

FIELD MONITORING INFORMATION FOR THE SWIFT (NGARRADJ) CREEK CATCHMENT NORTHERN TERRITORY

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1. INTRODUCTION

Initial field inspections during the dry season of 1998 (September) were carried out with a view to establishing a field program prior to the 1998/99 wet season. These inspections indicated that the dominant channel erosion processes in the Swift creek catchment were:

1. erosion of the outside bank on bends;
2. upstream migration of the primary knickpoint at the head of gullies;
3. channel widening subsequent to incision by the primary knickpoint;
4. bed degradation in the lower gully by the upstream migration of secondary knickpoints downstream of the gully head;
5. development of anabranches; and
6. erosion of flow-aligned scour pools, similar to those described by Scott and Erskine (1994).

The first four processes are the most important. A rapidly expanding literature has demonstrated that channel sources are an important and often the dominant sediment source on many Australian rivers (Erskine and Melville, 1983b; 1983b; Melville and Erskine, 1986; Erskine, 1992; 1994; 1996; 1999; Erskine and Saynor, 1996a; 1996b; Wasson *et al.*, 1996). To determine the significance of channel erosion as a sediment source in the Swift Creek catchment, it is essential to measure bank erosion and knickpoint migration rates at appropriate sites. The mine site tributaries and Swift Creek should be investigated in detail. The cross sections recommended for determining channel sediment storage are capable of measuring large scale bank erosion only (Wolman, 1959). Erosion pins are needed to measure relatively slow rates of bank retreat (Wolman, 1959; Erskine *et al.*, 1995).

To access changes erosion rates of material being moved through Swift creek, Erskine et al (in Press) made the following recommendations;

1. Selectively measure bank erosion rates and knickpoint migration rates (using erosion pins) to determine the significance of in-channel sediment sources in comparison to the sediment yields generated on the mine site;
2. Install permanently marked cross sections and use them to monitor the amount of bed sediment storage and/or large scale erosion throughout the channel network;
3. Install scour chains at each gauging station to determine the maximum depth of bed scour during each wet season;

The following sections document the location of gauging stations as well as details of the erosion pins, cross sections and scour chains that have been installed along Swift Creek and its tributaries. Figure 1 shows the location of the Swift Creek Catchment.

2. RIVER GAUGING STATIONS

To obtain baseline data on the hydrology and sediment transport of the channels in the Swift Creek catchment, it is essential that continuous streamflow data are obtained at several locations. Preliminary field inspections of the Swift Creek catchment in September 1998 identified potential gauging and sediment transport measurement sites on Swift Creek. Three gauging stations were established during November 1998 at the following sites;

- The main channel of Swift creek upstream of all mine influences (herein called Upmain - UM).
- The main channel of Swift Creek (herein called Swift Creek -SC) downstream of all of the mine influence and the tributaries of both the right and left banks.
- The main right bank tributary (East Tributary - ET) that flows into Swift Creek between upstream and downstream gauging stations. There is no mining activity this catchment.

The Swift Creek site is intended to measure any impact that the mine might have on sediment loads while the Tributary East and Upmain sites are intended to measure sediment loads in the undisturbed natural Swift Creek catchment. Tributary West (TW), also undisturbed is the largest of the left bank tributaries, draining the southern part of the catchment and has a discontinuous channel with large swampy areas. Ideally this tributary should have been gauged however the nature of the channel made the installation of a gauging station an impossibility. There are three smaller right bank tributaries called Tributary North (TN), Tributary Central (TC) and Tributary South (TS). The Jabiluka mine is located in close proximity to these tributaries and the mining company has installed gauging stations and equipment on these streams. Figure 1 shows the location of the gauging stations and the various tributaries in the Swift Creek catchment.

Each gauging station consisted of a stilling well with an aluminum shelter to house and protect the data logging equipment. Each site has the following sensors and equipment;

- A Unidata water level instrument with optical shaft encoder
- A Data Electronics DT 50, data logger
- A Hawk water level pressure sensor, as a backup stage indicator
- A Greenspan turbidity meter
- Gamet pump sampler – Automatic water sampler
- A Hydrological Services Pluviograph to measure rainfall
- Other miscellaneous items such as, solar panels, staff gauges, boat, wire cable across the channel and bench mark.

Pluviographs were installed at each site to measure rainfall amount and intensities. As part of the project it is intended to install additional pluviographs on the escarpment to pinpoint where in the catchment, rain falls and how long the water from these events take to reach the gauging stations (i.e. the lag time). Rain in the tropics usually occurs as individual thunderstorm events and widespread monsoonal activity.

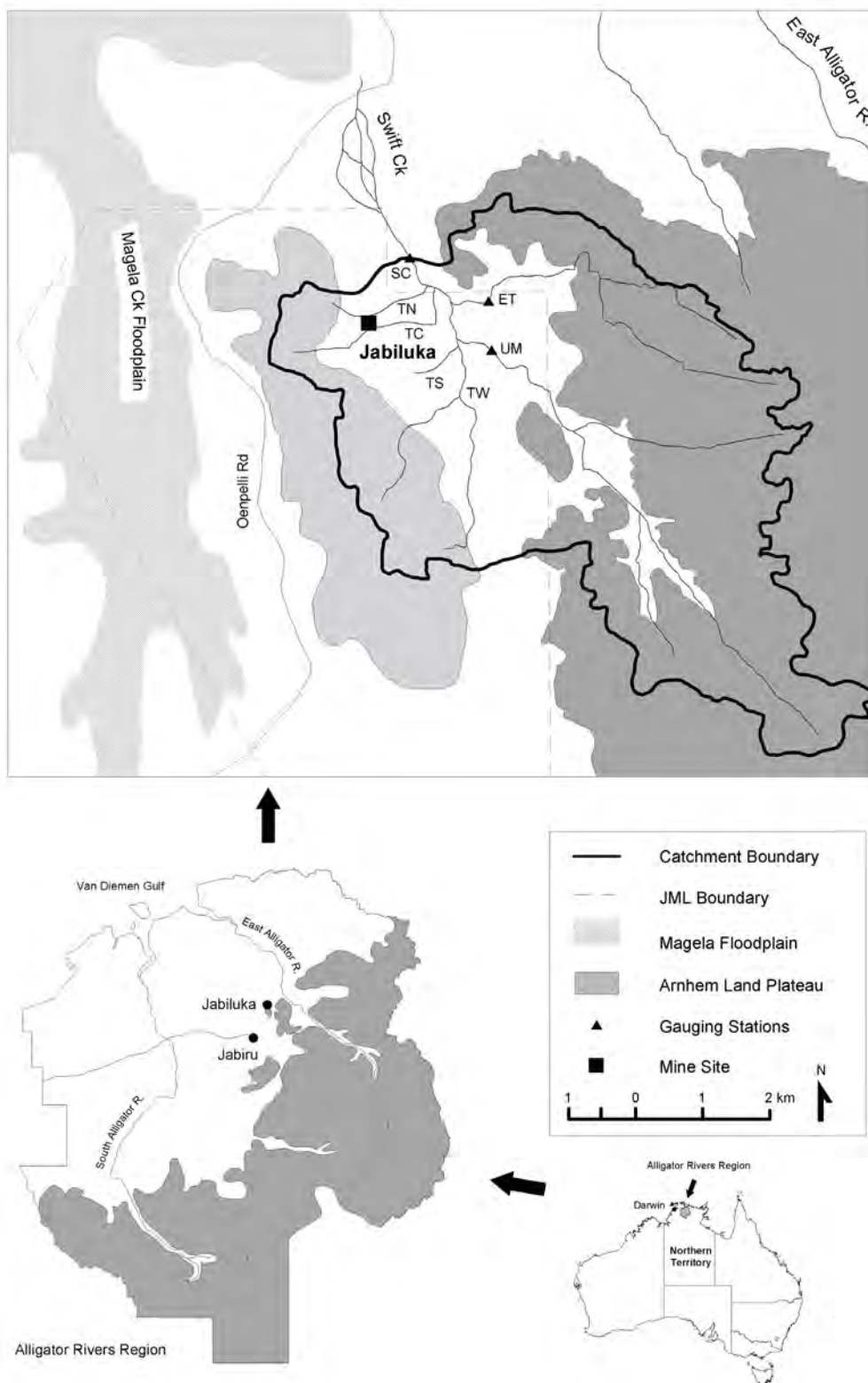


Figure 1: The Swift Creek catchment and tributaries showing the Jabiluka Mineral Lease and headworks, the gauging stations sites.

3. INSTALLATION OF EROSION PINS

3.1 EROSION PINS INSTALLED IN 1998

Erosion pins were installed during the late dry of 1998, on Tributary North and Tributary Central. Time did not permit the installation of erosion pins in the creek banks near the gauging stations that have been installed to monitor the hydrology and sediment movement. The erosion pins were 6 mm diameter metal rods, some 300 mm long and covered in white paint to reduce the amount of corrosion or rust. These pins were installed in the vertical section of bank near the cross sections on the two tributaries, with generally 30-50 mm left exposed so that they can be easily relocated. The pins were located either just up or down stream of the cross section (with the distances noted below) to reduce the possibility of the pins being trampled whilst the section was being re-surveyed. Erosion pins were only installed on one bank of the channel.

The amount of exposure of each pin was measured as the pins were installed. These pins were/are to be relocated as soon as possible after each wet season and the amount of the pin exposed re-measured. These erosion pins will be re-measured just prior to the beginning of each wet season as there appears to have been changes since the pins were measured earlier in the dry season. This may be due to several reasons,

- The complete drying out of the soil resulting in the sediments crumbling away. The weight of the erosion pin if more than 50% of its length is exposed could be contributing to this.
- Early rains could cause overland flow and wash over the banks and contribute to the erosion of sediments and materials.

3.2 EROSION PINS INSTALLED 1999

Erosion pins were installed during the late dry of 1999 in the banks of the channel near each of the gauging stations. The pins have been installed at those cross sections where scour chains have been dug into the beds. At these sites the erosion pins have been installed on the line of the cross- section to assist with the relocation of the scour chains. In most instances the pins have been installed on both of the banks when vertical. If the bank is gently sloping such as on the inside of a point bar than pins have not been installed.

Care MUST be taken during subsequent cross sectional surveys at each of the sections near the gauging stations, not dislodge the erosion pins. The pins should be resurveyed as soon as is practical after the conclusion of the wet season, and preferably prior to the surveys being undertaken.

The erosion pins in Tributary North and Central were also re-measured and if necessary reset (i.e. the pins pushed in and measured), additional pins were installed when appropriate along the banks.

3.3 TRIBUTARY NORTH EROSION PINS

Table 1 lists the number of pins that were installed in the late dry 1998 and 1999, at the cross sections on Tributary North. The pins that were installed in 1999 are in addition to those installed in 1998 except for TN01 where the pins had been eroded, the bank was under cut and looked unstable. It was preferable to install the pins in a more stable area just upstream of the TN01 cross section..

Table 1. Information about the erosion pins installed on Tributary North in December 1998.

Cross section	Located	Location from section	Number
Tributary North 1998			
TN01	RB	2m Upstream	3
TN02	LB	2-4m Upstream	3
TN03	LB	2m Upstream	4
TN04	RB	13m Downstream	3
TN04 Trib	RB	Just Upstream	3
TN05	RB	2m Upstream	3
TN06 Trib	LB	2m Downstream	3
TN07	RB	2m Downstream	3
TN07 Trib	RB	2m Upstream	3
TN08	LB	2m Upstream	4
TN08 Trib	RB	2-3m Upstream	4
TN09	RB	1-2m Upstream	4
Tributary North 1999			
TN01	RB	8-9m Upstream	3
	LB	9-10m Upstream	3
TN03	RB	2m Upstream	3
TN04 Trib	LB	Just Upstream	3

3.4 TRIBUTARY CENTRAL EROSION PINS

Table 2 lists the number of pins that were installed in the late dry 1998 and 1999, at the cross section on Tributary Central. The erosion pins on section TC07A had to be reinstalled (6 pins only) as they had been eroded away during the 1998/99 Wet season.

Table 2. Information about the erosion pins installed on Tributary Central in December 1998.

Cross section	Located	Location from section	Number
Tributary Central 1998			
TC01	RB	2m Downstream	3
TC03	RB	3m Downstream	3
TC04	LB	Just Downstream	4
TC05	RB	1-2m Upstream	5
TC06B	LB	On section	4
TC07	RB	Just Upstream	7
TC08	LB	3m Upstream	6
TC09	RB	1m Downstream	5
TC10	RB	1m Downstream	4
TC09	RB	2m Upstream	4
Tributary Central 1999			
TC01	RB	On section	3
TC06A	LB	1m Upstream	5
TC06C	LB	2m Downstream	3
TC07A	RB	Just Upstream	6
TC07B	RB	1m Upstream	5
TC07C	RB	2m Downstream	4
TC08	LB	3m Upstream	4

3.5 EROSION PINS AT THE GAUGING STATIONS

Erosion pins were generally installed at cross sections on the reaches near the gauging stations which also had scour chains on them. The location of in the creek bed is described in Section 4. Table 3 lists the location of erosion pins on the reaches at each of the gauging stations.

Table 3. Number of erosion pins along the reaches at the Gauging stations installed November 1999.

Cross section	Located	Location from Section	Number
East Tributary 1999			
ET01	RB	On section	4
	LB	On section	3
ET04	RB	On section	4
	LB	On section	3
ET07	LB	On section	4
ET08	LB	On section	4
Swift Creek 1999			
SM05	RB	On section	5
SM02	RB	On section	3
SM08	RB	On section	5
	LB	On section	3
Upmain 1999			
UM02	RB	On section	4
	LB	On section	5
UM05	RB	On section	4
	LB	On section	7
UM07	RB	On section	4
	LB	On section	4

4. SURVEY CROSS SECTIONS ALONG SWIFT CREEK.

4.1 INTRODUCTION

Cross sections have been established on Swift Creek and its tributaries. The cross sections have been marked for the duration of the project using a star picket driven into the ground with the top 0.3 m encased with a circular concrete collar (plinth) at each end of the cross section. A coach bolt has been set into the concrete to provide an accurate bench mark. At one end of the cross section a recovery star picket has been installed near the concrete plinth. The star picket is painted bright orange and has a small sign indicating that the equipment is part of research program being conducted by *Environmental Research Institute of the Supervising Scientist*

Table 4 lists the number of cross sections located on Swift Creek and its tributaries. These cross sections were surveyed soon after being installed in November 1998. The cross sections will be resurveyed on an annual basis during the dry.

Table 4: Number of cross sections installed

Location	Number of sections
Swift Creek	8
East Tributary	8
Upmain	7
Tributary North	13
Tributary Central	13

The locations of the sections along each of the reaches are shown in the figures at the end of each of the sections 3.2 to 3.6. It must be noted that the cross-sections are not always numbered sequentially downstream. This has occurred as the sections were numbered as they were installed and in some instances it was decided to install additional cross sections. Table 5 shows the abbreviations used for each of the reaches in the Swift Creek catchment which have cross sections installed on them.

Table 5: Long and short names for locations in the Swift Creek catchment

Long Name	Short Name
Swift Creek (ERA has its gauge very close by).	SM01
East Tributary	ET01
Swift Creek Upper (upmain)	UM01
Tributary North	TN01
Tributary Central	TC01

The following sections contain the coordinates and horizontal angles used when surveying the cross sections on Swift Creek and its tributaries.

4.2 SWIFT MAIN

These cross sections are located on the main single channel downstream of all the influences of the tributaries and mine influences or disturbances.

Cross section survey at the probable gauge site called **SM01** (original survey 26/9/98)

Instrument located over starpicket on **Right bank**, sighted to a star picket (top of) on the left bank, not the ERA benchmark near the tree.

Given the occupied Station Coordinates of

+1000,

+500,

+9.

The Horizontal angle sighted to a starpicket on the Left bank was 270°.

Note This is the only section at Swift Main with a set up on the RIGHT BANK

Cross section survey at the site called **SM02** (original survey 21/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+7000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

The survey crossed over the left bank Anabranh

Cross section survey at the site called **SM03** (original survey 21/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+6000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

The survey crossed over the left bank Anabranh.

Cross section survey at the site called **SM04** (original survey 21/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+9000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **SM05** (original survey 21/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+5000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **SM06** (original survey 21/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+8000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **SM07** (original survey 22/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+10000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **SM08** (original survey 22/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+11000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right bank was 90°.

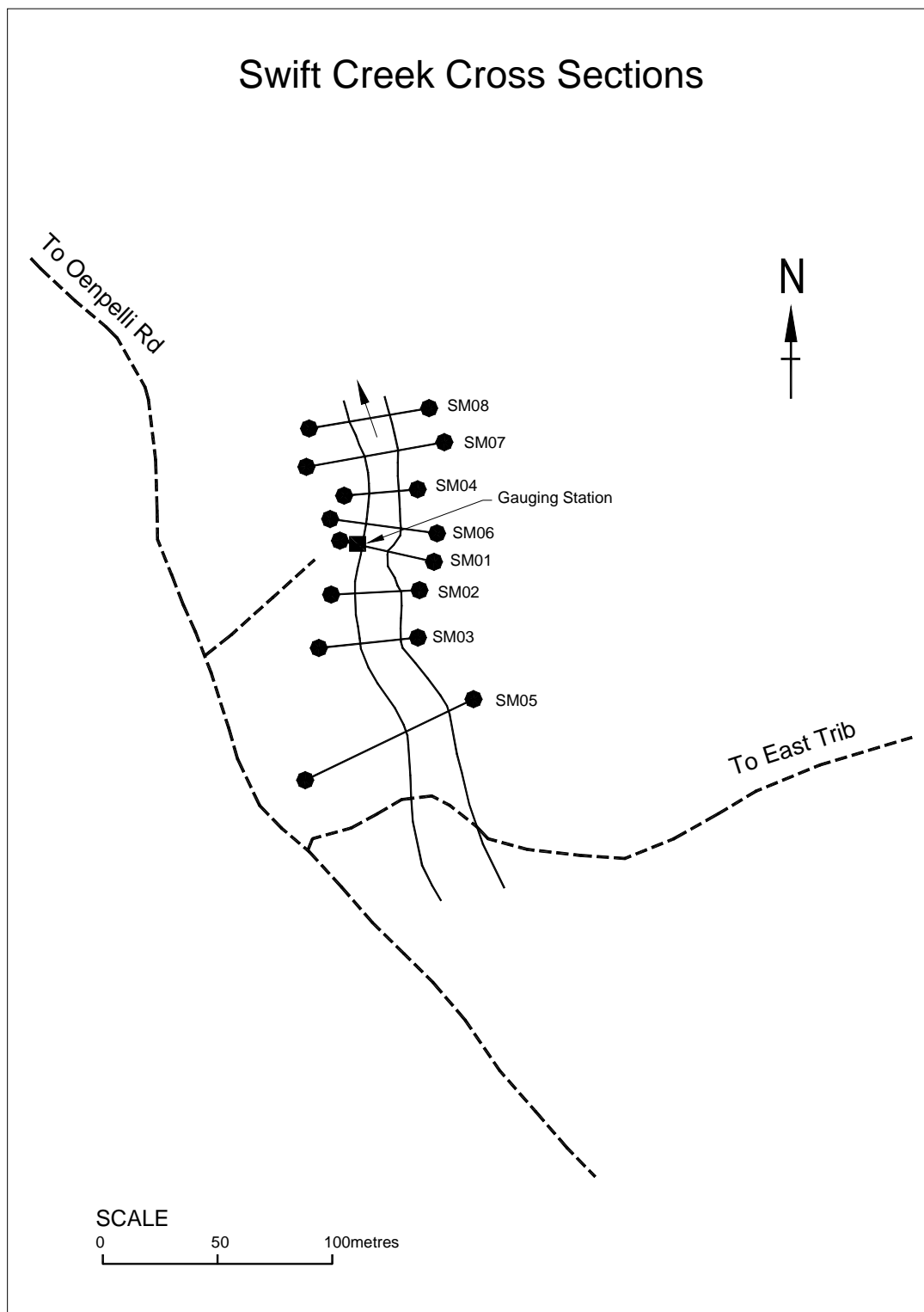


Figure 2: Location of the cross sections along the reach with the Swift Creek gauge.

4.3 EAST TRIBUTARY

These cross-sections are located on the main right bank tributary of Swift Creek. There are no disturbances or mining within the catchment of this tributary.

Cross section survey at the site called **ET01** (original survey 4/11/98)

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+1000,

+2000,

+15

The Horizontal angle sighted to a plinth on the Left bank was 180°.

Cross section survey at the site called **ET02** (original survey 4/11/98)

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+2000,

+2000,

+15

The Horizontal angle sighted to a plinth on the Left bank was 180°.

Cross section survey at the site called **ET03** (original survey 4/11/98)

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+3000,

+2000,

+15

The Horizontal angle sighted to a plinth on the Left bank was 180°.

Cross section survey at the site called **ET04** (original survey 4/11/98)

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+4000,

+2000,

+15

The Horizontal angle sighted to a plinth on the Left bank was 180°.

Cross section survey at the probable gauge site called formally called **ET01** (original survey 24/9/98), now called **ET05**

Instrument located over starpicket on Right bank,

Given the occupied Station Coordinates of

+2000,

+500,

+10.

The Horizontal angle sighted to a starpicket on the Left bank was 180°.

Cross section survey at the site called **ET06** (original survey 3/11/98)

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+6000,

+2000,

+15

The Horizontal angle sighted to a plinth on the Left bank was 180°.

Cross section surveys at sites called **ET07 and ET08** (original survey 9/11/98), both sections were surveyed from the plinth on the right bank.

Instrument located over plinth on Right bank,

Given the occupied Station Coordinates of

+7500,

+2000,

+15

The Horizontal angle sighted to a plinth on the **ET07** Left bank was 180°. Cross-section ET08 was surveyed from the same set up point without resetting the instrument.

East Trib Cross Sections

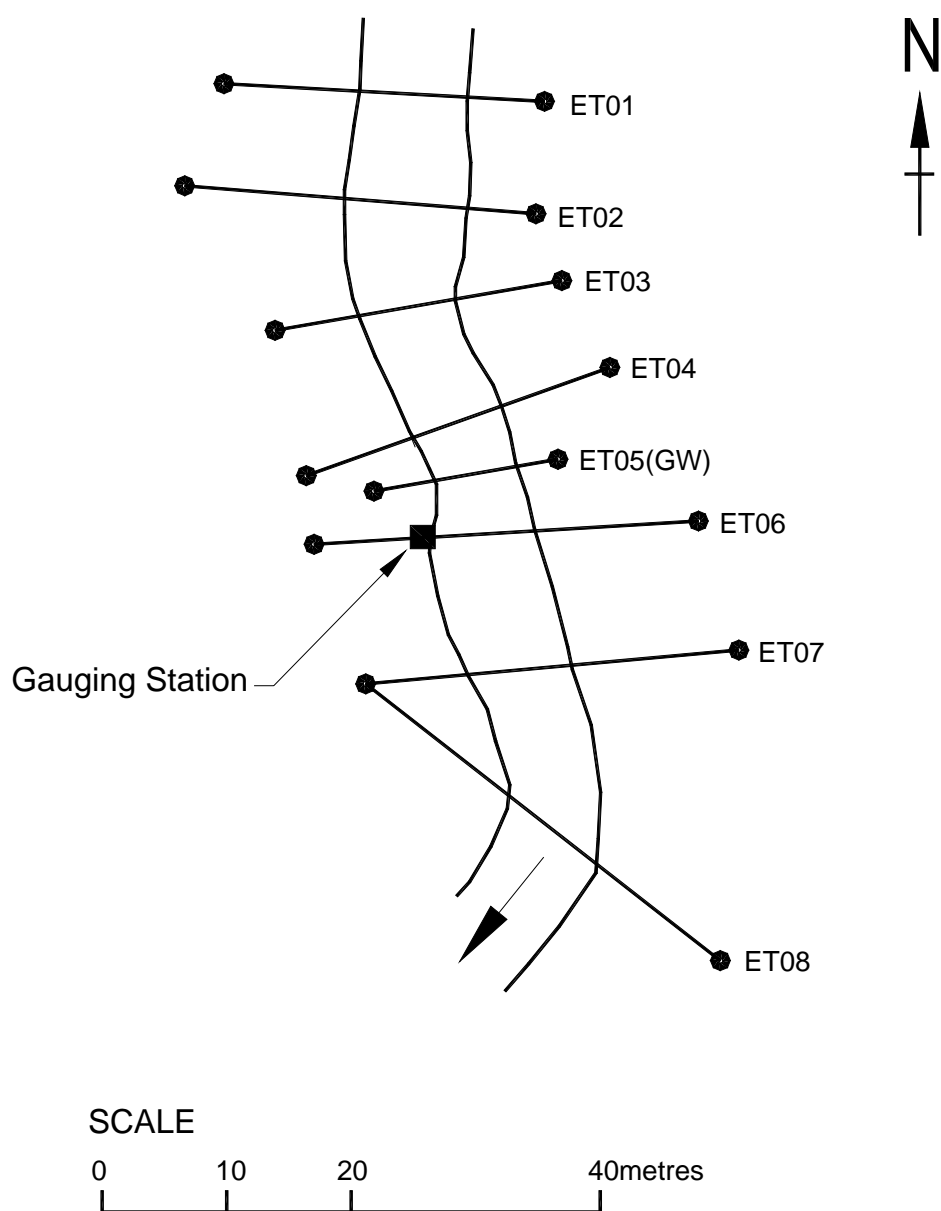


Figure 3: Location of the cross sections along the reach with the East Tributary gauge

4.4 SWIFT UPPER MAIN

These cross-sections are located on the main channel of Swift Creek upstream of any disturbances or mining activities.

Cross section survey at the site called **UM01** (original survey 30/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+1000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **UM02** (original survey 30/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+2000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **UM03** (original survey 30/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+3000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

A Gauging Wire was installed just prior to the 1998/99 wet season to enable velocity gaugings to be completed. This site is located between UM03 and UM04 and was surveyed on 31/08/99. It is called **UMGW**.

Instrument located over starpicket on Left bank,

Given the occupied Station Coordinates of

+5000,

+2000,

+10.

The Horizontal angle sighted to the concrete plinth on the Right Bank of the gauging wire section was 90°.

Cross section survey at the probable gauge site formally called **SMU01** (original survey 24/9/98)

This site has been renamed as **UM04**

Instrument located over starpicket on Left bank,

Given the occupied Station Coordinates of

+1000,

+500,

+10.

The Horizontal angle sighted to a starpicket on the Right bank was 90°.

Cross section survey at the site called **UM05** (original survey 30/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+5000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **UM06** (original survey 3/11/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+6000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Cross section survey at the site called **UM07** (original survey 3/11/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+7000,

+2000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 90°.

Upmain Cross Sections

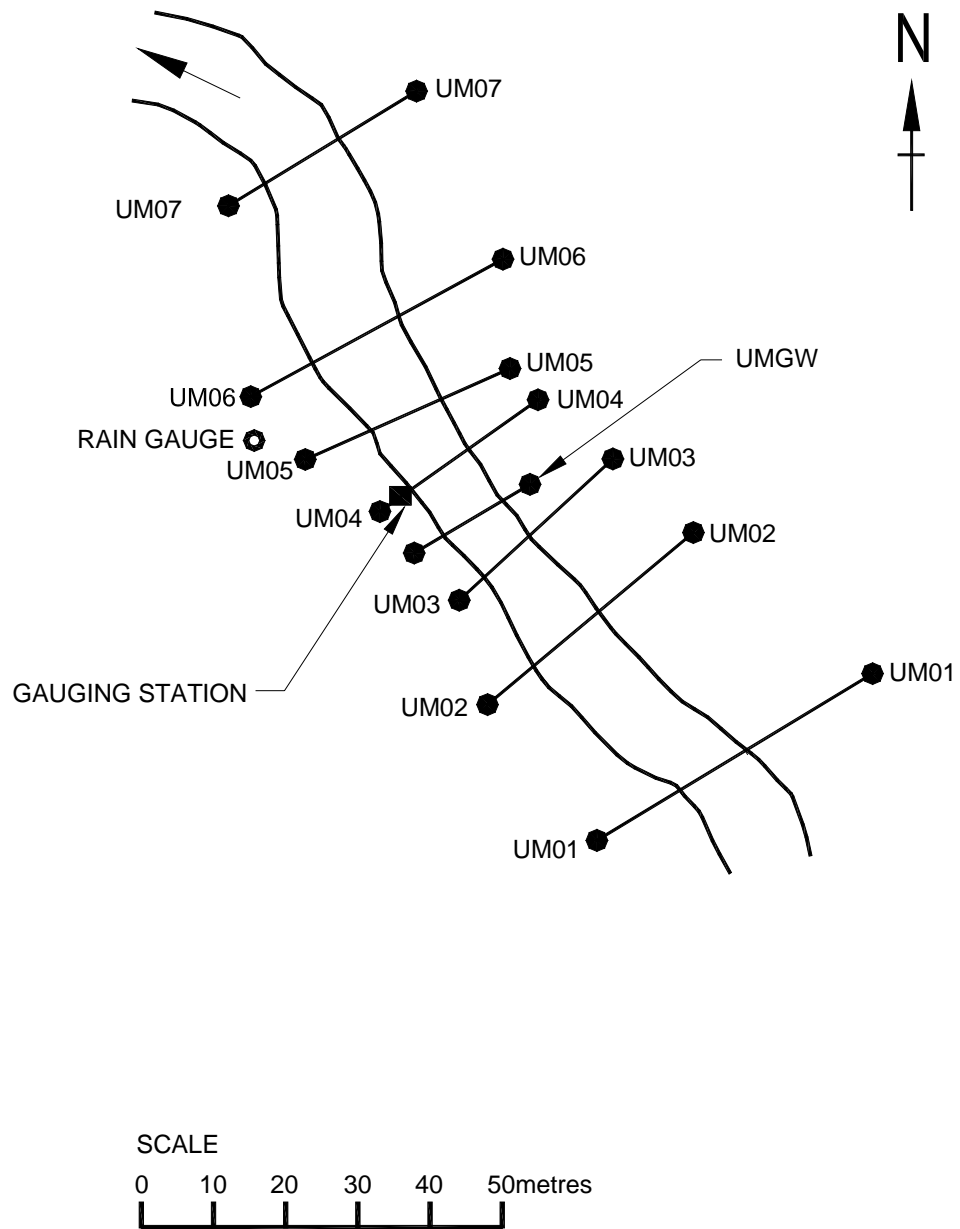


Figure 4: Location of the cross sections along the reach with the Upmain gauge.

4.5 TRIBUTARY NORTH

These cross-sections are located on the tributary which runs to the north of the Jabiluka mine site and down to Swift Creek. The channel is discontinuous and the cross sections have been located along various sections of the tributary.

Cross section survey at the site called TN01 (original survey 8/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+5000,

+1000,

+11

The Horizontal angle sighted to a plinth on the Right bank was 180°.

The top of the bank was also surveyed to provide some idea of the dimension of the creek, given that there is a Knickpoint at the upstream extent and also areas where flow moves into the channel. This survey was started on the right bank at an Ant hill (approximately 5 meters downstream from the cross section) and the traversed up the right bank, around through the Knick point and then back down to approximately 5m downstream from the cross section.

Cross section survey at the site called TN01 Extension (original survey 23/10/98)

Instrument located over plinth on Left bank of gully. Same plinth as used for the survey of the gullied channel.

Given the occupied Station Coordinates of

+5000,

+1000,

+11

The Horizontal angle sighted to a plinth on the Right bank of the gully was 180°. The instrument was then turned to site to the plinth on the far left side of the drainage depression. The actual reading was 357° 18' 30". This was reset using the horizontal angle to 0°.

Cross section survey at the site called TN02 (original survey 8/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+4000,

+1000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called TN03 (original survey 9/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+3000,

+1000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called TN04 (original survey 9/10/98)

Instrument located over plinth on Left bank of the main channel, which is in the middle of the two channels the main channel and the left bank tributary,

Given the occupied Station Coordinates of

+2000,

+1000,

+10

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called TN05 (original survey 9/10/98)

Instrument located over plinth on Right bank of the Tributary,

Given the occupied Station Coordinates of

+3500,

+1000,

+10

The Horizontal angle sighted to a plinth on the Left bank was 0°.

Cross section survey at the site called TN06 (original survey 14/10/98)

Instrument located over the plinth on Left bank of the main channel, which is in the middle of the two channels the main channel and the left bank tributary Given the occupied Station Coordinates of

+2000,

+1000,

+9

The Horizontal angle sighted to a plinth on the Left bank of the tributary was 0°.

Cross section survey at the site called TN07 (original survey 14/10/98)

Instrument located over the plinth on Left bank of the main channel, which is in the middle of the two channels the main channel and the left bank tributary Given the occupied Station Coordinates of

+2000,

+1000,

+9

The Horizontal angle sighted to a plinth on the Right Bank of the main channel was 180°.

The tributary channel was also surveyed, although there was no Plinth on the Left bank of the tributary channel. The instrument was turned through 180 (thus keeping the survey in a straight line) and some flagging tape was sighted too along a bearing of 0°.

Cross section survey at the site called TN08 (original survey 14/10/98)

Instrument located over the plinth on Left bank of the tributary channel.

Given the occupied Station Coordinates of

+5000,

+2000,

+8

The Horizontal angle sighted to a plinth on the Right Bank of the main channel was 180°. There is no Plinth in the middle section between the channels.

Both channels were surveyed as a continuous section along the same bearing.

Cross section survey at the site called **TN09** (original survey 14/10/98)

Instrument located over the plinth on Left bank of the channel. This section is located below the confluence of the two channels and therefore there is only one channel.

Given the occupied Station Coordinates of

+4000,
+1000,
+8

The Horizontal angle sighted to a plinth on the Right Bank of the main channel was 180° . The instrument was turned through 180° (thus keeping the survey in a straight line) to 0° , survey 3 points past the instrument.

Cross section survey at the site called **TN10** (original survey 23/10/98)

Instrument located over plinth on right bank

Given the occupied Station Coordinates of

+5000,
+2000,
+12

The Horizontal angle sighted to a plinth on the left bank was 0° .

Cross section survey at the site called **TN11** (original survey 23/10/98)

Instrument located over plinth on right bank

Given the occupied Station Coordinates of

+7000,
+2000,
+13

The Horizontal angle sighted to a plinth on the left bank was 0° .

Cross section survey at the site called **TN12** (original survey 23/10/98)

Instrument located over plinth on left bank

Given the occupied Station Coordinates of

+8000,
+2000,
+13

The Horizontal angle sighted to a plinth on the right bank was 180° .

Cross section survey at the site called **TN13** (original survey 23/10/98)

Instrument located over plinth on left bank

Given the occupied Station Coordinates of

+9000,
+2000,
+14

The Horizontal angle sighted to a plinth on the right bank was 180° .

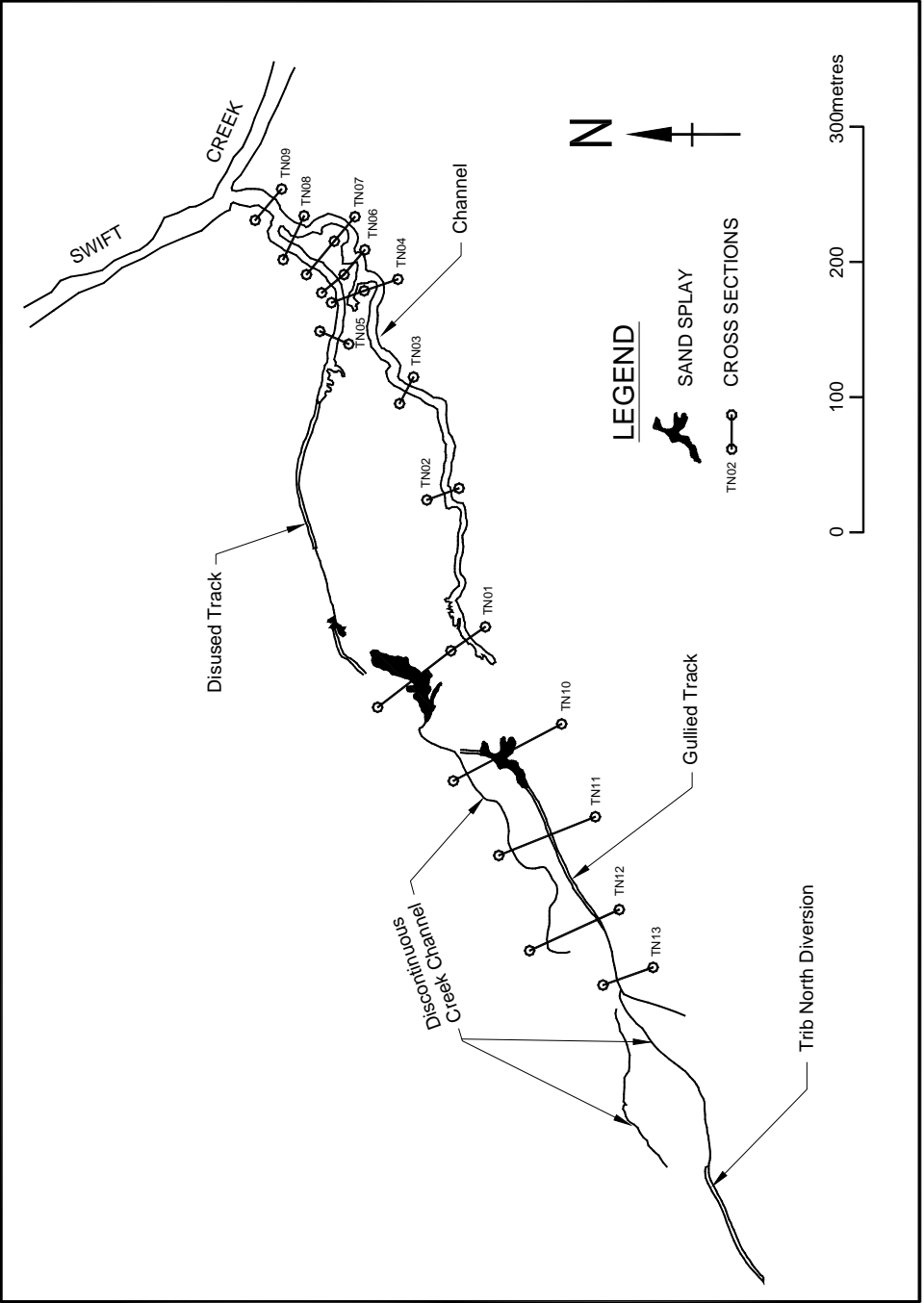


Figure 5: Location of the cross sections along Tributary North.

4.6 TRIBUTARY CENTRAL

These cross-sections are located on the tributary which runs along the south boundary of present Jabiluka minesite and down to Swift Creek. The channel is continuous and the cross sections have been located along various sections of the tributary.

Cross section survey at the site called **TC01** (original survey 19/10/98)

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+5000,

+2000,

+11

The Horizontal angle sighted to a plinth on the Right bank was 180°.

A small left bank tributary was surveyed, although there was no Plinth on the Left bank of the tributary channel. The instrument was turned through 180 (thus keeping the survey in a straight line) and the reflector sighted too along a bearing of 0°.

Cross section survey at the site called **TC02** (original survey 19/10/98). The section was a survey of the small left bank tributary just after it leaves the main channel. The instrument was located over the same plinth as for TC01 and therefore had the same coordinates and Instrument height. Only the horizontal angle was changed

Instrument located over plinth on Left bank (For TC01, actually right bank for TC02 as it is located on a tributary),

Given the occupied Station Coordinates of

+5000,

+2000,

+11

The actual horizontal angle from the survey plinth of TC01 to the survey plinth on the left bank was 287°, however this was reset as 270° to enable easier calculation of the cross section.

The Left bank plinth for TC01 is the same site for the right bank plinth in cross section TC02. The plinth sighted two on the left bank of the small tributary is the same as the left bank plinth for cross section TC03.

Cross section survey at the site called **TC03** (original survey 19/10/98) is upstream of the small left bank tributary and is therefore only a single channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+6000,

+1000,

+12

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called **TC04** (original survey 19/10/98) is located on a single channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+7000,

+1000,

+12

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called **TC05** (original survey 19/10/98) and traversed across a small left bank tributary or overflow and then a much deeper main channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+8000,

+1000,

+12

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section surveys at the site called **TC06A,B,C** (original survey 26/10/98). These were three sections across a point bar and a large eroded bank.

The instrument was located over plinth on the point bar (right bank), to survey all the section

Given the occupied Station Coordinates of

+9000,

+2000,

+14

The Horizontal angle sighted to the plinth for TC06A was 0°.

Whilst surveying this section the tops of the plinths at the end of TC06B & TC06C were surveyed to obtain the angles.

Top of LB TC06B, 33° 06''

Top of LB TC06C, 60° 51'' 15'

The instrument was left in place and the horizontal angles were not changed. This means that calculations will have to be made to obtain the straight line distances for TC06B & TC06C.

Both TC06B & TC06C were surveyed from the left bank plinth down through the channel and up over the point bar. TC06C was continued over the point bar to survey the channel upstream of the point bar, this section was not at right angles to the channel, however it will still give some indication. The bed sample is called TC06 upstream. The instrument was turned though 180°, (to read 213° for TC06B and 240°) to survey beyond the plinth on the point bar.

Cross section surveys at the site called **TC07A,B,C** (original survey 26/10/98). These were three sections across a point bar and a large eroded bank.

The instrument was located over plinth (the star picket is exposed above the plinth because it could not be driven into the underlying bedrock any further) on the point bar (left bank), to survey all the section

Given the occupied Station Coordinates of

+5000,

+1000,

+13

The Horizontal angle sighted to the plinth for TC07A was 90°.

Cross section TC07A was surveyed from the left bank plinth down through the channel and up over the point bar. The instrument was turned through 180°, (to read 0°) to survey beyond the plinth on the point bar (only three readings).

Whilst surveying this section the tops of the plinths at the end of TC07B & TC07C were surveyed to obtain the angles.

Top of LB TC07B, 64° 54' 35"

Top of LB TC07C, 29° 58' 45"

The instrument was left in place and the horizontal angles were not changed. This means that calculations will have to be made to obtain the straight line distances for TC07B & TC07C.

Both TC07B & TC07C were surveyed from the right bank plinth down through the channel and up over the point bar. The instrument was turned through 180°, (to read 244° for TC07B and 209°) to survey beyond the plinth on the point bar.

Cross section survey at the site called **TC08** (original survey 26/10/98) is located on a single channel. The section shares its right bank plinth with the Right bank plinth for TC07C.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+6000,

+2000,

+13

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called **TC09** (original survey 29/10/98) is located on a single channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+9000,

+2000,

+13

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called **TC10** (original survey 29/10/98) is located on a single channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+8000,

+2000,

+13

The Horizontal angle sighted to a plinth on the Right bank was 180°.

Cross section survey at the site called **TC11** (original survey 29/10/98) is located on a single channel.

Instrument located over plinth on Left bank,

Given the occupied Station Coordinates of

+7000,

+2000,

+13

The Horizontal angle sighted to a plinth on the Right bank was 180°.

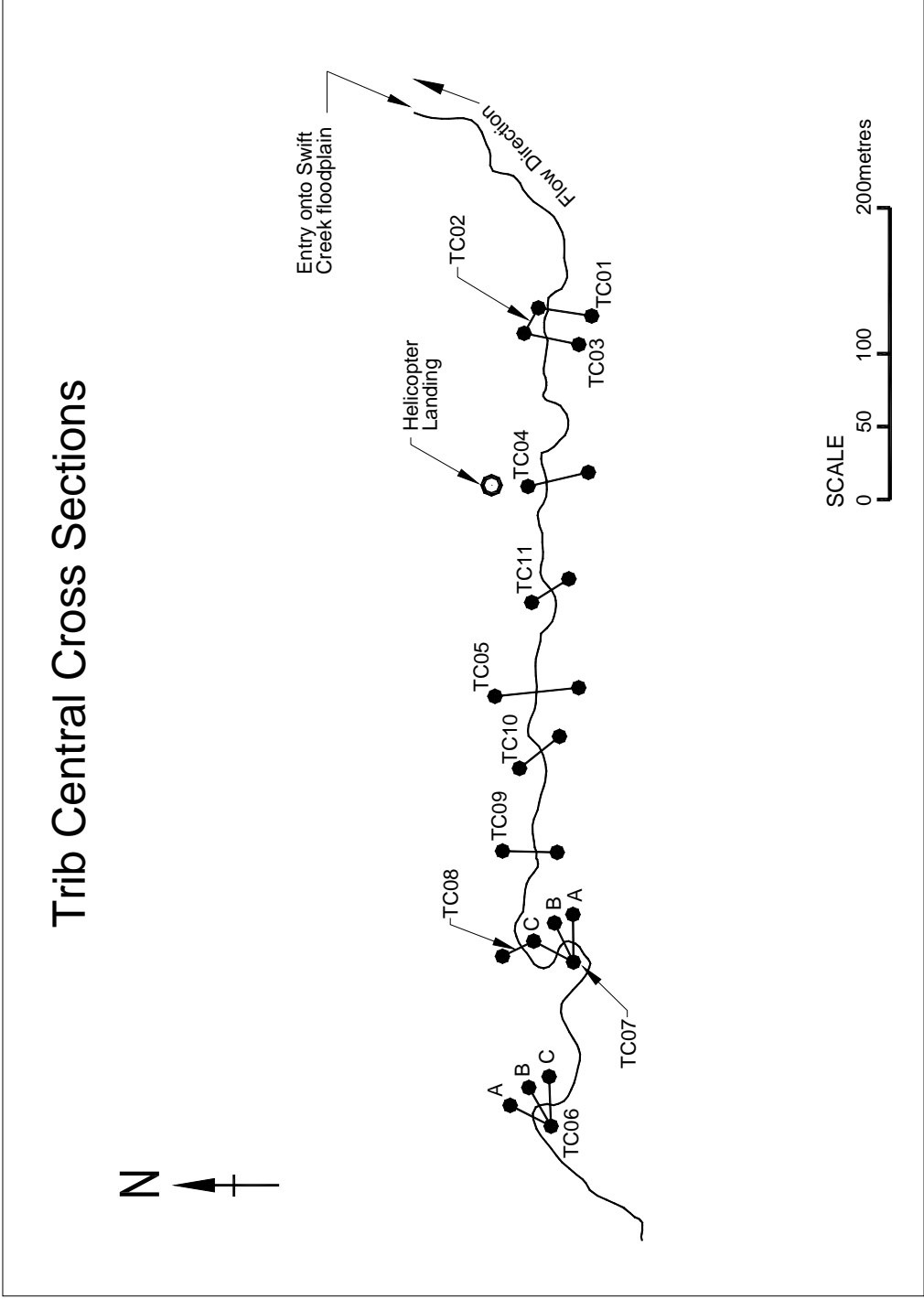


Figure 6: Location of the cross sections along Tributary Central.

5.0 SCOUR CHAINS

Each wet season, the bed material of Swift Creek and its tributaries is reworked and transported downstream at various rates to various sediment storages, such as the channel bed, various types of channel bars, floodouts, the braided reach above the Oenpelli road and the fan delta below the Oenpelli road.

Scour chains (interlocked metal chains placed vertically into the bed sediment during the dry season) are the best means of measuring scour depths (Leopold *et al.*, 1966). Chains must be installed before the onset of the wet season when it is possible to auger as deep as possible into the sandy bed material. ERA hydrographers found up to 0.2 m of bed scour and a maximum mean flow velocity of about 1 m/s during the 1997/98 wet season at their gauging section on Swift Creek. Observations by *eriss* staff during the two subsequent wet seasons suggest that this scour and fill might be in the order of 0.5 m. Therefore, a 1 m chain length should be sufficient to measure scour depth. It has been found in practice that the depth of the water table below the bed level also influences the depth to which sand can be excavated by the auger.

The theory of the linked chain is that the vertical chain will lie down horizontally on the scoured bed surface as bed level deepens and will be buried as the bed fills at the end of the wet season. Excavation of the chain should reveal a bent chain with the depth to the bend equaling the depth of scour. The location of each chain on each sampled cross section needs to be accurately determined and the whole cross section should be surveyed before chains are re-excavated after the wet season.

5.1 SCOUR CHAINS 1998

Prior to the 1998/99 wet season scour chains were installed at East Tributary, Upmain, Swift Creek gauging stations (Table 6). Several scour chains were also installed on Tributary Central (Table 6), however unfortunately time did not permit the installation of scour chains in Tributary North prior to the 1998/99 wet season. The scour chains were installed by digging a hole in the dry creek bed with a sand auger. Generally the auger was able to retain the sand until the water table was reached. The water table was typically around a depth of 1 metre, However at East Tributary the auger retained samples to depths of 2.5-3.0m, due to the high clay content. The material that was excavated from the auger hole was placed in order on a plastic sheet. This was described briefly in the field, in terms of sand texture and colour. Where one could be confident that the same layer was sampled in terms of these parameters, the sample was bulked together. Samples were bagged, labeled and transported back to *eriss* for a more detailed description at a later time. Once there was no recovery from the auger hole either by bedrock refusal or water table a scour chain was installed.

A plastic collar either 17cm or 32cm long was used at the top of the hole to prevent the dry sand from falling into auger hole as it was being dug. The chain used for the scour chains was 6 mm galvanized chain. The chain was cut to a length determined by the depth of the hole so that all the links would remain in the vertical position. The chain was then lowered into the hole and held at the top of the hole by a long steel rod (actually an excess erosion pin) across the hole. A length of string was tied to the top link to prevent the chain from dropping down the hole. The hole was then back filled with the material from the auger hole and compacted

to ensure that the chains was held firmly in place. A 50-60 cm length of bright orange flagging tape was tied to the top link to hopefully assist with the location of the chain after the wet season. The location of the scour chains was measured from the banks and where possible the distance to a distinctive nearby tree was also measured. A diagram was drawn of the location and distances to the chains on each of the cross-sections. These diagrams are shown in Appendix 1.

Table 6 list the locations of the scour chains and the number of chains on each section.

Location	Number of Chains	Length (cm)
East Tributary		
ET01	Chain 1	120
	Chain 2	114
ET04	Chain 1	91
ET07	Chain 1	98
ET08	Chain1	90
Upper Main		
UM02	Chain 1	70
	Chain 2	35
UM05	Chain 1	98
	Chain 2	75
UM07	Chain 1	53
	Chain 2	97
Swift Creek		
SM05	Chain 1	79
	Chain 2	82
	Chain 3	59
SM08	Chain 1	81
	Chain 2	90
	Chain 3	90
Trib Central		
TC03	Chain 1	90
TC09	Chain 1	98
TC11	Chain 1	89

Late in the dry season of 1999 the scour chains were searched for using the measurements and the diagrams but more importantly a metal detector. All the scour chains were found using this method, with the metal detector saving hours of searching. Various measurements were made with regard to the scour chains, and in all cases there was deposition over the scour chain. Once the measurements had been made the chain was carefully pulled up to reflect the new bed height and thus the links of the chains were all in the vertical again. The hole was back-filled and the sand compacted around the chain. A new piece of flagging tape (approximately 60cm) was tied to the top link and an aluminum tag tied to the other end. The chains were all reset in this way and also at this time some additional chains were installed at Swift Main and also on Tributary North

5.2 SCOUR CHAINS 1999

Additional chains were installed at Swift Creek and on Tributary North. At Swift Creek an additional cross section (SM02) had scour chains installed. There were also plastic scour chains installed on each of the three sections at Swift creek as an experiment to see if they behaved the same way as the metal chains. Scour chains were also installed on Tributary North. Table 7 contains information about the scour chains installed prior to the 1999/00 wet season.

Table 7 list the locations of the scour chains and the number of chains on each section.

Location	Number of Chains	Length (cm)
Swift Main		
SM02	Chain 1	90
	Chain 2	85
	Chain 3	90
	Plastic Chain 1	78
	Plastic Chain 2	91
SM05	Plastic Chain 1	91
	Plastic Chain 2	81
SM08	Plastic Chain 1	91
	Plastic Chain 2	91
Tributary North		
TN02	Chain 1	77
TN04	Chain 1	Approx. 110
TN05	Chain 1	Approx. 91
TN07 Main	Chain 1	93
TN07 Trib	Chain 1	91
TN09	Chain 1	91
	Chain 2	91

The chains were located using the diagrams and also a metal detector

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7.0 REFERENCES

- Erskine WD 1992. Channel response to large-scale river training works: Hunter River, Australia. *Regulated Rivers: Research and Management* 7, 261-278.
- Erskine, WD 1994. Sand slugs generated by catastrophic floods on the Goulburn River, New South Wales. *International Association of Hydrological Sciences* Publ. No. 224, 143-151.
- Erskine WD 1996. Response and recovery of a sand-bed stream to a catastrophic flood. *Zeitschriche fur Geomorphologie* 40(3), 359-383.
- Erskine WD 1999. Oscillatory response versus progressive degradation of incised channels in southeastern Australia. In: SE Darby & A Simon (Eds.), *Incised River Channels*. Wiley, Chichester, 67-95.
- Erskine WD & Melville, MD 1983a. Sedimentary properties and processes in a sandstone valley: Fernances Creek, Hunter Valley, New South Wales. In: RW Young & GC Nanson (eds.), *Aspects of Australian Sandstone Landscapes*. Australian and New Zealand Geomorphology Group Spec. Publ. No. 1, 94-105.
- Erskine WD & Melville MD 1983b. Impact of the 1978 floods on the channel and floodplain of the lower Macdonald River, NSW. *Australian Geographer* 15, 284-292.
- Erskine WD Rutherford ID & Tilleard JW 1990. *Fluvial Geomorphology of Tributaries to the Gippsland Lakes*. Department of Conservation and Environment, Victoria.
- Erskine WD & Saynor MJ 1996a. Effects of catastrophic floods on sediment yields in southeastern Australia. *International Association of Hydrological Sciences* Publ. No. 236, 381-388.
- Erskine WD & Saynor MJ 1996b. *The Influence of Waterway Management on Water Quality with particular reference to Suspended Solids, Phosphorus and Nitrogen*. Broken River Management Board and Department of Conservation and Natural Resources, Victoria, Wangaratta, 82pp.
- Erskine WD, Warner RF, Tilleard JW & Shanahan KF 1995. Morphological impacts and implications of a trial release on the Wingecarribee River, New South Wales. *Australian Geographical Studies* 33, 44-59.
- Erskine WD, Saynor MJ & Evans KG (2001) Monitoring and research programs to determine the Hydrologic, Sedimentologic and Geomorphic impacts of the Jabiluka Mine on Swift (Hgarraji) Creek Catchment, Northern Territory. Supervising Scientist Report, Supervising Scientist, Canberra
- Leopold LB, Emmett WW & Myrick RW 1966. Channel and hillslope processes in a semi-arid area, New Mexico. *U.S. Geological Survey Professional Paper* 352G.
- Melville MD & Erskine WD 1986. Sediment remobilization and storage by discontinuous gullyng in humid southeastern Australia. *International Association of Hydrological Sciences* Publ. No. 159, 277-286.
- Wasson RJ, Donnelly TH & Murray AS 1996. Imports can be dangerous – appropriate approaches to Australian rivers and catchments. *Proceedings of First National Conference on Stream Management in Australia, Meerijig, 19-23 February 1996*, 313-319.
- Wolman MG 1959. Factors influencing erosion of a cohesive river bank. *American Journal of Science* 257, 204-216.

APPENDIX 1