CHAPTER 2 : RESEARCH METHODOLOGY

2.1 OVERVIEW

The research methods employed to document the coastal changes of the Alligator Rivers Region may be separated into four congruent sections. The first part of the research involved interpretation from aerial photographs and topographical maps to reconstruct the general pattern of tidal creek and mangrove expansion in the Alligator Rivers Region. Specific sites were chosen for more detailed examination of evidence of saltwater intrusion. These were selected on the basis of preliminary observations from the 1:25,000 aerial photograph interpretation and discussions with *eriss* staff familiar with the changing environment. Detailed maps of tidal creek and mangrove changes of the selected sites were constructed from aerial surveys and from the collation of field survey and mapping data. The field surveys included application of Global Positioning System (GPS) techniques (ASHTECH equipment and Reliance software). Processed field mapping data was converted into a Geographic Information Systems (GIS) format for mapping purposes. Laboratory and qualitative analysis techniques were utilised to determine the rates and topological properties of the changes observed. The details of these steps have been outlined below.

2.2 MAPPING OF GENERAL CHANGES IN THE DISTRIBUTION OF TIDAL CREEKS AND MANGROVES

The progress of tidal creek expansion and mangrove encroachment of the Wildman, West, South and East Alligator Rivers of the eastern Alligator Rivers Region, was reconstructed from detailed maps drawn from aerial photographs for the years 1950, 1975, 1984 and 1991. The aerial photographs were flown during the Dry season of each year. This aided determination of the tidal reach of the creeks, as the creek tidal flows dominate over the freshwater floodwaters at this time. Although the photographs were seasonally consistent, they varied in scale and quality (Table 2.1). This instigated a problem of ensuring comparability between the dates.

To overcome this, mapping of tidal creeks was standardised in a manner consistent with that used by Knighton *et al.* (1992). Taking the most recent photograph set as the standard (1991), each tributary was assigned an identification number on the basis of stream order. The presence

TABLE 2.1 : Details of Aerial Photography

Date of photography	Scale	Height (m)	Colour	Quality*
May 1950	1:50,000	7620	black and white	3
June 1975	1:25,000	3810	colour	1
May 1984	1:25,000	un-defined	colour	2
May 1991	1:25,000	3962	colour	1

* Quality is defined on an arbitrary ordinal scale according to the ease with which creeks could be identified; where 1 is the easiest.

or absence of each numbered creek for the years mapped was determined by a set of rules devised by Knighton *et al.* (1992) for the Mary River. A creek that was present on consecutive sets of photographs was included when mapping. A creek that was absent from the middle of one of three consecutive sets, but present on the others was regarded as present on all three dates. Similarly, a creek that was present on the middle of three consecutive sets of photographs, but absent on the others was regarded as absent on all three dates. Knighton *et al.* (1992) noted that the latter of these conditions particularly affected the largest and best quality photographs, whereby many of the smallest tributaries were excluded. This particular condition has not posed a problem in this study, as the most detailed photographs, 1975, 1984 and 1991, were the same scale and of similar quality (Table 2.1).

Maps of the tidal creeks and mangroves were drawn at the same working scale of 1:100,000, so that overlays could be prepared to aid comparison of the presence or absence of streams. Overlays also enabled the comparison of the length and topologic properties of the tidal creeks, and the spatial distribution pattern of mangroves.

2.3 SITES FOR MORE INTENSIVE EXAMINATION

Specific sites were chosen for more detailed examination of the characteristics and trends of saltwater intrusion. Sites were selected from the South and East Alligator Rivers for the different stream segments identified by Chappell (1988). Selection of sites from the estuarine funnel, sinuous and cuspate segments of the rivers was in response to a number of informal selection criteria. Identification of suitable field sites was initially based on preliminary observations of tidal-creek and mangrove extensions from the aerial photograph interpretation. Discussions with *eriss* wetland protection and management staff drew attention to suitable sites for field mapping and ground survey work from a local knowledge of areas exhibiting evidence of saltwater intrusion. Given the time and practical restrictions on fieldwork in the remote areas of Kakadu National Park, site accessibility was a significant factor to be taken into consideration.

Examination of the selected sites incorporated detailed mapping of the tidal creek and mangrove changes from aerial photographs. Sources of the aerial photography used are detailed in Appendix 1. The progress of tidal creek expansion and mangrove encroachment at each site was reconstructed from maps drawn from aerial photographs for the four years, 1950, 1975, 1984 and 1991. Maps were compiled at a working scale of 1: 25,000, with particular attention given to detail, as the length and area properties of creeks and mangroves were the subject of analysis (see Section 2.5).

Three field sites were selected on the basis of the above criteria, to be mapped in detail as a baseline for future measurement and assessment of geomorphologic change. The geomorphological setting and rationale for individual site selections are outlined below.

2.3.1 Point Farewell

Site Point Farewell is located on the southern coastline of the East Alligator River estuarine funnel (Figure 2.1), approximately 2 km south-east of Point Farewell peninsula. The site was selected due to the processes of saltwater intrusion evident on the estuarine funnel segment of the tidal river system. Examination of aerial photographs for the years 1950 to 1991, as outlined above, revealed evidence of localised rapid tidal creek and mangrove extensions in the vicinity of the area (Plate 2.1). Remote sensing projects investigating the use of satellite imagery to predict the trends of saltwater intrusion are currently operating in conjunction with *eriss*. Point Farewell has been used for preliminary studies. The research described herein documents the present site morphology and potential change of field sites, in addition to the changes which have occurred in the recent past. The data attained from this research may therefore provide ground truthing information significant as a baseline for future measurement and assessment.

2.3.2 Munmarlary

Site Munmarlary is located on the transition from the funnel to the sinuous bends of the South Alligator River, 30 km upstream from the river mouth (Figure 2.1). The sinuous segment of the river generally occurs where the freshwater flood discharges exceed the flood tidal flows.

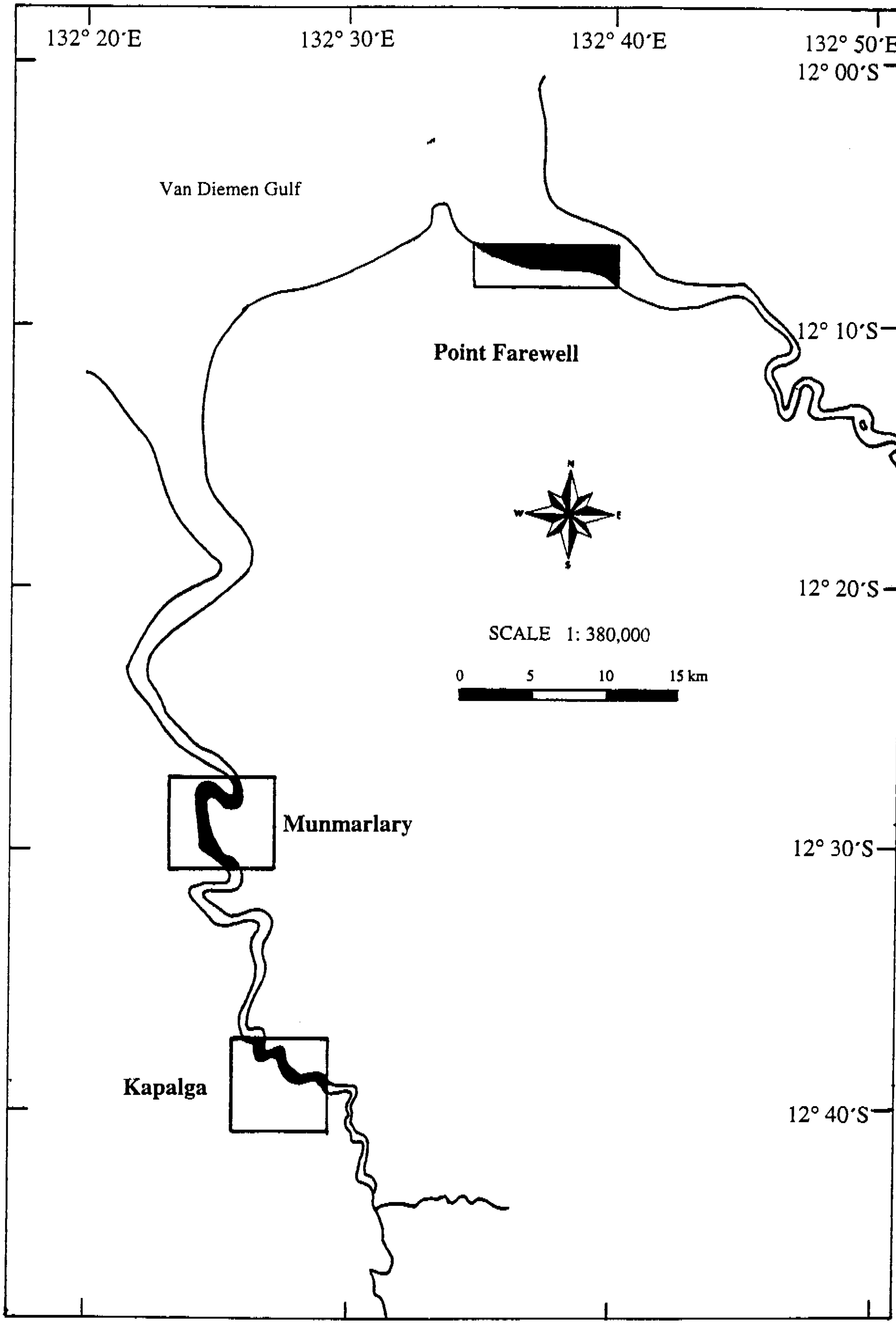

FIGURE 2.1 : Locality Map of Study Sites, Munmarlary, Kapalga and Point Farewell

Source: Base map information is correct to 1971, adapted from Australian 1:100,000 Topographic Survey maps, Series R621, published by the Royal Australian Survey Corps, 1976.

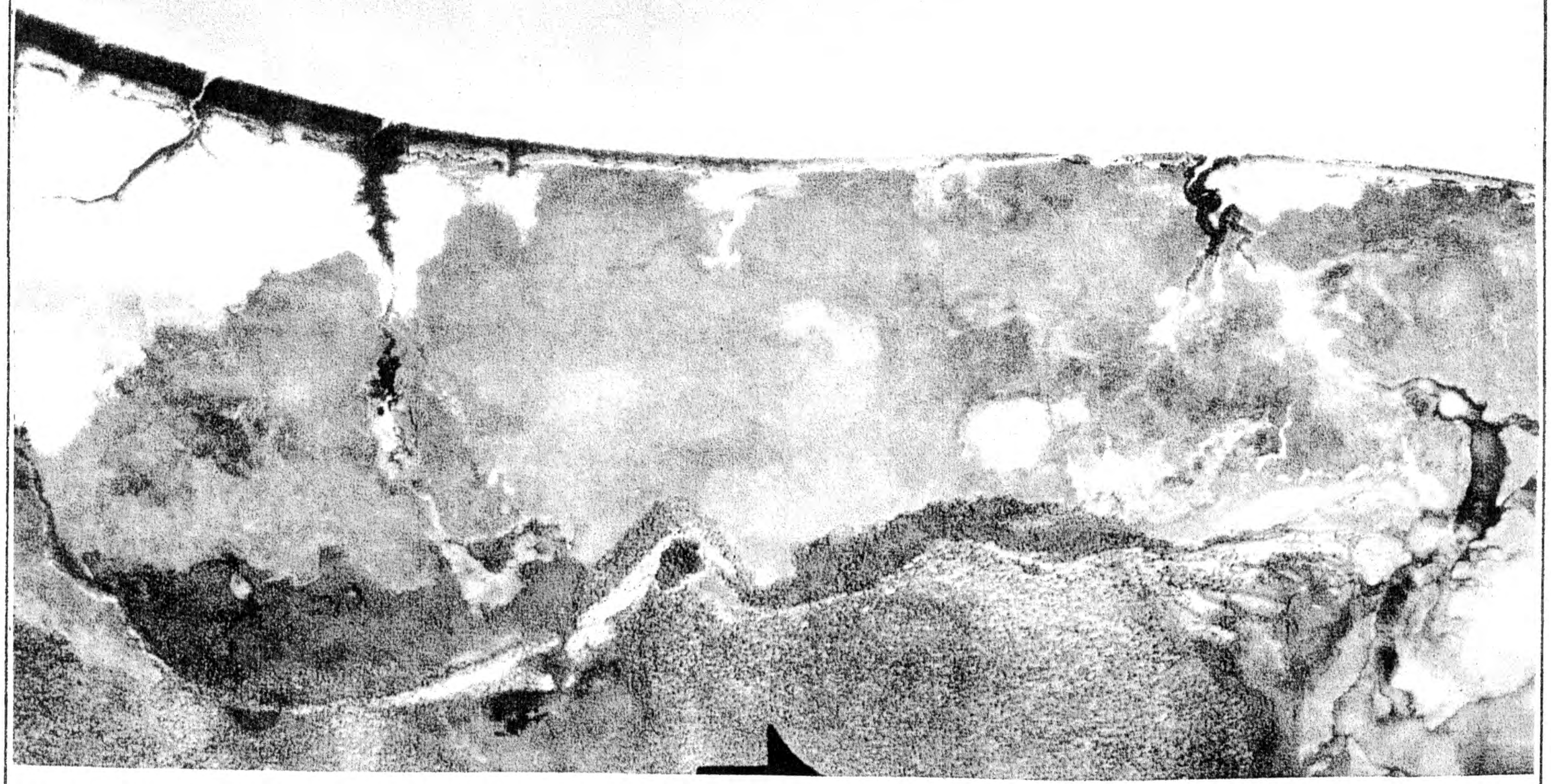

PLATE 2.1a: Aerial photograph of Point Farewell, East Alligator River, 1950.
Photographic evidence of tidal creek extension and mangrove colonisation on the East Alligator River. Scale, 1:50,000.

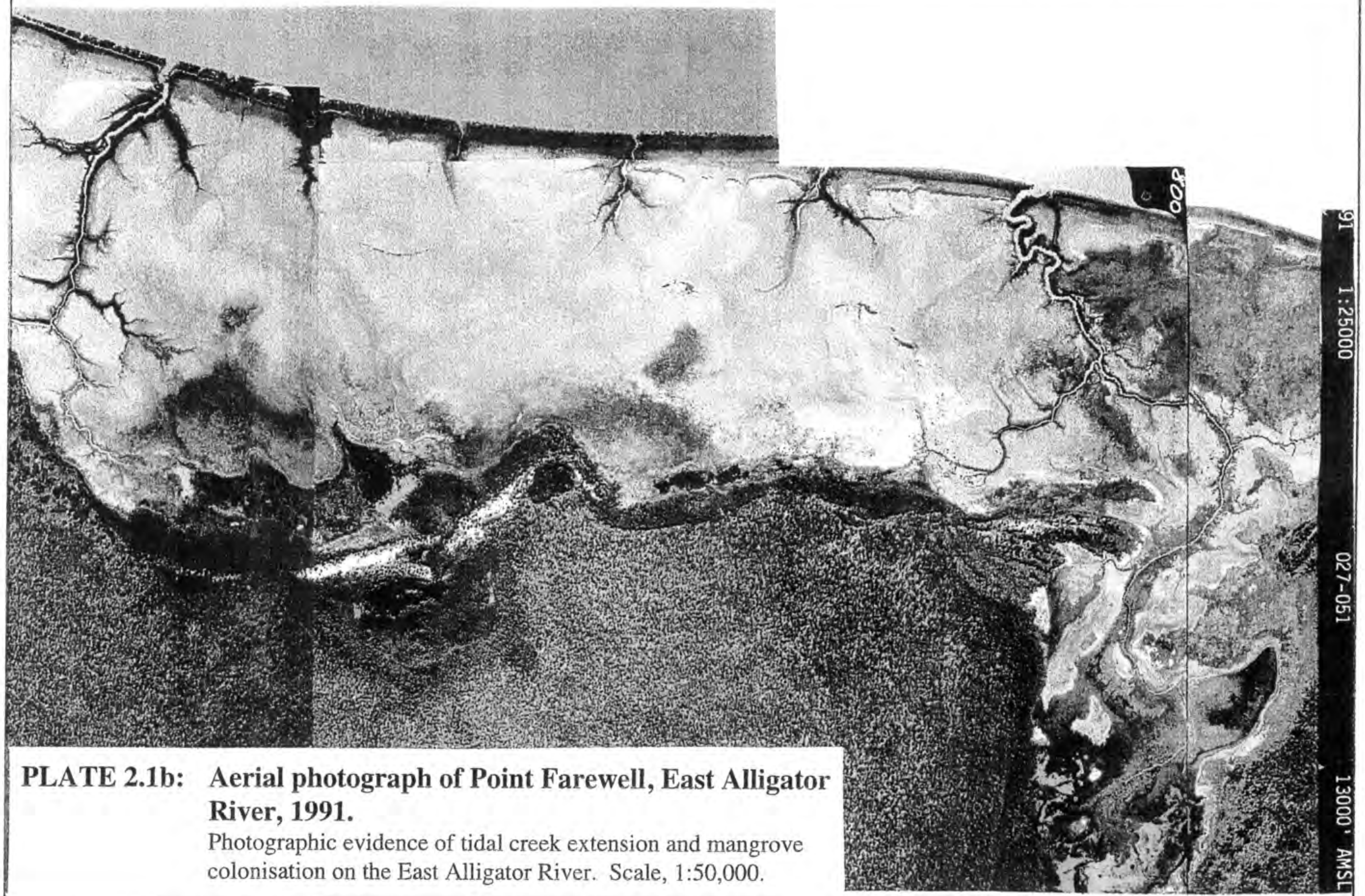

PLATE 2.1b: Aerial photograph of Point Farewell, East Alligator River, 1991.

Photographic evidence of tidal creek extension and mangrove colonisation on the East Alligator River. Scale, 1:50,000.

Munmarlary was selected as a site for the tidal processes operating on the sinuous segments of the river. Examination of aerial photographs for the years 1950 to 1991 revealed evidence of extensive growth of tidal creeks and mangrove encroachment within the confines of a palaeochannel swamp on the western flank of the river (Plate 2.2). Alternate to this trend, on the eastern side there was little evidence of tidal-creek extension (Plate 2.2). Increased mangrove colonisation along already existing creek lines is evidence of an increased saltwater influence. Accessibility to the creek extensions evident within the palaeochannel formation west of the river was limited and unpractical given the time restraints of the fieldwork. Field mapping of the present site morphology was conducted upon the tidal creek to the east of the river. Aerial photographs taken in 1950 and 1991 indicate the creek has remained stable, although mangroves have colonised it since 1950.

2.3.3 Kapalga

Kapalga is located on the cuspate bends of the South Alligator River, approximately 40 km upstream from the river mouth (Figure 2.1). Flood tidal flow is approximately equal to the seasonal freshwater flood discharge within the cuspate segment of the river (Chappell and Woodroffe, 1985). Kapalga was selected as a site for the hydrological processes dominating the mechanism of saltwater intrusion on the cuspate section of the river. Examination of aerial photographs for the years 1950 to 1991 indicate that extensive changes have occurred within the region (Plate 2.3). Analysis of the aerial photographs using a stereoscope indicated the extension of one main tidal creek network into a freshwater swamp, and also indicated evidence of Melaleuca dieback. The Kapalga site was the most accessible of the three field sites and subsequently was revisited over a number of days and the area was extensively mapped.

2.3.4 Potential Sites for Future Research

Field maps were not constructed for a site selected from the fluvial segment of the river due to time restraints. However, broad changes on the South and East Alligator Rivers in recent years are evident from preliminary examination of aerial photographs. The fluvial segment of the South and East Alligator Rivers were characterised by areas of both mangrove encroachment and tidal creek extension. The processes by which saltwater influence extends into the fluvial region may reflect the dominance of the floodwaters in this section of the tidal rivers. Given that there was evidence of saltwater intrusion within the upper reaches of the South and East Alligator Rivers, future research on the trends should include detailed mapping of the morphological characteristics of a changing fluvial environment.

PLATE 2.2a: Aerial photograph of Munmarlary, South Alligator River, 1950.

Photographic evidence of tidal creek extension and mangrove colonisation on the South Alligator River. Scale, 1:25,000.

PLATE 2.2b: Aerial photograph of Munmarlary, South Alligator River, 1991.

Photographic evidence of tidal creek extension and mangrove colonisation on the South Alligator River. Scale, 1:25,000.

PLATE 2.3a: Aerial photograph of Kapalga, South Alligator River, 1950.

Photographic evidence of tidal creek extension and mangrove colonisation on the South Alligator River. Scale, 1:25,000.

PLATE 2.3b: Aerial photograph of Kapalga, South Alligator River, 1991.

Photographic evidence of tidal creek extension and mangrove colonisation on the South Alligator River. Scale, 1:25,000.

The floodplain of the Magela Creek is located within the floodplain of the East Alligator River, some 15 km downstream of Ranger Uranium Mine (Wasson, 1992). The Magela Creek catchment has been subject to considerable research (Finlayson *et al.*, 1989; Finlayson and Woodroffe, 1995; Wasson, 1992). The floodplain has been identified within the literature as a site vulnerable to the long-term effects of climate change and was selected as a specific locality for assessment within the 1995 vulnerability assessment of predicted climate change and sea level rise (Bayliss *et al.*, 1995). The floodplain was viewed as susceptible to the effects of accelerated natural processes resultant from climate change on the tailings dam and other mine features (Wasson, 1992). The Magela Creek floodplain was also delineated as an area at risk to saltwater intrusion in response to sea level rise, shoreline retreat or change in the fluvial regime of the East Alligator River (Bayliss *et al.*, 1995).

The Magela catchment is already exhibiting evidence of environmental change. This change is evident from aerial photographs which indicate the extension of tidal creeks and mangrove colonisation of creeks in the area from 1975 to 1991 (Plate 2.4). The extensive research on the Magela catchment documented to date, in addition to its political significance establishes the area as a suitable site for baseline monitoring. Future research should incorporate a detailed account of the rates and trends of saltwater intrusion within the Magela Creek floodplain.

2.4 FIELD SURVEY TECHNIQUES

Detailed field mapping and general morphological descriptions were conducted at the three selected sites from different geomorphological settings exhibiting change; Point Farewell, Munmarlary and Kapalga. All field work was undertaken during the month of August in the Dry season, over a total period of eight days.

2.4.1 Differential Global Positioning System

The main morphological components of the field sites were mapped using an ASHTECH differential Global Positioning System (dGPS), as an accurate record of the boundaries of present site morphology, and an indication of the trends of saltwater intrusion currently occurring. The base station unit of the dGPS was a dual frequency z-12 receiver. It was necessary to set the receiver over a point of known location, such as a geodetic point or bench mark (Plate 2.5). The location of the known geodetic sites used as base stations for sites Kapalga and Munmarlary is listed in Table 2.2.

PLATE 2.4 a: Aerial photograph of the Magela Creek joining the East Alligator River, 1975.
Photographic evidence of increased mangrove colonisation of creek lines in the Magela catchment. Scale 1:25,000.

PLATE 2.4 b: Aerial photograph of the Magela Creek joining the East Alligator River, 1991.
Photographic evidence of increased mangrove colonisation of creek lines in the Magela catchment. Scale 1:25,000.

TABLE 2.2 : Location of Geodetic Sites

Name	Latitude	Longitude	Zone	Easting	Northing	Height m
Kapalga NTS 018	-12 42 33.2344	132 26 3.3034	53	221360.635	8593640.798	110.600
Munmarlary U 689	-12 28 47.5668	132 29 19.8213	53	227049.642	8619083.356	12.600

Coordinate Datum: AGD84

Plate 2.5: Dual frequency z-12 receiver

Base station equipment at geodetic site, Kapalga (NTS 018)

It was not possible to position the base station over the station mark at the Kapalga geodetic site (NTS 018), as the beacon would interfere with the signal. As an alternative the z-12 receiver was positioned over one of the marker spikes. Since the distance between the spike and the station mark was known, it was possible to determine the relative height of the spike. There was no known reference bench mark or geodetic site at Point Farewell. Therefore, the dGPS base station was positioned over an unknown datum. The base station required a field reference site and as there were no significant rocks or permanent features available, the receiver was set up over a randomly selected site. This location was marked with a star picket.

Features of each site were mapped using the Reliance rover of the dGPS. The rover had a portable Marine IV antenna which could be mounted on vehicle, boat, pole, or carried on back (Plate 2.6). The outskirts of the intruding creek at the Kapalga site were mapped using the rover receiver mounted on a boat (Plate 2.7). Tidal creeks were mapped during a spring high tide of seven metres. This enabled travelling as far upstream as possible without getting stranded as the tide went out. Features of each site that were mapped included the mangrove boundary flanking tidal creeks as an indicator of the extent of saline influence, areas of salt flats, patches of dead Melaleuca, boundaries of Melaleuca forest, tidal channels (Plate 2.8), single mangroves, areas of dead mangroves, and areas of mangrove seedlings. Five second logging intervals were set for line and area features, and 20 seconds for point features.

Plate 2.6: Reliance Rover Receiver
The Marine IV antenna of the Reliance rover receiver mounted on quad bike, operated by a hand-held control.

Plate 2.7: Mapping the outskirts of a tidal creek on boat, Kapalga
Outskirts of tidal creeks mapped by the Reliance rover receiver mounted on boat at spring high tide (seven metres).

Field observations and photos were recorded in order to document features of the site. This information included notes on the vegetation types and general distribution within the sites, soil structural characteristics and surface cover. Soil samples were taken from Kapalga and Point Farewell for descriptive laboratory analysis. Location of soil samples were mapped using the dGPS. An example of the field program is outlined in Appendix 2.

2.4.2 Data Processing

The dGPS data logged in the field was down-loaded daily from both the base station and the rover receiver to the Reliance software package. The down-loaded field data was then processed using the Reliance software, which generated the corrected data to a graphical format. Once processed, the data was exported to text files (txt.file) which may be viewed in Word or a spreadsheet. Logged information included recordings of latitude and longitude values, elevations, and measurements of accuracy. The processed data was exported into generate files (gen.files) and manipulated in Arc Info and Arc Edit to generate maps of each field site.

Plate 2.8: Mapping tidal creeks on quad bike, Kapalga

Tidal creeks mapped by the Reliance rover receiver mounted on quad bike. Tidal creeks were mapped at low tide.

2.5 ANALYSIS

2.5.1 Network Properties

Geometric and topologic properties of the Wildman, West, South and East Alligator River networks, were determined as measures of the rate and modes of tidal creek and mangrove growth over the years 1950 to 1991. Network magnitude is a topologic variable corresponding to the number of exterior links of first order channels (Shreve, 1967), and was used as a measure of network size. Mangrove area was calculated from the maps constructed for each year, 1950, 1975, 1984 and 1991, as a measure of the rate of mangrove encroachment. Network magnitude and mangrove area were calculated for each river system and for the field sites Kapalga, Munmarlary and Point Farewell that were mapped in detail.

Stream order is a topologic variable which expresses the hierarchical relationship between creek segments. The tidal creeks of the field sites Kapalga, Munmarlary and Point Farewell were ordered using the Strahler (1964) system, which defines a creek with no tributaries as a first order segment. A second order segment is a creek which is formed by the joining of two first order segments and a third order segment is joined by two second order segments and so on. Creek lengths were measured from the detailed maps constructed for each field site, Kapalga, Munmarlary and Point Farewell for the years 1950 to 1991 using an opisometer. Creek lengths were measured only for the field sites, given they were mapped at a large scale, 1: 25,000, and would therefore be measured with greater accuracy.

2.5.2 Laboratory

Soil electrical conductivity was determined for all soil samples collected in the field. The electrical conductivity of a soil : water extract is used to estimate soluble salt concentration in soils (McArthur, 1991). Electrical conductivity (range 0.51 - 41.30 mS/cm; mean 8.86 mS/cm) were measured on 1 : 5 soil water suspensions (Rayment and Higginson, 1992).