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Bed-material and floodplain sediments of the Ngarradj (Swift) Creek catchment, Jabiluka, Northern Territory

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Executive summary

Shallow stratigraphic data on the fluviatile sediments associated with the channels and floodplains in the Ngarradj (Swift) Creek catchment obtained by the authors as part of other work have been compiled in this report. The bed sediments at ***eriss***'s Swift Creek gauging station were sampled to a maximum depth of 1 m at three cross sections. Most of the bed sediment is slightly granular medium sand. The maximum gravel size measured was 36 mm but the mean maximum gravel size was 7 ± 0.7 mm (standard error of estimate). The bed sediments at ***eriss***'s upper Swift Creek gauging station were sampled to a maximum depth of 1.4 m at three cross sections. Bedrock or weathered bedrock was encountered between 0.35 and 1.4 m below the river bed in every hole. Sediments were texturally variable ranging from medium and coarse sand to medium sandy pebble gravel. The maximum gravel size measured was 32 mm but the mean maximum gravel size was 16 ± 3 mm. The bed sediments at ***eriss***'s East Tributary gauging station were sampled to a maximum depth of 2.8 m at four cross sections. Sediments were variable because of occasional high gravel and mud contents. The dominant textures were slightly pebbly medium sand to pebbly medium sand and slightly granular medium sand to granular medium sand. However, slightly granular muddy medium sand and coarse sandy pebble gravel represented the extremes. The maximum gravel size measured was 17 mm but the mean maximum gravel size was 10 ± 1 mm. The bed sediments on the lower gully of Tributary North (Erskine et al 2001) were sampled to a maximum depth of 1.5 m at five cross sections. Surficial sediments were generally slightly granular medium sand or slightly granular coarse-medium sand. Subsurface sediments varied between slightly granular sands, granular sands and slightly pebbly sands. Sand fractions covered the Wentworth range from very fine to coarse sand. At depth, the sediments in all holes were slightly granular very fine-fine sand. The maximum gravel size measured was 18 mm but the mean maximum gravel size was 7 ± 0.5 mm. The bed sediments on Tributary Central were sampled to a maximum depth of 2.8 m at three cross sections. Weathered sandstone bedrock was reached at the bottom of two holes. Sediments were variable ranging from slightly granular fine sand to medium sand/muddy medium sand to pebbly coarse sand to coarse sandy pebble gravel. The maximum gravel size measured was 35 mm but the mean maximum gravel size was 11 ± 2 mm.

Floodplain sediments were described at the three ***eriss*** gauging stations (Swift Creek, upper Swift Creek and East Tributary) and were found to comprise sandy fining upwards sequences deposited by laterally stable channels whose banks were well protected by monsoonal vine forest with extensive root systems and root mats. Sandy sediments were also described along the lower gullied reach (Erskine et al 2001) of Tributary North.

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Glossary

To assist the reader's understanding of the technical information contained in this report, all of the sedimentological terms used, are defined below.

Armour layer – This is a surficial layer of gravel that is usually one grain diameter thick and that is both coarser and better sorted than the sub-armour sediment (Gomez 1984, Erskine 1992). It may be mobile or immobile under the current hydrologic regime (Erskine et al 1985) and is important for preventing excessive bed scour and for reducing bed load transport fluxes (Lagasse et al 1980, Erskine 1992).

Boulder – According to the Wentworth grade scale for sediments, boulder refers to a part of the gravel fraction with an intermediate (b-axis) diameter greater than 256 mm or –8.0 ϕ.

Clay – According to the Wentworth grade scale for sediments, clay refers to a part of the mud fraction with an intermediate diameter less than 0.0039 mm or 8.0 ϕ. According to the International Society of Soil Science, clay refers to a part of the fine earth fraction with a diameter less than 0.002 mm or 9 ϕ.

Cobble – According to the Wentworth grade scale for sediments, cobble refers to a part of the gravel fraction with intermediate diameters between 64 and 256 mm or between –6.0 and –8.0 ϕ.

Fine Earth Fraction – According to the International Society of Soil Science, the fine earth fraction refers to sediment or soil with the gravel fraction (intermediate diameter greater than 2 mm or –1.0 ϕ) removed. It is used for all laboratory determinations.

Granule – According to the Wentworth grade scale for sediments, granule refers to a part of the gravel fraction which has intermediate diameters between 2.0 and 4.0 mm or between –1.0 and –2.0 ϕ.

Gravel – According to the Wentworth grade scale for sediments and the International Society of Soil Science, gravel is sediment with an intermediate diameter greater than 2 mm or –1.0 ϕ. It is further divided into four gravel fractions, according to the Wentworth grade scale for sediments, as outlined in Table 1.

Mud – According to the Wentworth grade scale for sediments, mud is sediment with an intermediate diameter less than 0.0625 mm or 4.0 ϕ. It is further divided into silt and clay fractions.

Pebble – According to the Wentworth grade scale for sediments, pebble refers to a part of the gravel fraction with an intermediate diameter between 4 mm and 64 mm or between –2.0 ϕ and –6.0 ϕ.

Phi (ϕ) – This is a notation system used to describe the grain size of clastic sediment by sedimentologists. It is a logarithmic scale in which each grade limit is twice as large as the next smaller grade limit (Folk 1974). Phi (ϕ) is formally defined as:

$$\phi = -\log_2 d \qquad 1$$

where d is the grain diameter in mm.

Sand – According to the Wentworth grade scale for sediments, sand is sediment with an intermediate diameter ranging between 2 mm and 0.0625 mm or between –1.0 ϕ and 4.0 ϕ. It is further divided into five sand fractions, as outlined in table 1. According to the International Society of Soil Science, sand refers to a part of the fine earth fraction with an intermediate

diameter ranging between 2 mm and 0.02 mm or between –1.0 ϕ and 5.64 ϕ. It is further subdivided into coarse and fine sand with the boundary at 0.2 mm or 2.3 ϕ.

Silt – According to the Wentworth grade scale for sediments, silt refers to a part of the mud fraction with an intermediate diameter between 0.0625 mm and 0.0039 mm or between 4.0 ϕ and 8.0 ϕ. It is further divided into four silt fractions, as outlined in table 1. According to the International Society of Soil Science, silt refers to a part of the fine earth fraction with an intermediate diameter ranging between 0.02 mm and 0.002 mm or between 2.3 ϕ and 9 ϕ.

Sub-armour layer – This sediment is a different population to the overlying armour layer in that it is much finer due to the presence of a significant sand fraction (Erskine 1985, 1992, Erskine et al 1985, 1996). The gravel fraction is usually finer than in the armour layer also (Erskine 1985, Erskine et al 1985).

Bed-material and floodplain sediments of the Ngarradj (Swift) Creek catchment, Jabiluka, Northern Territory

Wayne D Erskine, MJ Saynor & AA Webb

Introduction

During field investigations of the Ngarradj (Swift) Creek catchment (fig 1) as part of the Supervising Scientist Division's monitoring and research activities on the Jabiluka Mineral Lease, the authors have collected a substantial amount of information on surficial soils and sediments. The purpose of this report is to provide a permanent record of the shallow stratigraphic data of the fluviatile sediments associated with the channels and floodplains in the Ngarradj (Swift) Creek catchment obtained by the authors as part of the work reported by Saynor et al (2001, 2002a, 2002b, 2003) and Erskine et al (2001, 2003). This information may prove important in the future for evaluating:

1. how the river channels respond to mining, should it proceed,
2. where specific sediment fractions will be stored in the channel network, and
3. what sediment fractions are deposited on the floodplains.

Sediment textural information is also important for determining:

1. sediment budgets,
2. storage sites for heavy metals and radionuclides,
3. processes of floodplain formation, and
4. the late Holocene alluvial history of the Ngarradj (Swift) Creek catchment.

Additional information is still needed to supplement the present data for the above purposes.

This Internal Report should be read in conjunction with Saynor et al (2001, 2002a, 2002b, 2003) which contain the details of the cross sections at which scour chains were installed. Erskine et al (2003) discuss channel and floodplain sediments at the ***eriss***'s gauging stations on upper Ngarradj (Swift) Creek and East Tributary. Furthermore, Saynor et al (2003) present changes in bed-material grain size statistics between 1998 and 2001 at each of the ***eriss*** monitoring cross sections in the Ngarradj (Swift) Creek catchment (see also Saynor et al 2001, 2002a). The Glossary and Methods define the sedimentological terms used in this report.

Methods

Bed-material samples

Shallow pits were initially excavated by shovel and then extended by sand auger into the river bed to a maximum depth of 2.8 m on selected cross sections of the mine site tributaries (Tributaries North and Central) and at the ***eriss*** gauging stations (lower and upper Ngarradj (Swift) Creek and East Tributary) to install scour chains at permanently monumented cross sections (Saynor et al 2001, 2002b).

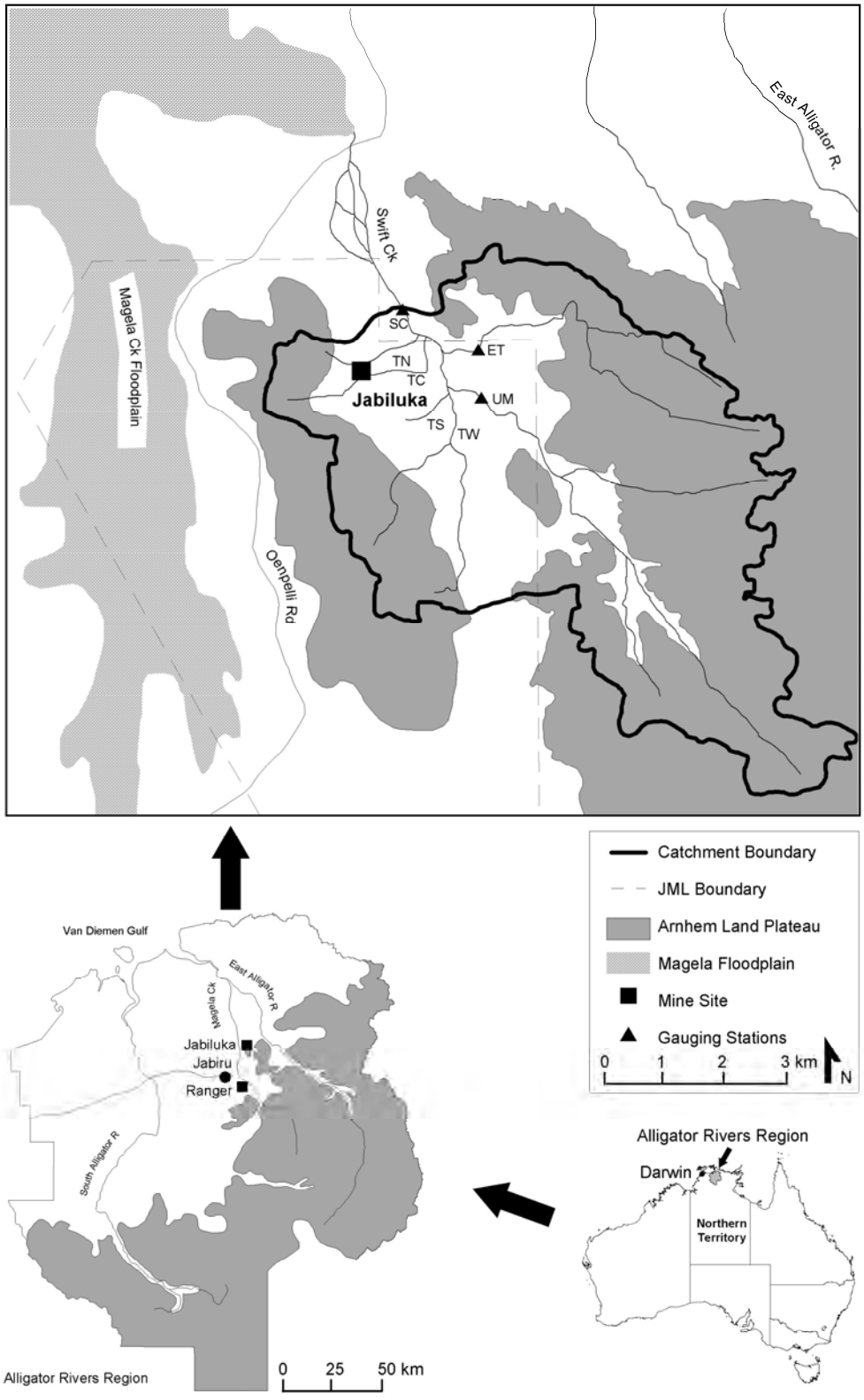

Figure 1 The Ngarradj (Swift) Creek catchment. TN refers to Tributary North, TC to Tributary Central, TS to Tributary South, TW to Tributary West, SC to the Swift Creek gauge, ET to the East Tributary gauge and UM to the upper Swift Creek gauge

The excavated sediments were carefully laid out onto plastic sheets in the same sequence as they were removed from the river bed and sampled for subsequent textural description in the laboratory. The sediment textural classification used for bed-material samples is that of Folk (1954, 1974) for unconsolidated materials and is based on a ternary diagram showing the proportions of gravel, sand and mud on separate axes (figure 2). This texture triangle is split into 15 groups and the median diameter is determined, where possible, for each component fraction. Each sediment fraction can be expressed in terms of one of the Wentworth size classes (table 1). To place a sample into one of the 15 major groups, only two properties need to be determined, namely the gravel percentage (boundaries at 80, 30, 5 and a trace or 0.01 %) and the ratio of sand to mud with boundaries at 9:1, 1:1 and 1:9 (Folk 1954, 1974). The gravel content is partly a function of the highest current velocity and the maximum grain size of the supplied sediment. The sand: mud ratio reflects the amount of winnowing (washing away of fine sediment) that has occurred. For samples lacking gravel, a further ternary diagram (figure 3) is used which expands the bottom tier of figure 2. It is based on the proportions of sand, silt and clay (see Folk 1954, 1974). The textural classifications were based on limited laboratory analyses involving dry sieving, measurement of the intermediate or b-axis diameters of gravels, visual comparison with charts of all five Wentworth sand fractions and an estimate of the mud percentage.

Sediment colour was determined by visual comparison with the colour chips contained in the Munsell Soil Colour Charts (Munsell 1975). Colour is described in terms of three coordinates, Munsell Hue, Value and Chroma, and relate to the colour characteristics of dominant wavelength, lightness and colour saturation respectively. Verbal descriptors for various combinations of Hue, Value and Chroma are included in Munsell (1975) and are used below. However, they are not as precise as the Hue, Value and Chroma notation which is also cited below. The Munsell System is the standard to which all other systems are compared (Billmeyer & Saltzman 1981) and has been used for this reason here. The recommendations of Melville & Atkinson (1985) were followed for the correct measurement of soil colour. In particular, only moist colours of disrupted samples in diffuse daylight with 45° side illumination and viewing normal to the sample and colour charts were determined by experienced operators with normal colour vision. Viewing masks appropriate to the colour Value of the sample were used. We agree with Melville & Atkinson (1985, 495) that:

> Soil colour for its own sake has little significance. The importance of soil colour lies in the fact that the soil profile has some set of properties that relate either to the overall colour that is perceived or to one of its colour variables and that this profile's colour is different from another.

Floodplain samples

Floodplain sediments were sampled by sand auger to a maximum depth of 2.8 m and arranged on a plastic sheet in the same sequence as they were excavated. The sediments were systematically described in the field using the methods of Northcote (1984) and McDonald & Isbell (1990). Sediment colour was determined by visual comparison with the colour chips contained in the Munsell Soil Colour Charts (Munsell 1975), as outlined above. Field texture was determined by the behaviour and response of a bolus to manipulation, following the method of Northcote (1984). The field texture grades have been correlated with particle size results and are based on Marshall's (1947) ternary diagram of sand, silt and clay percentages (figure 4). As noted on figure 4, the sand, silt and clay size fractions for field textures are **not** equivalent to those of Folk (1954, 1974) or the Wentworth scale. The International Society of Soil Science sediment fractions are used in which gravel refers to sediment coarser than 2 mm, sand to sediment with diameters between 2 mm and 20 μm, silt to sediment with diameters between 20 μm and 2 μm, and clay with diameters less than 2 μm. Furthermore,

field texture grades are based on field determination of texture and not on laboratory determinations of the percentage of the various particle size fractions (Northcote 1984, McDonald & Isbell 1990). Field textures are only based on the fine earth fraction (the <2 mm fraction) and hence do not include gravels. Therefore, the textural classes of Folk (1954, 1974) were used when gravels were present. Furthermore, to enable a direct comparison between bed-material and floodplain sediments, equivalent Folk (1954, 1974) texture classes have also been included for the field texture grades of Northcote (1984) in the tables for floodplain sediments.

Table 1 The Wentworth grain size scale for sediments (after Folk 1974). See Glossary for further details.

Finest Grain Size (mm)	Finest Grain Size (ϕ)	Wentworth Size Class
256	-8	Boulder
64	-6	Cobble
4	-2	Pebble
2	-1	Granule
1.00	0	Very coarse sand
0.50	1	Coarse sand
0.25	2	Medium sand
0.125	3	Fine sand
0.0625	4	Very fine sand
0.031	5	Coarse silt
0.0156	6	Medium silt
0.0078	7	Fine silt
0.0039	8	Very fine silt
0.00006	14	Clay

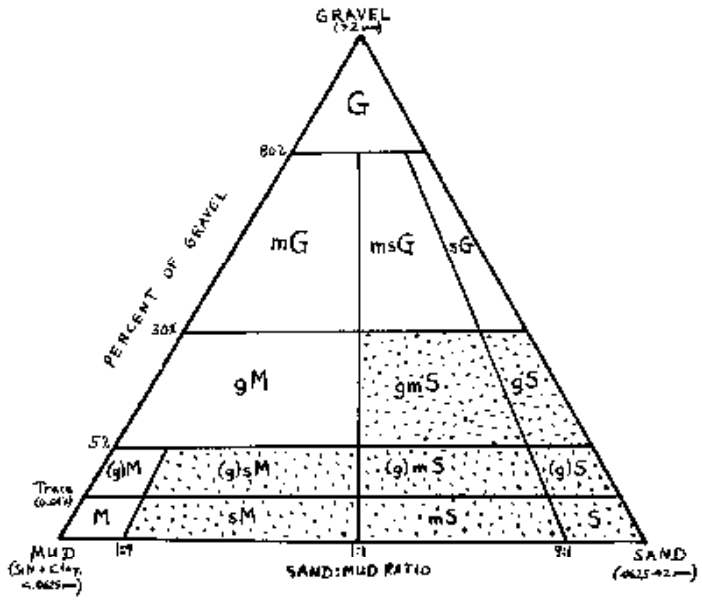

Figure 2 Folk's (1974) textural groups. G is gravel; sG sandy gravel; msG muddy sandy gravel; mG muddy gravel; gS gravelly sand; gmS gravelly muddy sand; gM gravelly mud; (g)S slightly gravelly mud; (g)mS slightly gravelly muddy sand; (g)sM slightly gravelly sandy mud; (g)M slightly gravelly mud; S sand; mS muddy sand; sM sandy mud; M mud.

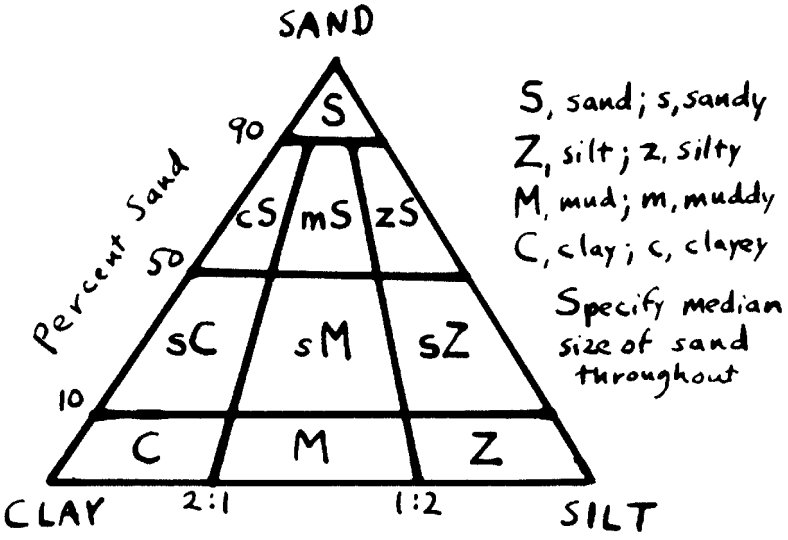

Figure 3 Folk's (1974) expansion of the bottom tier of figure 2 to show textural classes for sediments lacking gravel. S is sand; zS silty sand; mS muddy sand; cS clayey sand; sZ sandy silt; sM sandy mud; sC sandy clay; Z silt; M mud; and C clay.

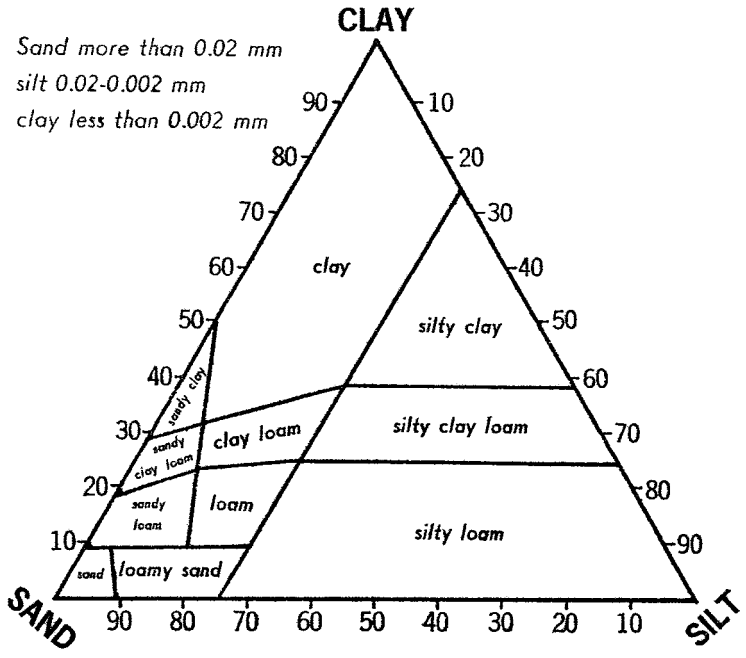

Figure 4 Marshall's (1947) ternary diagram of soil textures

A complete soil profile description was also completed of a bank exposure on Tributary North at cross section TN01. For this profile, Butler's (1955) method of consistence description was used, otherwise the procedures of Northcote (1984) and McDonald & Isbell (1990) were adopted.

Results

Bed material sediments

Swift Creek

The location of the cross sections referred to in the following tables is shown in figure 5. Three holes were excavated on each of the three cross sections at which scour chains were installed (cross sections SM05, SM02 and SM08) (Saynor et al 2002b). Sections SM05 and SM08 were excavated on 30 October 1998 but SM02 was excavated on 4 November 1999.

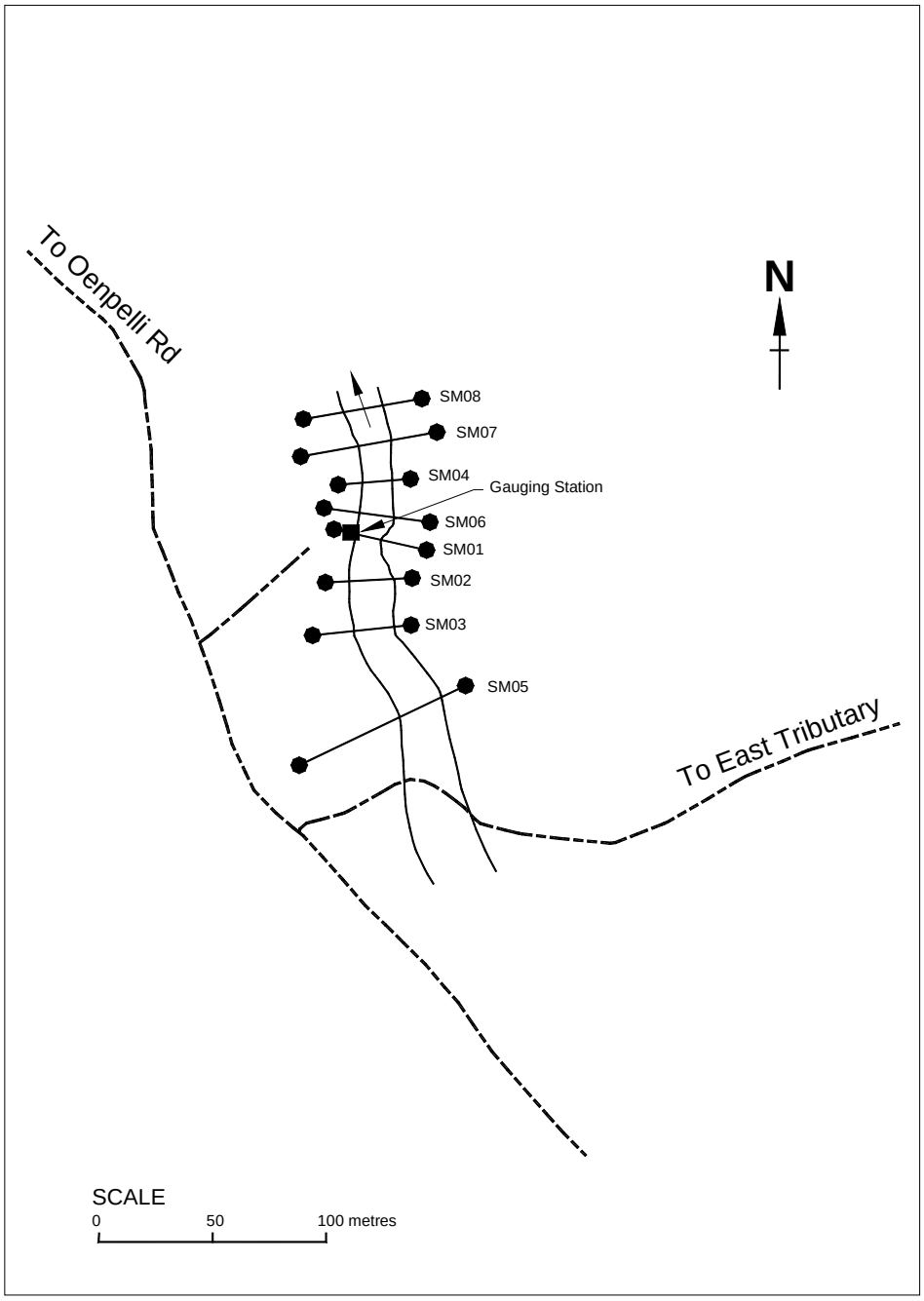

Figure 5 Location of channel and floodplain cross sections at the ***eriss***'s gauging station on lower Ngarradj (Swift) Creek

Bulk samples were collected for subsequent textural description in the laboratory. The bed sediments were sampled to a maximum depth of only 1 m and are described in tables 2 to 10 inclusive. Depth to water table varied between 0.6 and 0.9 m and limited the success of deeper hand augering through the sandy sediments. Most of the bed sediment is slightly granular medium sand. The maximum gravel size measured was 36 mm but the mean maximum gravel size was only 7 ± 0.7 mm (standard error of estimate). Saynor et al (2002b) found that the maximum average scour depth during the Wet season was 505 mm between 1998 and 2001. Hence at best only the upper 0.5 m of bed sediments described in tables 2 to 10 inclusive was mobile during a wet period when annual rainfall had average recurrence intervals between 1:13 and 1:71 years (Moliere et al 2002).

Selective armouring of the bed surface with 4 to 36 mm gravel is possible should bedload supply to the gauge reach be reduced. Localised gravel armoured scour holes currently form next to large woody debris or tree trunks or extensive root mats in the channel.

Table 2 Swift Creek bed material – Swift main – Cross section SM 05 – scour chain site SM 05–1, 2.5 m from left bank – date collected 30 October 1998

Depth (m)	Sediment Characteristics
0-0.2	Brown (10YR 5/3*); clean, well sorted, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter; contained a lot of charcoal and some roots
0.2-0.3	Light brownish grey (10YR 6/2*); slightly granular medium sand**; largest gravel clast (quartz) was 8 mm in diameter; contained a lot of leaves, roots and charcoal
0.3-0.5	Light brownish grey (10YR 6/2*); slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained some charcoal
0.5-0.7	Light brownish grey (10YR 6/2*); slightly granular fine-medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contains some charcoal
0.7-0.8	Grey-light grey (10YR 6/1*); clean, well sorted, medium sand**
0.8-0.9	Grey (10YR 5/1*); slightly granular fine-medium sand**; largest gravel clast (quartz) was 9 mm in diameter; mudballs present; also contains a 20 mm thick layer of black (10YR 2/1*); silty fine sand**; water table at 0.9 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 3 Swift Creek bed material – Swift main – Cross section SM 05 – scour chain site SM 05–2, 4.5 m from left bank – date collected 30 October 1998.

Depth (m)	Sediment Characteristics
0-0.2	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 5.5 mm in diameter
0.2-0.4	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter
0.4-0.6	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained some roots and charcoal
0.6-0.8	Light brownish grey (10YR 6/2*); clean, slightly granular coarse sand**; largest gravel clast (quartz) was 8 mm in diameter; water table at 0.8 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 4 Swift Creek bed material – Swift main – Cross section SM 05 – scour chain site SM 05–3, 6.5 m from left bank – date collected 30 October 1998

Depth (m)	Sediment Characteristics
0-0.3	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 6.5 mm in diameter
0.3-0.4	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter
0.4-0.5	Light grey (10YR 7/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter
0.5-0.6	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 5.5 mm in diameter; water table at 0.6 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 5 Swift Creek bed material – Swift main – Cross section SM 02 – scour chain site SM 02–1, 1.5 m from left bank – date collected 4 November 1999

Depth (m)	Sediment Characteristics
0-0.3	Pale brown (10YR 6/3*); clean, well sorted, granular fine-medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained a 28 mm long, 5 mm diameter stick
0.3-0.5	Pale brown (10YR 6/3*); clean, well sorted, granular fine sand**; largest gravel clasts (quartz and sandstone) were 9 mm in diameter
0.5-0.6	Very dark brown (7.5YR 2.5/1*); slightly granular muddy very fine sand**; largest gravel clast (quartz) was 5 mm in diameter; contained roots and charcoal
0.6-0.8	Brown (10YR 5/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 4 mm in diameter; water table at approximately 0.7 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 6 Swift Creek bed material – Swift main – Cross section SM 02 – scour chain site SM 02–2, 5.0 m from left bank – date collected 4 November 1999

Depth (m)	Sediment Characteristics
0-0.2	Light brownish grey (10YR 6/2*); clean, well sorted, slightly granular medium sand**; largest gravel clast (quartz) was 4 mm in diameter; contained charcoal
0.2-0.4	Greyish brown (10YR 5/2*); well sorted, slightly granular medium sand**; largest gravel clast (quartz) was 4 mm in diameter; contained charcoal; also contained dark grey (10YR 4/1) mudballs
0.4-0.6	Brown (10YR 5/3*); clean, slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 3 mm in diameter
0.6-0.8	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter; water table at approximately 0.7-0.8 m
0.8-1.0	Very pale brown (10YR 7/3*); slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 8 mm in diameter

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 7 Swift Creek bed material – Swift main – Cross section SM 02 – scour chain site SM 02–3, 7.5 m from left bank – date collected 4 November 1999

Depth (m)	Sediment Characteristics
0-0.2	Light brownish grey (10YR 6/2*); clean, slightly granular medium-fine sand**; largest gravel clasts (quartz and sandstone) were 6 mm in diameter
0.2-0.4	Light brownish grey (10YR 6/2*); clean, granular medium sand**; largest gravel clasts (quartz and sandstone) were 8 mm in diameter
0.4-0.6	Pale brown (10YR 6/3*); slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 9 mm in diameter
0.6-0.8	Very pale brown (10YR 7/3*); slightly granular fine sand**; largest gravel clast (quartz) was 5 mm in diameter
0.8-1.0	Pinkish grey (7.5YR 7/2*); relatively clean, slightly granular fine sand**; largest gravel clast (quartz) was 5 mm in diameter; water table at about 0.95 m
1.0-1.2	Very pale brown (10YR 7/3*); slightly granular medium-fine sand**; largest gravel clast (quartz) was 7 mm in diameter

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 8 Swift Creek bed material – Swift main – Cross section SM 08 – scour chain site SM 08–1, 2.1 m from left bank – date collected 30 October 1998

Depth (m)	Sediment Characteristics
0-0.15	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained rare leaves and twigs
0.15-0.4	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 4 mm in diameter; contained rare leaves
0.4-0.7	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter
0.7-0.8	Grey (10YR 5/1*); clean, slightly pebbly medium sand**; largest gravel clast (quartz) was 7 mm in diameter; contains mudballs; also contains a 20 mm layer of black (10YR 2/1*); silty sand**
0.8-1.0	Light brownish grey (10YR 6/2*); clean, slightly pebbly fine-medium sand**; largest gravel clast (quartz) was 6 mm in diameter; water table at 0.9 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 9 Swift Creek bed material – Swift main – Cross section SM 08 – scour chain site SM 08–2, 4.1 m from left bank – date collected 30 October 1998

Depth (m)	Sediment Characteristics
0-0.3	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter; contained large amounts of charcoal
0.3-0.4	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 5 mm in diameter; contained rare charcoal
0.4-0.6	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 8 mm in diameter; contained very rare charcoal
0.6-0.7	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter
0.7-0.8	Grey (10YR 5/1*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained a lot of charcoal
0.8-1.0	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 5 mm in diameter; contained a lot of iron-stained charcoal. Water table at 0.9 m.

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 10 Swift Creek bed material – Swift main – Cross section SM 08 – scour chain site SM 08–3, 6.1 m from left bank – date collected 30 October 1998

Depth (m)	Sediment Characteristics
0-0.2	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 5 mm in diameter; contained some large roots up to 8 mm in diameter
0.2-0.3	Light brownish grey (10YR 6/2*); clean, slightly granular coarse sand**; largest gravel clast (quartz) was 8 mm in diameter; contained mudballs and some charcoal
0.3-0.4	Light brownish grey (10YR 6/2*); clean, slightly pebbly medium sand**; largest gravel clast (quartz) was 8 mm in diameter; contained charcoal
0.4-0.6	Light brownish grey (10YR 6/2*); clean, slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter; contained rare charcoal
0.6-0.7	Pale brown (10YR 6/3*); clean, slightly granular medium sand**; largest gravel clast (sandstone) was 36 mm in diameter; 10% of sample was porous, clayey fine sand** balls; clay balls were yellowish brown (10YR 5/4*)
0.7-0.8	Light yellowish brown-very pale brown (10YR 6.5/4*); slightly granular muddy medium sand**; largest gravel clast (quartz) was 7 mm in diameter; 50 % of sample was porous, clayey fine-medium sand** balls; clay balls were mottled comprising 50 % brownish yellow (10YR 6/8*) and 50 % very pale brown (10YR 7/4*)
0.8-1.0	Light grey (10YR 7/2*); slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Upper Swift Creek

The location of the cross sections referred to in the following tables is shown in figure 6. Two holes were excavated on each of the three cross sections at which scour chains were installed (cross sections UM02, UM05 and UM07) on 13 and 25 November 1998 (Saynor et al 2002b). Bulk samples were collected for subsequent textural description in the laboratory. The bed sediments were sampled to a maximum depth of 1.4 m and are described in tables 11 to 16 inclusive.

Table 11 Swift Creek bed material – Upmain – Cross section UM 02 – scour chain site UM 02–1, 3.5 m from right bank – date collected 25 November 1998.

Depth (m)	Sediment Characteristics
0-0.3	Grey-light grey (10YR 6/1*); slightly granular fine-medium sand**; largest gravel clast (quartz) was 9 mm in diameter; contained small pieces of charcoal and fine roots
0.3-0.4	Grey-light grey (10YR 6/1*); clean, slightly pebbly medium sand**; largest gravel clast (sandstone) was 19 mm in diameter; contained fine roots
0.4-0.6	Light grey (10YR 7/2*); slightly pebbly coarse sand**; largest gravel clast (sandstone) was 21 mm in diameter; contained many fine roots
0.6-0.7	Dark grey (10YR 4/1*); slightly granular coarse sand**; largest gravel clast (quartz) was 11 mm in diameter; contained large pieces of eroded root (up to 22 mm in diameter)
0.7-0.8	White (10YR 8/2*); clean, pebbly medium sand**; largest gravel clast (sandstone) was 13 mm in diameter; contained some medium size roots
0.8-0.85	White (10YR 8/2*); clean, pebbly coarse sand**; largest gravel clast (sandstone) was 16 mm in diameter
0.85+	Sandstone bedrock

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

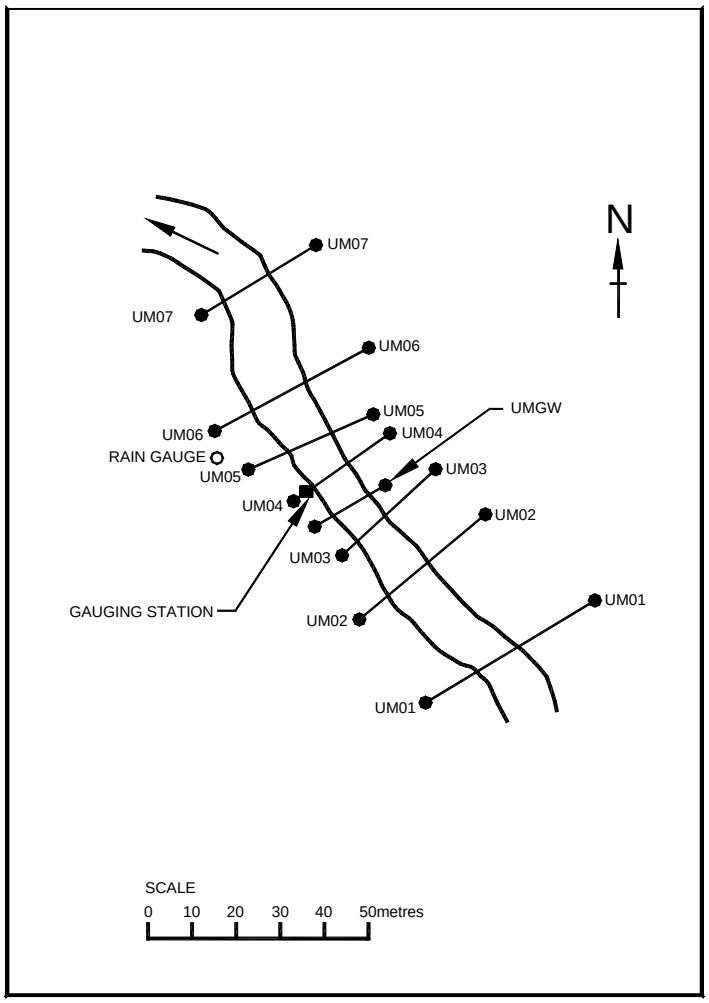

Figure 6 Location of channel and floodplain cross sections at ***eriss***'s gauging station on upper Ngarradj (Swift) Creek

Bedrock (iron-indurated sandstone) or weathered bedrock was encountered between 0.35 and 1.4 m below the river bed in every hole and is exposed at the surface at cross section UM01. Sediments are texturally variable ranging from medium and coarse sand to medium sandy pebble gravel. The maximum gravel size measured was 32 mm but the mean maximum gravel size was only 16 ± 3 mm (standard error of estimate). Saynor et al (2002b) found that the maximum average scour depth during the Wet season was 278 mm between 1998 and 2001. Hence at best only the upper 0.28 m of bed sediments described in tables 11 to 16 inclusive was mobile during a wet period when annual rainfall had average recurrence intervals between 1:13 and 1:71 years (Moliere et al 2002).

Selective armouring of the bed surface with 4 to 32 mm gravel is possible should bedload supply to the gauge reach be reduced. Localised gravel armoured scour holes currently form next to large woody debris or tree trunks in the channel or at sites of local scour around bedrock outcrops.

Table 12 Swift Creek bed material – Upmain – Cross section UM 02 – scour chain site UM 02–2, 1.5 m from right bank – date collected 25 November 1998.

Depth (m)	Sediment Characteristics
0–0.35	Grey-light grey (10YR 6/1*); slightly granular fine-medium sand**; largest gravel clast (quartz) was 9 mm in diameter; contained small pieces of charcoal and fine roots
0.35+	Sandstone bedrock. Auger could grind slightly into it.

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 13 Swift Creek bed material – Upmain – Cross section UM 05 – scour chain site UM 05–1, 2 m from left bank – date collected 13 November 1998.

Depth (m)	Sediment Characteristics
0–0.3	Light brownish grey (10YR 6/2*); pebbly coarse sand**; largest gravel clast (sandstone) was 14 mm in diameter; contained leaves, twigs and wood
0.3–0.4	Light brownish grey (10YR 6/2*); slightly pebbly medium sand**; largest gravel clast (quartz) was 12 mm in diameter; contained twigs, roots and charcoal
0.4–0.5	Light brownish grey (10YR 6/2*); slightly pebbly medium sand**; largest gravel clast (quartz) was 16 mm in diameter; contained twigs, roots and charcoal
0.5–0.6	Dark grey (10YR 4/1*); slightly pebbly medium sand**; largest gravel clast (quartz) was 9 mm in diameter; contained fluvially rounded charcoal with a median diameter of 10 mm
0.6–0.7	Grey to light grey (10YR 6/1*); pebbly coarse sand**; largest gravel clast (quartz) was 12 mm in diameter; contained rare twigs and charcoal
0.7–0.8	Light brownish grey (10YR 6/2*); clean medium sand**
0.8–0.9	Light brownish grey (10YR 6/2*); clean medium to coarse sand**
0.9–1.0	Light brownish grey (10YR 6/2*); clean coarse sand**; largest gravel clast (sandstone) was 10 mm in diameter
1.0–1.2	Light brownish grey (10YR 6/2*); clean coarse sand**; contained rare roots; largest gravel clast (quartz) was 9 mm in diameter
1.2–1.4	Light brownish grey (10YR 6/2*); clean coarse sand**; largest gravel clast (sandstone) was 17 mm in diameter

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 14 Swift Creek bed material – Upmain – Cross section UM 05 – scour chain site UM 05–2, 4 m from left bank – date collected 13 November 1998.

Depth (m)	Sediment Characteristics
0–0.2	Light brownish grey (10YR 6/2*); slightly pebbly medium sand**; largest gravel clast (sandstone) was 19 mm in diameter; contained two roots
0.2–0.4	Light brownish grey (10YR 6/2*); pebbly coarse sand**; largest gravel clast (sandstone) was 16 mm in diameter; contained one root and one piece of charcoal;
0.4–0.6	Light brownish grey (10YR 6/2*); pebbly coarse sand**; largest gravel clast (sandstone) was 26 mm in diameter; contained one root and two pieces of charcoal
0.6–0.8	Greyish brown (10YR 5/2*); clean, fine to medium sand**; largest gravel clast (quartz) was 5 mm in diameter; contained a few roots;
0.8–1.0	Dark grey (10YR 4/1*); fine to medium sand**; largest gravel clast (quartz) was 6 mm in diameter; contained a lot of charcoal
1.0–1.2	Dark grey (10YR 4/1*); pebbly medium sand** with many clay balls or clay segregations; largest gravel clast (quartz) was 23 mm in diameter; contained roots and charcoal
1.2–1.4	Very pale brown (10YR 7/3*); pebbly clayey medium sand** with soft sandstone concretions; largest gravel clast (quartz) was 38 mm in diameter; weathered sandstone bedrock

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 15 Swift Creek bed material – Upmain – Cross section UM 07 – scour chain site UM 07–1, 2.5 m from left bank – date collected 13 November 1998.

Depth (m)	Sediment Characteristics
0–0.2	Light grey (10YR 7/1*); poorly sorted, slightly granular coarse sand**; largest gravel clast (quartz) was 7.5 mm in diameter; contained some rounded charcoal
0.2–0.3	Greyish brown (10YR 5/2*); clean, slightly granular medium sand**; largest gravel clast (sandstone) was 20 mm in diameter; contained a lot of roots and some charcoal
0.3–0.4	Dark greyish brown (10YR 4/2*); well sorted, slightly pebbly fine sand**; largest gravel clast (sandstone) was 13 mm in diameter; sand was well sorted; contained a lot of roots and charcoal
0.4–0.5	Grey (10YR 5/1*); poorly sorted, medium sandy pebble gravel**; largest gravel clast (sandstone) was 32 mm in diameter and all clasts > 25 mm in diameter were angular sandstone; sand was poorly sorted; contained a large root
0.5+	Sandstone and ironstone bedrock

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 16 Swift Creek bed material – Upmain – Cross section UM 07 – scour chain site UM 07–2, 5.5 m from left bank – date collected 13 November 1998.

Depth (m)	Sediment Characteristics
0–0.2	Light brownish grey (10YR 6/2*); poorly sorted, slightly granular medium sand**; largest gravel clast (quartz) was 8 mm in diameter
0.2–0.3	White (10YR 8/1*); poorly sorted, slightly granular coarse sand**; largest gravel clast (quartz) was 10 mm in diameter
0.3–0.4	Light brownish grey (10YR 6/2*); poorly sorted, pebbly medium sand**; largest gravel clast (sandstone) was 31 mm in diameter
0.4–0.5	Pale brown (10YR 6/3*); poorly sorted, medium sandy pebble gravel**; largest gravel clast (sandstone/ironstone) was 24 mm in diameter
0.5-0.6	Light grey (10YR 7/1*); slightly pebbly muddy medium sand**; largest gravel clast (quartz) was 24 mm in diameter
0.6-0.8	White (10YR 8/1*); clean, slightly pebbly muddy medium sand**; largest gravel clast (quartz) was 18 mm in diameter
0.8-1.0	White (10YR 8/1*); slightly pebbly muddy medium sand**; largest gravel clast (sandstone) was 23 mm in diameter
1.0-1.1	White (10YR 8/1*); slightly granular medium sand**; largest gravel clast (sandstone) was 11 mm in diameter; no recovery below 1.1 m; bedrock at 1.1 m

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

East Tributary

The location of the cross sections referred to in the following tables is shown in figure 7. Two holes were excavated on cross section ET01 but only one hole was excavated on each of cross sections ET04, UM07 and ET08 on 3 and 4 November 1998 because of the narrower bed width. These holes correspond to the sites where Saynor et al (2002b) installed scour chains. Bulk samples were collected from each hole for subsequent textural description in the laboratory. The bed sediments were sampled to a maximum depth of 2.8 m because of a higher mud content and the presence of a fine root mat which often retained sediment in the auger head when below the water table which was usually encountered between 1.55 and 1.7 m below the river bed. Buried large woody debris prevented the retrieval of sediment below 1.25 m at one hole (cross section ET08). Sediments are described in Tables 17 to 21 inclusive and are variable because of occasional high gravel and mud contents. The dominant textures are slightly pebbly medium sand to pebbly medium sand and slightly granular medium sand

to granular medium sand. However, slightly granular muddy medium sand and coarse sandy pebble gravel represent the extremes. The maximum gravel size measured was 17 mm but the mean maximum gravel size was 10 ± 1 mm (standard error of estimate). Saynor et al (2002b) found that the maximum average scour depth during the Wet season was 350 mm between 1998 and 2001. Hence at best only the upper 0.35 m of bed sediments described in Tables 11 to 16 inclusive were mobile during a wet period when annual rainfall had average recurrence intervals between 1:13 and 1:71 years (Moliere et al 2002).

Selective armouring of the bed surface with 4 to 17 mm gravel is possible should bedload supply to the gauge reach be reduced. Localised gravel armoured scour holes currently form next to large woody debris or tree trunks in the channel or below log steps.

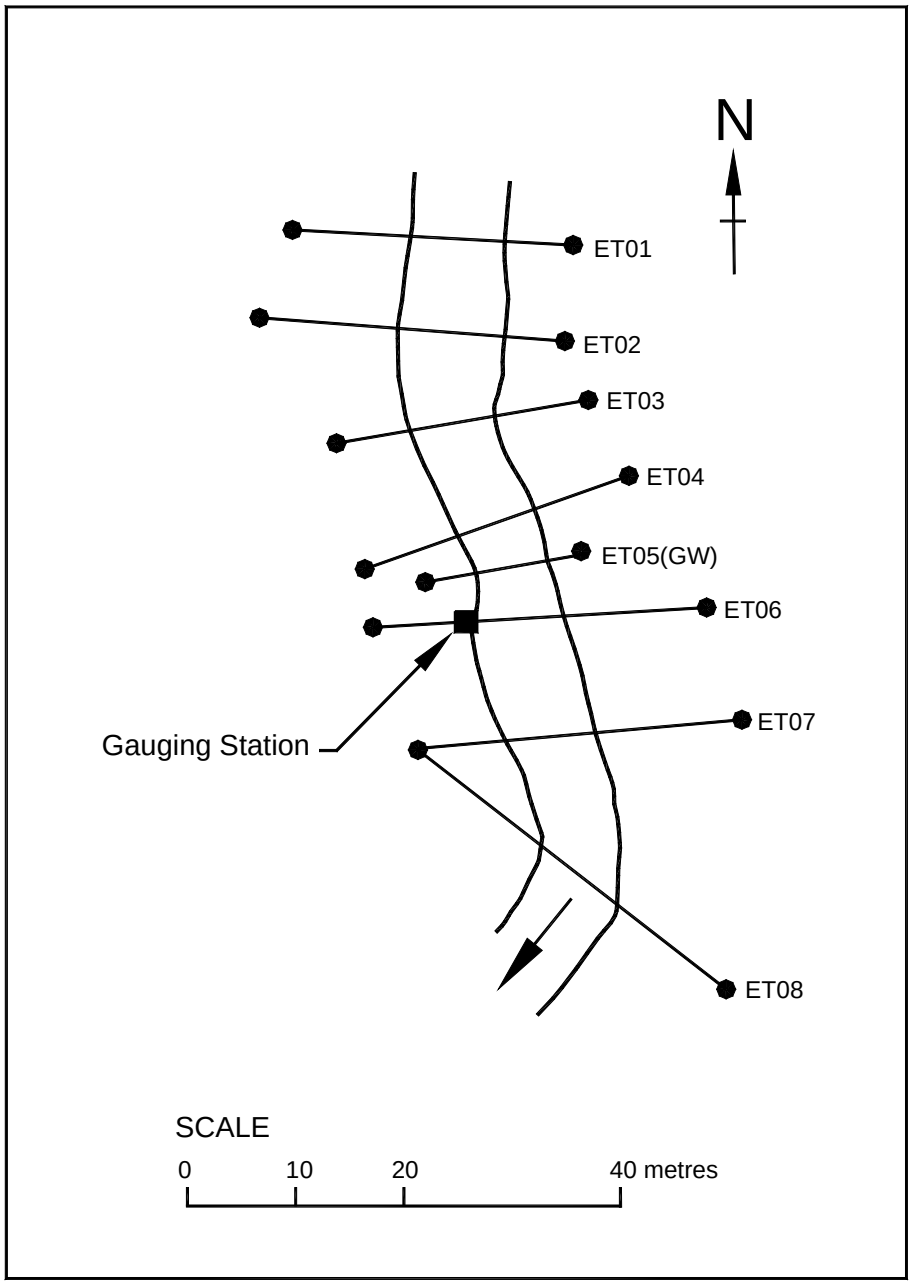

Figure 7 Location of channel and floodplain cross sections at ***eriss***'s gauging station on East Tributary

Table 17 East Tributary bed material – Cross section ET 01 – scour chain site ET 01–1, 1.7 m from left bank – date collected 3 November 1998.

Depth (m)	Sediment Characteristics
0–0.2	Pale brown (10YR 6/3*); pebbly medium sand**; largest gravel clasts (quartz and sandstone) were 12.5 mm in diameter; contained twigs and roots;
0.2–0.35	Light brownish grey (10YR 6/2*), slightly pebbly medium sand**; largest gravel clasts (sandstone and quartz) were 12.5 mm in diameter; contained roots
0.35–0.6	Very dark greyish brown (10YR 3/2*); pebbly medium sand**; largest gravel clasts (sandstone and quartz) were 17 mm in diameter; contained roots
0.6–0.85	Dark greyish brown (10YR 4/2*); pebbly medium-coarse sand**; largest gravel clasts (sandstone and quartz) were 9.5 mm in diameter; contained rare roots and charcoal;
0.85–1.2	Light grey (10YR 7/2*); slightly granular muddy coarse sand**; largest gravel clast (quartz) was 5.5 mm in diameter; contained rare roots;
1.2–1.5	Light grey (10YR 7/2*); slightly granular muddy fine sand**; largest gravel clast (quartz) was 6.5 mm in diameter; contained a small amount of roots
1.5–1.75	Light grey (10YR 7/2*); slightly granular muddy medium sand**; largest gravel clast (quartz) was 7 mm in diameter; water table at 1.7 m
1.75–2.05	White (10YR 8/1*); slightly granular muddy medium sand**; largest gravel clast (quartz) was 11 mm in diameter
2.05–2.3	Light grey (10YR 7/1*); slightly pebbly muddy medium sand**; contained mudballs
2.3–2.5	Light grey (10YR 7/1*); slightly pebbly muddy coarse sand**; largest gravel clast (quartz) was 8 mm in diameter

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 18 East Tributary bed material – Cross section ET 01 – scour chain site ET 01–2, 3.7 m from left bank – date collected 3 November 1998.

Depth (m)	Sediment Characteristics
0–0.3	Pale brown (10YR 6/3*); granular medium-coarse sand**; largest gravel clasts (quartz and sandstone) were 12 mm in diameter; contained charcoal
0.3–0.63	Brown (10YR 5/3*), granular medium sand**; largest gravel clast (quartz) was 9.5 mm in diameter
0.63–0.93	Dark grey (10YR 4/1*); slightly pebbly medium sand**; largest gravel clast (quartz) was 8 mm in diameter
0.93–1.1	Greyish brown (10YR 5/2*); slightly granular medium sand**; largest gravel clast (quartz) was 7 mm in diameter; contained very rare fine roots
1.1–1.2	Light brownish grey (10YR 6/2*); granular medium-coarse sand**; largest gravel clasts (quartz) were 9.5 mm in diameter; contained rare roots
1.2-1.35	Mixed greyish brown (10YR 5/2*); pebbly coarse sand**; largest gravel clast (quartz) was 9 mm in diameter; and light grey (10YR 7/2*); slightly granular muddy medium sand**; largest gravel clast (quartz) was 8.5 mm in diameter
1.35-1.5	Clayey medium sand**
1.5-1.8	White (10YR 8/1*); slightly granular medium sand**; largest gravel clast (quartz) was 6 mm in diameter; water table at 1.55 m
1.8-2.4	Light grey (10YR 7/1*); slightly granular muddy medium sand**; largest gravel clast(quartz) was 7.5 mm in diameter
2.4–2.7	Light grey (10YR 7/1*); slightly pebbly muddy fine-medium sand**; largest gravel clast (quartz) was 8 mm in diameter
2.7-2.8	Poor recovery of gravelly muddy sand**

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 19 East Tributary bed material – Cross section ET 04 – scour chain site 2.2 m from left bank – date collected 4 November 1998.

Depth (m)	Sediment Characteristics
0–0.2	Pale brown (10YR 6/3*); poorly sorted, granular medium sand**; largest gravel clast (quartz) was 5.5 mm in diameter; contained very rare leaves, roots and twigs
0.2-0.45	Very dark grey (10YR 3/1*); slightly pebbly medium sand**; largest gravel clast (quartz) was 10 mm in diameter; contained a lot of roots and charcoal
0.45-0.6	Dark grey (10YR 4/1*); pebbly coarse sand**; largest gravel clast (quartz) was 17 mm in diameter
0.6-0.8	Grey (10YR 5/1*); pebbly coarse sand**; largest gravel clast (quartz) was 10 mm in diameter; contained fine roots and charcoal
0.8-1.0	Pale brown (10YR 6/3*); pebbly coarse sand**; largest gravel clast (quartz) was 10 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 20 East Tributary bed material – Cross section ET 07 – scour chain site in centre of cross section – date collected 4 November 1998.

Depth (m)	Sediment Characteristics
0–0.1	Light brownish grey (10YR 6/2*); poorly sorted, slightly granular medium sand**; largest gravel clast was 8 mm in diameter; contained leaves, twigs and charcoal
0.1–0.3	Light brownish grey (10YR 6/2*); poorly sorted, slightly granular medium sand**; largest gravel clast was 12 mm in diameter; contained leaves, roots and charcoal
0.3–0.6	Very dark grey (10YR 3/1*); slightly granular fine sand**; largest gravel clast was 9 mm in diameter; contained roots and charcoal
0.6–0.7	Very dark grey (10YR 3/1*); slightly pebbly fine sand**; largest gravel clast was 7 mm in diameter; contained roots and charcoal
0.7–0.8	Very dark greyish brown (10YR 3/2*); granular fine sand**; largest gravel clast was 12 mm in diameter; contained rare twigs and charcoal
0.8–1.0	Brown (10YR 5/3*); slightly granular medium sand**; largest gravel clast was 7 mm in diameter; contained two pieces of charcoal
1.0–1.1	Dark greyish brown (10YR 4/2*); pebbly medium sand**; largest gravel clast was 12 mm in diameter; contained a lot of mudballs with some roots and charcoal
1.1–1.3	Very dark grey (10YR 3/1*); medium sand**
1.3–1.6	Very dark grey (10YR 3/1*); medium sand**; contained mudballs
1.6–1.8	Black (10YR 2/1*); muddy medium sand**; contained occasional roots

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 21 East Tributary bed material – Cross section ET 08 – scour chain site ET 08–1, 2.8 m from left bank – date collected 4 November 1998.

Depth (m)	Sediment Characteristics
0–0.1	Pale brown (10YR 6/3*); slightly granular medium sand**; largest gravel clast (quartz) was 4.5 mm in diameter; contained mudballs, leaves and twigs
0.1-0.3	Light grey (10YR 7/2*); slightly granular medium sand**; largest gravel clast (quartz) was 9 mm in diameter; contained occasional fine roots and leaves
0.3-0.5	Light grey (10YR 7/2*); pebbly coarse sand**; largest gravel clast (quartz) was 10 mm in diameter; contained transported large charcoal and wood up to 20 mm in diameter
0.5-0.85	Light grey (10YR 7/2*); coarse sandy pebble gravel**; largest gravel clast (quartz) was 14 mm in diameter; contained some roots
0.85-1.05	Grey-light grey (10YR 6/1*); pebbly coarse sand**; largest gravel clast (quartz) was 11 mm in diameter; contained some fine roots
1.05-1.25	Greyish brown (10YR 5/2*); granular medium sand**
1.25+	Hit a log and could not recover any more sediment

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Tributary North

The location of the cross sections referred to in the following tables is shown in figure 8. A single hole was excavated in the centre of the gully bed on cross sections TN02, TN04, TN05, and TN07 (both on the main gully and on the tributary gully) but two holes were excavated on the most downstream and wider cross section, TN09, on 5 and 8 November 1999. These holes correspond to the sites where Saynor et al (2002b) installed scour chains. Bulk samples were collected from each hole for subsequent textural description in the laboratory. The bed sediments were sampled to a maximum depth of 1.5 m. Sediments are described in Tables 22 to 28 inclusive and are less variable than at other sites. Surficial sediments are generally slightly granular medium sand or slightly granular coarse-medium sand. Subsurface sediments varied between slightly granular sands, granular sands and slightly pebbly sands. Sand fractions covered the Wentworth range from very fine to coarse sand. At depth, the sediments in all holes were slightly granular very fine-fine sand. The maximum gravel size measured was 18 mm but the mean maximum gravel size was 7 ± 0.5 mm (standard error of estimate). Saynor et al (2002b) found that the maximum average scour depth during the Wet season was only 81 mm between 1999 and 2001. Hence at best only the upper 0.08 m of bed sediments described in Tables 22 to 28 inclusive were mobile during a wet period when annual rainfall had average recurrence intervals between 1:21 and 1:71 years (Moliere et al 2002).

Selective armouring of the bed surface with 4 to 18 mm gravel is possible should bedload supply to the channel be reduced. However, this is unlikely while the gully head is actively migrating upstream (Saynor et al 2002a) and hence actively supplying sandy sediment to the lower gully.

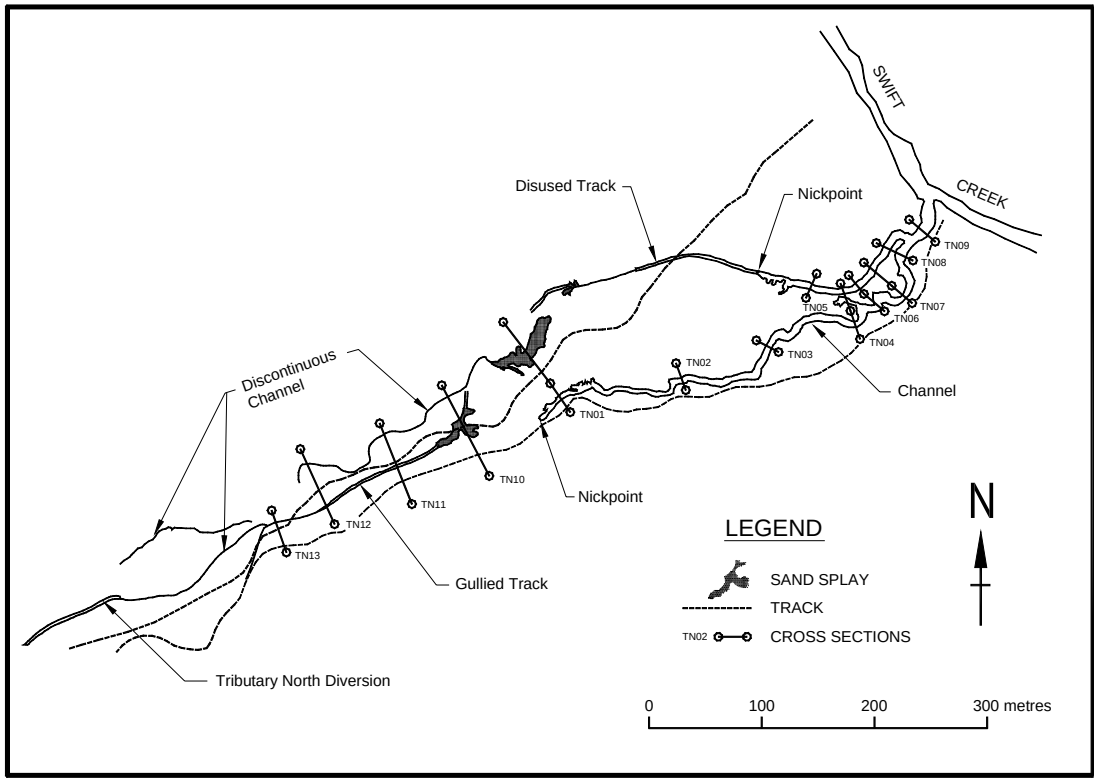

Figure 8 Location of the cross sections on Tributary North

Table 22 Tributary North bed material – Cross section TN 02 – scour chain site TN 02, located 0.5 m from right bank – date collected 8 November 1999.

Depth (m)	Sediment Characteristics
0-0.2	Brown (7.5YR 5/4*); slightly granular coarse-medium sand**; largest gravel clast (quartz) was 4 mm in diameter
0.2-0.4	Yellowish brown (10YR 5/4*); slightly granular medium sand**; largest gravel clast (sandstone) was 11 mm in diameter; contained mudballs up to 10 mm in diameter
0.4-0.6	Reddish yellow (7.5YR 6/6*); granular coarse-medium sand**; largest gravel clast (sandstone) was 18 mm in diameter
0.6-0.7	Yellow (10YR 7/6*); slightly granular medium sand**; largest gravel clasts (sandstone, quartz and ironstone) were 13 mm in diameter
0.7-1.0	Yellow (10YR 7/8*); slightly granular fine sand**; largest gravel clasts (sandstone and quartz) were 5 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 23 Tributary North bed material – Cross section TN04 – scour chain site TN04, located in middle of channel 0.6 m from left bank – date collected 8 November 1999.

Depth (m)	Sediment Characteristics
0-0.2	Brownish yellow (10YR 6/6*); clean, slightly granular coarse-medium sand**; largest gravel clasts (ironstone, sandstone and quartz) were 8 mm in diameter
0.2-0.4	Light brown (7.5YR 6/4*); slightly granular fine sand**; largest gravel clasts (ironstone, sandstone and quartz) were 9 mm in diameter
0.4-0.6	Light brown (7.5YR 6/4*); slightly granular medium-fine sand**; largest gravel clasts (ironstone, sandstone and quartz) were 4 mm in diameter
0.6-0.8	Light brown (7.5YR 6/4*); slightly granular fine sand**; largest gravel clasts (sandstone and quartz) were 5 mm in diameter
0.8-1.0	Very pale brown (10YR 7/4*); slightly granular fine sand**; largest gravel clast (quartz) was 4 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 24 Tributary North bed material – Cross section TN05 – scour chain site TN05, located in middle of creek – date collected 5 November 1999.

Depth (m)	Sediment Characteristics
0-0.2	Brown-dark brown (7.5YR 4/3*); slightly granular fine-medium sand**; largest gravel clasts (quartz and sandstone) were 10 mm in diameter; contained small amount of 1 mm diameter roots
0.2-0.4	Reddish yellow (7.5YR 6/6*); slightly granular fine sand**; largest gravel clasts (quartz and ironstone) were 10 mm in diameter
0.4-0.6	Brownish yellow (10YR 6/6*); slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 5 mm in diameter
0.6-0.8	Reddish yellow (7.5YR 7/8*); slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 4 mm in diameter
0.8-1.0	Reddish yellow (7.5 YR 7/6*); slightly granular fine sand**; largest gravel clast (quartz) was 4 mm in diameter
1.0-1.2	Pink (7.5YR 8/4*); slightly granular very fine-fine sand**; largest gravel clast (quartz) was 5 mm in diameter
1.2-1.4	Very pale brown (10YR 7/3*); slightly granular very fine-fine sand**; largest gravel clast (quartz) was 4 mm in diameter
1.4-1.5	Very pale brown (10YR 7/3*); slightly granular very fine-fine sand**; largest gravel clast (quartz) was 4.5 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 25 Tributary North bed material – Cross section TN07 – scour chain site TN07 – main channel, located in middle of channel 0.65 m from left bank – date collected 8 November 1999.

Depth (m)	Sediment Characteristics
0-0.2	Yellowish brown (10YR 5/4*); slightly granular medium-fine sand**; largest gravel clasts (ironstone and quartz) were 7 mm in diameter; contained several soft mudballs
0.2-0.4	Reddish yellow (7.5YR 6/6*); slightly granular fine sand**; largest gravel clasts (quartz and ironstone) were 5 mm in diameter
0.4-0.6	Reddish yellow (7.5YR 6/6*); slightly granular fine sand**; largest gravel clast (quartz) was 5 mm in diameter
0.6-0.8	Very pale brown (10YR 7/4*); slightly granular fine sand**; largest gravel clasts (ironstone and quartz) were 10 mm in diameter
0.8-1.0	Pinkish grey-pink (7.5YR 7/3*); slightly pebbly medium-fine sand**; largest gravel clasts (ironstone and quartz) were 12 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 26 Tributary North bed material – Cross section TN07 – scour chain site TN07 – tributary, located in middle of channel – date collected 5 November 1999.

Depth (m)	Sediment Characteristics
0-0.4	Strong brown (7.5YR 4/6*); well sorted, slightly granular medium sand**; largest gravel clasts (sandstone and quartz) were 8 mm in diameter, contained a small amount of charcoal
0.4-0.6	Reddish yellow (7.5YR 7/6*); slightly granular fine sand**; largest gravel clasts (sandstone and quartz) were 8 mm in diameter
0.6-0.8	Pink (7.5YR 7/4*); well sorted, slightly granular medium-fine sand**; largest gravel clast (sandstone) was 13 mm in diameter
0.8-1.0	Pink (7.5YR 7/4*); slightly granular fine sand**; largest gravel clast (quartz) was 4 mm in diameter
1.0-1.2	Pink (7.5YR 7/4*); slightly granular fine sand**; largest gravel clast (quartz) was 5 mm in diameter
1.2-1.4	Very pale brown (10YR 7/4*); slightly granular very fine-fine sand**; largest gravel clast (quartz) was 4 mm in diameter
1.4-1.5	Very pale brown (10YR 7/4*); slightly granular very fine-fine sand**; largest gravel clast (sandstone) was 8 mm in diameter

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 27 Tributary North bed material – Cross section TN09 – scour chain site TN09-1, located 0.91 m from left bank – date collected 5 November 1998.

Depth (m)	Sediment Characteristics
0-0.2	Yellowish brown (10YR 5/4*); slightly granular medium sand**; largest gravel clasts (sandstone, ironstone and quartz) were 10 mm in diameter
0.2-0.4	Reddish yellow (7.5YR 6/6*); slightly fine-medium sand**; largest gravel clasts (sandstone and quartz) were 7 mm in diameter
0.4-0.6	Brownish yellow (10YR 6/6*); slightly granular fine sand**; largest gravel clasts (sandstone and quartz) were 5 mm in diameter
0.6-0.8	Brownish yellow (10YR 6/6*); slightly granular fine sand**; largest gravel clasts (sandstone and quartz) were 7 mm in diameter
0.8-1.0	Reddish yellow (7.5YR 6/8*); slightly granular very fine-fine sand**; largest gravel clasts (sandstone and quartz) were 5 mm in diameter
1.0-1.1	Reddish yellow (7.5YR 7/8*); slightly pebbly very fine-fine sand**; largest gravel clast (quartz) was 6 mm in diameter; water table

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 28 Tributary North bed material – Cross section TN09 – scour chain site TN09-2, located 3 m from left bank – date collected 5 November 1998.

Depth (m)	Sediment Characteristics
0-0.2	Yellowish brown (10YR 5/4*); slightly granular medium sand**; largest gravel clast (quartz) was 9 mm in diameter
0.2-0.4	Yellowish brown (10YR 5/4*); slightly pebbly fine sand**; largest gravel clast (quartz) was 8 mm in diameter; contained a brownish yellow (10YR 6/8) clay ball 26 mm in diameter
0.4-0.6	Very pale brown (10YR 7/4*); slightly granular medium-fine sand**; largest gravel clast (quartz) was 4 mm in diameter
0.6-0.8	Brownish yellow (10YR 6/6*); slightly granular medium-fine sand**; largest gravel clast (quartz) was 7 mm in diameter
0.8-1.0	Brownish yellow (10YR 6/6*); slightly granular fine sand**; largest gravel clast (quartz) was 5 mm in diameter
1.0-1.1	Yellow (10YR 7/6*); slightly granular very fine-fine sand**; largest gravel clast (quartz) was 4 mm in diameter; water table

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Tributary Central

The location of the cross sections referred to in the following tables is shown in figure 9. A single hole was excavated in the centre of the channel bed on cross sections TC09, TC11 and TC 03 on 2 and 3 December 1998 because of the narrow bed width. These holes correspond to the sites where Saynor et al (2002b) installed scour chains. Bulk samples were collected from each hole for subsequent textural description in the laboratory. The bed sediments were sampled to a maximum depth of 2.8 m. Weathered sandstone bedrock (mottled sandy clay) was reached at the bottom of two of the three holes. The water table was relatively deep and was reached in only one hole at 2.4–2.6 m at TC03. Sediments are described in Tables 29 to 31 inclusive and are variable ranging from slightly granular fine sand to medium sand/muddy medium sand to pebbly coarse sand to coarse sandy pebble gravel. The maximum gravel size measured was 35 mm but the mean maximum gravel size was 11 ± 2 mm (standard error of estimate). Saynor et al (2002b) found that the maximum average scour depth during the Wet season was 249 mm between 1998 and 2001. Hence at best only the upper 0.25 m of bed sediments described in Tables 29 to 31 inclusive was mobile during a wet period when annual rainfall had average recurrence intervals between 1:13 and 1:71 years (Moliere et al 2002).

Table 29 Tributary Central bed material – Cross section TC 09 – scour chain site TC 09, located in middle of creek – date collected 2 December 1998.

Depth (m)	Sediment Characteristics
0–0.2	Brown (10YR 5/3*); pebbly coarse sand**; contained mudballs
0.2-0.3	Brown (10YR 5/3*); pebbly coarse sand**; contained rare mudballs
0.3-0.4	Dark greyish brown (10YR 4/2*); slightly pebbly medium sand**; contained small pieces of charcoal and rare mudballs
0.4-0.5	Brownish yellow (10YR 6/6*); poorly sorted, slightly pebbly medium sand**; slightly cemented
0.5-0.7	Very pale brown (10YR 7/4*); medium sand**; weakly cemented;
0.7-1.0	Very pale brown (10YR 7/4*); medium sand**; weakly cemented
1.0-1.1	Very pale brown (10YR 7/4*); medium sand**
1.1-1.3	Very pale brown (10YR 7/3*); medium sand**
1.3-1.5	Very pale brown (10YR 7/4*); muddy medium sand**
1.5-1.6	White (10YR 8/2*); muddy medium sand**
1.6-1.8	Light grey (10YR 7/2*); muddy medium sand**; contains rare gravel
1.8-1.9	Mottled 50 % white (10YR 8/2*) and 50 % red (2.5YR 4/8*); pebbly muddy coarse sand**

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

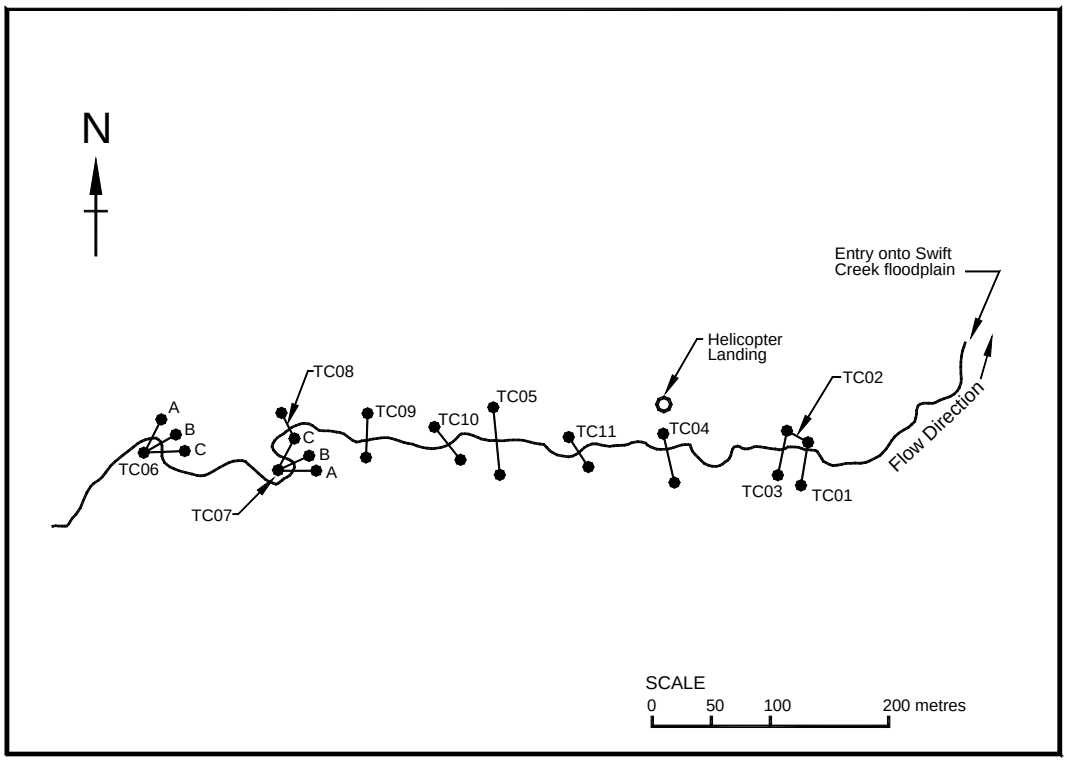

Figure 9 Location of cross sections on Tributary Central

Selective armouring of the bed surface with 4 to 35 mm gravel is possible should bedload supply to the channel be reduced. Localised gravel armoured scour holes currently form next to debris dams or tree trunks in the channel or immediately downstream of bedrock bars. Gravel armoured riffles are also present, especially upstream of cross section TC04, but were not sampled as part of the present work.

Table 30 Tributary Central bed material – Cross section TC 11 – scour chain site TC 11, located in middle of creek 1.95 m from left bank– date collected 3 December 1998.

Depth (m)	Sediment Characteristics
0–0.1	Pinkish grey (7.5YR 7/2*); coarse sandy pebble gravel**; largest gravel clast (sandstone) was 35 mm in diameter
0.1–0.2	Light brownish grey (10YR 6/3*); coarse-medium sandy pebble gravel**; largest gravel clast (sandstone/ironstone) was 22 mm in diameter
0.2–0.5	Very pale brown (10YR 7/3*); granular fine sand**; largest gravel clast (sandstone) was 13 mm in diameter
0.5–0.7	Pinkish grey-pink (7.5YR 7/3*); slightly granular fine sand**; largest gravel clasts (quartz and sandstone) were 9 mm in diameter
0.7–0.9	Mottled 95 % very pale brown (10YR 7/3*) and 5 % red (10R 4/8*); slightly granular fine-very fine sand**; largest gravel clast (quartz) was 3 mm in diameter
0.9–1.1	Mottled 90 % pink (7.5YR 7/4*) and 10 % dark red (10R 2.5/6*); slightly granular fine sand**; largest gravel clast (quartz) was 4.5 mm in diameter
1.1–1.3	Mottled 90 % pinkish grey-pink (7.5YR 7/3*) and 10 % red (10R 4/6*); slightly granular fine sand**; largest gravel clast (quartz) was 9 mm in diameter
1.3–1.5	Mottled red (10R 4/6*), white (10YR 8/1*) and reddish yellow (7.5YR 7/8*); sandy clay** with sandstone and quartz pebbles; weathered sandstone bedrock
1.5–1.6	Essentially the same as above; weathered sandstone bedrock

* Munsell Soil Colour of moist sample; ** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 31 Tributary Central bed material – Cross section TC 03 – scour chain site TC 03, located in middle of creek 1.75 m from left bank– date collected 3 December 1998.

Depth (m)	Sediment Characteristics
0–0.2	Yellowish brown (10YR 5/4*); well sorted, pebbly coarse sand**; largest gravel clast (sandstone) was 14 mm in diameter
0.2–0.35	Dark greyish brown (10YR 4/2*); granular coarse sand**; largest gravel clast (sandstone) was 16 mm in diameter; contained about 2.5 %, very dark grey (10YR 3/1*) mudballs up to 14 mm in diameter
0.35–0.4	Very dark grey (10YR 3/1*); slightly granular medium sand**; largest gravel clast (sandstone) was 13 mm in diameter
0.4–0.5	Greyish brown (10YR 5/2*); well sorted, slightly granular fine-medium sand**; largest gravel clasts (quartz and sandstone) were 10 mm in diameter
0.5–0.8	Light brownish grey (10YR 6/2*); slightly granular medium sand**; largest gravel clasts (quartz and sandstone) were 7 mm in diameter; contained very fine root material 0.5 mm in diameter
0.8–1.0	Pale brown (10YR 6/3*); slightly granular medium sand**; largest gravel clasts (quartz and sandstone) were 9 mm in diameter; contained very fine root material 0.5 mm in diameter
1.0–1.25	Very pale brown (10YR 7/3*); clean, well sorted, pebbly medium sand**; largest gravel clasts (quartz, sandstone and ironstone) were 16 mm in diameter
1.25–1.4	Reddish yellow (7.5YR 6/6*); clean, slightly granular fine sand**; largest gravel clasts (quartz, sandstone and ironstone) were 9 mm in diameter
1.4–1.7	Yellow (10YR 7/6*); well sorted, slightly granular very fine-fine sand**; largest gravel clast (quartz) was 3 mm in diameter
1.7–2.0	Very pale brown (10YR 7/4*); slightly granular fine sand**; largest gravel clast (quartz) was 3 mm in diameter
2.0–2.2	Very pale brown (10YR 8/3*); slightly granular fine sand**; largest gravel clast (quartz) was 4 mm in diameter
2.2–2.4	Very pale brown (10YR 7/4*); slightly pebbly very fine-fine sand**; largest gravel clasts (quartz and sandstone) were 15 mm in diameter
2.4–2.6	Mottled 75 % light grey (10YR 7/2*), 15 % brownish yellow (10YR 6/8*) and 10 % yellowish red (5YR 5/6*); slightly granular fine sand**; largest gravel clast (quartz) was 4 mm in diameter; water table
2.6–2.8	Mottled 50 % white (10YR 8/1*) and 50 % weak red-red (5YR 5/5*); sandy clay** with sandstone and quartz granules; probably weathered sandstone bedrock

* Munsell Soil Colour of moist sample

** Folk (1954, 1974) textural class (see figures 2 and 3)

Floodplain sediments

Swift Creek

To date, only one auger hole has been described on the left bank floodplain at the ***eriss***'s gauging station (table 32). This hole was augered during the late Dry season and extended to about 1.0 m below bed level in the adjacent channel (maximum depth of 2.8 m) and about 0.6-0.7 m below the water table. The sand fraction fines upward from medium to coarse at the base to very fine to fine at the surface (table 32). Vertical overbank accretion (Nanson & Croke 1992) produced the fining upwards sequence because the channel is currently laterally stable and flanked by large *Melaleuca* sp. and *Syzygium forte* sp. *potamophilum*. The age of the floodplain is currently unknown but is thought to be young (<3000 y) due to the lack of soil development (table 32).

Table 32 Swift Creek floodplain – Cross section SM01 – auger hole on left bank floodplain 4 m towards the channel from the left bank plinth – described on 26 September 1998.

Depth (m)	Sediment Characteristics
0–0.30	Dark grey (10YR 4/1*); water repellent, loamy very fine-fine sand**; muddy very fine-fine sand***; contained abundant roots
0.30–0.80	Very dark grey (10YR 3/1*); fine sandy loam** which exhibited slight fining upwards; rare sand interbeds; muddy fine sand***; contained some roots
0.80–1.20	Dark grey (10YR 4/1*); loamy very fine-fine sand**; muddy very fine-fine sand***; contained a few roots
1.20–1.40	Dark grey (10YR 4/1*); loamy fine sand**; muddy fine sand***; contained a single (12 mm diameter) root
1.40–1.80	Dark grey (10YR 4/1*); loamy fine-medium sand**; muddy fine-medium sand*** contained a few roots
1.80–2.05	Dark greyish brown (10YR 4/2*); changing to very dark greyish brown (10YR 3/2*) at depth; loamy medium-coarse sand**; muddy medium-coarse sand***; contained a few roots up to 2 mm in diameter and small amounts of charcoal
2.05–2.55	Interbedded pale brown (10 YR 6/3*), coarse-very coarse sand** and very dark grey (10YR 3/1*), loamy fine-medium sand**; coarse-very coarse sand*** and muddy fine-medium sand***; water table between 2.1 and 2.2 m
2.55–2.80+	Mottled 70% pale brown (10YR 6/3*) and 30% olive yellow (2.5Y 6/6*); clayey medium-coarse sand**; clayey medium-coarse sand***; poor recovery due to saturated sediments

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Upper Swift Creek

Five auger holes were described on cross section UM07, two on the left bank floodplain and three on the right bank (tables 33 to 37 inclusive) (fig 10). The sediments on the left bank exhibit both a lateral and upwards fining which is indicative of a laterally stable channel. No recovery of floodplain sediments on the left bank was obtained from below the water table. The right bank sediments fine upwards but deepen towards the channel. The thickness of the floodplain sediments on the right bank floodplain is constrained by shallow ironstone/sandstone bedrock which forms a sloping shelf dipping towards the channel. Such shallow bedrock inhibits lateral migration to the right bank. However, the dense but linear strip of riparian vegetation (Erskine et al's (2001) forested meandering reach) also restricts lateral migration because of the supply of energy dissipating large woody debris to the channel and because the river banks are usually protected from fluvial erosion by tree trunks, roots and root mats (Erskine et al 2003). The lack of soil development in the floodplain sediments suggests a very recent origin.

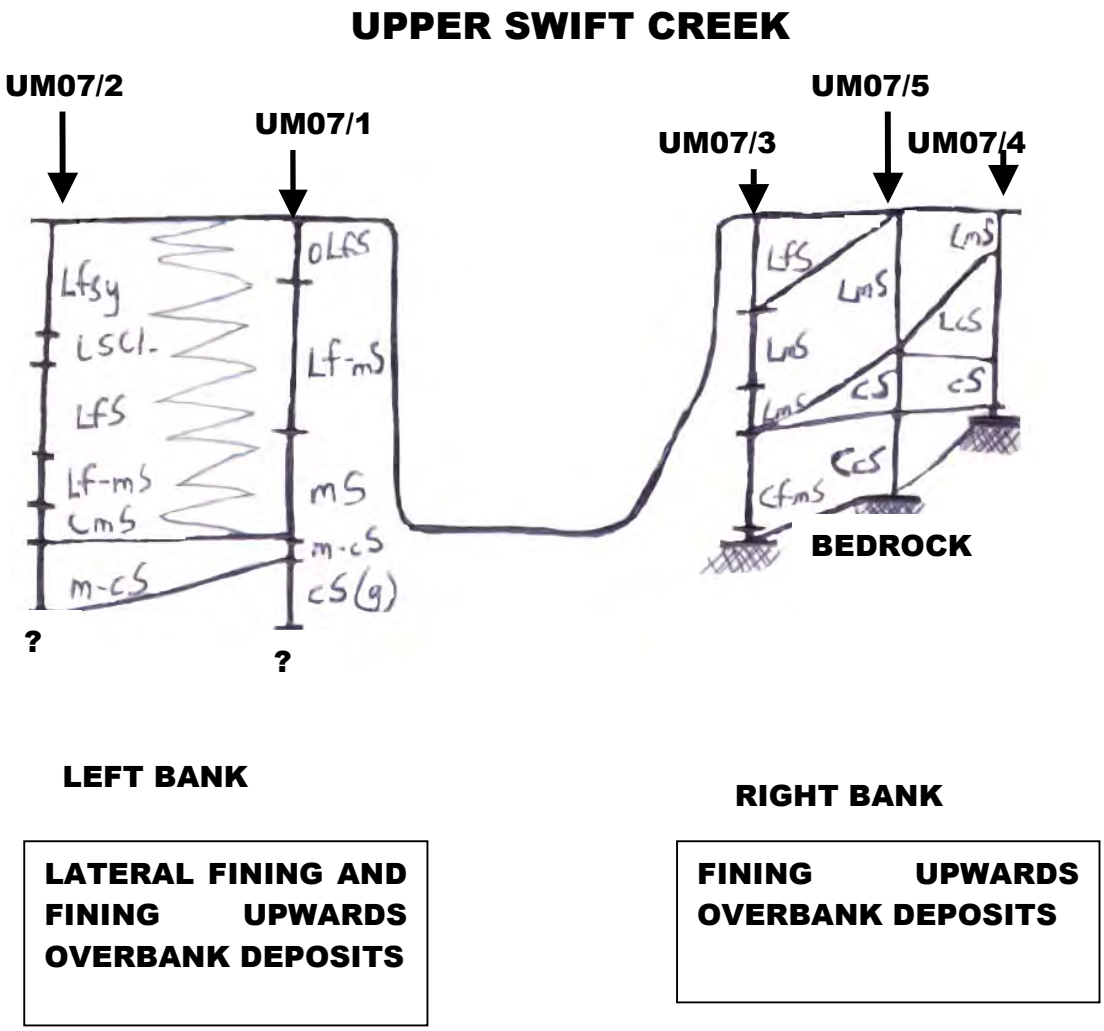

Figure 10 Generalised floodplain sediments at cross section UM07. Detailed sediment descriptions are contained in Tables 33 to 37 inclusive. Sediment textures are: Lfsy loam fine sandy; lSCL light sandy clay loam; LfS loamy fine sand; Lf-mS loamy fine-medium sand; CmS clayey medium sand; m-cS medium-coarse sand; oLfS organic loamy fine sand; mS medium sand; cS(g) slightly gravelly coarse sand; LmS loamy medium sand; Cf-mS clayey fine-medium sand; CcS clayey coarse sand; LcS loamy coarse sand. See Northcote (1984) and McDonald & Isbell (1990) for further details of textural groups. Source: Wayne Erskine's Field Notes No. 89, 2002-2003, page 22.

Table 33 Upper Swift Creek floodplain – Cross section UM 07 – auger hole UM 07/1 on left bank floodplain 3 m towards channel from left bank plinth – described on 19 May 2002.

Depth (m)	Sediment Characteristics
0–0.125	Very dark grey (10YR 3/1*); slightly hydrophobic; organic loamy fine-medium sand**; muddy fine-medium sand***
0.125–0.33	Very dark greyish brown (10YR 3/2*); slightly hydrophobic; organic loamy fine sand**; muddy fine sand***
0.33–0.455	Dark brown (10YR 3/3*); organic loamy fine sand**; muddy fine sand***
0.455–0.61	Dark brown (10YR 3/3*); organic loamy fine sand**; muddy fine sand***
0.61–0.79	Bark brown (10YR 3/3*); organic loamy fine sand**; muddy fine sand***; contained very fine specs of charcoal
0.79–0.97	Dark grey (10YR 4/1*); loamy fine-medium sand**; muddy fine-medium sand***
0.97–1.14	Dark grey (10YR 4/1*); loamy medium sand with occasional coarse sand**; muddy medium sand with occasional coarse sand***
1.14–1.30	Dark grey (10YR 4/1*); loamy medium sand**; muddy medium sand*** contained flakes of charcoal
1.30–1.52	Dark greyish brown (10YR 4/2*); medium sand**; medium sand***
1.52–1.67	Brown (10YR 5/3*); medium sand with occasional quartz very coarse sand**; medium sand with occasional quartz very coarse sand***; contained some charcoal
1.67–1.885	Light grey (10YR 7/2*); medium sand with some coarse sand**; medium sand with some coarse sand***
1.885–2.02	Greyish brown (10YR 5/2*); medium sand**; medium sand***
2.02–2.07	Light brownish grey (10YR 6/2*); medium sand**; medium sand***; contained some small pieces of charcoal
2.07–2.15	Light grey (10YR 7/2*); medium-coarse sand**; medium-coarse sand***
2.15–2.50	Light grey (10YR 7/2*); slightly pebbly medium-coarse sand***
2.50–2.55+	Greyish brown (10YR 5/2*); coarse sand**; coarse sand***; saturated with no recovery below 2.55 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 34 Upper Swift Creek floodplain – Cross section UM 07 – auger hole UM 07/2 on left bank floodplain 27 m away from left bank plinth – described on 19 May 2002.

Depth (m)	Sediment Characteristics
0–0.50	Very dark grey (10YR 3/1*); loam fine sandy**; muddy fine-very fine sand***
0.5–0.72	Very dark greyish brown (10YR 3/2*); loam fine sandy**; muddy fine-very fine sand***
0.72–0.96	Dark brown (7.5YR 3/2*); light sandy clay loam**; muddy fine sand***
0.96–1.235	Brown to dark brown (7.5YR 4/4*); loamy fine sand**; muddy fine sand***
1.235–1.53	Brown (7.5YR 5/2*); loamy fine sand**; muddy fine sand***
1.53–1.84	Pale brown (10YR 6/3*); loamy fine-medium sand**; muddy fine-medium sand***
1.84–2.06	Mottled 60% pinkish grey (7.5YR 7/2*), 35% reddish yellow (7.5YR 6/6*) and 5% yellowish red (5YR 5/6*); clayey medium sand**; clayey medium sand***; contained some ferruginous nodules
2.06–2.47+	Mottled 70% light yellowish brown (10YR 6/4*) and 30% brownish yellow (10YR 6/6*); medium-coarse sand**; medium-coarse sand***; saturated with no recovery below 2.47 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 35 Upper Swift Creek floodplain – Cross section UM 07 – auger hole UM 07/3 on right bank floodplain 9 m towards the channel from right bank plinth – described on 19 May 2002.

Depth (m)	Sediment Characteristics
0–0.22	Very dark greyish brown (10YR 3/2*); organic loamy medium sand**; muddy medium sand***
0.22–0.43	Brown to dark brown (7.5YR 4/4*); loamy medium sand**; muddy medium sand***
0.43–0.61	Brown to dark brown (7.5YR 4/3*); loamy medium sand**; muddy medium sand***
0.61–0.85	Brown (7.5YR 5/4*); loamy medium sand**; muddy medium sand***
0.85–1.06	Yellowish brown (10YR 5/4*); loamy medium sand**; muddy medium sand***
1.06–1.39	Pale brown (10YR 6/3*); loamy medium sand**; muddy medium sand***
1.36–1.68	Mottled 90% very pale brown (10YR 7/4*) and 10% yellowish red (5YR 5/8*); clayey medium-coarse sand**; clayey medium-coarse sand***; contained haematitic nodules
1.68–1.94	Mottled 55% very pale yellow (10YR 7/4*), 35% reddish yellow (7.5YR 6/6*) and 10% red (2.5YR 4/8*); clayey medium-coarse sand**; clayed medium-coarse sand***; contained haematitic nodules
1.94–2.00	Mottled 90% yellowish light brown (10YR 6/4*) and 10% yellow (10YR 7/6*); gravelly light sandy clay loam**; pebbly clayey coarse sand***
2.00+	Sandstone bedrock – refusal

* Munsell Soil Colour of moist sample; ** Northcote (1984) textural class (see figure 4); *** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 36 Upper Swift Creek floodplain – Cross section UM 07 – auger hole UM 07/4 on right bank floodplain 16 m past right bank plinth across the floodplain – described on 19 May 2002.

Depth (m)	Sediment Characteristics
0–0.21	Very dark greyish brown (10YR 3/2*); loamy medium sand with some coarse and very coarse sand**; muddy medium sand with some coarse and very coarse sand***
0.21–0.42	Brown to dark brown (10YR 4/3*); loamy coarse sand with some very coarse sand**; muddy coarse sand with some very coarse sand***
0.42–0.61	Brown (10YR 5/3*); loamy coarse sand with some very coarse sand**; muddy coarse sand with some very coarse sand***
0.61–0.80	Light yellowish brown (10YR 6/4*); loamy coarse sand**' muddy coarse sand***
0.80–1.19	Very pale brown (10YR 7/3–7/4*); coarse sand with some very coarse sand**; coarse sand with some very coarse sand***
1.19–1.24	Disaggregated sandstone bedrock
1.24+	Sandstone bedrock – refusal

* Munsell Soil Colour of moist sample; ** Northcote (1984) textural class (see figure 4); *** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 37 Upper Swift Creek floodplain – Cross section UM 07 – auger hole UM 07/5 on right bank floodplain 7.4 m past right bank plinth across the floodplain – described on 19 May 2002.

Depth (m)	Sediment Characteristics
0–0.20	Dark brown (10YR 3/3*); loamy medium to coarse sand**; muddy medium to coarse sand***
0.20–0.39	Brown to dark brown (10YR 4/3*); loamy medium to coarse sand with some very coarse sand**; muddy medium to coarse sand with some very coarse sand***
0.39–0.58	Dark yellowish brown (10YR 4/4*); loamy medium to coarse sand with some very coarse sand**; muddy medium to coarse sand with some very coarse sand***
0.58–0.86	Yellowish brown (10YR 5/4*); loamy medium to coarse sand with some very coarse sand**' muddy medium to coarse sand with some very coarse sand***
0.86–1.47	Light grey (10YR 7/2*); medium to coarse sand with some very coarse sand**; medium to coarse sand with some very coarse sand***
1.47–1.75	Brownish yellow (10YR 6/8*); clayey coarse sand**; slightly granular muddy coarse sand***; contained haematitic nodules
1.75–1.83	Disaggregated sandstone bedrock
1.83+	Sandstone bedrock – refusal

* Munsell Soil Colour of moist sample; ** Northcote (1984) textural class (see figure 4); *** Folk (1954, 1974) textural class (see figures 2 and 3)

East Tributary

Six auger holes were described on cross section ET01 (fig 7), three on the floodplain on each side of the channel (tables 38 to 43 inclusive). The left bank floodplain (tables 38 to 40 inclusive) consists of a fining upwards sequence from a basal medium to coarse sand to an intermediate loamy sand to a surficial fine sandy loam/loam fine sandy (fig 11). No recovery of floodplain sediment was obtained below the water table which varied in depth between 2.55 and 2.66 m. The right bank floodplain exhibits more uniform sediments, except for an intermediate fine textured layer (sandy loam/loam fine sandy) in holes ET01/1 and 2 (tables 41 and 43) (fig 11). Again no recovery was obtained below the water table which varied in depth between 1.92 and 2.26 m. Fining upwards sequences can be formed by laterally stable channels (Nanson 1986) as well as by laterally migrating streams (Wolman & Leopold 1957; Leopold & Wolman 1960; Allen 1965). In the present case, the dense riparian vegetation (forested meandering reach of Erskine et al (2001)) and high loading of large woody debris indicate that the channel is currently laterally stable (Erskine et al 2003). This is also supported by a well developed natural levee on the left bank. The lack of soil development on the floodplain suggests a very recent origin.

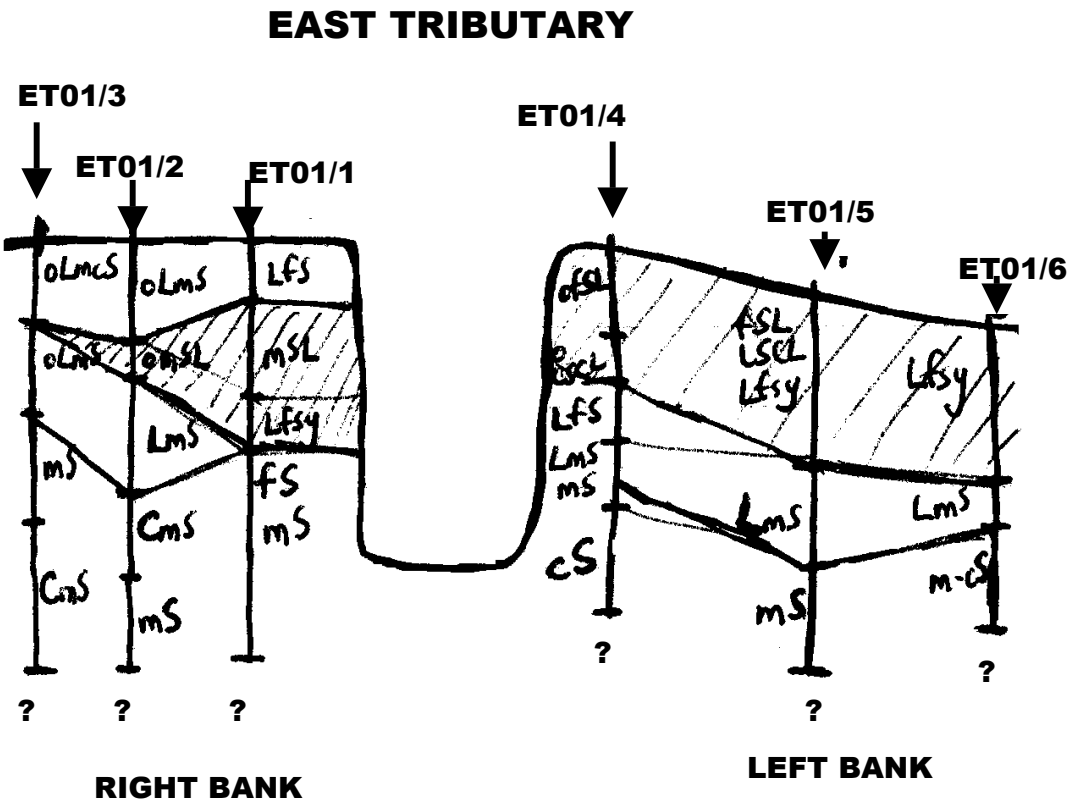

Figure 11 Generalised floodplain sediments at cross section ET01. Detailed sediment descriptions are contained in Tables 38 to 43 inclusive. Sediment textures are: oLmcS organic loamy medium-coarse sand; oLmS organic loamy medium sand; mS medium sand; CmS clayey medium sand; omSL organic medium sandy loam; LmS loamy medium sand; LfS loamy fine sand; mSL medium sandy loam; Lfsy loam fine sandy; fs fine sand; ofSL organic fine sandy loam; olSCL organic light sandy clay loam; LfS loamy fine sand; cS coarse sand; fSL fine sandy loam; lSCL light sandy clay loam; m-cS medium-coarse sand. See Northcote (1984) and McDonald & Isbell (1990) for further details of textural groups. Source: Wayne Erskine's Field Notes No. 89, 2002-2003, page 63.

Table 38 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/1 on right bank floodplain 3.2 m towards channel from right bank plinth – described on 21 May 2002.

Depth (m)	Sediment Characteristics
0–0.30	Very dark greyish brown (10YR 3/2*); organic loamy fine sand**; muddy fine sand***
0.30–0.53	Dark brown (10YR 3/3*); medium sandy loam**; muddy medium sand***; contained charcoal
0.53–0.95	Very dark greyish brown (10YR 3/2*); medium sandy loam**; muddy medium sand***
0.95–1.27	Very dark greyish brown (10YR 3/2*); loam fine sandy**; muddy fine sand***
1.27–1.43	Greyish brown (10YR 5/2*); fine sand**; fine sand***
1.43–1.59	Brown (10YR 5/3*); fine sand**; fine sand***
1.59–1.89	Pale brown (10YR 6/3*); fine sand**; fine sand***
1.89–1.97	Light grey (10YR 7/2*); medium sand**; medium sand***
1.97–2.55	Pale brown (10YR 6/3*); medium sand**; medium sand***; saturated with no recovery below 2.55 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 39 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/2 on right bank floodplain 1.65 m towards channel from right bank plinth – described on 22 May 2002.

Depth (m)	Sediment Characteristics
0–0.20	Black (10YR 2/1*); hydrophobic, organic loamy medium to coarse sand with some very coarse sand and gravel**; muddy medium to coarse sand with some very coarse sand and rare granules***; contained a lot of particulate organic matter
0.20–0.37	Very dark greyish brown (10YR 3/2*); organic loamy medium to coarse sand**; muddy medium to coarse sand***
0.37–0.60	Very dark grey (10YR 3/1*); organic loamy medium to coarse sand**; granular muddy medium to coarse sand***
0.60–0.80	Very dark greyish brown (10YR 3/2*); organic medium to coarse sandy loam**; slightly granular muddy medium to coarse sand***
0.80–1.02	Very dark greyish brown (10YR 3/2*); organic loamy medium to coarse sand**; muddy medium to coarse sand***
1.02–1.26	Brown (10YR 5/3*); loamy medium sand**; muddy medium sand with some coarse and very coarse sand***
1.26–1.51	Brown (10YR 5/3*); loamy medium sand**; muddy medium sand with some coarse sand***
1.51–1.77	Yellowish brown (10YR 5/4*); clayey medium sand**; clayey medium sand***
1.77–2.02	Brownish yellow (10YR 6/7*); clayey medium sand**; clayey medium sand***
2.02–2.16	Light yellowish brown (10YR 6/4*); medium sand**; medium sand***
2.16–2.45	Light grey (10YR 7/1*); clayey medium sand with some coarse and very coarse sand**; medium sand with some coarse and very coarse sand***
2.45–2.57	Light grey (10YR 7/2*); clayey medium sand with some coarse and very coarse sand**; medium sand with some coarse and very coarse sand***
2.57–2.66	Light grey (10YR 7/2*); clayey medium sand with some coarse and very coarse sand**; medium sand with some coarse and very coarse sand***; saturated with no recovery below 2.66 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 40 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/3 on right bank floodplain 1.4 m across floodplain beyond right bank plinth – described on 24 May 2002.

Depth (m)	Sediment Characteristics
0–0.38	Very dark greyish brown (10YR 3/2*); slightly hydrophobic, organic loamy medium to coarse sand with some very coarse sand**; muddy medium to coarse sand with some very coarse sand***
0.38–0.47	Very dark grey (10YR 3/1*); organic loamy medium to coarse sand with some very coarse sand**; muddy medium to coarse sand with some very coarse sand***
0.47–0.54	Very dark grey (10YR 3/1*); organic loamy medium sand with coarse sand**; muddy medium sand with coarse sand***
0.54–0.67	Black (10YR 2/1*); organic loamy medium sand**; muddy medium sand***
0.67–0.81	Very dark grey (10YR 3/1*); organic loamy medium sand**; muddy medium sand***
0.81–1.00	Dark greyish brown (10YR 4/2*); loamy medium sand**; muddy medium sand with some coarse sand***
1.00–1.18	Brown (10YR 5/3*); medium sand**; poorly sorted, slightly granular medium to coarse sand***
1.18–1.49	Brown (10YR 5/3*); medium sand**; medium sand with some coarse sand***
1.49–1.72	Pale brown (10YR 6/3*); medium sand**; medium sand with some coarse sand***
1.72–1.98	Mottled 90% brownish yellow (10YR 6/6*) and 10% yellowish red (5YR 5/8*); medium sand**; medium sand with some coarse sand***
1.98–2.22	Mottled 60% light grey (10YR 7/1*) and 40% very pale brown (10YR 7/4*); clayey medium sand with some coarse sand**; medium sand with some coarse sand***
2.22–2.48	Mottled 80% very pale brown (10YR 7/4*) and 20% light yellowish brown (10YR 6/4*); clayey medium to coarse sand**; medium to coarse sand with some very coarse sand***
2.48–2.64	Light grey (10YR 7/2*); clayey medium sand with some coarse sand**; medium to coarse sand with some very coarse sand***; saturated with no recovery below 2.64 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 41 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/4 on left bank floodplain 1.4 m towards channel from left bank plinth – described on 24 May 2002.

Depth (m)	Sediment Characteristics
0–0.31	Dark brown (10YR 3/3*); slightly hydrophobic, organic fine sandy loam**; muddy fine sand***
0.31–0.56	Very dark greyish brown (10YR 3/2*); fine sandy loam**; muddy fine sand***
0.56–0.75	Black (10YR 2/1*); organic light sandy clay loam**; muddy fine sand***
0.75–0.97	Black (10YR 2/1*); organic loamy fine to medium sand**; muddy fine to medium sand***
0.97–1.24	Very dark greyish brown (10YR 4/2*); loamy fine sand**; muddy fine sand***
1.24–1.36	Dark greyish brown (10YR 4/2*); loamy medium sand**; muddy medium sand***
1.36–1.56	Brown (10YR 5/3*); medium sand**; medium sand***
1.56–1.64	Dark greyish brown (10YR 4/2*); coarse sand**; slightly pebbly coarse sand***
1.64–1.79	Greyish brown (10YR 5/2*); coarse sand**; slightly pebbly coarse sand***
1.79–2.26	Greyish brown (10YR 5/2*); coarse sand**; coarse sand with some very coarse sand***; saturated with no recovery below 2.26 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 42 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/5 on left bank floodplain 16.2 m past left bank plinth – described on 24 May 2002.

Depth (m)	Sediment Characteristics
0–0.25	Dark brown (10YR 3/3*); slightly hydrophobic, organic fine to medium sandy loam**; muddy fine to medium sand***
0.25–0.50	Very dark grey (10YR 3/1*); organic light sandy clay loam**; muddy fine sand***
0.50–0.79	Black (10YR 2/1*); organic loam fine sandy**; muddy fine sand***; probable buried soil or fine grained slackwater deposit
0.79–1.09	Dark greyish brown (10YR 4/2*); loamy medium sand**; muddy medium sand***
1.09–1.25	Brown (10YR 5/3*); loamy medium sand**; muddy medium sand with some coarse sand***
1.25–1.42	Mottled 70% light yellowish brown (10YR 6/4*) and 30% brownish yellow (10YR 6/6*); medium sand**; medium sand with some coarse sand***
1.42–1.68	Mottled 60% yellowish red (5YR 4/6*) and 40% brown (10YR 5/3*); medium sand**; medium sand***
1.68–1.87	Mottled 50% brown (10YR 5/3*) and 50% yellowish brown (10YR 5/6*); medium sand**; medium sand***
1.87–2.24	Dark greyish brown (10YR 4/2*); medium sand**; medium sand***; water table at 2.24 m
2.24–2.37+	Saturated sand with poor recovery

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Table 43 East Tributary floodplain – Cross section ET 01 – auger hole ET 01/6 on left bank floodplain 33.1 m past left bank plinth – described on 24 May 2002.

Depth (m)	Sediment Characteristics
0–0.40	Very dark grey (10YR 3/1*); slightly hydrophobic, organic loam fine sandy**; muddy fine sand***
0.40–0.77	Very dark grey (10YR 3/1*); organic loam fine sandy**; muddy very fine sand***; contained charcoal
0.77–0.99	Very dark grey (10YR 3/1*); organic loam fine sandy**; muddy very fine sand***; very moist and a probable aquaclude
0.99–1.26	Dark greyish brown (10YR 4/2*); loamy medium sand**; muddy medium sand***
1.26–1.46	Yellowish brown (10YR 5/4*); medium to coarse sand**; medium to coarse sand***
1.46–1.59	Yellowish brown (10YR 5/4*); medium sand**; medium sand with some coarse sand***
1.59–1.92	Yellowish brown (10YR 5/4*); coarse sand**; poorly sorted, slightly pebbly coarse sand***; saturated sand with no recovery below 1.92 m

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

Tributary North

To date only one sediment/soil description has been completed on Tributary North at cross section TN01 (table 44). The soil is an arenic rudosol (Isbell 1996) which is characterised by a uniform coarse textured profile and by minimal development of a weakly coherent, sandy A_1 horizon over more than 1 m of sandy regolith. Roots are common in the A_1 horizon but not at depth. Pedotubules and mesofaunal activity were also concentrated in the A_1 horizon. Examination of multiple bank exposures along the gullied reach of Erskine et al (2001) on lower Tributary North revealed a similar sedimentary and soil sequence to that described in Table 44. As the channel is either ill-defined or channelised upstream of the gully (Erskine et al 2001), there are few exposures of the sedimentary sequence upstream of cross section TN01.

Table 44 Tributary North – Cross section TN01 – bank exposure – described by on 24 September 1999. Soil is an arenic rudosol according to the Isbell (1996) classification scheme.

Depth (m)	Sediment Characteristics
0-0.2	Dark grey (10YR 4/1*); loamy medium sand**; slightly granular medium sand***; apedal massive; dry, force II, brittle****; contained abundant roots between 0.5 and 10 mm in diameter; diffuse, horizontal lower boundary to:
0.2-0.35	Brown (10YR 5/3*); loamy medium sand; slightly granular medium sand; apedal massive; porous with voids up to 1 mm in diameter; dry, force I, brittle; contained less abundant roots (between 0.2 and 2 mm in diameter) than above layer; wormy fabric; contained 3 mm diameter pedotubules; 50 mm thick wavy lower boundary to:
0.35-0.69	Yellowish brown (10YR 5/6*); loamy medium sand; slightly granular medium sand; apedal massive; porous with voids up to 1 mm in diameter; dry, force II, brittle; contained less abundant roots (between 0.2 and 2 mm in diameter) than above layer; contained infilled mesofaunal channels-infill comprised above two layers; 10 mm thick horizontal lower boundary to:
0.69-0.9+	Brownish yellow (10YR 6/6*); medium sandy loam; slightly granular muddy medium sand; apedal massive; moderately moist, force I, brittle

* Munsell Soil Colour of moist sample

** Northcote (1984) textural class (see figure 4)

*** Folk (1954, 1974) textural class (see figures 2 and 3)

**** Butler (1955) method of consistence description

Conclusions

This report is a permanent record of the shallow stratigraphic data on the fluviatile sediments associated with the channels and floodplains in the Ngarradj (Swift) Creek catchment obtained by the authors as part of the work reported by Saynor et al (2001; 2002a; 2002b; 2003) and Erskine et al (2001; 2003). The bed sediments at ***eriss***'s Swift Creek gauging station were sampled to a maximum depth of 1 m at three cross sections. Most of the bed sediment is slightly granular medium sand. The maximum gravel size measured was 36 mm but the mean maximum gravel size was 7 ± 0.7 mm (standard error of estimate). The bed sediments at ***eriss***'s upper Swift Creek gauging station were sampled to a maximum depth of 1.4 m at three cross sections. Bedrock or weathered bedrock was encountered between 0.35 and 1.4 m below the river bed in every hole. Sediments were texturally variable ranging from medium and coarse sand to medium sandy pebble gravel. The maximum gravel size measured was 32 mm but the mean maximum gravel size was 16 ± 3 mm. The bed sediments at ***eriss***'s East Tributary gauging station were sampled to a maximum depth of 2.8 m at four cross sections. Sediments were variable because of occasional high gravel and mud contents. The dominant textures were slightly pebbly medium sand to pebbly medium sand and slightly granular medium sand to granular medium sand. However, slightly granular muddy medium sand and coarse sandy pebble gravel represented the extremes. The maximum gravel size measured was 17 mm but the mean maximum gravel size was 10 ± 1 mm. The bed sediments on the lower gully of Tributary North (Erskine et al 2001) were sampled to a maximum depth of 1.5 m at five cross sections. Surficial sediments were generally slightly granular medium sand or slightly granular coarse-medium sand. Subsurface sediments varied between slightly granular sands, granular sands and slightly pebbly sands. Sand fractions covered the Wentworth range from very fine to coarse sand. At depth, the sediments in all holes were slightly granular very fine-fine sand. The maximum gravel size measured was 18 mm but the mean maximum gravel size was 7 ± 0.5 mm. The bed sediments on Tributary Central were sampled to a maximum depth of 2.8 m at three cross sections. Weathered sandstone bedrock was reached at the bottom of two holes. Sediments were variable ranging from slightly granular fine sand to medium sand/muddy medium sand to pebbly coarse sand to coarse

sandy pebble gravel. The maximum gravel size measured was 35 mm but the mean maximum gravel size was 11 ± 2 mm.

Floodplain sediments were described at the three ***eriss*** gauging stations (Swift Creek, upper Swift Creek and East Tributary) and were found to comprise sandy fining upwards sequences deposited by laterally stable channels whose banks were protected by monsoonal vine forest with extensive root systems and root mats. Sandy sediments were also described along the lower gullied reach (Erskine et al 2001) of Tributary North.

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