coffey geotechnics
SPECIALISTS MANAGING THE EARTH

14 November 2007

ATA Environmental
2 Bulwer Street
PERTH WA 6000

Attention: Ms Edith O'Shea

Dear

RE: St Andrews District Structure Plan Stage 1 to 3 - Desktop Geotechnical Karst Assessment

1 INTRODUCTION

This letter has been prepared by Coffey Geotechnics Pty Ltd (Coffey) at the request of Ms Edith O'Shea of ATA Environmental (ATA) on behalf of Tokyu Corporation and outlines the results of a desktop study for the above site to assess the requirement for a karst landform management plan. The boundaries of Stage 1 to 3 were provided by ATA on a plan produced by Robertsday Town Planning + Design (Ref: TOK CON Staging Series 09.06.06) and comprise areas around the existing Two Rocks and Yanchep development areas and extending inland from Yanchep.

The provided plan shows Stage 1 including Lots 201 and 202 Breakwater Drive. Coffey has previously undertaken extensive work within these two lots and it understood that the development approval process is well advanced and separate to the remaining Stage 1 areas. It must be noted that Lots 201 and 202 Breakwater Drive are not included as part of this assessment.

2 DATA SOURCES

Information used in this assessment is as follows:

- Gozzard, J. R., 1982. Yanchep sheet 2034 IV, Environmental Geology Series, Geological Survey of Western Australia.
- The results of field investigations undertaken by ATA including 10 boreholes drilled with air core techniques to depths of between 41m and 54m. The locations of test sites are shown Figure 1 attached to this letter.
- A report by Logiden titled "Interim Report on St Andrews Property" (Ref: Logiden; October 1; 07)

- Davidson, W.A. 1995, Hydrology and Groundwater Resources of the Perth Region, Western Australia; Geological Survey of Western Australia, Bulletin 142.
- Water and River Commission 1997, *Perth Ground Water Atlas.*
- *Perth Groundwater Atlas*, Second Edition 2004. Department of Environment.

In addition to the above information, our assessment is based on Coffey experience and observations from previous geotechnical work undertaken within and adjacent to the project area.

3 SITE CONDITIONS

The 1:50,000 geology map (Yanchep Sheet) indicates that the site is predominantly within an area of Tamala Limestone with areas of younger Safety Bay Sand comprising parabolic dune systems overlying the Tamala Limestone surface. A shale unit is indicated in one of the ATA boreholes (BH1) at a depth of 50m underlying variably cemented sands of the Tamala Limestone. The shale unit is inferred from information outlined in Davidson (1995) to be part of the Kings Park Formation. Ground surface elevations at the site range from 54mAHD to 16mAHD, broadly decreasing towards the coast (west). Groundwater elevations range from about 5mAHD within the eastern part of the site to about 1mAHD within the western part of the site. East of the site, broadly defined by a chain of lakes and lower lying terrain is a geomorphological unit described on the 1:50,000 geology sheet as “Interbarrier depression with prominent karstic phenomena”. A localised low lying area extending west of the zone outlined on the 1:50,000 geology sheet is inferred to encroach into the site at two locations along the south eastern boundary in the vicinity of Yanchep Beach Road. The extent of this area is shown on Figure 1. Borehole logs provided by ATA indicate inferred cavity zones within the vertical depth intervals of 32.5m to 34.0m (Bore 8) and 36.0m to 38.0m (Bore 9). The inferred cavity zones were encountered within calcrete and calcareous cemented sand materials.

4 DISCUSSION AND RECOMMENDATIONS

Surface features such as caves, closed depressions, dolines and sink holes can be observed within the area of known karst east of the site as outlined on the 1:50,000 geology sheet. The area within the south eastern edge of the site, as shown on Figure 1, is considered a possible western extension of the known karst zone. West of this zone, significant karst features are not observed at the surface. The Logiden report outlines a mechanism by which infiltrating rainfall which recharges the groundwater and migrates west from the chain of lakes to the coast may dissolve calcium carbonate creating voids at depth below the site. Our understanding of this process is that it has occurred over a geological time scale to result in the landforms we observe today and that the continuation of this process over the relative time length of the project (eg 100 years) is insignificant. From a geotechnical engineering perspective and as observed from the two cavity zones encountered within the drilling, existing karst features that may underlie the site are considered to be at sufficient depth to not create a significant engineering risk for the proposed development. An exception to this is the two areas described in Section 2 and illustrated in Figure 1 where further investigation is warranted prior to development. Additional investigations would be aimed at assessing the presence of near surface loose sand zones or voids within shallow limestone and would provide data for input into engineering design to accommodate subsurface conditions that may (or may not) be present within the south eastern edge of the site. It is anticipated that further investigations would be part of normal geotechnical investigations undertaken at the engineering design stage (rather than structure plan stage) of development.

For the remainder of the site, in the absence of any direct indications of karstic features, we recommend that the development of a karst landform management plan need not progress beyond the desk top assessment outlined in this letter.

5 CLOSURE

We trust that this letter meets your current requirements. If you have any queries relating to this letter or we can be of further assistance, please contact the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

PHILIP MATHER

Principal Engineering Geologist

Attachments: Figure 1 Site Location Plan - Inferred Western Extension of Potential Karst Zone

Interim Report
on
The Geology of The St Andrews Property, Yanchep-Two Rocks District.
by
Logiden Pty Ltd
October, 2007

THE REPORT

Aims and Karst Focus

This report is the result of geological study carried out in the southern part of the St Andrews Property, during January 2007. The study was to assess risks related to the observed presence of extensive karst landforms.

The study consisted of a field project involving geomorphic analysis and exploration of subsurface conditions by means of test wells and ground-penetrating radar. Later office study involved analysis of field data and integrated to provide the basis of an understanding of the subsurface stratigraphic and geohydrologic environment.

The study has confirmed earlier findings:- that in the case of the St Andrews Property, planning for development should involve comprehensive, integrate geomorphic analysis, exploration drilling and geophysical studies. The broad objectives of such work being the definition of karst domains undesirable as foundations; as against sandy, post-karst domains with stable subsurface conditions.

Karst features including caves and tunnels, troughs, scarps and pinnacle fields and have been of central interest in the present analysis of subsurface features. The study had reveal that the eastern part of the Property contains numerous caves. Analysis of the regional geohydrology also indicates the high probability that there are cave networks beneath the western part. These caves deliver groundwater to the sea.

Karst & Urbanisation

Karst terranes originated through leaching of soluble rocks, such as calcarenite (a variety of limestone) by percolating groundwater. The leaching and related mass loss results in cave development with consequences that includes meter- to hectometer-scale subsidence and foundation instability. In the context of centuries-long urban development there is an enduring risk of foundation failure with a range of probabilities from single, hectometer-scale collapses to sequential subsidence in small-scale events. Sub-surface karst features such as pinnacle fields and caves also are costly impediments to building and infrastructure installation.

Karst terranes also are notoriously prone to groundwater contamination and subsequent rapid transmission of concentrated pollutants to distant sites, via cave networks. This is a concern in that the St Andrews Property lies across westward flow path from the Gnangara Mound. Global experience is that voluminous abstraction for water-supply purposes, accelerates karstification and attendant instability. Decline of groundwater tables is reported in the Yanchep district and there are plans for voluminous abstraction as part of a regional water supply scheme (Davidson, 1994).

THE PROPERTY

Geomorphology

The Property lies within a highly pitted karst plateau that is underlain by a 45m-thick foundation composed of quartzose, sandy limestone. The formation, which has been termed the “Yanchep Calcarenite” consists of weakly lithified limestone composed of sand-size skeletal fragments of marine organisms and significant percentages of quartz grains. The formation It is about 45m–thick and overlies west-sloping unconformity on Cretaceous-age formations that mostly are aquicludes. The karst base is at about -22mAHD under Lot 202 and Lot 203 in the east and is at about -30mAHD at the coast.

The Terrane is characterized by a widespread development of kilometer-scale karst troughs and plateau remnants; sinkholes of various dimensions, caves and pinnacle fields. Areas of this karst terrane are obscured by meter-thick blankets of residual quartz sand while other parts are bare with rock outcrop, sinkholes, pinnacle fields and caves. Mostly remnants of the karst top lies at an elevations between 30mAHD and 40mAHD.

Covered-karst landscapes dominate in the central part of the Property. Here the underlying Calcarenite foundation is obscured by thick blanket of residual sand or and occasionally by younger, 10m-high parabolic dunes and meter-thick sheets of the Holocene, Quindalup Fm. The Calcarenite foundation crops out on some ridges but most high points are Quindalup dune crests at elevations between 30m and 60mAHD. Hectometer-scale karst troughs and karst stopes are at 10m to 15mAHD. In the central area of there are a number of hectometer- to kilometer- scale, sub-circular closed basins with floors at some 10m to 15m below the general level. These large basins are suspect cover-collapse- or cover-subsidence sinkholes that may reflect presence of cavernous voids in the underlying limestone.

Bare-karst landscapes are characterized by rocky surfaces with irregular soil veneers, abundant sinkholes and occasional dolines. The largest bare-karst area occurs in a 3km-wide zone west of Lot 202, in the Lot 203 reserve and in the Yanchep National Park. Bare-karst areas also are common in various coastal localities where there are steep descents to the shore.

Geohydrology and Caves

There are abundant caves in the area east of the Property and analysis of the regional geohydrology indicates the high probability that there also are caves beneath the western part.

The Yanchep Calcarenite functions as a conduit for flow of pressurized groundwater from the Gnangara Mound to the sea. The overall head is about 40m. There are reports of fresh-water discharge in offshore areas, which if correct, indicate voluminous outflow from seafloor caverns that are sourced in the Property (Davidson, 1996).

The Gnangara groundwater mostly enters the Calcarenite along a NNW–trending, 3km-wide intake zone that lies east of the bare-karst outcrop zone. The intake contains in southward sequence:- the western side of the Lot 201/202 depression, Loch McNess, Yonderup Lake, Pipidinny Swamp, the Mindarie and Carabooda and Nowergup Lakes. Water levels in the intake area descend from 16mAHD at Nowergup to about 7m AHD in Loch McNess. The situation is one where there is high potential for extensive occurrence of karst features and for on-going karstification in the area downslope.

English *et al* (2000) cite 315 caves in the Yanchep National Park of which 46 contain pools or seeps. These caves are sub-horizontal reflecting dissolution along bedding surfaces in the Calcarenite. They are several meters to a decameter in height and contain speleothems, cave sediments and collapse breccia. Some caves lie in the phreatic zone and some have decimeter-deep water streams while others lie in a meters-thick damp, transitional zone; others lie in the vadose zone. This is a situation reflecting cave genesis in declining water-table conditions and is a natural phenomena related to cave development and consequent acceleration of drainage.

There also are caves in the western part of Lot 202, that apparently direct phreatic drainage westward to the Lot 203 reserve along the northeastern border of the Property. In Lot 202 a cave with a height of 9m and a 2.5m deep pond, at a level of -3.4mAHD. was encountered Several test wells also have revealed cavities up to 1m to 2m high. These features are in the western part of Lot 202 and are in the phreatic zone where the Calcarenite foundation is

immersed in the Gnangara aquifer.

Unfortunately the data on caves in the central and western part of the Property is sparse. The recent test drilling and GPR traverses has revealed two 4m-high caves in the central part of the Property. These caves about 2km from the coast and lie in SSW-trending linear depressions that may be partly filled-karst tunnels.

METHODS & RESULTS

Test Wells

Ten test wells were drilled by air-core technique. Average well depth was 45m and the total project meterage was 451m. The wells were logged with attention to presence of cavities, location of the groundwater-table and the depth (sgl) of the karst-formation base.

Ground-Penetrating Radar (GPR)

Ground Penetrating Radar is a means of identification and charting of sub-surface features on a 2D, and possibly 3D basis. A GPR survey of about 10km length was carried out in accessible areas to north and south of the Yanchep Road. GPR charting provides a better than 0.5m-level of precision in respect to sub-surface boundaries. GPR applications require precise control on location and level in respect to survey lines. Spatial control was provided by Fugro Spatial Solutions using differential GPS. The operator, Georadar Research also exerted control on a peg-to-peg basis during traverses. The GPR charts were interpreted by Logiden Pty Ltd.

The maximum penetration depth was about 21m. The charts revealed fine details of sub-surface features including:- i) contacts between the Spearwood Sand (Soil) and underlying Yanchep Calcarenite; ii) profiles of the superficial Quindalup dunes; iii) zones of intense karstification and; iv) possible cave-roof features. Unfortunately a 21m sgl penetration limitation, precluded scans of the Yanchep Calcarenite karst-base zone that has been defined in bore holes as between 25msgl to 45msgl.

Geomorphic Analysis

Geomorphic analysis showing the distribution of landforms and geohydrologic terranes is essential or planning and property development. Unfortunately the database for such analysis in the Yanchep District has been sparse and as a consequence there have been erroneous interpretations in some early publications.

The analysis of the St Andrews Property commenced with a brief desktop study by Logiden (2006) based on historical data from Gozzard, (1982) and CALM (1986). The scope of the analysis has been extended with the recent availability of an ortho-image with a superposed 5m-contour grind. The landform analysis also has benefited from the availability of sub-surface data from the GPR projects t. The outcome has been new insights and understanding of landscape in the Property.

CONCLUSIONS

The present study has confirmed earlier findings and indicate that planning for urban development in the St Andrews Property should involve comprehensive, integrate geomorphic analysis, exploration drilling and geophysical studies since there is a high probability of the occurrence of cave networks. There also are other impediments to development such as extensive pinnacle fields.

In the Property, there also are post-karst areas that are underlain by decameter-thick sections composed of residual quartz sand and thus stable and suitable for urban development. The

parameters of the residual sand blanket are poorly defined; observations being from a few boreholes and sand pits. Some sandy domains contain extensive pinnacle fields. Pinnacles are tower or spire-shaped, rock pillars that rear-up meters to decameters through residual sand above the parent calcarenite foundation. They usually are sub-circular and diameters range widely from a few centimeters to several meters. Pinnacles, between 0.5m and 5m high are common in the terrains where they mostly lie hidden in the overlying residual soil. Characteristically, pinnacles occur in extensive fields. In such fields, pinnacle frequency is between 3000-5000/ha.

Pinnacle fields present impediments to development particularly in respect to installation of sub-surface infrastructure involving trenching and drainage. There also is some question as to their bearing strength is respect to large structures. The question mainly relates to the fact that in areas of advanced decalcification, pinnacles do not descend to the karst foundation but are supported only in sand.

In the context of urbanization the overall questions concerning any locality in the Property are:- i) whether the karst process has advanced to the stage where the foundation is now mostly thick, residual quartz sand and thus suitable for urbanization or, ii) the area is underlain by caverns and residual karst and thus undesirable as a foundation for buildings and infrastructure.

BIBLIOGRAPHY

Davidson, W.A. 1995, Hydrology and Groundwater Resources of the Perth Region, Western Australia; GSWA, Bulletin 142.

Dept. of Conservation and Land Management, 1986, Yanchep sheet.

English, V. *et al;* 2000. Interim Recovery Plan Aquatic Root Mat Community of Caves of the Swan Coastal Plain, 2000-2003; Aust. Govt.; Dept of Environment and Heritage; 134p.

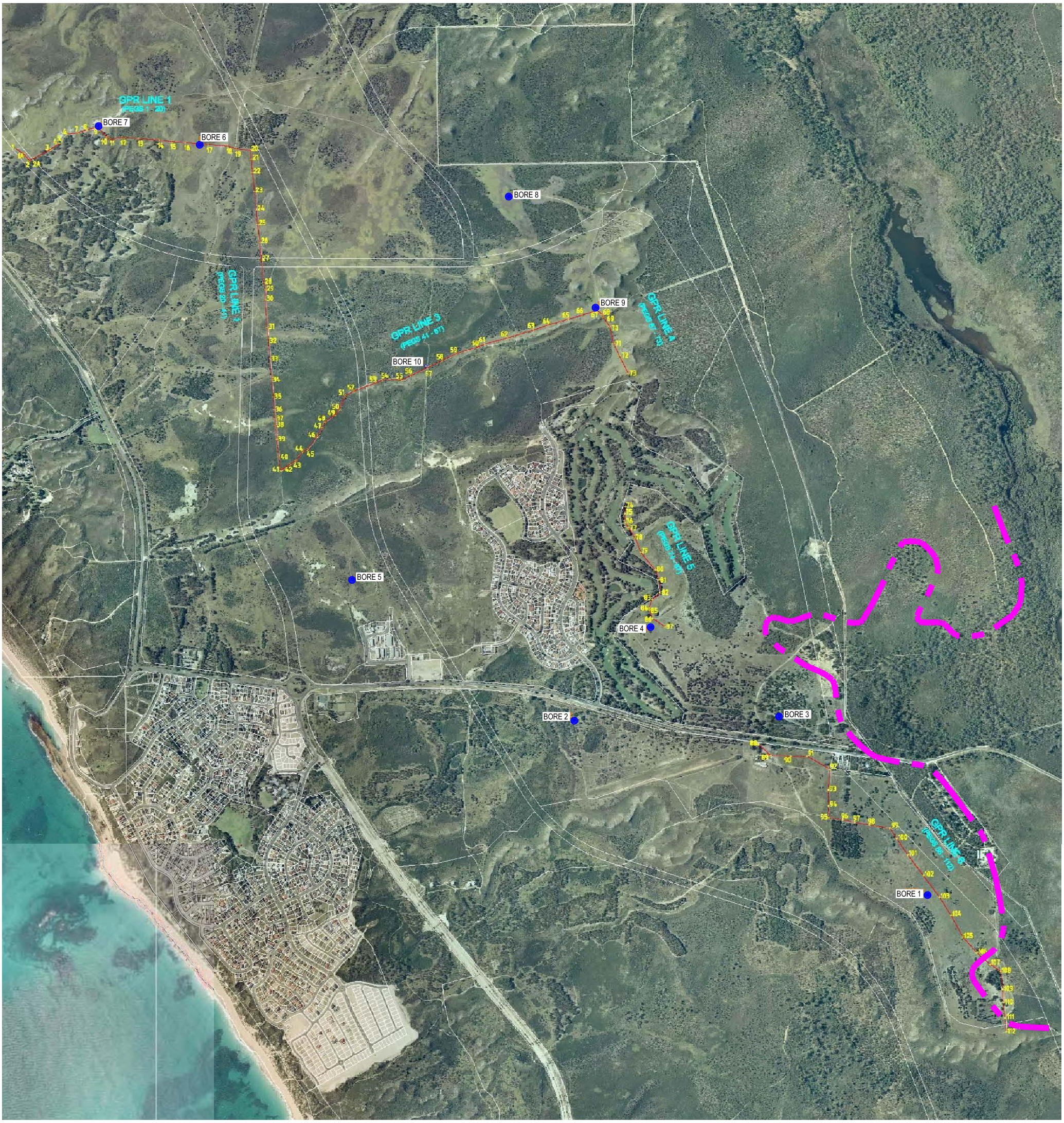
Environmental Protection Authority, 1999, City of Wanneroo Town Planning Scheme No. 1: Amendment 837 - Rezone from rural to rural community, Lots 201 and 202, Breakwater Drive, Two Rocks; Report and recommendations of the Environmental Protection Authority. EPA Bulletin 956.

Gerritse, R.G., Barber, C. and J. A. Adeney, 1990. The Impact of Residential Urban Areas on Groundwater Quality: Swan Coastal Plain, WA. CSIRO Water Resources Series 3.

Gozzard, J. R., 1982. Yanchep sheet 2034 IV; Map Environmental Geology Series, GSWA.

Gozzard, J. R., 2007. Geology and landforms of the Perth Region; GSWA; 126p.

Water and Rivers Commission, 2003, EPA Progress Report 2003- Section 46, Review of Environmental Conditions on Management of the Gnangara and Jandakot Mounds.



LEGEND

INFERRED WESTERN BOUNDARY OF ZONE WHERE GEOTECHNICAL DESIGN MAY REQUIRE CONSIDERATION OF THE POTENTIAL FOR KARSTIC FEATURES

78 GROUND PROBING RADAR LINE

BORE HOLE

REF:
DWG: F:\Geotechnical\HERD08000\GEOTHERD08359AA Yanchep Karst Tokyu\DWG\GH8359AA FIG1.dwg

drawn	LB
approved	
date	7/12/07
scale	1:20 000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: ATA ENVIRONMENTAL

project: ST ANDREWS STRUCTURE PLAN STAGE 1 TO 3

title: SITE LOCATION PLAN - INFERRED WESTERN EXTENSION OF POTENTIAL KARST ZONE

project no:	fig no:	rev:
GEOTHERD08359AA	FIGURE 1	

GEORADAR RESEARCH

PROJECT No. R2007/215

REPORT ON GROUND PENETRATING RADAR SURVEY AT ST ANDREWS ESTATE, YANCHEP, W. A.

For

ATA Environmental Pty Ltd
&
Coffey Environments Pty Ltd

On Behalf of

Yanchep Sun City

June 2007

Georadar Research *Pty Ltd*
ACN 003-776-743
412 Eastbank Road, Coramba
Coffs Harbour, N.S.W.
Tel: 02 6654 4162 Fax: 02 6654 4043
E-mail: georadar@bigpond.com

CONTENTS

APPENDIX

REPORT ON GROUND PENETRATING RADAR SURVEY AT ST ANDREWS ESTATE, YANCHEP FARM, YANCHEP, W.A.

1. EXECUTIVE SUMMARY

This report describes the detailed field logistics and presents the radargram plots from a non-destructive geophysical survey using Ground Penetrating Radar (GPR). This survey was conducted at the site of a proposed large subdivision at St Andrews Estate, Yanchep Road, W.A.

The geology of this site consists of sands overlying weathered calcarenite limestone. The purpose of the radar survey was to try to determine if large subsurface solution caverns exist within the limestone.

The GPR data was recorded in January 2007 by Georadar Research Pty Ltd, using a GSSI dual channel GPR system. The fieldwork consisted of recording six transect lines, which were numbered sequentially from 1 to 6. The data was acquired using a pair of 100 MHz shielded antennae fitted with a high voltage (1,000 v) transmitter, with the recording depth range set at 350 ns (approximately 21 m depth).

The raw GPR data has been processed and corrected for topographic elevation.

The Appendix of this report contains plots of the processed and elevation corrected 100 MHz data. These plots are also presented as WORD and pdf images on the accompanying CD. High-resolution bitmap images of the processed radar files (exported as BMP format files) are also included on the accompanying CD.

The geotechical interpretation of the results of this GPR survey and the follow-up drilling to calibrate the radar results is due to be conducted by ATA Environmental Pty Ltd / Coffey Environments Pty Ltd. These integrated results will then be used to develop a karst feature management plan for the site, and in due course a detailed structural plan.

2. INTRODUCTION

In 2005, Georadar Research conducted a subsurface ground radar investigation on an area of karstic calcarenite limestone at Lot 202 Breakwater Drive, approximately 10 km to the north of Yanchep. Ground penetrating radar proved to be an effective tool for mapping subsurface structures to a depth of approximately 12 m.

Concerns have been expressed that the St Andrews Estate development site at Yanchep, which occurs in a similar calcarenite limestone environment, may possibly contain features deemed to be subsurface caverns, or "sinkholes".

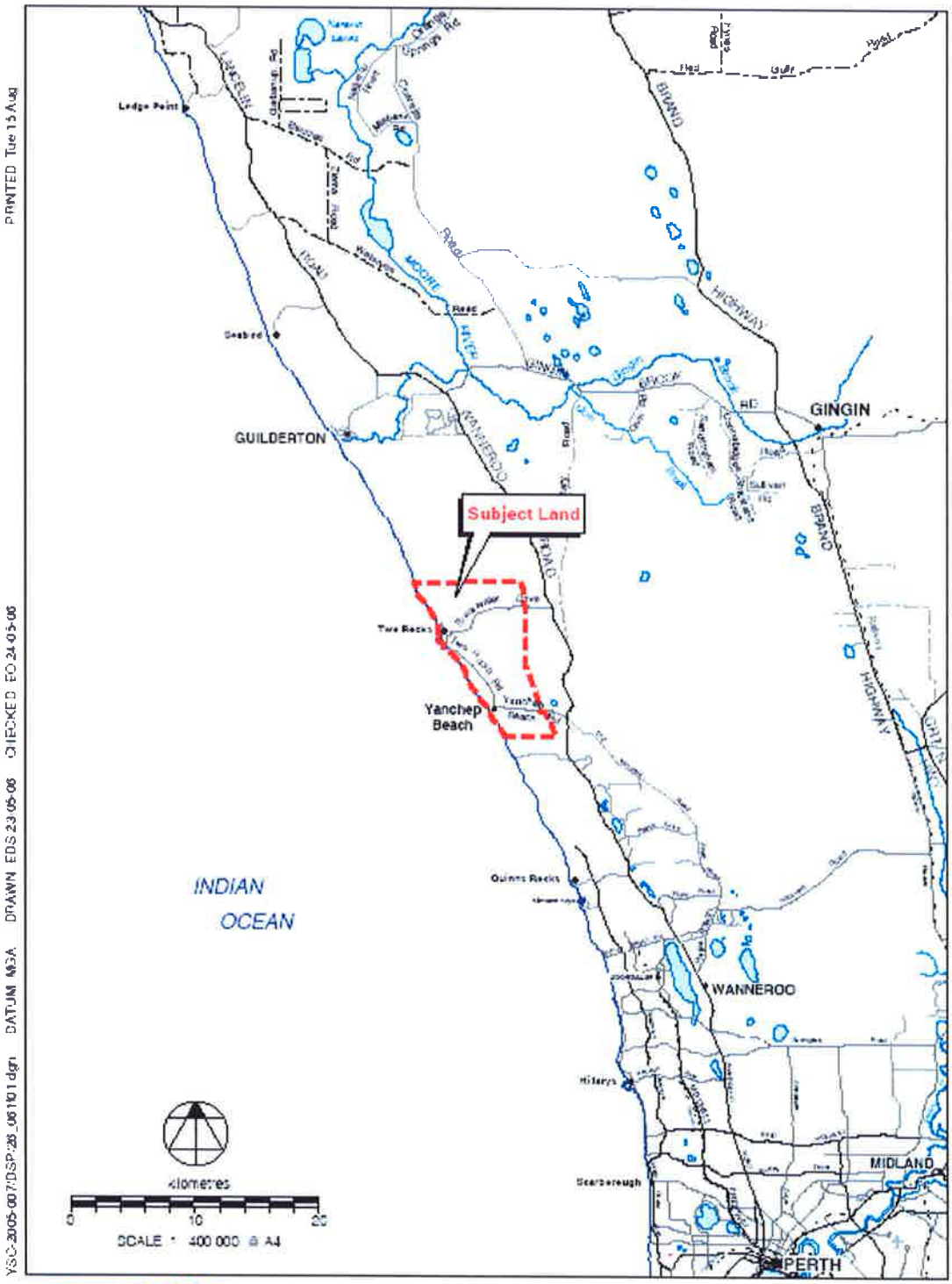
In order to maximise the yield of the number of residential blocks which can be accommodated on the site consistent with good environmental and geotechnical practice, it is necessary to identify the extent and location of these features prior to development, so that allowance for them can be incorporated into the Structural Plan.

Accordingly a GPR survey was conducted in January 2007 along 6 transect lines at locations designated by ATA Environmental Pty Ltd / Coffey Environments Pty Ltd staff. The data from this project has been processed and corrected for elevation variations along the transect lines.

The processed results of the GPR survey have been delivered on CD to ATA Environmental Pty Ltd. This data needs to be examined to select appropriate drilling targets targeted to investigate any subsurface features with radar characteristics indicative of caverns or sinkholes. The results of the drilling program will be used to calibrate the depths on the radar profiles and to conduct the interpretation of the GPR results. This data will be used to develop a karst feature management plan for the site, and in due course a detailed structural plan.

3. OBJECTIVES

The objectives of the Ground Penetrating Radar (GPR) survey were to record scans to the maximum possible depth along six preselected survey lines, to assist the Coffey Environments project development team in defining the geological conditions across the site.



PRINTED Tue 13 Aug DATUM MGA DRAWN EDS 23-05-06 CHECKED EO 24-05-06 YSC-2005-007/DSP-26_060101.dgn

ATA Environmental
environmental scientists

ST ANDREWS DISTRICT STRUCTURE PLAN

REGIONAL LOCATION

FIGURE 1

Figure 2: Regional location of GPR Survey Area at St Andrews Estate, on Yanchep Farm, Yanchep, WA. Refer to Figure 5 for an orthophoto map of the site and to the Appendix for the detailed location of the GPR survey lines.

4. GPR SURVEY METHOD

GPR is a non-destructive and non-invasive geophysical technique for rapidly imaging the shallow subsurface (typically up to 10 m depth) and producing high-resolution colour sections in real time. Parallel scans can be used to create 3D images.

In principle, the GPR technique is normally operated in the reflection mode (like an echosounder), except that high frequency impulses of electromagnetic energy are transmitted rather than sound waves. Typically 100,000 impulses per second are transmitted downwards into the ground from a shielded antenna placed close to the ground surface (Figure 3). These impulses are of very short duration (each pulse has a rise time of 1 – 5 nanoseconds) and contain a wide spectrum of frequencies, typically between 100 MHz and 1 GHz. The energy levels transmitted are very low (only milliwatts of average power), which is only a fraction of the power used by a mobile phone.

Signals are reflected back from interfaces in the ground where there is a contrast in the dielectric properties between two adjacent layers. The target depth is proportional to the time taken for the signal to travel down and back from a given layer. An optical encoder wheel is used to measure horizontal distance as the antenna is pulled across the ground surface. Marks can be inserted on the data scans (called radargrams) opposite features of interest.

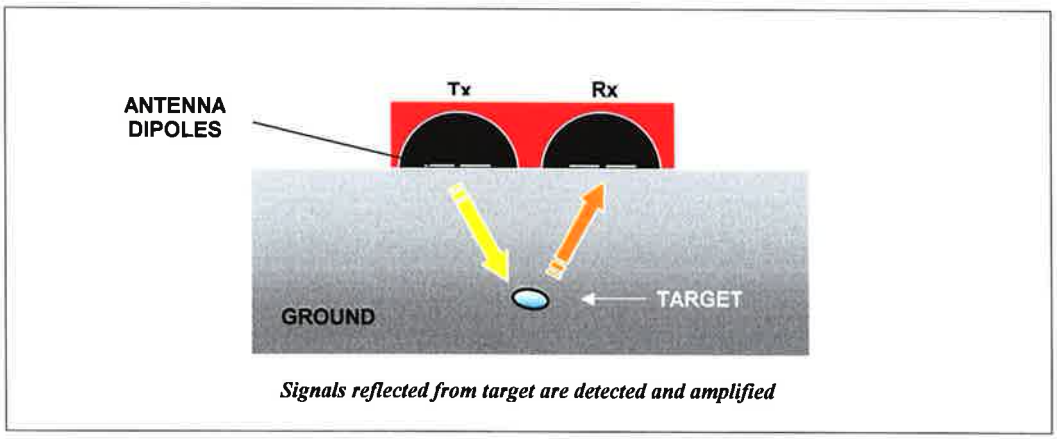


Figure 3: Principle of Ground Penetrating Radar

5. SITE PREPARATION

Prior to the GPR Survey, the GPR survey line locations were selected by ATA-Environmental Pty Ltd and Coffey Environments Pty Ltd Perth office, with consideration of the geological, hydrogeological and botanical characteristics of the site.

The GPR survey consisted of six transect lines, which were pre-marked with survey pegs (Figure 5). Survey pegs were deployed by Fugro Spatial Solutions Pty Ltd at nominal 100 m spacing, or at changes in direction, crests or troughs.

These pegs were numbered sequentially along the GPR Survey Lines, with the first number denoting the survey line number, and the second number denoting the peg sequence number. For example, survey pegs 1/1, 1/2, 1/3, denote the first part of survey line 1 and the peg sequence of 1, 2 and 3, etc.

The Easting, Northing and Elevation coordinates were recorded for each survey peg by Fugro using Differential GPS. This position data is summarised in an Excel spreadsheet in the Appendix.

Prior to the GPR survey, the track of the survey lines was graded to remove surface logs, isolated boulders and long grass (Figure 4). For obstructions, such as isolated trees located on the GPR survey line, the graded track deviated around the obstruction.

Figure 4. (Facing South) GPR Survey Line 02, starting at peg 2/20 (shown in foreground). The survey lines were prepared by lightly grading the tracks. Survey pegs were placed at nominal 100 m intervals, and at changes in direction, hill crests, or troughs.

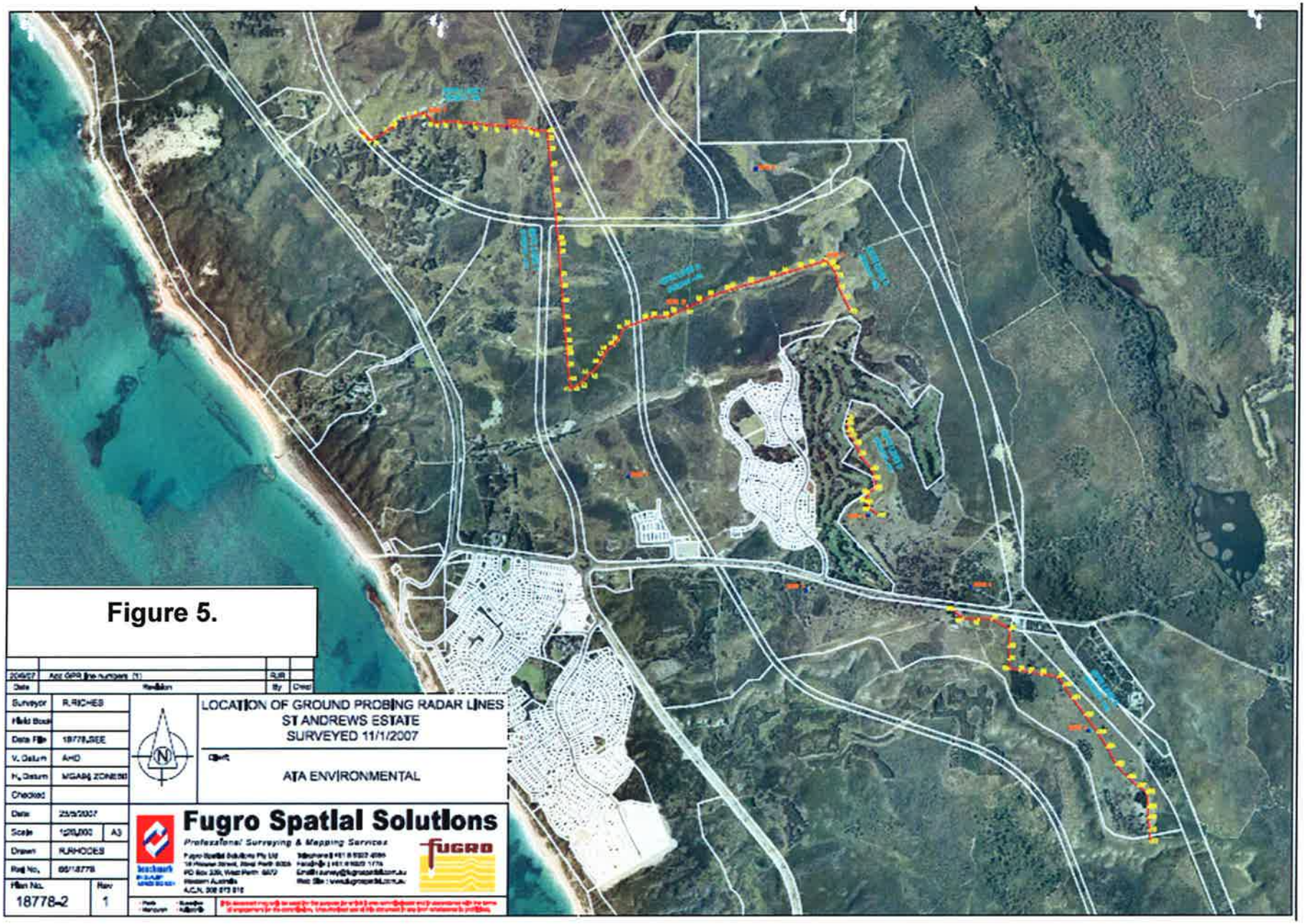


Figure 5.
LOCATION OF GROUND PROBING RADAR LINES
ST ANDREWS ESTATE
SURVEYED 11/1/2007
ATA ENVIRONMENTAL
Fugro Spatial Solutions
Professional Surveying & Mapping Services
FUGRO
Surveyor R.RICHES
Data File 18778_SEE
V. Datum AHD
H. Datum MGA94 ZONE50
Date 25/5/2007
Scale 1:20,000 A3
Drawn RJRHODES
Plan No. 18778-2
Rev 1

6. GPR SURVEY LOGISTICS

The GPR data was recorded by Richard Yelf and Daniel Yelf of Georadar Research Pty Ltd between the 10 – 13 January, 2007. The survey work was supervised and facilitated by Mark Shepherd of ATA Environmental Pty Ltd.

The radar lines were recorded using an enhanced dual channel GSSI SIR-10R system which was mounted in a Toyota Landcruiser 4WD.

6.1 Antenna Tests

Prior to the production survey, extensive tests were done using two shielded antennae of different frequencies used simultaneously. These antennae were mounted on a survey trolley (Figure 6) and towed behind the 4WD vehicle (Figure 7) while continuously recording the GPR data.

For the preliminary tests, Channel 1 of the survey system was recorded with an antenna with a nominal centre frequency of 200 MHz providing approx. 5 m penetration. This 200 MHz antenna was mounted in the front of the survey trolley and connected to the radar control unit via a 13 m control cable. This produced high resolution images of individual calcarenite pinnacles within the sand overburden.

Channel 2 of the radar survey system was connected to a separate transmitter and receiver (called a bistatic pair), with a nominal centre frequency of 100 MHz. These 100 MHz antennae were mounted at the rear of the survey trolley and connected to the control unit via a 17.5 m control cable. A fibre optic trigger was used to control the 100 MHz antennae, ensuring no direct coupling between the transmitter and receiver units. This configuration provided approximately 12 m penetration depth.

Figure 6. (Facing southwest): GPR survey trolley containing 200 MHz antenna (front) and a 100 MHz antennae bistatic pair (rear). The trolley is positioned at peg 1/1 at the start of GPR Survey Line 01, during the preliminary antenna-testing phase of the GPR survey.

Figure 7. Antenna array with 200 MHz and 100 MHz antennae used for recording the trial GPR Survey lines. The trolley was pulled by a 4WD along the pre-graded path. Distance was measured via a survey wheel (fitted with an optical encoder) attached to the rear of the 4WD. Position marks were inserted onto the radar data as the antennae passed adjacent to the survey pegs.

Further trials were conducted with various configurations and electronics boards to maximise the penetration depth with the 100 MHz antenna. Considerable research effort was expended to achieve a maximum depth range, while minimising system noise and interference. As a result of these trails the penetration depth was increased to in excess of 20 m, at the expense of increased signal ringing.

At the conclusion of the trial survey period, the data from the trials were critically reviewed on site to obtain the optimal settings for the production survey. These settings were then applied universally to the production survey to provide consistency between all of the GPR survey lines.

6.2 Production GPR Survey

At the client's request, the production survey concentrated on using the 100 MHz antenna in single channel mode (Figure 8) configured to obtain maximum depth penetration.

The GPR data was recorded centrally along the graded path adjacent to the survey pegs. The distance travelled along each survey line was measured with a precision encoder wheel mounted on the rear of the survey vehicle. The length of each GPR line was limited to approximately 500 m to maintain a reasonable size for each of the digital data files. Digital marks were manually inserted into the GPR data as the antennae passed adjacent to the survey pegs. Marks were also placed at other significant points, such as intersecting survey lines and nearby boreholes. These

features and marks are recorded in our field observer's logs. Copies of these observer's logs have been already been supplied to ATA Environmental Pty Ltd.

Figure 8. GPR survey trolley with bistatic pair of 100 MHz antennae as used for the production survey. The trolley is positioned near Peg 99 on GPR Survey Line 06.

In total, 24 GPR data files were recorded at Yanchep Farm. Details of these files are summarised in Table 1 entitled "Summary of GPR Lines" in the Appendix. [1] The coordinates of the survey lines and pegs are shown in Table 2 in the Appendix.

Plans showing the locations of each of the survey lines are also given in the Appendix.

Further details of each survey line are given below:

- Survey Line 01 was recorded between pegs 1/1 and 1/20 inclusively in the direction from approximately west to east. Line 01 was recorded in four parts, each part with a separate GPR file, named 01_A to 01_D respectively.

- Survey Line 02 was recorded between pegs 2/20 and 2/41 inclusively, running in the direction approximately from north to south, The GPR survey line was recorded in four parts, named 02_A to 02_D.

[1] Table 1 lists details of the survey lines arranged logically in numerical order, rather than the sequence in which the files were actually recorded.

- Survey Line 03 was recorded between pegs 3/41 and 3/67 inclusively, in the direction from approximately from southwest to northeast. The GPR survey line was recorded in four parts, named 03_A to 03_D.

- Survey Line 04 was recorded between pegs 4/67 and 4/73 inclusively, in the direction approximately from north to south. The survey line was recorded with a single file, named 04_A.

- Survey Line 05 was recorded between pegs 5/74 and 5/87 inclusively, approximately north to south. The GPR survey line was recorded in two parts, named 05_A and 05_B.

- Survey Line 06 starts at peg 6/88 and finishes at peg 6/112. The line changes direction on multiple occasions, deviating between west-east, northwest-southeast and north-south. The GPR survey line was recorded in five parts, named 06_A to 06_E respectively.

7. GEOLOGICAL SETTING

Yanchep farm lies in a geomorphic province termed the Spearwood Dune System (McArthur and Bettenay, 1960) that extends as a 15 km wide ridge along the edge of the Swan Coastal Plain. The ridge rises from the Indian Ocean shore to various inland crests at 20 m to 80 m AHD [2]

The System is a complex of shore-face beds, longitudinal beach-ridges and dunes and parabolic dunes composed of calcareous sand (calcarenite). These sediments were deposited along shores probably related to fluctuating high-stand sea levels of the Wurm interglacial stage, about 120,000 years ago (Teichert, 1967; Veeh 1966).

The Spearwood deposits are variable admixtures of calcitic, skeletal fragments from marine organisms and lesser quantities of quartz grains. During the millennia since deposition, the depositional landforms forms have been considerably reduced and internally modified by complex karstification and soil-forming processes linked to groundwater behaviour. The alteration product is an extensive 10 m to 60 m thick stratigraphic sequence termed the Tamala Formation consisting of soil, strongly lithified calcarenite layers and karstogenic deposits.

TAMALA FORMATION

The geological formation underlying the Spearwood Province is denoted as the "Tamala Formation" in this and related project reports. In the Yanchep –Two Rocks area the Tamala Formation is composed of two intergradational units. In stratigraphic order, these are:

Top of Tamala Section

Tamala Fm. Layer 2, (thickness 0 m to 20 m): Sand, yellow and grey-brown, medium-grained, quartz sand with occasional decimeter-thick layers of calcrete and calcareous sandstone.

Tamala Fm. Layer 1, (variable thickness; 10 m to 50 m): Mostly strongly consolidated calcarenite and quartzose calcarenite sandstone (commonly logged as "limestone"). This calcarenite is host to abundant karst features.

Bottom of Tamala Section

Tamala Layer 2 is characterised by a residual soil consisting of quartz sand, weathered rock fragments, and root moulds. It results from decalcification of the ancestral limey, quartzose sand. The decalcification is a leaching process related to gravitational percolation of acidic rainwater. In the long-term, decalcification advances downward to create a residual soil layer over an irregular top on the

[2] Geological setting based on notes prepared by Dr B. Logan, February 2005.

underlying parent calcarenite.

Tamala Layer 1 is characterized by calcarenite, a sedimentary rock composed of a variable admixtures of calcareous, skeletal-fragments from marine organisms and detrital quartz grains. The fragments and grains are cemented by intergranular crystal mosaics composed of calcite that provide varying degrees of coherence.

Layer 1 has a strongly layered structure with decimetre- to centimetre-thick calcarenite beds that are separated by prominent partings. The stratification reflects layer-by-layer differences in composition (quartz grains v. skeletal fragments) and in cementation intensity. Frequently beds and bed packages are continuous over distances of hectometres and they also dip at angles up to about 40 degrees from horizontal. The dips reflect the original dune morphology.

Layer 1 is host to abundant karst features that include: - interlinked metre- to decametre-high caverns; grikes (fissures), windows (roof-collapse structures) and breccias composed of host rock-fragments. There are brief accounts of caves in the Yanchep-Two Rocks area in various local reports (internet publ.) and by Anderson et al, (2002). One report states that there are over 1,000 caves in the Yanchep-Two Rocks area but presents no evidence for this assertion. The well-known Yanchep Caves are described as of "fissure-type" and are up to several metres to a decametre or so in height.

Formation thickness is important in limiting the extent of karst development, with thicker sections providing opportunities for more extensive karst domains, other generative factors being equal. The thickness of Layer 1 probably varies as with the ancestral dune landform. Thus under ridges which are dune remnants thickness ranges to about 50 m. In low areas that formerly were inter-dune swales, limestone thickness probably is about 20 m to 30 m.

Figure 9: Calcified pinnacles located near the start of GPR Survey Line 02-C near survey Peg 2/31.

8. SURVEY RESULTS

The results of the survey are is presented in the Appendix of this report and also as digital data files on the accompanying CD in the following formats:

RAW DATA – GSSI standard format *.dzt files suitable for viewing and processing by using GSSI's RADAN Program [3].

Refer to Table 1 in the Appendix for details.

Examples of the raw field data recorded from the high powered 100 MHz antennae are shown below in Figures 10 and 11. Chainage distance is shown across the top of the record and the approximate depth is shown on the right on the screen.

PROCESSED DATA – Horizontally filtered and topographically corrected data in REFLEX format (these files can be converted to GSSI *.dzt format if required).

WORD PLOTS – Low resolution images of the processed Very High Power 100 MHz data as labelled MS-WORD plots, showing peg locations and summary geological comments.

These plots are included in the Appendix of this report and on the accompanying CD.

BIT MAP IMAGES – High Resolution images of processed topographically corrected High Power 100 MHz data as unlabelled bitmaps, showing the chainage distance along the top of each plot (zoom in to read the chainage distance).

[3] ATA Environmental owns a registered copy of this GSSI software.

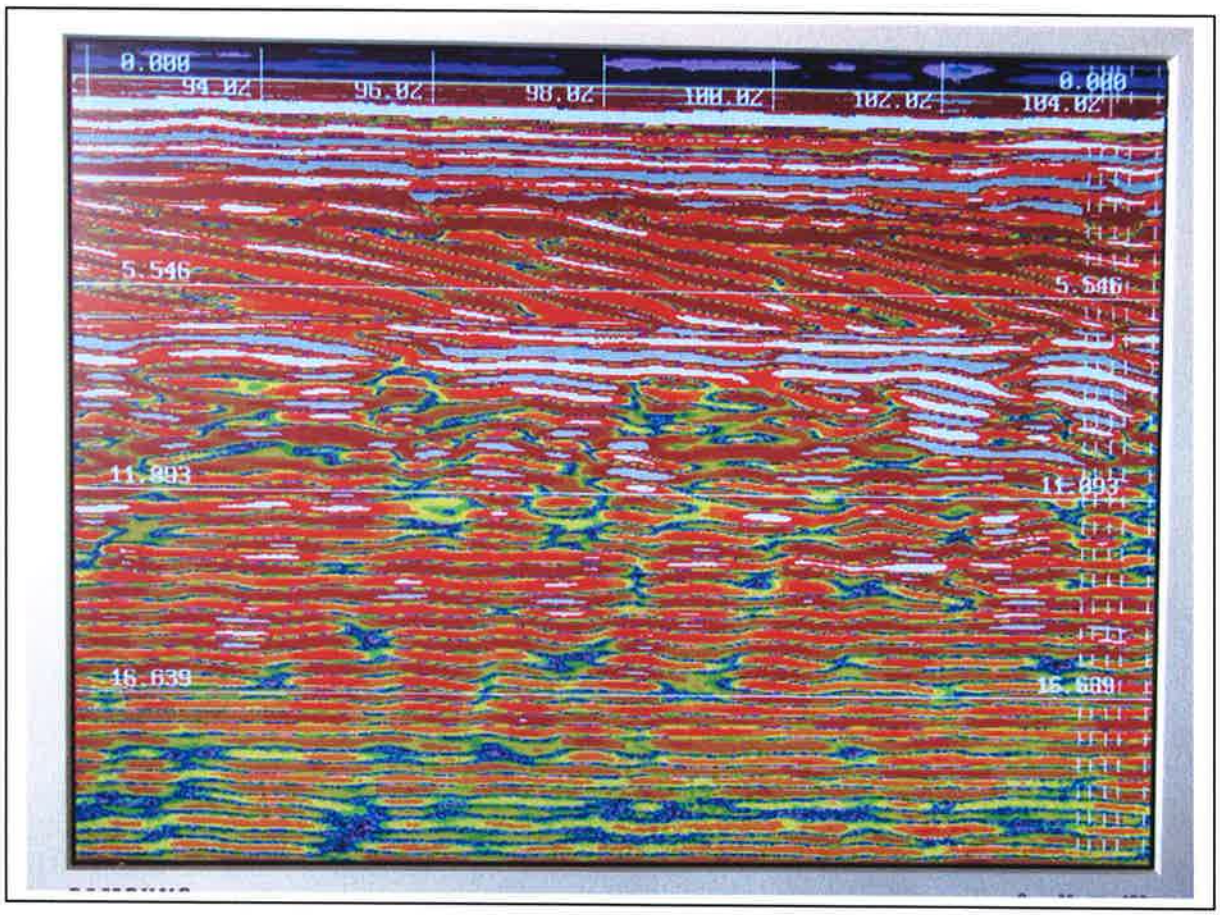


Figure 10: Raw radar data photographed in the field off radar screen from GPR Survey Line 1 (data file D01-BB), recorded on Survey Day 1.

The chainage distance (in metres) from the start of Line 1 is shown across the top of the screen. Depth (in metres) is shown on the right of the screen. Vertical dashed white marks on the data screen denote the position BH 7 at Peg 1/9. Note the dipping avalanche fore sets in the upper sand layers and strong calcaranite reflector at 6 m depth. Note also numerous subvertical solution channels through the calcarenite.

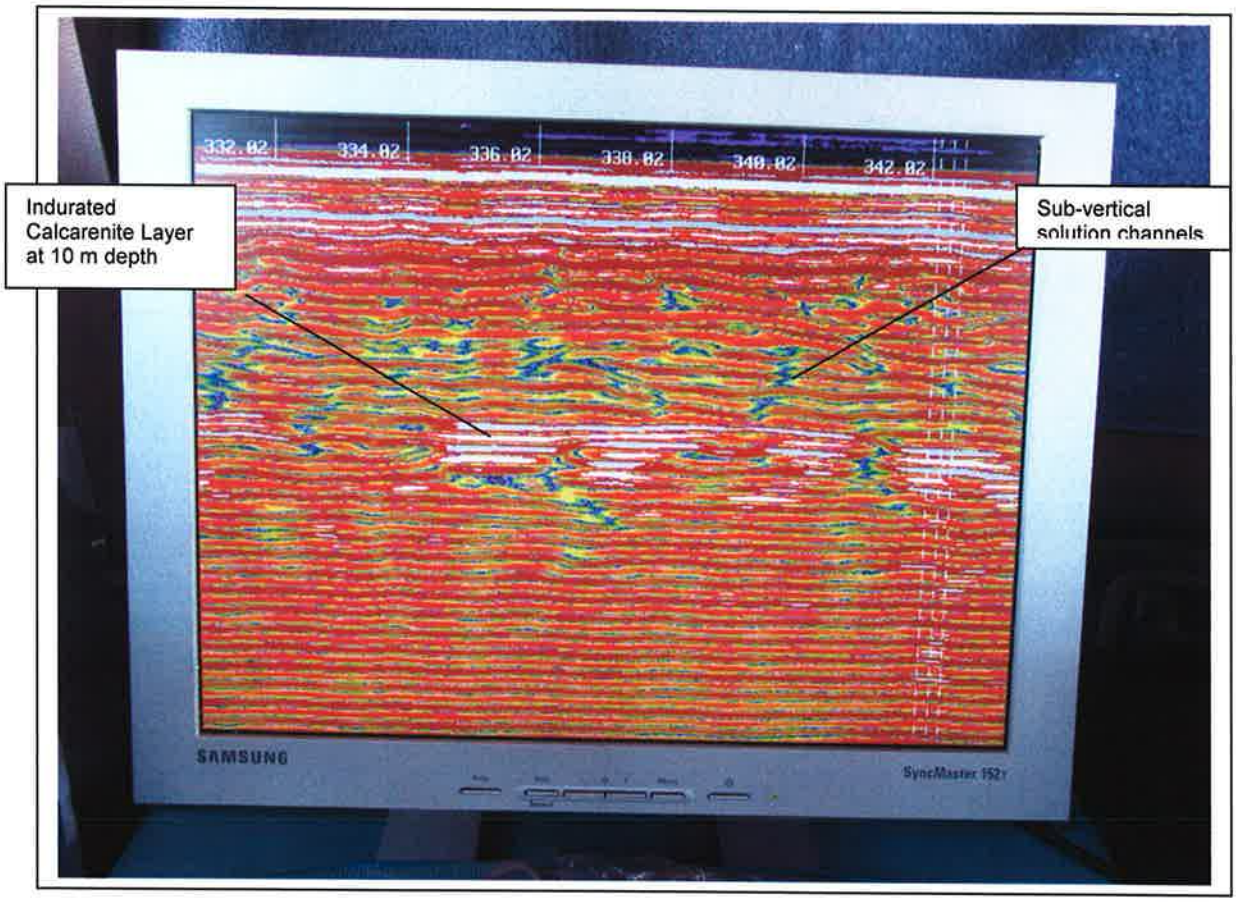


Figure 11: Indurated calcarenite limestone layer visible at 10 m on raw data from GPR Line 3 (Data file 03_A). The three vertical dashed lines indicate the location of Survey Peg 3/48. Note the subvertical solution channels through the partly cemented sand overlying calcarenite.

9. PRELIMINARY CONCLUSIONS

1. A GPR survey has been conducted along 6 transect lines across the St Andrew Estate on Yanchep Farm, Yanchep, W. A.

2. An initial trial survey was conducted using dual frequency antennae. A 200 MHz antenna was used to image the subsurface to 5 m depth and a pair of 100 MHz antennae with standard and high powered transmitters were utilised to image to depths of approximately 12 and 21 m respectively.

3. The 200 MHz data showed excellent resolution of the buried karstic surface and the presence or absence of calcarenite limestone pinnacles. This mode would be useful for geotechical purposes for siting individual house blocks.

4. At the client's request the production survey was conducted using the high powered 100 MHz antenna with a time range of 350 ns (approx. 21 m depth at a velocity of 0.1267 m/ns).

5. The 100 MHz data showed layers of cemented calcarenite limestone, which appear to overlie cemented sands at typically 10 – 12 m depth.

6. Strong horizontal ringing is present on the high powered 100 MHz data, which makes interpretation difficult especially below 12 m depth. This ringing was partially removed by digital signal processing using a background subtraction filter.

7. Localised sub-vertical solution channels are visible in areas with cemented sands. The channels are clearly developed in areas of jointed limestone on the higher ground. These solution channels appear to mainly have been refilled with loose sand.

8. No large open voids, or cavern-like features, were detected on lines 1 to 6 during the field radar survey. The processed data requires detailed scrutiny for possible voids and to select locations for follow up drilling.

I trust that this summary report and the attached drawings provide you with the information required by your verbal brief.

If you require clarification on any points arising from this investigation, please do not hesitate to contact me.

Yours faithfully

Georadar Research Pty Ltd

Richard Yelf

APPENDIX

Table 1. Summary of GPR Survey Lines

Table 2. Coordinates of Survey Pegs along GPR Lines at St Andrews District, Yanchep.

Plan Showing Location of All GPR Survey Lines 1 -6.

Plans showing Location of Individual Survey Lines 1 – 6.

Processed GPR Data from Survey Lines 1 – 6.

Note: These documents and plots are also presented in either WORD or Excel formats on the accompanying CD.

GROUND PENETRATING RADAR SURVEY AT YANCHEP FARM, W.A.

TABLE 1. SUMMARY OF GPR LINES

GPR SURVEY LINE	START SURVEY PEG	END SURVEY PEG	GPR LINE LENGTH (m)	DATE RECORDED	FIELD SURVEY DAY No.	NOTES
LINE 1						
01_A	1/1	1/7	393	12-Jan-07	3	VHP Tx - DA2 Rx
01_B	1/7	1/9 BH7	106	12-Jan-07	3	VHP Tx - DA2 Rx
01_B2	1/9 BH7	1/15	414	12-Jan-07	3	VHP Tx - DA2 Rx
01_C	1/15	1/20	409	12-Jan-07	3	VHP Tx - DA2 Rx
						VHP Tx - DA2 Rx
01_A	1/1	1/9 BH7	513	13-Jan-07	4	VHP Tx - DA2 Rx
01_A2	1/6	1/9 BH7	164	13-Jan-07	4	VHP Tx. Repeat of last part of line 1-A
01_A3	1/1	1/9 BH7	504	13-Jan-07	4	Med power Tx (777 Board)
TEST 777	-	-	-	13-Jan-07	4	Test Line with Medium Power Tx (777 Board)
LINE 2						
02_A2	2/20	2/26	460	12-Jan-07	3	VHP Tx
02_B	2/26	2/31	424	12-Jan-07	3	"
02_C	2/31	2/37	445	12-Jan-07	3	"
02_D	2/37	2/41	256	12-Jan-07	3	"

GPR SURVEY LINE	START SURVEY PEG	END SURVEY PEG	GPR LINE LENGTH (m)	DATE RECORDED	FIELD SURVEY DAY No.	NOTES
LINE 3						
03_A	3/41	3/50	439	12-Jan-07	3	VHP Tx
03_B	3/50	3/57	498	12-Jan-07	3	"
03_C	3/57 / BH 10	3/63	558	12-Jan-07	3	"
03_D	3/63	Approx 105 m past peg 3/67	330 + 105	12-Jan-07	3	"
LINE 4						
04_A	4/67	7.5 m before peg 4/73	335	12-Jan-07	3	VHP Tx
LINE 5						
05_A	5/74	5/81	426	13-Jan-07	4	VHP Tx
05_B	5/81	ends 224 m past peg 5/87	306 + 224 extension	13-Jan-07	4	"
LINE 6						
06_A	6/88	6/93	514	13-Jan-07	4	VHP Tx
06_B	6/93	6/99	464	13-Jan-07	4	"
06_C	6/99	6/103	436	13-Jan-07	4	"
06_D	6/103	6/108	501	13-Jan-07	4	"
06_E	6/108	6/112	380	13-Jan-07	4	"

VHP = Very high powered (1,000 volt) Transmitter.

DA2 = Dual stage high senstivity receiver

Table 2. Coordinates of Survey Pegs along GPR Lines at St Andrews District, Yanchep

Survey Date: January 2007
Projection - Perth Coastal Grid

LINE No.	Peg Number	Easting	Northing	RL	GPR LINE No.	DIFF. EASTING	DIFF NORTHING	HYP. DISTANCE	CUM. DIST	Y	RL
01_A	1	31496	311121	37.05	Start Line 1				0.00	0	37.05
	1A	31537	311093	35.743		40.7	-27.5	49.2	51.00	0	35.743
	2	31565	311059	30.023		27.4	-34.1	43.7	94.00	0	30.023
	2A	31591	311073	28.665		26.6	14.1	30.1	126.00	0	28.665
	3	31671	311115	31.128		80.2	42.1	90.6	216.00	0	31.128
	4	31720	311146	35.55		48.6	30.3	57.3	274.00	0	35.55
	5	31730	311159	36.834		9.8	13.3	16.6	291.00	0	36.834
	6	31759	311193	35.233		29.4	34.0	44.9	338.00	0	35.233
	7	31816	311200	36.62		56.3	6.8	56.7	394.00	0	36.62
	8	31863	311213	37.861		47.3	13.3	49.1	442.00	0	37.861
	9	31916	311227	38.436		52.8	13.7	54.5	503.00	0	38.436
01_B2	9	31916	311227	38.436					0.00	0	38.436
	10	31964	311176	41.64		48.8	-51.2	70.7	76.00	0	41.64
	11	31980	311164	38.533		15.7	-12.1	19.8	96.00	0	38.533
	12	32039	311172	34.054		59.3	8.9	60.0	158.00	0	34.054
	13	32126	311168	35.131		86.7	-4.6	86.8	244.00	0	35.131
	14	32228	311157	30.842		102.0	-10.6	102.6	348.00	0	30.842
	15	32293	311150	33.446		64.9	-7.4	65.3	414.00	0	33.446
01_C	15	32293	311150	33.446					0	0	33.446
	16	32364	311143	28.317		70.7	-6.6	71.0	70	0	28.317
	17	32479	311131	30.526		115.3	-12.4	116.0	186	0	30.526
	18	32580	311124	41.885		101.0	-6.6	101.2	291	0	41.885
	19	32624	311110	38.739		43.5	-14.7	45.9	336	0	38.739
	20	32695	311101	39.072	End Line 1	71.9	-8.5	72.4	409	0	39.072

LINE No.	Peg Number	Easting	Northing	RL	GPR LINE No.	DIFF. EASTING	DIFF NORTHING	HYP. DISTANCE	CUM. DIST	Y	RL
02_A2	20	32695	311101	39.072	Start Line 2				0.00	0	39.07
	21	32701	311054	34.071		5.6	-47.4	47.7	47.70	0	34.07
	22	32706	310985	34.95		4.8	-68.5	68.7	116.40	0	34.95
	23	32715	310888	29.647		9.7	-97.2	97.6	214.04	0	29.65
	24	32724	310795	27.633		8.5	-93.1	93.5	307.54	0	27.63
	25	32730	310721	26.591		6.4	-74.0	74.3	381.84	0	26.59
	26	32741	310629	25.031		10.4	-92.1	92.7	474.54	0	25.03
02_B	26	32741	310629	25.031					0.00	0	25.03
	27	32746	310539	26.379		4.9	-89.9	90.1	90.06	0	26.38
	28	32757	310422	22.785		11.1	-117.0	117.5	207.56	0	22.79
	29	32766	310386	23.059		9.4	-36.1	37.3	244.87	0	23.06
	30	32764	310336	23.823		-2.0	-49.9	49.9	294.80	0	23.82
	31	32774	310193	32.332		9.6	-143.3	143.7	438.46	0	32.33
02_C	31	32773.79	310192.6	32.332					0.00	0	32.33
	32	32779	310121	28.421		5.6	-71.4	71.6	71.60	0	28.42
	33	32786	310029	25.752		6.2	-92.3	92.5	164.08	0	25.75
	34	32793	309923	28.966		7.8	-105.9	106.2	270.28	0	28.97
	35	32801	309836	33.289		7.2	-87.1	87.4	357.63	0	33.29
	36	32806	309769	33.201		4.9	-66.5	66.7	424.34	0	33.20
	37	32809	309723	36.874		3.6	-46.0	46.2	470.50	0	36.87
	38	32812	309691	35.174		2.5	-32.5	32.5	503.04	0	35.17
02_D	38	32811.61	309691	35.174					0.00	0	35.17
	39	32817	309617	38.196		5.1	-74.1	74.3	102.00	0	38.20
	40	32825	309526	36.798		8.3	-90.9	91.3	190.00	0	36.80
	41	32834	309458	35.417	End Line 2	9.1	-67.8	68.5	256.00	0	35.42
03_A	41	32834.17	309458.1	35.417	Start Line 3				0.00	0	35.42
	42	32880	309488	34.886		46.1	30.1	55.1	56.00	0	34.89
	43	32913	309506	35.346		32.4	17.3	36.7	91.00	0	35.35
	44	32946	309554	37.558		33.0	48.5	58.6	150.00	0	37.56
	45	32971	309563	35.736		25.0	8.6	26.5	176.00	0	35.74
	46	33023	309631	31.58		51.8	68.0	85.5	260.00	0	31.58
	47	33049	309676	36.727		26.2	45.8	52.8	308.00	0	36.73
	48	33065	309705	37.848		16.0	28.4	32.6	342.00	0	37.85
	49	33115	309740	34.715		50.7	35.2	61.7	402.00	0	34.72

Table 2. Coordinates of GPR Line Survey Pegs at Yanchep 2007_6.xls

LINE No.	Peg Number	Easting	Northing	RL	GPR LINE No.	DIFF. EASTING	DIFF NORTHING	HYP. DISTANCE	CUM. DIST	Y	RL
	50	33139	309770	32.693		23.2	29.6	37.6	439.00	0	32.69
03_B	50	33138.59	309769.8	32.693					0.00	0	32.69
	51	33169	309839	32.373		30.7	69.3	75.8	74.00	0	32.37
	52	33214	309860	37.641		44.3	21.2	49.1	122.00	0	37.64
	53	33328	309904	36.667		114.9	43.5	122.8	238.00	0	36.67
	54	33359	309917	32.624		30.7	12.8	33.2	272.00	0	32.62
	55	33456	309913	32.359		97.1	-3.4	97.1	362.00	0	32.36
	56	33503	309938	32.851		47.0	24.3	52.9	412.00	0	32.85
	57	33587	309976	33.032		83.7	38.5	92.1	498.00	0	33.03
03_C	57	33586.83	309976	33.032					0.00	0	33.03
	58	33667	310012	32.282		80.6	35.6	88.1	85.00	0	32.28
	59	33738	310046	36.179		71.0	34.1	78.8	160.00	0	36.18
	60	33849	310079	43.149		110.9	33.0	115.7	270.00	0	43.15
	61	33885	310094	41.425		35.7	14.9	38.7	308.00	0	41.43
	62	33998	310124	37.666		113.4	30.3	117.3	424.00	0	37.67
	63	34135	310164	34.668		136.6	40.4	142.4	558.00	0	34.67
03_D	63	34134.95	310164.4	34.668					0.00	0	34.67
	64	34213	310189	37.931		77.6	24.2	81.3	80.00	0	37.93
	65	34314	310217	42.411		101.8	28.3	105.7	181.00	0	42.41
	66	34385	310238	36.343		70.9	21.3	74.0	252.00	0	36.34
	67	34463	310260	34.751	**End Line 3**	77.6	22.0	80.6	330.00	0	34.75
04_A	67	34462.77	310260.3	34.751	**Start Line 4**				0.00	0	34.75
	68	34487	310242	38.664		23.8	-18.6	30.2	21.00	0	38.66
	69	34493	310226	36.313		6.8	-15.6	17.0	39.00	0	36.31
	70	34527	310179	26.189		33.2	-47.5	57.9	96.00	0	26.19
	71	34544	310091	23.421		17.6	-87.2	89.0	180.00	0	23.42
	72	34574	310028	30.725		30.0	-63.6	70.3	240.00	0	30.73
	73	34619	309937	40.774	**End Line 4**	45.1	-90.9	101.5	335.20	0	40.77
05_A	74	34597	309255	27.781	**Start Line 5**				0.00	0	27.78
	75	34593	309219	29.839		-3.8	-35.6	35.8	35.84	0	29.84
	76	34595	309172	28.29		1.4	-47.2	47.2	83.03	0	28.29
	77	34612	309145	27.192		16.9	-27.1	32.0	114.99	0	27.19
	78	34643	309094	36.47		31.5	-51.1	60.0	174.97	0	36.47

Table 2. Coordinates of GPR Line Survey Pegs at Yanchep 2007_6.xls

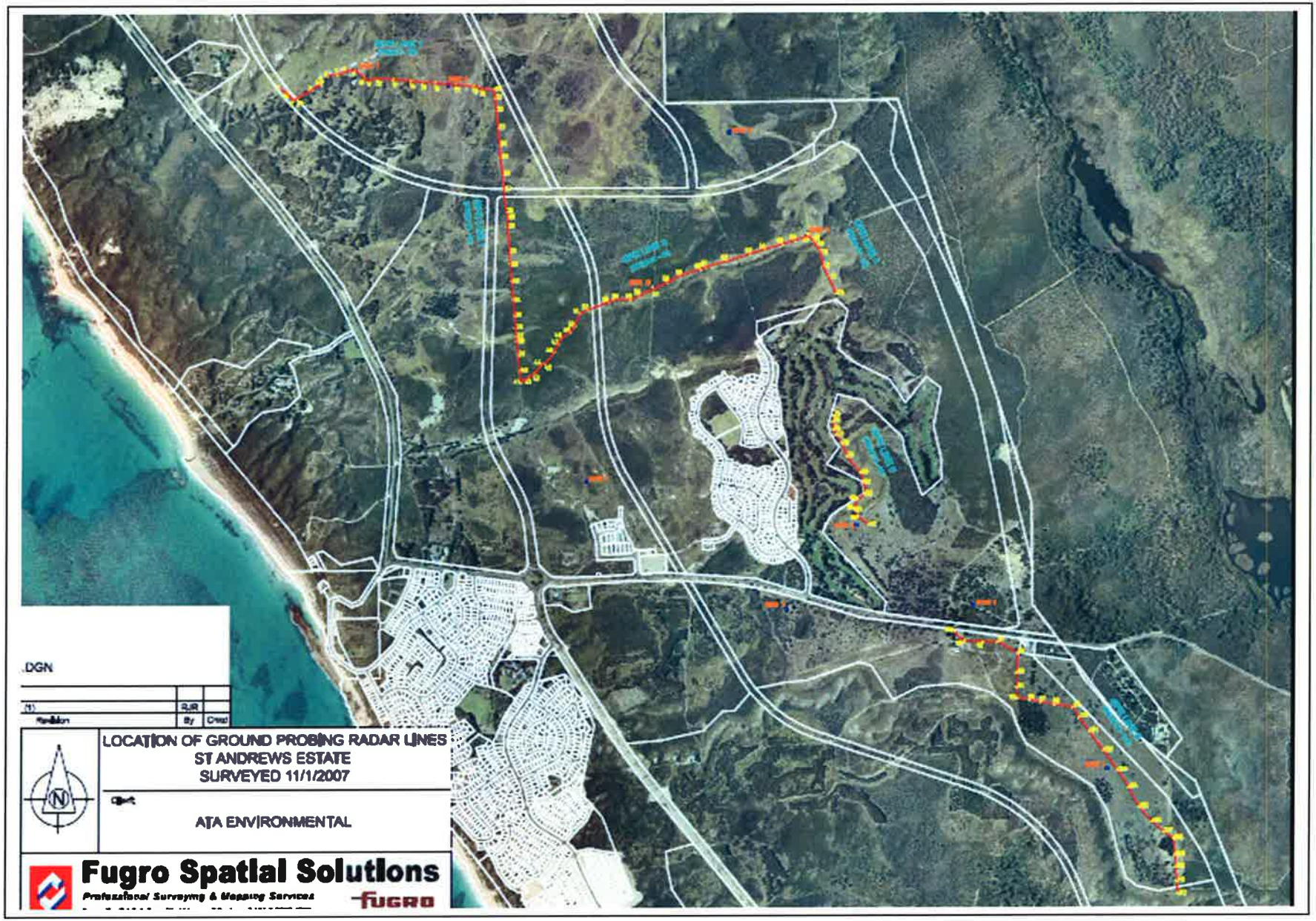
LINE No.	Peg Number	Easting	Northing	RL	GPR LINE No.	DIFF. EASTING	DIFF NORTHING	HYP. DISTANCE	CUM. DIST	Y	RL
	79	34673	309017	33.475		29.8	-76.5	82.1	257.12	0	33.48
	80	34746	308927	32.764		72.6	-89.8	115.5	372.59	0	32.76
	81	34765	308878	29.053		19.7	-49.8	53.6	426.17	0	29.05
05_B	81	34765.34	308877.7	29.053					0.00	0	29.05
	82	34772	308809	31.023		6.4	-69.0	69.3	69.34	0	31.02
	83	34728	308777	30.975		-43.3	-32.1	53.9	123.26	0	30.98
	84	34712	308734	34.134		-16.5	-42.9	45.9	169.16	0	34.13
	85	34715	308723	33.885		3.4	-11.0	11.6	180.71	0	33.89
	86	34729	308679	29.9		13.5	-43.4	45.4	226.14	0	29.90
	87	34793	308635	32.201		63.9	-44.6	77.9	304.05	0	32.20
	EOL				End Line 5	Line extended beyond last peg.			530.00	0	34.00
06_A	88	35264	308029	21.65	Start Line 6	470.8	-606.0	767.4	0.00	0	21.65
	89	35327	307970	21.909		63.4	-58.2	86.1	86.07	0	21.91
	90	35429	307966	19.351		102.4	-4.9	102.5	188.60	0	19.35
	91	35513	307966	19.579		83.2	0.1	83.2	271.75	0	19.58
	92	35629	307898	24.186		116.3	-67.7	134.5	406.28	0	24.19
	93	35619	307791	26.045		-10.0	-107.1	107.6	513.87	0	26.05
06_B	93	35618.81	307790.9	26.045					0.00	0	26.05
	94	35620	307708	24.376		1.5	-82.6	82.6	82.58	0	24.38
	95	35621	307647	19.855		1.2	-61.0	61.0	143.58	0	19.86
	96	35691	307635	17.581		70.0	-11.9	71.0	214.59	0	17.58
	97	35753	307624	18.913		61.1	-11.7	62.2	276.82	0	18.91
	98	35829	307608	17.696		76.1	-15.5	77.7	354.53	0	17.70
	99	35934	307590	24.882		105.2	-17.9	106.8	461.28	0	24.88
06_C	99	35933.96	307590.3	24.882					0.00	0	24.88
	100	35968	307537	24.391		34.2	-53.6	63.5	63.54	0	24.39
	101	36026	307453	22.096		57.5	-83.4	101.3	164.81	0	22.10
	102	36106	307348	24.976		80.7	-105.0	132.4	297.21	0	24.98
	103	36185	307234	25.552		78.7	-114.4	138.8	436.05	0	25.55
06_D	103	36184.92	307234	25.552					0.00	0	25.55
	104	36243	307140	27.691		58.3	-93.9	110.6	110.56	0	27.69
	105	36303	307029	27.272		59.3	-110.8	125.7	236.22	0	27.27
	106	36374	306947	25.54		71.1	-82.4	108.9	345.10	0	25.54

Table 2. Coordinates of GPR Line Survey Pegs at Yanchep 2007_6.xls

LINE No.	Peg Number	Easting	Northing	RL	GPR LINE No.	DIFF. EASTING	DIFF NORTHING	HYP. DISTANCE	CUM. DIST	Y	RL
	107	36441	306888	17.474		67.3	-59.1	89.6	434.69	0	17.47
	108	36495	306851	16.068		53.8	-37.0	65.3	500.03	0	16.07
06_E	108	36494.85	306850.7	16.068					0.00	0	16.07
	109	36503	306760	16.823		8.5	-91.1	91.5	91.46	0	16.82
	110	36507	306691	19.429		3.4	-69.0	69.1	160.53	0	19.43
	111	36515	306611	23.868		8.1	-79.3	79.7	240.21	0	23.87
	112	36519	306540	26.498	End Line 6	3.7	-71.4	71.5	311.75	0	26.50

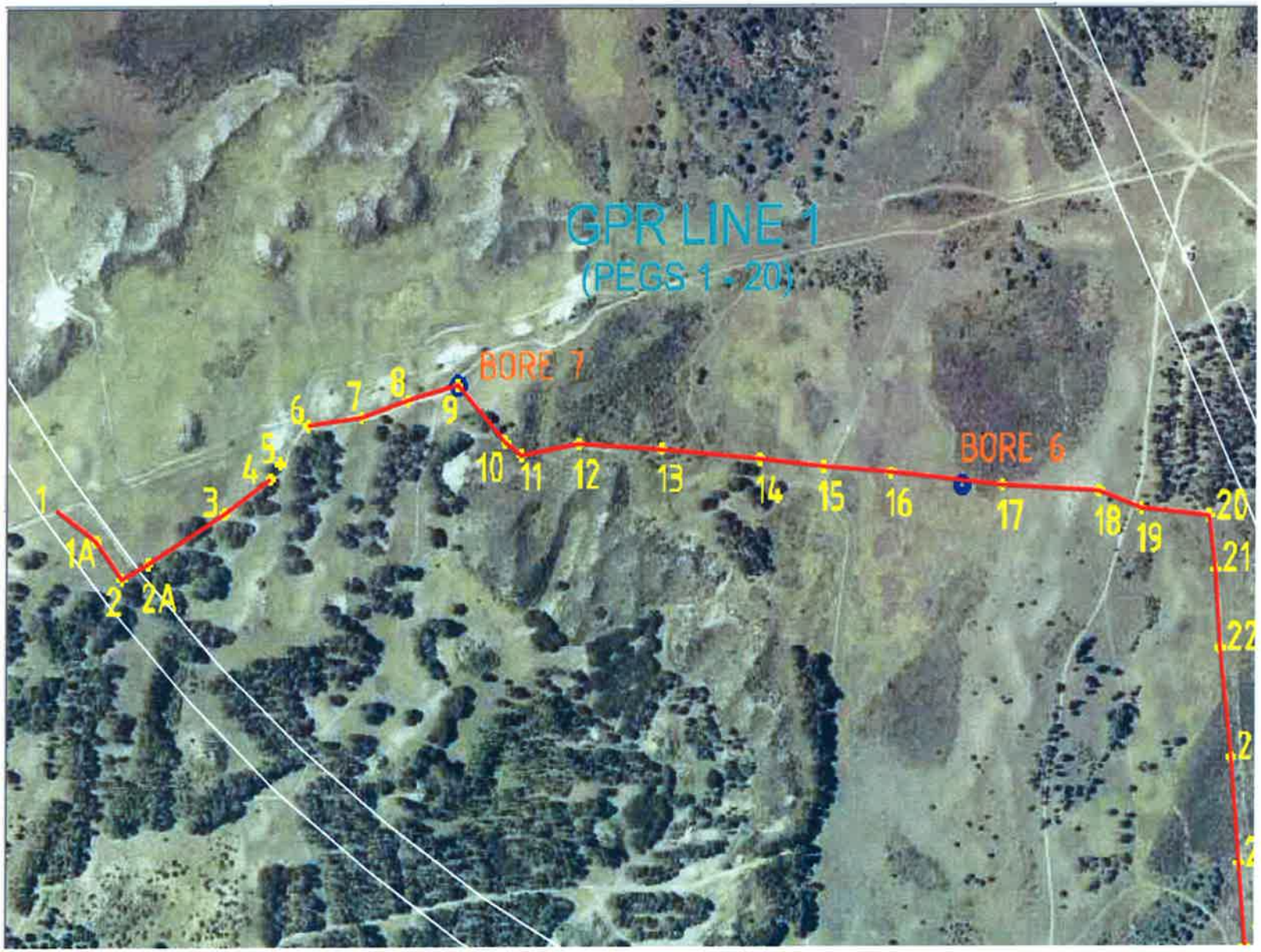
BORE1	36126	307247	22.393
BORE2	34324	308164	22.74
BORE3	35374	308172	26.01
BORE4	34721	308634	31.218
BORE5	33196	308897	33.363
BORE6	32438	311132	28.368
BORE7	31916	311226	38.46
BORE8	34020	310850	32.193
BORE9	34457	310275	32.707
BORE10	33583	309985	32.876

Table 2. Coordinates of GPR Line Survey Pegs at Yanchep 2007_6.xls



Location of GPR Survey Lines 1 - 6.
St ANDREWS ESTATE, YANCHEP

LINE 1



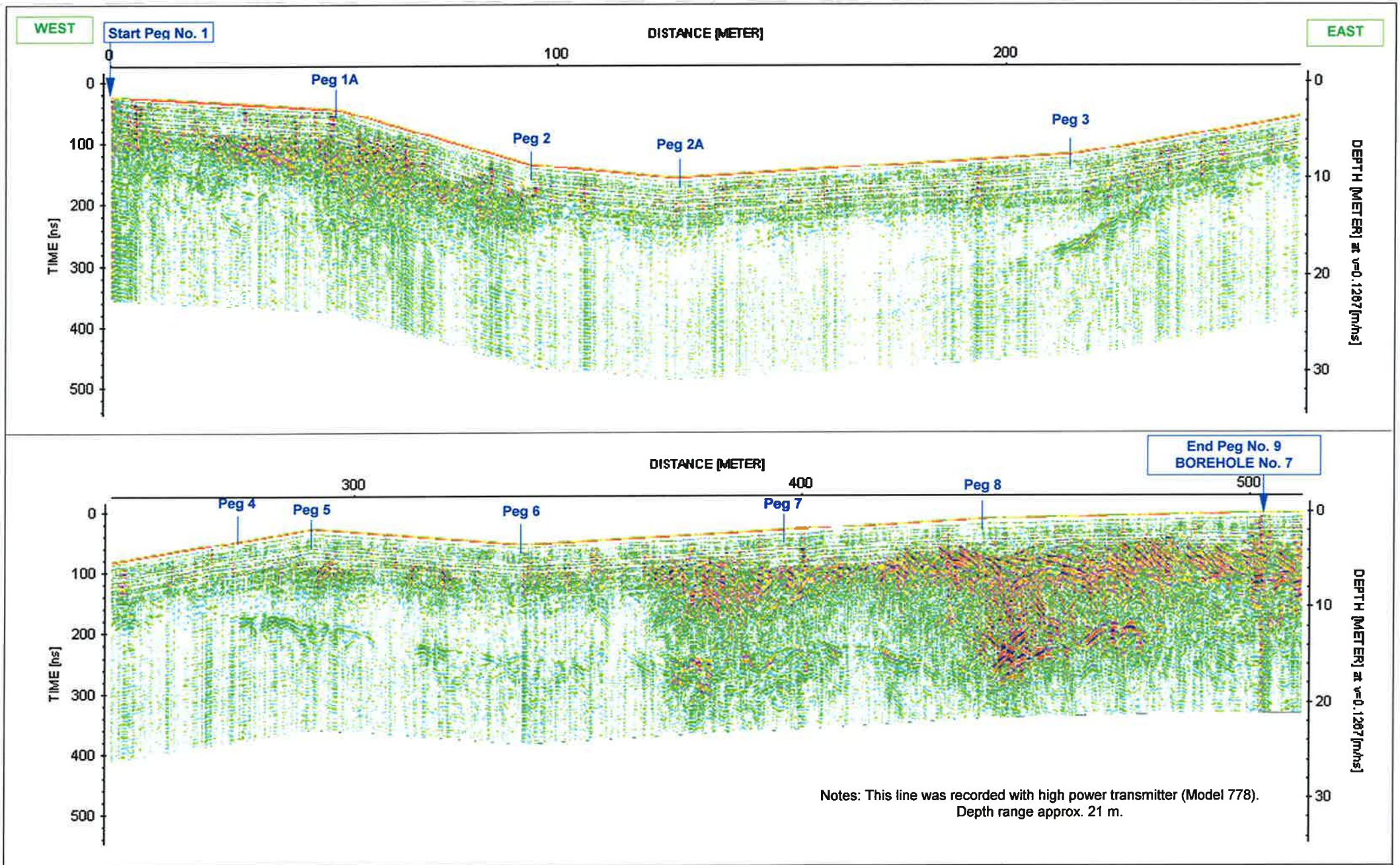
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 1
Survey Pegs 1 – 20



Notes: This line was recorded with high power transmitter (Model 778).
Depth range approx. 21 m.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.

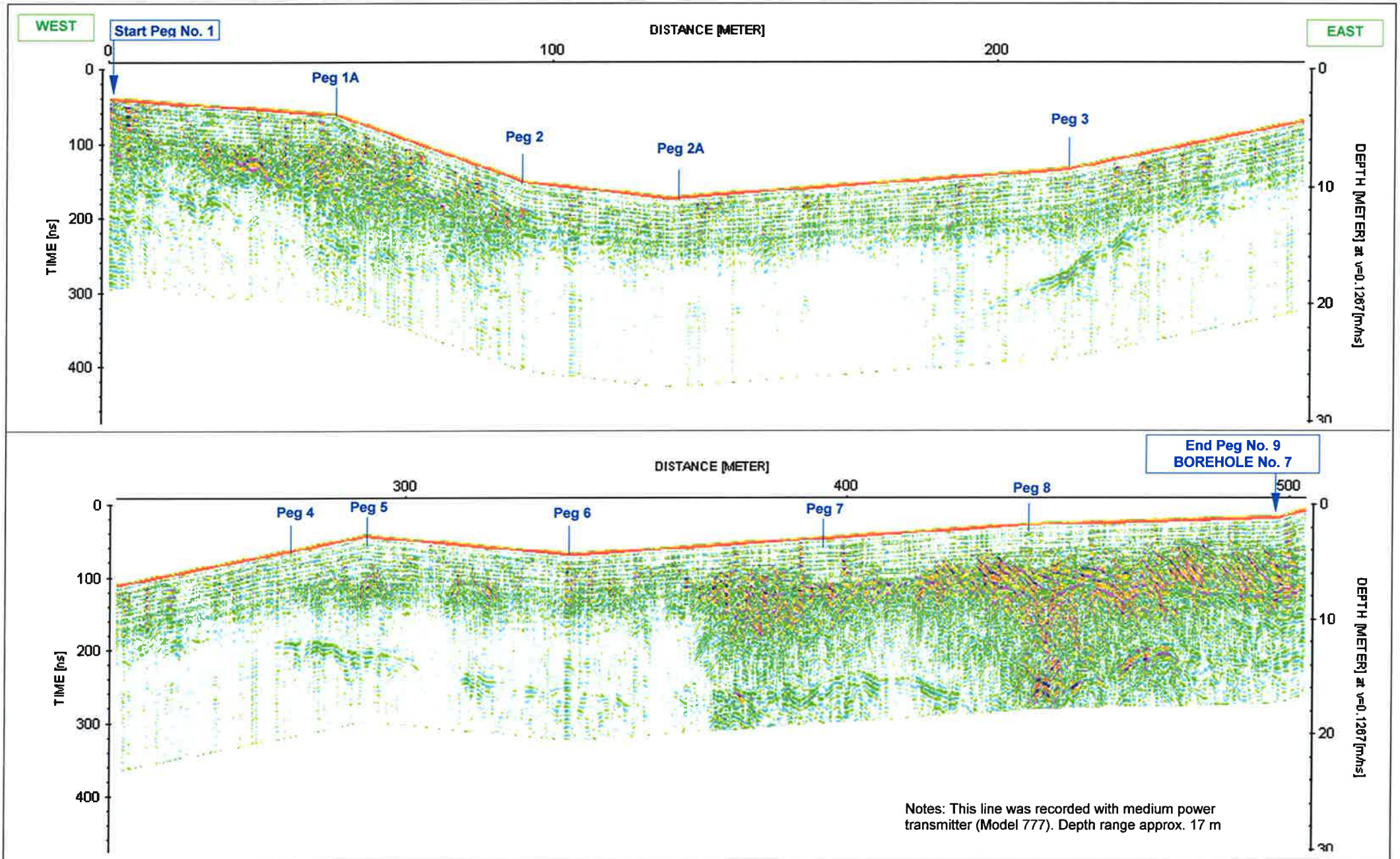
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 01_A

Pegs 1 to 9



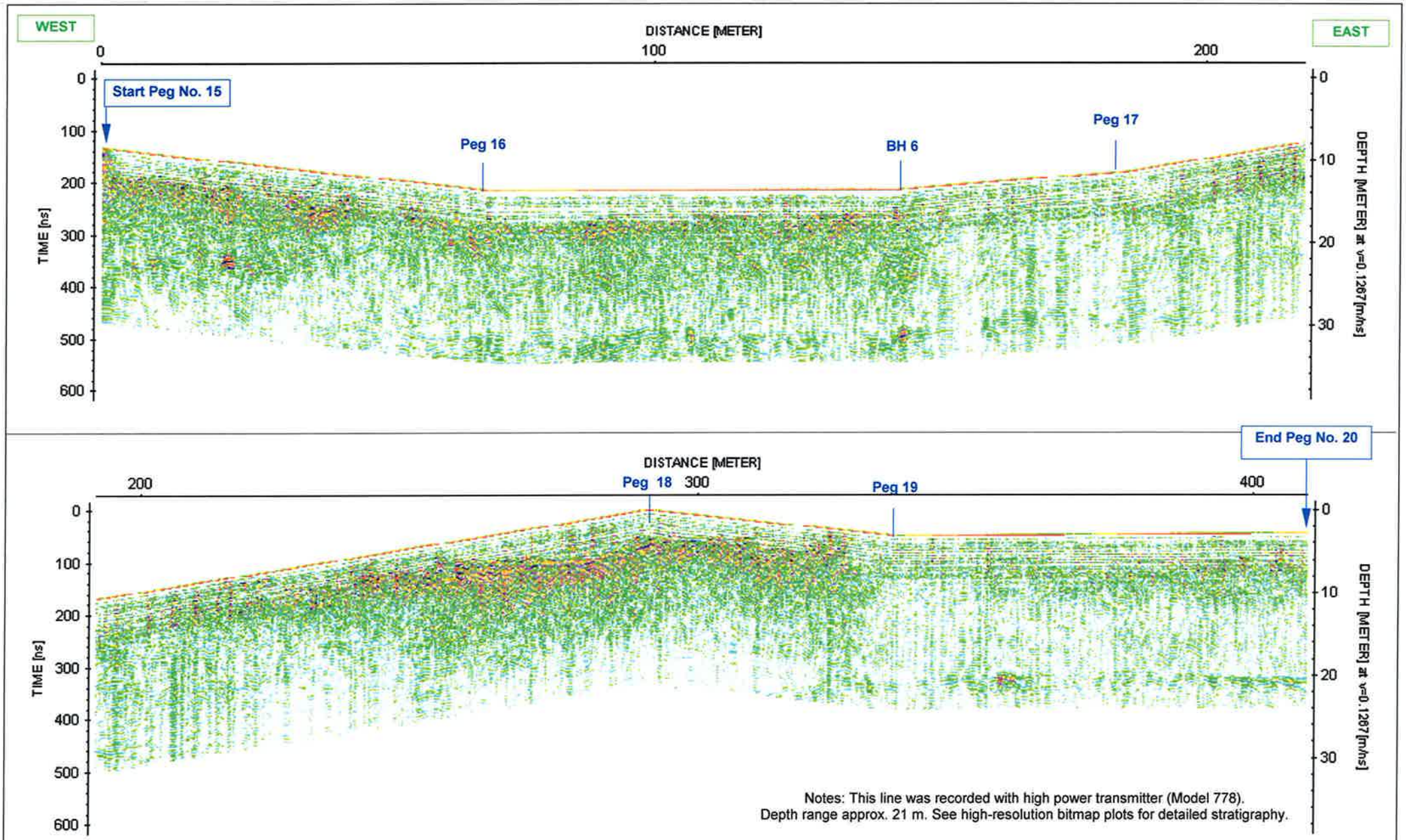
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 01_A3
ELEVATION CORRECTED DATA
Pegs 1 to 9



GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 01_C
Pegs 15 to 20 (EOL)

LINE 2

Note : GPR survey line 2 (pegs 20 – 41) is incorrectly shown in blue as Line 1 on large format base plan supplied by Fugro.

N

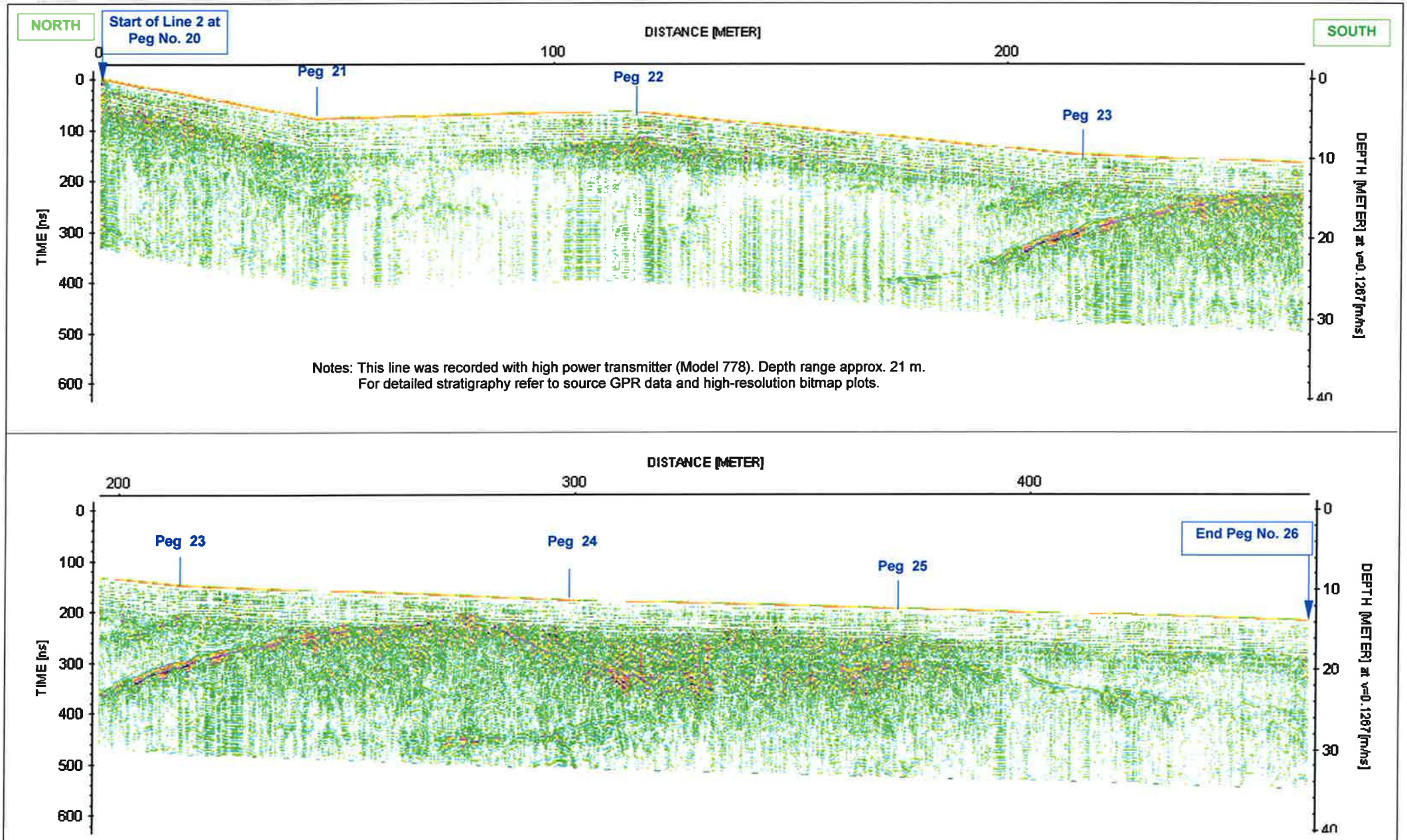
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 2
Survey Pegs 20 – 41



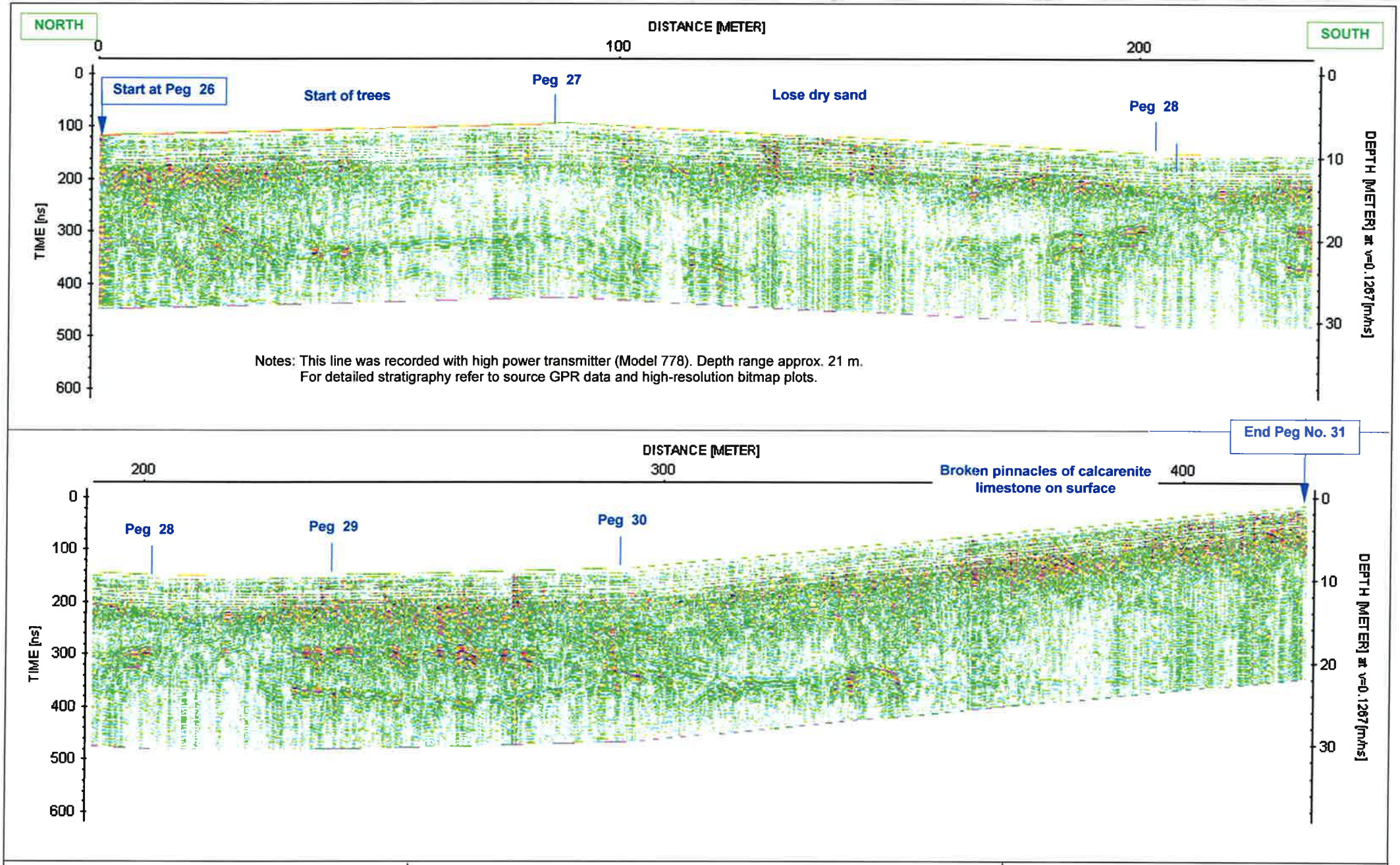
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 02_A2
Pegs 20 to 26



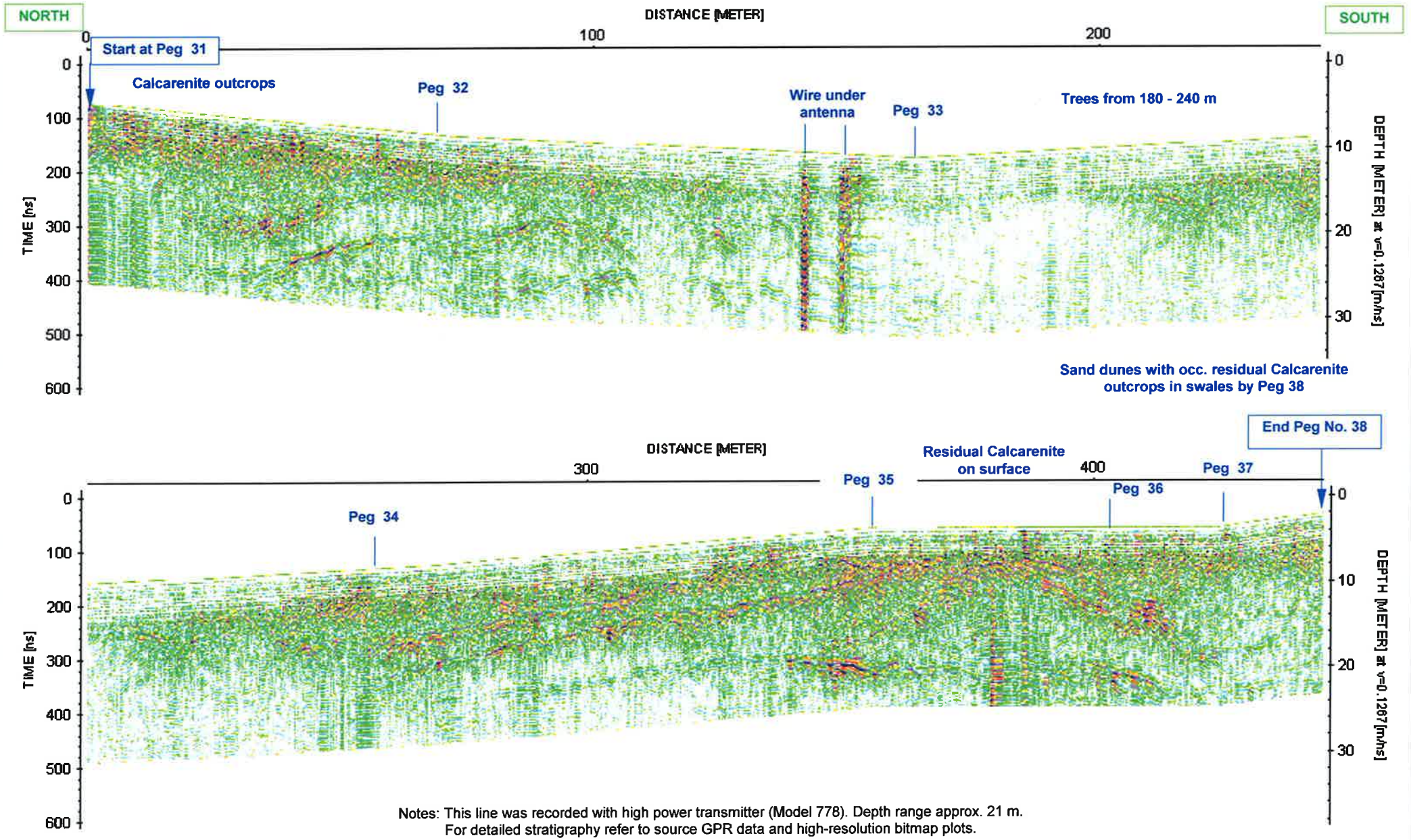
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 02_B
Pegs 26 to 31



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

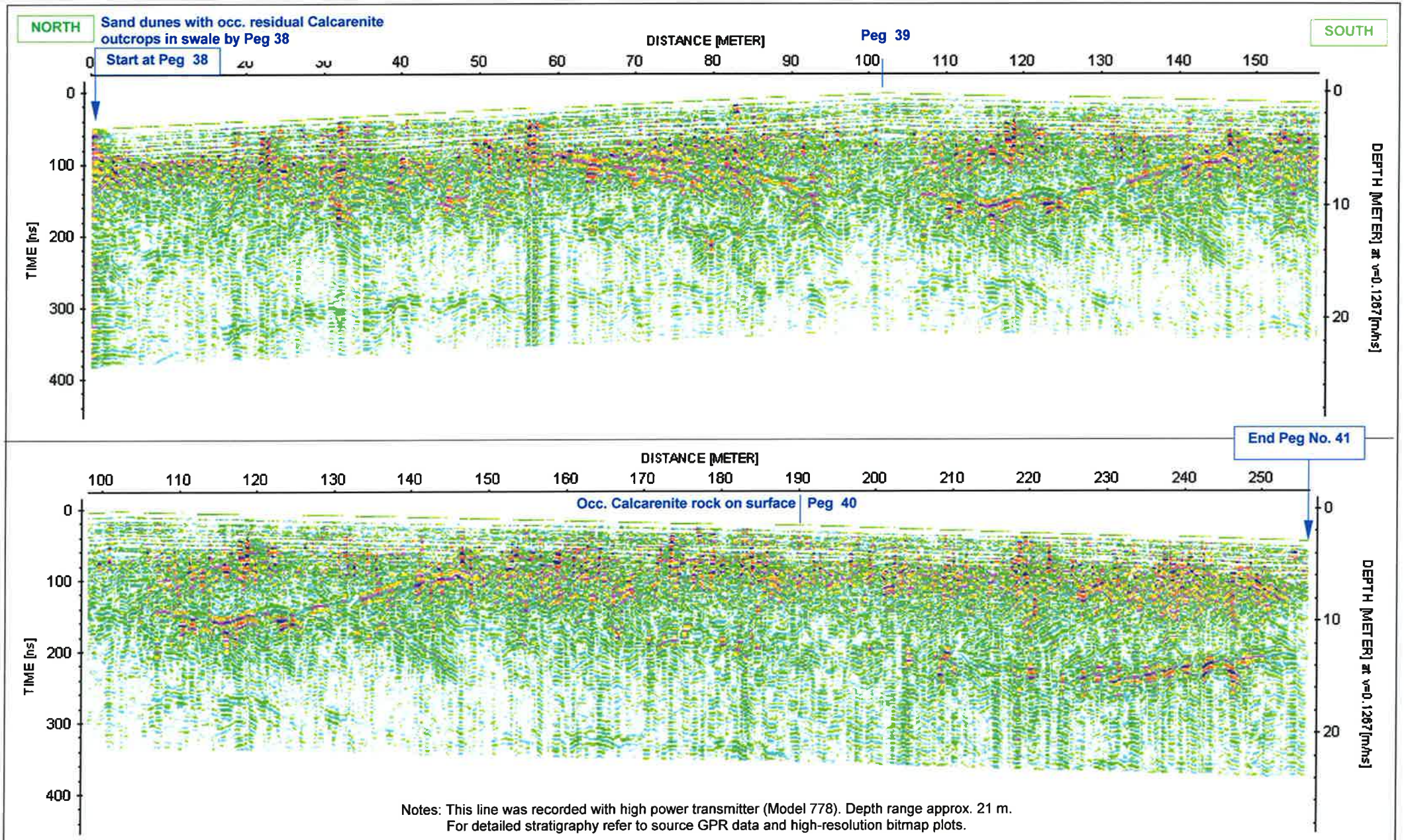
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 02_C
Pegs 31 to 38



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 02_D
Pegs 38 to 41

LINE 3

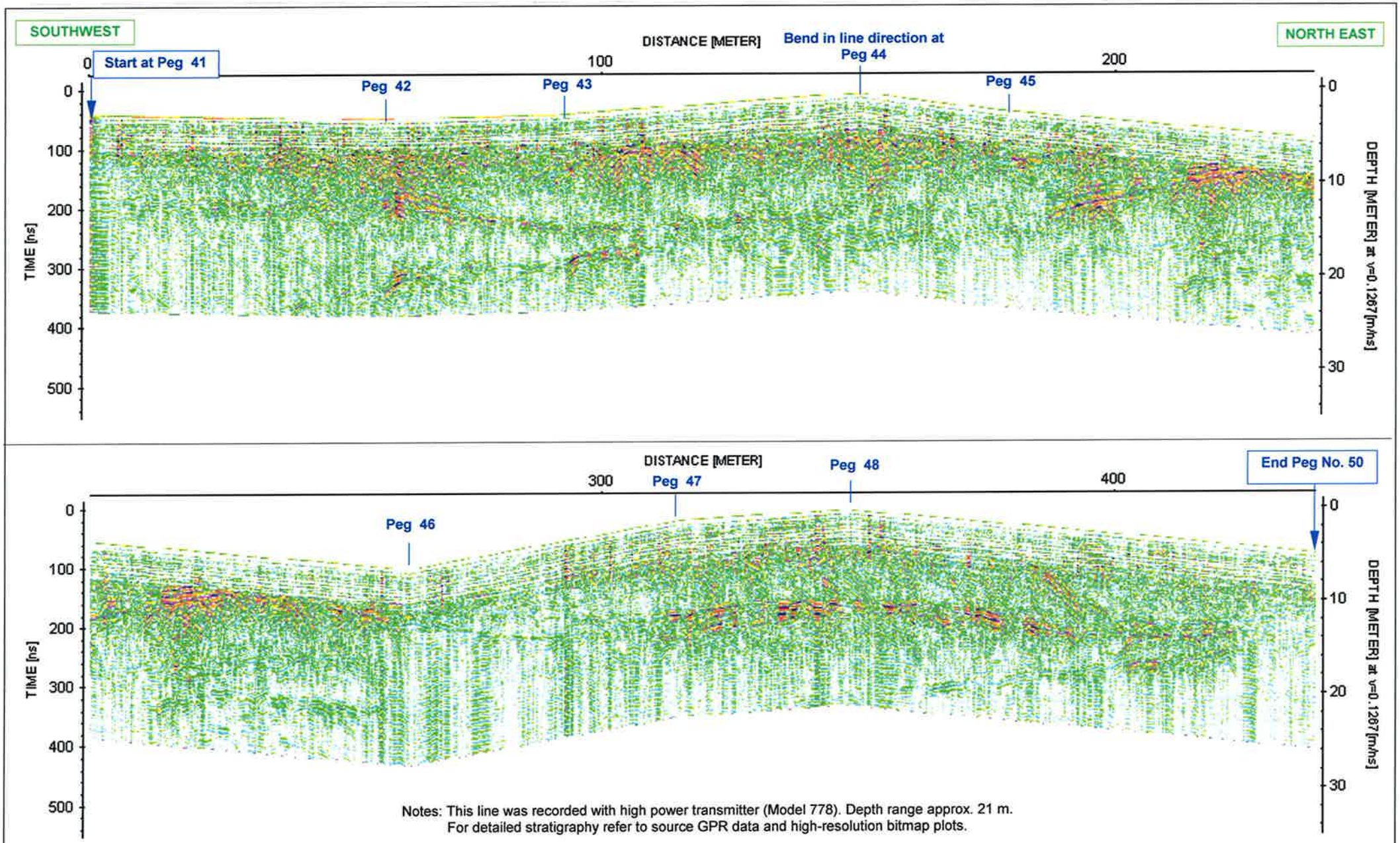
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 3
Survey Pegs 20 – 41



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

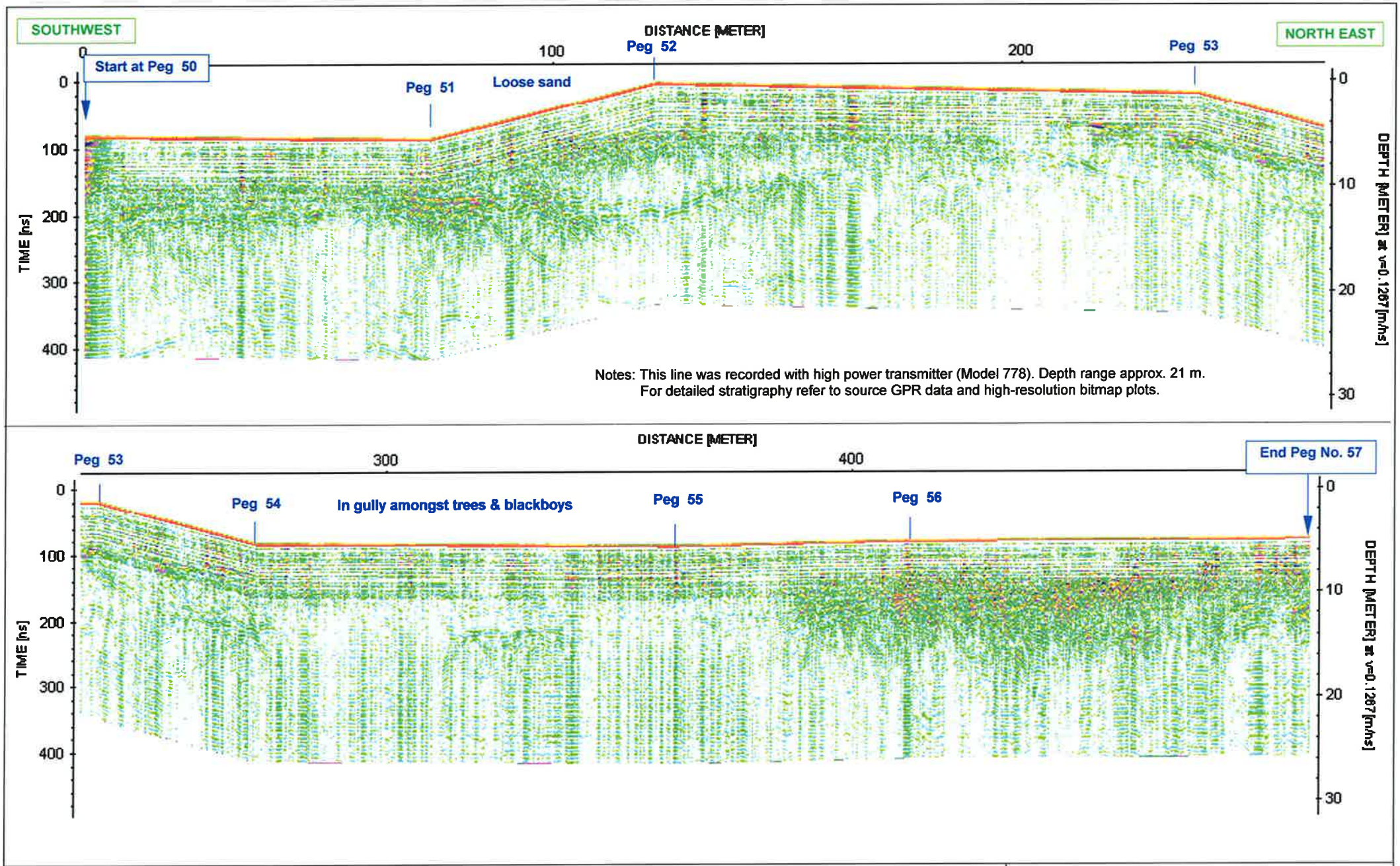
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 03_A
Pegs 41 to 50



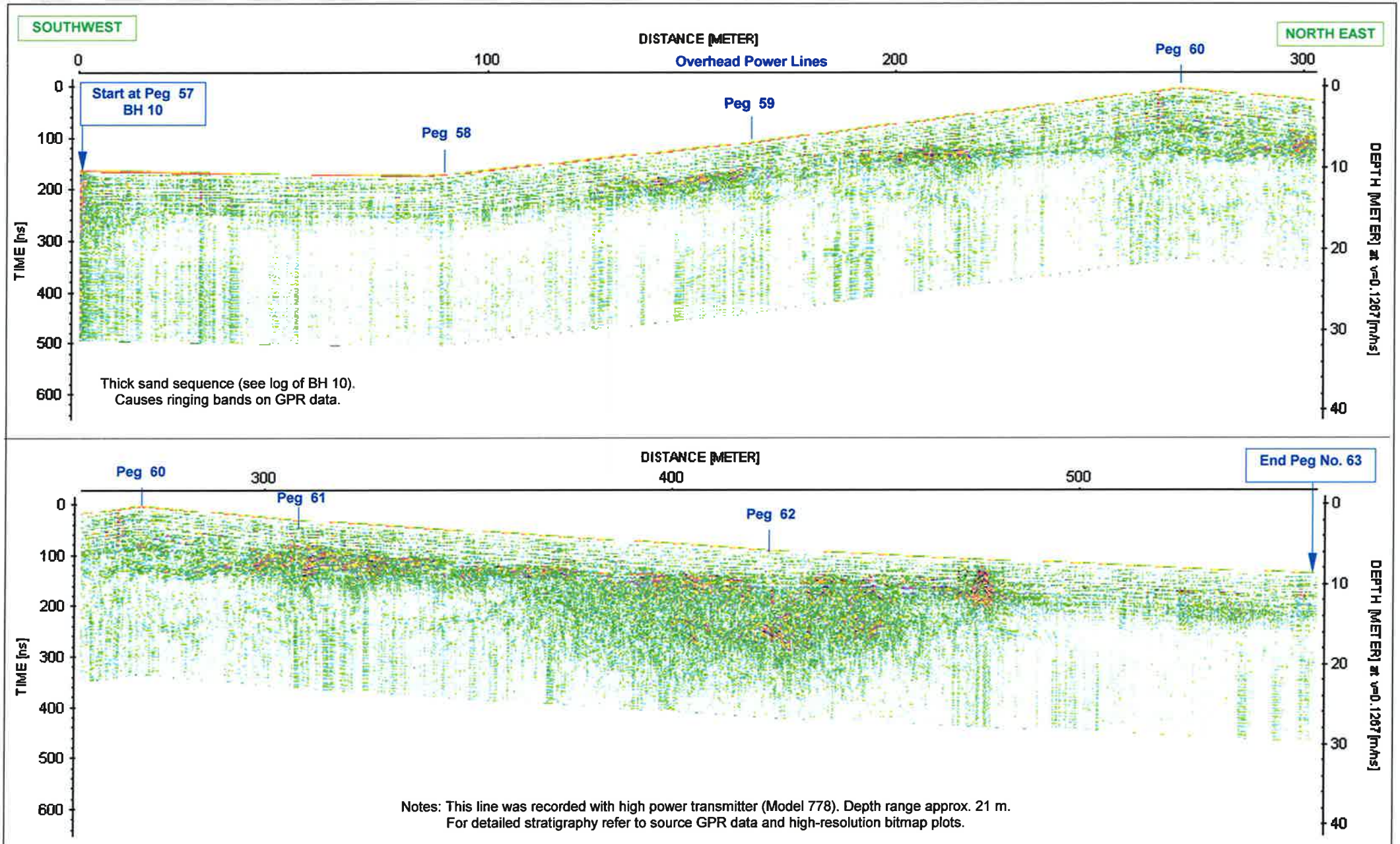
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 03_B
Pegs 50 to 57



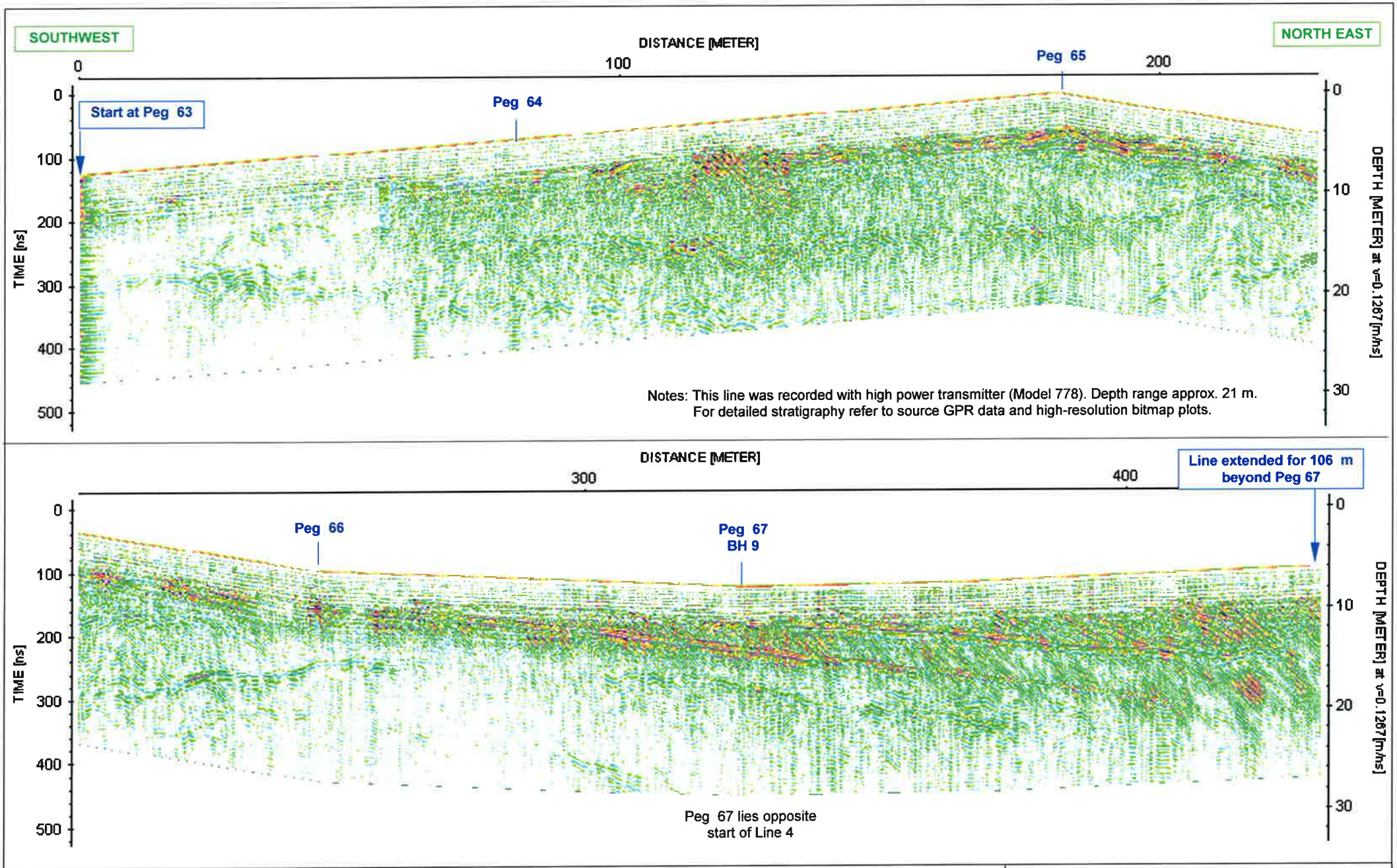
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 03_C
Pegs 57 to 63



GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

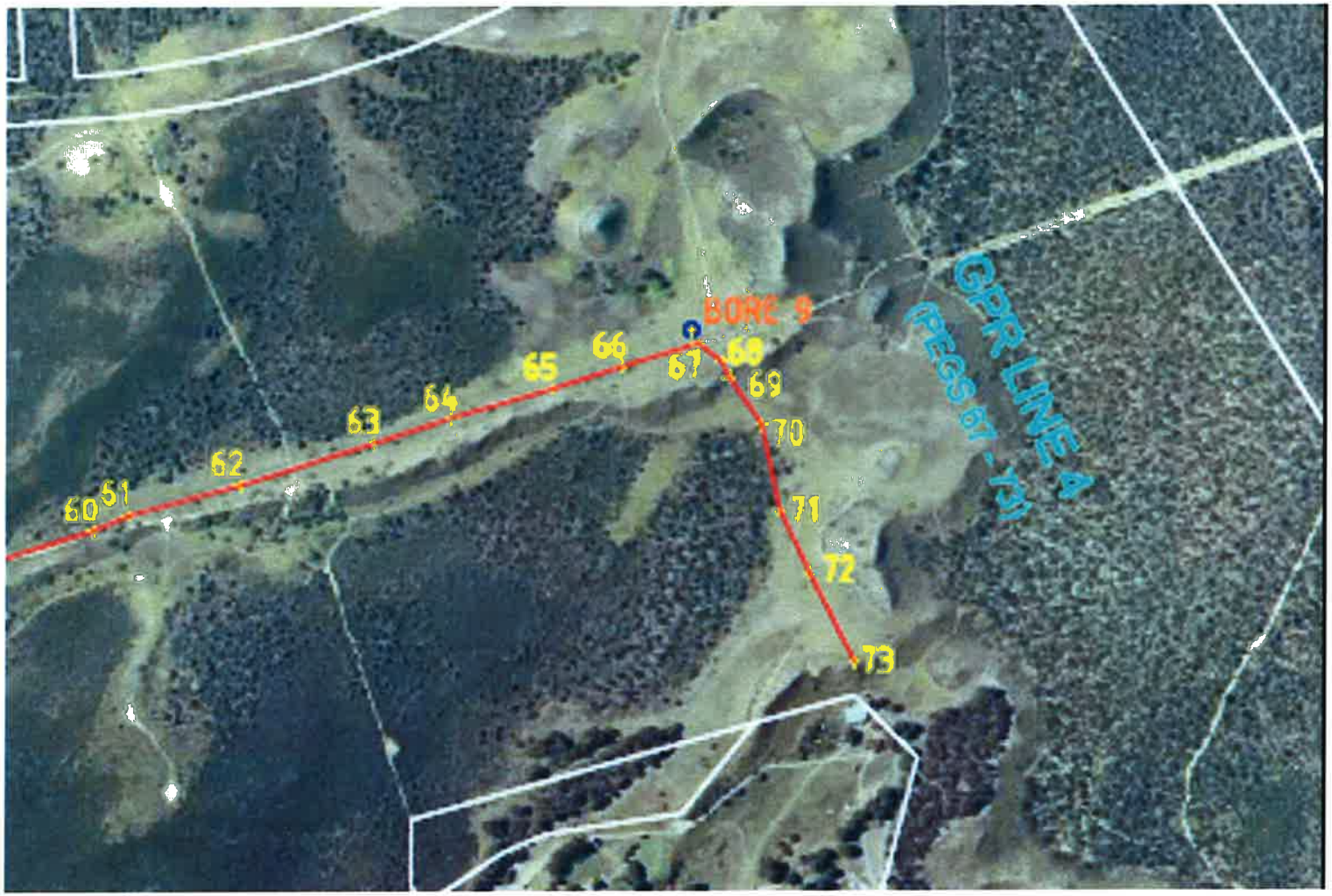
GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 03_D
Pegs 63 to 67

LINE 4



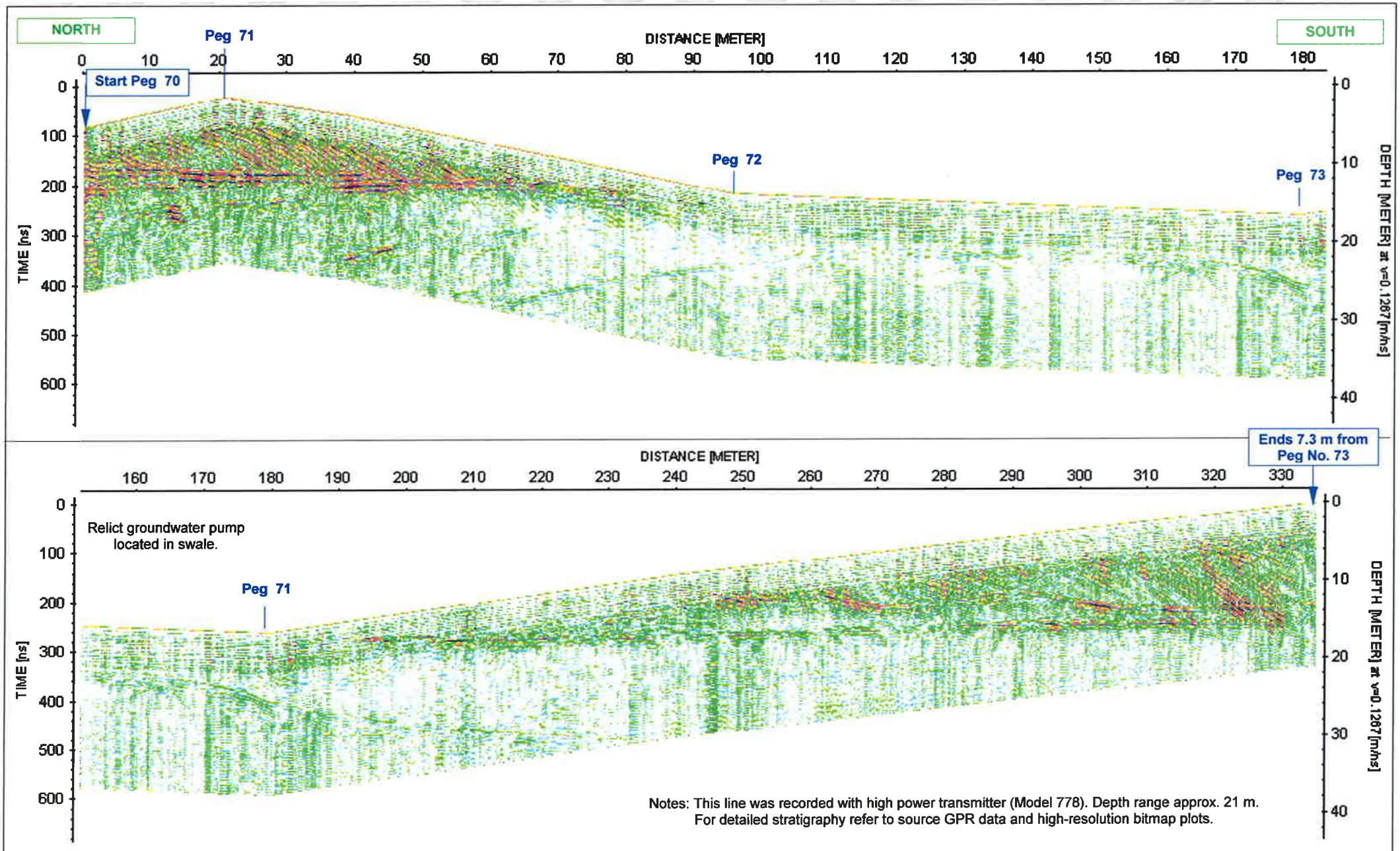
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 4
Survey Pegs 67 – 73



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 04_A
Pegs 70 to 73

LINE 5

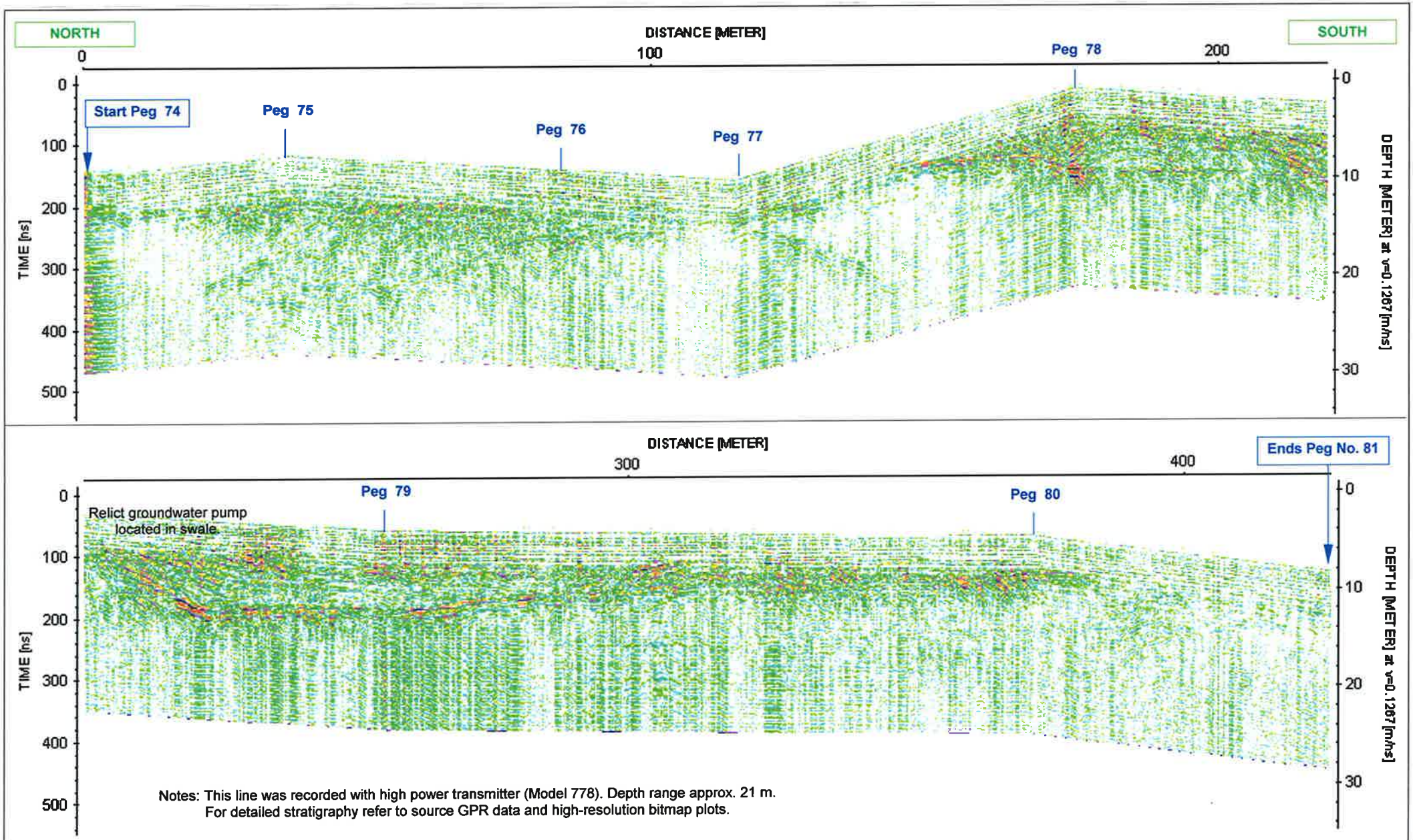
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 5
Survey Pegs 74 – 87



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

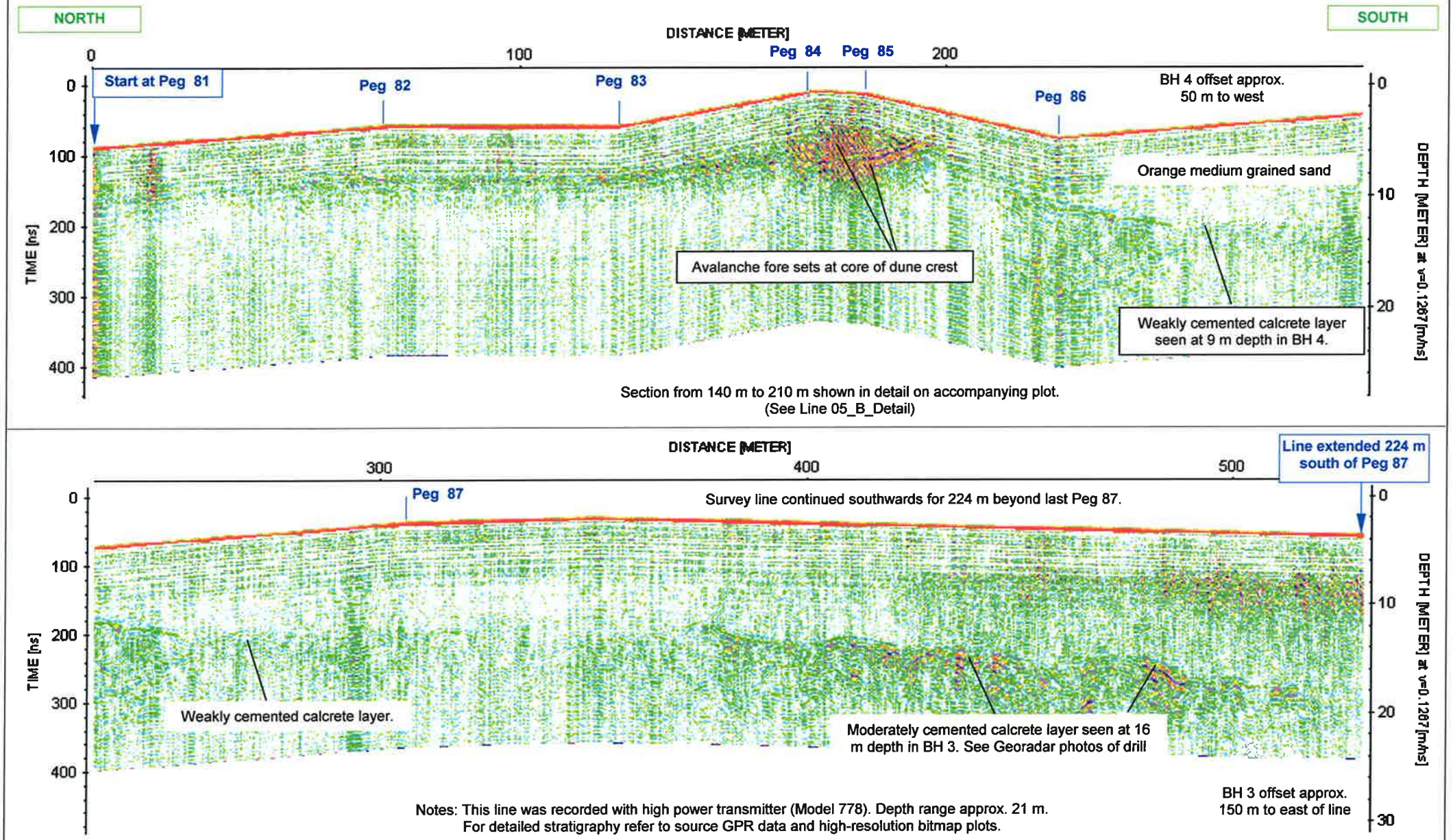
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 05_A
Pegs 74 to 81



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

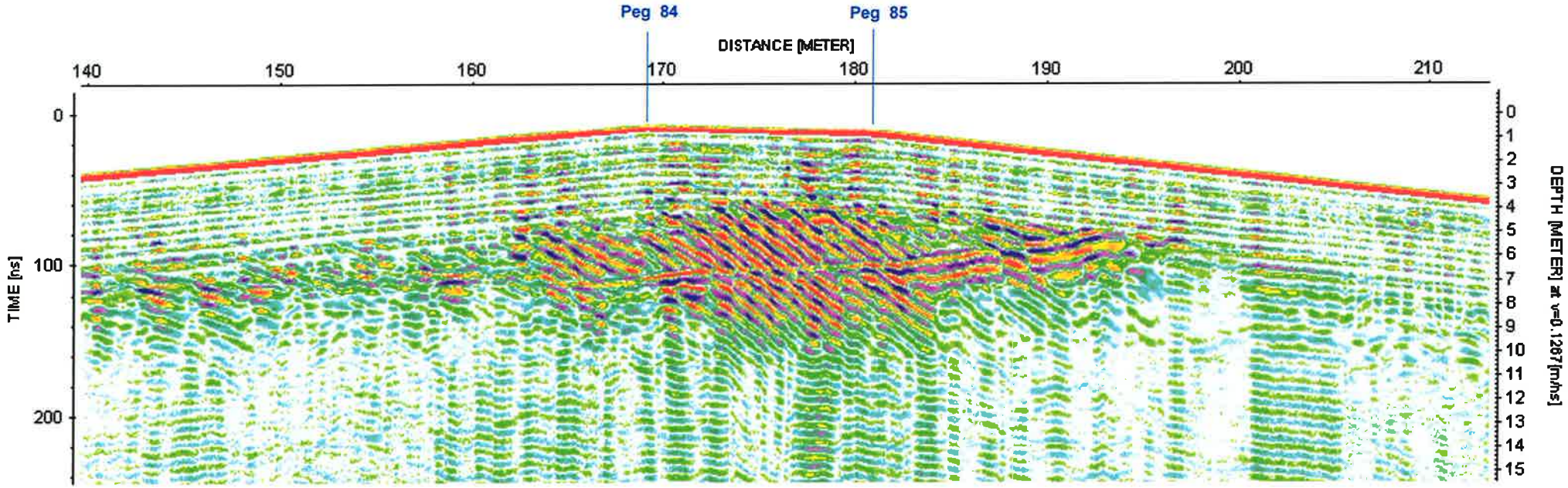
SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 05_B
Pegs 81 to 87 + Extension to South

NORTH

SOUTH

Detail of section from 140 m to 210 m showing avalanche fore sets
at core of dune crest .



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

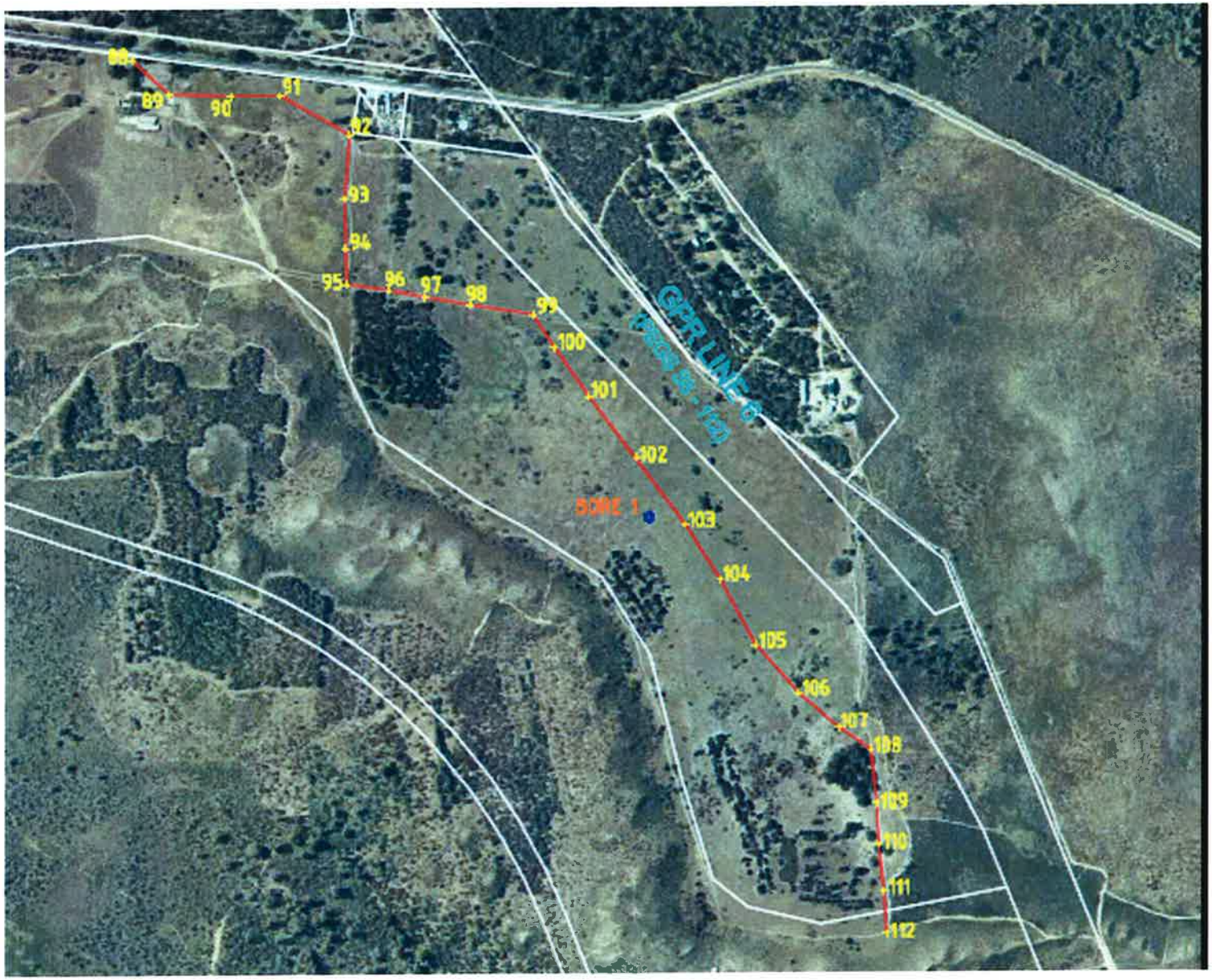
GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 05_B
Detail of section from 140 – 215 m

LINE 6



GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

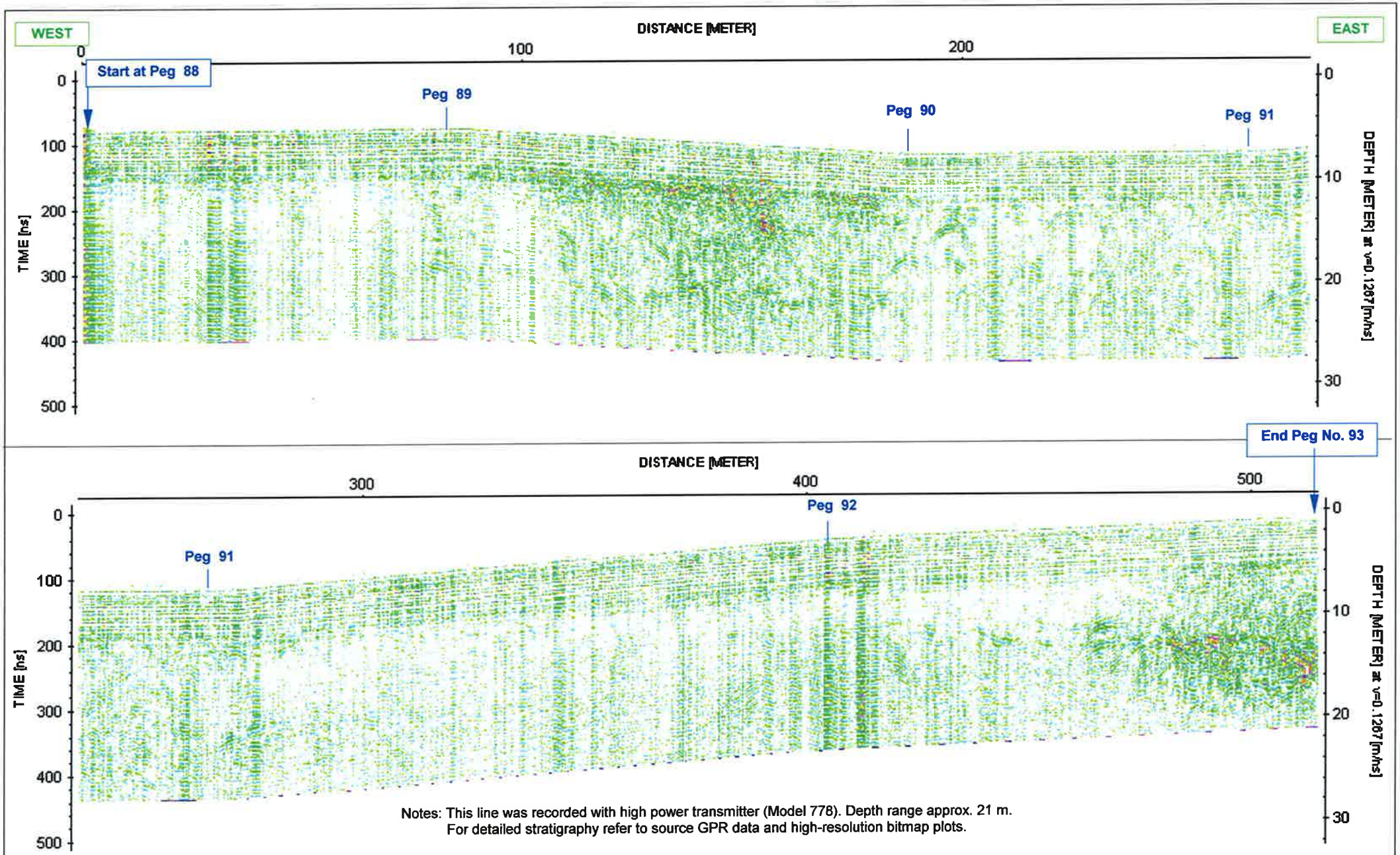
GROUND PENETRATING RADAR SURVEY AT St ANDREWS DISTRICT, YANCHEP, W.A.

Project No. R2007/215

SURVEY DATES: 10 - 13 JANUARY

GPR Survey Line 6

Survey Pegs 88 – 112



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

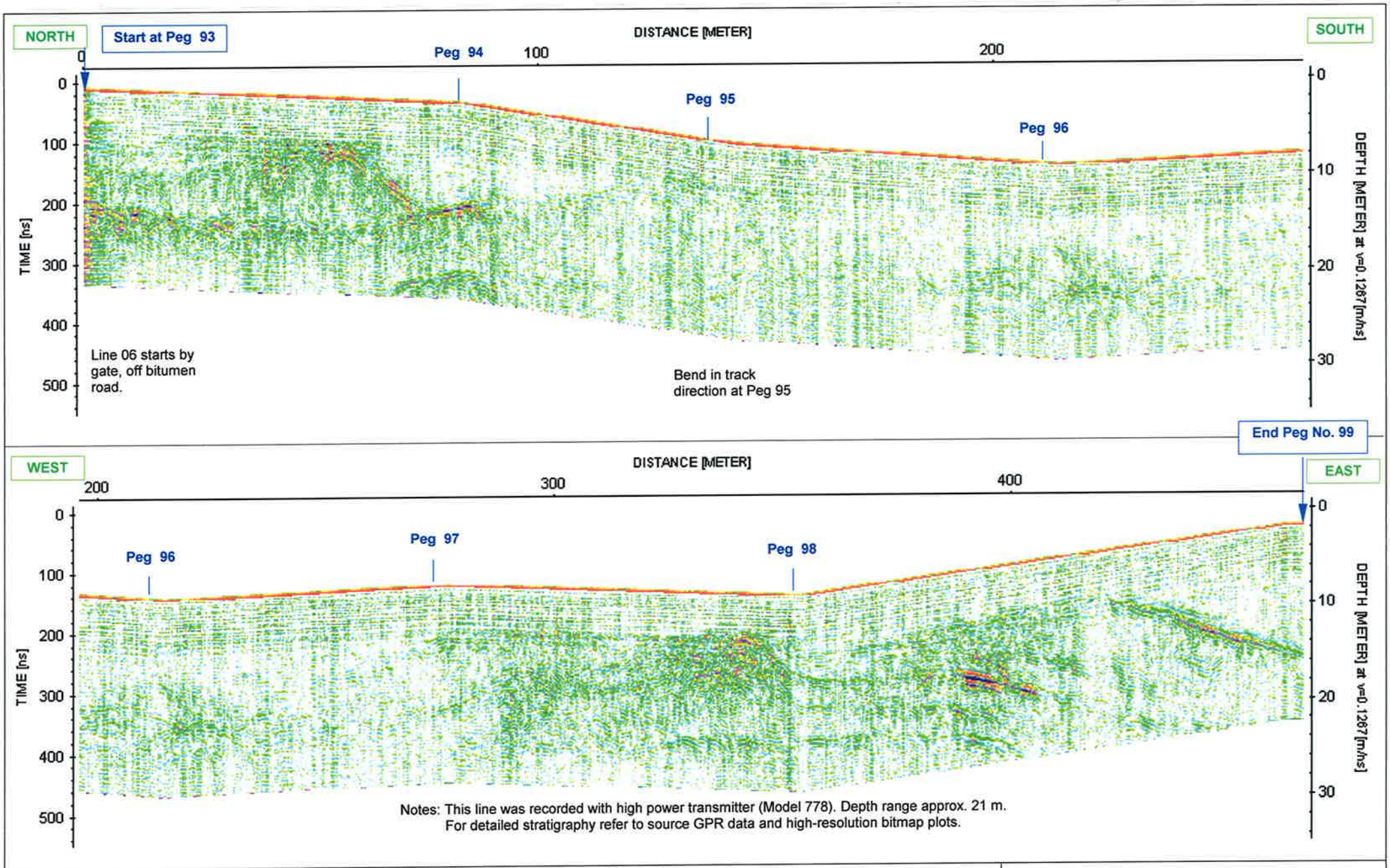
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 06_A
Pegs 88 to 93



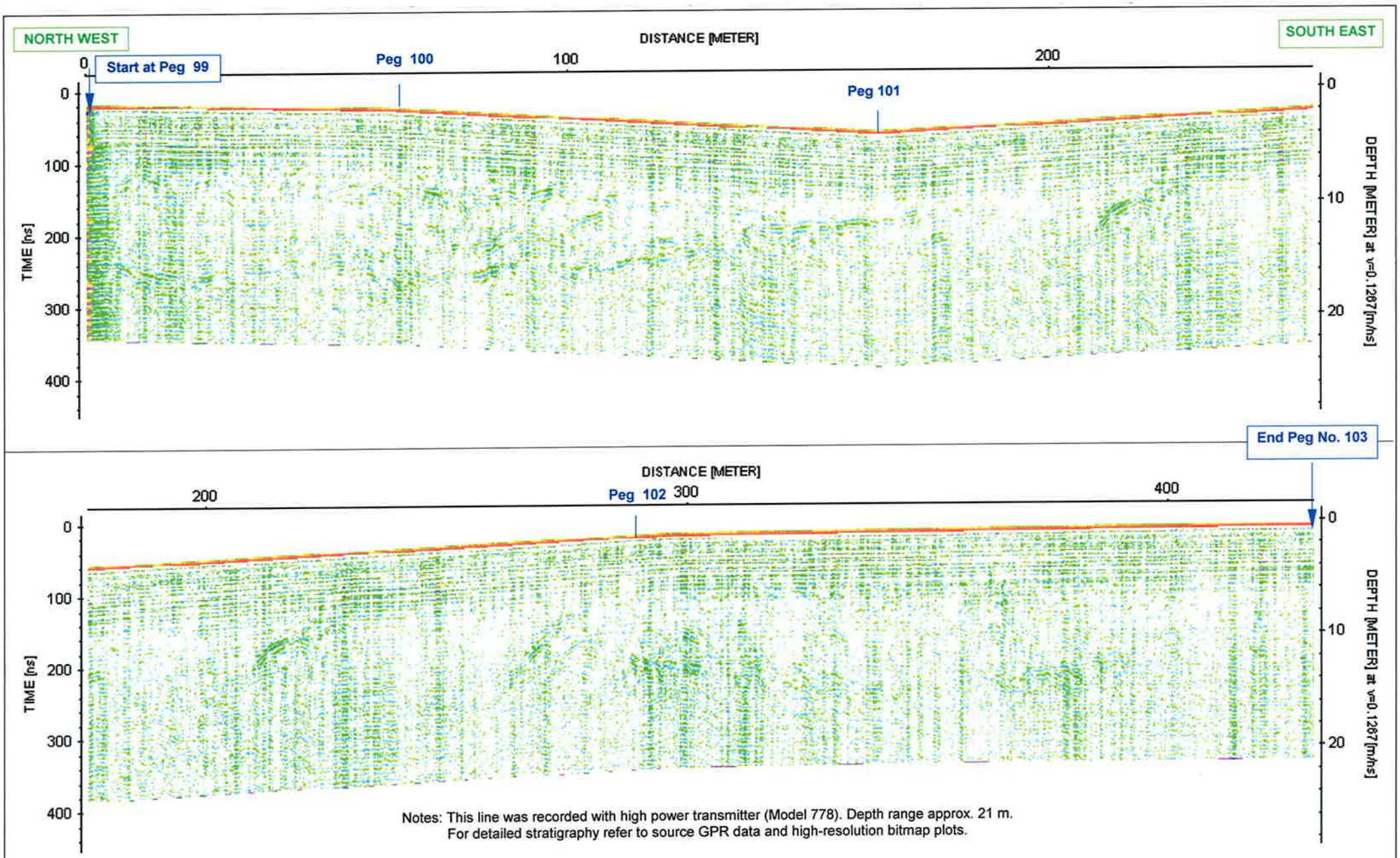
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 06_B
Pegs 93 to 99



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

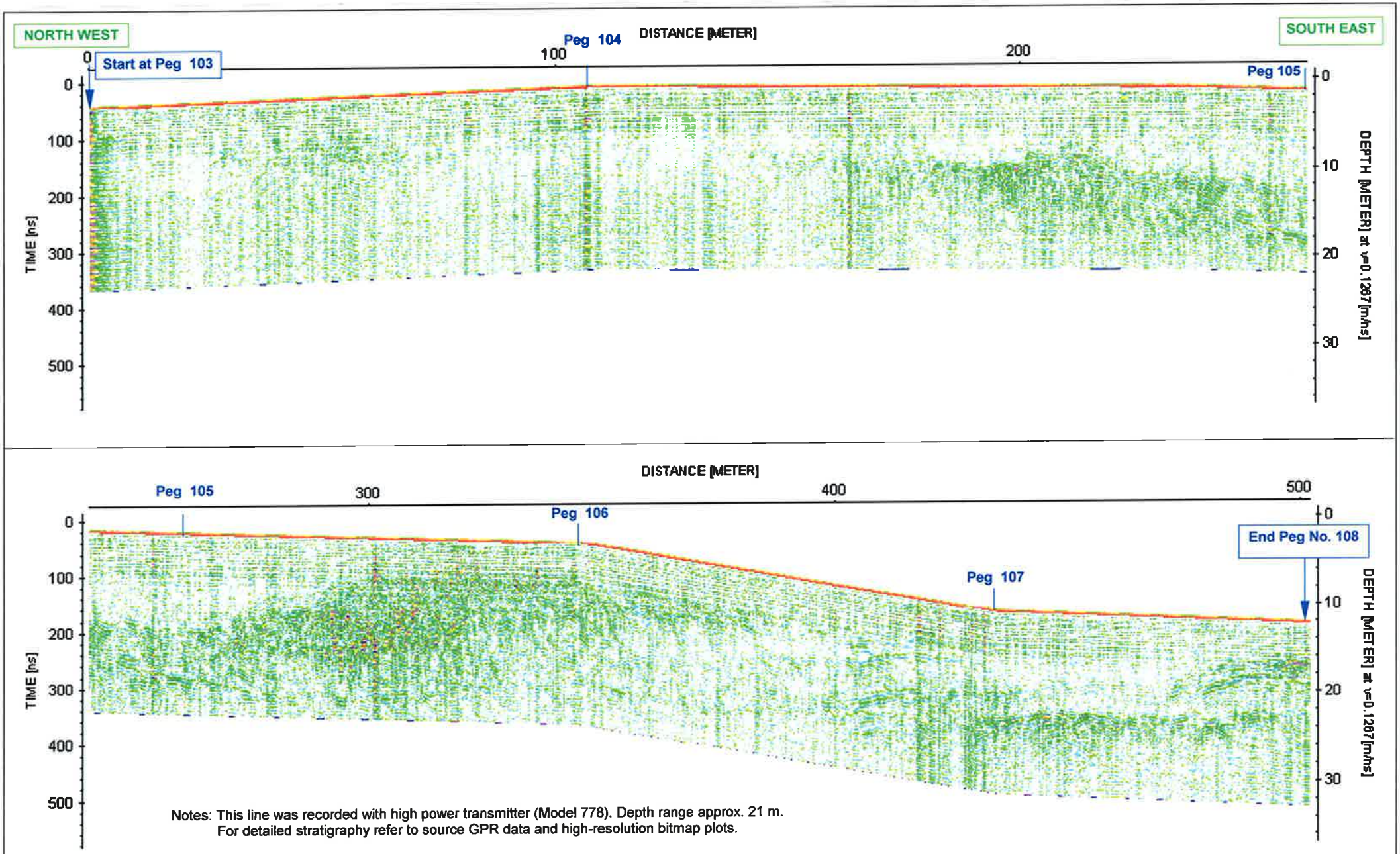
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 06_C
Pegs 99 to 103



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

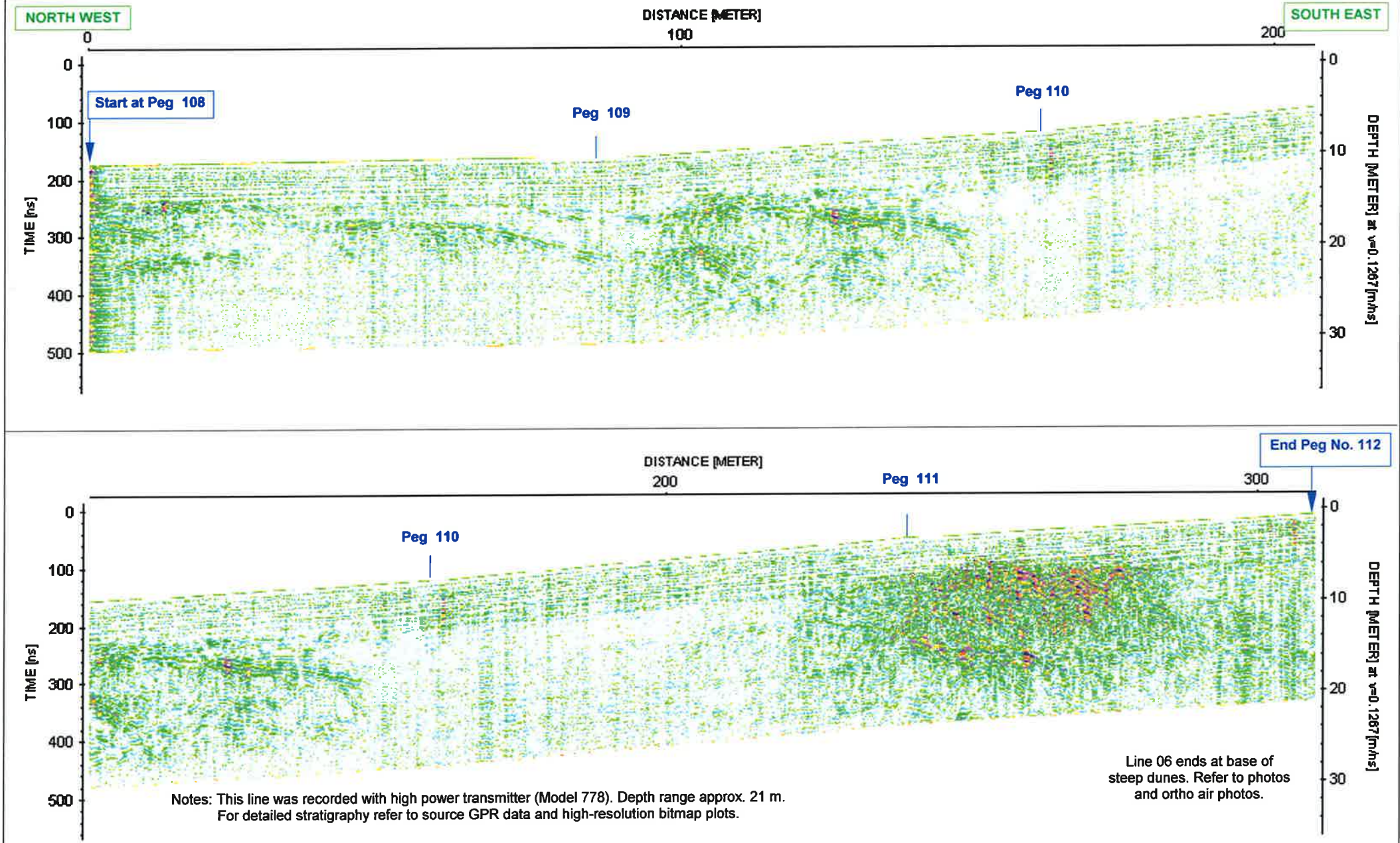
GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.
Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 06_D
Pegs 103 to 108



Notes: This line was recorded with high power transmitter (Model 778). Depth range approx. 21 m.
For detailed stratigraphy refer to source GPR data and high-resolution bitmap plots.

GEORADAR RESEARCH PTY LTD
412 EASTBANK RD, CORAMBA, NSW, 2450, AUSTRALIA
TEL: (02) 6654 4162 FAX: (02) 6654 4043
EMAIL: georadar@bigpond.com

GROUND PENETRATING RADAR SURVEY AT YANCHEP, W.A.

Project No. R2007/215

CLIENT: ATA ENVIRONMENTAL Pty Ltd

SURVEY DATES: 10 - 13 JANUARY 2007

GPR SURVEY LINE No. 06_E

Pegs 108 to 112