Acid Sulphate Soil Classification

No environmental settings were considered HIGH or MEDIUM to LOW risk along Loop 8.

A 1 km interval of MEDIUM risk soils were identified in association with earthy sands, often underlain by ironstone gravels, laterite or an indurated mottled or pallid zone in areas intercepting the Moore River (unassessed wetland).

Approximately 97.5 km of LOW risk soils were identified at higher elevation along Loop 8. LOW risk is generally associated with laterite/silcrete/calcrete OR earthy sands in areas where depth to ground water greater than 10 mbgs and/or located greater than 500m from a river / lake.

The acid sulphate soil risk ranking is illustrated in Appendix I4.

11.5 Proposed ASS and Hydrogeologic Investigation

Table 11.1 summarises the preliminary acid sulphate soil sample and analysis plan for Loop 8. A soil bore depth of 3 m has been assumed for all bores, however, soil bores will need to be installed to 1 m below the proposed depth of pipeline excavation.

Groundwater monitor bores are proposed to be installed to a depth of 5 m at 2 km intervals in those areas where groundwater is encountered.

Table 11.1 Summary Sampling and Analysis Plan

ASS Risk Ranking	No. Kilometers	No. Proposed Soil Bores	No. Proposed Monitor Bores	No. Proposed Field Tests	No. Proposed S_{CR} Analysis
LOW	97.5	0	0	0	0
MEDIUM to LOW	0	0	0	0	0
MEDIUM	0.5	3	2	33	7
HIGH	0	0	0	0	0

1 Soil bores are assumed to be installed to 3 metres below ground level

2 This includes the entire length of Stage 5, loop 8 required for assessment for the environmental approvals process (98 km).

12. Loop 9

Loop 9 comprises a distance of 99 km (KP 1,272 to KP 1,371). As part of the environmental approval process a total of 127 km has been assessed (KP 1,272 to KP 1,399) between Mirilla and Gosnells. The site is located within the Perth Basin at an elevation of approximately 1 to 83 mAHD.

Appendix J depicts the occurrence of the geological, wetland, vegetation and water table characteristics and WAPC ASS risk rating encountered along the Stage 5 Loop 9 pipeline route and these parameters are tabulated in Appendix U.

12.1 Geologic Setting

Regionally the site is characterised by Quaternary sands, clays, silt and gravels (coluvium and alluvium) overlying Mesozoic sandstones, siltstones and limestones.

Soil types are typically Bassendean / Spearwood Sands overlying Guildford Clays. Within low lying wetland areas Lacustrine/peaty deposits are generally encountered.

12.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from WRC, Perth Groundwater Atlas and numerous groundwater bores within the area.

Depth to groundwater along the pipeline route is generally predicted to be shallow (0 – 10 mbgs) in most areas between KP1281 and KP1395 excluding a few isolated 1-5 km areas where pipeline crosses topographical highs. Based on the WRC, Perth Groundwater Atlas, the inferred groundwater flow direction is generally westerly towards the Indian Ocean. However, groundwater flow direction changes to flow towards major water courses (such as the Swan and Canning Rivers) in areas located within close proximity to these water courses.

12.3 Water Bodies and Wetlands

Numerous wetlands, waterbodies and rivers cross Loop 9. Major rivers and water bodies include Gingin Brook, Swan River, Helena River, Canning River, Wright Lake, Melaleuca Park Wetland, Armadale Sumpland, Mandogalup Swamp North and Spectacles Wetland. Water quality varies between fresh to saline dependent on proximity to coast. Conservation wetlands, resource enhancement wetlands, rivers and lakes can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

12.4 Acid Sulphate Soil Classification

Approximately 11.5 km of HIGH risk soil were identified along Loop 9. HIGH risk was applied to all areas previously classified as High Risk using WAPC Bulletin 64 - South Metropolitan Region Scheme Acid Sulphate Soil Map. These areas typically coincide with peaty wetland areas.

Approximately 69 km of MEDIUM risk soil was identified along Loop 9. MEDIUM risk was applied to all areas previously classified as Moderate to Low using the WAPC Bulletin 64, with a depth to groundwater less than 5 mbgs.

Approximately 26.5 km of MEDIUM to LOW risk soil was identified along Loop 9. MEDIUM to LOW risk was applied to all areas previously classified as Moderate to Low using the WAPC Bulletin 64, with a depth to groundwater greater than 5 mbgs and in areas where there are no conservation or resource enhancement wetlands.

Approximately 20 km of LOW risk soil was identified along Loop 9. LOW risk was applied to all area previously classified as Low to No risk using WAPC Bulletin 64 - South Metropolitan Region Scheme Acid Sulphate Soil Map.

The acid sulphate soil risk ranking is illustrated in Appendix J3.

12.5 Proposed ASS and Hydrogeologic Investigation

Table 12.1 summarises the preliminary acid sulphate soil sample and analysis plan for Loop 9. A soil bore depth of 3 m has been assumed for all bores, however, soil bores will need to be installed to 1 m below the proposed depth of pipeline excavation.

Groundwater monitor bores are proposed to be installed to a depth of 5 m at 2 km intervals in those areas where groundwater is encountered.

Table 12.1 Summary Sampling and Analysis Plan

ASS Risk Ranking	No. Kilometers	No. Proposed Soil Bores	No. Proposed Monitor Bores	No. Proposed Field Tests	No. Proposed S_{CR} Analysis
LOW	20	0	0	0	0
MEDIUM to LOW	26.5	0	0	0	0
MEDIUM	69	345	34	4,485	242
HIGH	11.5	115	6	1,495	308

1 Soil bores are assumed to be installed to 3 metres below ground level

2 This includes the entire length of Stage 5, loop 9 required for assessment for the environmental approvals process (127 km).

13. Loop 10

Loop 10 comprises a distance of 62 km (KP 1,421 to KP 1,483). As part of the environmental approval process the same distance was assessed (KP 1,421 to KP 1,483) between Hopeland and west of Wagerup. The site is located within the Perth Basin at an elevation of approximately 2 to 22 mAHD.

Appendix K depicts the occurrence of the geological, wetland, vegetation and water table characteristics and WAPC ASS risk rating encountered along the Stage 5 Loop 10 pipeline route and these parameters are tabulated in Appendix V.

13.1 Geologic Setting

Regionally the site is characterised by Tertiary sediments overlying Mesozoic sandstones, siltstones and limestones.

Soil types are typically Bassendean overlying Guildford Clays. Within low lying wetland areas Lacustrine/peaty deposits are generally encountered.

13.2 Groundwater

Information pertaining to the depth to groundwater in the area has been derived from numerous groundwater bores within the area.

Depth to groundwater along the pipeline route is generally predicted to be shallow (0 – 10 mbgs) in most areas excluding a few isolated 1-5 km areas where pipeline crosses topographical highs.

13.3 Water Bodies and Wetlands

Numerous conservation and resource enhancement wetlands, waterbodies and rivers cross Loop 10. Major rivers include North Dandalup River, South Dandalup River, Murray River, Harvey River. Water quality within these rivers is generally fresh to brackish. Conservation wetlands, resource enhancement wetlands, rivers and lakes can be considered sensitive receptors to any impacts resulting from the disturbance of acid sulphate soils.

13.4 Acid Sulpahte Soil Classification

Approximately 3.5 km of HIGH risk soil were identified along Loop 10. HIGH risk was applied to all areas previously classified as High Risk using WAPC Bulletin 64 - South Metropolitan Region Scheme Acid Sulphate Soil Map. These areas typically coincide with peaty wetland areas.

Approximately 40 km of MEDIUM risk soil was identified along Loop 10. MEDIUM risk was applied to all areas previously classified as Moderate to Low using the WAPC Bulletin 64, with a depth to groundwater less than 5 mbgs.

Approximately 18.5 km of MEDIUM TO LOW risk soil was identified along Loop 10. MEDIUM TO LOW risk was applied to all areas previously classified as Moderate to Low using the WAPC Bulletin 64, with a depth to groundwater greater than 5 mbgs and in areas where there are no conservation or resource enhancement wetlands.

No environmental settings were identified as LOW risk along Loop 10.

The acid sulphate soil risk ranking is illustrated in Appendix K3.

13.5 Proposed ASS and Hydrogeologic Investigation

Table 13.1 summarises the preliminary acid sulphate soil sample and analysis plan for Loop 9. A soil bore depth of 3 m has been assumed for all bores, however, soil bores will need to be installed to 1 m below the proposed depth of pipeline excavation.

Groundwater monitor bores are proposed to be installed to a depth of 5 m at 2 km intervals in those areas where groundwater is encountered.

Table 13.1 Summary Sampling and Analysis Plan

ASS Risk Ranking	No. Kilometers	No. Proposed Soil Bores	No. Proposed Monitor Bores	No. Proposed Field Tests	No. Proposed S_{CR} Analysis
LOW	0	0	0	0	0
MEDIUM to LOW	18.5	0	0	0	0
MEDIUM	40	200	20	2,600	140
HIGH	3.5	35	2	455	49

1 Soil bores are assumed to be installed to 3 metres below ground level

2 This includes the entire length of Stage 5, Loop 10 required for assessment for the environmental approvals process (62 km).

14. Conclusions

Based on the results of the desktop investigation, and within the limitations detailed in Section 15, the following conclusions have been drawn regarding the acid generating potential of near surface soils along the Stage 5 Loop 0-10 expansions:

- LOOP 0: - 15 km have been ranked HIGH risk in areas associated with cracking clays (marine sediments) and depth to groundwater less than 5 mbgs and 30 km were given a MEDIUM risk ranking in areas associated with cracking clays with depth to groundwater greater than 5 mbgs. All other areas along the line have been classified as LOW or MEDIUM to LOW risk.
- LOOP 1to 8: - No environmental settings were considered HIGH risk within Loops 1 to 8.
- MEDIUM risk was associated with two areas that intercepted the Irwin River (Loop 7) (0.3 km) and Moore River Wetlands Area (Loop 8) (0.5 km).
- MEDIUM TO LOW risk was generally associated with hard setting loamy soils, red yellow earths, hard red duplex soils or earthy sands in areas intercepting or in close proximity to water bodies and rivers or areas of shallow groundwater (5-10 mbgs). Elevation in these areas is generally high and in areas where the river intercepts the pipeline, flows are seasonal and high. Therefore, the likelihood of deposition of sulphides is considered low.
- All other areas along Loop 1 to 8 have been classified as LOW risk.
- LOOP 9: - 80.5 km along Loop 9 have been classified as MEDIUM or HIGH risk (69 km MEDIUM risk, 11.5 km HIGH risk) due to the presence of high water tables and wetlands on or adjacent to the line and based on the WAPC risk rating. All other areas along the line have been classified as LOW or MEDIUM TO LOW risk.
- LOOP 10: - 43.5 km along Loop 10 have been classified as MEDIUM or HIGH (40 km MEDIUM risk, 3.5 km HIGH risk) due to the presence of high water tables and wetlands on or adjacent to the line and based on the WAPC risk rating. All other areas along the line have been classified as LOW or MEDIUM TO LOW risk.

15. Statement of Limitations

Scope of Services

This environmental site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Parsons Brinckerhoff (PB) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, PB has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, PB has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. PB will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to PB.

Environmental Conclusions

In accordance with the scope of services, PB has relied upon the data and has not conducted any environmental field monitoring or testing in the preparation of the report. The conclusions are based upon the data and visual observations and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Within the limitations imposed by the scope of services, the assessment of the site and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

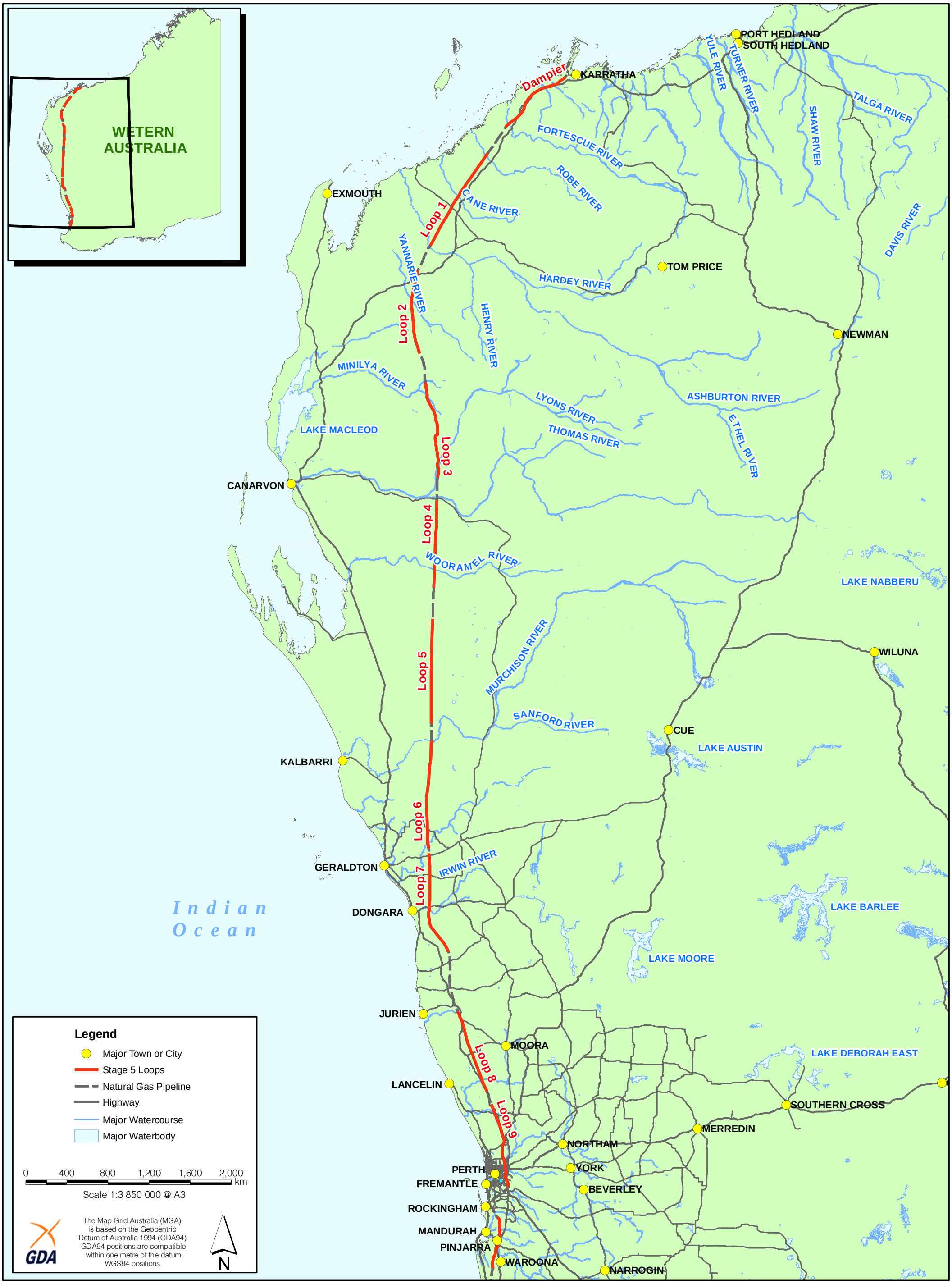
Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. PB assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of PB or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

PB will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.



DBNGP - STAGE 5 DESKTOP ASSESSMENT

FIGURE 1

LOCATION MAP AND STAGE 5 PIPELINE LOOPINGS

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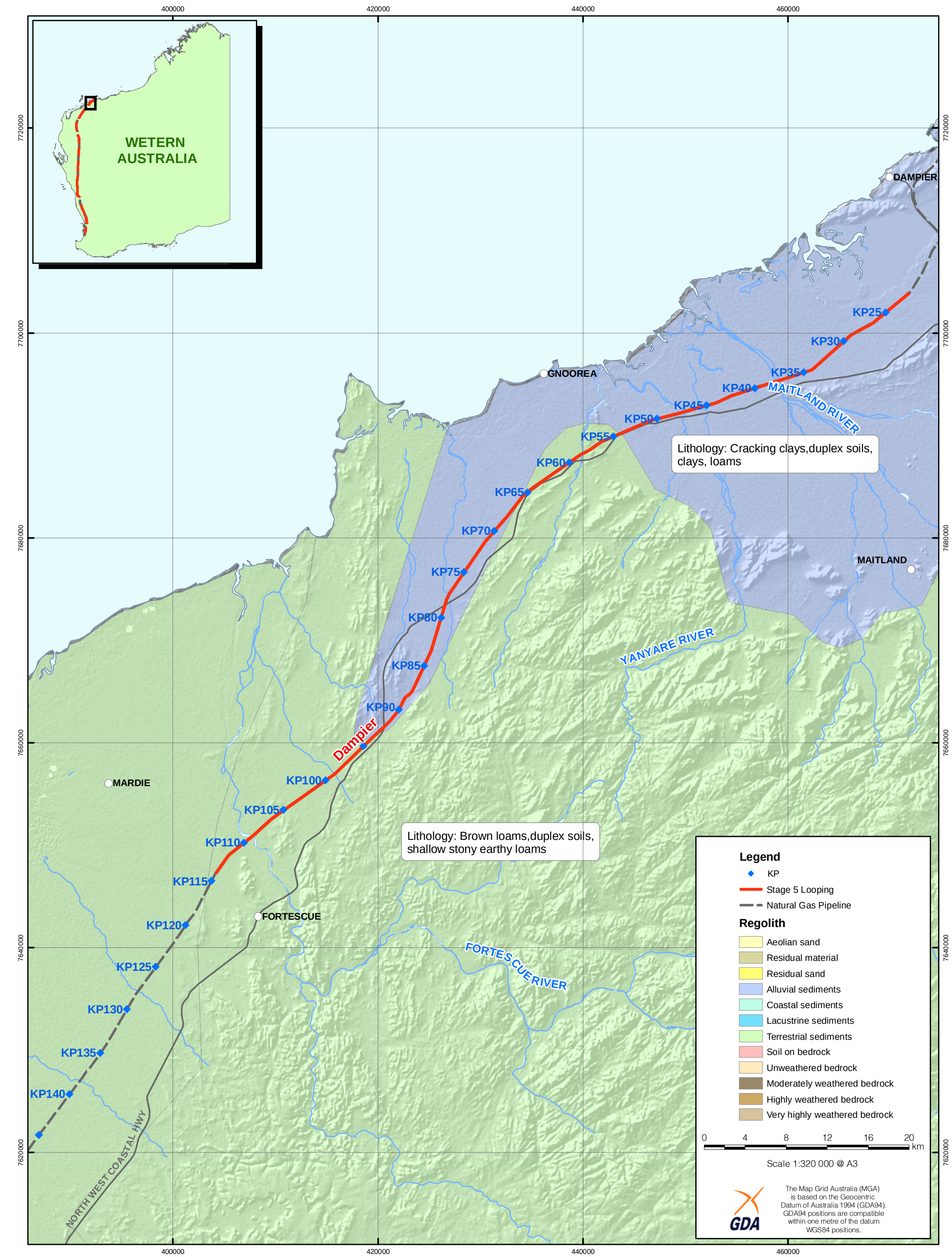
Appendix A

Loop 0 Maps



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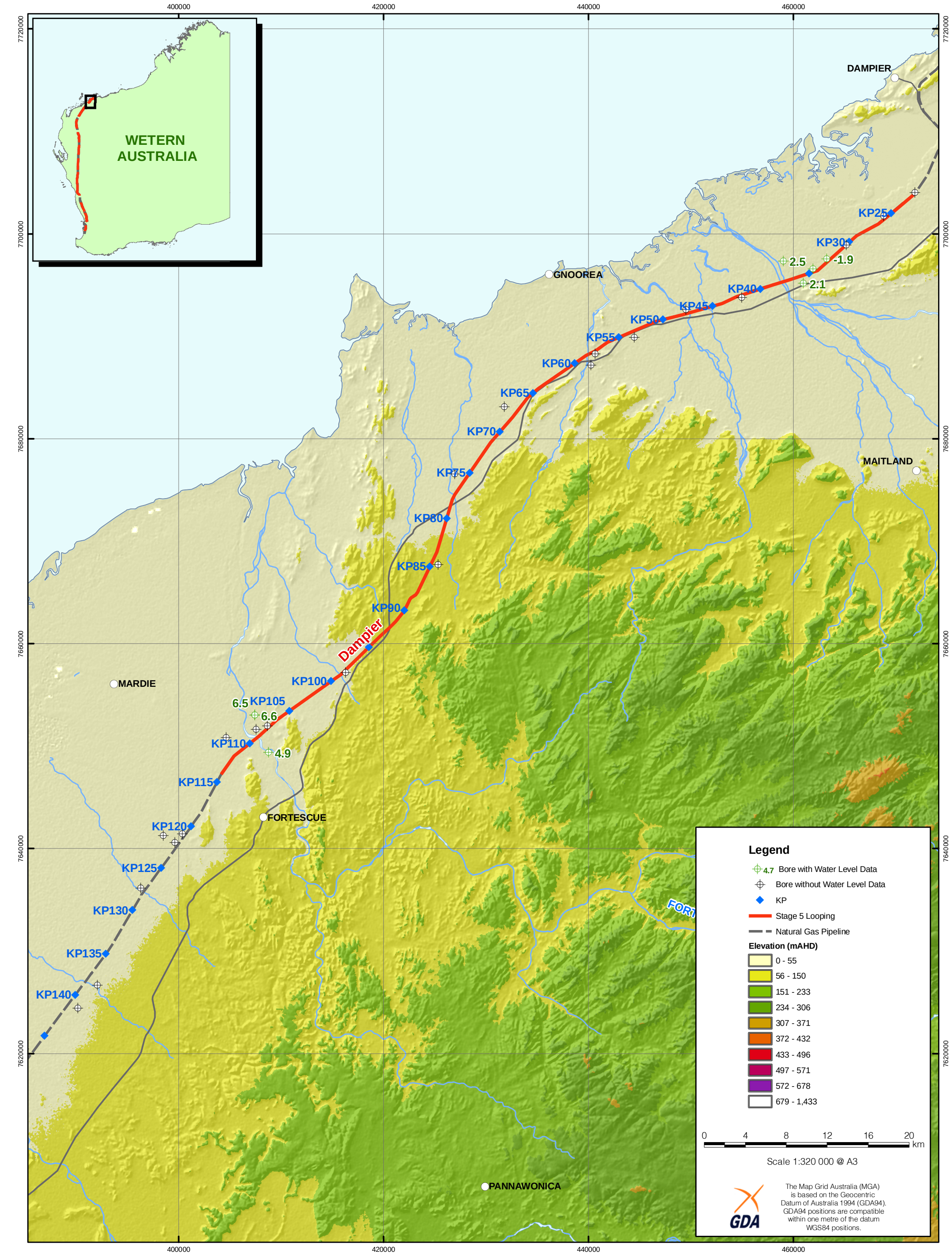
APPENDIX A1

LOOPING 0 (DAMPIER) - REGOLITH AND LITHOLOGY



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APPENDIX A2

LOOPING 0 (DAMPIER) - TERRAIN AND DEPTH TO GROUNDWATER (mBGL)

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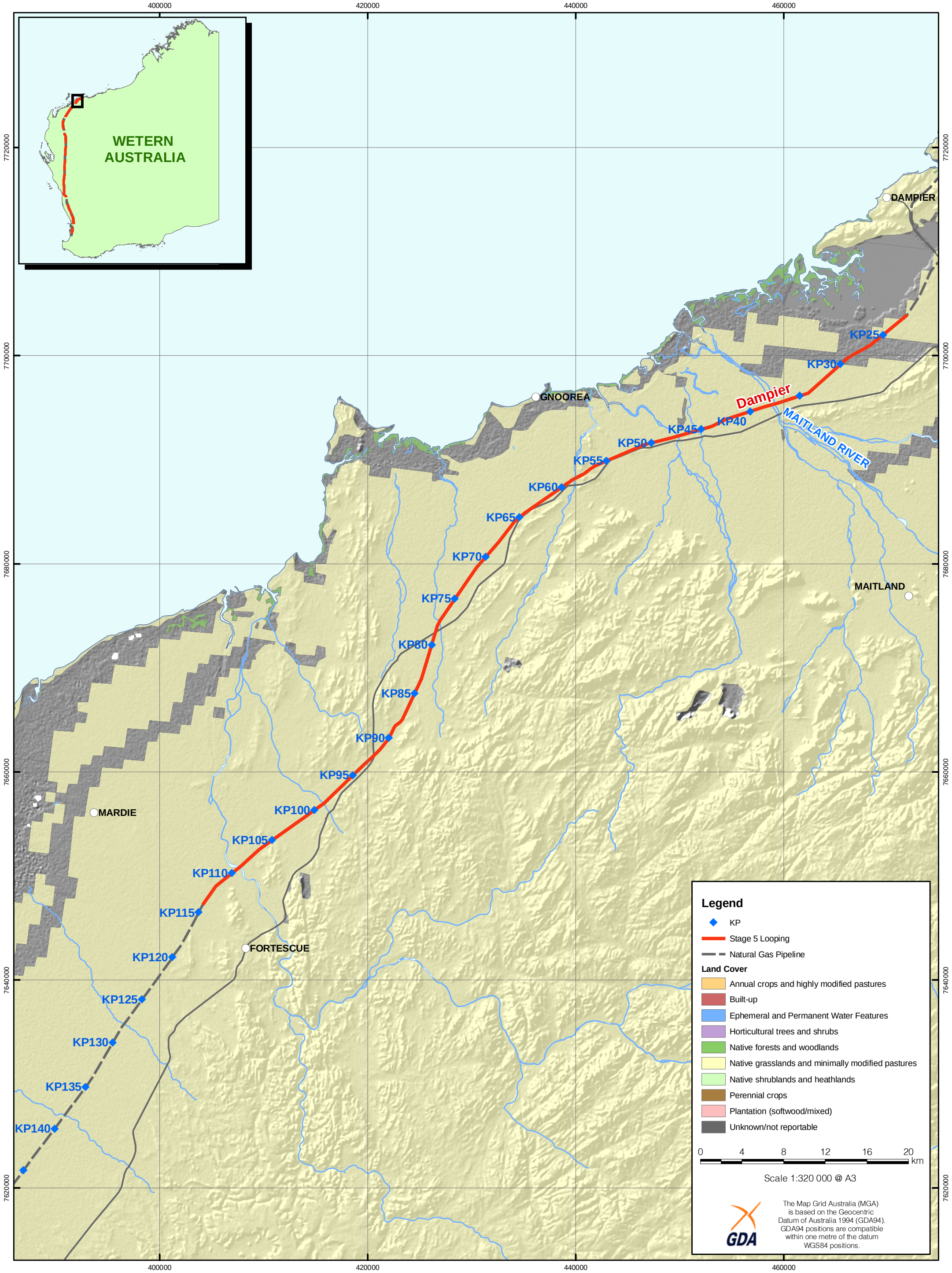
DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



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APPENDIX A3

LOOPING 0 (DAMPIER) - LAND COVER

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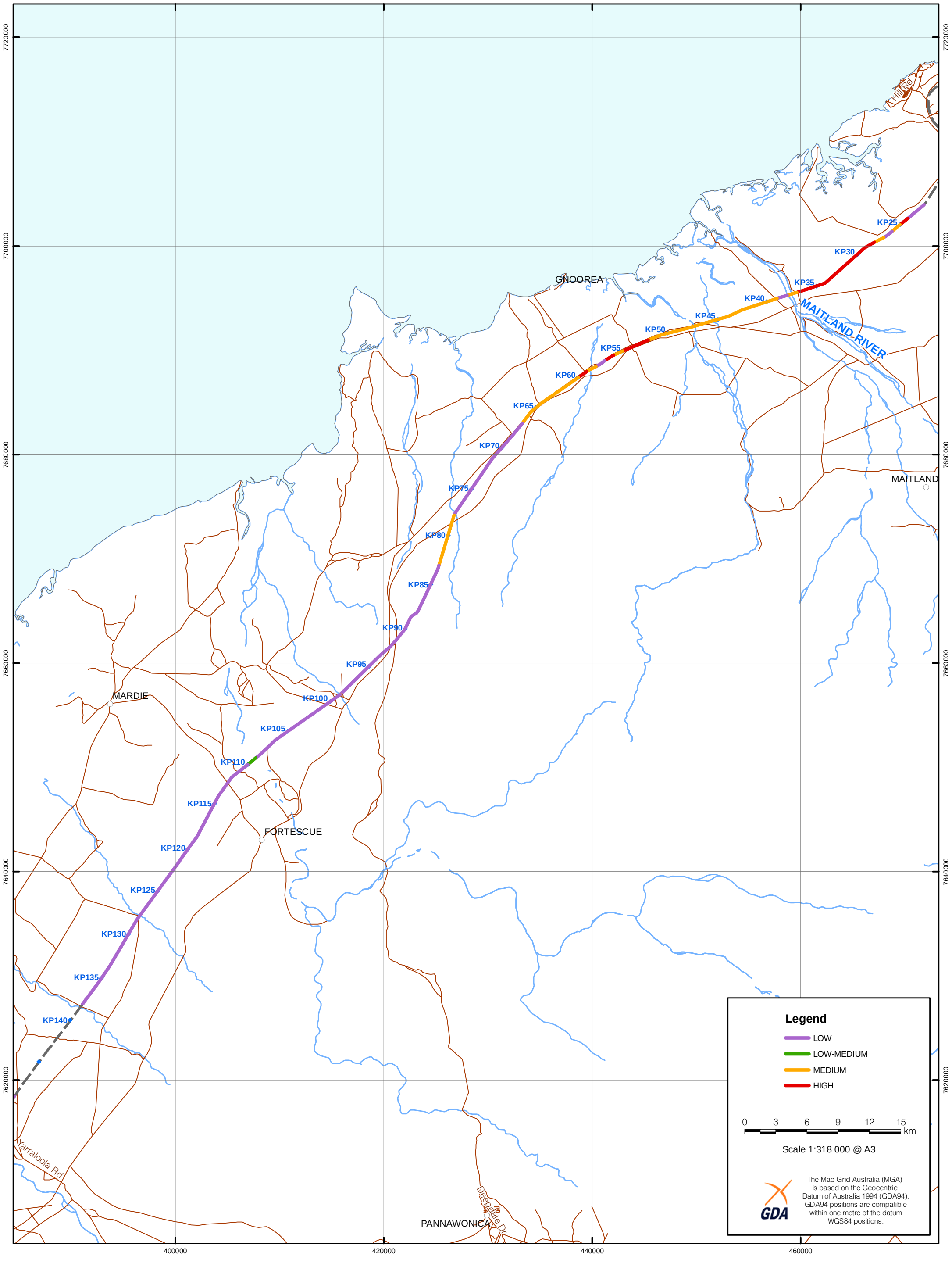

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APPENDIX A4

LOOPING 0 (DAMPIER) - ACID SULFATE SOIL RISK

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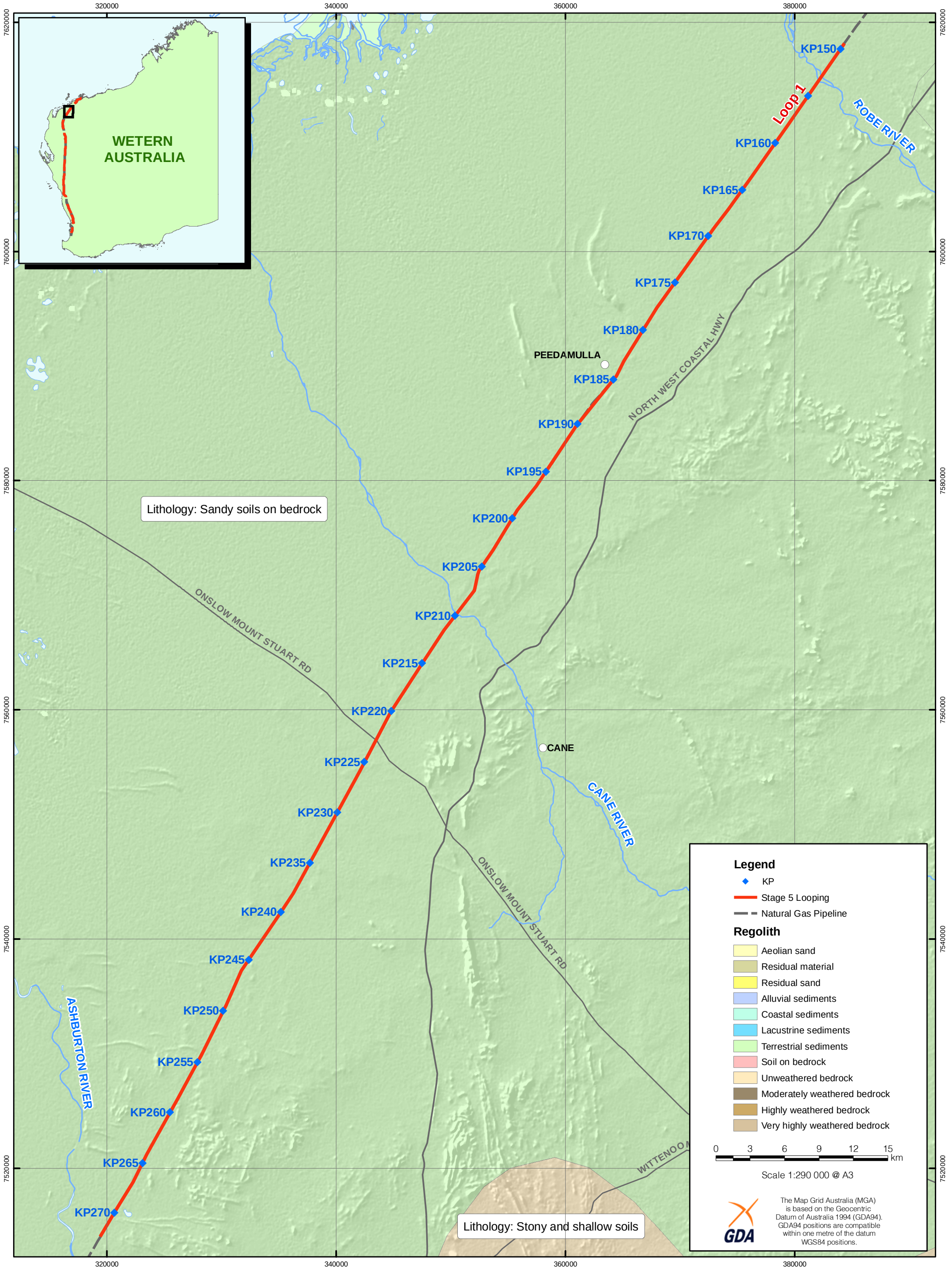
DRN: JH CHKD: SP • Date: 30/06/2006 • PLAN No: 2145243A

Appendix B

Loop 1 Maps



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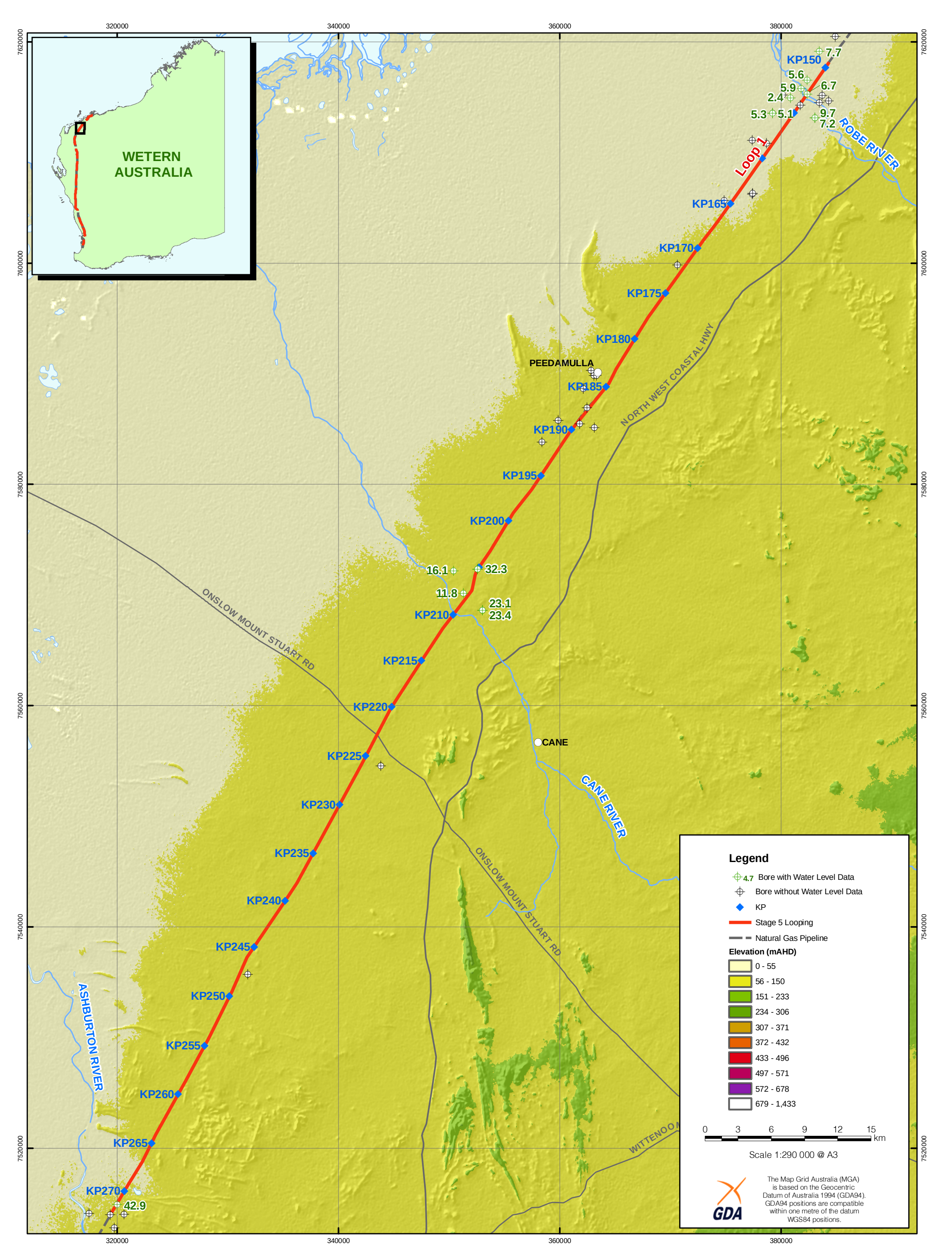
APPENDIX B1

LOOPING 1 - REGOLITH AND LITHOLOGY



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APPENDIX B2

LOOPING 1 - TERRAIN AND DEPTH TO GROUNDWATER (mBGL)

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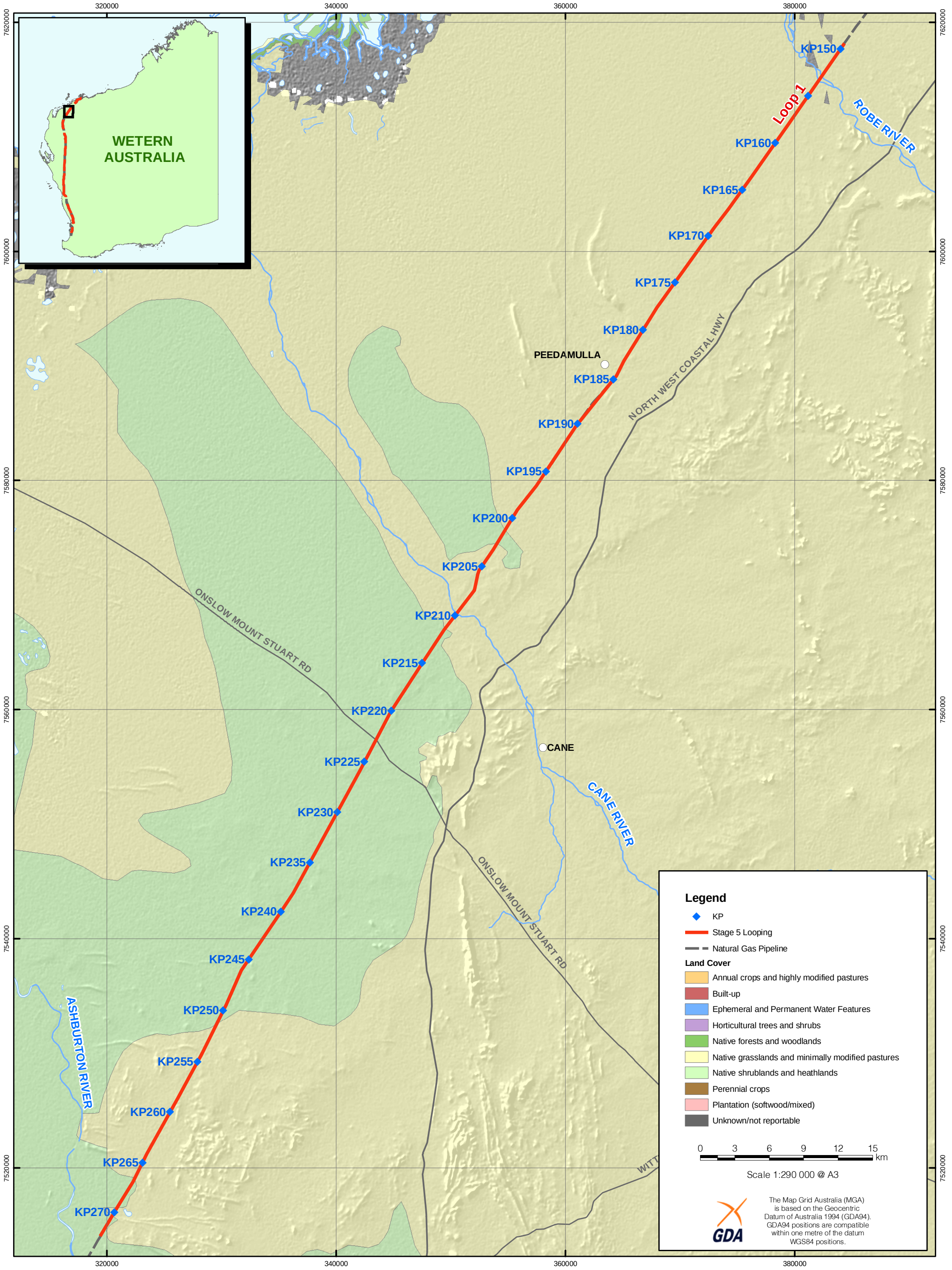
DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



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APPENDIX B3

LOOPING 1 - LAND COVER

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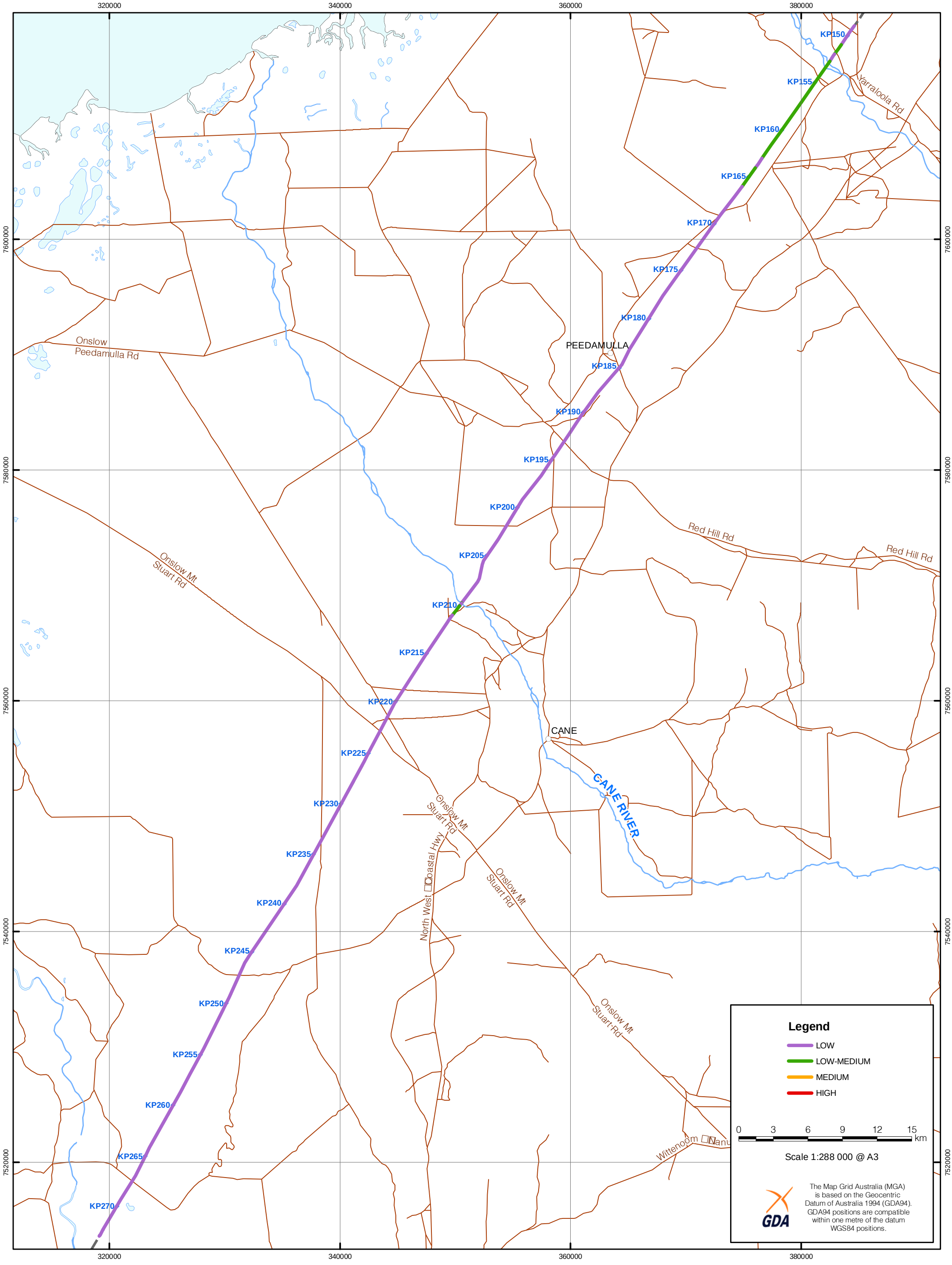

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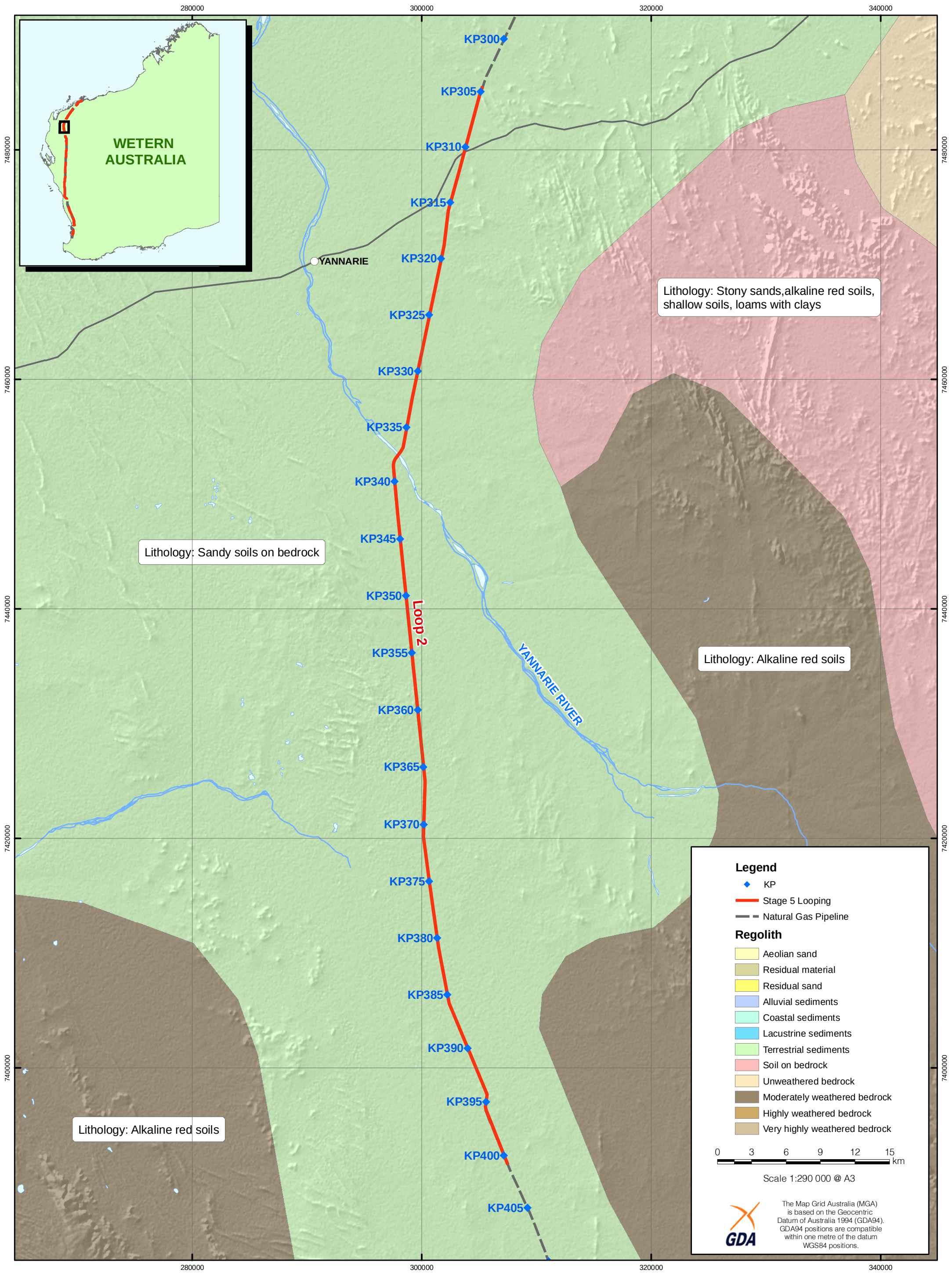
APPENDIX B4

LOOPING 1 - ACID SULFATE SOIL RISK

Appendix C

Loop 2 Maps



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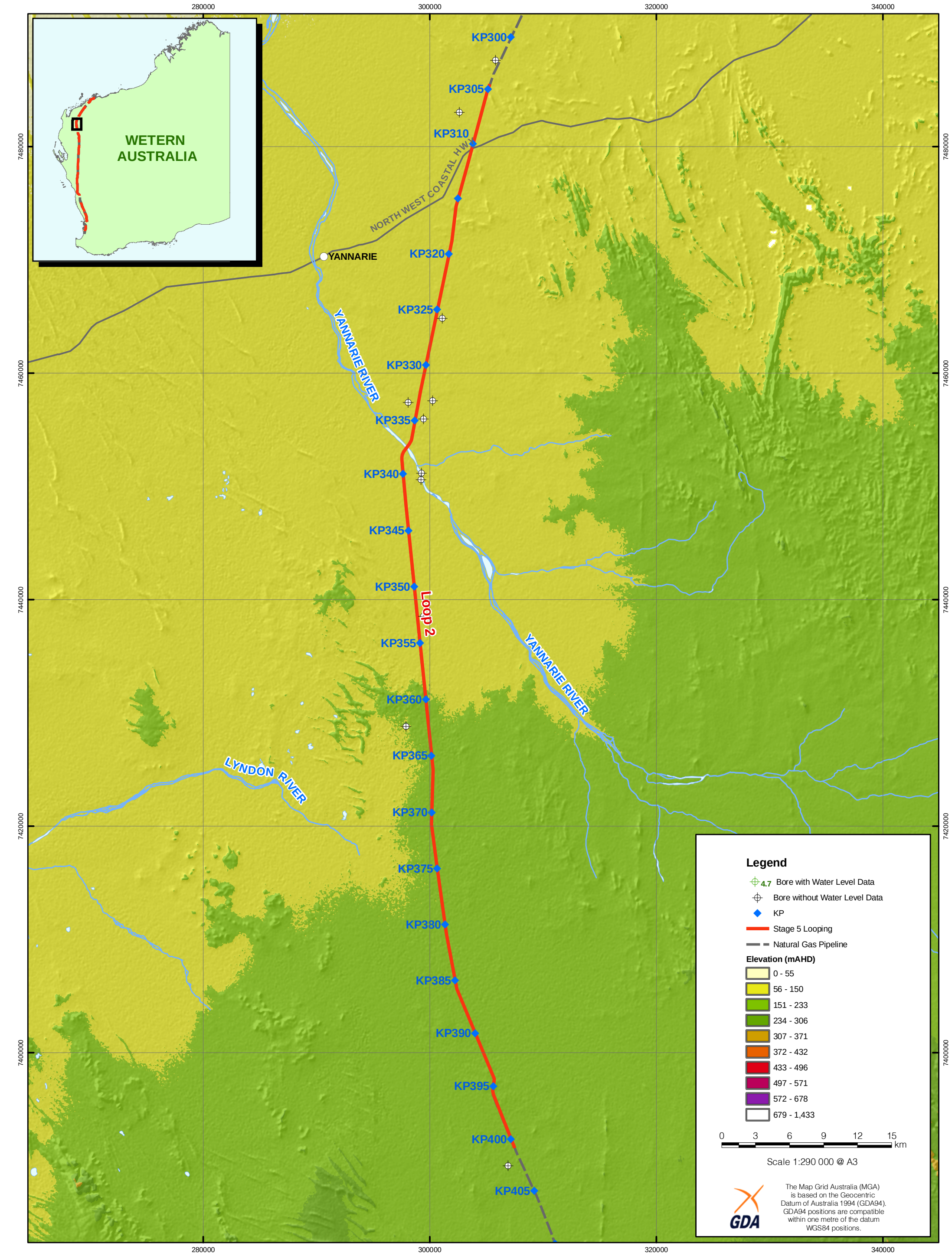
APPENDIX C1

LOOPING 2 - REGOLITH AND LITHOLOGY



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APPENDIX C2

LOOPING 2 - TERRAIN AND DEPTH TO GROUNDWATER (mBGL)

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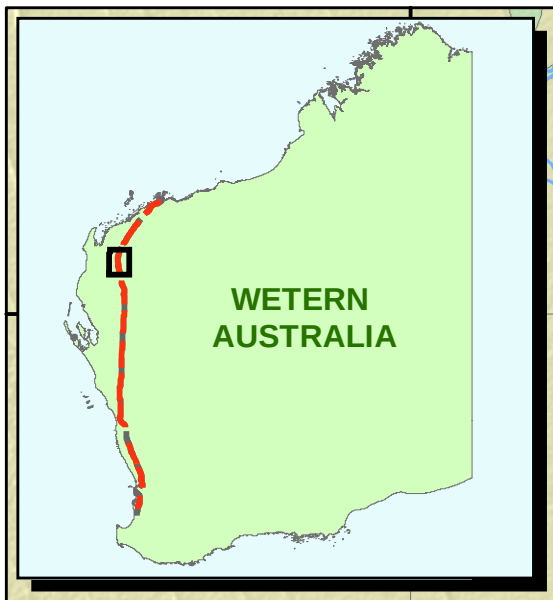

KP300
KP305
KP310
KP320
KP325
KP330
KP335
KP340
KP345
KP350
KP355
KP360
KP365
KP370
KP375
KP380
KP385
KP390
KP395
KP400
KP405

YANNARIE
NORTH WEST COASTAL HWY
YANNARIE RIVER
Loop 2
YANNARIE RIVER
LYNDON RIVER

280000
300000
320000
340000
7480000
7460000
7440000
7420000
7400000

Legend

- KP
- Stage 5 Looping
- Natural Gas Pipeline

Land Cover

- Annual crops and highly modified pastures
- Built-up
- Ephemeral and Permanent Water Features
- Horticultural trees and shrubs
- Native forests and woodlands
- Native grasslands and minimally modified pastures
- Native shrublands and heathlands
- Perennial crops
- Plantation (softwood/mixed)
- Unknown/not reportable

0 3 6 9 12 15 km

Scale 1:290 000 @ A3

GDA

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94). GDA94 positions are compatible within one metre of the datum WGS84 positions.

DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX C3

LOOPING 2 - LAND COVER

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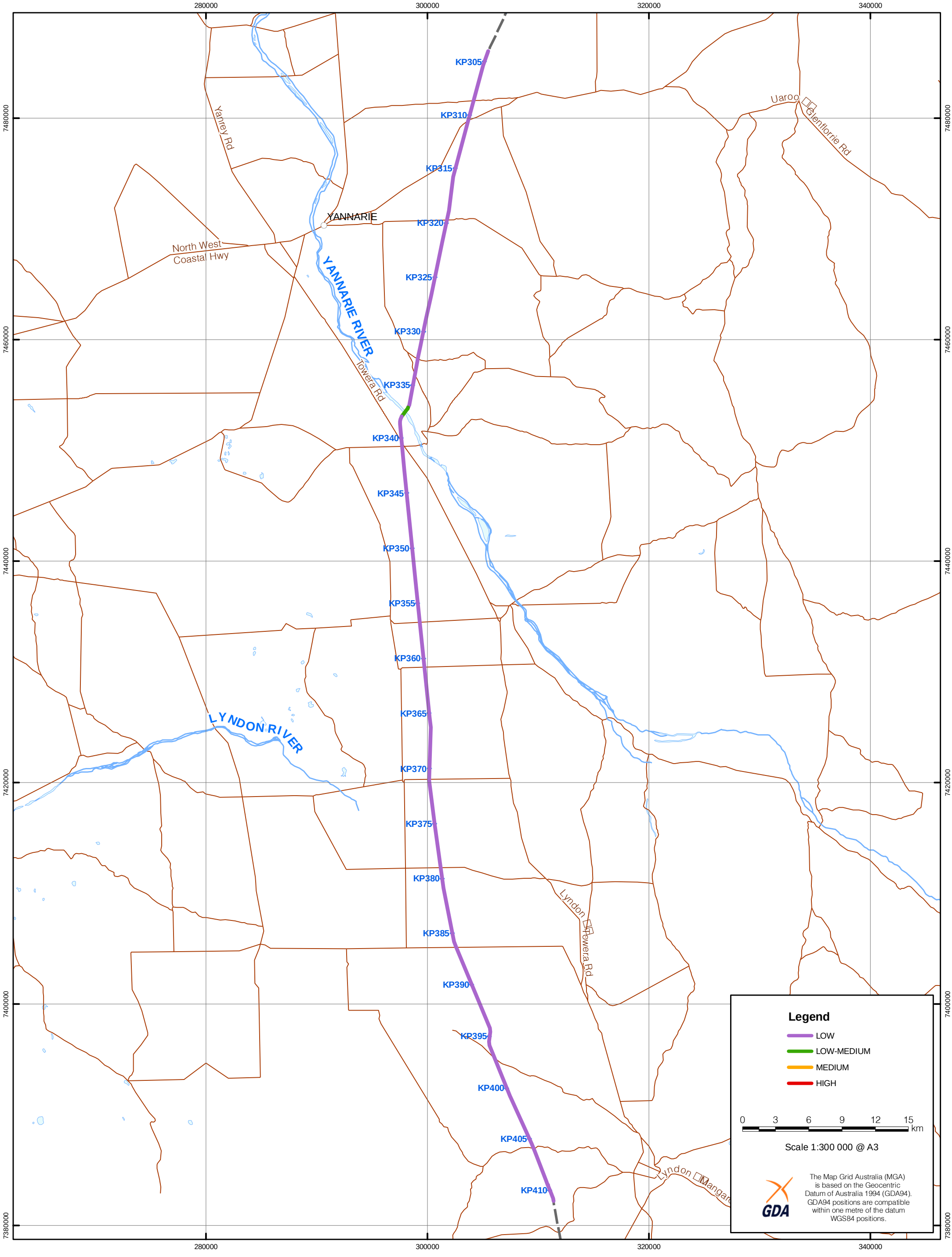
DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



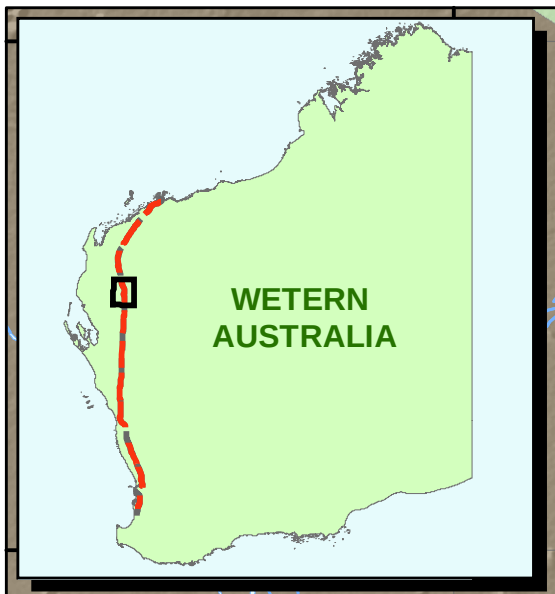
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX C4

LOOPING 2 - ACID SULFATE SOIL RISK

Appendix D

Loop 3 Maps



KP435
KP440
KP445
KP450
KP455
MOOGOOREE
KP460
KP465
KP470
KP475
KP480
KP485
KP490
KP495
KP500
KP505
KP510
KP515
KP520
KP525
KP530
KP535
KP540
KP545
Looping 3
LYONS RIVER
EUDAMULLAH
COONANT
WIGEMBURNA

Lithology: Alkaline red soils

Lithology: Sandy soils on bedrock

Legend

- KP
- Stage 5 Looping
- Natural Gas Pipeline

Regolith

- Aeolian sand
- Residual material
- Residual sand
- Alluvial sediments
- Coastal sediments
- Lacustrine sediments
- Terrestrial sediments
- Soil on bedrock
- Unweathered bedrock
- Moderately weathered bedrock
- Highly weathered bedrock
- Very highly weathered bedrock

0 3 6 9 12 15 km

Scale 1:296 000 @ A3

GDA

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94). GDA94 positions are compatible within one metre of the datum WGS84 positions.

300000 320000 340000 360000

7360000 7340000 7320000 7300000 7280000 7260000

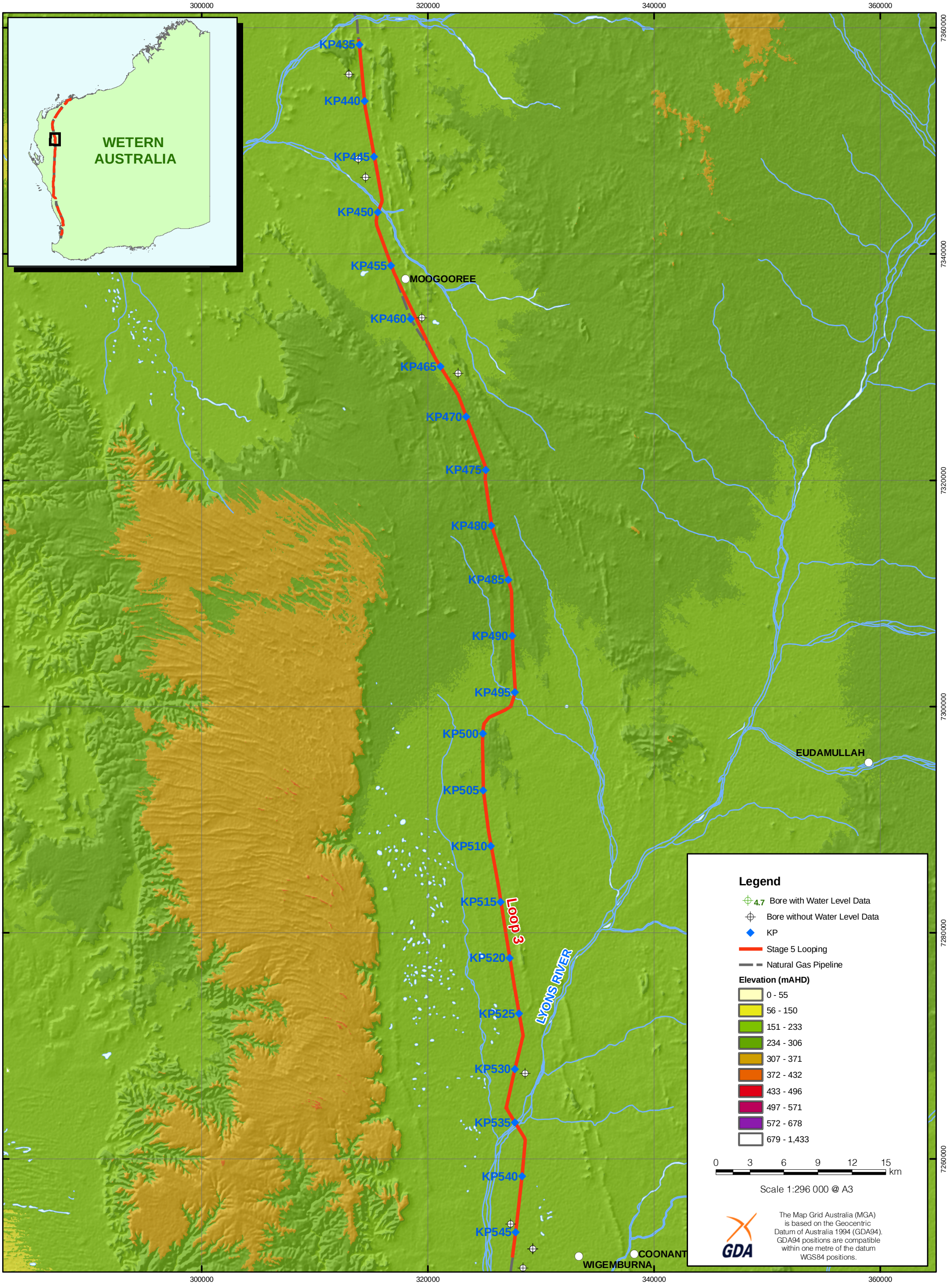
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX D1

LOOPING 3 - REGOLITH AND LITHOLOGY

PARSONS BRINCKERHOFF • Email: perth@pb.com.au

DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX D2

LOOPING 3 - TERRAIN AND DEPTH TO GROUNDWATER (mBGL)

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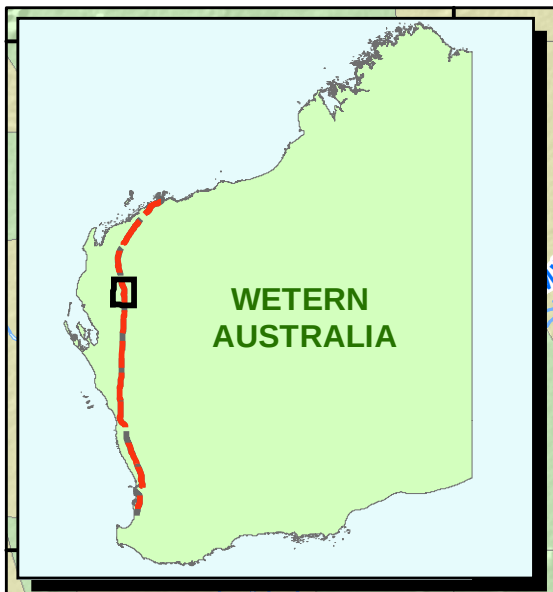
DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



300000 320000 340000 360000

7360000 7340000 7320000 7300000 7280000 7260000

KP435 KP440 KP445 KP450 KP455 KP460 KP465 KP470 KP475 KP480 KP485 KP490 KP495 KP500 KP505 KP510 KP515 KP520 KP525 KP530 KP535 KP540 KP545

Loop 3

MOOGOOREE

EUDAMULLAH

COONANT

WIGEMBURNA

MINILYA RIVER

LYONS RIVER

Legend

- KP
- Stage 5 Looping
- Natural Gas Pipeline

Land Cover

- Annual crops and highly modified pastures
- Built-up
- Ephemeral and Permanent Water Features
- Horticultural trees and shrubs
- Native forests and woodlands
- Native grasslands and minimally modified pastures
- Native shrublands and heathlands
- Perennial crops
- Plantation (softwood/mixed)
- Unknown/not reportable

0 3 6 9 12 15 km

Scale 1:296 000 @ A3

GDA

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94). GDA94 positions are compatible within one metre of the datum WGS84 positions.

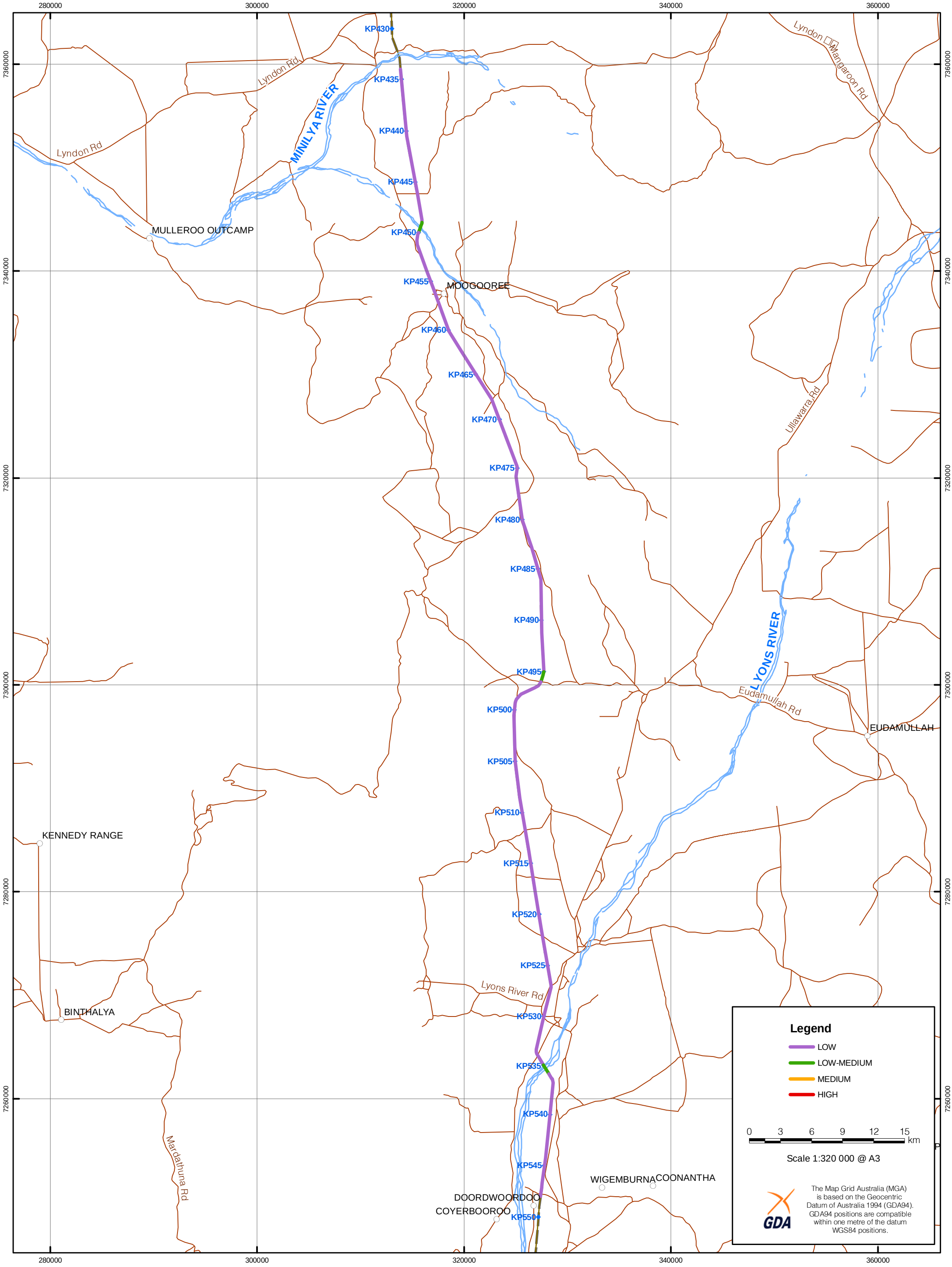
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX D3

LOOPING 3 - LAND COVER

PARSONS BRINCKERHOFF • Email: perth@pb.com.au

DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



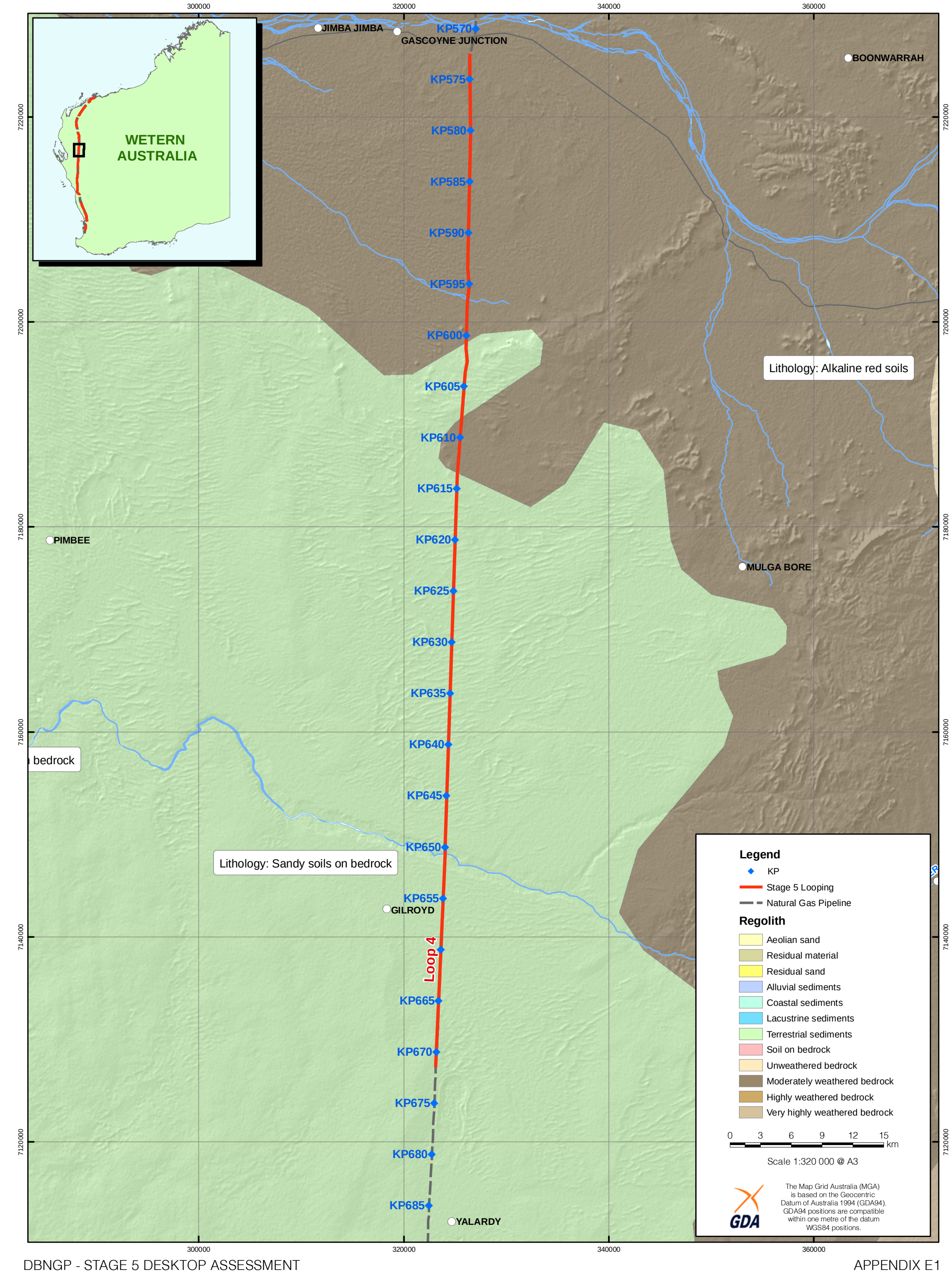
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX D4

LOOPING 3 - ACID SULFATE SOIL RISK

Appendix E

Loop 4 Maps



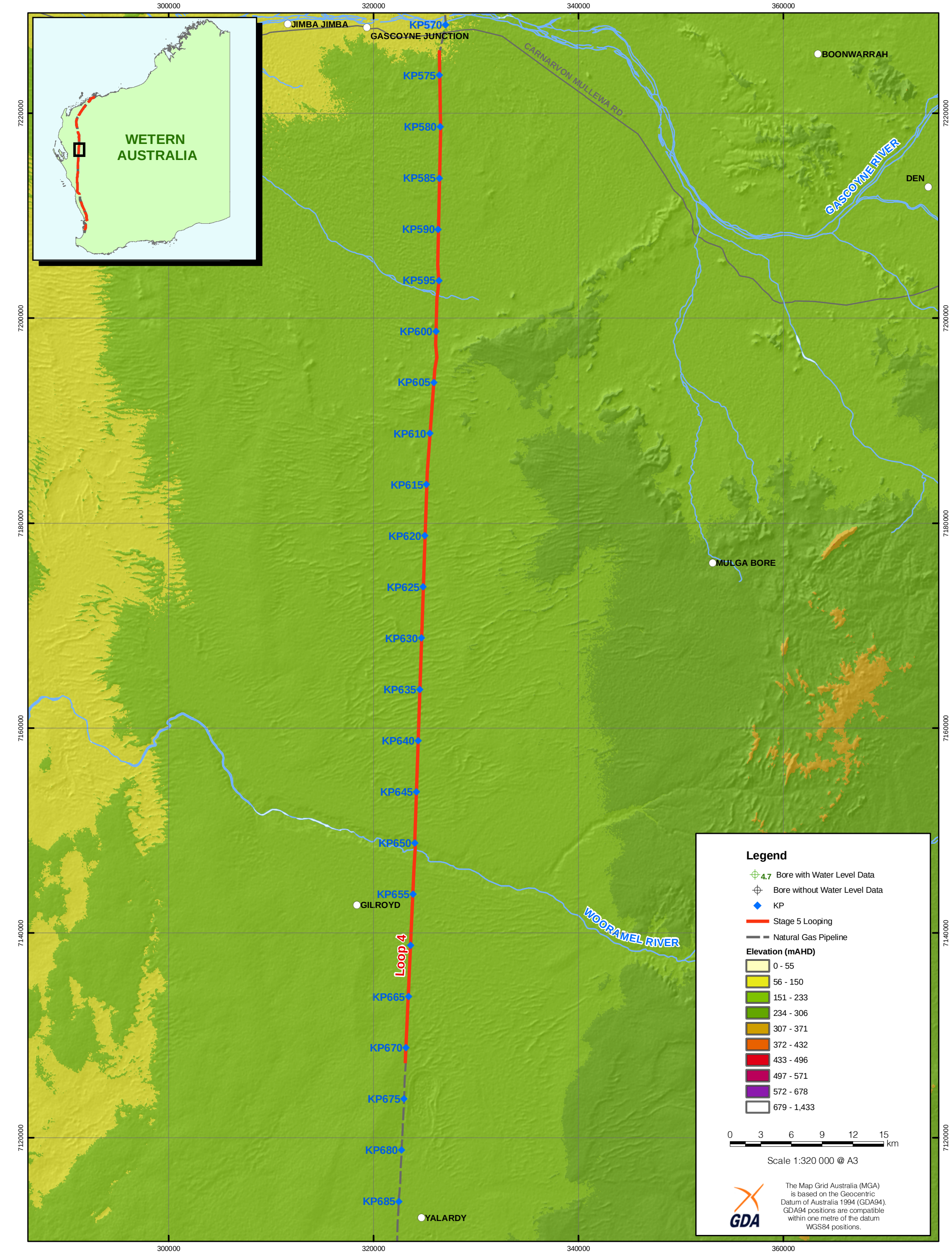
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX E1

LOOPING 4 - REGOLITH AND LITHOLOGY

PARSONS BRINCKERHOFF • Email: perth@pb.com.au

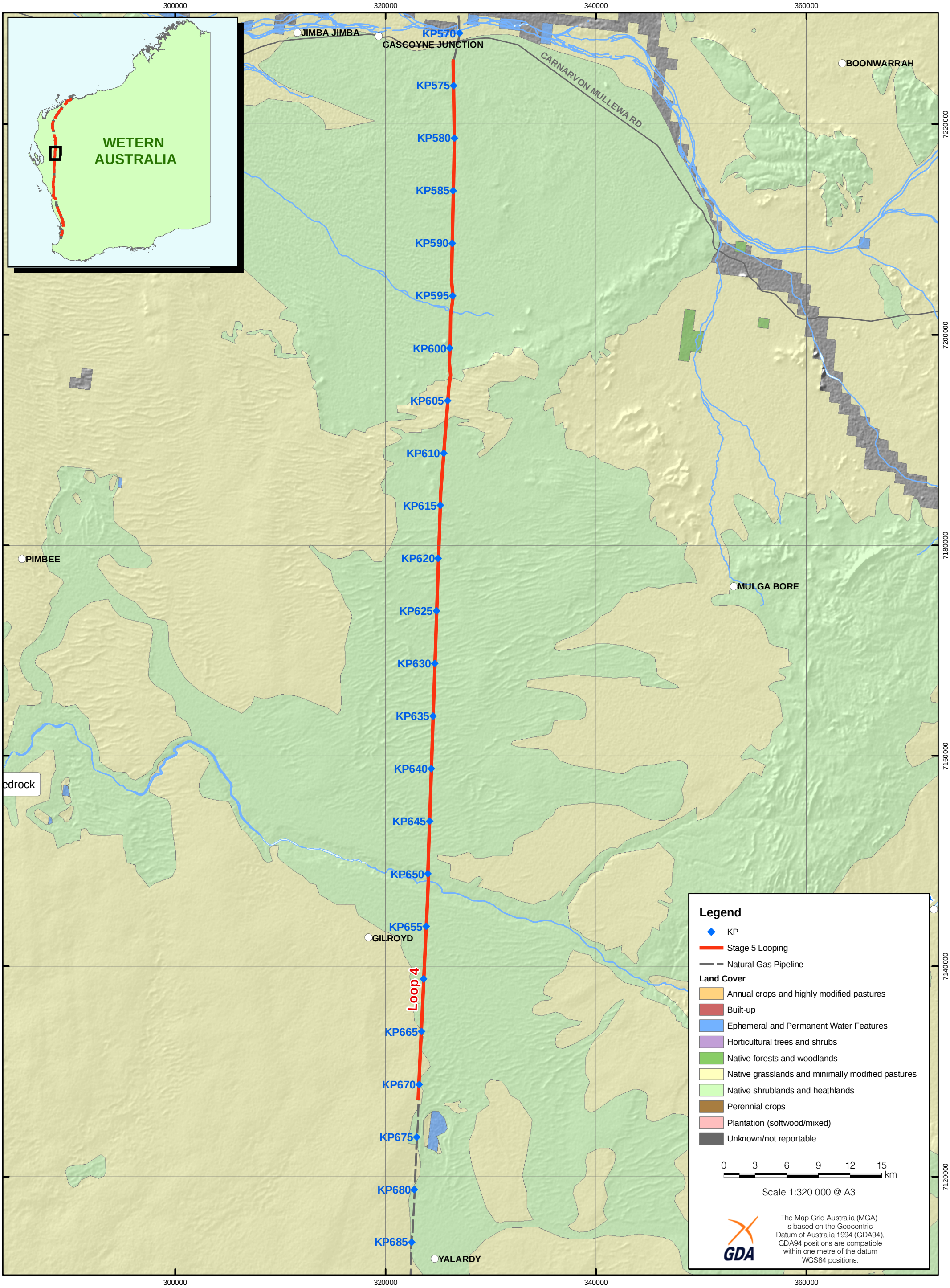
DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



LOOPING 4 - TERRAIN AND DEPTH TO GROUNDWATER (mBGL)

PARSONS BRINCKERHOFF • Email: perth@pb.com.au

DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



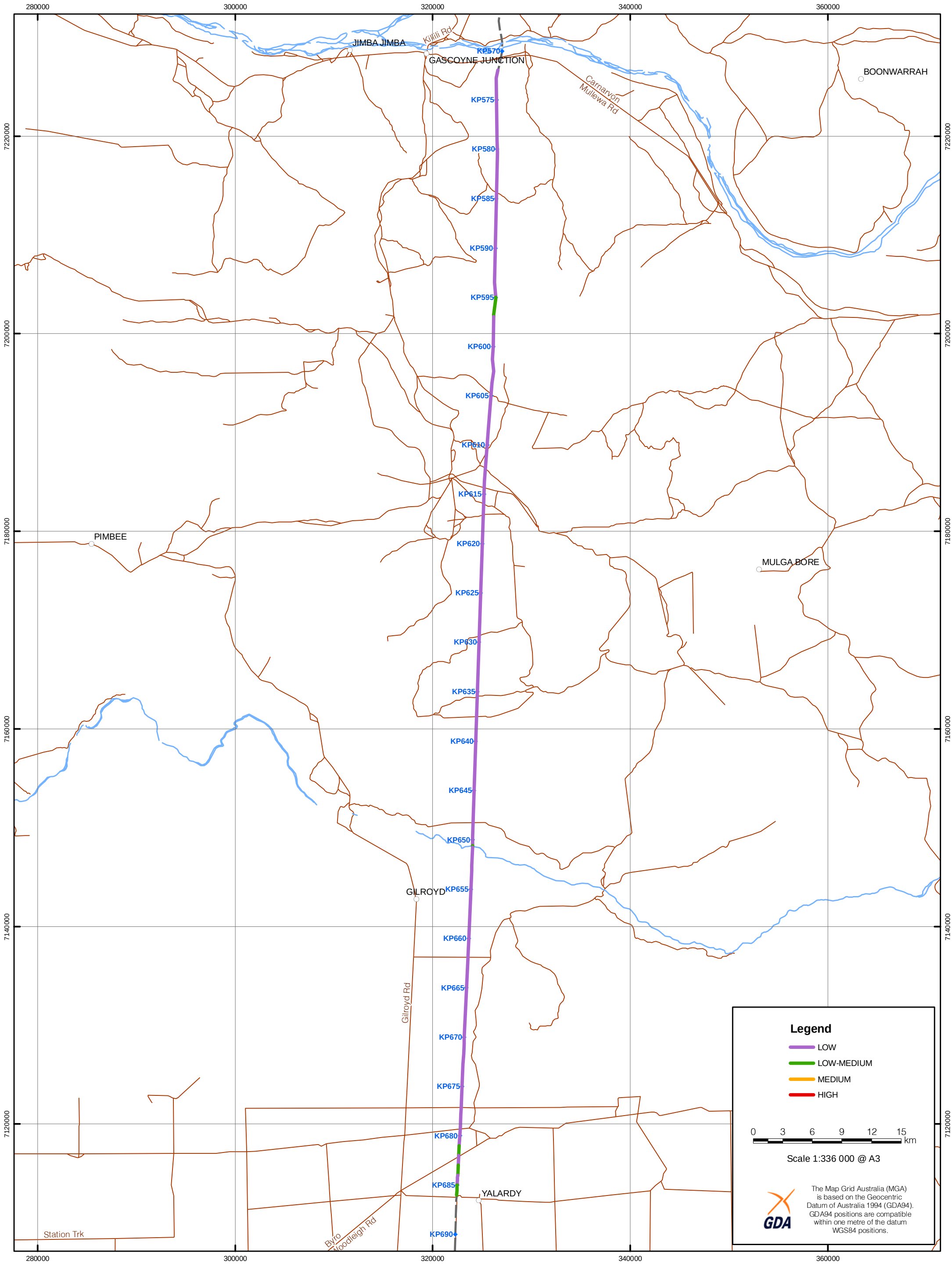
DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX E3

LOOPING 4 - LAND COVER

PARSONS BRINCKERHOFF • Email: perth@pb.com.au

DRN: JH CHKD: SP • Date: 07/06/2006 • PLAN No: 2145243A



DBNGP - STAGE 5 DESKTOP ASSESSMENT

APPENDIX E4

LOOPING 4 - ACID SULFATE SOIL RISK