Fort Dundas: First Settlement In Northern Australia.

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for
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Abstract

In 1824 the British landed in northern Australia, ready to defend it against the French or the Dutch. They found a hard country, ungiving and unforgiving. The settlers built a fort and a settlement they named Fort Dundas, after the First Lord of the Admiralty. Five years later they abandoned the settlement and moved to Fort Wellington further to the east. What went wrong?

This report uses GIS to examine the defence network set up at Fort Dundas. The project created a digital elevation model of the Aspley Strait area of Melville Island. It modelled the gun and lookout positions in the area and used viewshed analysis to evaluate the effectiveness of the defence system established by the British. The project found that, although the Fort Dundas eventually failed, the artillery strategy proved effective in the settlement's defence. The project also notes that the settlement was vulnerable to attack from inland. In reality, this attack came not from the Europeans, but from the Tiwi Islanders defending their land.

Predictive modelling techniques were used to investigate the role of one building and the possible location of a lookout on Luxmore Head. The results of the GIS indicated that building commonly referred to as the 'magazine' or 'church' may have had another function and been a fundamental part of the British defence strategy.
Fort Dundas was a British military fort and settlement situated on Aspley Strait, Melville Island, about 150 km north of the modern city of Darwin. About 120 soldiers, sailors, marines and convicts landed in September 1824, on a promontory they named Point Barlow after their first commandant. They quickly constructed a defensive fortification approximately 80 metres long and 60 metres wide. They situated a number of 9lb naval guns in the fort bastions. The colonists built a number of other buildings including housing for the officers and soldiers, a convict barracks, a hospital, a magazine, a church, commissariat store, a Governor's residence and a number of free settlers houses.

Some sources state that further military positions were prepared on nearby Harris Island, supposedly a gun position facing south and another facing north (Pye 1998 p.10). The two gun positions were linked by a track (information from Traditional Land Owners). It is also suggested by some that a lookout post was situated some 8 km north of Barlow Point on Luxmore Head. Gardens were started on the site of the modern Tiwi Aboriginal community of Pularumpi. These gardens eventually gave rise to the English name for Pularumpi, Garden Point. Tracks were developed into the hinterland and a brush fence built across the point in an attempt to keep the Melville Islanders out of the settlement area. A sketch of the site done in 1824 shows a busy settlement, with impressive buildings and fortifications, apparently there to stay. A map made in 1827 shows the numerous buildings, the fort and fields, neatly set out in the familiar colonial pattern (Crosby 1975 p.30).

However, this success was not to last. Scurvy struck the settlement as the colonists ran short of fresh food. Agriculture failed due to poor soils, water shortages and lack of experience (Calley 1998 p.20). Antagonistic British attitudes toward the Tiwi Islanders limited friendly interchange of information. The settlers seemed disinterested in learning about local foods from the Tiwi people, a problem later partially remedied at the Port Essington settlement (Earl 1863). Malaria followed scurvy as the colonists immune systems weakened (Calley 1998 p.29). These diseases remained for the life of the settlement and added a number of graves to the area near what is possibly the remains of the church. Further disaster struck then the two vessels attached to the settlement, the Lady Nelson and the Stedcombe journeyed to Timor, but were taken by pirates (Crosby 1975 p.5). The settlement was then isolated from the world.
The settlers cleared as much land as they could, given the poor state of health of many. Even so, only 21 hectares were cleared in the first two years, and a further 34.3 hectares were felled but not cleared (Crosby 1975 p.3). This gave the Tiwi warriors ample cover as they ambushed the settlers even within the bounds of the brush fence. Some sources indicate that spears were hurled even through the hospital, only 150 metres from the fortifications.

Trade was not forthcoming with the Macassans, who avoided the area due to hostility of the Tiwi Islanders and possibly due to the paucity of trepang in the area. Trade with others was not productive either, for although the settlers bought products freely from visiting ships, there was no produce to backload to other ports. The 'Singapore of the South' ideal was never to eventuate.

The commandants after Barlow wrote dispatches to the colonial office indicating the problems encountered by the settlement. The nature of these dispatches gives us an indication that historical sources, although valuable, are not to be relied on in all cases. Captain Bremer, the original expedition leader commented on the richness of the soil in the area, the possibility of successful agriculture and the bountiful nature of the gardens (Calley 1998 p.16). The second commandant, Campbell, believed that the area was completely useless for agriculture, advising the Colonial Office that the settlement should be abandoned. The last commandant, Hartley, was more positive about the success of the settlement, but the die was already cast. Most of the settlers were relocated to the Fort Wellington settlement in 1827. All useful equipment was relocated there in 1829, and Fort Dundas closed. Fort Wellington was also abandoned later in the same year, leaving the remains to the encroaching bush.

The conflicting opinions on the viability of the settlement highlight the unreliability of historical accounts. Furthermore, Colonial office records do not conclusively deal with the reasons for starting and ending the settlement. This leaves the field open for archaeological investigation of the site.
Archaeological significance of the project:

The project is archaeologically significant because it aims to test the hypothesis that the settlement was a purely military manoeuvre by examining the efficiency of the defence system used by the British. In particular it aims to analyse the positioning of the guns and tests if other command structures may have been in use to increase the efficiency of the guns. If the defence system proves effective, then there is at least one positive aspect of the selection of the site, given that the possibilities for trade and agriculture were extremely limited.

The project proposes to:

1. Use a GIS to create a three dimensional survey of the remains of Fort Dundas.
2. Using a viewshed analysis to examine the effectiveness of the defence system employed at the Fort.
3. Using predictive modelling to indicate where sites may be located. These sites may be investigated during the next field season.

Hence, the project plans to use archaeology and GIS to examine a number of questions about the location of the Fort that are so far unanswerable by traditional historical research methods. These include the reasons for the fort's existence, the identification of some buildings and the defence strategy used by the British.

Stakeholders.

The principle stakeholders in this project were:

- Tiwi Land Council and the Tiwi people. The Tiwi people are justifiably proud of their history and their success in limiting settlement by the British and Dutch on their land. The Tiwi Land Council supported the project with permission to conduct field work and stay in the Garden Point community. The Pularumpi people also gave the field team valuable assistance in the form of verbal stories of the settlement and subsequent archaeological investigators.
The Department of Lands, Planning and Environment gave the team support in the form of $3000 in grants, plus the loan of their DGPS unit. Unfortunately this unit failed during operation. Thanks also to Steve Sutton and Darryl Guse for their support and valuable advice.

The field team consisted of Dr Clayton Fredericksen, Colin De La Rue and David Steinberg. Their efforts over the three week season were invaluable in collecting the data in this report.

Project Scope.

The project timeframe was one academic year. The area covered is 148.4 square kilometres of Melville and Bathurst Islands including Aspley Strait. The survey work was largely limited to Point Barlow, the site of the settlement approximately 3 sq km.

All work was completed within a budget of $3000 for field work, plus some extra private funds.
Literature Review

This literature review critically examines references to the Fort Dundas in a number of broad categories:

1. Historical background to the site.
2. Previous archaeological research on the site.
3. Theoretical approaches to archaeology using GIS as an analytical and planning tool.

The project is broken into these categories due to the disparate nature of the sources themselves. The site has had relatively few archaeological researchers, and none have ventured into the realm of GIS analysis. Archaeological research and GIS is a new area, with much yet to be said on theoretical and practical issues.

Historical background.

As mentioned in the introduction, the primary historical sources leave much of the Fort Dundas story untold. This has been due to a number of factors including loss of important primary source material, and the difficulty and expense of searching through the archived sources of the British colonial office in London. Hence, we turn to archaeology to solve some of the questions associated with the site.

Despite this, historical sources construct an important framework onto which we hang our archaeological research. Historical sources can generally be categorised into two general groups: primary source material, such as documents from the Colonial Office in London, books and journals from eyewitnesses, and maps drafted during the period of the site occupation, and secondary source material, which provides important overviews of the historical background to the site, particularly where primary research is not possible. Historical archaeology relies on both sources of material, however, as archaeology is the primary focus, thorough searches for primary source material is often left to the historians.

One of the major secondary sources the Fort Dundas was commissioned by Peter Spillett in his 1972 work on Port Essington Forsaken Settlement. While Spillett's work concentrates on the later settlement at Port Essington, he does give a potted history of Fort Dundas, along with a cursory examination of the motives of the British in settling northern Australia (Spillett 1972 pp.11-16). Overall Spillett's work is a
useful introduction to the subject, however his work is primarily descriptive, without a robust analytical basis on the reasons for the settlements.

Jim Allen's work *Port Essington: a successful limpet port?* challenges commonly held views on setting up the settlements. While Allen focuses on Port Essington, the analytical base of this work can be applied to Fort Dundas. Allen's asserts that both settlements were successful strategic manoeuvres, rather than costly failures. He contends that the British withdrew their forces from the settlements not due to supply, economic or disease reasons, but because they had served their purpose. (Allen 1972 p.352). Allen states that the settlements were primarily to forestall Dutch or French occupation of the north coast of Australia. As that danger passed, the need to support the settlements disappeared. The later settlement at Escape Cliffs and then Darwin were agricultural and trading enterprises rather than military in nature.

Another source of local information on the site comes via John Pye's book *The Tiwi Islands*. Pye mentions the gun positions on Harris Island only as a passing reference (p.10). Historical sources on the ordinance of the nineteenth century are sometimes difficult to find. Wise and Hook's book *Artillery Equipment's of the Napoleonic Wars* is somewhat of a classic, being the only book available on the artillery of that era though *Napoleon's bookshop* in Sydney. Besides showing delightful sketches of artillery of that period, the book gives detailed instructions on how to load such a piece should one come across one. The book also details effective and maximum ranges for the 9lb naval artillery that historical sources state were installed at Fort Dundas (Hook and Wise 1979 p.29).

Another secondary source of interest is Graham Calley's book, *The Pumpkin Settlements*. Calley deals conclusively with the agriculture and health issues surrounding Fort Dundas, Fort Wellington and Port Essington. He convincingly argues that a major reason for the failure of all three settlements can be attributed to agricultural failure, poor soils, water availability and the health of the settlers.

Dora Howard's 1933 work *The English activities on the north Coast of Australia* is a useful background work. Howard's position was that Fort Dundas and Fort Wellington were primarily military occupations, not intended to be thriving settlements, even though the trader William Barnes was enthusiastic about starting a trading post (Howard 1933 p.99). Howard (pp.92-93) asserts that Port Essington had a trading motive, the 'Singapore of the South' theory.

It is beyond the scope of this report to include a major literature review of primary sources, however there are some useful works easily available in the NTU special collection. These include George Earl Windsor's *Enterprise, Discoveries and...*
Adventures in Australia (1846) and A Handbook for colonists in Tropical Australia (1863.) Windsor drew his information from experiences in Port Essington, but makes mention of Fort Dundas on several occasions. His comments on agriculture, fishing, malaria, scurvy and relations with the Aborigines are particularly useful for both areas.  

Archaeological research.  

Eleanor Crosby's work Survey and Excavation at Fort Dundas, Melville Island, Northern Territory, 1975 was the first thorough survey of the site. Crosby conducted a detailed planometric survey of Barlow Point, listing 74 features representing what is supposed to be the remains of buildings, the fort itself, paths, walls and other artefactual features. Her map, drafted in 1976 by the Australian Survey Office, Darwin, remains an important interpretation of the Fort Dundas remains. Her labels on features, such as the Commandants house, the military barracks and the hospital, are sometimes contested by archaeologists, but conclusive evidence either for or against her interpretation is not yet forthcoming. Crosby's book also includes a copy of the 1827 map drawn on site.  

Crosby excavated part of the trench and embankment at the fort, reconstructing diagrammatically the original construction of logs, stones and earth from the remains in the bottom of the trench. Crosby lists a number of artefacts, including a military shako plate, part of the head dress regalia of the 3rd British regiment, the "Buffs".  

Crosby also includes a thorough historical background. Her perspective is that the British wanted to control the activities of the Dutch, French and Portuguese in the Indonesian and SE Asian area (p.1). Hence they decided in 1824 to establish a colony on the north west Australia and sent Captain Bremer with three ships to locate a suitable place, and establish the colony. As well providing a pre-emptive garrison forestalling other European countries, Crosby cites evidence that the British hoped that the colony would flourish as a trading settlement. She notes that Singapore was established in 1819 and was already a successful trading settlement.  

Crosby (p.2) continues with a narrative of the selection of the location for the colony by Captain Bremer. She comments on the defensive aid given by the selected terrain in particular the elevation of Point Barlow and the position of Harris Island being important. She also notes that the tidal stream and shoals in Aspley Strait make approaching the settlement difficult from the north and almost impossible from the south. Bremer had apparently visited Port Essington on the way to Melville Island, and on discovering no regular water supply, decided against a settlement there. Ironically at the time of settlement, the only two really suitable sites in the area, Port Darwin and Bynoe Harbour, were about the only places on the coast that had not been
charted by Matthew Flinders and Philip Parker King. Crosby also makes mention of the proximity of the settlement to the major shipping route between India and Sydney, a reference to the idea that a haven for shipwrecked mariners was needed somewhere between the two ports.

Archaeologically, Crosby's work was significant as it was the first thorough survey of the site. She notes that the terrain is difficult to work in, as extensive clearing and burning is required to locate and access some of the remains. She also makes mention of the apparent discrepancy in the dimensions given on the 1827 map to the reality of the remains today (Crosby 1975 p.19). She notes that the distances between building are exaggerated, as is the overall size of the fort. One can surmise that the British were attempting to exaggerate the size of their colony and its defensive fortifications to impress both any possible enemy, and their colonial masters in London.

Crosby's discussion notes that she was unable to examine Harris Island (p.18). Garden Point people reported to her that there was a landing place and some stonework on the southern end of the island. The northern end seems to be a more logical place for a gun emplacement, as the southern reach of Aspley Strait is makes for extremely difficult navigation.

A number of local land owners, Tracy, Neil and Marius Purantatameri reported to the 2001 field team that stone work existed at the southern end of Harris Island. They also mentioned a flattened position on the northern end of Harris Island, plus a track linking the two sites. Both Tracy and Neil worked with Eleanor Crosby on the 1975 field team as teenagers. They were able to give our team valuable assistance in both in historical and geographic knowledge of the area.

Our team was not able to penetrate the island's forest, however further research may show the extent of the British position there. Hence this report is proceeding on the premise that their was a gun position on the northern end of Harris Island facing north into Port Cockburn. It is hoped that the 2002 field season will be able to find the sites mentioned by the Purantatameri clan. The aim of this field work will be to spatially locate the sites and then be able to locate them in time to either the Fort Dundas period, or the Second World War period. While the information given by the Purantatameri's definitely linked these sites to the Fort Dundas period, artefacts found by our team near the bastion itself leads us to believe that there was extensive activity in the area in WWII, principally logging for the landing at Garden Point, where a military base was established (Pye 1998 p.78).

Fort Dundas: GIS evaluation of defensive works.
Theoretical approaches to Archaeological Problems.

This project focuses on two GIS techniques in archaeology: cumulative viewshed analysis and predictive modelling. Cumulative Viewshed Analysis is covered by Wheatley in "Cumulative viewshed analysis: a GIS-based method for investigating intervisibility, and its archaeological application" (1995 p.171). Wheatley takes a functionality, viewshed analysis, common to most GIS software packages and extends in the archaeological area. Wheatley first considers the ordinary viewshed: the predicting the visibility or line of sight from one point in the surrounding area, for example a lookout from a ships mast. Cumulative viewshed analysis calculates the visible areas from more than one point. In this project, the cumulative viewshed will be from the Fort Dundas bastions, the gun emplacements on Harris Island and the possible lookout position on Luxmore Head.

In this scenario, we can guess from looking at the topographical map that Luxmore Head was not visible from Barlow Point, the location of Fort Dundas. However, the real question is was the lookout visible from the high point approximately one kilometre to the south of the fort? Was there a system of intervisibility that included the Fort, the high point to the south of the fort, Harris Island and Luxmore Head? This could be tested by actually visiting each site and checking the line of sight. However, this would be expensive, involving use of planes, four wheel drive vehicles and boats. Furthermore it does not give us the true line of sight for the period, as we know from historical sources that the colonists cleared the tall trees from most of the Barlow Point area.

The GIS area is well served by a number of authoritative texts. Among these Michael DeMers text Fundamentals of GIS (2000 pp.264-268) gives useful information on the process of interpolating a DEM grid from a point theme. Issues surrounding the techniques commonly used are conceptually explained. This project uses Inverse Distance Weighting (IDW) to interpolate a grid, a process which causes some problems as discussed in the methodology section. DeMers also discusses Kriging, another interpolation technique which may have been more useful in this project. (ArcView was not able to use this method.)

Longley, Goodchild, Maguire and Rhind's book Geographic Information Systems and Science (2001) evaluates some of the problems in using IDW as a method of interpolating a grid. They note that "a weighted average that uses weights that are never negative must always return a value that is between the limits of the measured values" (p.297). Applied to this project, this concept means that as the sea level value given an elevation value of zero, any grid square that did not contain a zero value would interpolate as a number above zero as the process considers values at a distance,
even though it doesn't weight them as much as close values. In a practical sense, this is why some values in the sea and the low lying mangroves returned elevation values above zero. This was ignore for this project as it didn't have a great bearing on the overall result. One way of dealing with this problem is to use break lines to define the zero elevation values at sea level.
Resources used.

The project used a number of data, soft and hardware resources.

**Hardware resources:**

Nikon D60 EDM (total station)
Garmin 12 handheld GPS.
Magellen GPS 315
Prismatic compass.

**Software resources:**

ESRI ArcView 3.2
Erdas Imagine
GDAit transformation software.
Microsoft Excel spreadsheeting.
Lotus Approach.

**Data Resources:**

- Historical maps of the settlement from 1827, Mitchell Library, Sydney.
- 1:2000 Archaeological survey map and survey notes by Eleanor Crosby in 1975.
- Survey of site by Ian Pengelly 1986. (Sheets CP 4700 1:1000 series.)
- Primary source historical notes, books and journals.
- 1:50,000 topographic map Pularumpi.
- Detailed survey of the site by Clayton Fredericksen and others. (2000 X,Y,Z co-ordinates around the site acquired using total station.)
- Technical data on the types of weapons used in the fort such as range and effectiveness.
- Survey data from 2001 field season by Richard Woolfe and David Steinberg.
- DGPS datum at Garden Point Airfield provided by Survey Generals N.T.
- Temporary Bench Marks (to mean sea level) provided by Survey Generals N.T.
- Auslig 9 second DEM of Melville and Bathurst Islands.
Methodology

Overview of methodology.

As noted above, the project was designed to create a Digital Elevation Model capable of accurately analysing the potential of the fort site for self defence, hence adding to our understanding of the reasons that the site was chosen over other potential sites such as Port Essington. Given that rational, it followed to create a DEM over a wide area of Aspley Strait, then conduct a viewshed analysis of the guns and lookout positions at the bastion, on Harris Island and Luxmore Head. The DEM created has far more points than necessary in some areas so as to be of use in further archaeological investigations of the site.

Project Area.

The project area was bounded by eastings 654000 to 655600 and northings 8749000 to 8735000. This gives a total area of 148.4 square kilometres. This includes most of Aspley Strait north of Harris Island up to Luxmore Head on Melville Island, including the modern Indigenous community of Pularumpi (Garden Point).

The project datum was WGS 84. This datum was chosen as the standard datum for GPS. The co-ordinate system is UTM, quoted in eastings and northings in zone 52 south. The height datum used is a local datum provided by Survey Generals NT, however this datum is estimated to be within one metre of Australian Height Datum (AHD). The local datum was used as the tidal flow in Aspley Strait is such that a mean tidal height at Garden Point may not be the same as Darwin.

Survey Plan.

The 2001 field season aimed at collecting data for a number of archaeological projects. The field team consisted of Richard Woolfe, David Steinberg, Colin De LaRue and Dr Clayton Fredericksen. The team worked on the site for three weeks in August/ September 2001. The survey plan was essentially a field guide to data collection for the site as a whole and for this project in particular. Unfortunately, the DGPS provided by Department of Lands Planning and Environment suffered a technical fault on the first day, and was of no further use for the field season. These were the main guides for the work:

Fort Dundas: GIS evaluation of defensive works.
1. Locate Benchmarks and DGPS datum provided by Survey General N.T.

2. Check gross error of handheld GPS at DGPS survey datum, apply error in bearing and distance to each handheld GPS record. (important GPS readings were averaged as well, a function available on both the Garmin and the Magellan to increase accuracy.)

3. Use EDM and GPS to fix WGS84 co-ordinates for the primary bench mark near the Garden Point barge landing. (see appendix for position, sketch plan of locality etc.)

4. Establish base datum at Barlow Point. Average hand held GPS positions over 5 days. Use EDM to gain foresight and backsight positions with reference to Barge temporary bench mark.

5. Reconnaissance survey control points for closed traverse around site (approx. 1000m) Hammer in stakes, take GPS positions for these CPs for gross error check. Calculate UTM co-ordinates for these control points using GridCalc. Check for gross error, perform closure calculation and adjust points accordingly. Expected error less than 100 mm in horizontal plane and vertical plane.

6. Perform radiation survey from each of the twenty control points across site, ensuring even spacing of points, noting major features such as the high tide line, cultural features such as the fort remains and major topographical features such as ridge and cliff lines.

7. Calculate x,y,z co-ordinates for radiation survey using excell spreadsheets to within one metre error in horizontal plane and 100mm in vertical plane.

8. Convert this data to WGS 84 eastings and northings for creation of table within ArcView.

9. Survey main Barlow Point track from termination near site datum to remains of 'magazine' building near highest point on the ridge. (see map for details.)

10. Take GPS points for north and south ends of Harris Island at high tide line.

11. Use EDM to for remote heighting survey of Harris Island. (vegetation to thick to use either GPS or EDM.)

12. Calculate X, Y, Z co-ordinates for highest point on Harris Island, plus a number of other points.

13. Establish similar method to gain heights on Luxmore and Tamar Head.

14. Establish by survey the convenient points for landing on or near the Fort. The assumption was made here that the terrain has not changed much in the intervening years. 4 possible landing points were recorded, processed into data tables and published in the results.

15. Use Auslig 9 second theme for heights across rest of project area.
1. The 1:50,000 topographic map was scanned and georeferenced using Erdas Imagine, then imported into ArcView. This process was repeated for the aerial photograph, Crosby's 1975 map, the 1827 map and Pengelly's 1986 survey.

2. Topo data from the field season was processed using an Excel spreadsheet (see appendix) recording the results of the radiation survey. This data was added to a table with the following fields: Point identification, Eastings, Northings, Elevations, Notes. The data was projected in MGA94 for compatibility with WGS84, the datum used for GPS results. (Difference 100mm, not significant for our project).

3. The excell spreadsheets were copied into Lotus Approach for importing into ArcView.

4. Data extensively checked for reliability using error checking procedures below.

5. Harris Island and Luxmore Head elevation and position data was added to the data base table. (DEMtopo.dbf).

6. The table was imported to ArcView using the add event theme function.

7. The Auslig 9 second theme was imported as a DEM theme to ArcView, however, the scale of the data precluded it being used effectively in this project. This was because the grid cell size of the data was approxiamately 250m. When some smaller areas, such as Harris Island were checked, the surrounding sea level was averaged with the land heights, giving incorrect data. (ie the spot height of 19 metres for Harris Island south, was averaged with the surrounding sea to give a cell elevation of 5 metres.) Using this data would be impractical. To overcome this problem the large areas of the procect area were digitised from the topographic map.

8. Additional points were added to the table representing the sea level in the project area, using the 1:50,000 topographic map. These points were assigned an elevation of 0 metres, representing mean tidal level for the area. They were added to the table using the digitizing extension, with the topographic map as a guide.

9. Mangrove areas were digitized to the the base map with an assigned elevation of 2 metres.

10. Spot heights and contour lines were assigned to the point theme from the topographic map.

11. A grid theme was interpolated using the IDW method with a cell size of 100m. This was reclassified into 7 classes using equal intervals of 5 metres of elevation. The other grid interpolation method, spline was attempted, but the results were not valid for this project. See section on interpolating grids to produce Digital Elevation Models in the literature review for further clarification.

12. 5 metre contour lines were then added to the grid, and saved as a shape file. This created a base map consisting of the topographic map scanned in, with a 5 metre contour overlaid. The DEM surface was saved as a grid file.

Fort Dundas: GIS evaluation of defensive works.
**Viewshed analysis: Luxmore Head.**

The view from Luxmore Head was analysed using a standard viewshed function on *ArcView*. The following steps were used to conduct this evaluation:

1. A database file was created using Lotus Approach to record the co-ordinates and elevations associated with Luxmore Head, the suspected lookout position. The gun positions in the bastion and on the north and south ends of Harris Island were also included on this table. This was imported into ArcView using add event theme.
2. This table was edited to include only one record, the GPS position at Luxmore Head. This was saved as a point theme.
3. A standard viewshed analysis was then conducted using the DEM surface and the Luxmore Head point. The results of this analysis are recorded in the results section.
4. Another viewshed analysis was conducted using all five points in the original point theme (Luxmore, Harris Island and the Fort). This results of this cumulative viewshed analysis are also recorded in the results section.

**Evaluation of effectiveness of the defences at Fort Dundas.**

This evaluation was conducted using ArcView model builder to create an arithmetic overlay. The rationale behind this was to evaluate the visibility available to the artillery men on the Fort and the Harris Island north position overlaid with the maximum and effective ranges of the guns from these positions. As noted in the project aims, the objective of the evaluation was to test the hypothesis that any opposition would be able to sail into Port Cockburn, land a force in one of several places without being in range of the British artillery. The results of this analysis should determine whether the fort was placed well for defence. The following steps were used in the evaluation:

1. Create point theme for landing points. These points were established as good landing points for an attacking force in the 1820's (who would need to use long boats to land hopefully on a sand beach rather than a mud flat or in mangroves.) This theme was created and saved using the same method as previous point themes.
2. The gun position table was edited to include only Harris Island North and the two western bastions on Fort Dundas.
3. To ease use of computer resources a find distance function was used for each of the four gun positions. (Model builder could have been used for the next two steps, but the PC used was unable to cope with the demands.)
4. The resulting four themes were reclassed to effective gun range (830m), max gun range (1555m) and out of range. Effective gun range was classed as value 2, max gun range value 1 and the rest value 0.

5. Map calculator was then used to multiply the visibility theme for each point by the range of the gun at each point. As the range themes were weighted with out of range equalling value 0, the resulting theme only mapped visible and in range areas. The resulting themes were converted to grid and saved. A common legend was loaded for each reflecting the two areas. The flow chart on the next page reflects the process above.

6. Model builder was used to create a decision process using the arithmetic overlay function. The four grid themes were added together with the resulting areas given a rating of effectiveness on a scale of 1 to 5, with 1 being a safe place to be, and 5 meaning in effective range of 2 or more guns, and hence not a great place to loiter.

7. The resulting map was then visually analysed with the landing place map to ascertain if any point was a feasible and safe spot to land. The results are included overpage.

The following decision criteria were used:

1. The main artillery piece used was the British 91lb naval gun with a maximum range of 1550 metres and an effective range of 830 metres (refer Hook and Wise p.28)
2. Such artillery pieces needed to directly sight their targets, hence the target needed to be in view to fire. Modern indirect artillery fire was not possible at that time.
3. The four landing places were weighted according to whether they were in field of fire.
4. The best rated defensive position was where effective range fire was possible from two places at once. (ie a crossfire).

The following assumptions were made:

1. Potential attackers would have been interested in capturing the settlement and fort using a landing party.
2. The landing party would have landed near enough to march easily to the settlement, from the most convienient direction.
3. They would have used long boats to land.
4. They would have preferred to be landing in a point out of the viewshed of the defenders artillery. (even 19th century artillery using round shot, cannister or sherical shell would do incredible damage to a long boat full of soldiers.)
5. The attackers would have arrived in ships from the north: Aspley Strait is far to shallow and trecherous for sail and oar powered vessels. The tidal flow there in often up to 6 knots (field work data collected 2001.)
Results and Discussion.

*Effectiveness of defence.*

The GIS process showed that the British had set their defences well, with any hostile ship entering the Port Cockburn area in range of cannon fire. The area to the east of Harris Island, the deepest channel in the Strait was especially well covered, with effective fire possible from the bastion, as well as from the island. The effective ranges from both the fort and the island overlapped, meaning any ship in the channel would be in an effective crossfire.

The result of the landing party analysis showed that assault from the land would be hard to defeat. The beach at Pularumpi was completely hidden from view of the fort and out of range of the gun on the northern part of the island. A force would have a relatively short march around the Kings Cove area to attack the settlement from the rear. The other landing places wouldn't have been feasible, as they would have been under cannon fire for a considerable time before landing.

Historically, the only force that did attack to fort was the Indigenous Melville Islanders. They came from the land area and threw spears into various buildings, precisely where the British would have had difficulty in defending against a European force.
Map 1: Cross fire area from Fort Dundas and Harris Island. Port Cockburn and Aspley Strait. Not to scale.

Red shading: Most effective crossfire.
Buff shading: Effective crossfire.
Lilac shading: Least effective crossfire area.
Viewshed from Luxmore Head.

The initial viewshed from Luxmore Head indicated no intervisibility with Point Barlow. A completely different result occurred when 3 metres was added to the ground elevation of the building on Barlow Point. Construction of such a tower would have been relatively easy for the settlers. With this in place, the viewshed analysis indicated that a large part of Luxmore Head is visible from the 'magazine' site as well as all the gun positions. Was this the 19th century version of a command post?

Map 2: 1827 map of the Fort and settlement. North is oriented to the left edge of the page. The Fort shown as a large rectangle near the bottom centre, the 'magazine' is top centre at the intersection of four lines. The vertical line represents the main track to the fort. The near horizontal lines are probably the line of the brush fence. The complete map is included in the index (courtesy Crosby/ Mitchell Library Sydney).

The 1827 map shows what is probably this building located in a central position along a fence. Historically this is mentioned as a picket and brush construction, used to either keep animals in or out of the settlement, or as a line of defence against incursion from the west. Was the building a defence point in this fence line as well as a command post for the gun positions? Certainly without such a tower there could have been no way of a lookout on Luxmore Head contacting the fort in time of possible threat.

Fort Dundas: GIS evaluation of defensive works.
Map 3: Luxmore Head viewshed. Luxmore Head is the prominatory facing north west on the eastern side of the strait. The viewshed from this point is the dark blue shading to the west. The effective gun range from Harris Island and Fort Dundas area inside the shaded lilac rings. The shade lilac areas are the max range areas from the same guns. Note that Luxmore Head cannot be seen from either Harris Island or Point Barlow.
The predictive modelling section of this project has certainly raised some questions about the interpretation of the building, and given the next field team some areas to ground survey for remains.

**Three dimensionality and archaeology.**

Crosby surveyed the site in 1975. Her map was drawn from this survey data in 1976 by the Survey General's office in Darwin. Ian Pengelly, a professional surveyor, mapped the site in 1986 and produced a planimetric survey map at 1:2000 scale. While both of these maps are quality works, they are two dimensional surveys.

Archaeologists are very familiar with the third spatial dimension in their excavation work. Stratigraphy is part of the course for every undergraduate student. Mapping stratigraphy is part of their first few field work experiences. However, in the area of survey archaeology or surveying the existing ground level for artefacts, the third dimension is often overlooked. Modern landscape or environmental archaeology incorporates elevation as a factor in archaeological research.

On the Fort Dundas site, Crosby identified various building remains, and labelled a few of remanent structures in her report. However, a further study needs to look at the relationship of these buildings and structures to each other. Archaeologists often use assumptions in regard to the relationships of sites and features to each other. One of these assumptions is that building or structures are placed by typology or functionality. In the Fort Dundas case, the question to ask is whether the defensive structures are ideally placed for defence, or where there other factors involved in the site selection?
Predictive Modelling

In the course of creating a base map and adding other data themes this project has raised a number of interesting questions in the predictive modelling area. Based on the results of the GIS data manipulation, I would suggest that the field team conduct the following surveys:

1. A thorough survey of the Luxmore Head area, including a 50 metre radius around the co-ordinates 651370 E 8745300 N and 651490 E 8745200 N. The viewshed analysis indicated that Luxmore Head was not visible from the 'Magazine' site on Barlow Point. However, when the Magazine elevation was raised by three metres, some parts of Luxmore became visible. This indicates that there is a possibility that, if the British had used the magazine as a lookout, then they may have been able to signal from Luxmore to the gun positions on Harris Island and the Fort. It is an interesting speculation, but worth following up with a field visit.

2. A survey of the north and south parts of Harris Island, looking for the stone platform rumoured by locals and mentioned in several sources.

Sources of Error:

The project identified a number of possible sources of error in the field and laboratory:

1. Data collection error in the field. Possible error in collecting x,y,z points using the Nikon Total Station.
2. GPS error on Barge TBM or site datum
3. Data entry error.
4. Overgeneralisation in the creation of a DEM. ie Not enough points to interpolate an accurate DEM.
5. The IDW method of interpolation may not be the most effective. Kriging may have been a better choice, had it been available on ArcView.
1. Error checking in the field consisted of standard survey error checking methods. The survey controls were sighted twice (foresight and backsight) and the error checked and resighted if need be.

2. Some stations were triangulated for error checking: referencing a third station two others using standard trig solutions.

3. Closure calculations: standard closure was calculated and distributed for horizontal and vertical closure. The error distributed was 104 mm in the vertical plane and 2.992 m in the horizontal. Total distance for the traverse was 1001.15m. This gives a total error of 0.01% in the vertical plane and 0.299% in the horizontal plane. These errors are well within the limits used by professional surveyors.

4. Gross error check on data entry: Any point outside the standard range was checked, re-entered or deleted.

5. Minor error check on data entry: Risk management strategy employed using standard techniques. 10% of data checked for data error and re-entered if necessary.

Confidence in results.

The project results are accurate within limits:

1. The closed traverse field survey around Barlow Point closed to within 100mm in the vertical and 2 m in the horizontal plane. When this error was distributed the resulting X,Y,Z co-ordinates should be accurate to within one metre, provided the GPS averaging was within one metre.

2. The main GPS datums were averaged on reading and measured on at least 5 occasions in the field season. These results were averaged to give final co-ordinates. They should be accurate to within 2-3 metres.

3. The radiation survey results were checked for gross error, resulting in about 20 points being deleted from the data set. The remaining points should be accurate to within 100 mm in the vertical plane and 1 metre in the horizontal plane, relative to the co-ordinates of the control points.

4. The data entry process was checked thoroughly for errors, resulting in a number of points being deleted as outside of confidence limits. Luckily for this project there are many well defined waterways leading to the easy discovery of gross errors and their elimination.
Conclusions.

The project demonstrated that GIS is an effective tool in Australian Historical Archaeology. Viewshed analysis is a technique that has applications in defence studies, such as this study of Fort Dundas. The viewshed analysis of the gun positions indicated that the British had established an effective defensive post. This tends to lend weight the view advanced by Allen and Howard that the location of the Fort was a military decision, with all other factors secondary to achieving an adequate defensive post. Viewshed analysis was a useful tool to use, as changes in the terrain from 1824, particularly the height of vegetation, make other means of modelling the area inaccurate.

Predictive modelling offers a cheap alternative to planning survey strategies in field archaeology. The standard practice in field surveys is to walk transects over a grid pattern. Field workers are usually at fairly close spacing, depending on density of the terrain. Hence, a one kilometre square with a 10 metre transect spacing will mean 100 transects, each 1000 m long, a total of 100 km of walking. This means a costly exercise, or encouraging many undergraduate students to participate.

To limit the survey work, field archaeologists employ a number of survey strategies, including random and intuitive sampling. Predictive modelling, using a GIS, can be another method of deciding which area to sample. In the Fort Dundas project, the position of the unknown building at the south end of the settlement seems to indicate that it may have been used for purposes other than those interpreted by archaeologists such as Crosby. By adding three metres to the ground elevation at this point Luxmore Head came into view, suggesting that the position may have been linked to the defensive strategy for the Fort.

While these results can look encouraging, there are limits to the confidence one can place in this type of modelling. Firstly, there may have been a lookout on the point as suggested by local stories. Another possibility is that there was a navigation beacon installed on Luxmore Head. The British installed a navigation beacon on the entrance to Port Essington 14 years after the establishment of Fort Dundas. This may have a common strategy in colonising remote locations. The existence of a beacon may have been mistaken for a lookout position in the local histories and legends. There may well have been a lookout near the magazine site, but not part of the unknown building. Hence, the predictive modelling results given here can be only be guides to further fieldwork. It is only by field survey and excavation that the true picture of what happened at Fort Dundas can be recorded.
Visibility of Sw.dbf Value

Distance to Sw.dbf Value

Visibility of Nw.dbf Value

Distance to Nw.dbf Value

Visibility of South.dbf Value

Distance to South.dbf Value

Visibility of North.dbf Value

Distance to North.dbf Value

Reclass

Reclass

Reclass

Reclass

Arithmetic Overlay

Arithmetic Overlay

Arithmetic Overlay

Arithmetic Overlay

SW range

SW Bastion

NW Bastion

Harris Is South

Harris Is North

Model