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15 June 1993

Department of Aboriginal Sites
WA Museum
35 Havelock Street
WEST PERTH WA 6005

Attention: Registrar of Aboriginal Sites

Dear Sir,

We are pleased to submit our report "Ground Probing Radar Survey - Phase 4, Rottnest Island, Western Australia, June 1993".

The Phase 4 survey has substantially delineated the extent of the Aboriginal Prisoners Cemetery at the road intersection site south of Tentland.

Further, the survey has identified likely burial sites within the Tentland area. However, as burials have not been proven within Tentland, and as the area has accommodated many people over the years, including internees during the World Wars, there remains a possibility that the disturbed ground identified within Tentland may have been dug for other reasons. Only a conventional archaeological examination of ground probing radar sites would provide absolute proof that a cemetery existed in Tentland.

We are most grateful for the assistance provided by personnel from your Department, which we believe has helped to make the survey a success.

Yours sincerely,

D. Wilson

VC Wilson
Senior Lecturer
DEPARTMENT OF EXPLORATION GEOPHYSICS

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VOLUME 1 **PAGE**

FIGURES

APENDICES

1. INTRODUCTION

Ground Probing Radar Survey - Phase 4, Rottnest Island, Western Australia, is the fourth ground probing radar survey supervised by the Department of Exploration Geophysics at Curtin University of Technology on behalf of the Department of Aboriginal Sites to delineate 19th century burial sites at Rottnest Island.

Based on evidence that burials had earlier been uncovered by workers at the road intersection site (now named as the Rottnest Island Aboriginal Prisoners Cemetery) adjacent to, and south of, Tentland a ground probing radar trial survey was conducted at this site in December 1990. It was concluded from this survey that the ground probing radar method had successfully identified ground disturbed by digging at this known burial site, as well as at known locations of buried cables and pipes. Further, the survey had identified additional evidence of disturbed ground, in the form of trenches, around the road intersection site. It was concluded that one possible explanation for these trenches was that they represented burial sites.

Additional surveys were conducted in March 1991 (Phase 2) and May 1992 (Phase 3), both of which were aimed at determining the extent of the cemetery at the road intersection site, as well as investigating areas within Tentland to determine the likelihood of an extension or separate cemetery in this region. Conclusions from this work were that additional work was required to properly determine the areal extent of ground disturbance at the intersection site and that there was evidence of disturbed ground in Tentland, which should be further investigated.

The Phase 4 Survey was planned to more fully define the extent of ground disturbances at both sites. Further, work was completed at the Rottnest Island Cemetery and the Mogumber Cemetery to provide ground probing radar signatures over known grave sites. It was also hoped that the ground probing radar work at these two locations may identify unmarked burials at these sites. A survey was also completed at The Elbow, a site near the Mogumber Cemetery and close to the Moore River, to determine the likelihood of burials there.

Data was acquired by Ground Radar Australia Pty Ltd at Rottnest Island during the period 12 to 17 November 1992 and at Mogumber/The Elbow during the period 15 to 16 December 1992.

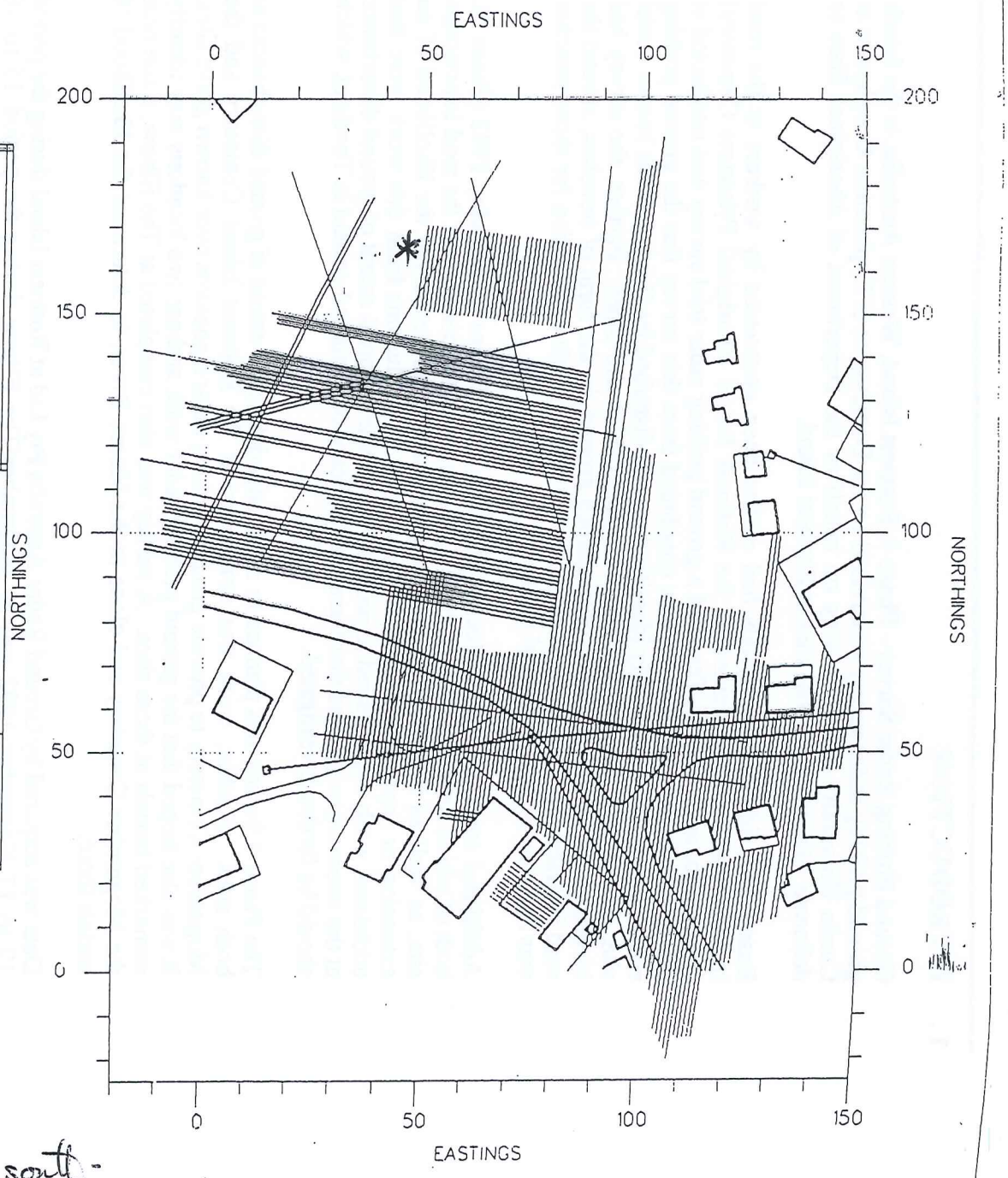
See Locality Plan, Fig. 1 for the location of ground probing radar lines at the road intersection and Tentland sites on Rottnest Island. Phase 4 lines are dark blue, Phase 1 are red, Phase 2 are green and Phase 3 are light blue.

Please note that the full three volume Phase 4 report is retained by the Department of Aboriginal Sites. This full report includes the interpretation, acquisition and processing reports as well as GPR processed data for all lines.

TITLE	:	Phase 4 – GPR Survey Map
CLIENT	:	Curtin University/ WA Museum
COUNTRY	:	Western Australia
AREA	:	ROTTNEST ISLAND

	EASTINGS	NORTHINGS
MAXIMUM	150.00	200.00
MINIMUM	−20.00	−25.00

SCALE 1500.00 DATE: November 1992



Note: Original shows each set of GPR survey areas in different colours as areas were cumulatively added.

* Area checked for relocation of [illegible] Item from area immediately south-

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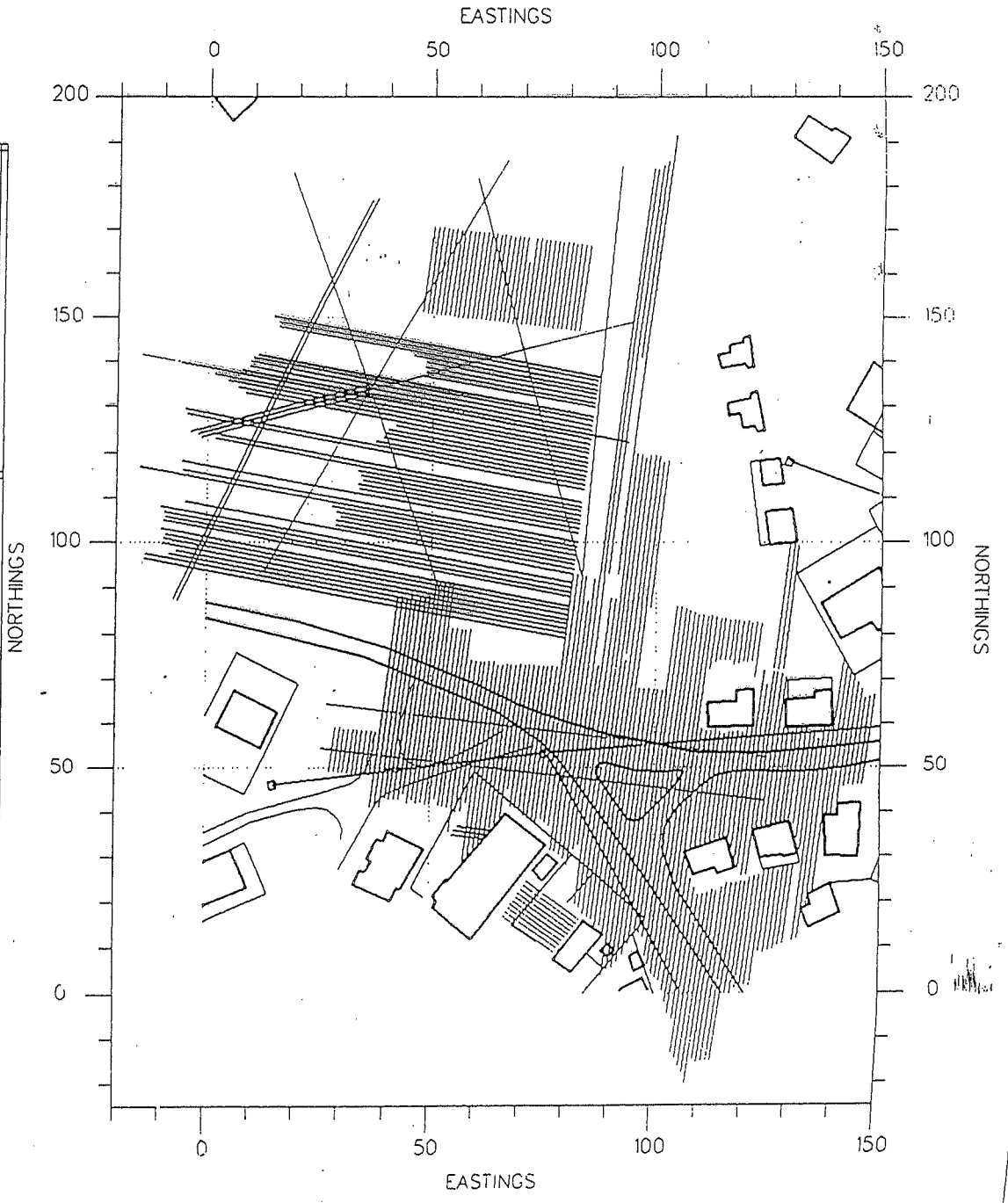
MAXIMUM	150.00	200.00
MINIMUM	−20.00	−25.00

[illegible]	1500.00	DATE: November 1992



TITLE : Phase 4 – GPR Survey Map

CLIENT : Curtin University/ WA Museum

COUNTRY : Western Australia

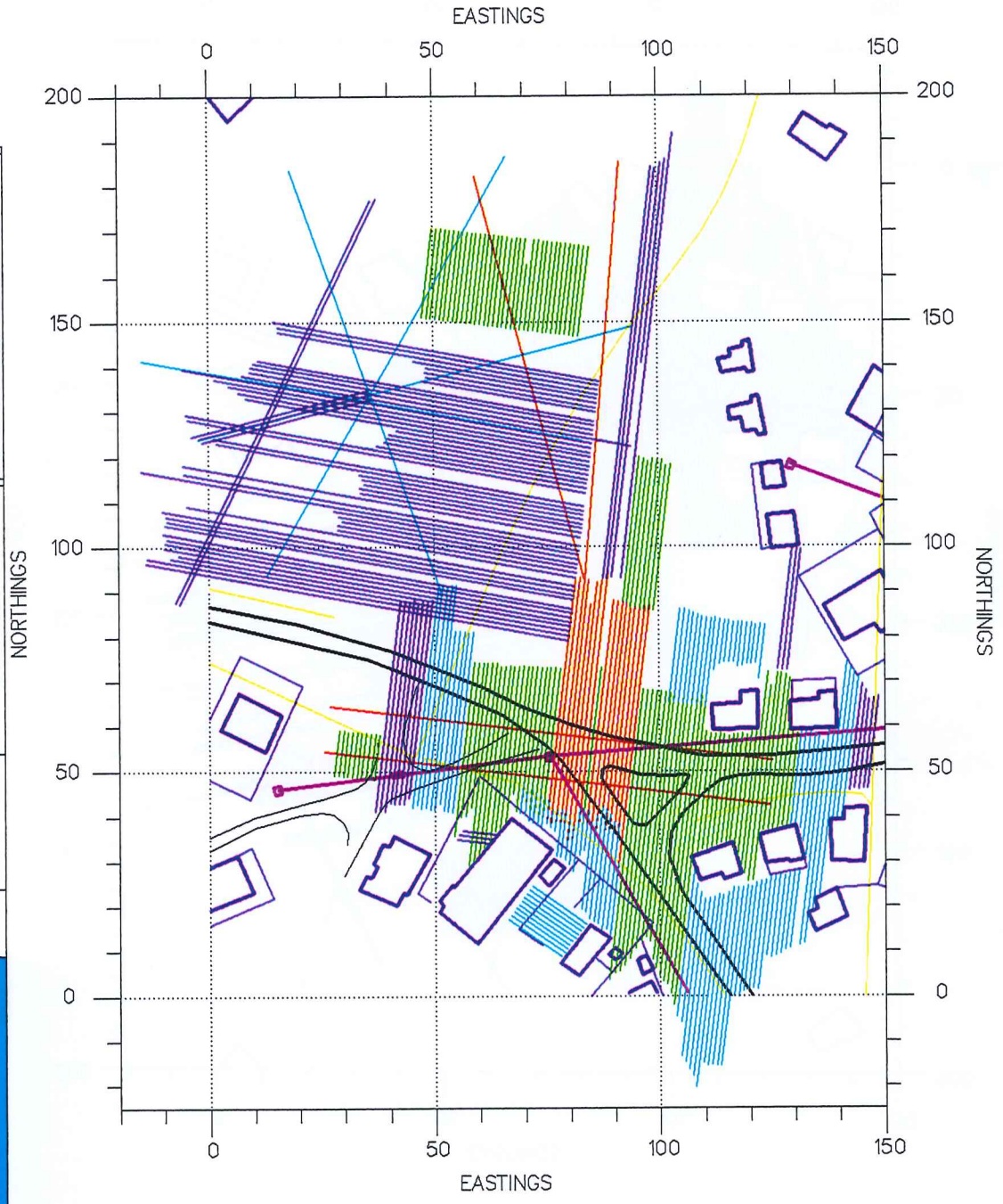
AREA : ROTTNEST ISLAND

	EASTINGS	NORTHINGS
MAXIMUM	150.00	200.00
MINIMUM	−20.00	−25.00

SCALE: 1 : 1500.00 DATE: November 1992

Produced by: Ground Radar Australia Pty Ltd, Perth, Australia

GROUND RADAR AUSTRALIA



2. JOB PHILOSOPHY

An important requirement of any method used on Rottnest Island to determine the extent of Aboriginal burials, is that digging of the ground is contrary to Aboriginal wishes. Thus geophysical techniques, whereby signals are sent into the ground and are returned bearing information about the subsurface, must be considered.

Following a one day trial of several readily available geophysical techniques at the Rottnest Island Cemetery in mid 1990, the Department of Exploration Geophysics recommended to the Department of Aboriginal Sites that ground probing radar techniques be tested. It was further strongly recommended, due to the likelihood of interference to the radar signal from many sources (trees, huts, pipes, etc), that seismic processing techniques would be required to filter out this interference, so as to provide data suitable for interpretation. It was intended that the processed signal would be capable of showing discontinuities in the earth's strata where earth had been dug, mixed and replaced. Unlike surveys previously reported overseas using the technique, the burials at Rottnest were not in coffins, nor associated with significant metal. The effect of coffins and metal on the ground probing radar signal is usually quite significant.

Mr C Frampton, then of Waveform Pty Ltd and now of Ground Radar Australia Pty Ltd, was contracted by the Department of Exploration Geophysics to acquire the data and use suitable processing to optimise the signals for interpretation for all four phases of the work.

Following the Phase 1 test survey, it was clear that ground probing radar had located known dug areas. Further, it had located additional sites indicating digging had taken place. The major characteristics of these ground probing radar anomalous sites were:

- discontinuities in strata were obvious
- depth extent was 1.5 m to 3.0 m from surface
- negligible interference from other features
- width varied from 1 m to several metres
- shape was trench like
- generally, but not always, reflectors were evident above and below the anomaly - with the upper reflection often raised probably due to higher porosity (air content) of the disturbed ground.

It was concluded that a possible explanation for these anomalies was that they represented burial sites.

Phase 2 and Phase 3 Surveys were conducted to both determine more fully the extent of possible burials at the road intersection site and to see whether similar evidence of disturbed ground could be found in Tentland.

The Phase 4 Survey was planned to further investigate the above sites, as well as to provide ground probing radar data over known graves at Rottnest Island Cemetery and at Mogumber Cemetery to provide comparison with the data recorded at both the intersection and Tentland sites. Further, the survey was intended to locate unmarked grave sites at Rottnest Island Cemetery, Mogumber Cemetery and at The Elbow site, near the Mogumber Cemetery should they be present.

3. GROUND PENETRATING RADAR (GPR) METHODS

The GPR technique is designed to show a cross-section of the earth layers. An electromagnetic pulse is sent into the ground where it is reflected by boundaries within the earth and returned to the surface. The received pulse is digitised and stored for later display. Disturbed strata is evidenced by discontinuities in the reflected data.

The pulse is of the order of 10 nanoseconds long and has a bandwidth of between 10 to 200 MegaHertz. The reflecting boundaries in the earth are changes in conductivity. As the velocity of the electromagnetic wave is very fast (of the order of 0.1 metres/nanosecond) the recording time is very short. Typical values are 700 nanoseconds to record to 30 metres depth. With this short recording time and the stationarity of the pulse wavelet, it is possible to record many times at one point and sum the recordings together. This improves the signal to random noise ratio and values of 100 to 300 stacks of waveform are usual.

The GPR technique is very similar to the seismic exploration used in the oil industry. Previous GPR systems recorded the data onto small thermal paper plotters in the field. All information was recorded by analog methods. The state-of -the-art equipment now uses digitisation of the recorded signals to store the data in 16 bit samples. This increases the dynamic range of the system greatly. The major differences from the seismic to the GPR techniques are that the seismic wave is reflected by impedance (velocity/density) contrasts in the earth, whereas the GPR wave is reflected by conductivity contrasts.

Penetration of the GPR signal is limited by the water content and salinity and clay content of the earth layers. In ideal conditions, penetration can be more than 10 metres.

4. DATA ACQUISITION

Data was acquired during the period 12 to 17 November 1992 at Rottnest and during the period 15 to 16 December 1992, at Mogumber and The Elbow.

Mr VC Wilson of the Department of Exploration Geophysics supervised the project work and completed the interpretation of all data. Mr C Frampton of Ground Radar Australia Pty Ltd acquired and processed all the data.

Assistance was provided by:

Rottnest Island Deaths Group, especially Mr G. Merritt and Mr T. Riley as well as several observers.

Wheatbelt Aboriginal Corporation Heritage Committee, especially Mrs J. Mogeridge and Mrs B. Nannup.

Rottnest Island Authority, especially Mr C. Hansen.

Department of Exploration Geophysics, Curtin University, Mr M. Lekaunyane.

Consultant Archaeologist, Mr R. Bate.

Department of Aboriginal Sites staff (Mr J. Barber, Mr T. Bennell, Mr G. Merritt, Mr J. Patterson and Mr P. Randolph).

The Ground Probing Radar system used was the Pulse EKKO IV, comprising a 200 MHz transmitter and receiver.

Profile Type: .....Reflection
Number of Stacks: 64
Sample Rate: .....0.8 ns
Trace Spacing.....0.2 m
Antenna Spacing.....0.4 m
Recording Time:.....200 ns

Data was recorded at the following areas:

Rottnest Island

1. Extensions to the lines of the main grid at the road intersection site (to east, west and north). Lines A, 008E - 011E, 48E - 50E, 67E - 71E, 30W - 37W: SPQ 1 - 3 inc.

2. An area of Tentland. Lines K4R, 5-9 Inc; and L52N - 110N

3. Rottnest Island Cemetery. Lines RIC 1-12.

Mogumber Cemetery

1. Area A - Lines to the west side of cemetery.
2. Area B - Lines to the east side of cemetery.

Elbow Site

1. Area C - Lines south-east of dam.
2. Area D - Lines south-west of dam.

The Survey Line Lists are presented as Table 1.

GPR REPORT - CURTIN UNIVERSITY/ROTTNEST ISLAND

TABLE 1

SURVEY LINE LIST

AREA 1

Extend Main Grid (A) further North to North Bitumen Road

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
A008E	461	66.6	158.6
A009E	460	66.6	158.4
A010E	464	67.2	159.8
A002E	229	115.2	160.8
A011E	498	67.2	166.6

AREA 2

Detailed Grid over Central and Western "Tentland".

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
L110N	369	0.0	73.6
L109N	363	0.0	72.4
L108N	362	0.0	72.2
L107N	208	0.0	41.4
L106N	194	0.0	38.6
L105N	194	0.0	38.6
L104N	193	0.0	38.4
L103N	196	0.0	39.0
L101N	380	0.0	75.8
L100N	385	0.0	76.8

GPR REPORT - CURTIN UNIVERSITY/ROTTNEST ISLAND

L099N	388	0.0	77.4
L098N	388	0.0	77.4
L096N	462	0.0	92.2
L095N	426	0.0	85.0
L094N	409	0.0	81.6
L093N	398	0.0	79.4
L092N	389	0.0	77.6
L091N	218	0.0	43.4
L090N	226	0.0	45.0
L089N	227	0.0	45.2
L088N	230	0.0	45.8
L087N	238	0.0	47.4
L086N	453	0.0	90.4
L085N	450	0.0	89.8
L082N	419	0.0	83.6
L081N	415	0.0	82.8
L080N	253	0.0	50.4
L079N	249	0.0	49.6
L078N	246	0.0	49.0
L077N	251	0.0	50.0
L076N	250	0.0	49.8
L075N	449	0.0	89.6
L073N	447	0.0	89.2
L072N	494	0.0	98.6
L071N	276	0.0	55.0
L070N	271	0.0	54.0
L069N	266	0.0	53.0
L068N	270	0.0	53.8

L067N	270	0.0	53.8
L066N	439	0.0	87.6
L064N	466	0.0	93.0
L063N	461	0.0	92.0
L062N	459	0.0	91.6
L061N	461	0.0	92.0
L059N	462	0.0	92.2
L058N	457	0.0	91.2
L057N	458	0.0	91.4
L056N	459	0.0	91.6
L055N	442	0.0	88.2
L054N	450	0.0	89.8
L053N	476	0.0	95.0
L052N	477	0.0	95.2

AREA 3

Extend Main Grid (A) West.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
A030W	223	12.8	57.2
A031W	226	11.6	56.6
A032W	227	11.4	56.6
A033W	226	11.2	56.2
A034W	228	11.4	56.8
A035W	235	9.2	56.0
A036W	234	9.4	56.0
A037W	236	9.0	56.0

AREA 4

Extend Main Grid (A) East.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
A067E	119	26.4	50.0
A068E	110	26.8	48.6
A069E	101	26.8	46.8
A070E	101	27.2	47.2
A071E	103	27.2	47.6

AREA 5

Extend Lines A-048E to A-050E North behind Huts B11 and B12.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
A048E	137	51.0	78.2
A049E	138	51.0	78.4
A050E	137	51.0	78.2

AREA 6

Three lines perpendicular to a GPR anomaly next Northern Section of Single Persons Quarters.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
SPQ1	37	0.4	7.6
SPQ2	39	0.2	7.8
SPQ3	38	0.6	8.0

AREA 7

Three lines about previous Line K-004 in "Tentland" to inspect a GPR anomaly.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
K004R	197	0.0	39.2
K005	195	0.0	38.8
K006	203	0.4	40.8

AREA 8

One GPR line along main track in central "Tentland".

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
K007	439	0.4	88.0

AREA 9

Two parallel GPR lines along Western Bitumen Road through "Tentland".

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
K008	501	0.0	100.0
K009	497	0.8	100.0

AREA 10

Several areas in Rottnest Island European Cemetery over marked graves.

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
RIC1	107	0.0	21.2

GPR REPORT - CURTIN UNIVERSITY/ROTTNEST ISLAND

RIC2	112	0.0	22.2
RIC3	125	0.2	25.0
RIC4	62	0.0	12.2
RIC5	38	0.0	7.4
RIC6	43	0.0	8.4
RIC7	46	0.0	9.0
RIC8	44	0.0	8.6
RIC9	45	0.0	8.8
RIC10	81	0.0	16.0
RIC11	81	0.0	16.0
RIC12	111	0.0	22.0

SURVEY LINE LIST

AREA A

Mogumber Mission Cemetery - West Side

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
A1	151	-6.0	24.0
A2	152	-6.0	24.0
A3	167	-9.2	24.0
A4	151	-6.0	24.0
A5	151	-6.0	24.0
A6	151	-6.0	24.0
A7	151	-6.0	24.0
A8	152	-6.0	24.2

AREA B

Mogumber Mission Cemetery - East Side & Along East Fire Break

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
B1	119	0.4	24.0
B2	119	0.4	24.0
B3	119	0.4	24.0
B4	119	0.4	24.0
B5	119	0.4	24.0

GPR REPORT - CURTIN UNIVERSITY/MOGUMBER

B6	116	1.0	24.0
B7	118	0.4	23.8
B8	119	0.4	24.0
B9	119	0.4	24.0
B1X	29	0.4	6.0
B2X	29	0.4	6.0
B3X	29	0.4	6.0
B4X	29	0.4	6.0
B5X	29	0.4	6.0
B6X	29	0.4	6.0
B7X	30	0.4	6.2
B8X	29	0.4	6.0
B9X	31	0.4	6.4
B10X	29	0.4	6.0
B15X	29	0.4	6.0
B16X	29	0.4	6.0
B17X	27	0.4	5.6
B18X	29	0.4	6.0
B19X	29	0.4	6.0
B20X	29	0.4	6.0
B21X	29	0.4	6.0
B22X	29	0.4	6.0
B23X	29	0.4	6.0
B24X	29	0.4	6.0
B29X	29	0.4	6.0
B30X	29	0.4	6.0
B31X	29	0.4	6.0
B32X	29	0.4	6.0

C3	61	0.0	12.0
C4	61	0.0	12.0
C5	61	0.0	12.0
C6	61	0.0	12.0

AREA D

"Elbow" Site - South-West of Dam

LINE	TRACES	START RANGE (Metres)	END RANGE (Metres)
D1	52	0.0	10.2
D2	50	0.2	10.0
D3	51	0.0	10.0
D4	51	0.0	10.0

8. CONCLUSIONS

The ground probing radar surveys completed at Rottnest Island have enabled the mapping of ground which has been disturbed at depth in a manner consistent with known burial sites. The survey data has provided evidence of disturbed ground by mapping discontinuities in the strata formed by the digging and then return of mixed earth to the ground. The data cannot distinguish a burial from a trench of the same dimensions dug for other purposes.

The interpretation models used to locate potential burial sites from the GPR data have been substantiated at both the Rottnest Island Cemetery and the Mogumber Cemetery and have also been used to locate possible unmarked grave sites within those cemeteries. The survey has been completed at The Elbow, near Mogumber. This is a site considered to have possibly once been a burial site. Evidence of likely burials have been located at the site by the GPR work.

The extent of ground disturbance at the road intersection site (now known as the Aboriginals Prisoners Cemetery), south of Tentland, has been substantially determined. It is concluded therefore (without adequate explanation of alternative reasons for the distribution and extent of the disturbed ground) that the Aboriginal Prisoners Cemetery has been effectively delineated at the road intersection site.

An area of disturbed ground has been confirmed at the western side of the single persons quarters. There remains the possibility however, that any single location of disturbed ground, particularly if located away from the majority and/or located close to a building may have been dug for purposes other than for burial.

The survey work has identified several locations of disturbed ground in Tentland. It is considered highly likely that these locations represent burial sites. However, considering that people have been continuously accommodated in the area over many years, it is possible that there are other reasons that these trenches were dug. Only a conventional archaeological examination of GPR located sites would provide absolute proof that a cemetery existed in Tentland.

9. RECOMMENDATIONS

It is recommended that:

1 Consideration be given as to whether the extent of the Rottnest Island Prisoners Cemetery at the road intersection site has been adequately delineated by ground probing radar. If so, then no further ground probing radar is warranted at this location.

2 Consideration should be given to requesting permission to conduct a conventional archaeological examination of ground probing radar sites, particularly those of importance in determining future site usage and which are on the outer perimeter of the main Aboriginal Prisoners Cemetery.

3 Ground probing radar has determined several locations of likely burial sites in Tentland. However, because of the large number of people that have been accommodated in the area over the years, and the possible digging of the area for other purposes, it is recommended that permission be sought for a conventional archaeological examination at suitable ground probing radar sites. Such examination would provide direct proof as to whether a cemetery existed in Tentland.

4. Should there be a requirement to more fully map the Rottnest Island Cemetery, the Mogumber Cemetery and The Elbow site for unmarked burials, then ground probing radar would be the optimum method to locate the most likely locations.

EASTINGS

NORTHINGS

NORTHERN TENTLAND

HUT B11

HUT B12

SINGLE PERSONS QUARTERS

GARDENERS COTTAGE

OLD HOSPITAL

TITLE : Phase 4 – GPR Survey Map

DEPARTMENT OF ABORIGINAL SITES
Ground Probing Radar Survey - Phase 4

GPR INTERPRETATION PLAN
ROTTNEST ISLAND

By: Curtin University of Technology
Department of Exploration Geophysics 5/93 FIGURE 2.

POSSIBLE BURIAL SITE (G.P.R.)

	EASTINGS	NORTHINGS
MAXIMUM	150.00	200.00
MINIMUM	−20.00	−25.00

SCALE: 1 : 250.00 DATE: November 1992

GROUND RADAR AUSTRALIA