An analysis of channel change on the Rivers Tay and Tummel, Scotland, using GIS and remote sensing techniques.

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Volume Two: figures and diagrams.

Volume Two: figures and diagrams.

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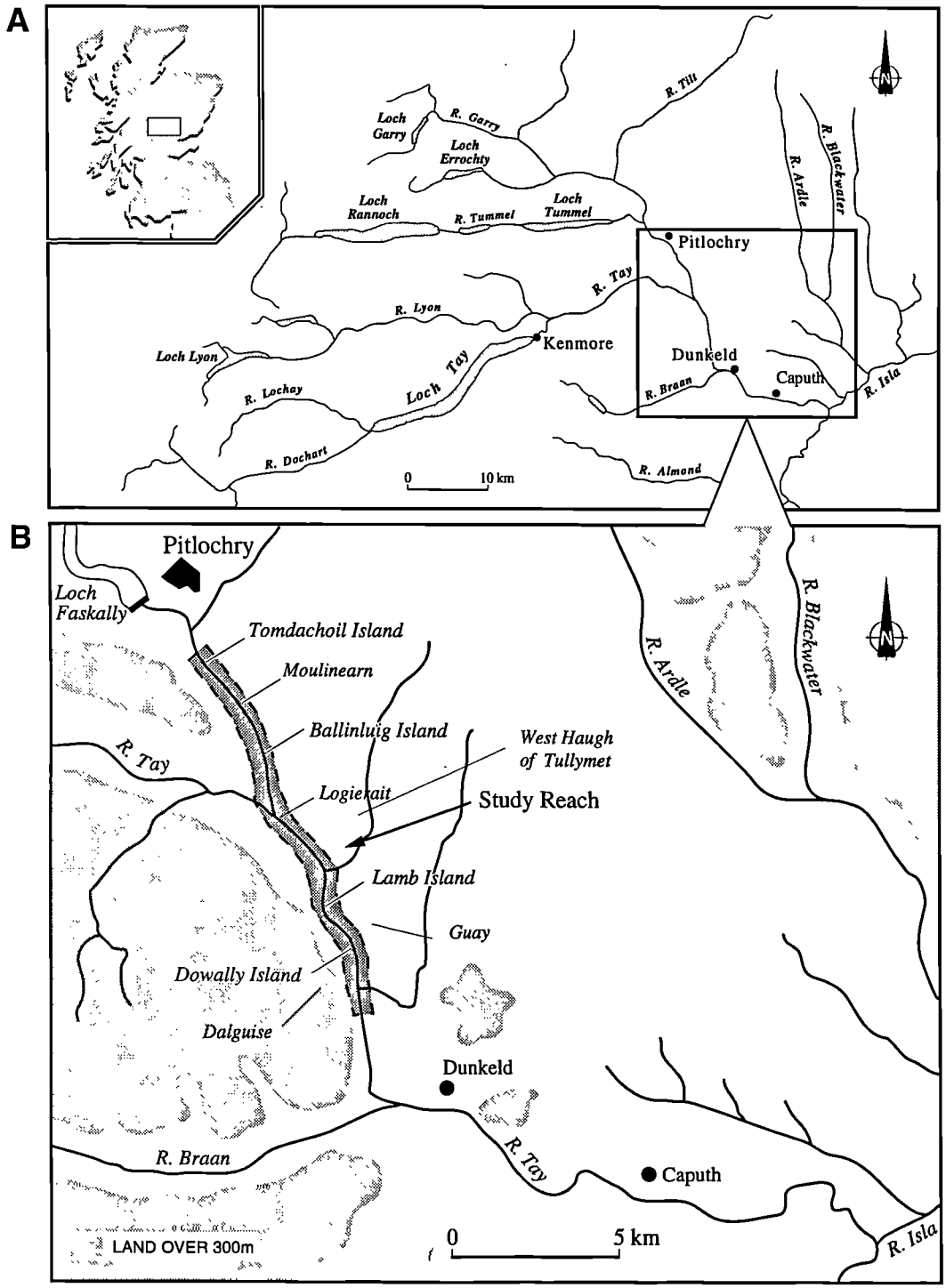


Figure 1.1. Location map of the study area.

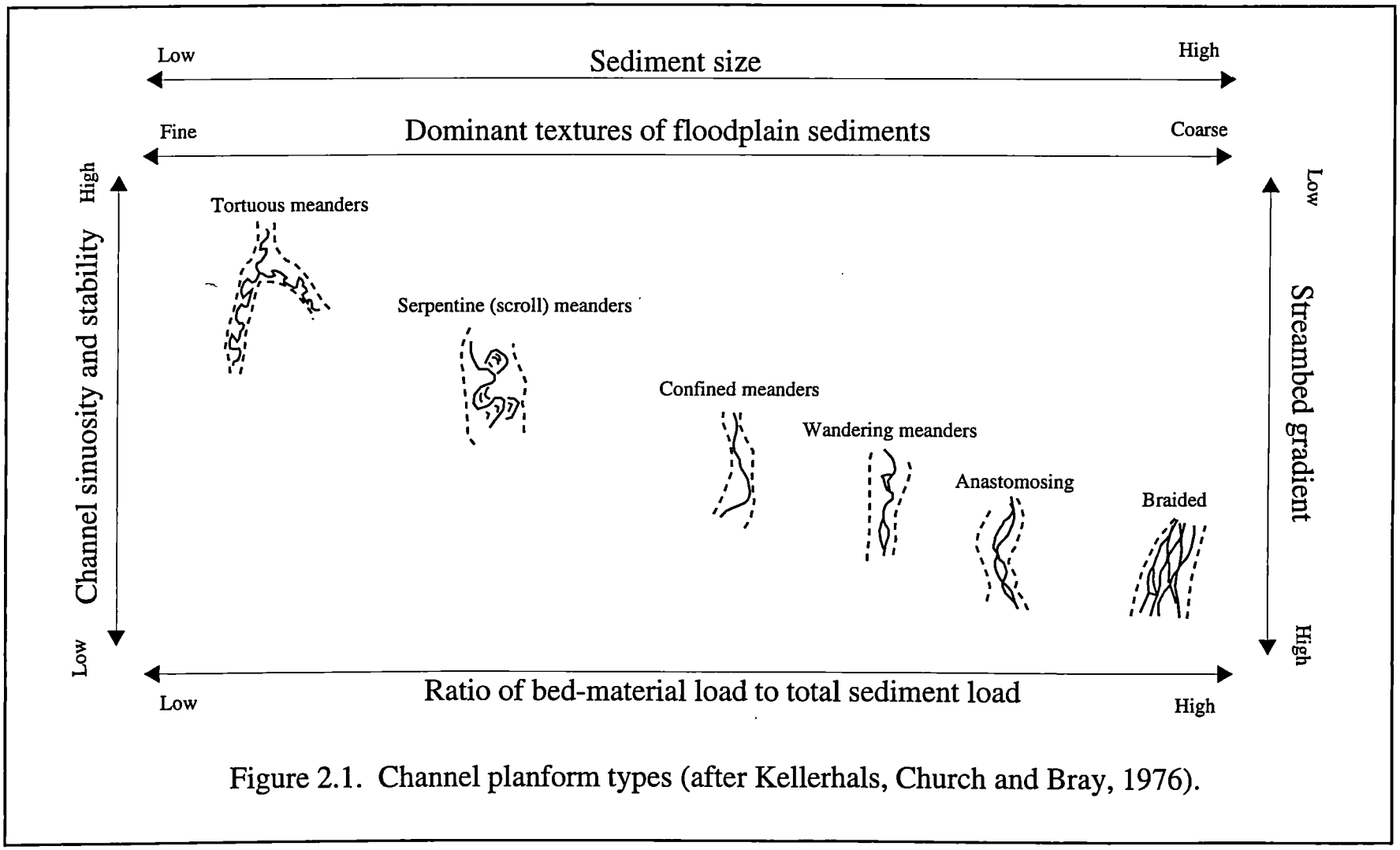
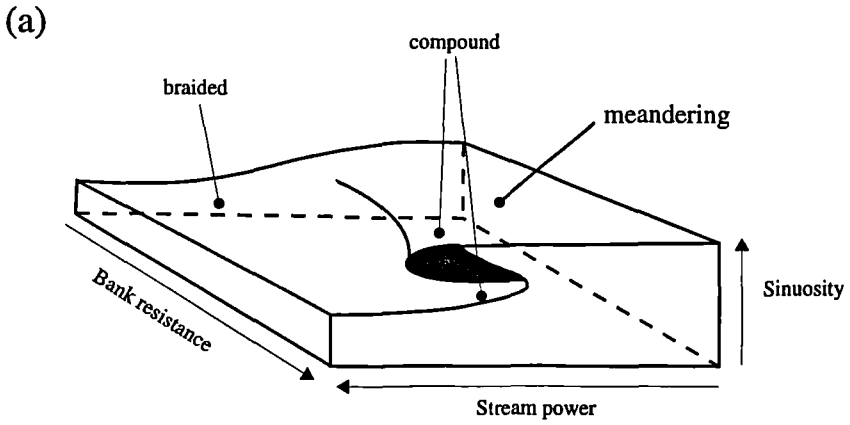
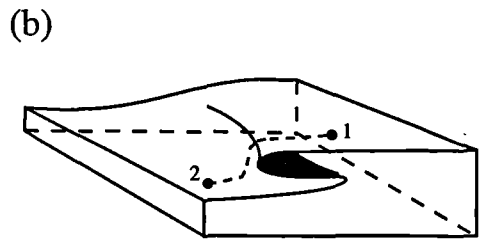
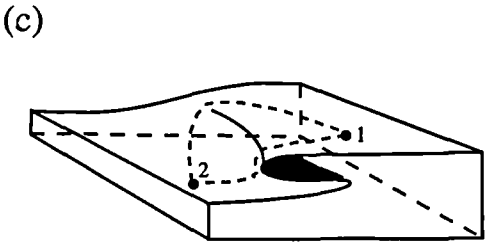


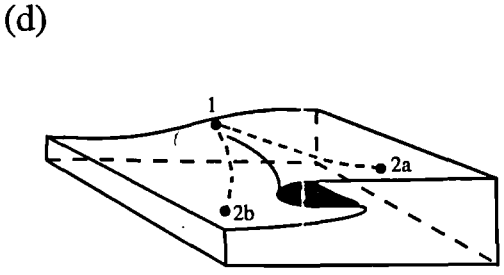
Figure 2.1. Channel planform types (after Kellerhals, Church and Bray, 1976).

Figure 2.2. The cusp catastrophe relating to the control factors of stream power and bank resistance with the responding variable of sinuosity to produce various channel patterns (after Graf, 1988).









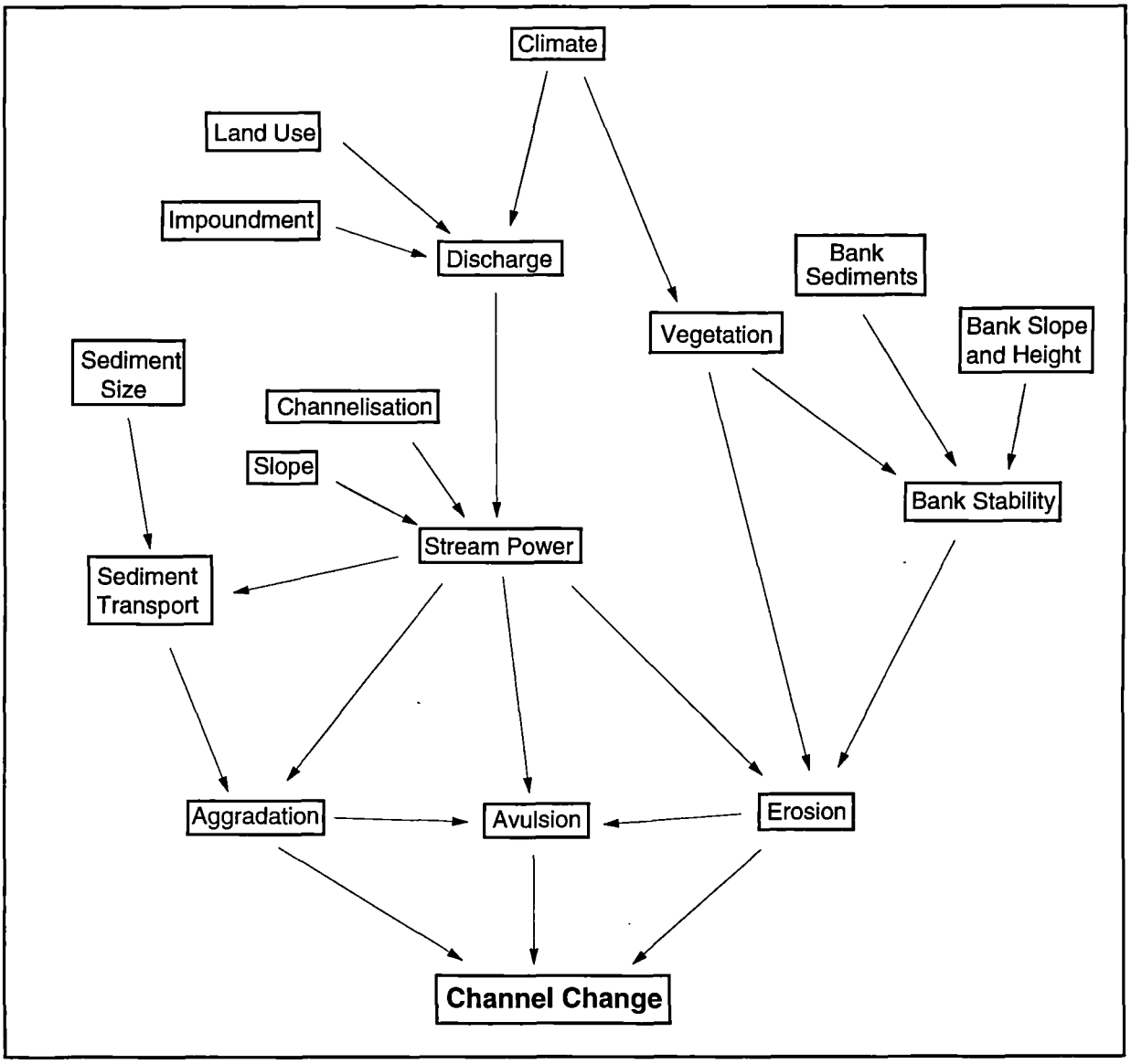


Figure 2.3. The interaction of variables influencing rate and distribution of channel change.

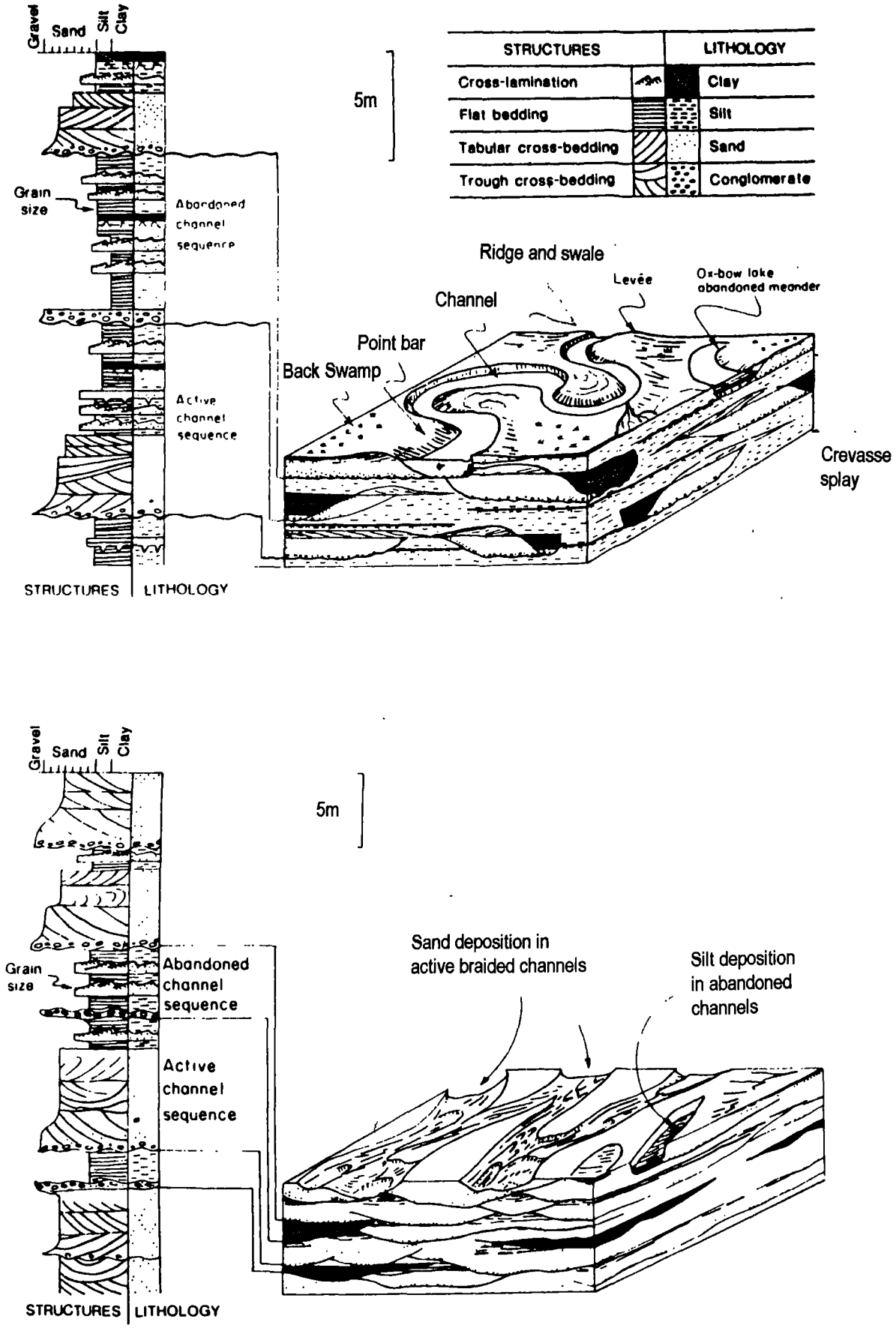


Figure 2.4. Typical types of floodplain formed by a) meandering rivers, b) braided rivers.

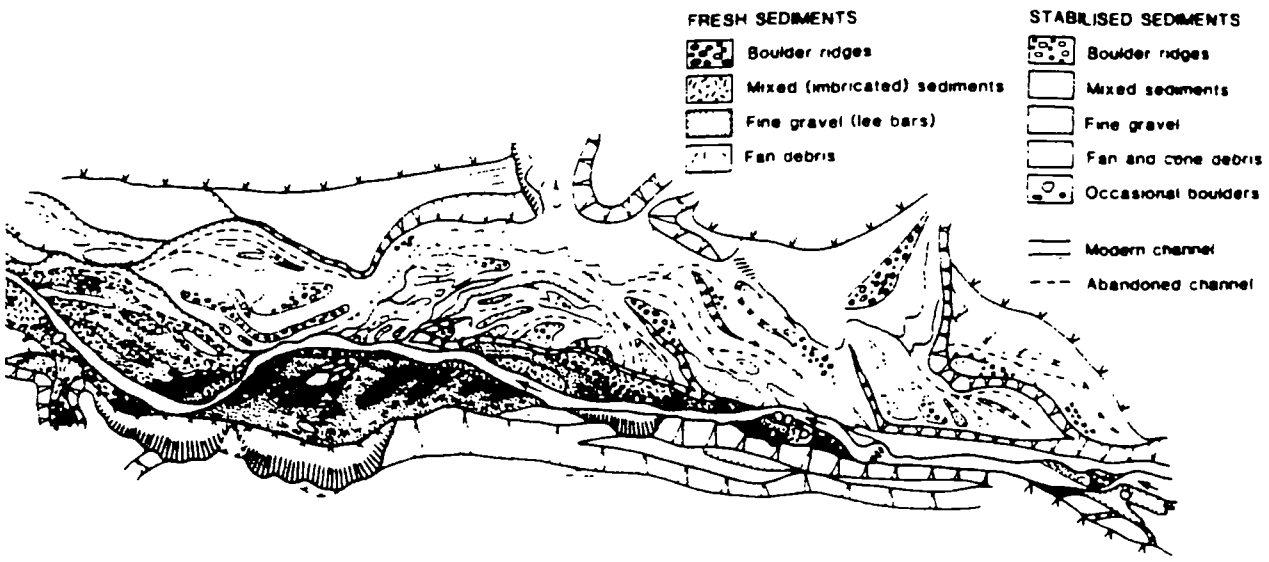


Figure 2.5. Morphology and sedimentology formed by a wandering gravel-bed river (Harvey et al. (1984).

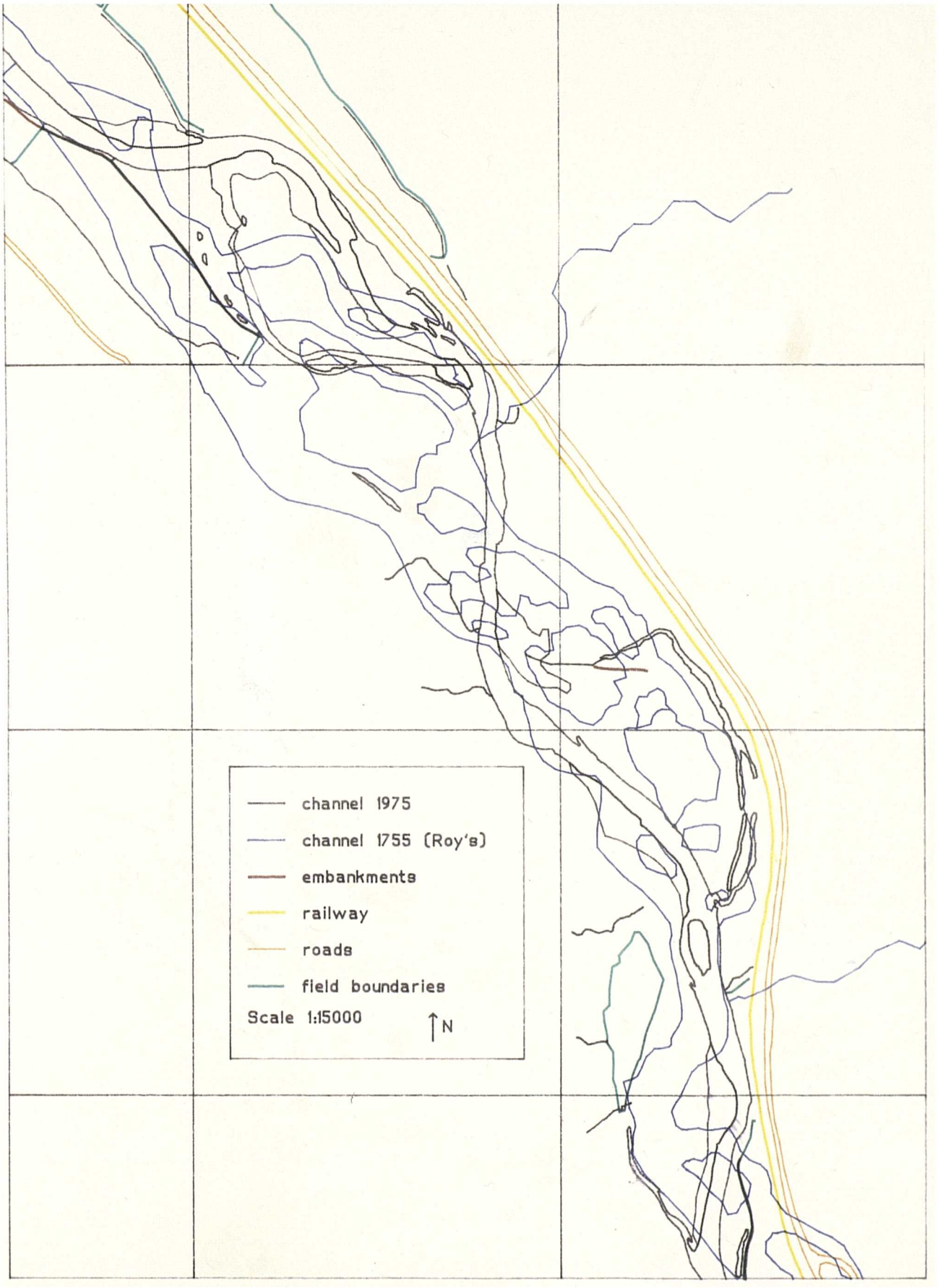


Figure 3.1a. River channel 1755 from Roy's Military Survey rectified to the O.S. 1:10000 base map.

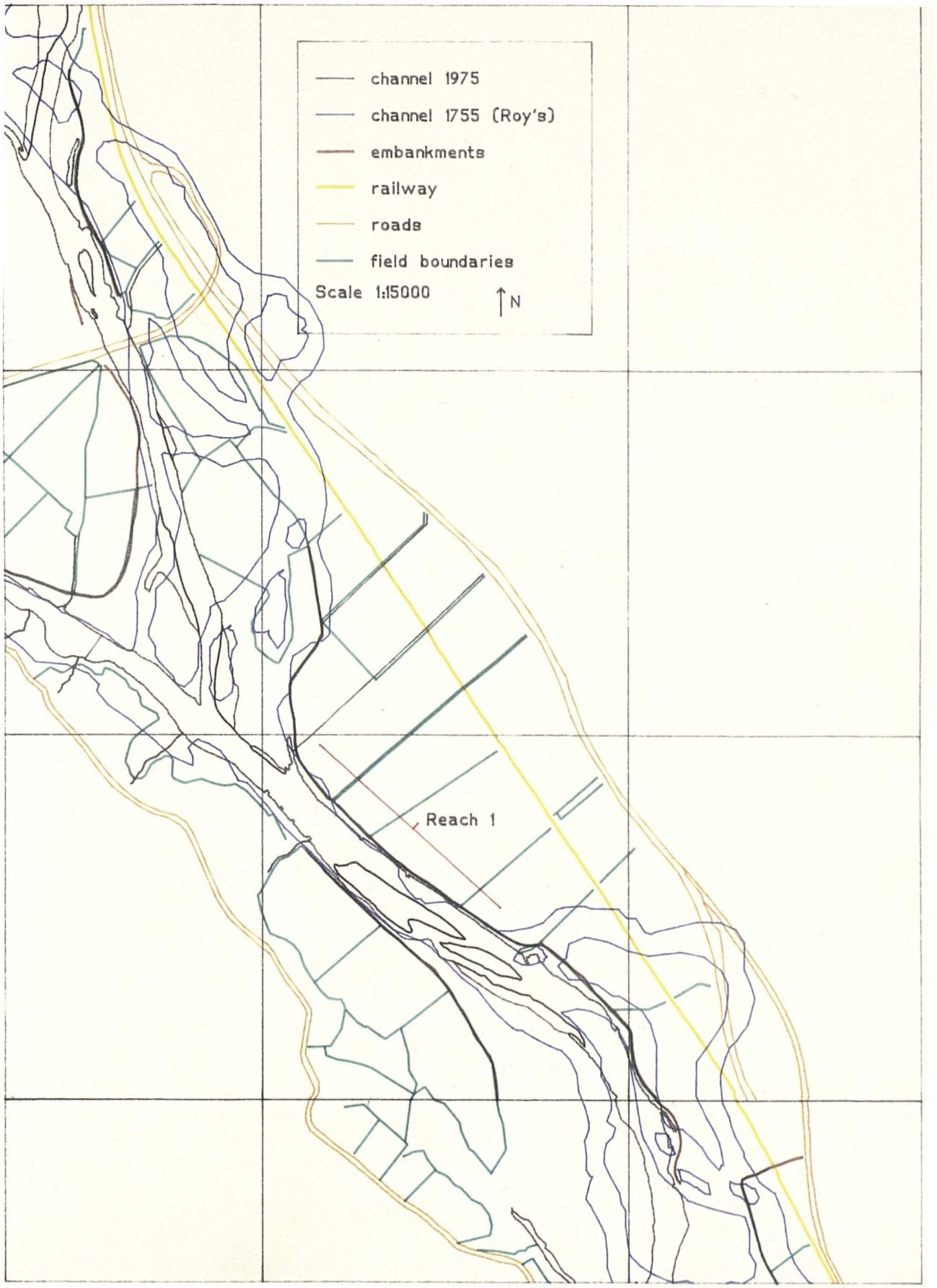


Figure 3.1b. River channel 1755 from Roy's Military Survey rectified to the O.S. 1:10000 base map.

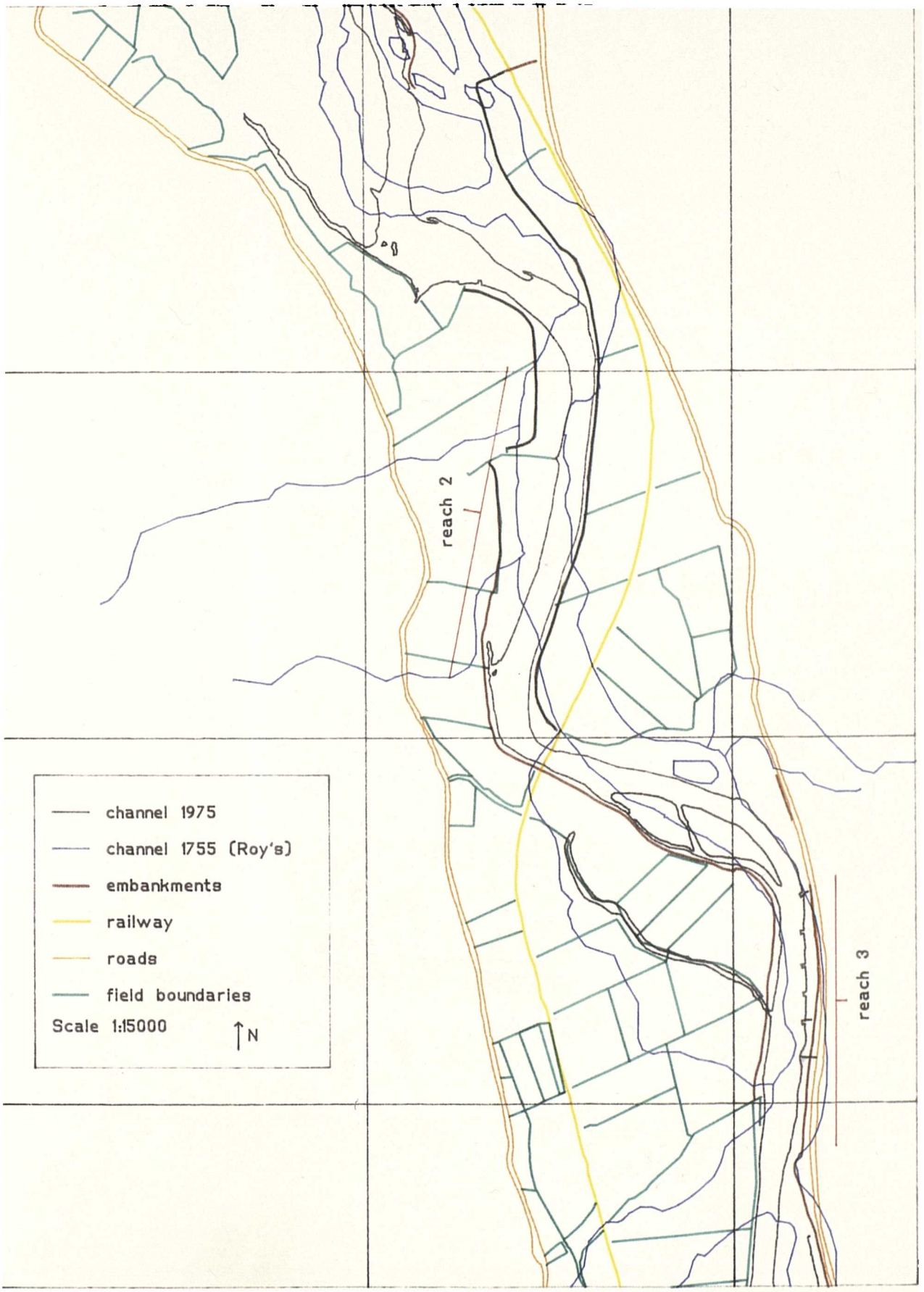


Figure 3.1c. River channel 1755 from Roy's Military Survey rectified to the O.S. 1:10000 base map.

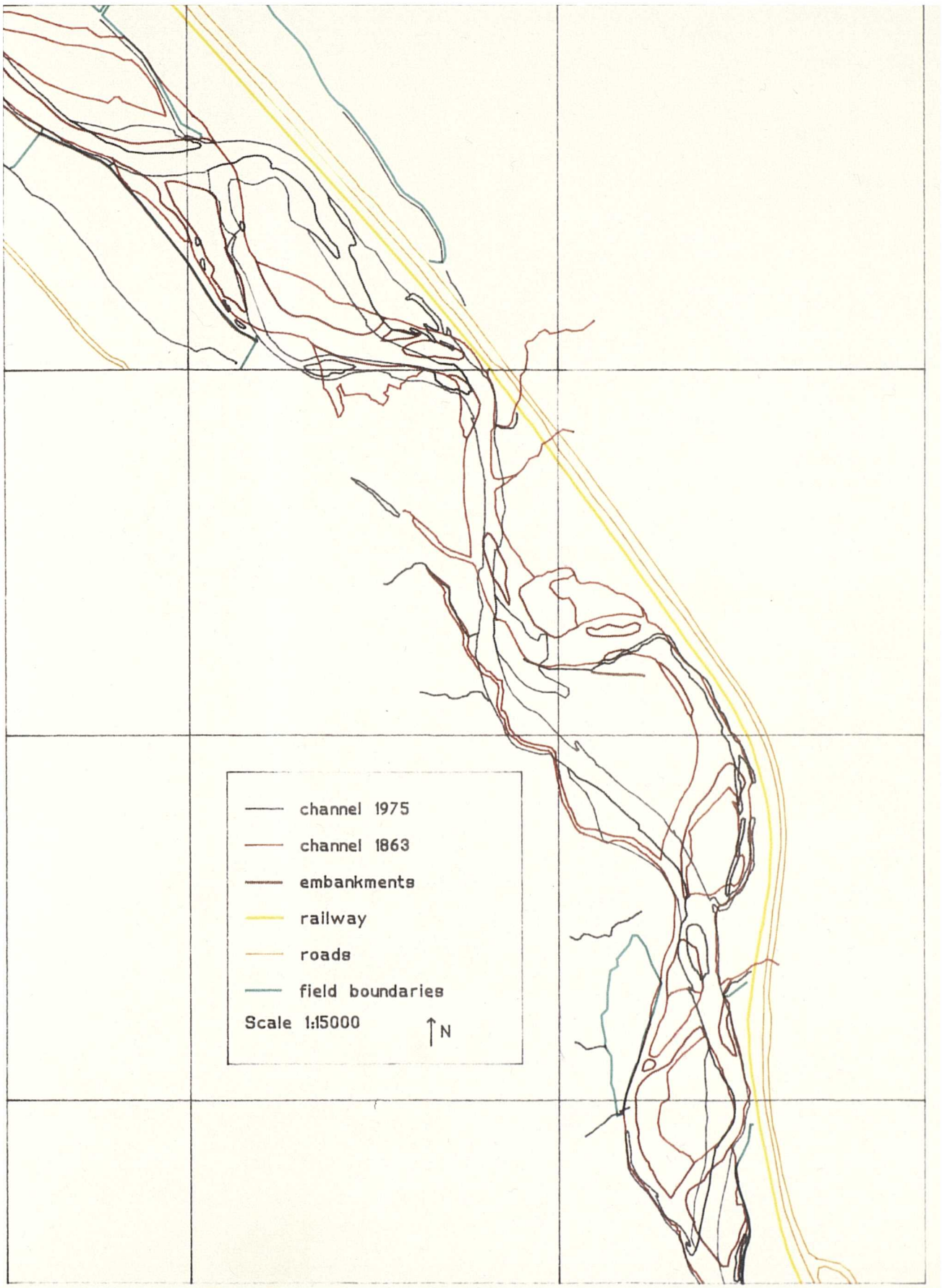


Figure 3.2a. River Channel 1863 from 1st Edition O.S. map rectified to the O.S. 1:10000 base map.

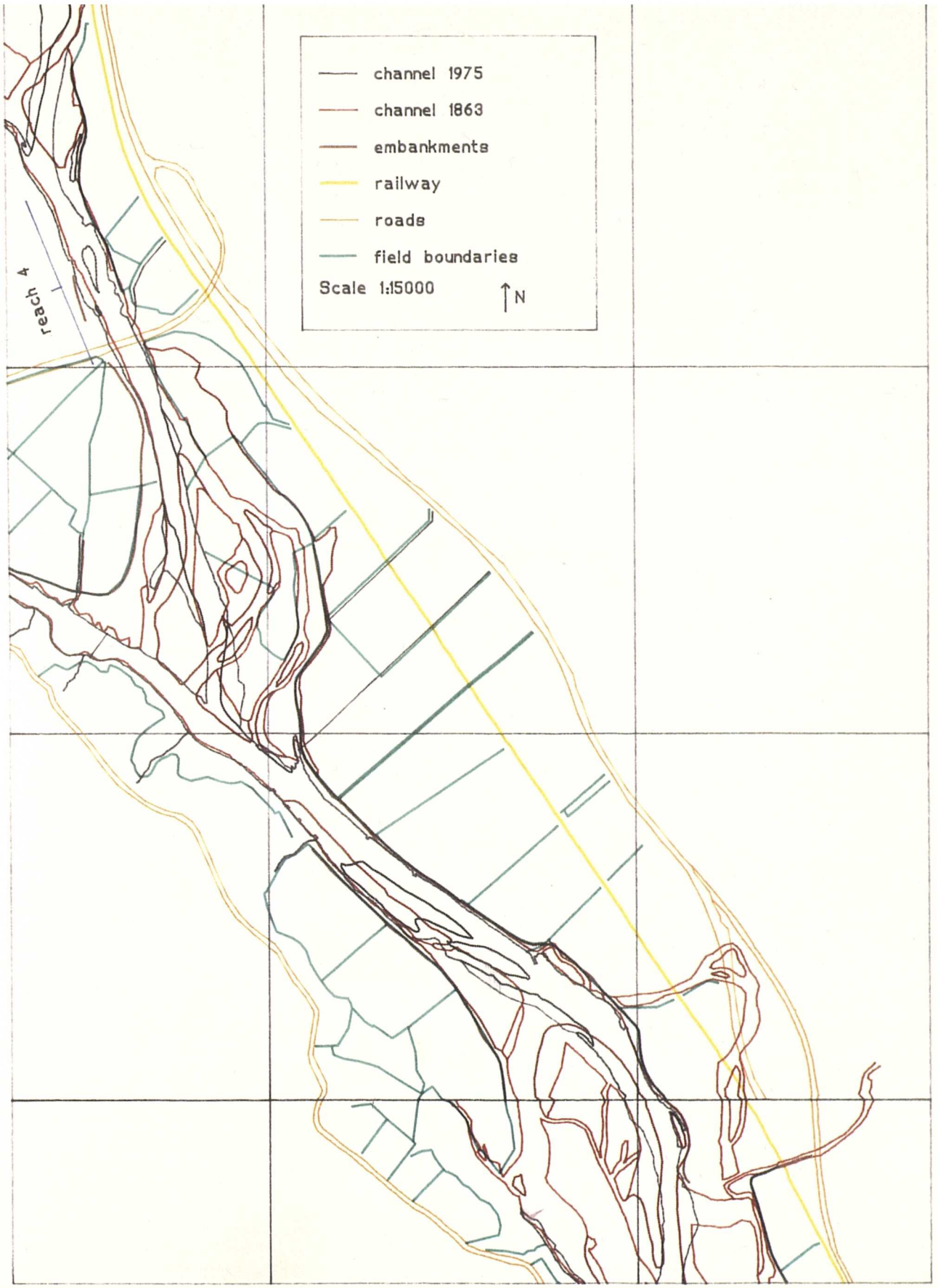


Figure 3.2b. River Channel 1863 from 1st Edition O.S. map rectified to the 1:10000 O.S. base map.

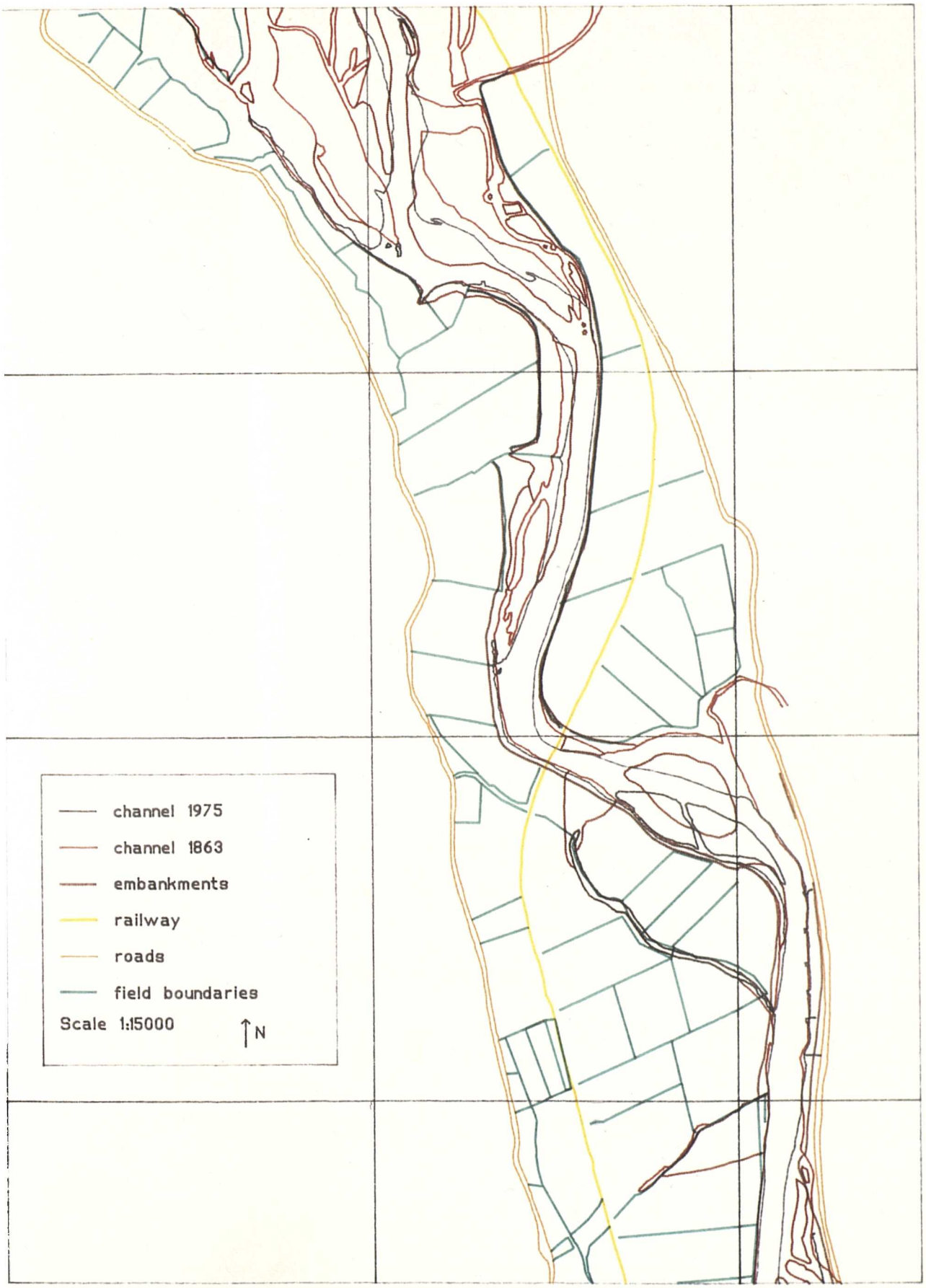


Figure 3.2c. River Channel 1863 from 1st Edition O.S. map rectified to the 1:10000 O.S. base map.

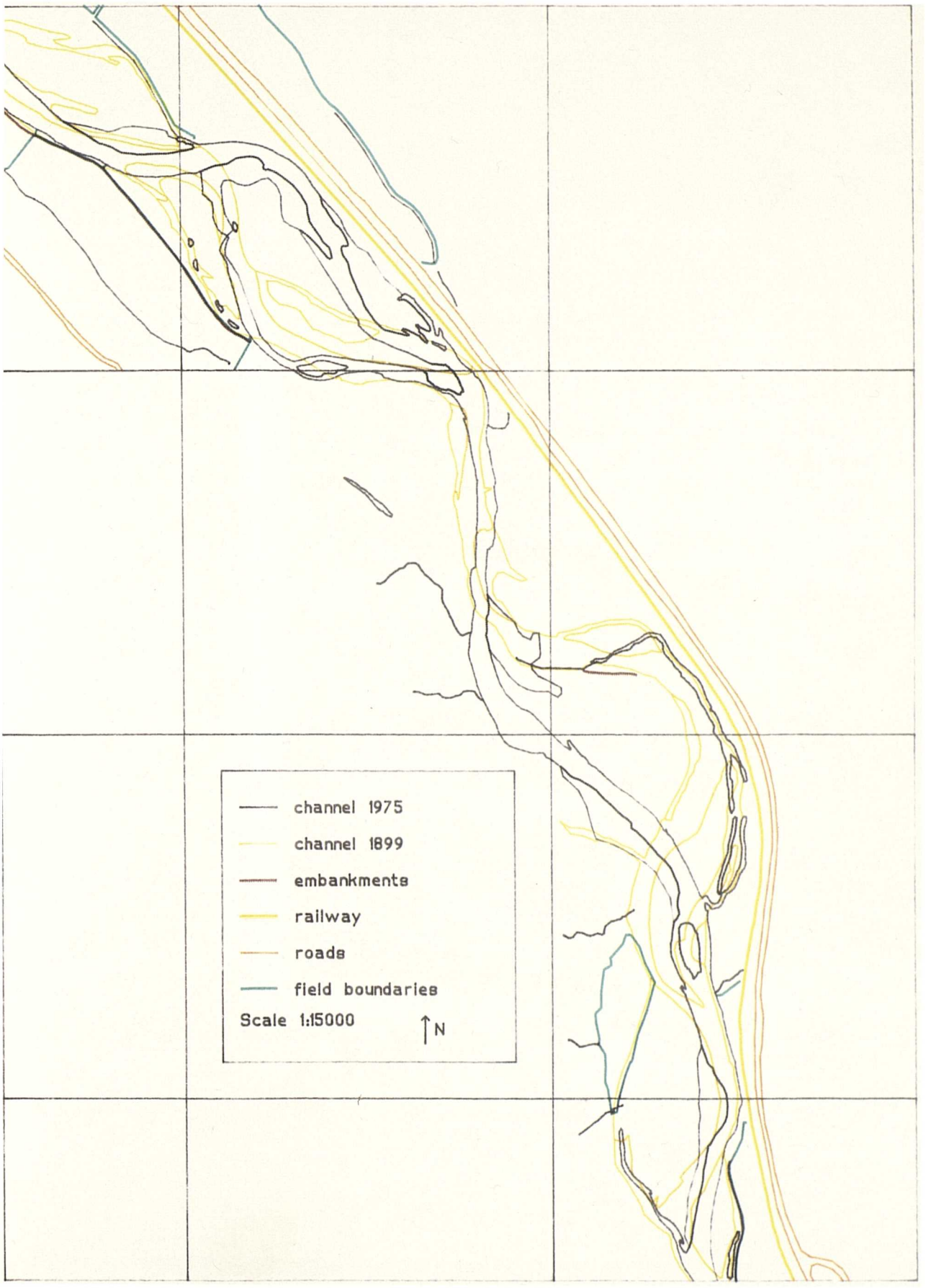


Figure 3.3a. River Channel 1899 from 2nd Edition O.S. map rectified to the O.S. 1:10000 base map.

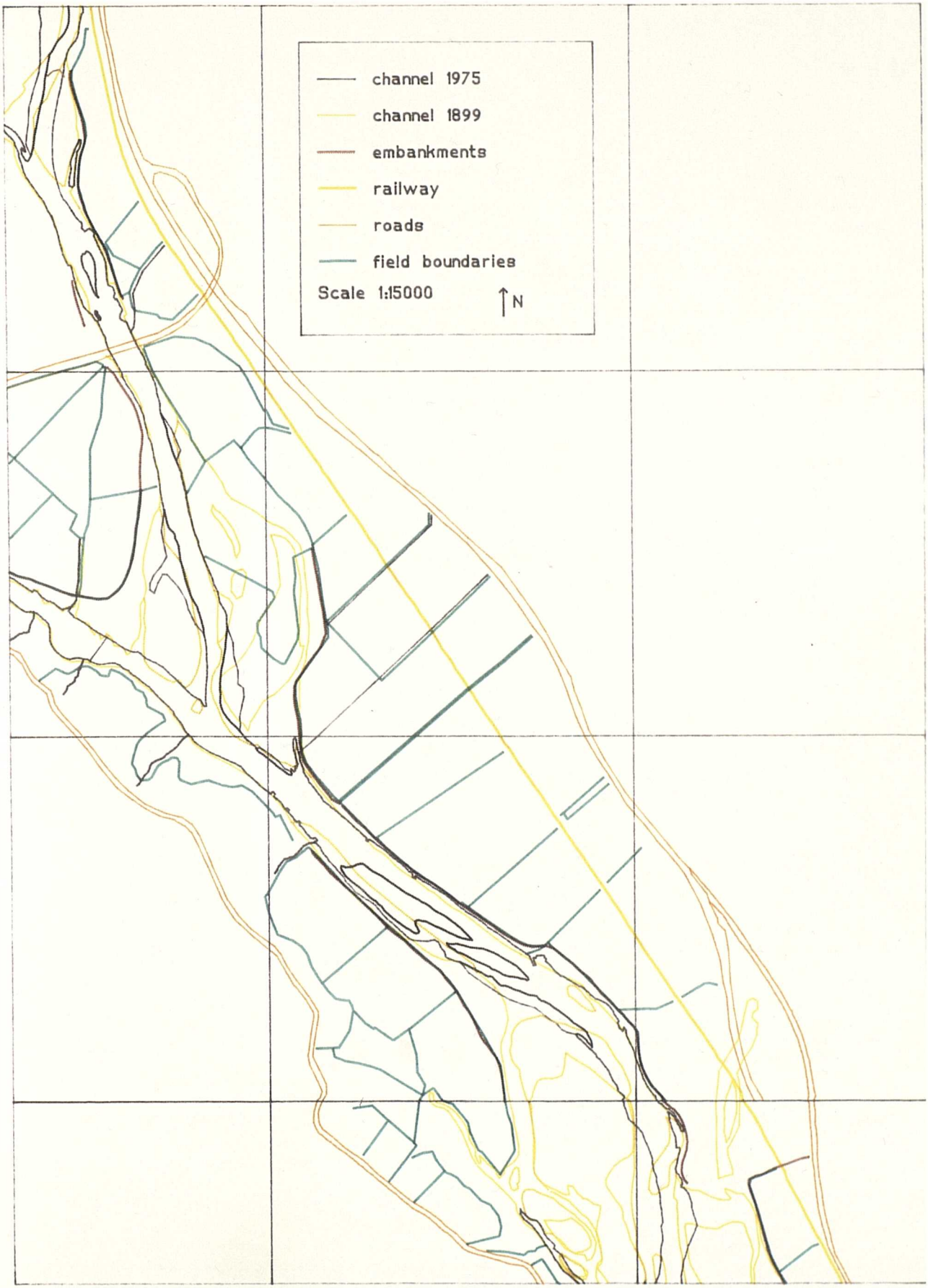


Figure 3.3b. River Channel 1899 from 2nd Edition O.S. map rectified to the 1:10000 O.S. base map.

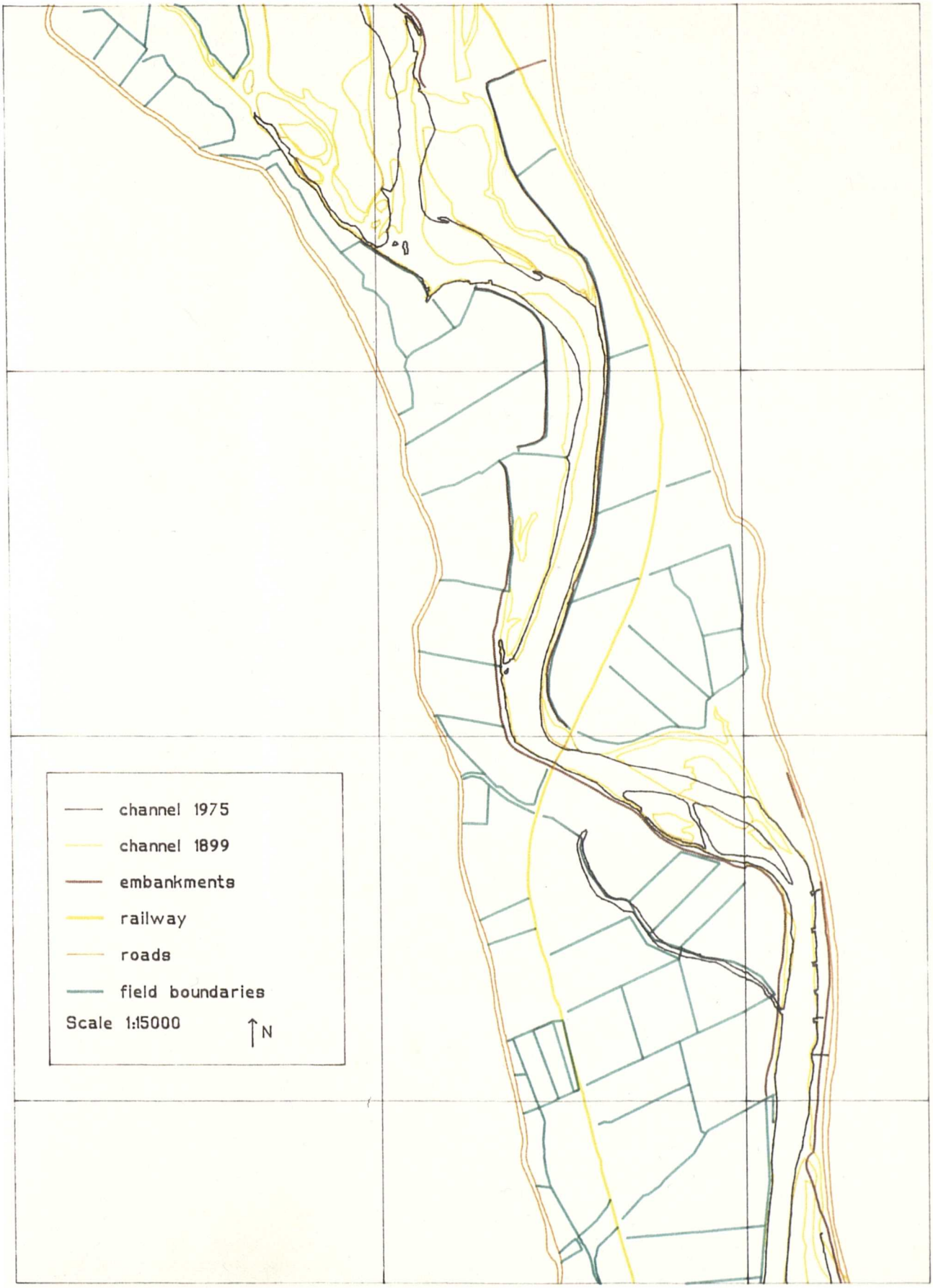


Figure 3.3c. River Channel 1899 from 2nd Edition O.S. map rectified to the 1:10000 O.S. base map.

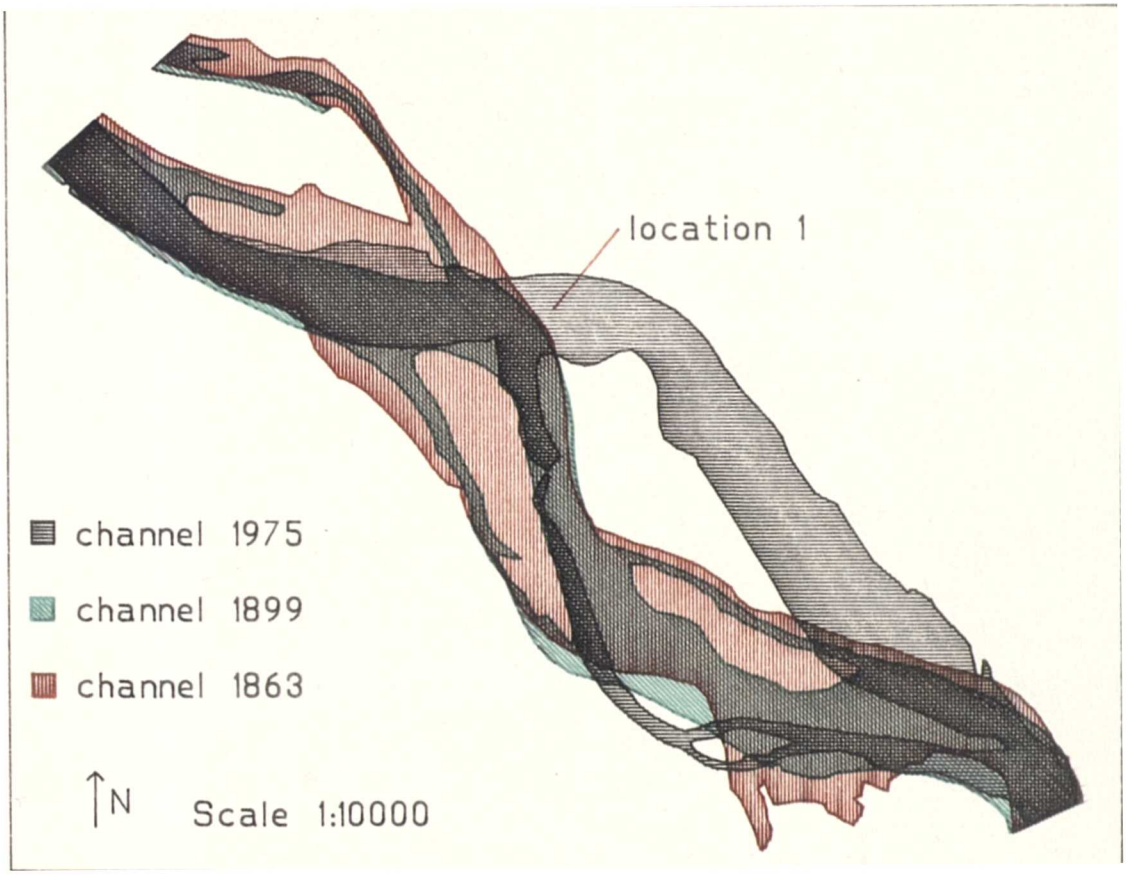
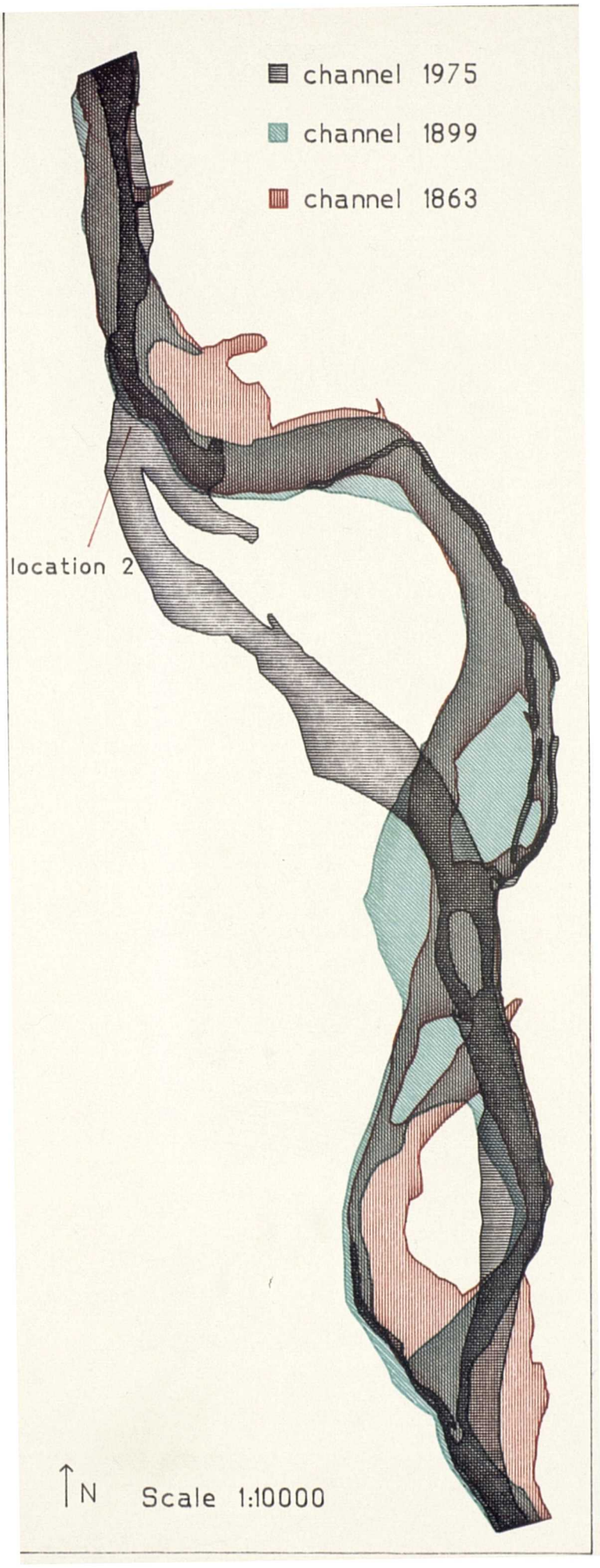


Figure 3.4a. Section 1. (unstable)



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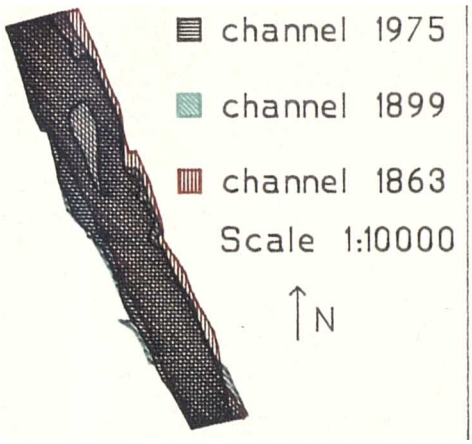
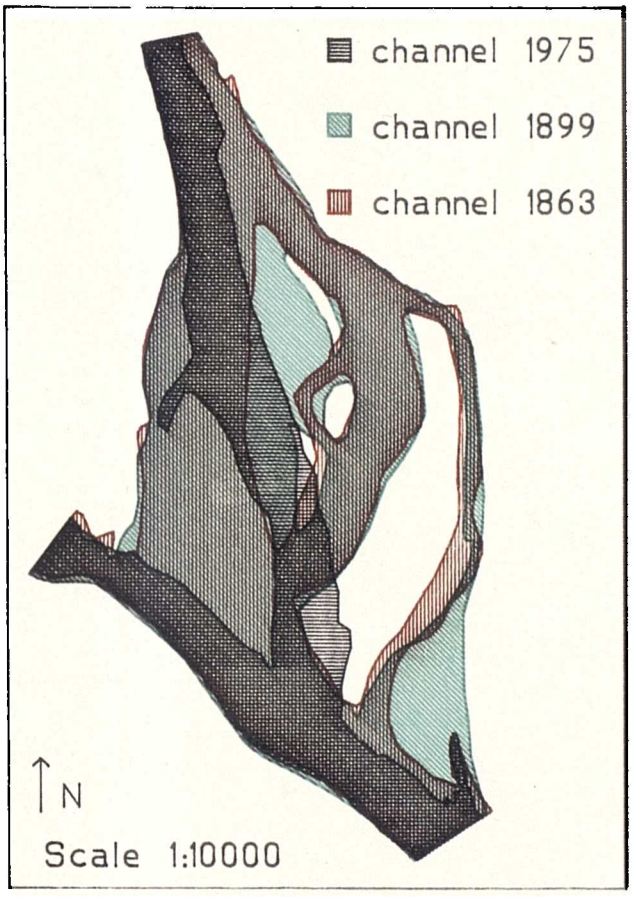


Figure 3.4c.
Section 3. (stable)



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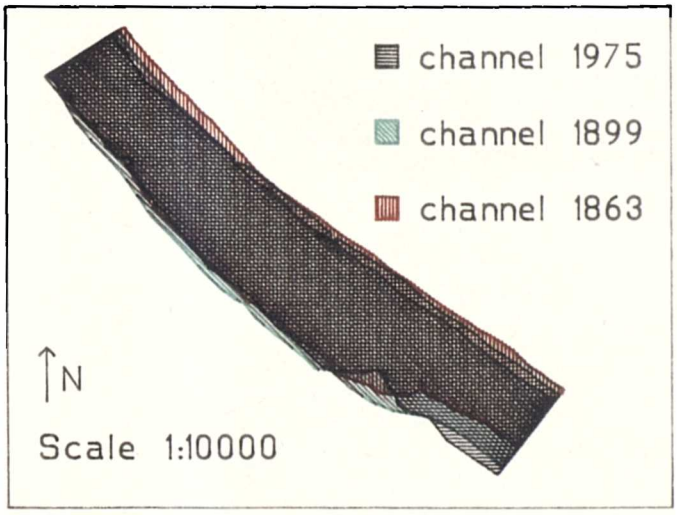

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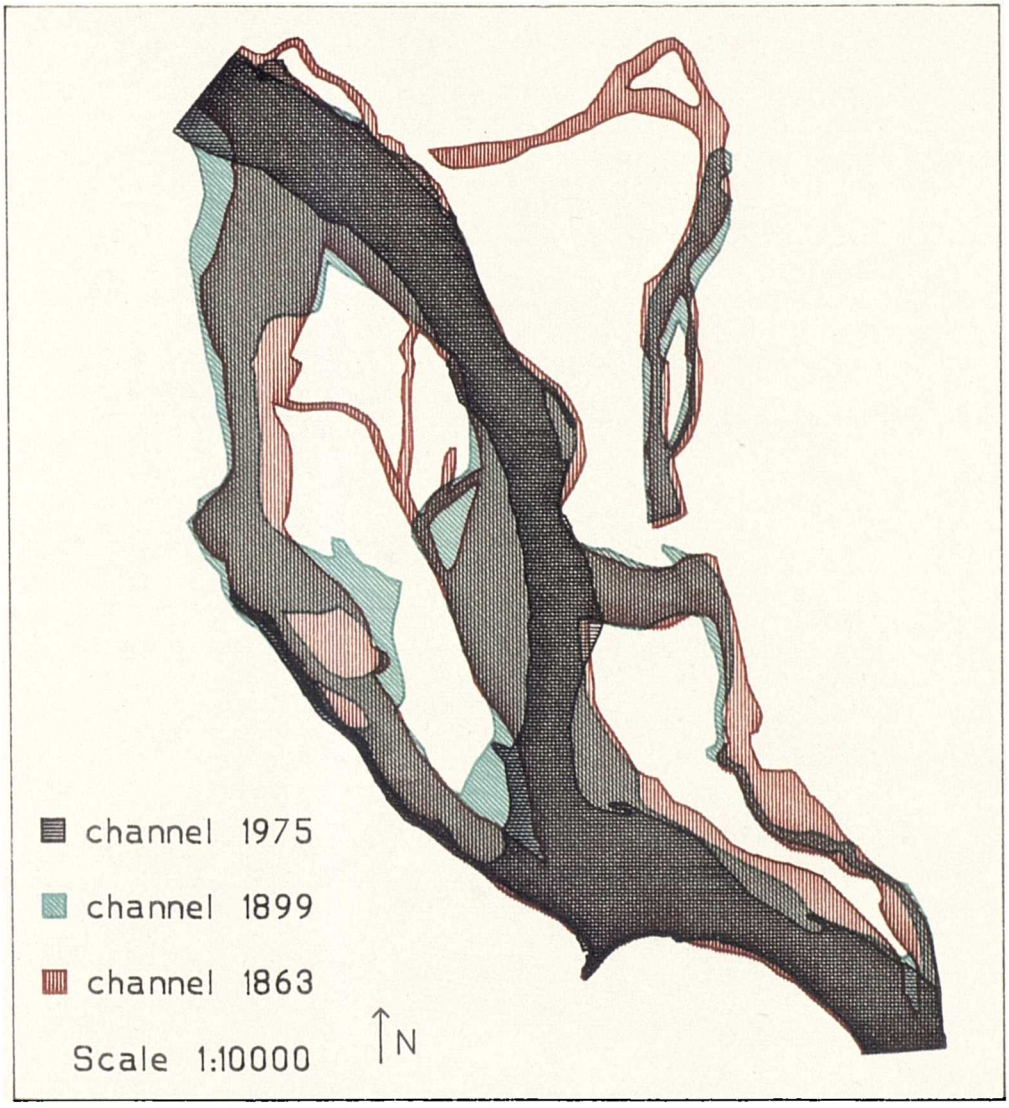

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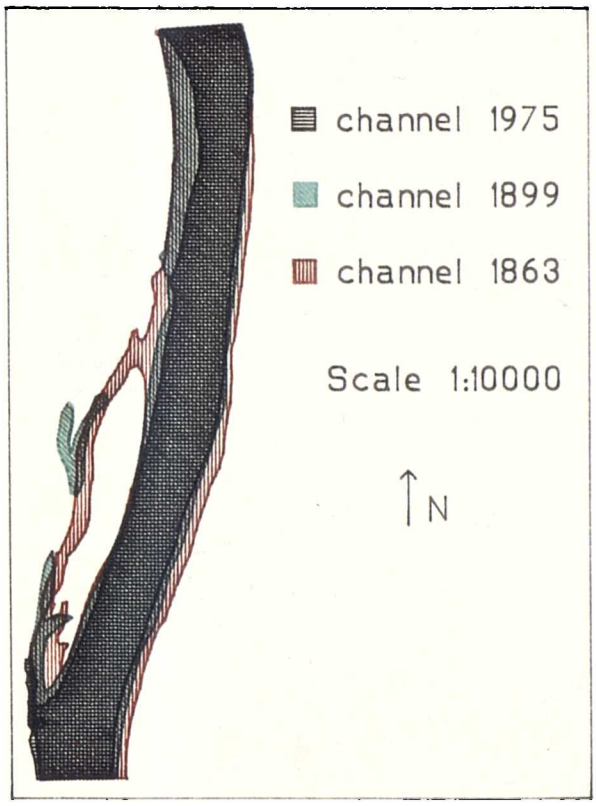

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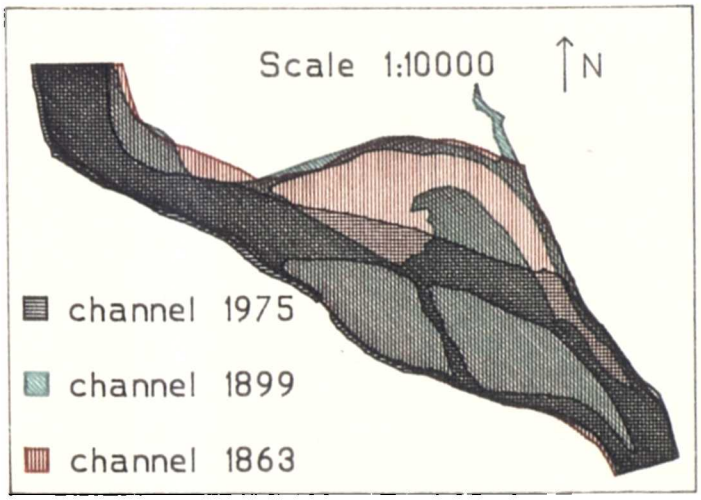

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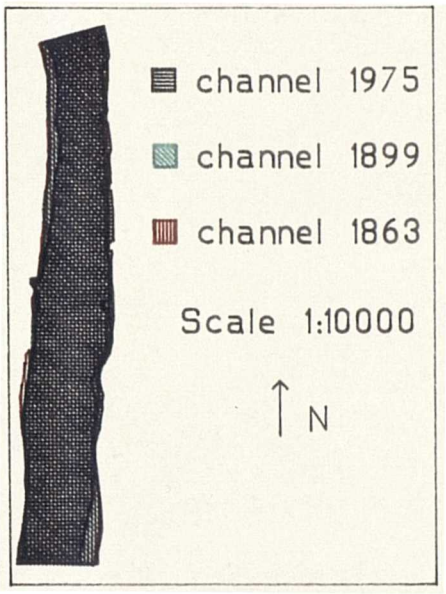
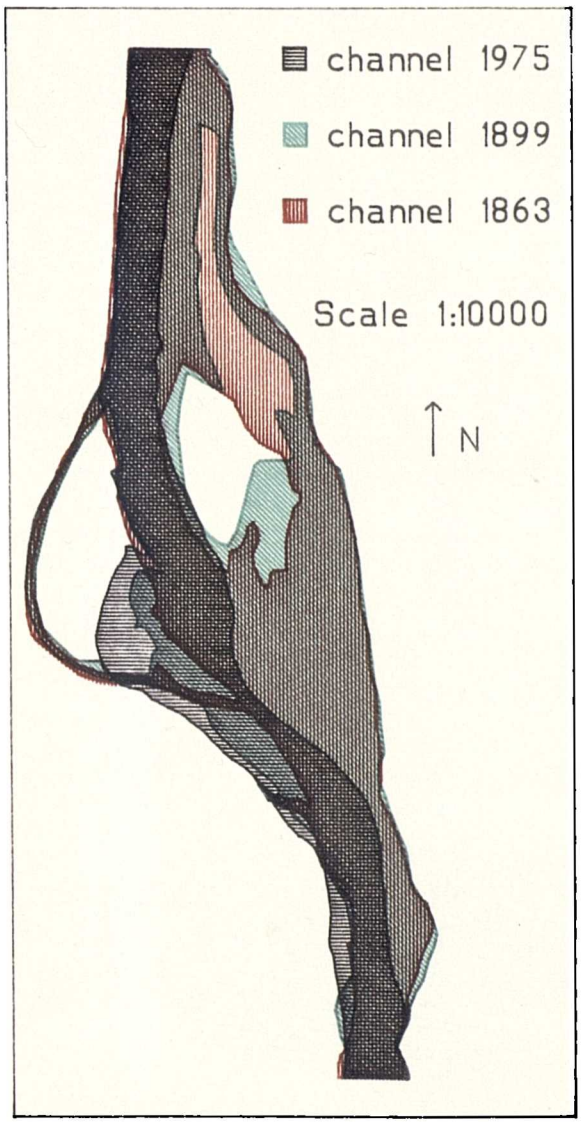


Figure 3.4i. Section 9. (stable)



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(unstable)

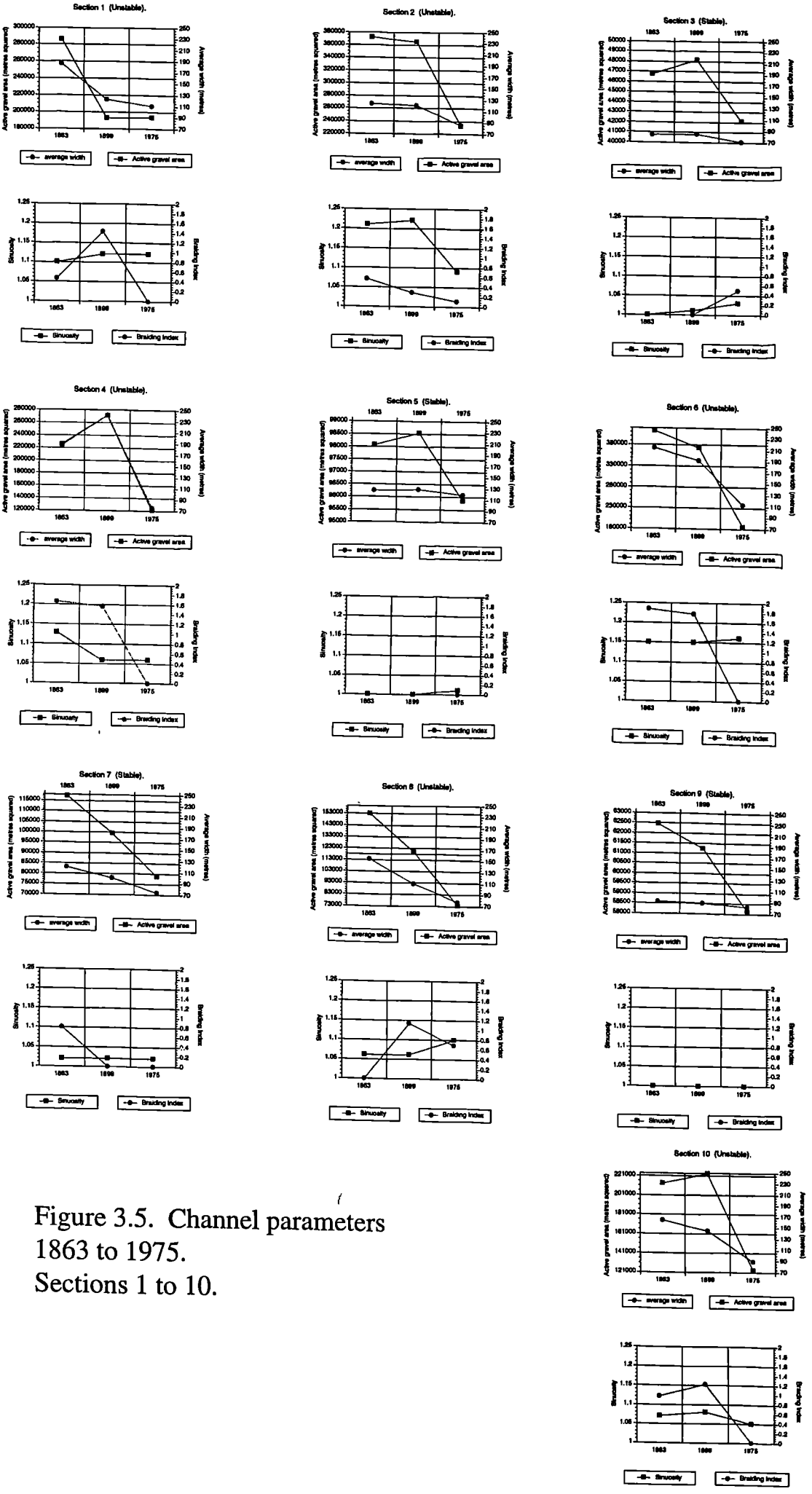
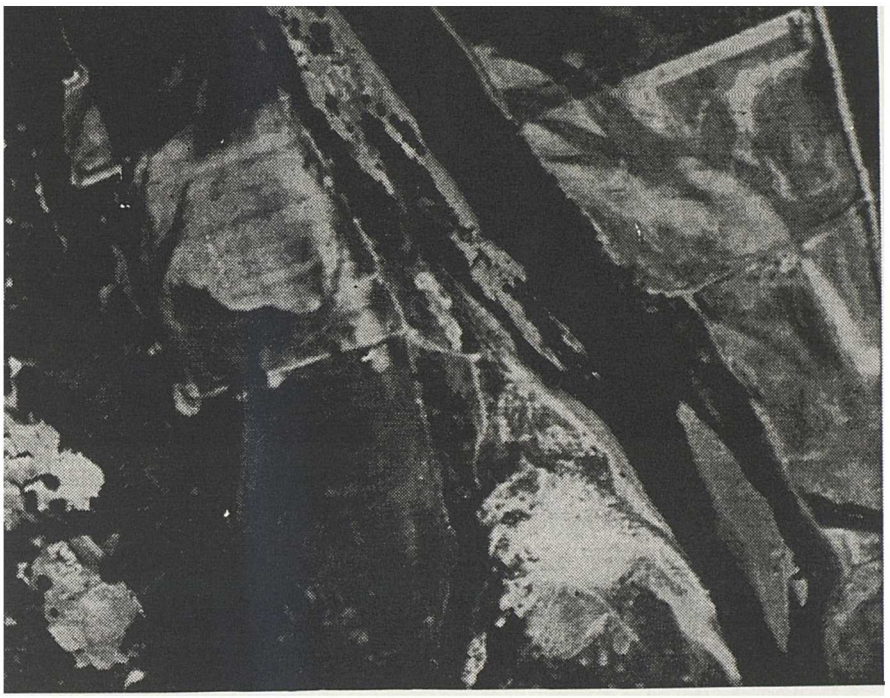


Figure 3.5. Channel parameters 1863 to 1975.
Sections 1 to 10.

a.



b.

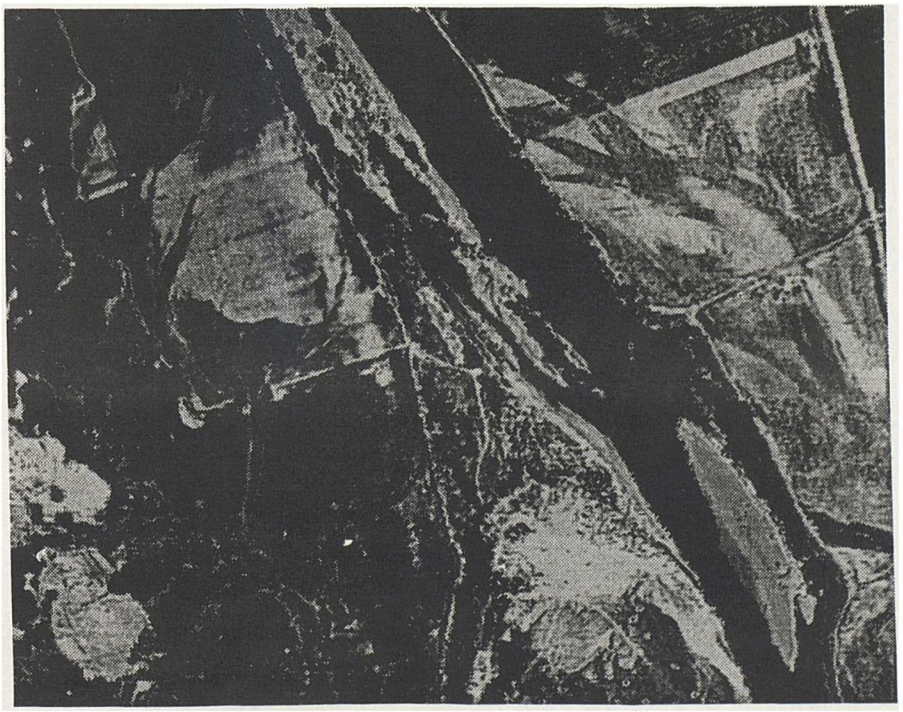


Figure 3.6. ATM imagery (band 11) of the River Tay showing floodplain features, a) raw data, b) enhanced by contrast stretch and edge enhancement filter.

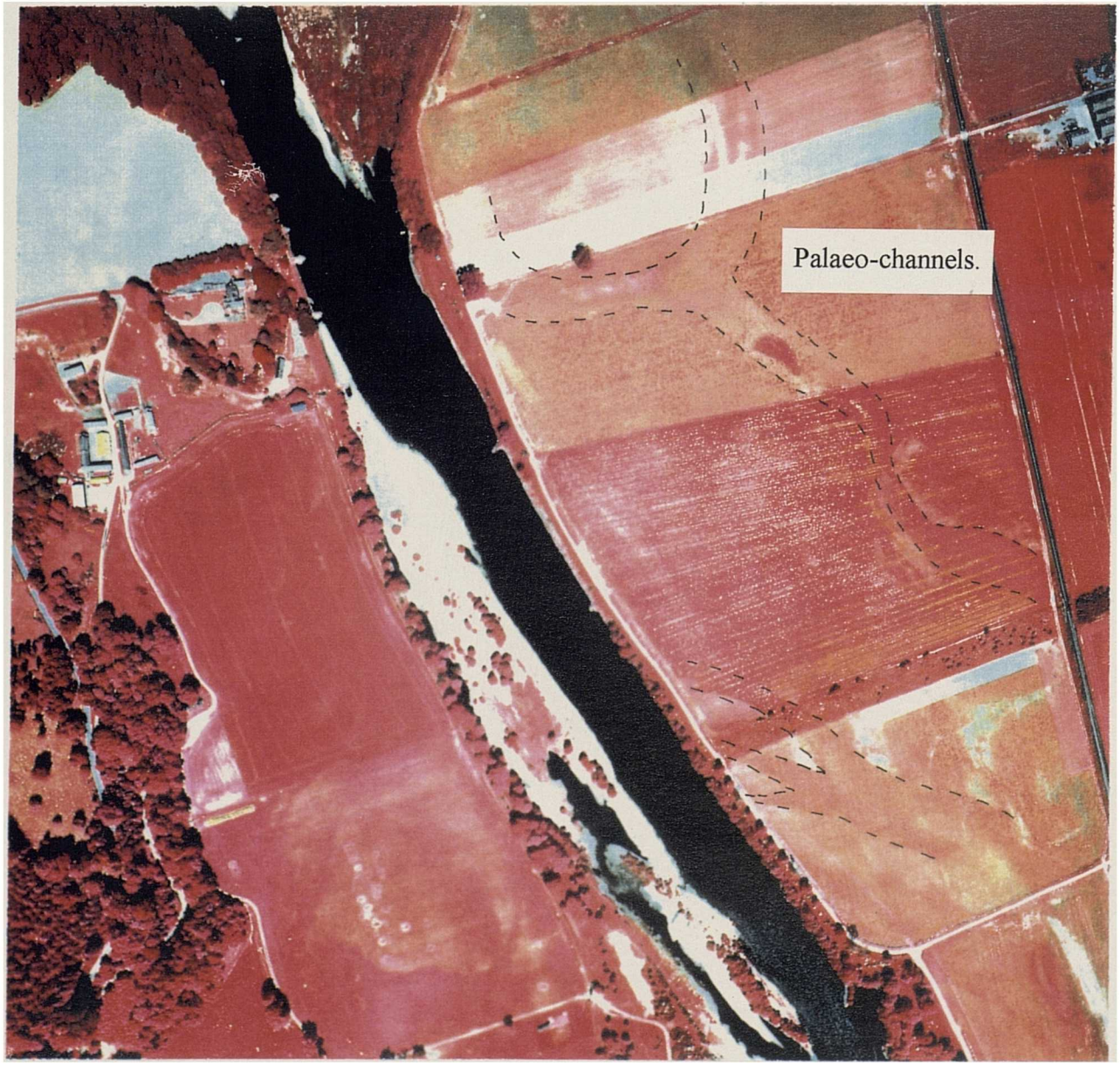


Plate 3.1. False colour infra-red aerial photograph showing floodplain sedimentary features.

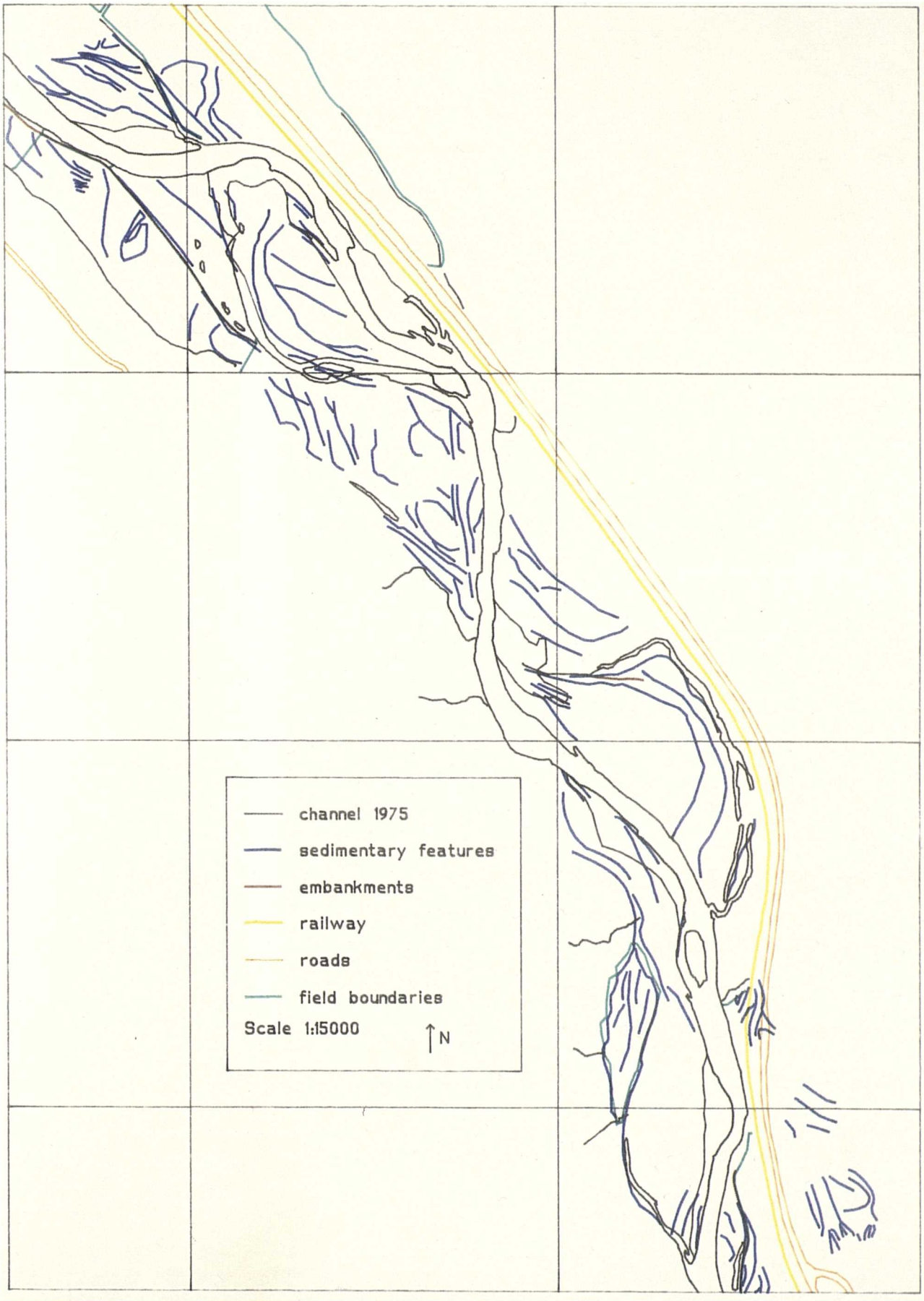


Figure 3.7a. Palaeofluvial sedimentary features rectified to the O.S. 1:10000 base map.

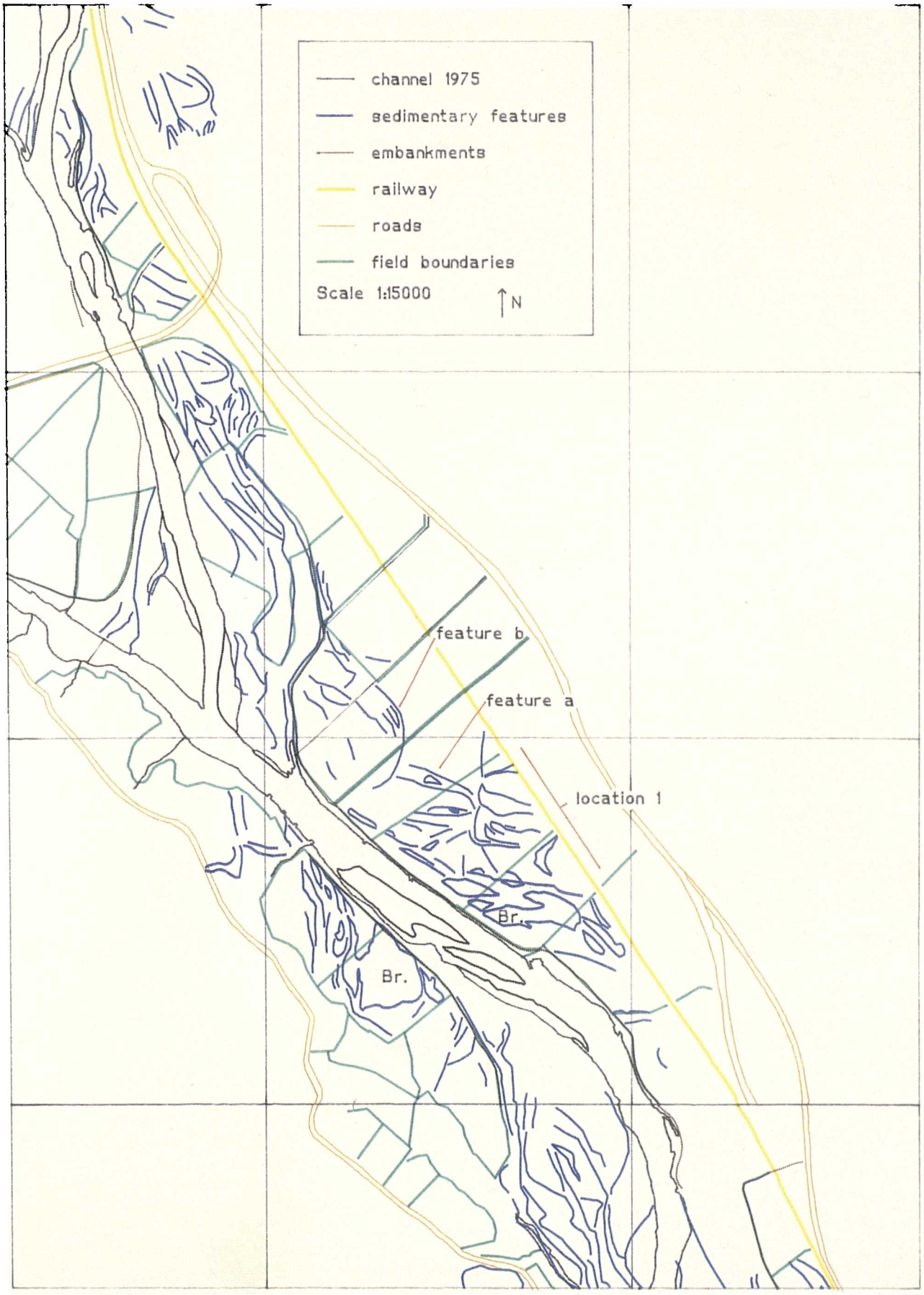


Figure 3.7b. Palaeofluvial sedimentary features rectified to the 1:10000 O.S. base map.

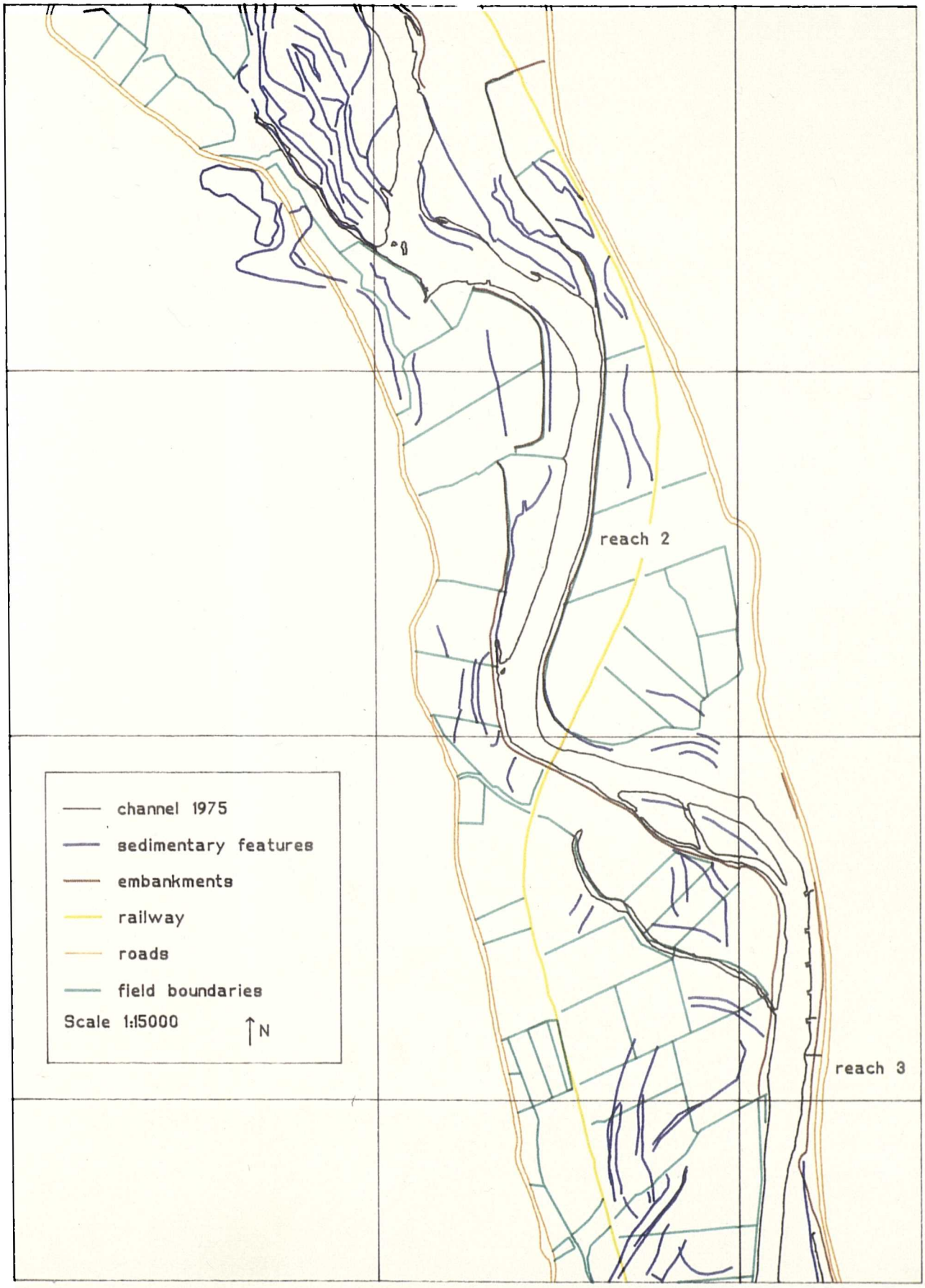


Figure 3.7c. Palaeofluvial sedimentary features rectified to the 1:10000 O.S. base map.

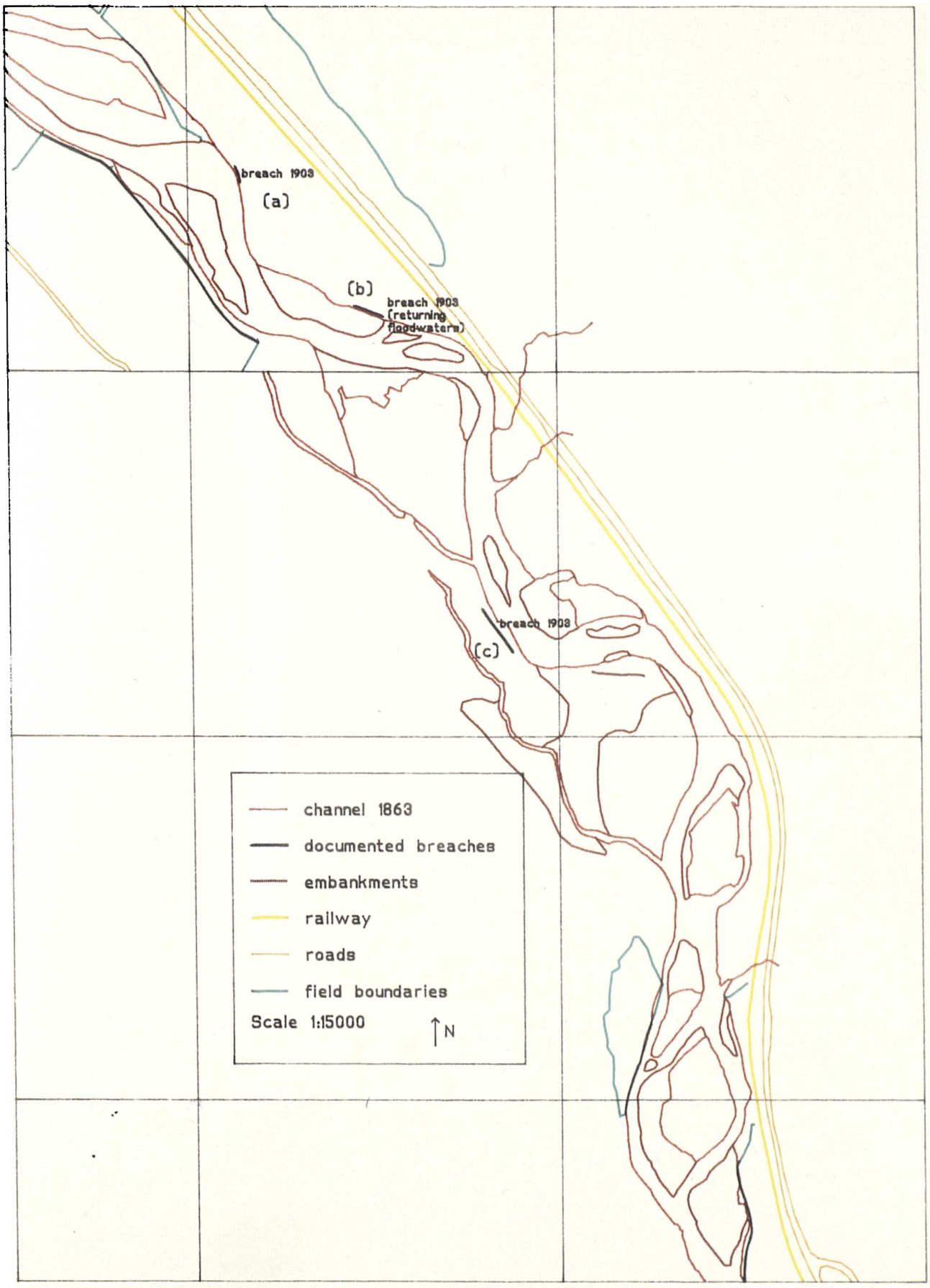


Figure 3.8a. Historically documented embankment breaches.

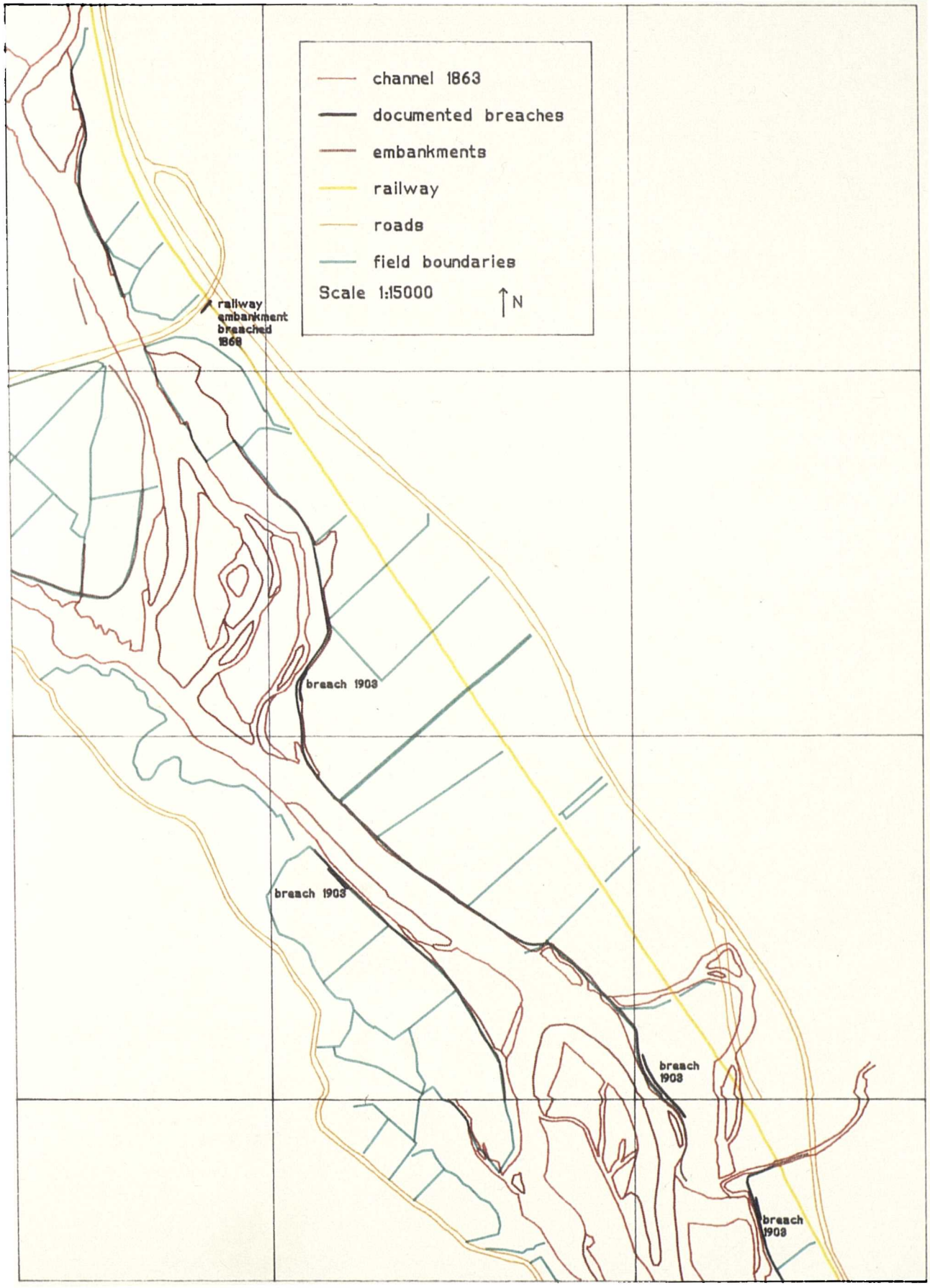


Figure 3.8b. Historically documented embankment breaches.

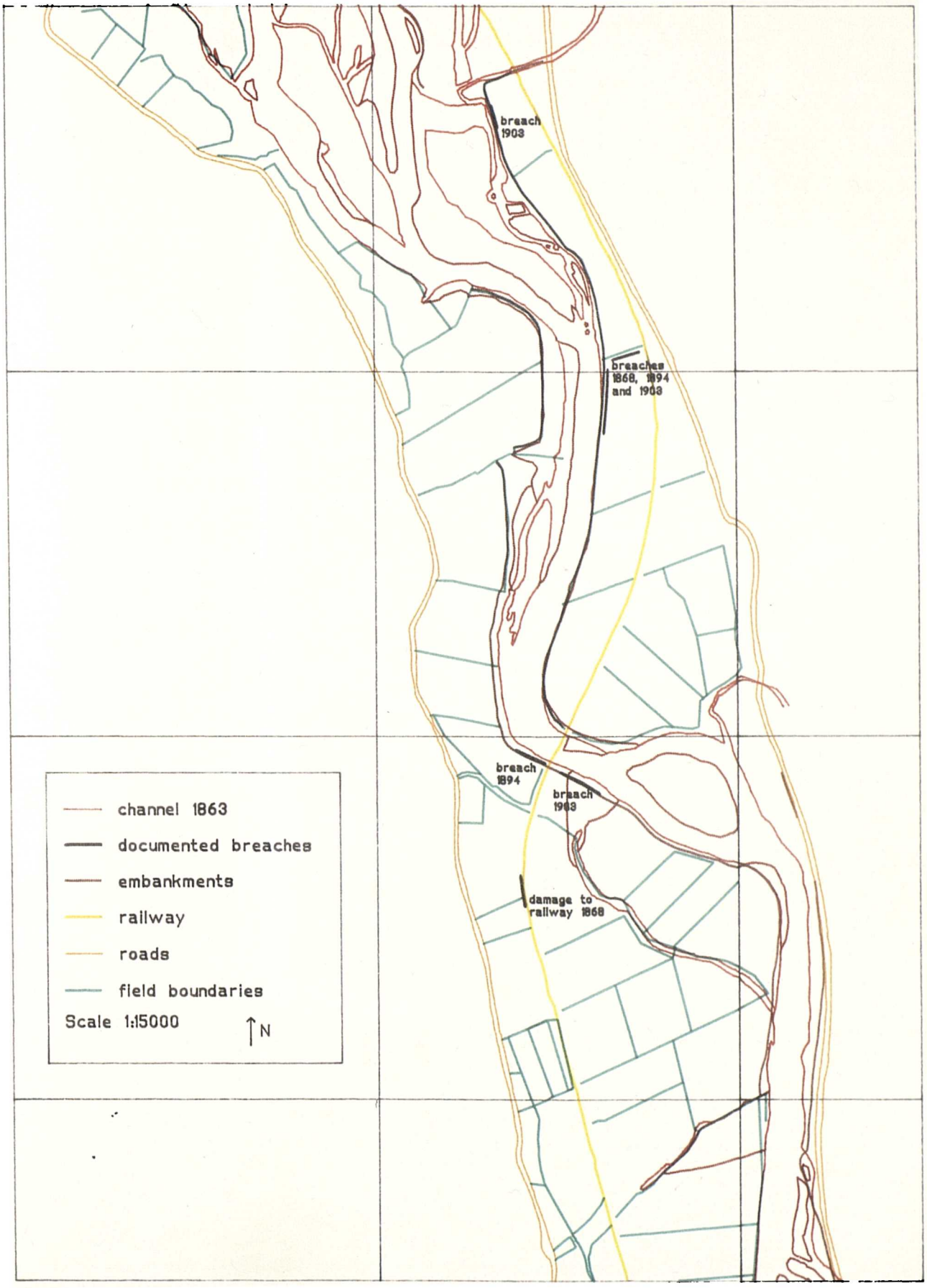


Figure 3.8c. Historically documented embankment breaches.

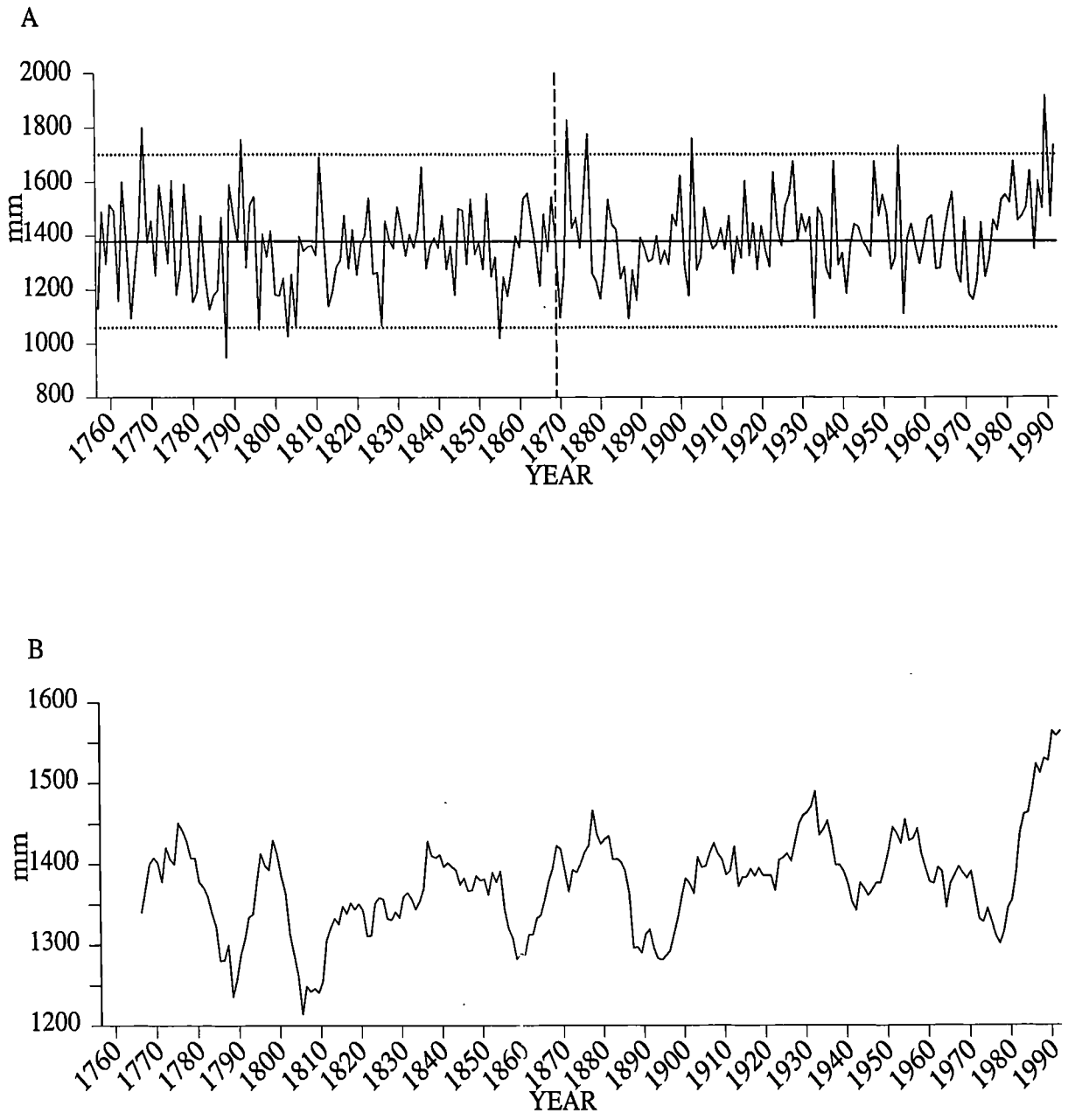


Figure 3.9. Precipitation variability in Scotland 1760 to 1990 (after Smith, 1995).
a) Annual rainfall, b) 10 year running mean.

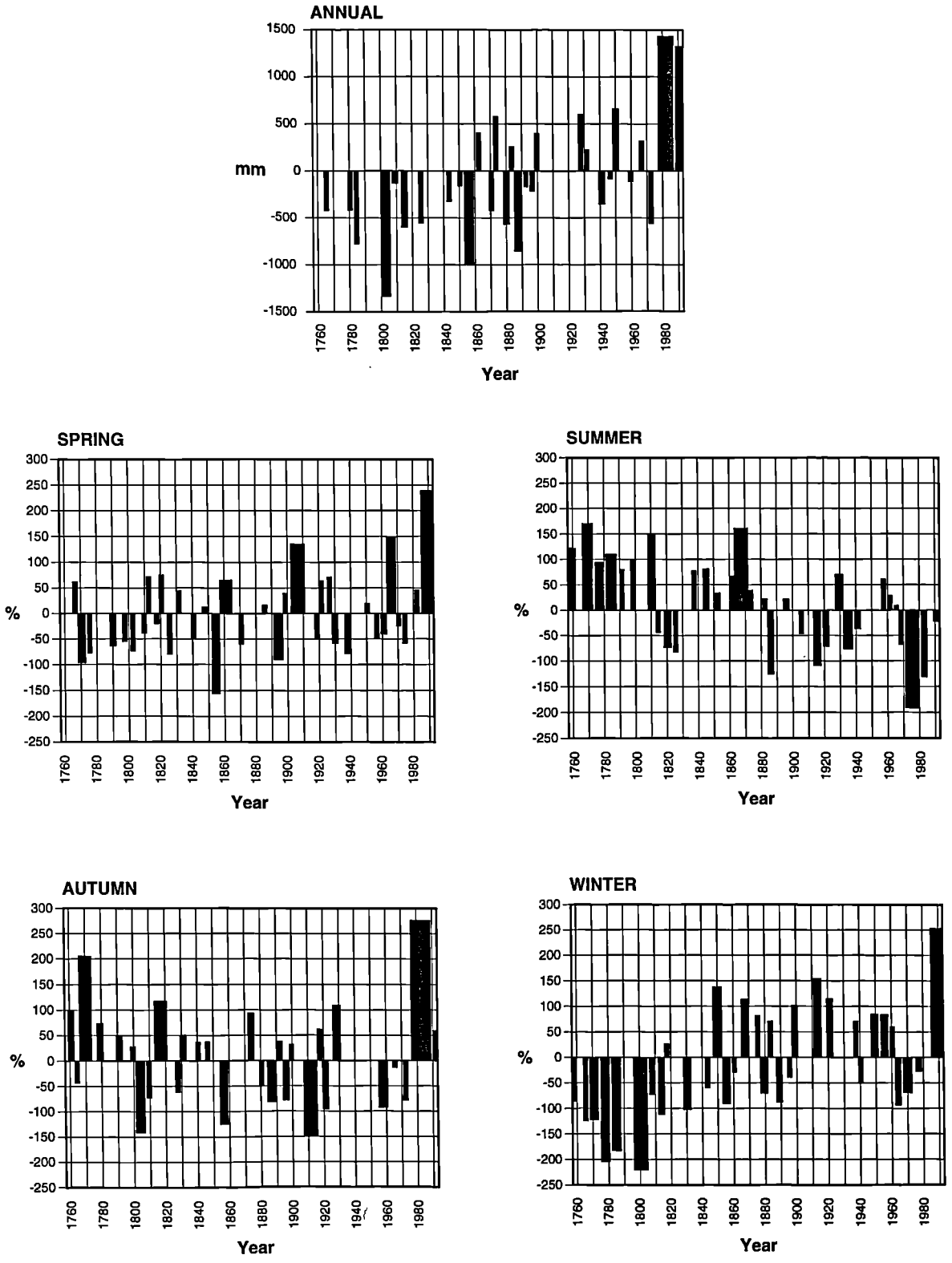


Figure 3.10. Cumulative departures of precipitation from the long-term (1757-1992) mean for periods with three or more consecutive years or seasons above or below the mean. Annual departures in millimetres and seasonal departures in percentage (Smith, 1995).

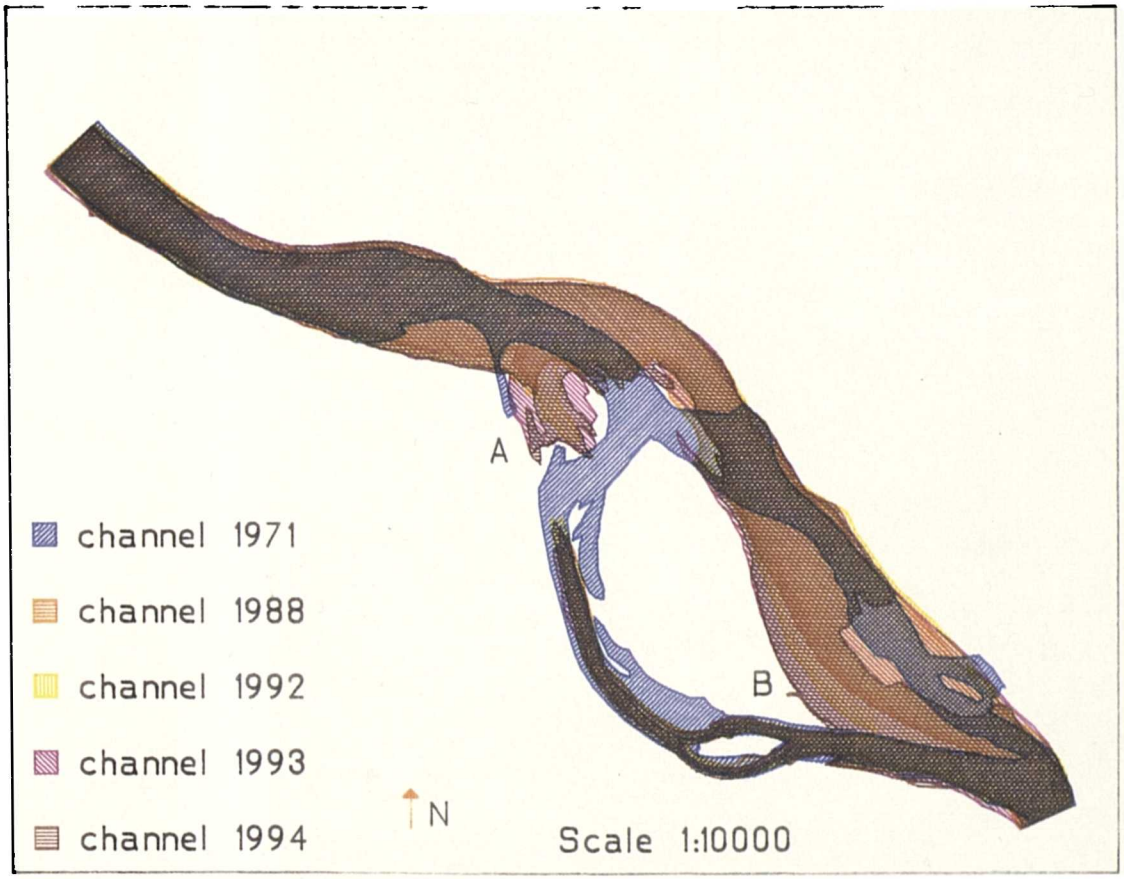
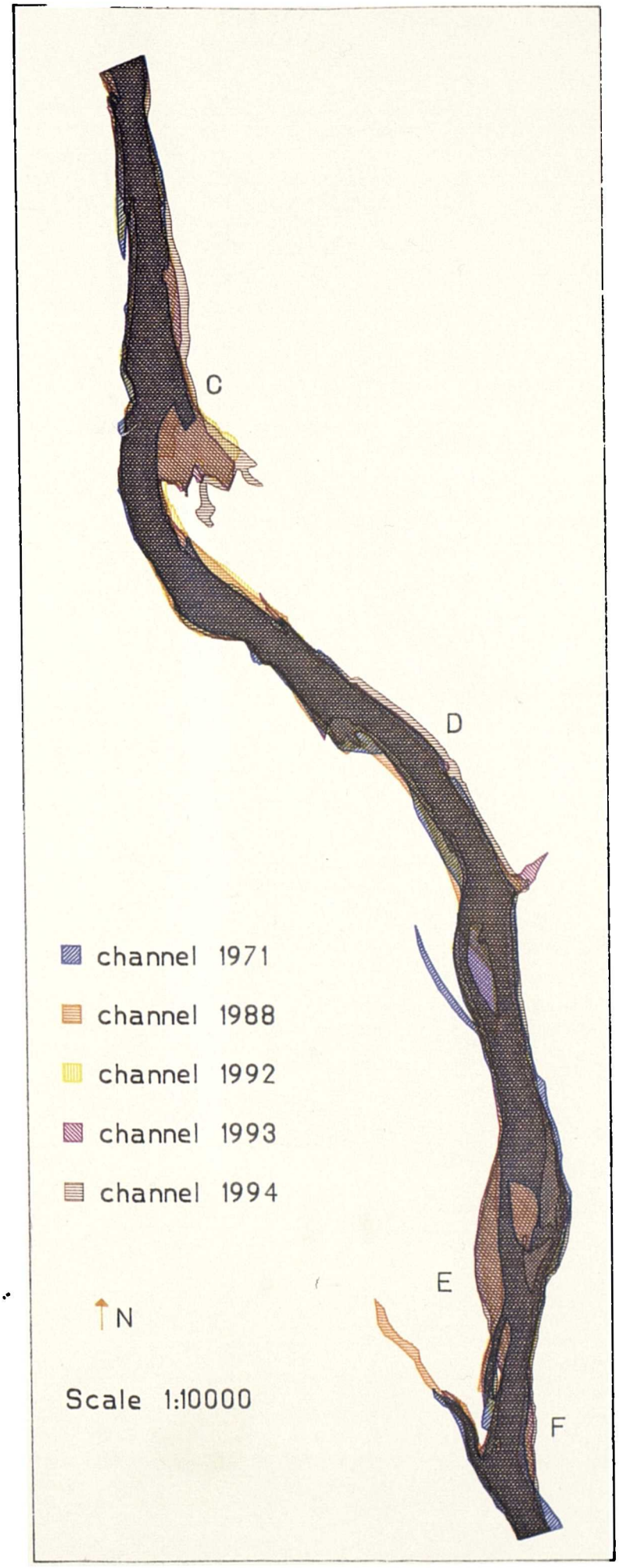


Figure 4.1a. Section 1. (unstable).



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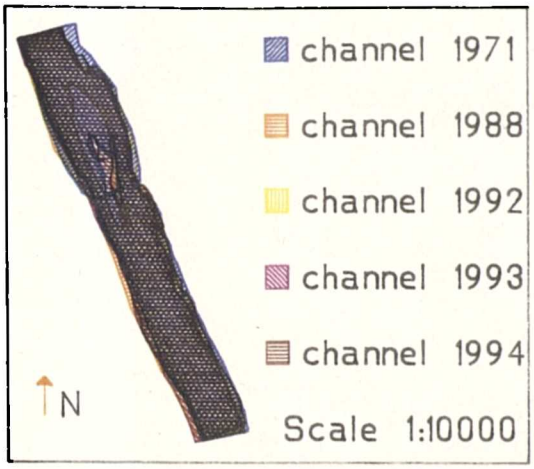
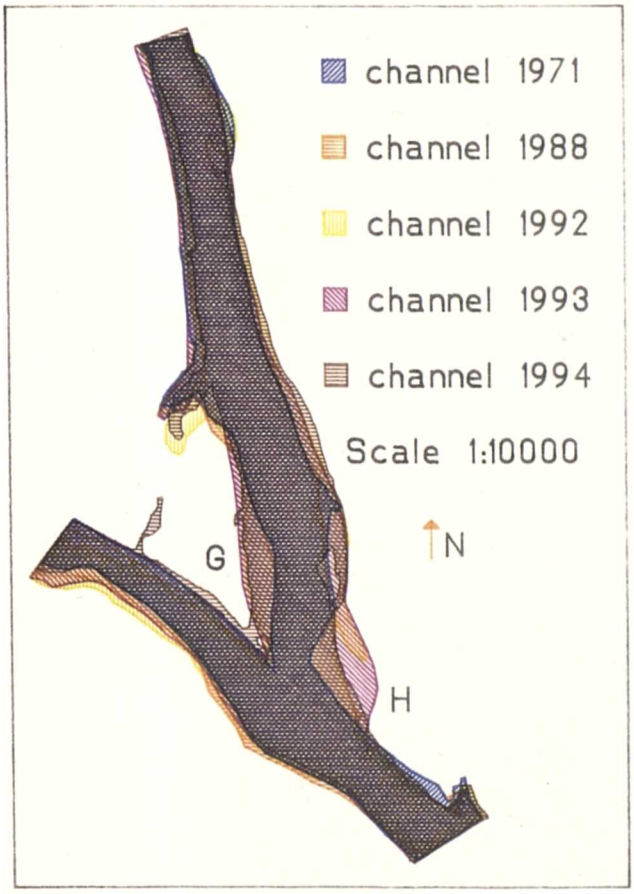


Figure 4.1c. Section 3. (stable)



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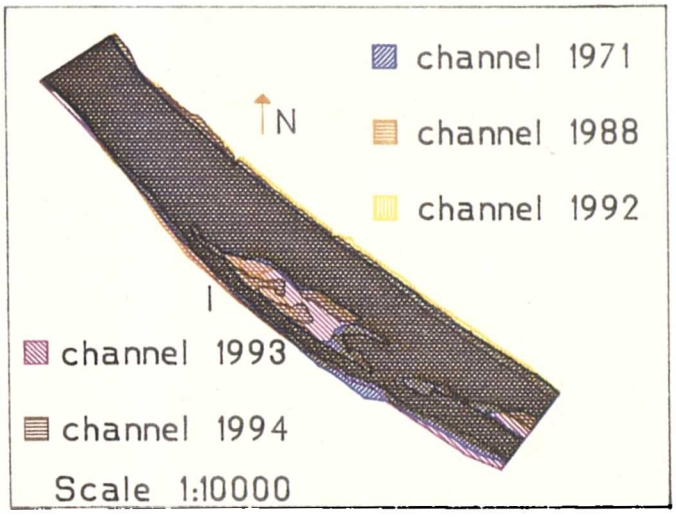

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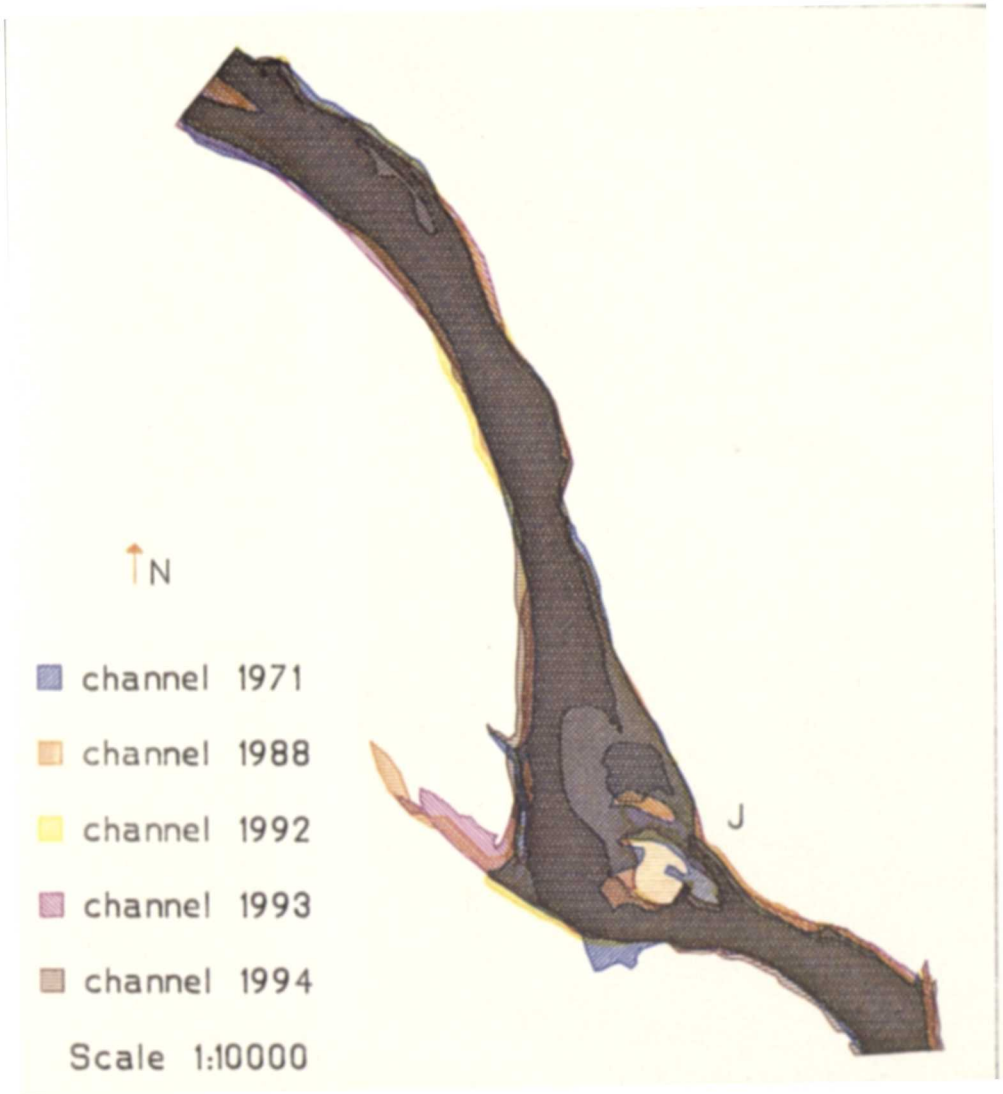


Figure 4.1f. Section 6. (unstable)

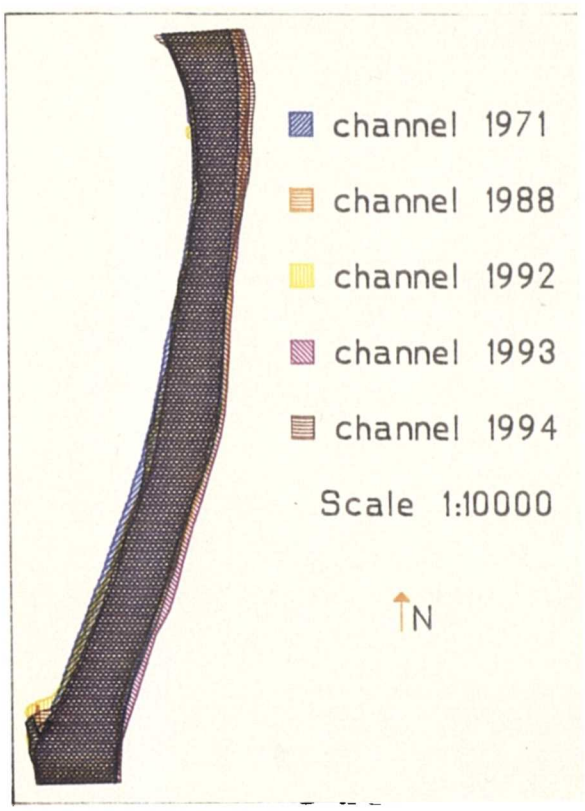


Figure 4.1g. Section 7. (stable)

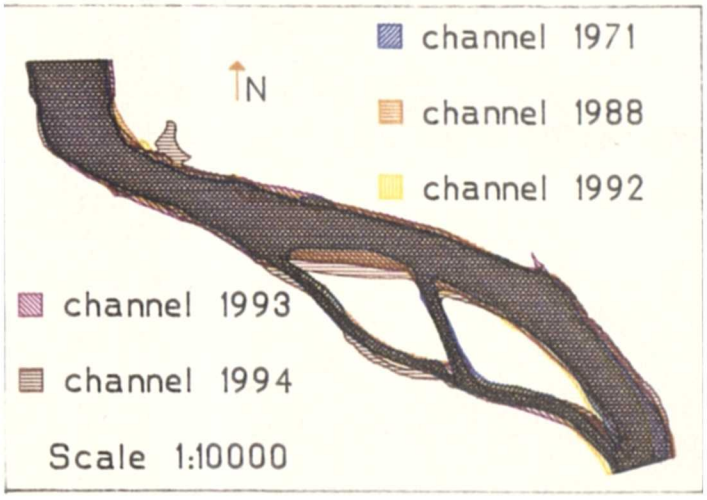


Figure 4.1h. Section 8. (unstable)

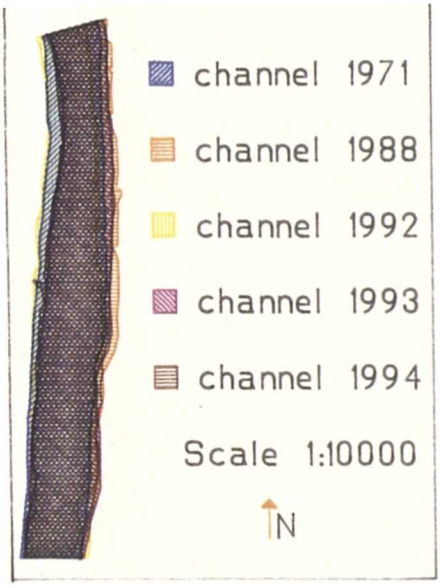


Figure 4.1i. Section 9. (stable)

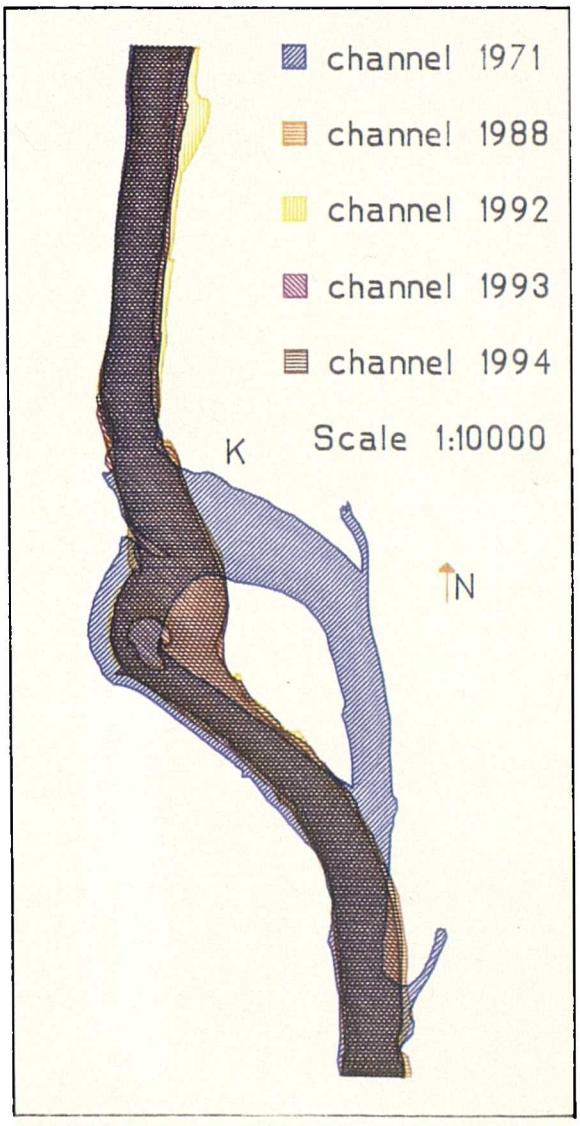


Figure 4.1j. Section 10.
(unstable)

Figure 4.2.

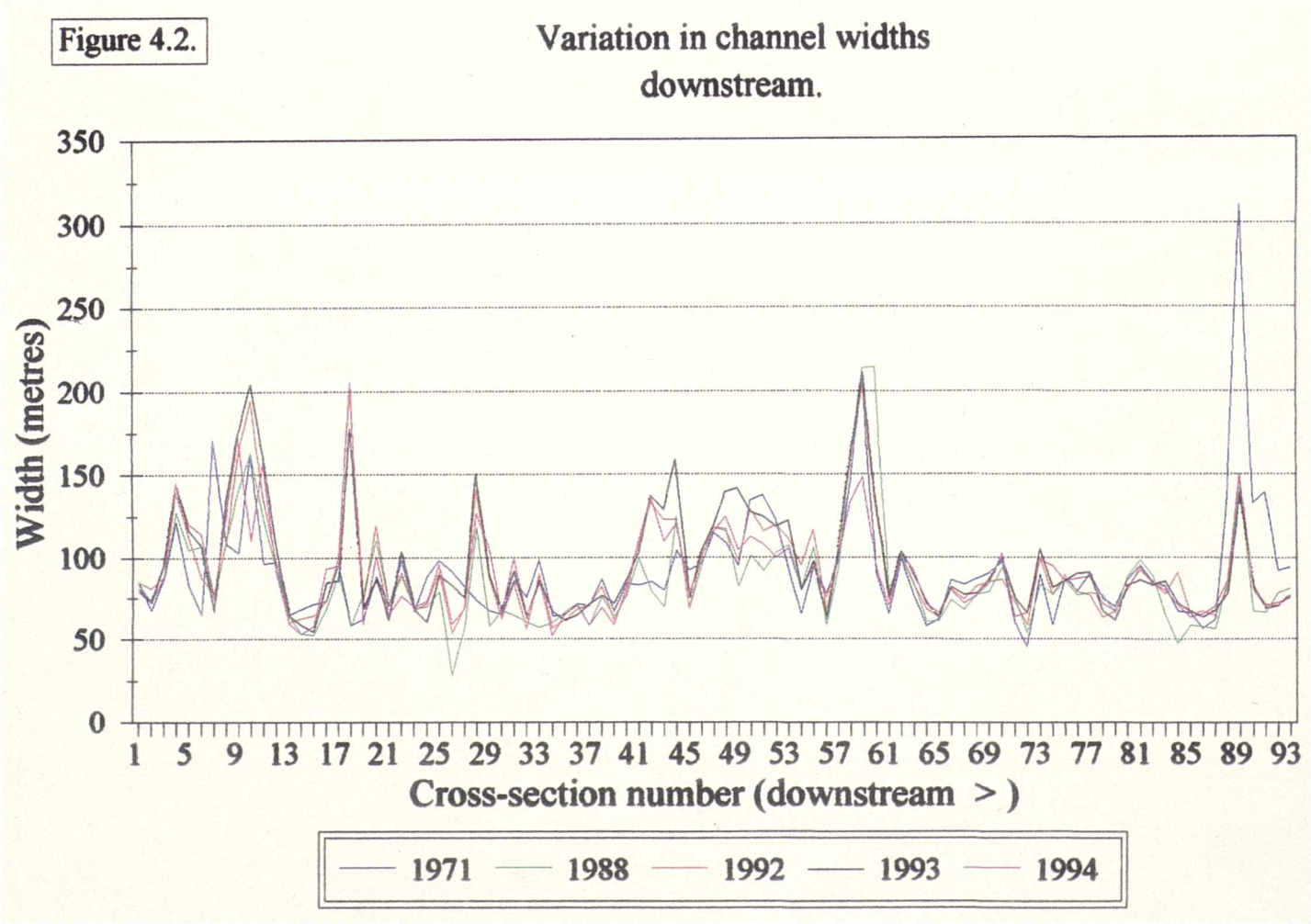

Variation in channel widths downstream.
Width (metres)
350
300
250
200
150
100
50
0
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93
Cross-section number (downstream >)
1971
1988
1992
1993
1994

Figure 4.3.

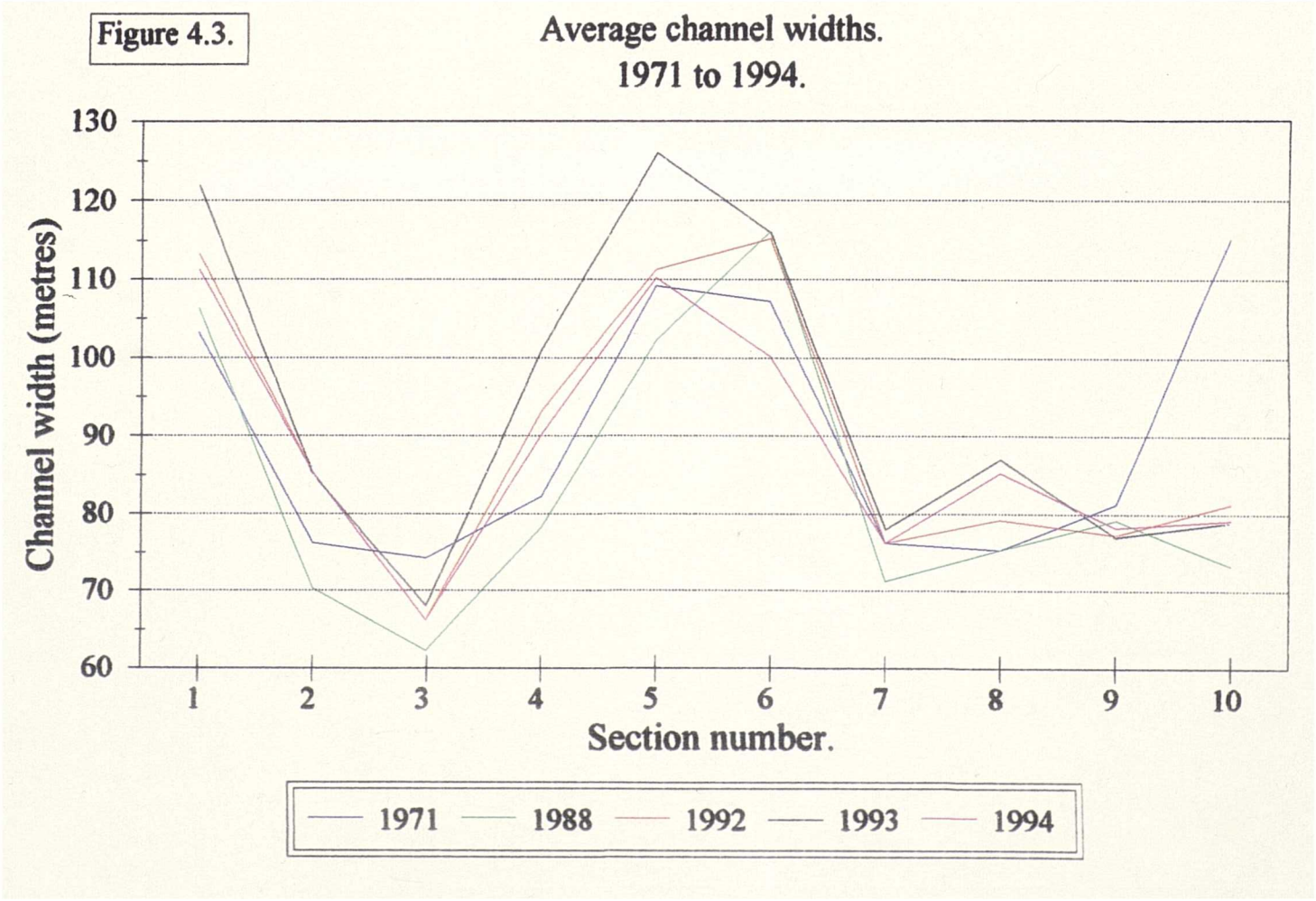
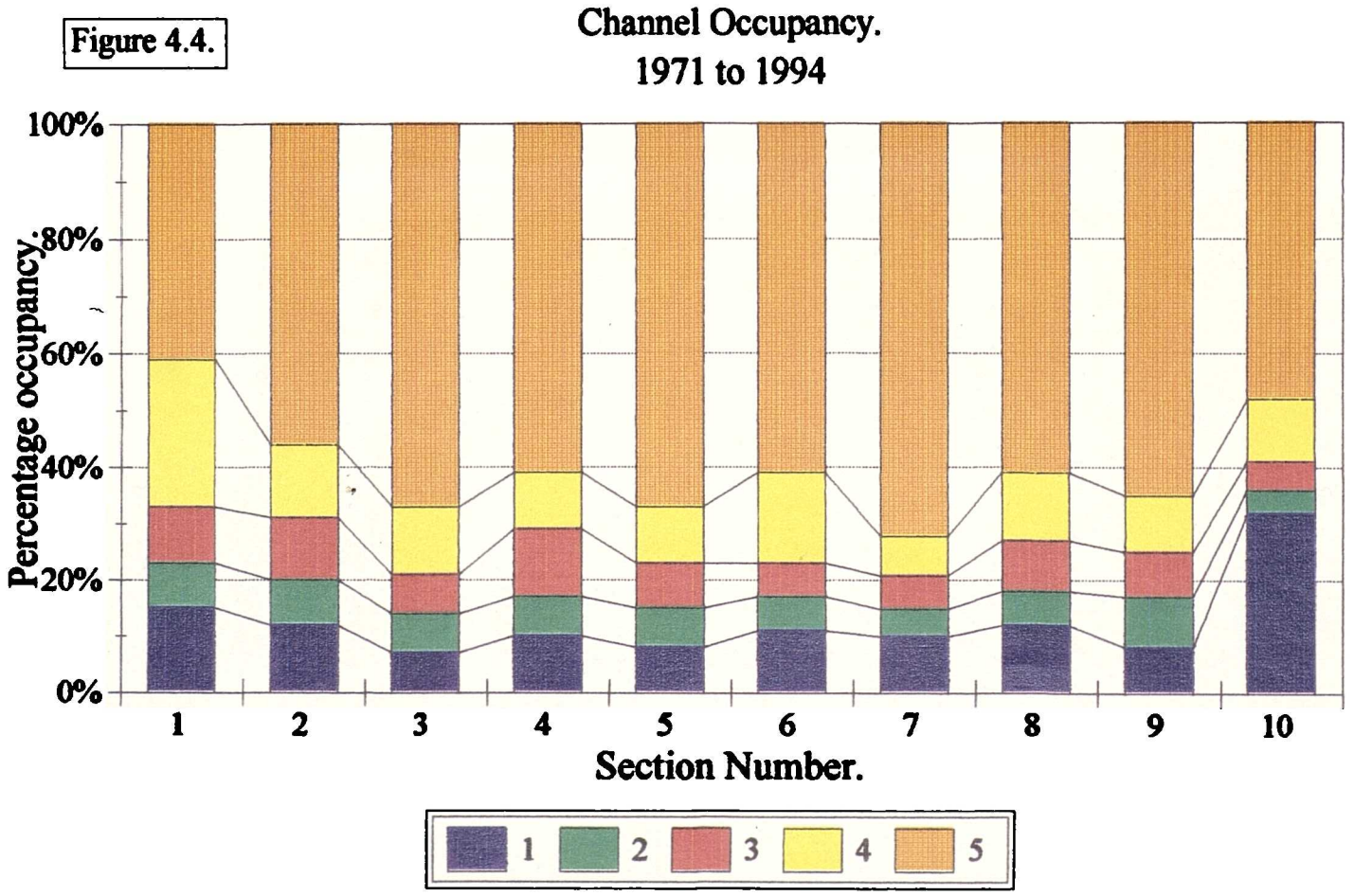

Average channel widths.
1971 to 1994.
Channel width (metres)
130
120
110
100
90
80
70
60
1
2
3
4
5
6
7
8
9
10
Section number.
1971
1988
1992
1993
1994

Figure 4.4.


Channel Occupancy.
1971 to 1994
100%
80%
60%
40%
20%
0%
Percentage occupancy.
1
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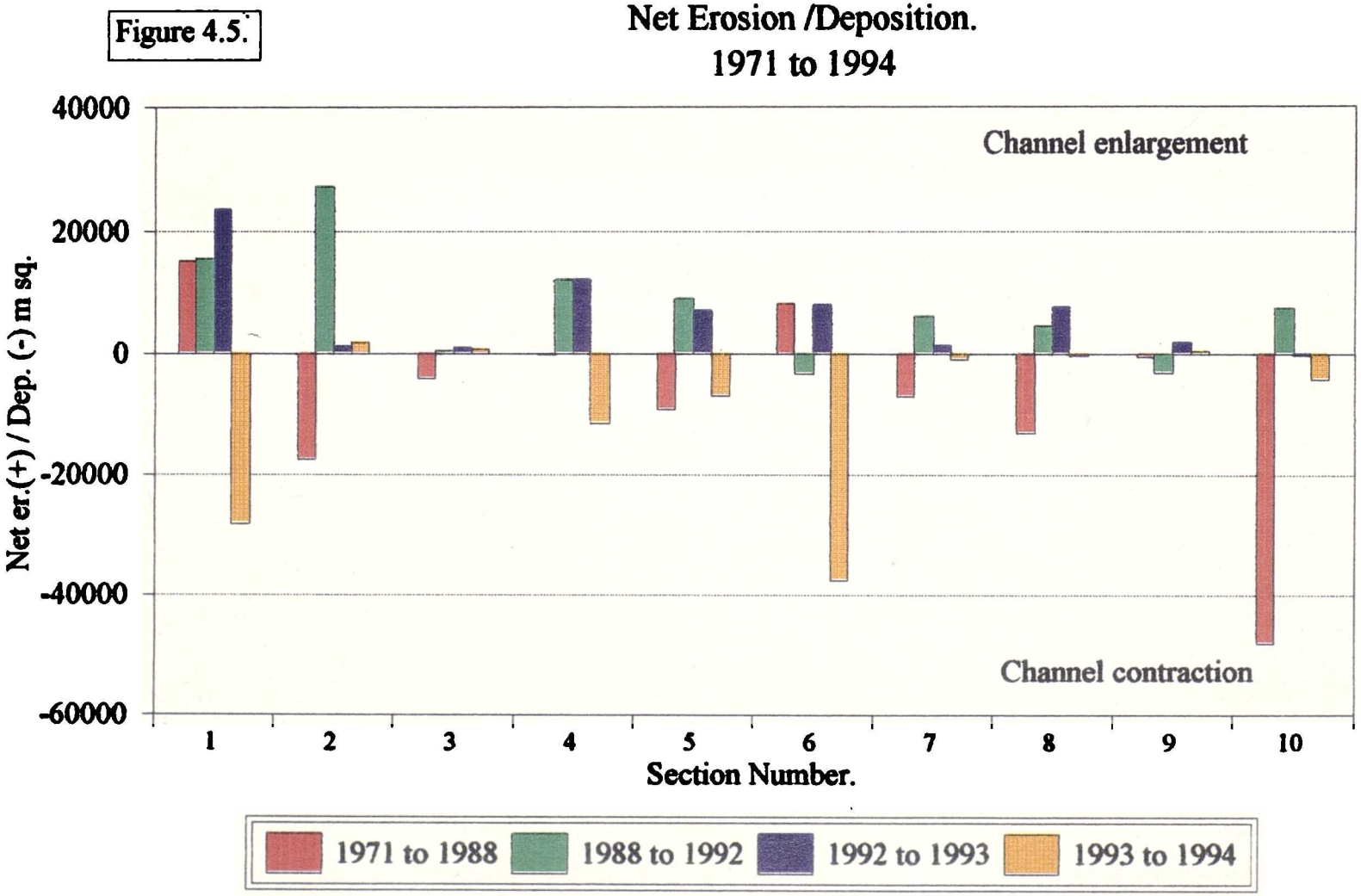
3
4
5
6
7
8
9
10
Section Number.
1
2
3
4
5

Figure 4.5.


Net Erosion /Deposition.
1971 to 1994
Channel enlargement
Channel contraction
Net er.(+) / Dep. (-) m sq.
40000
20000
0
-20000
-40000
-60000
1
2
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4
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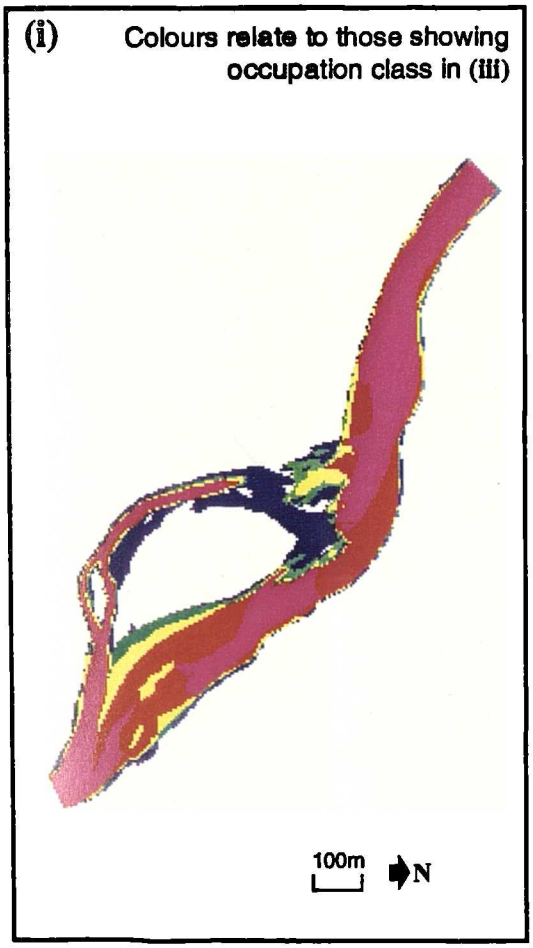
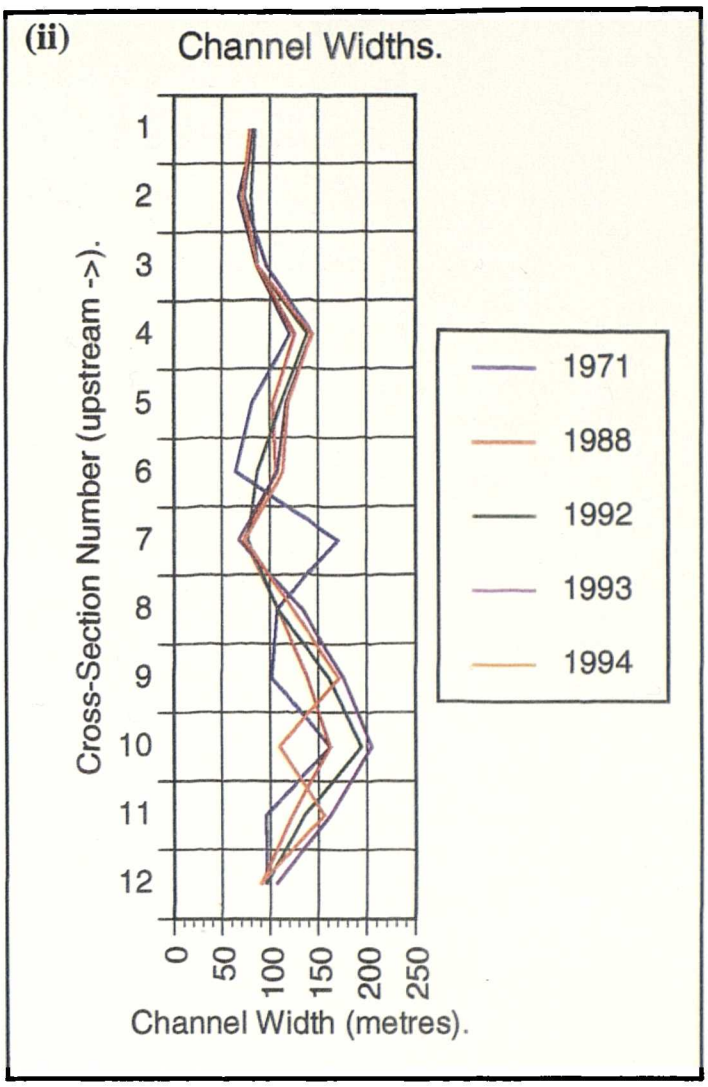
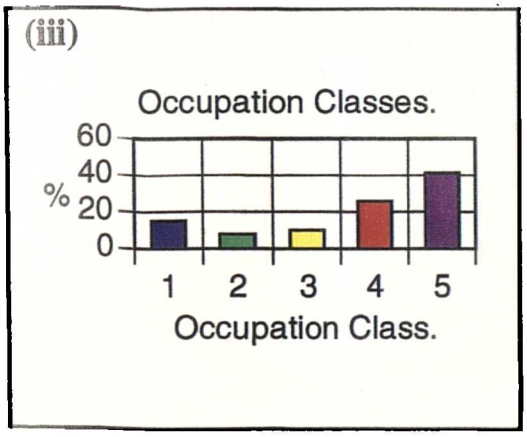
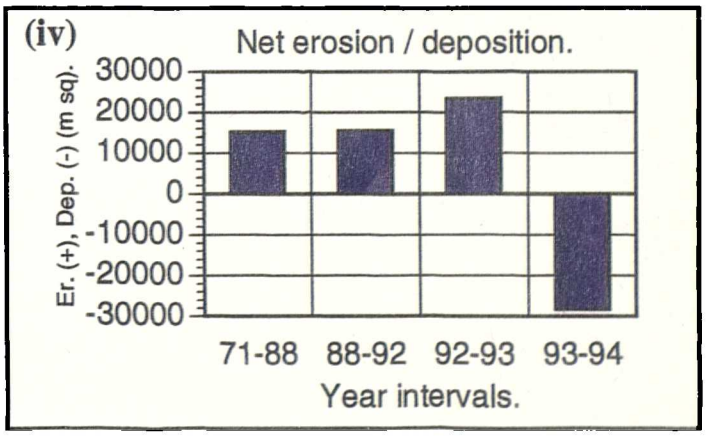
6
7
8
9
10
Section Number.
1971 to 1988
1988 to 1992
1992 to 1993
1993 to 1994

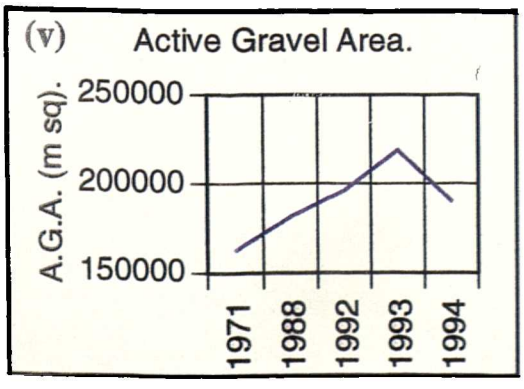
Section 1











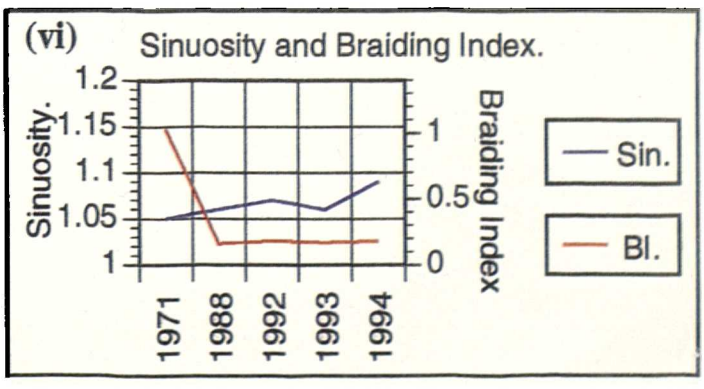
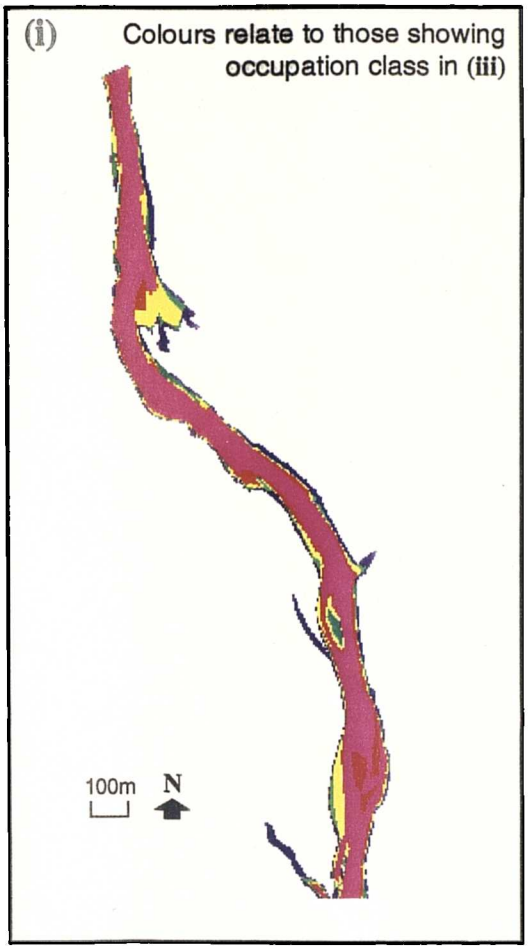
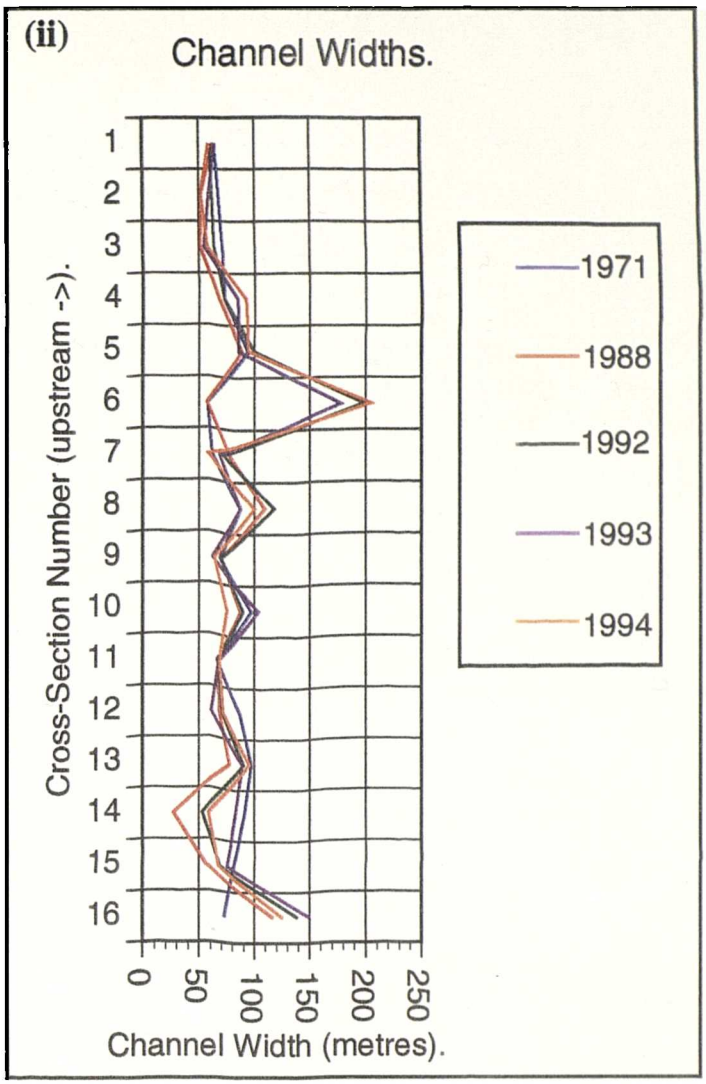
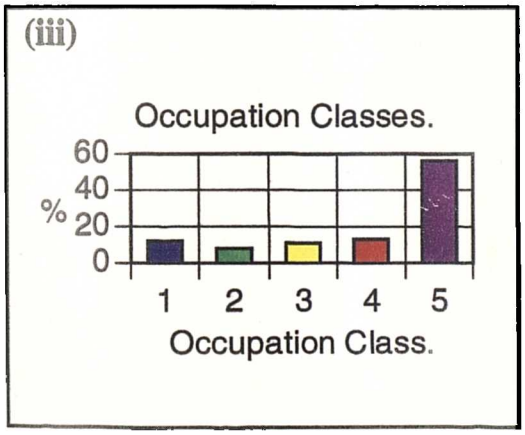
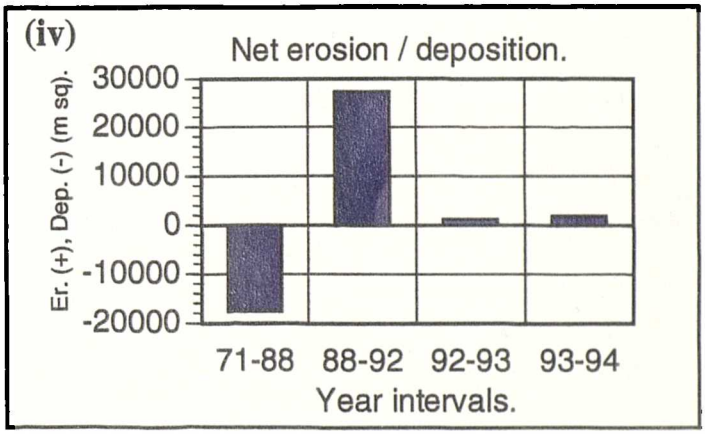


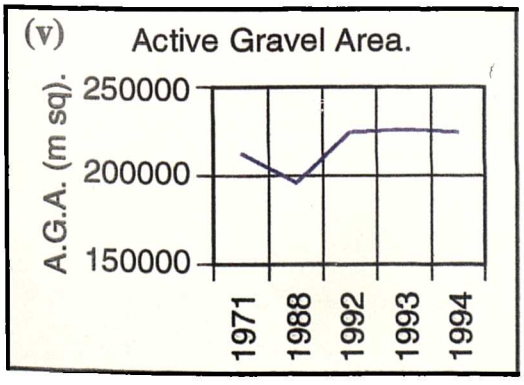
Figure 4.6a : Channel parameter changes 1971 to 1994.











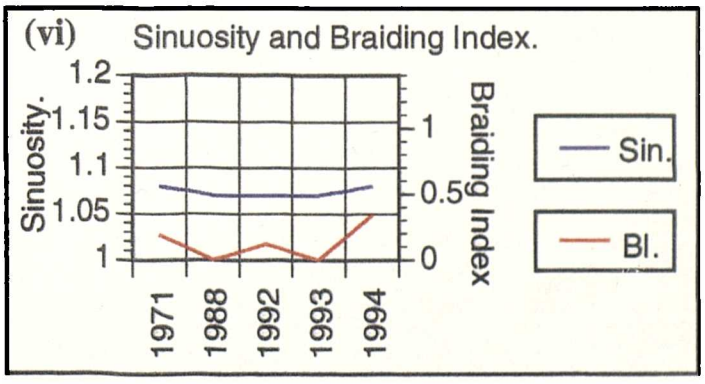
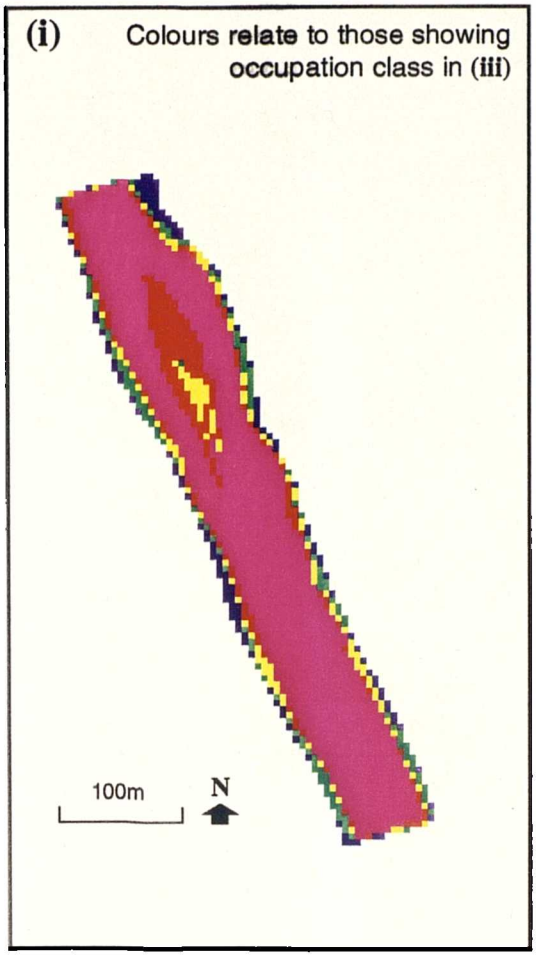
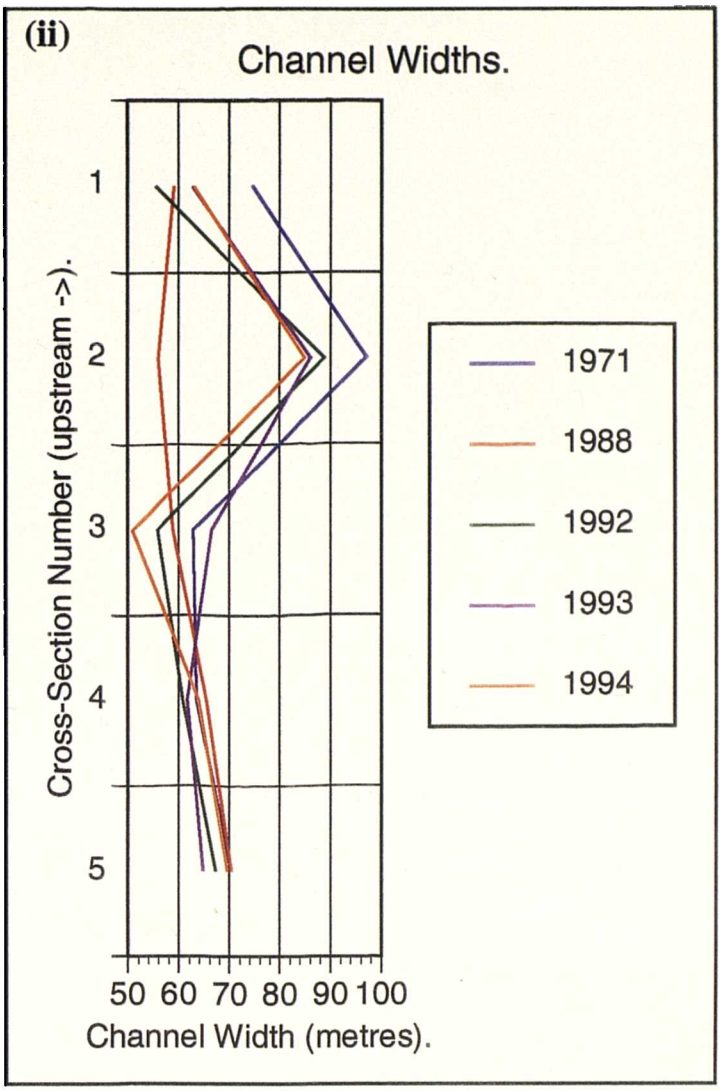
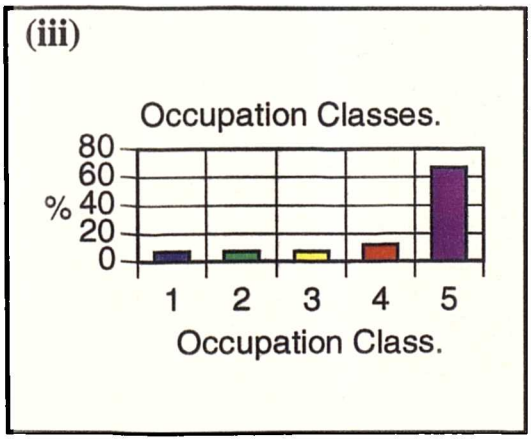
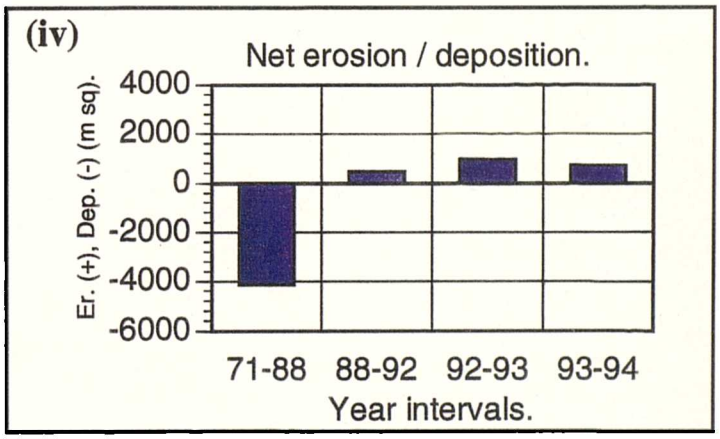


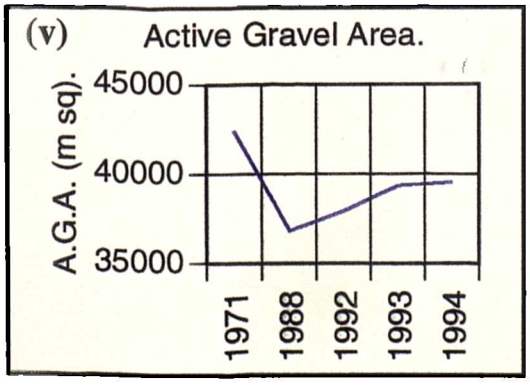
Figure 4.6b : Channel parameter changes 1971 to 1994.











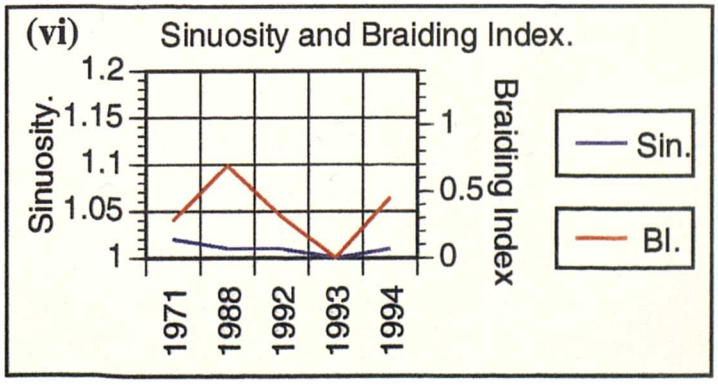
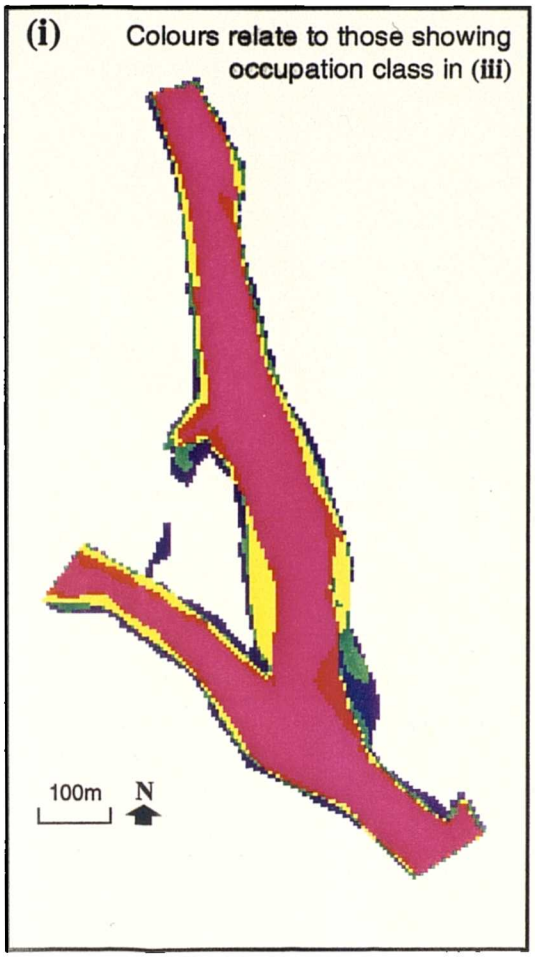
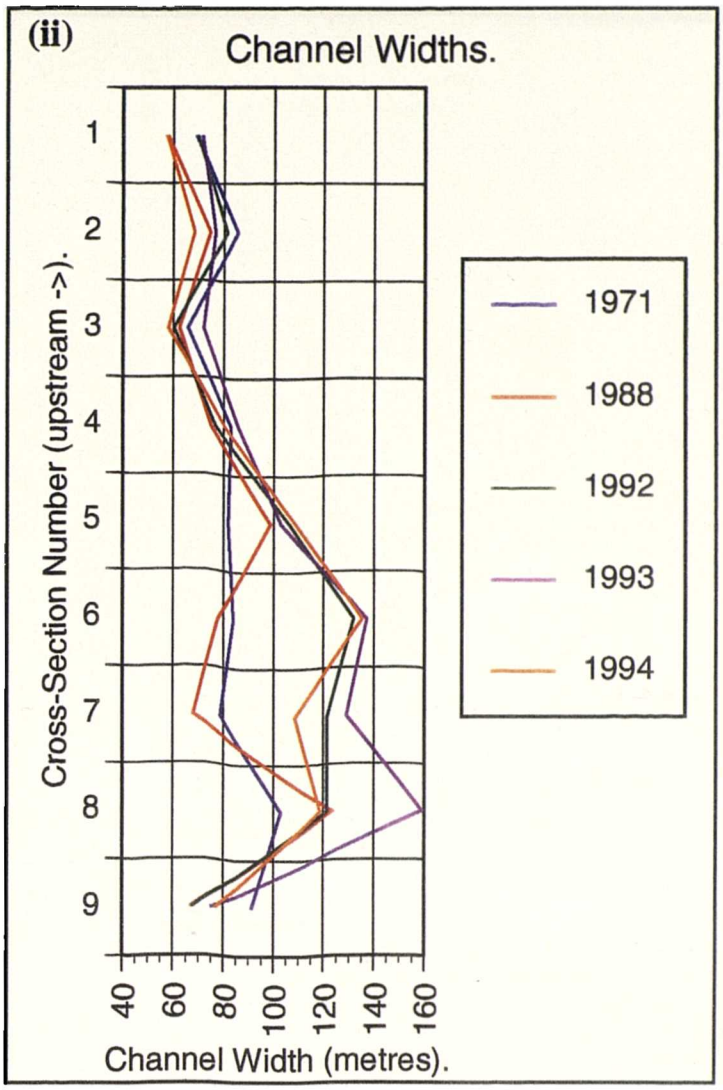
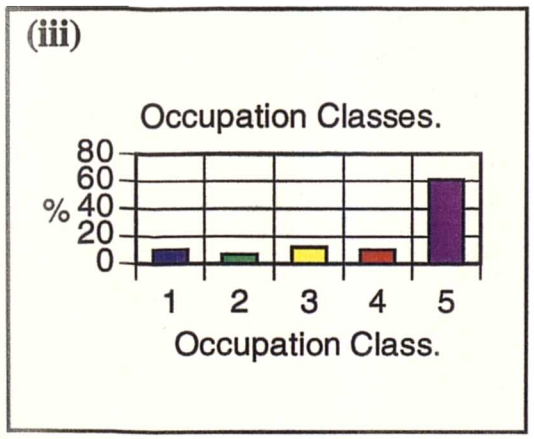
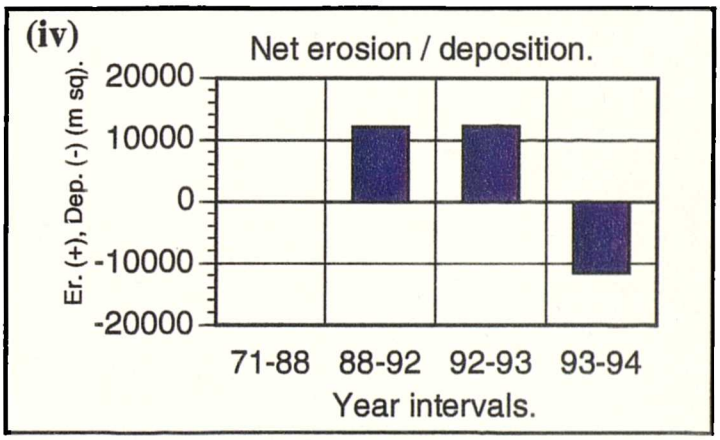


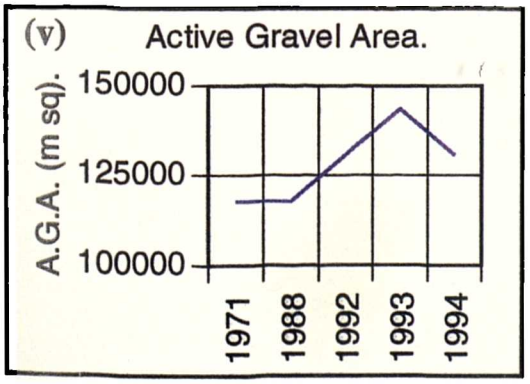
Figure 4.6c : Channel parameter changes 1971 to 1994.











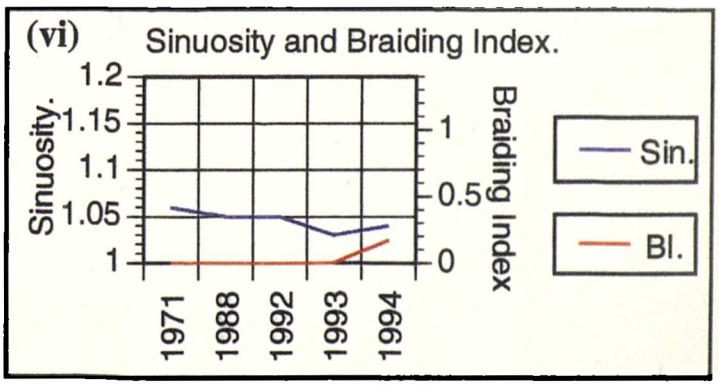
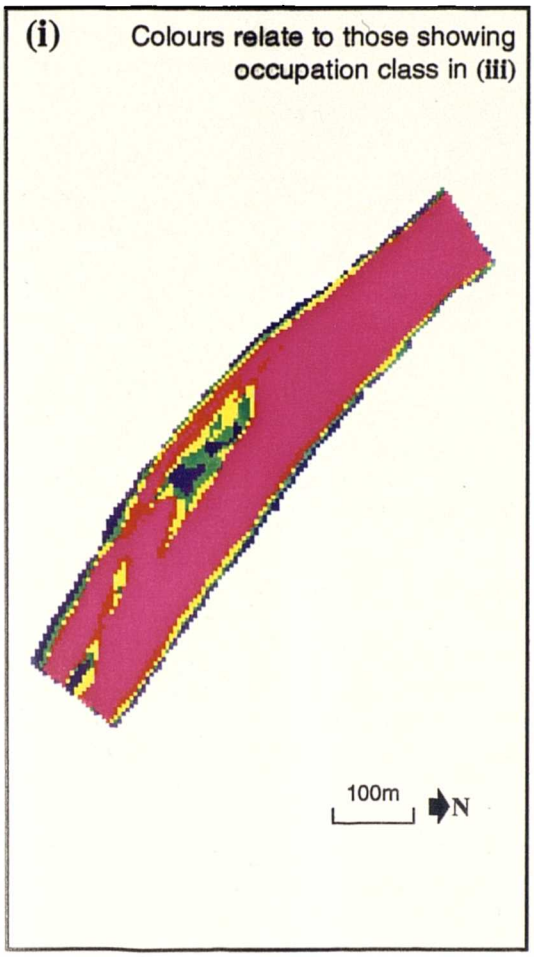
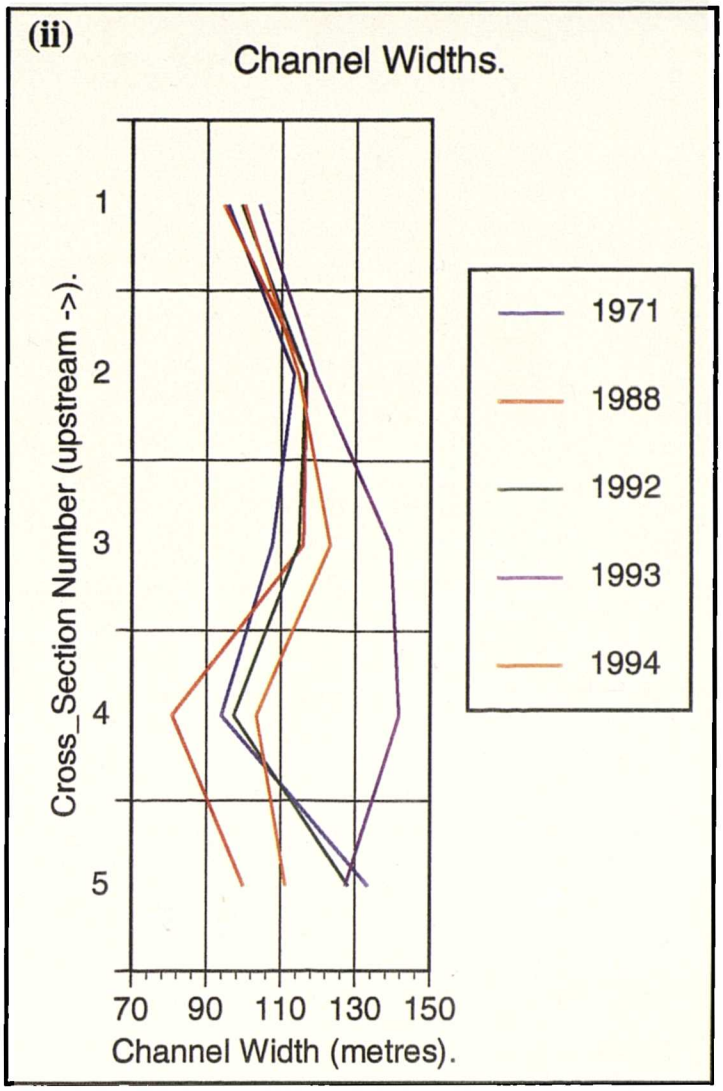
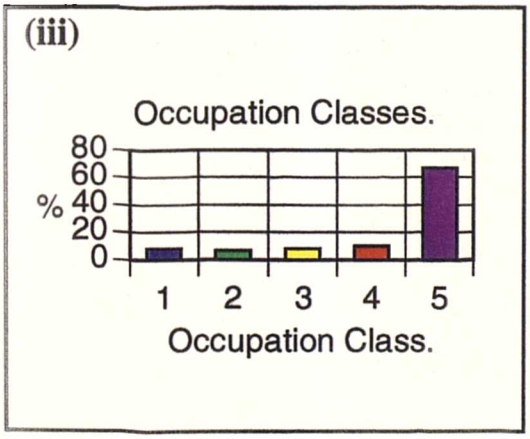
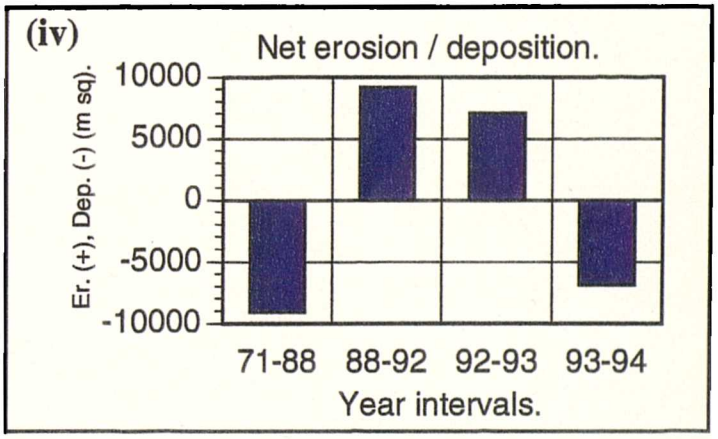


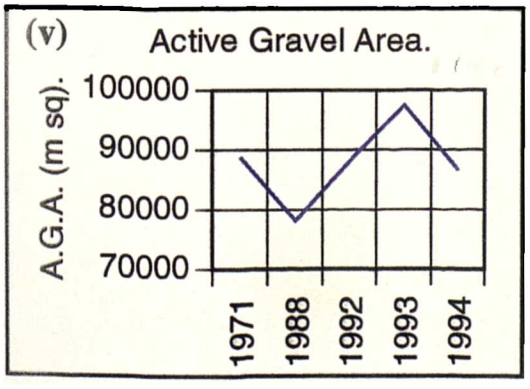
Figure 4.6d : Channel parameter changes 1971 to 1994.











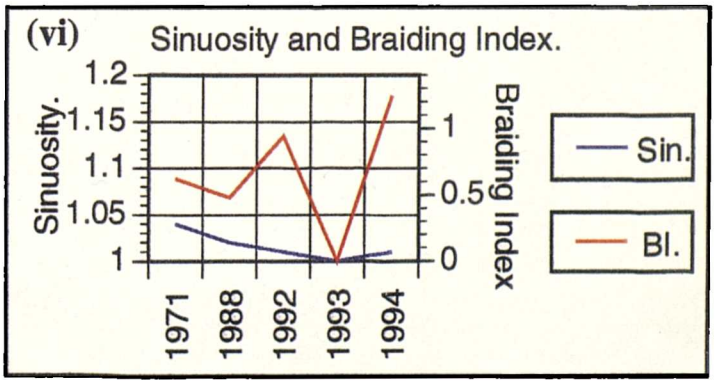
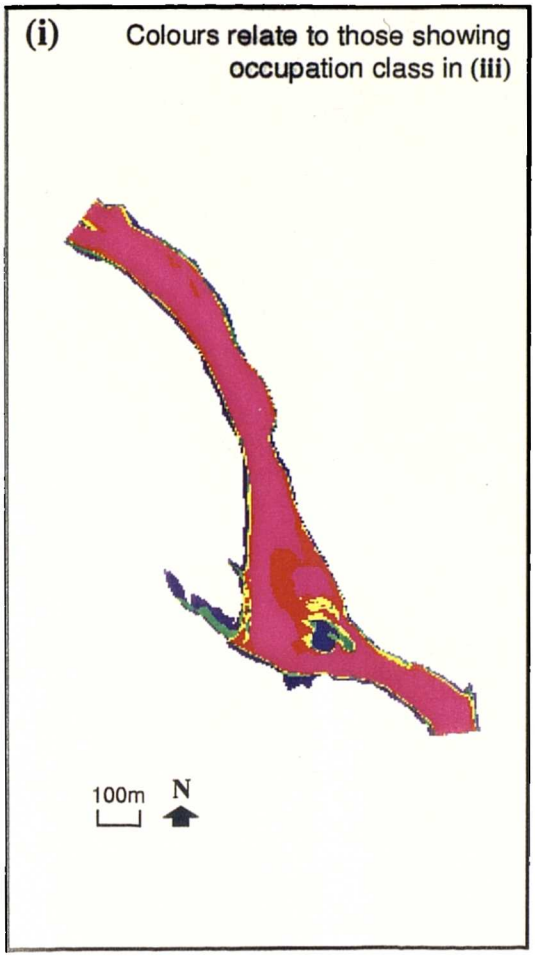
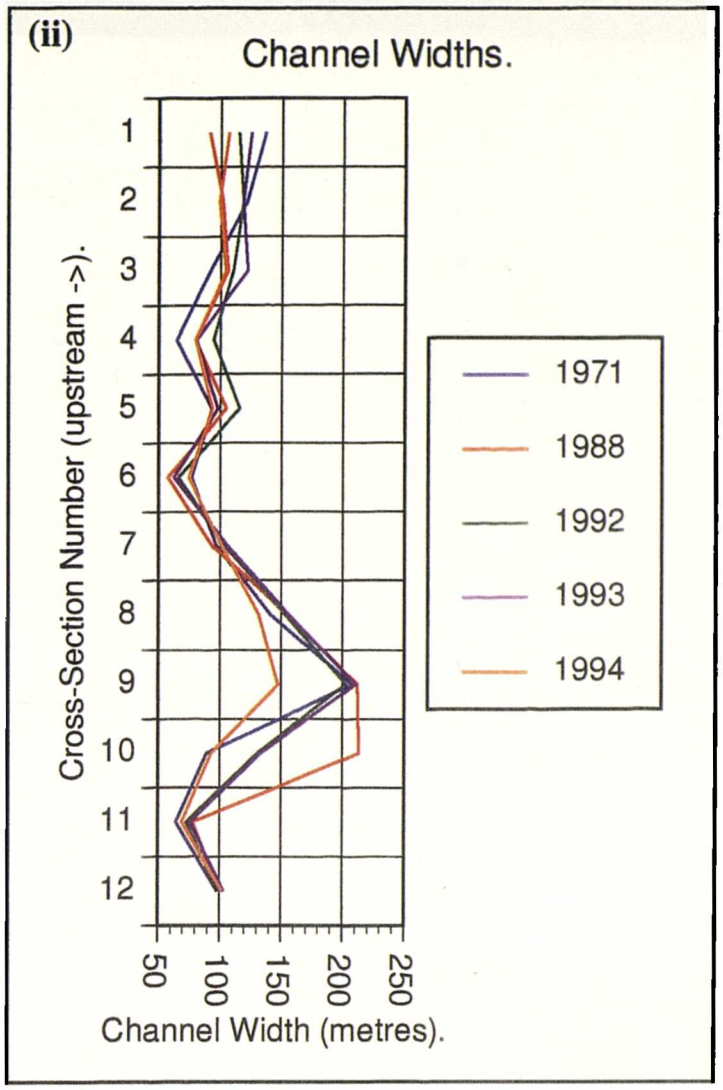
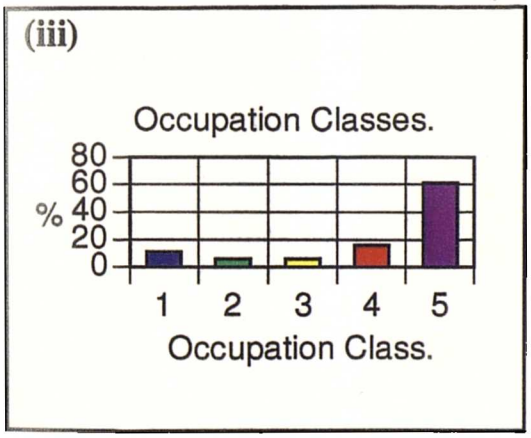
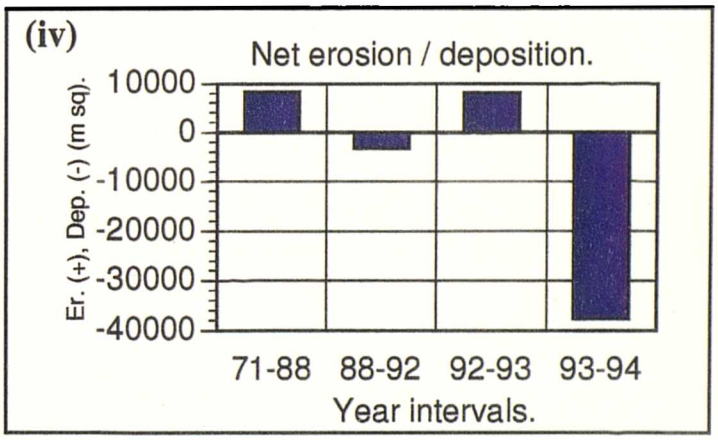


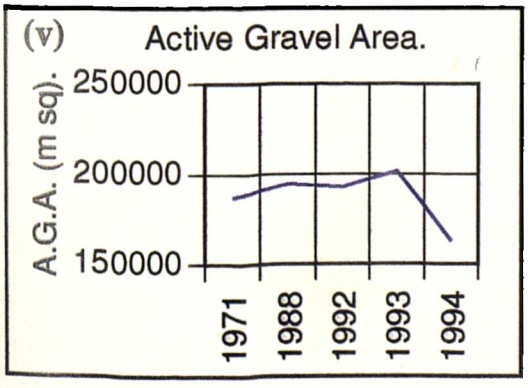
Figure 4.6e : Channel parameter changes 1971 to 1994.











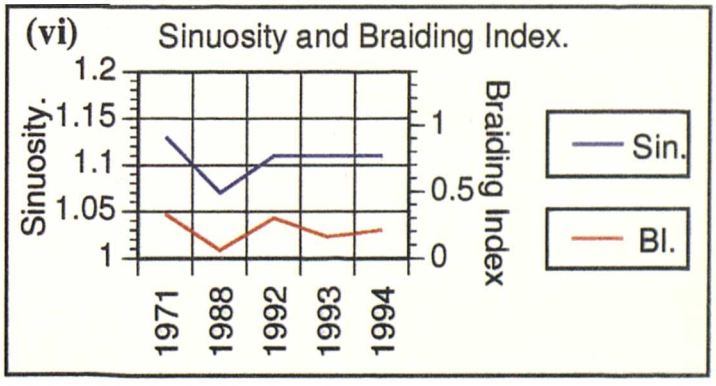
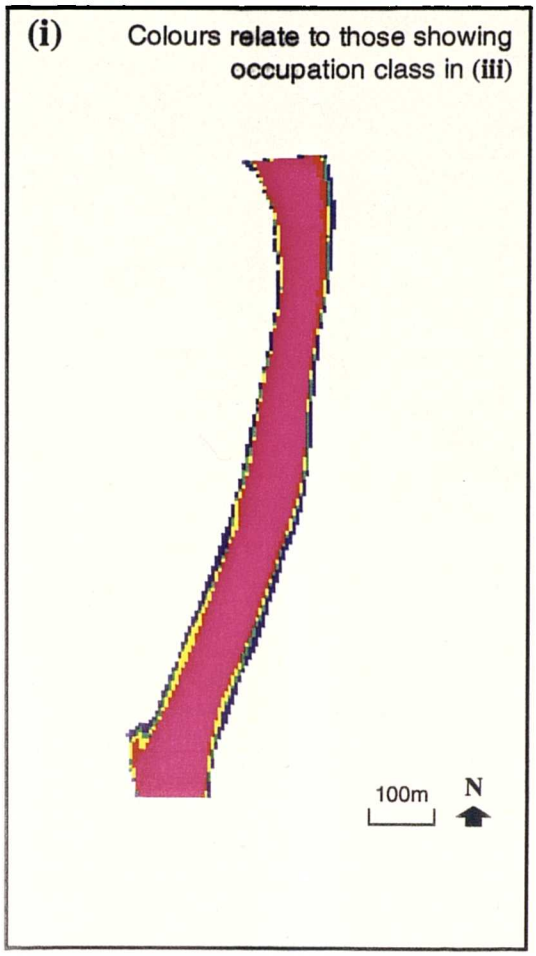
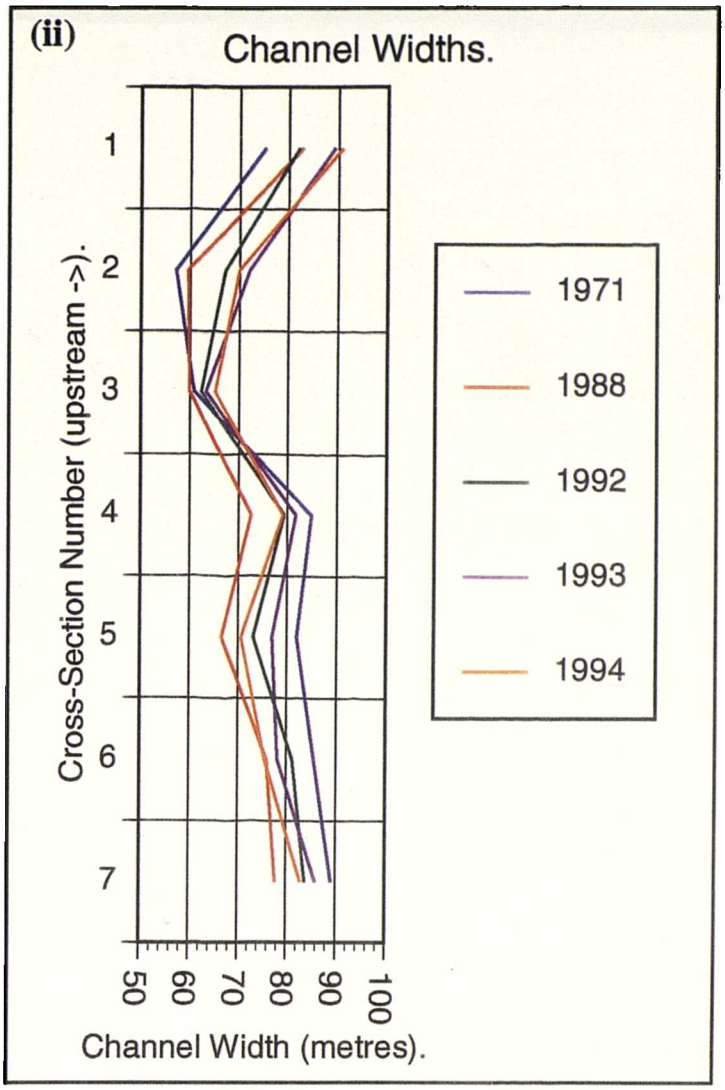
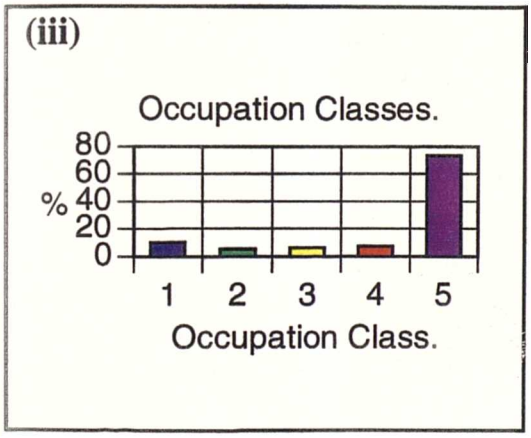
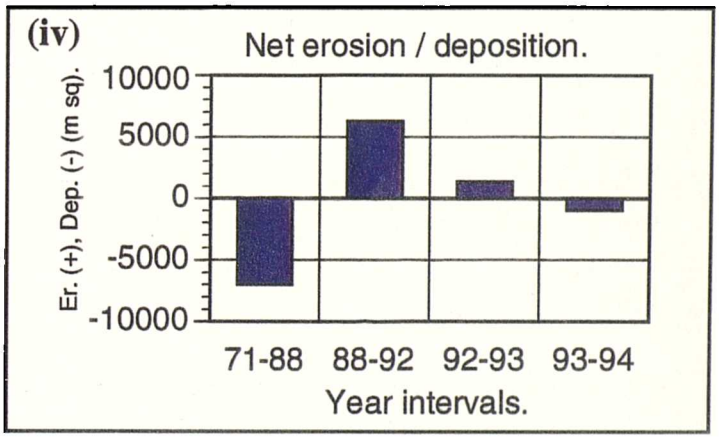


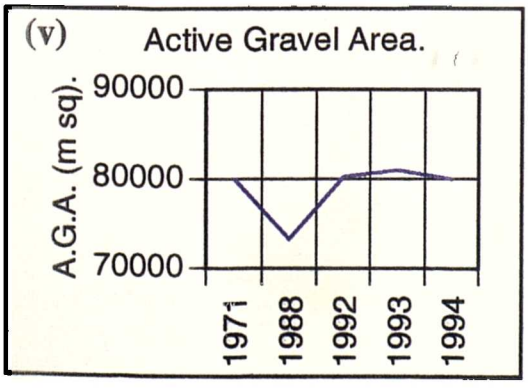
Figure 4.6f : Channel parameter changes 1971 to 1994.











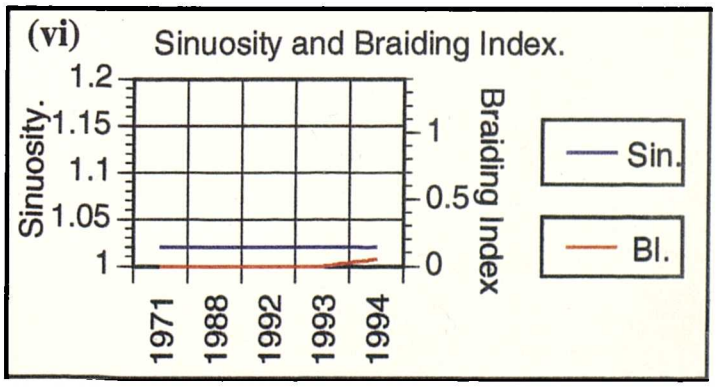
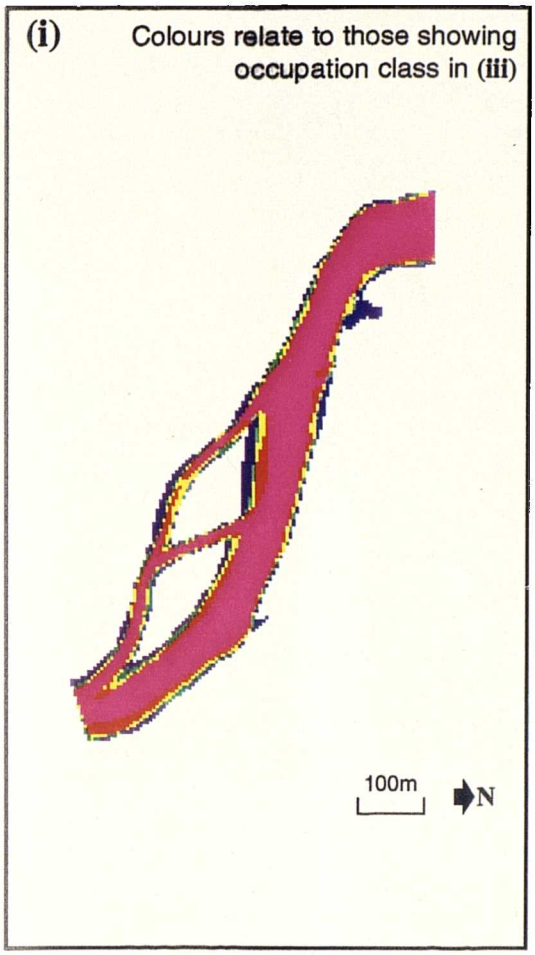
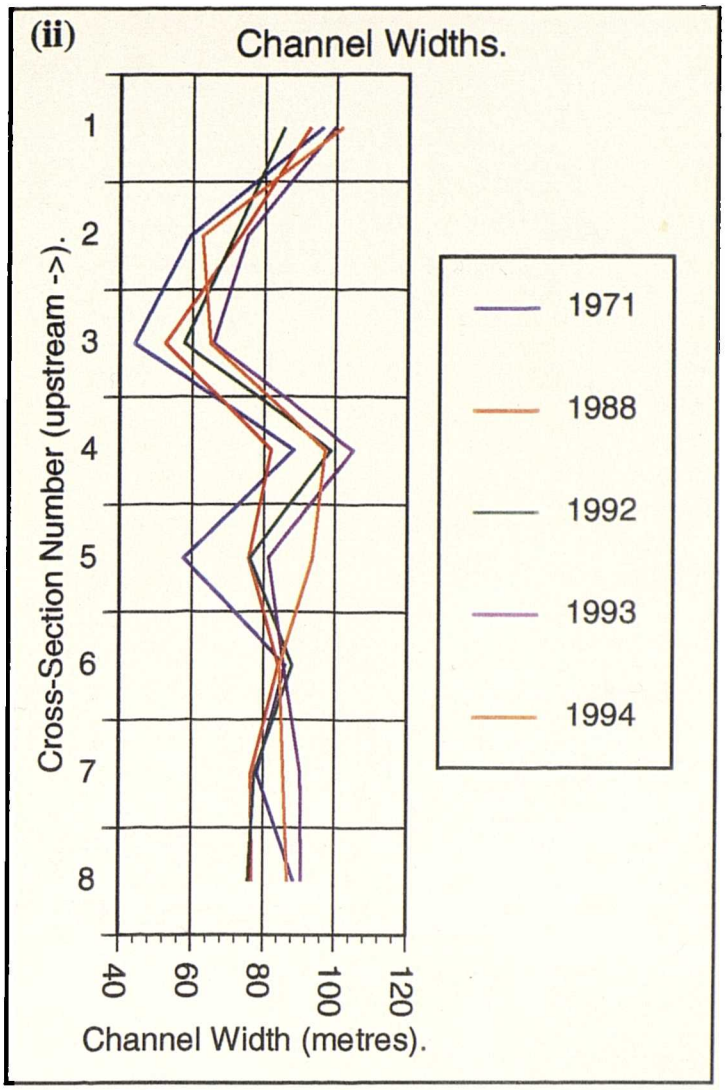
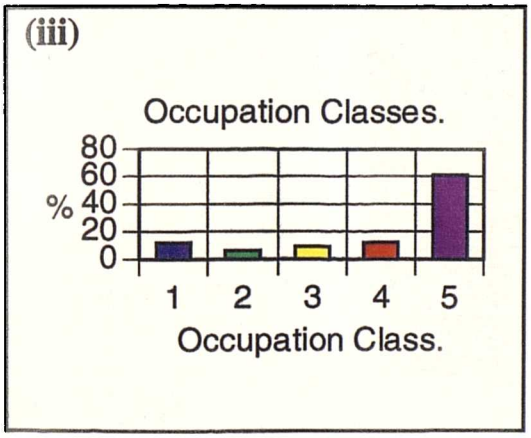
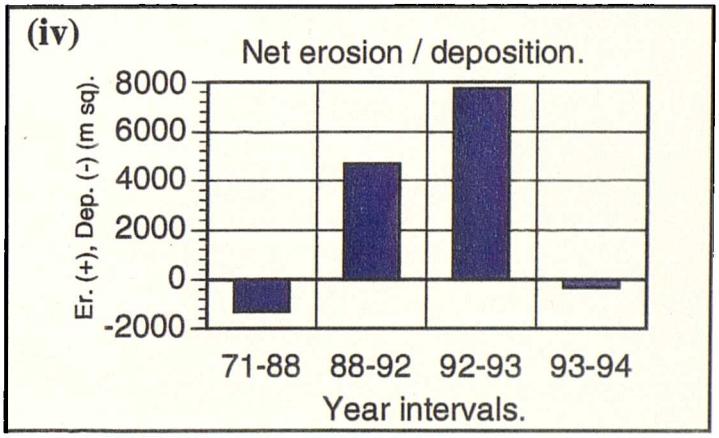


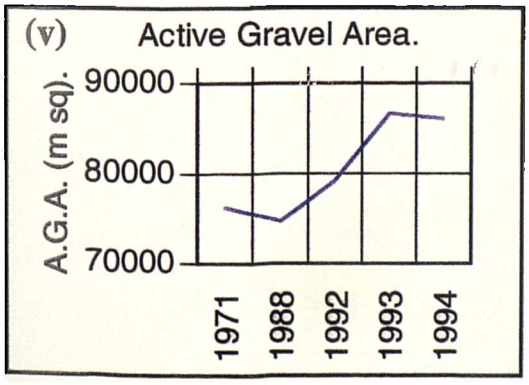
Figure 4.6g : Channel parameter changes 1971 to 1994.











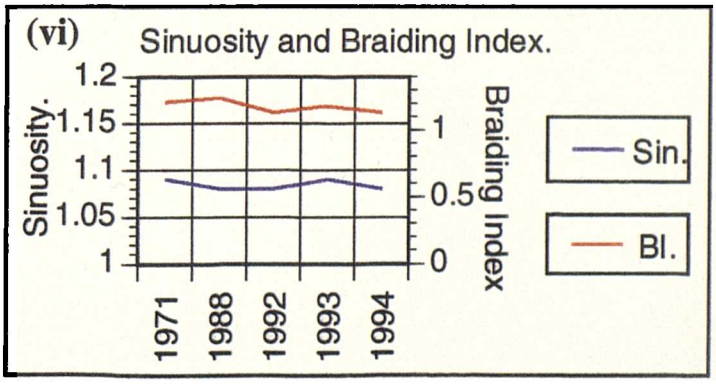
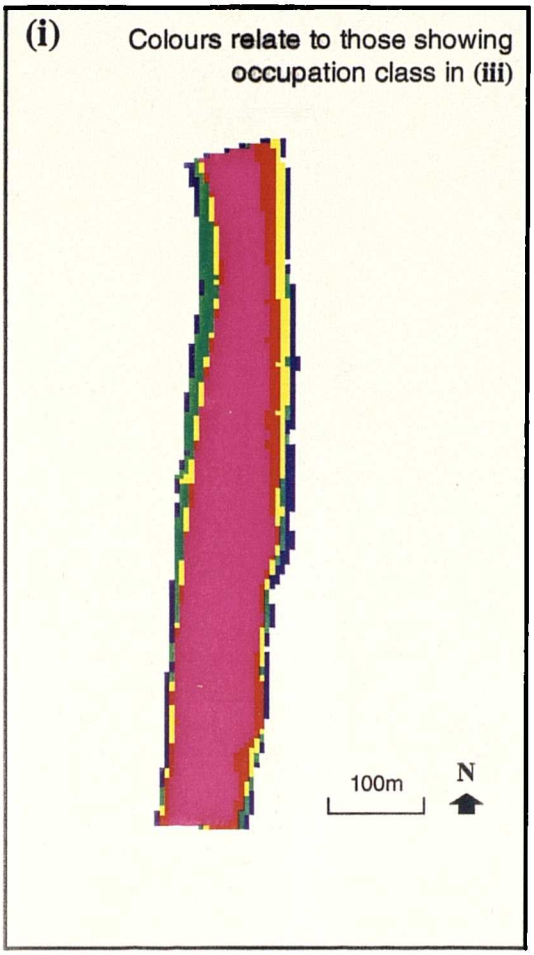
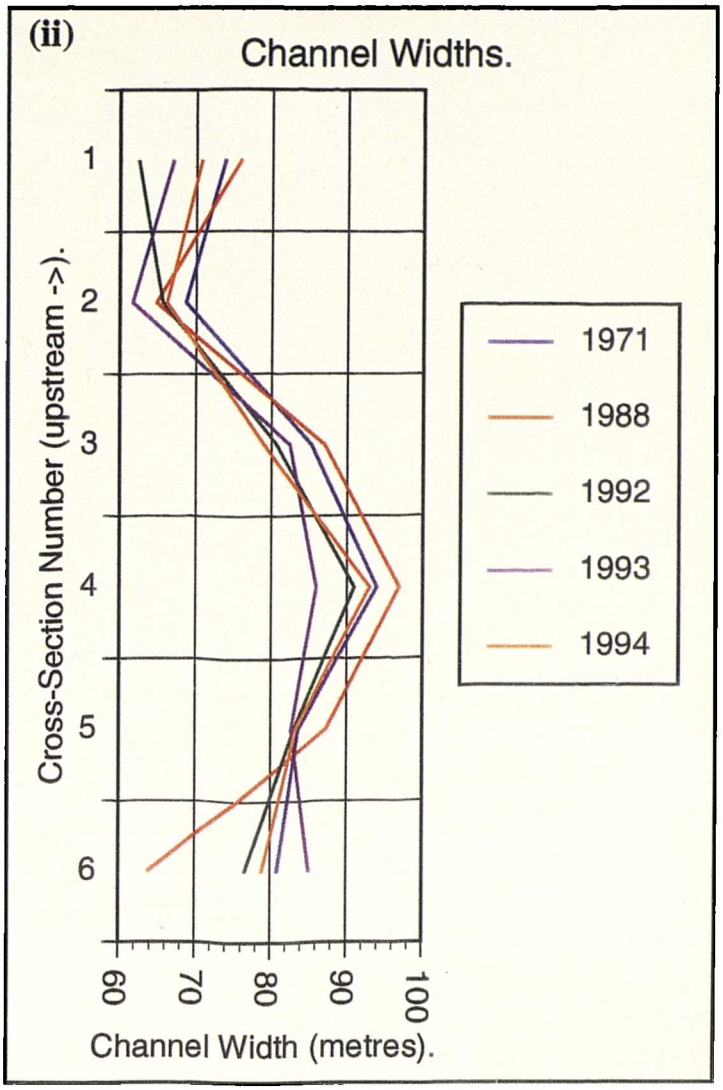
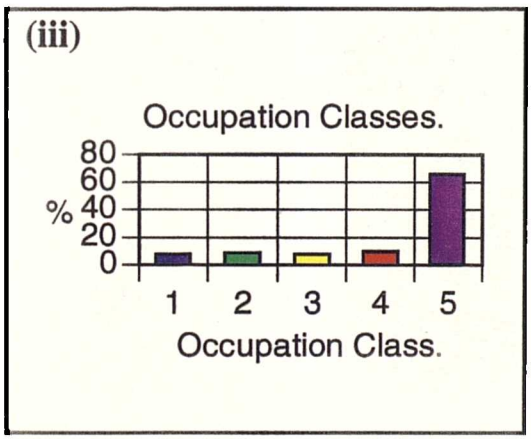
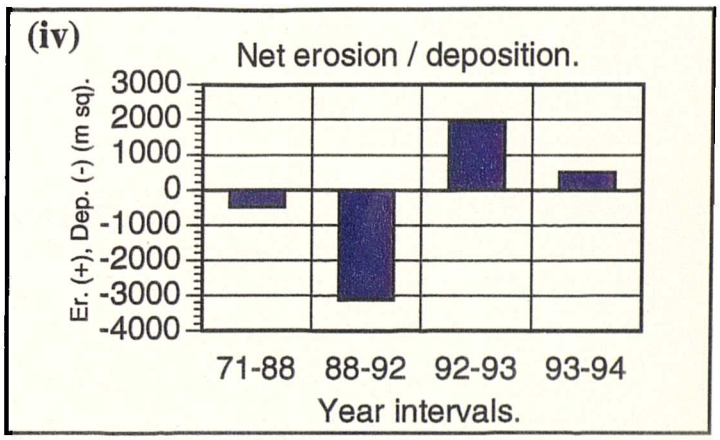


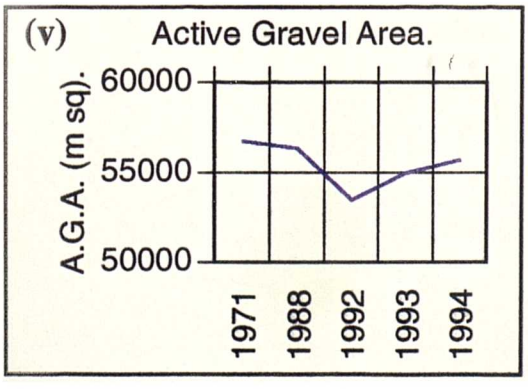
Figure 4.6h : Channel parameter changes 1971 to 1994.











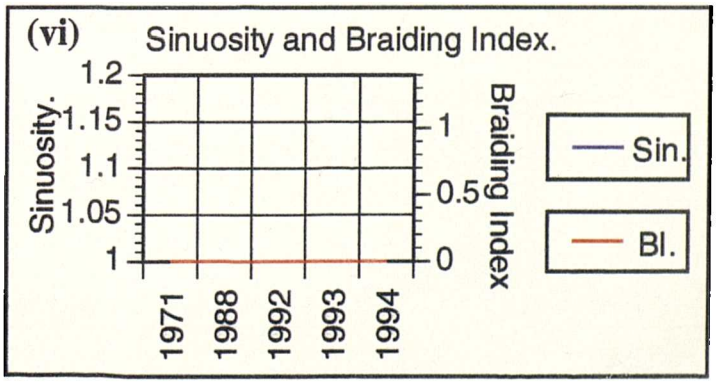
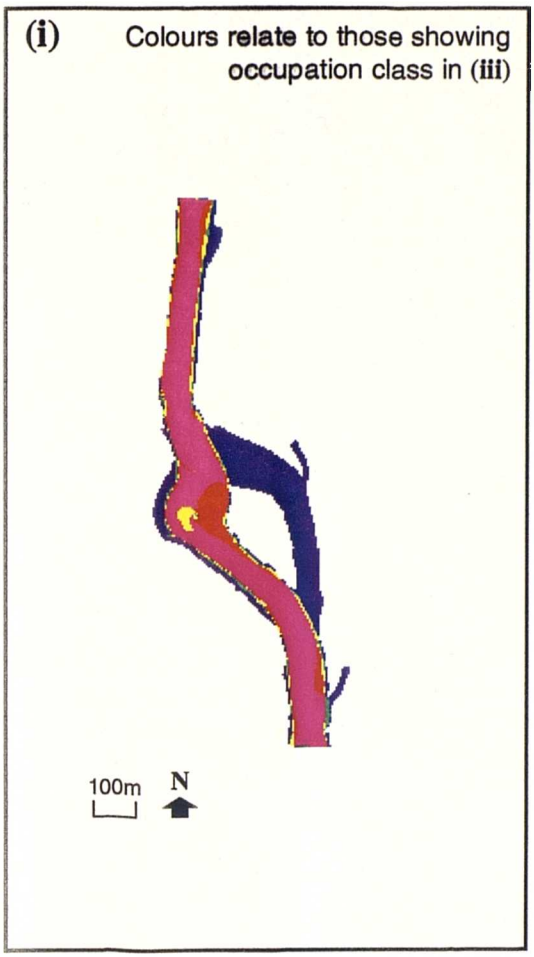
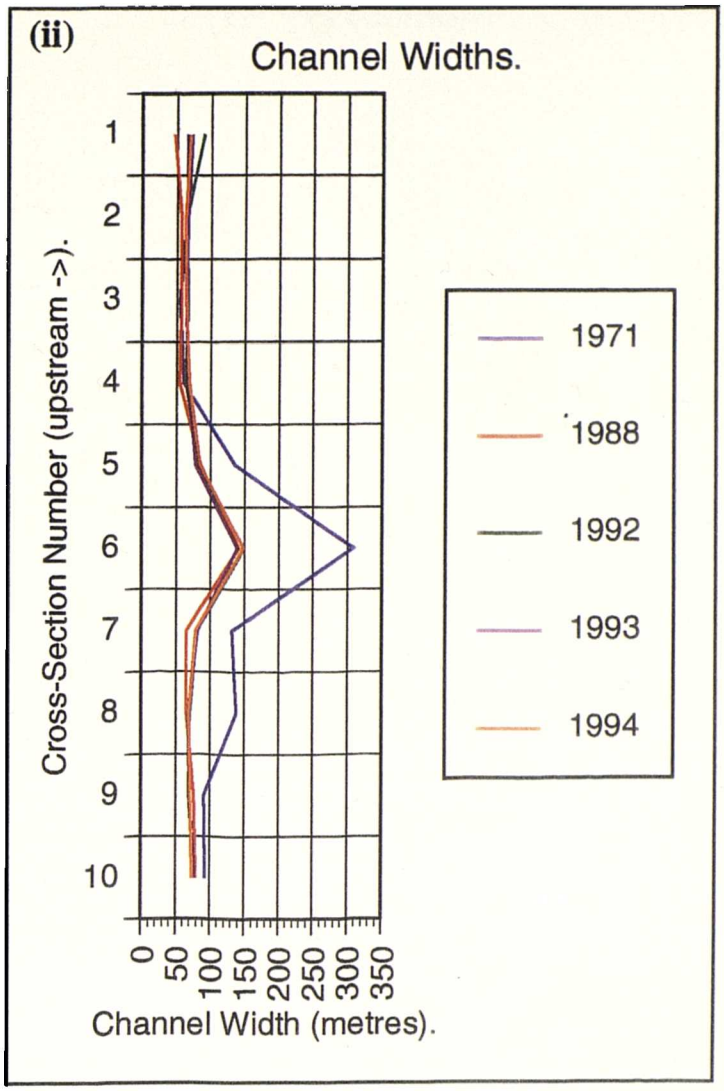
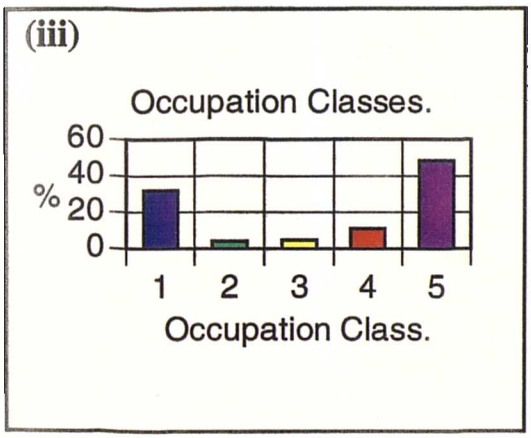
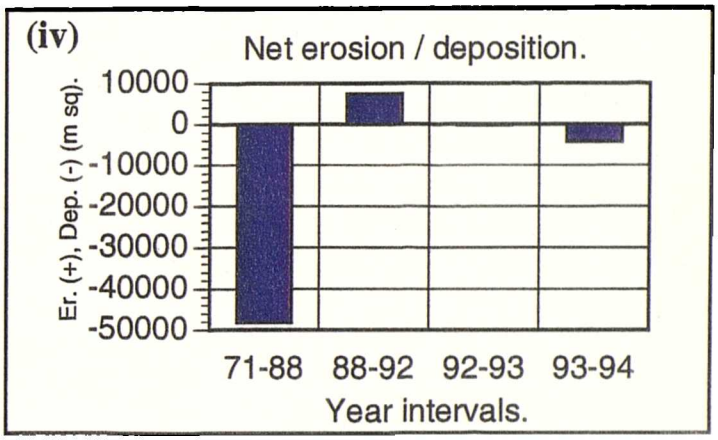


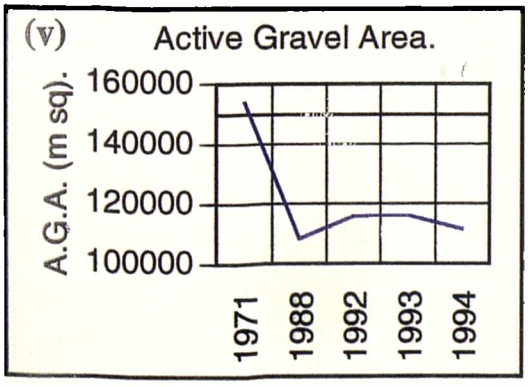
Figure 4.6l : Channel parameter changes 1971 to 1994.











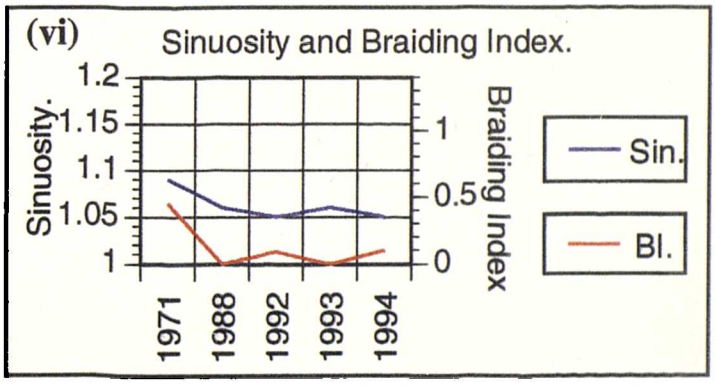


Figure 4.6j : Channel parameter changes 1971 to 1994.

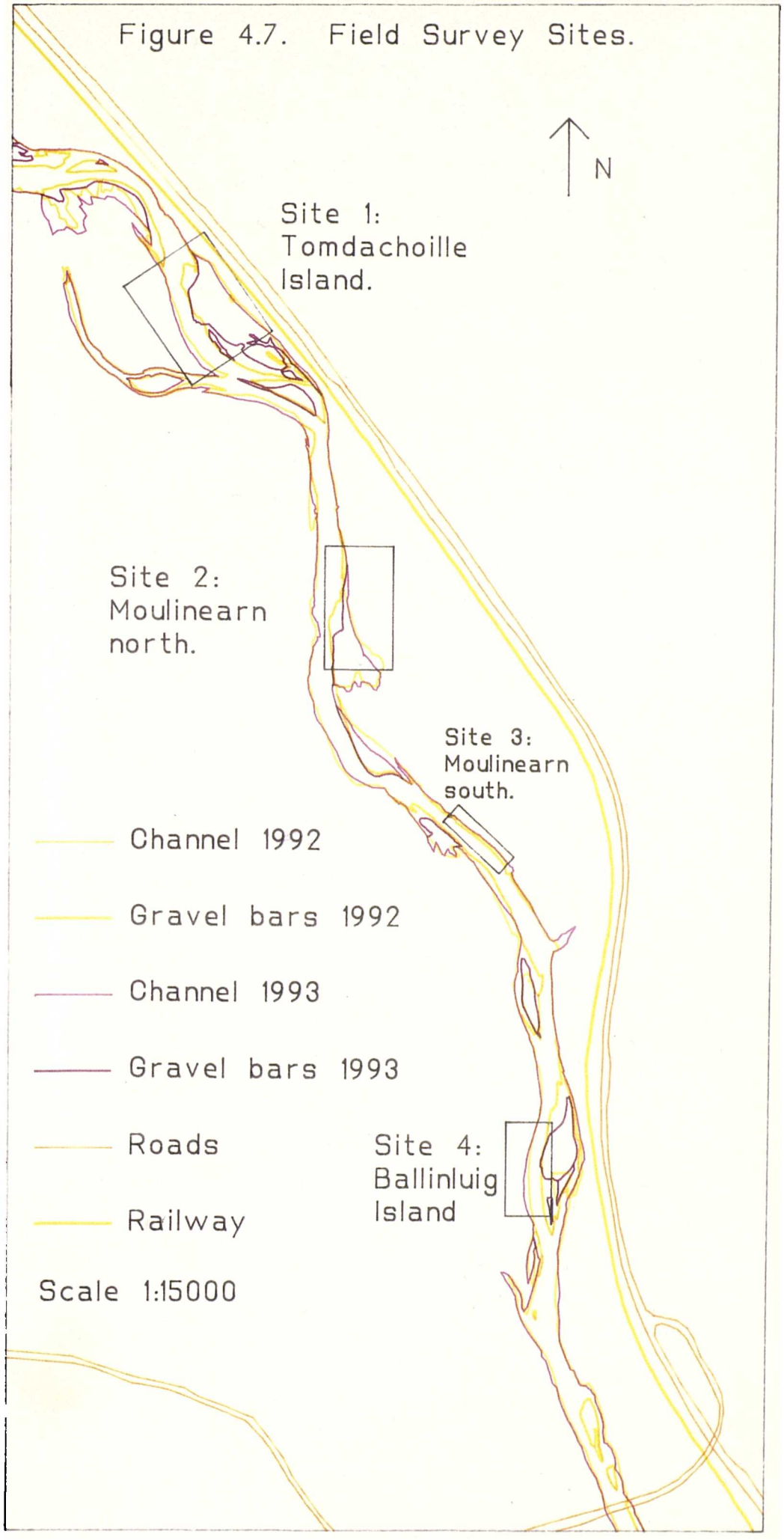


Figure 4.7. Field Survey Sites.
N
Site 1:
Tomdachoille
Island.
Site 2:
Moulinearn
north.
Site 3:
Moulinearn
south.
Site 4:
Ballinluig
Island
Channel 1992
Gravel bars 1992
Channel 1993
Gravel bars 1993
Roads
Railway
Scale 1:15000

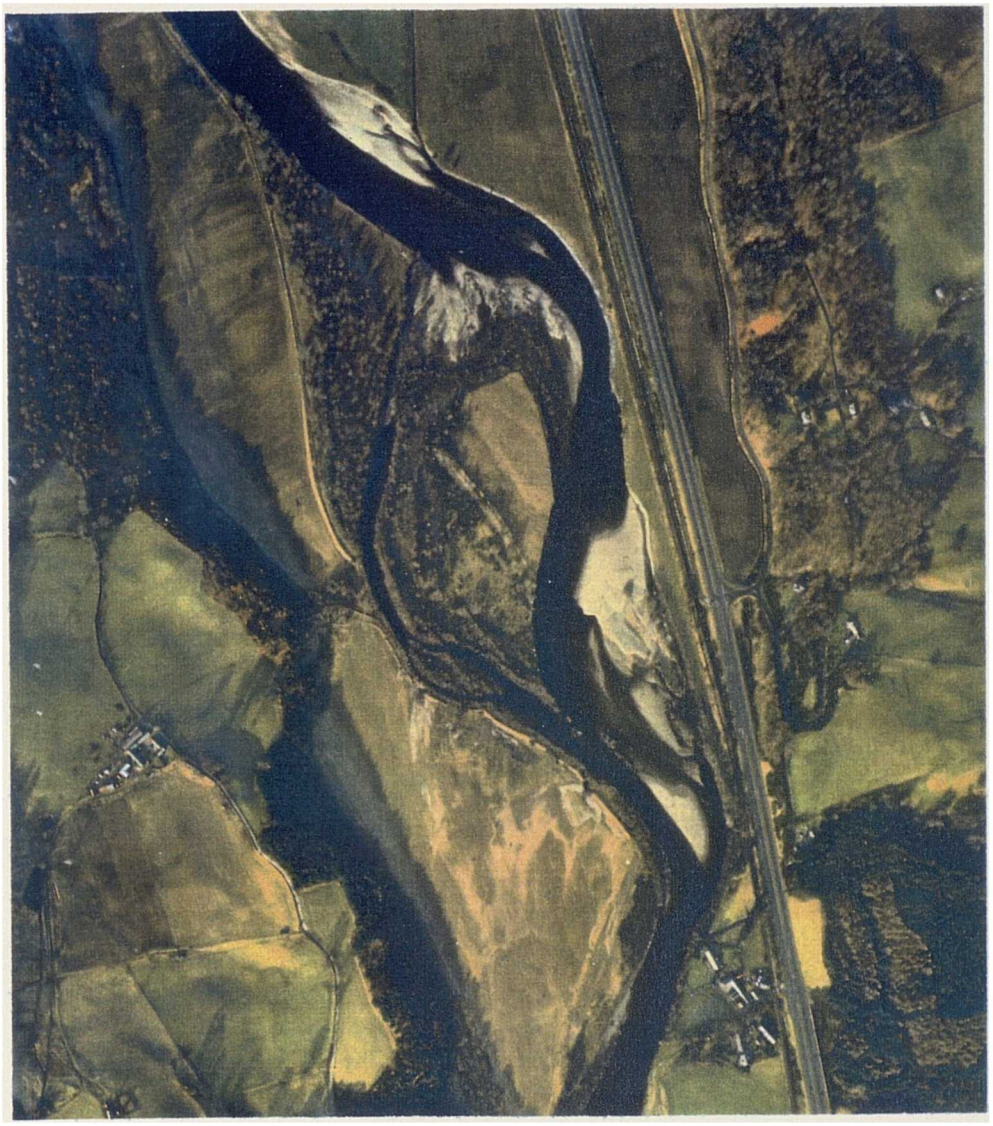


Plate 4.1. Colour aerial photograph of Tomdachoille Island, field site 1.

Plate 4.2. River bank at Moulinearn (north) field site 2

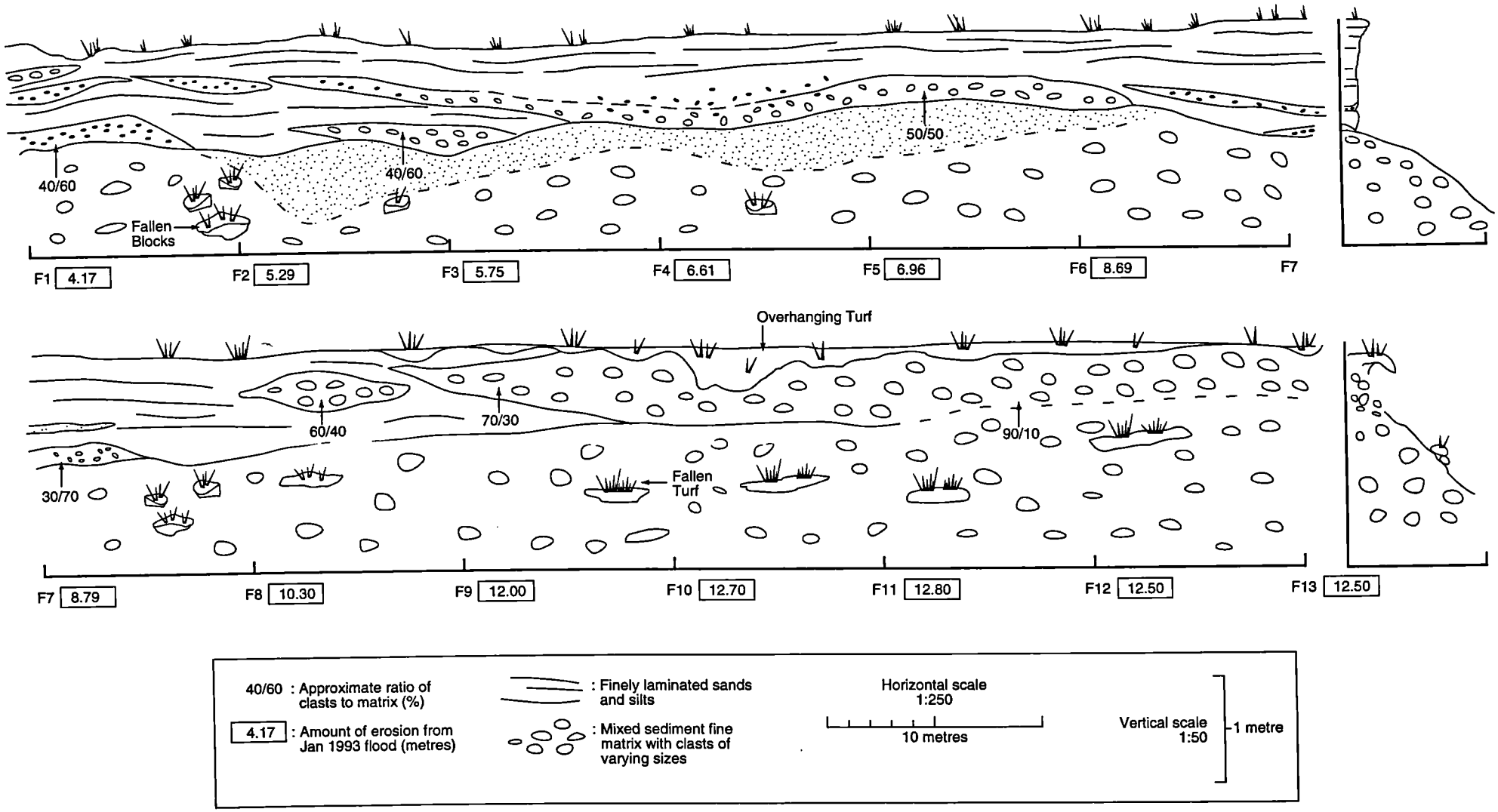


Figure 4.8 : Field sketch of east river bank, Moulinearn (site 2)

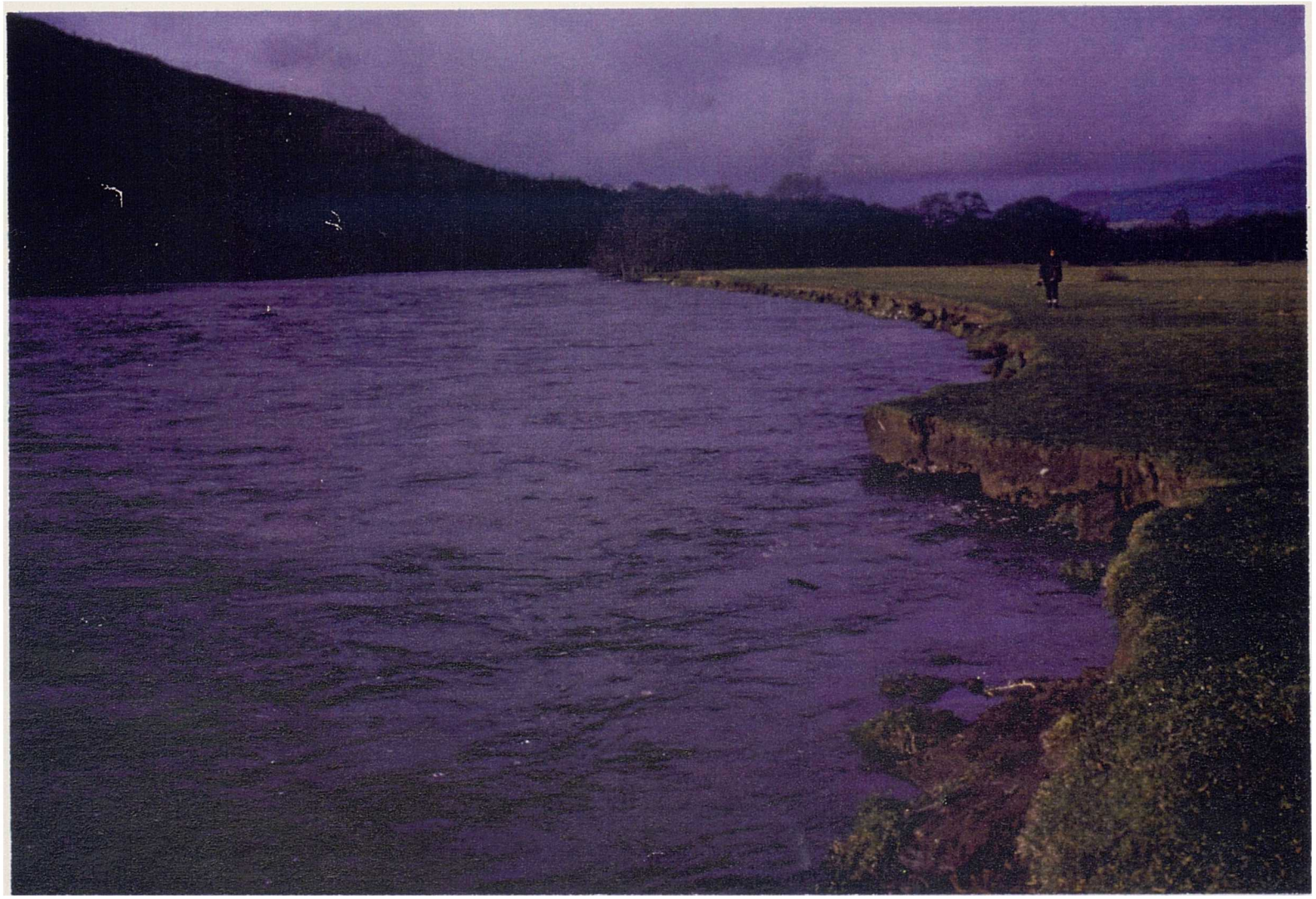
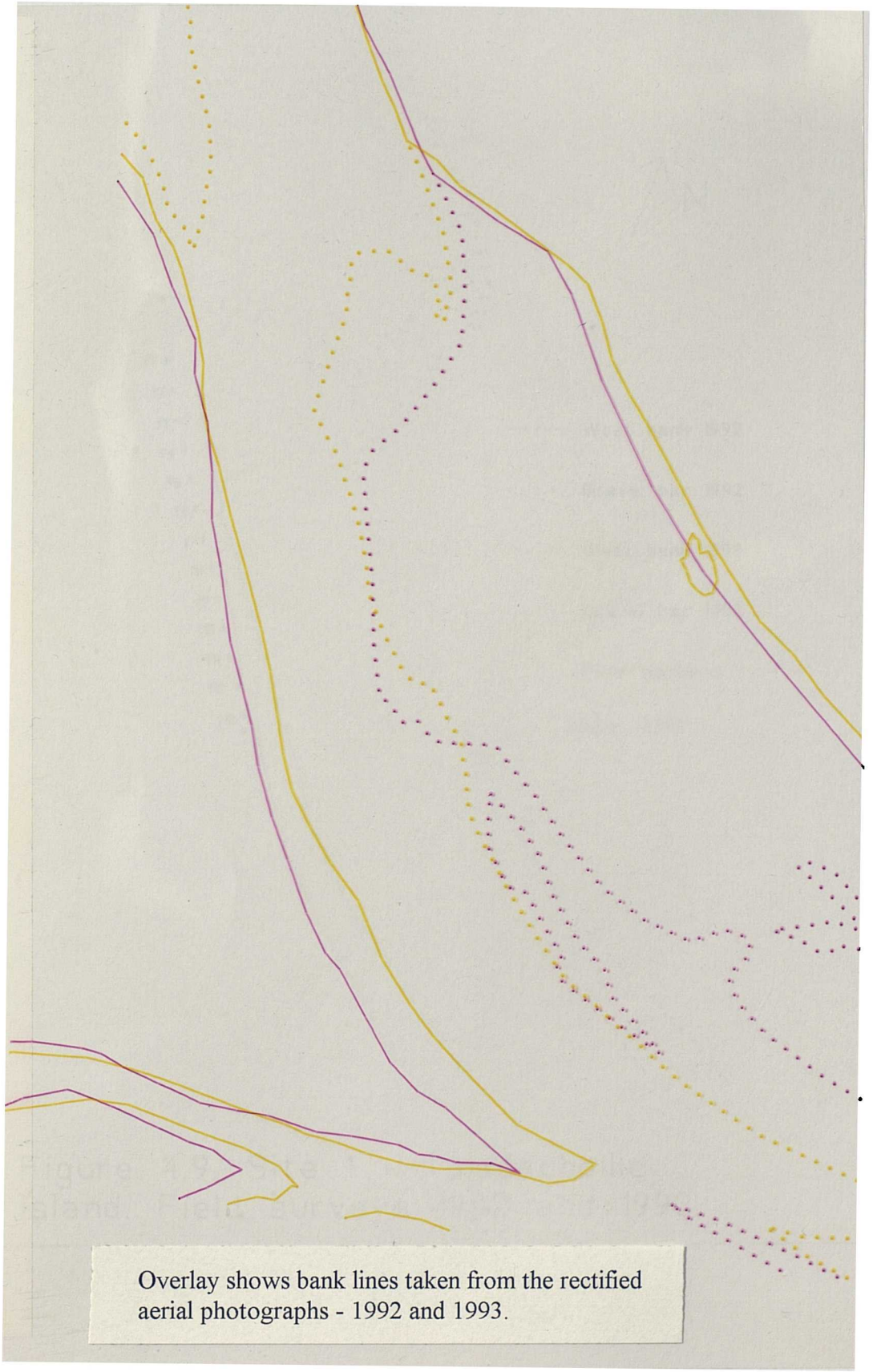


Plate 4.3. River bank at Moulinearn (south) field site 3.

Plate 4.4. River bank at Ballinluig Island, field site 4.



Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.

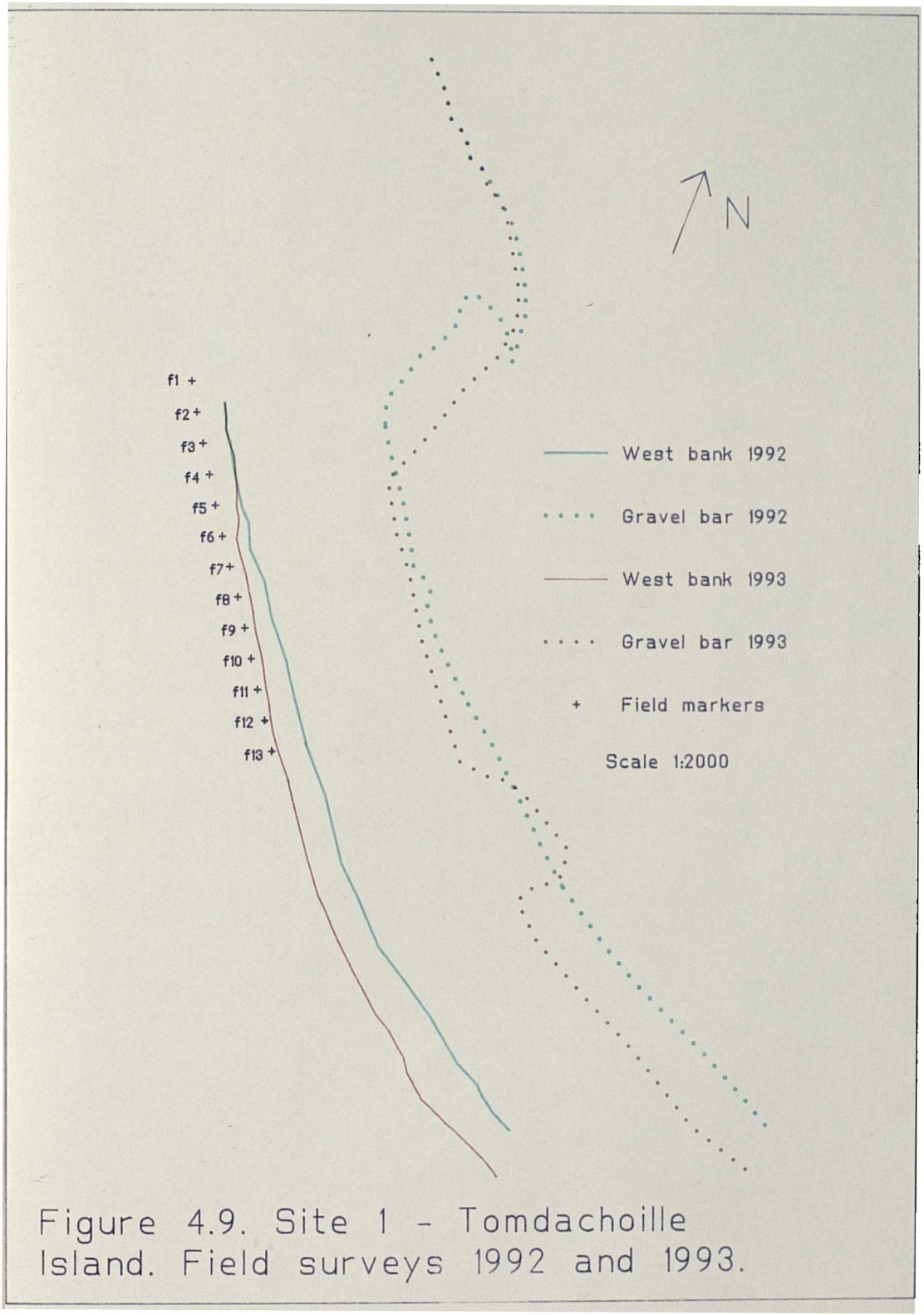


Figure 4.9. Site 1 - Tomdachoille Island. Field surveys 1992 and 1993.

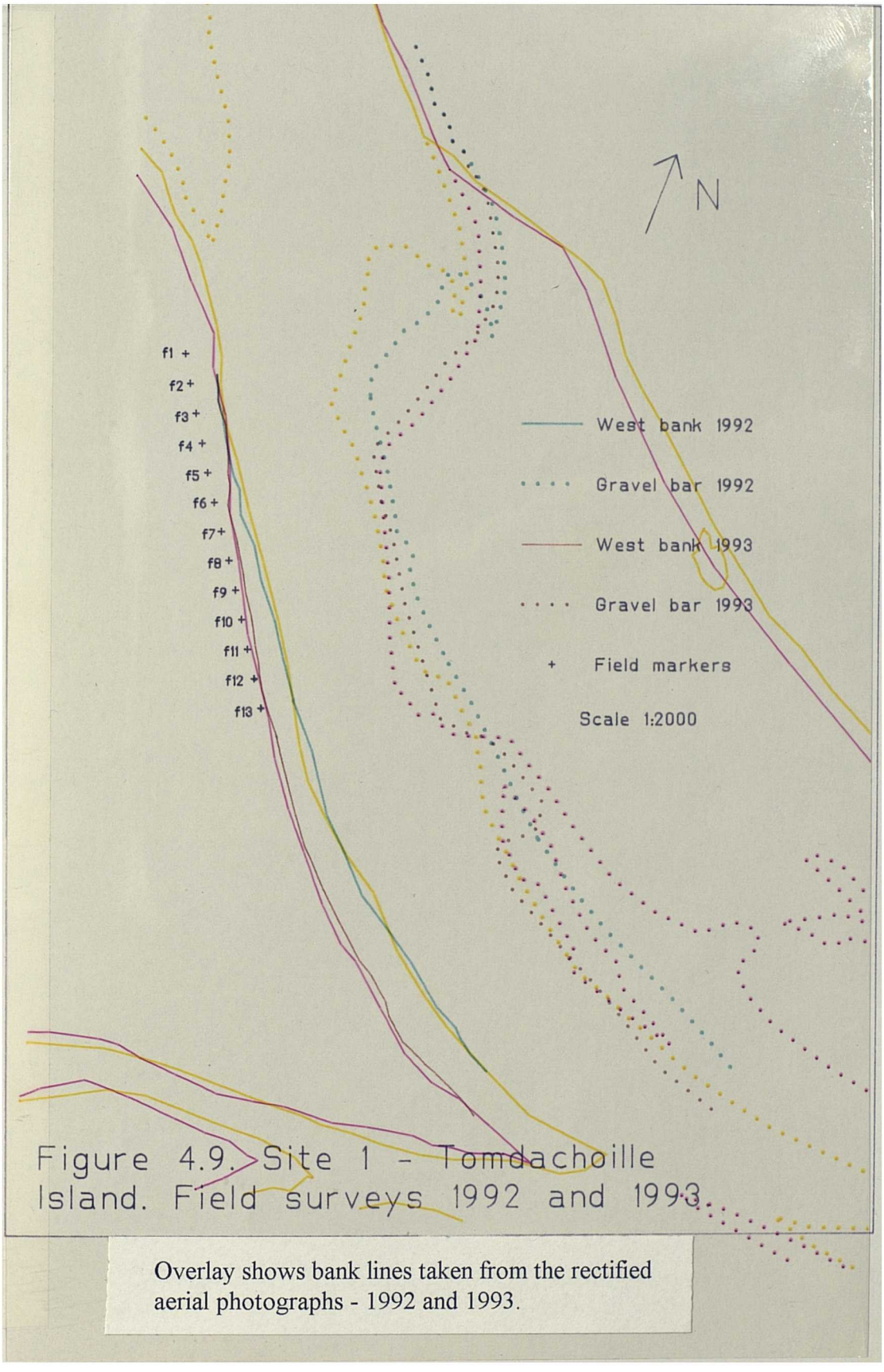
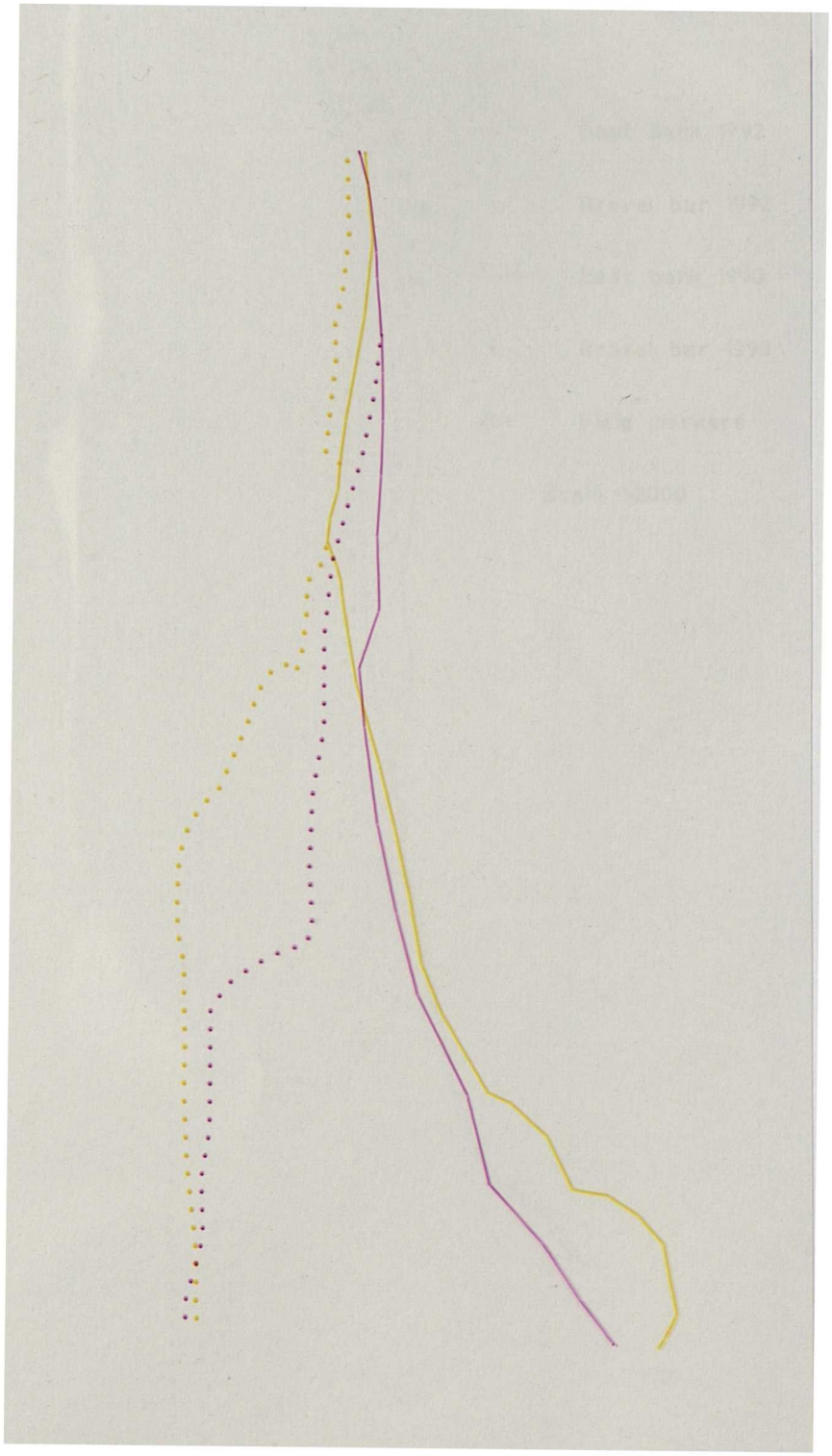


Figure 4.9. Site 1 - Tomdachoille Island. Field surveys 1992 and 1993.

Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.



Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.

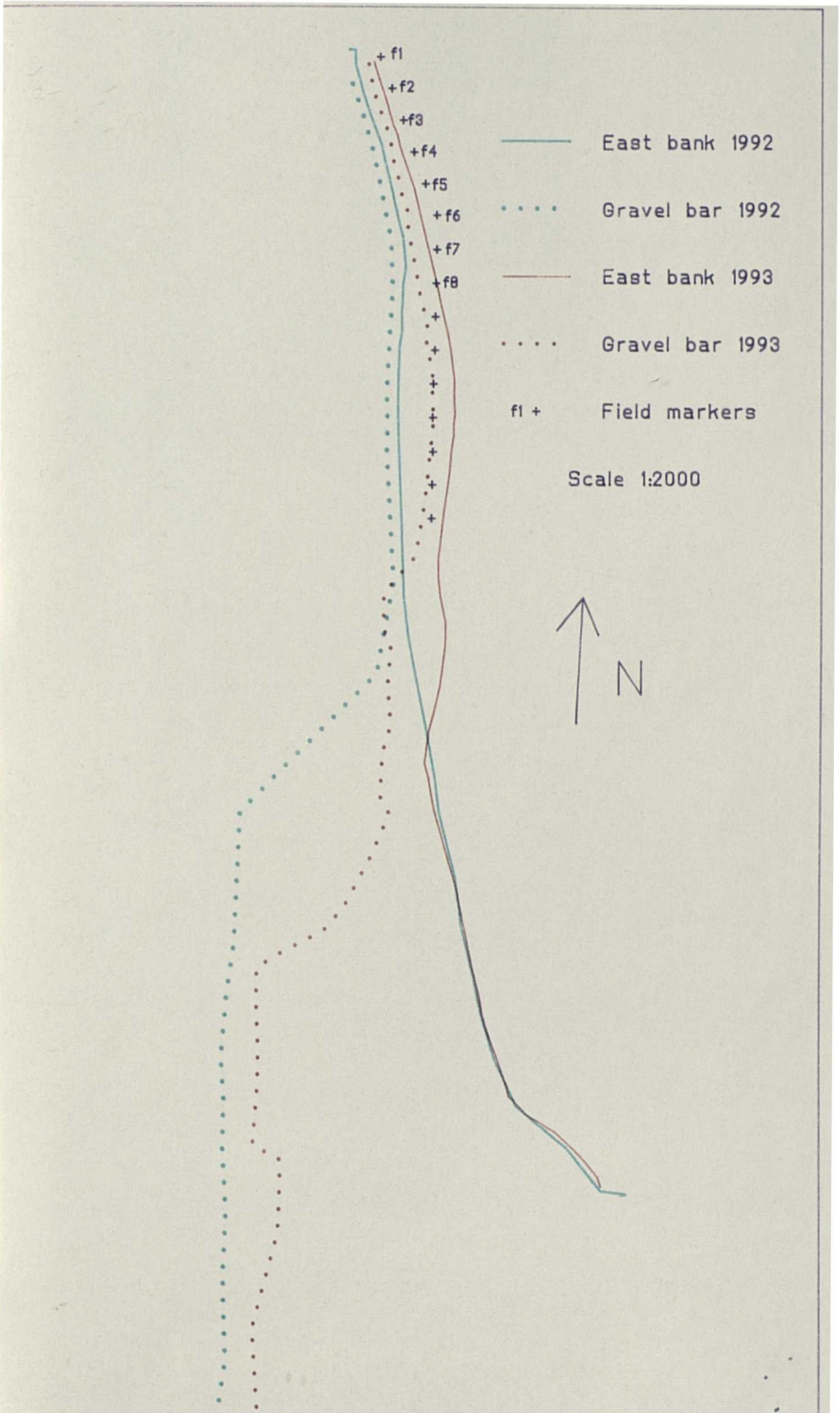


Figure 4.10. Site 2 - Moulinearn north. Field surveys 1992 and 1993.

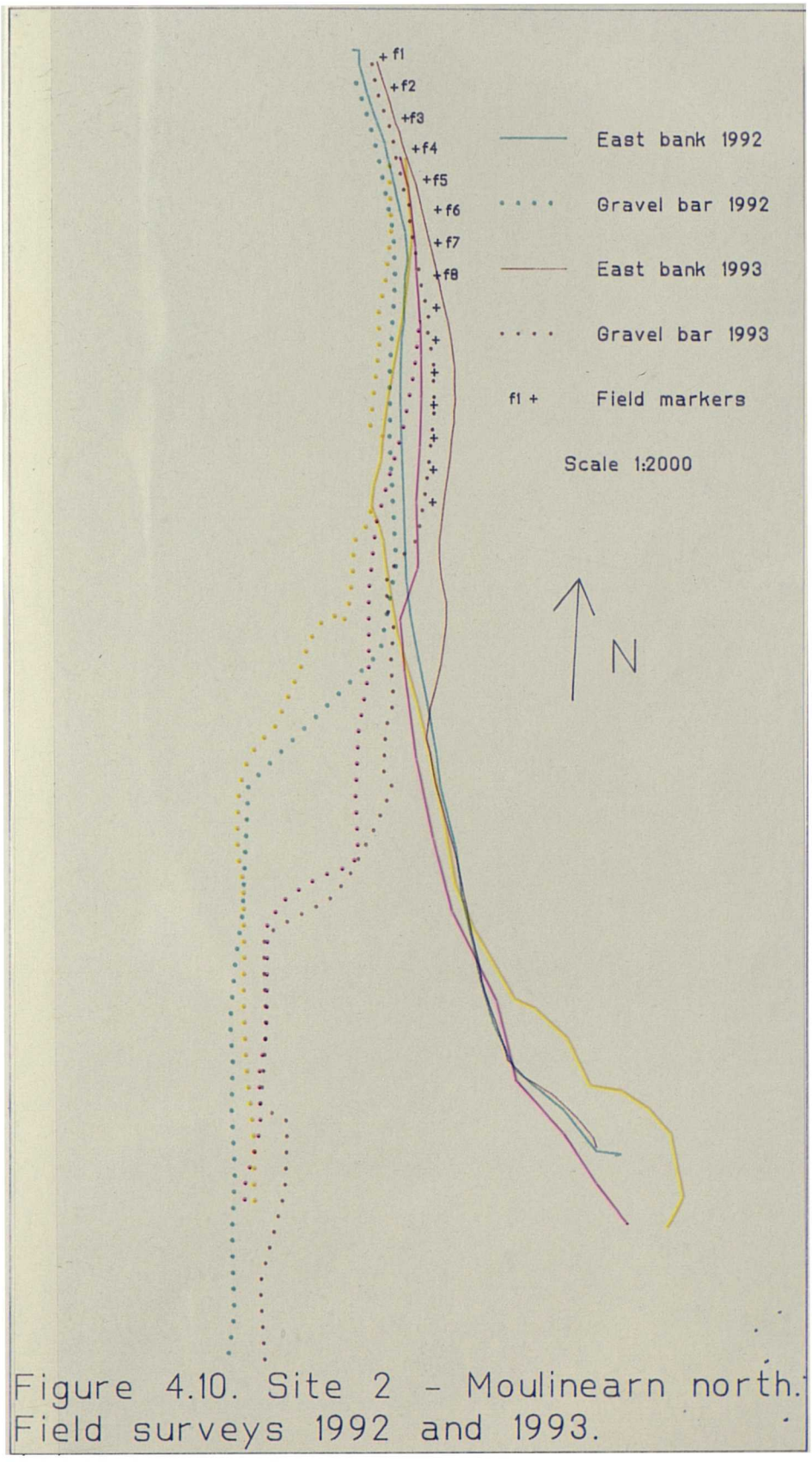
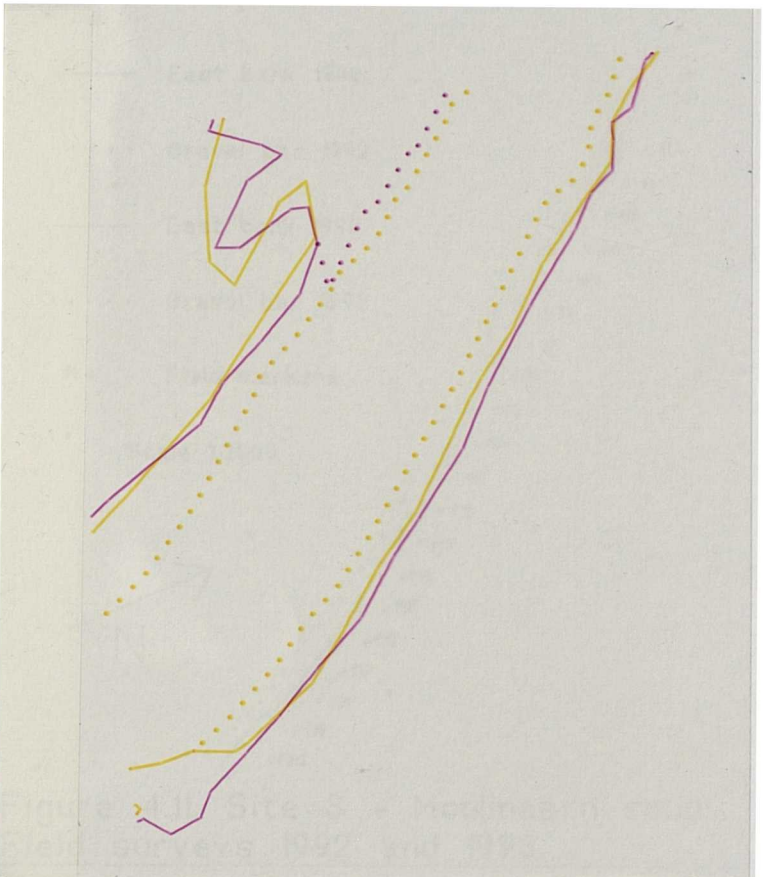


Figure 4.10. Site 2 - Moulinearn north. Field surveys 1992 and 1993.

Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.



Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.

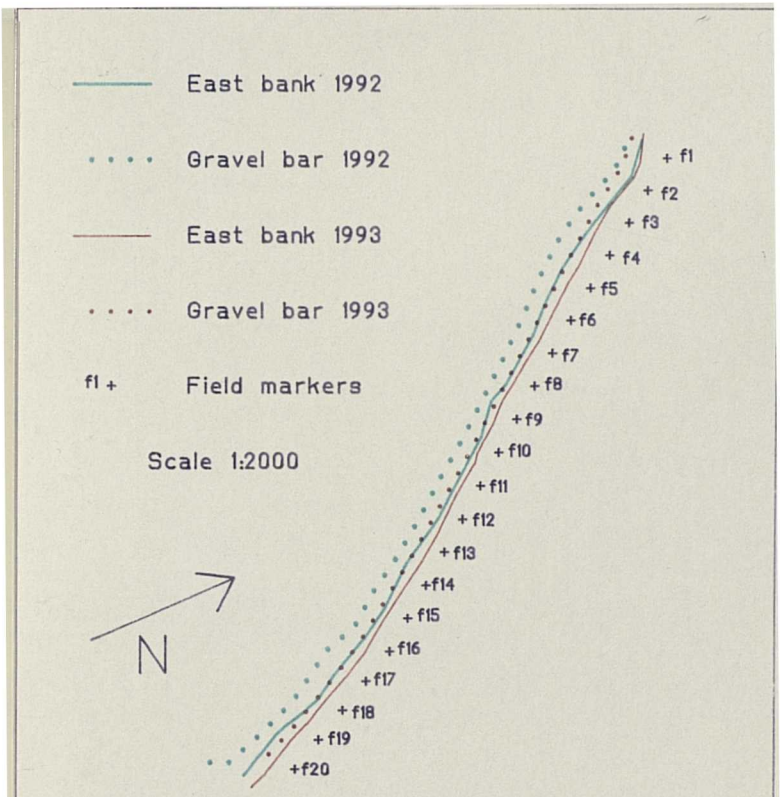


Figure 4.11. Site 3 - Moulinearn south. Field surveys 1992 and 1993.

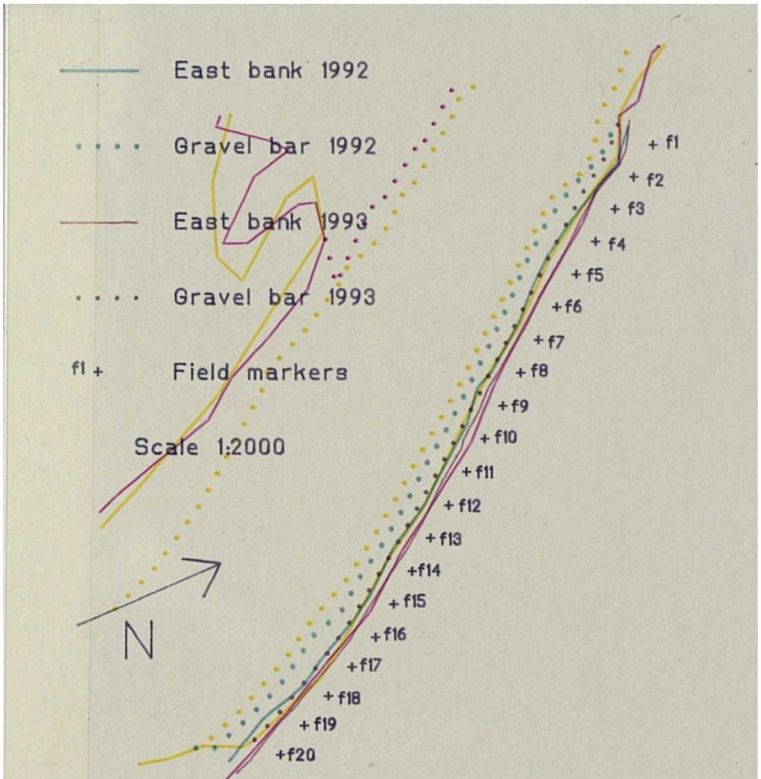
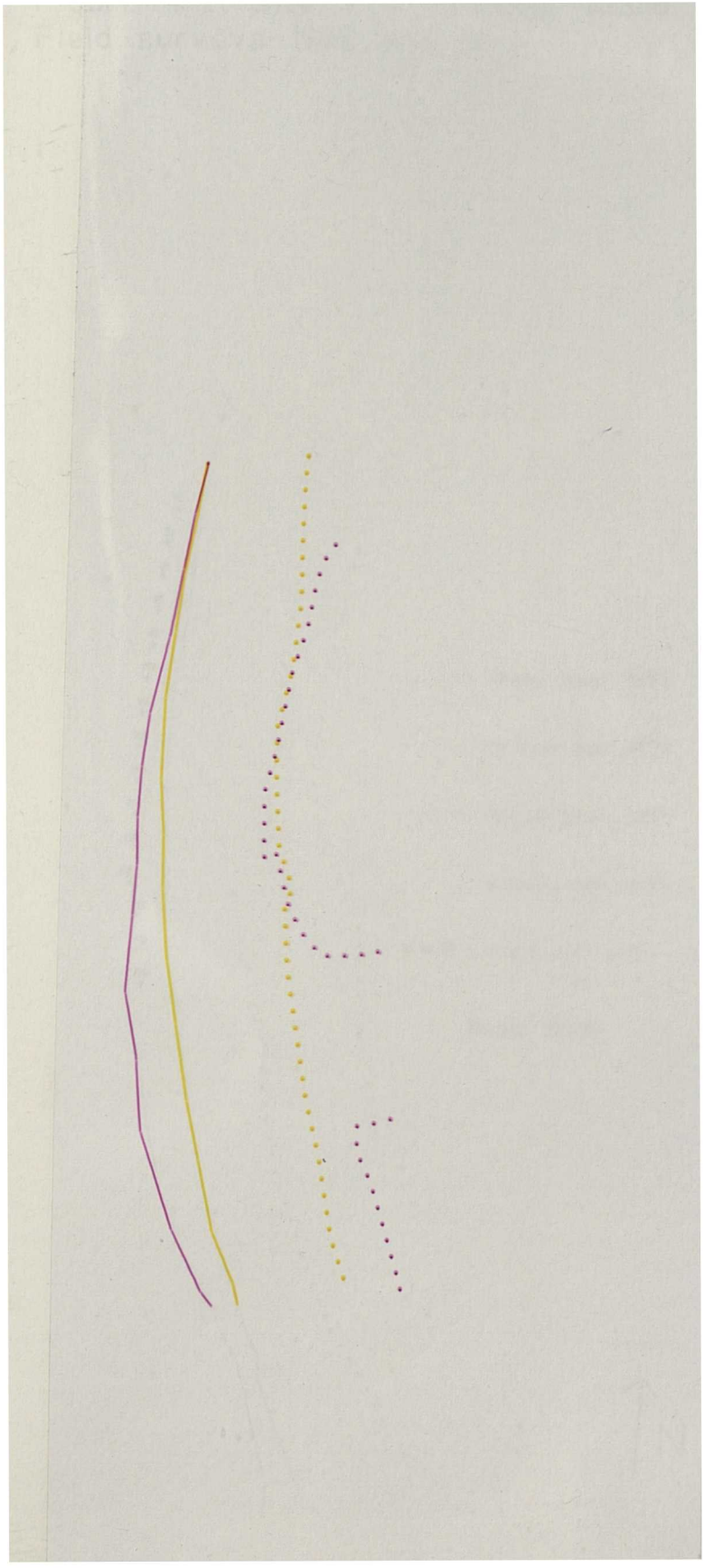


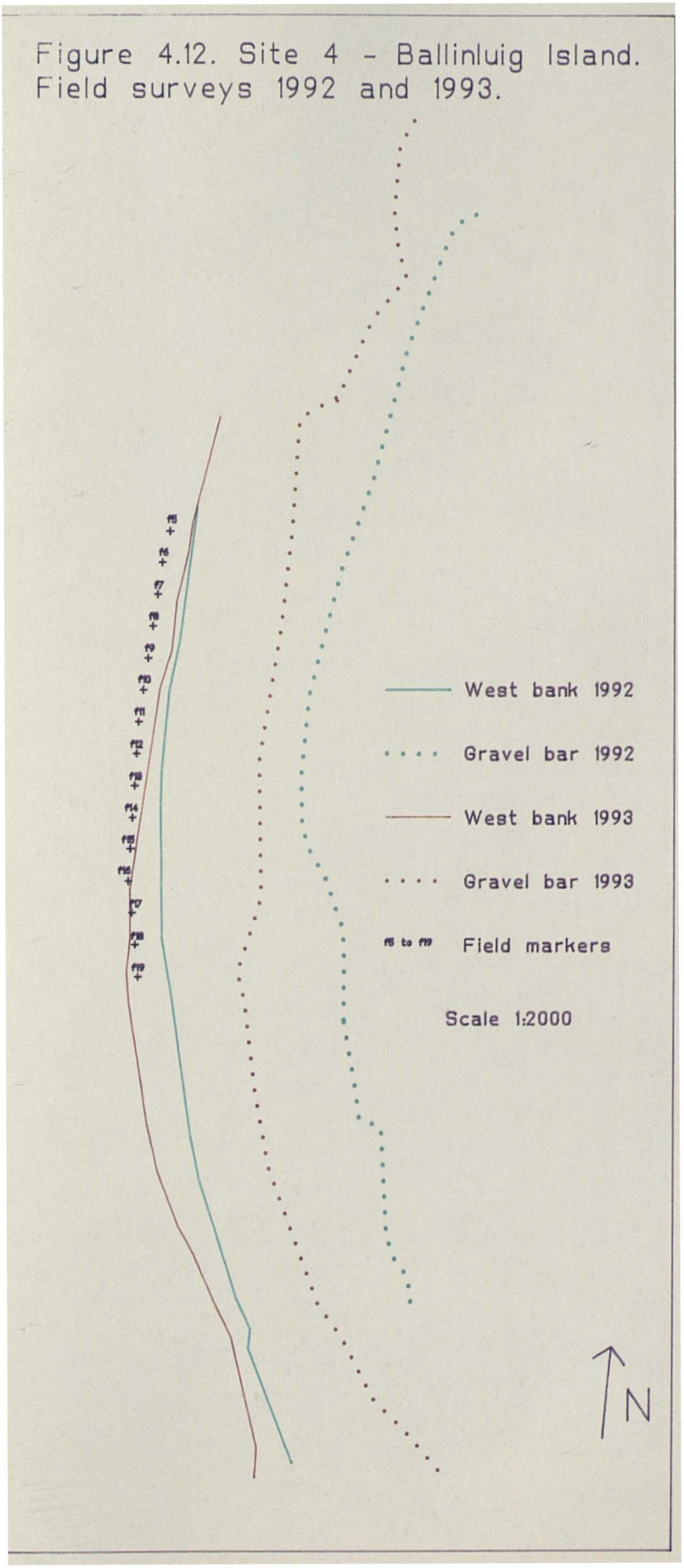
Figure 4.11. Site 3 - Moulinearn south. Field surveys 1992 and 1993.

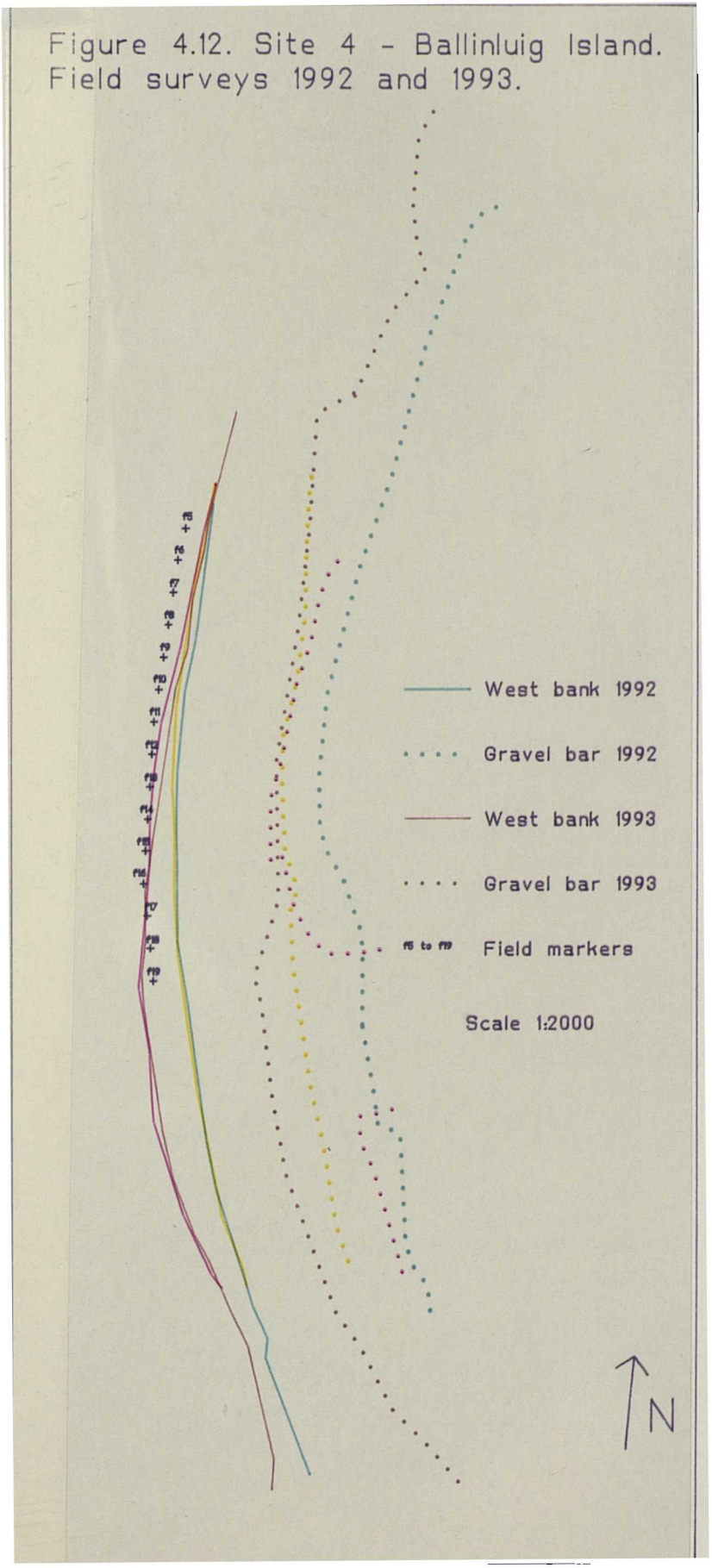
Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.



Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.

Figure 4.12. Site 4 - Ballinluig Island.
Field surveys 1992 and 1993.





Overlay shows bank lines taken from the rectified aerial photographs - 1992 and 1993.

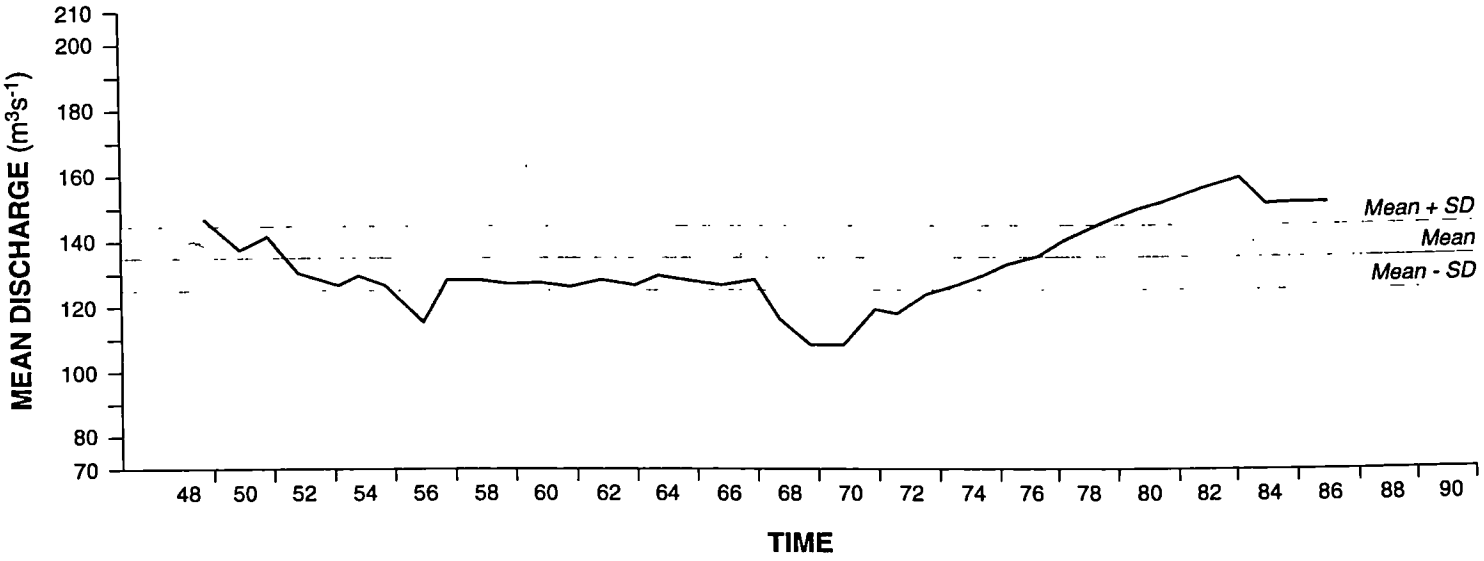


Figure 4.13. Discharge at Caputh, 1948 to 1990.
5 year running mean.

Figure 4.14.

Discharge - Port-na-Craig.
1973 to 1992 (3 year running mean).

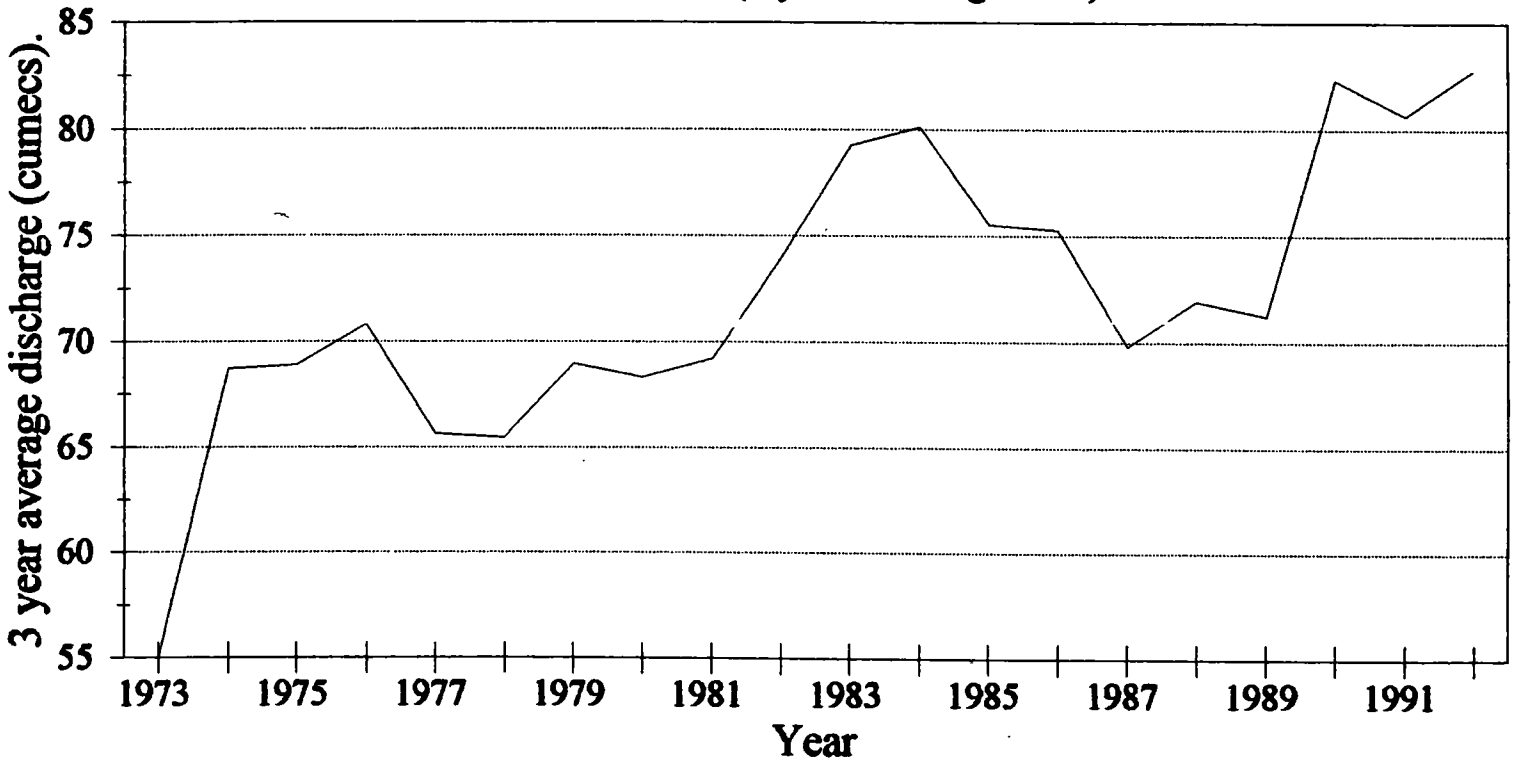


Figure 4.15.

Seasonal discharge, Port-na-Craig.
1973 to 1992 (3 year running mean).

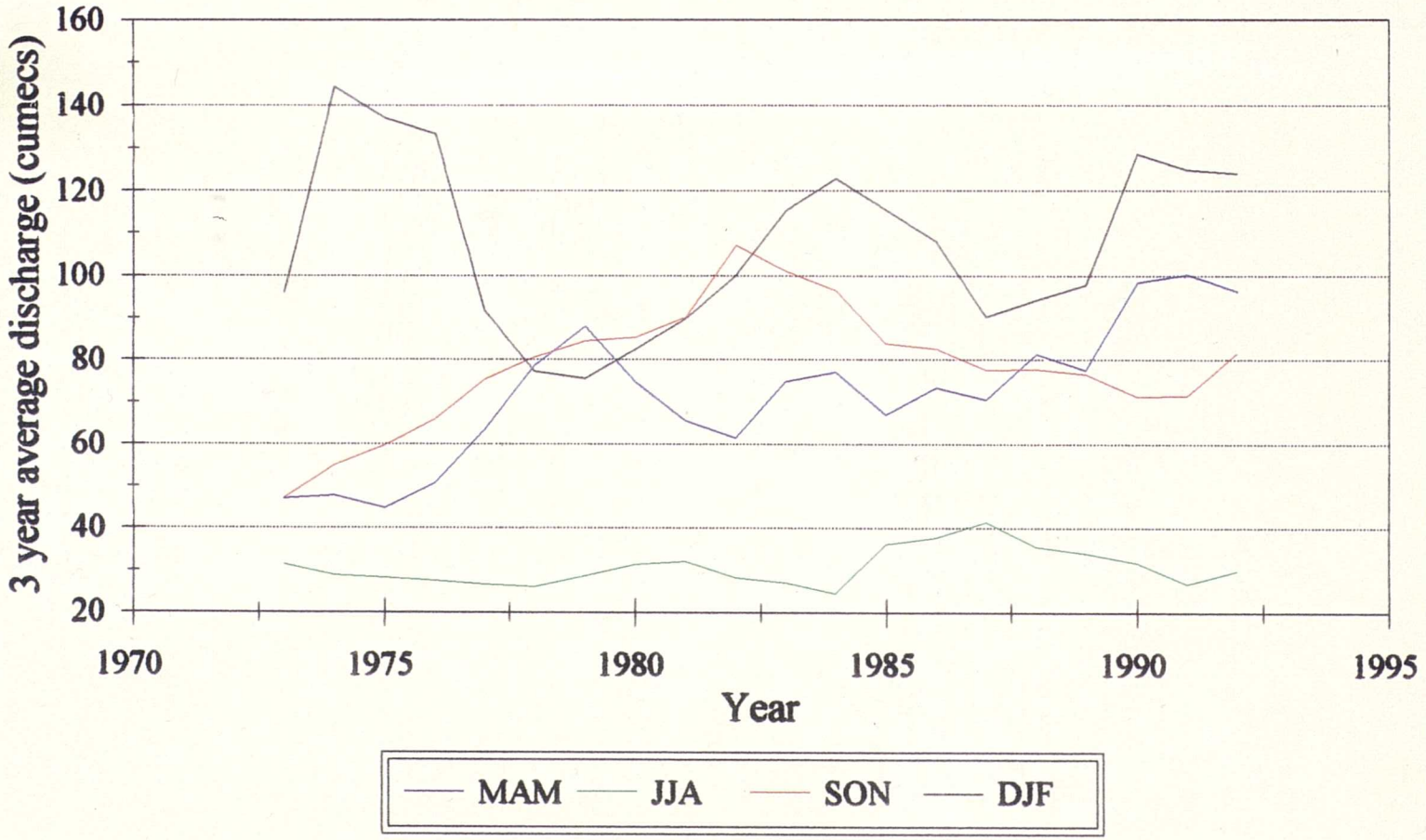


Figure 4.16a.

Flood magnitude /frequency.
Caputh 1952 to 1992.

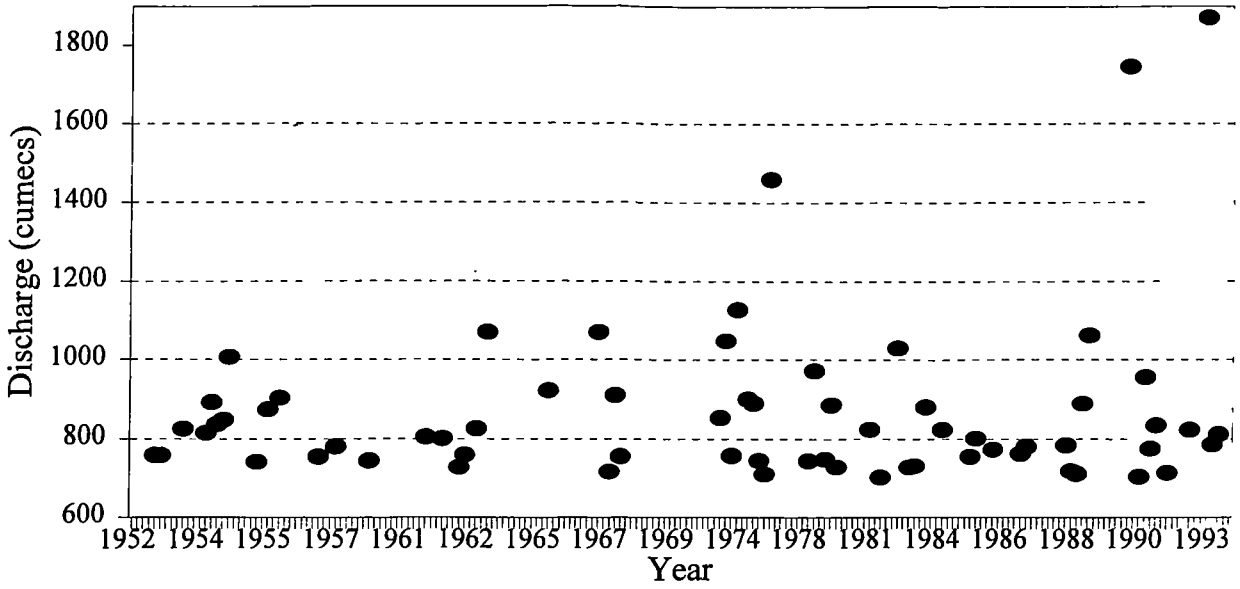


Figure 4.16b.

Flood magnitude / frequency.
Smeaton's Bridge, Perth 1814 to 1993

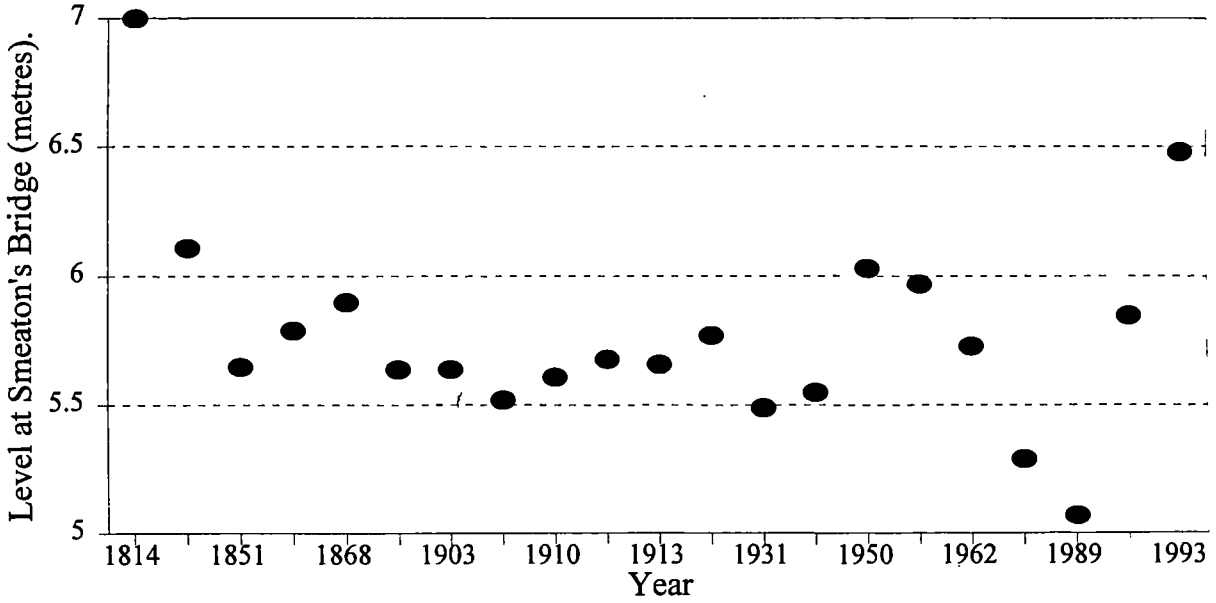
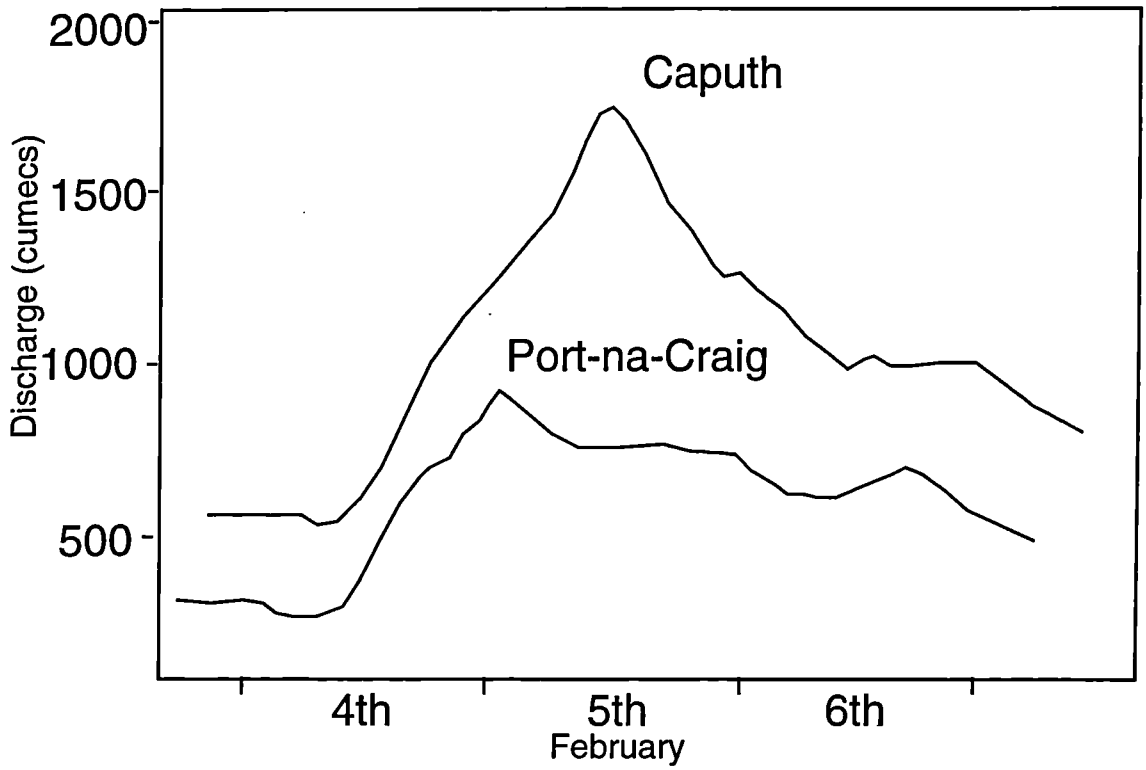
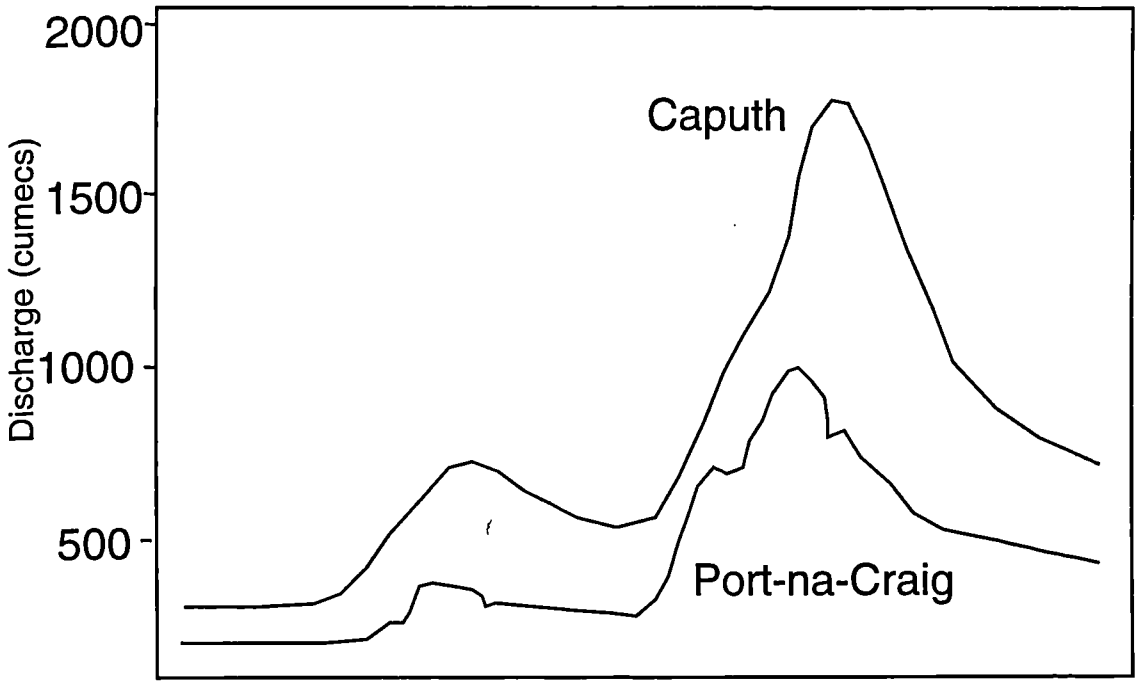


Figure 4.17.

A. Flood Hydrograph: February 1990.



B. Flood Hydrograph: January 1993.



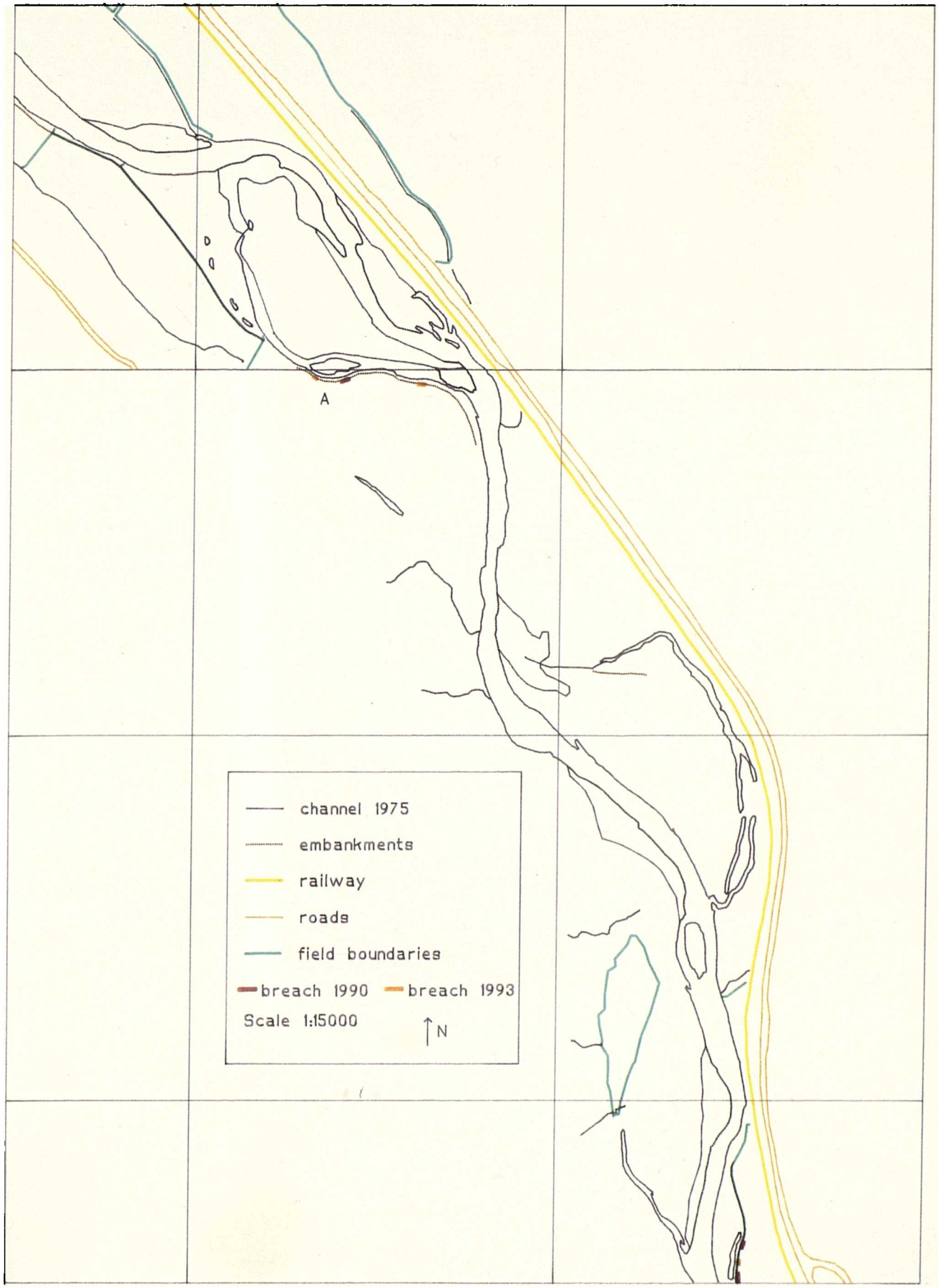


Figure 4.18a. Embankment Breaches 1990 and 1993.

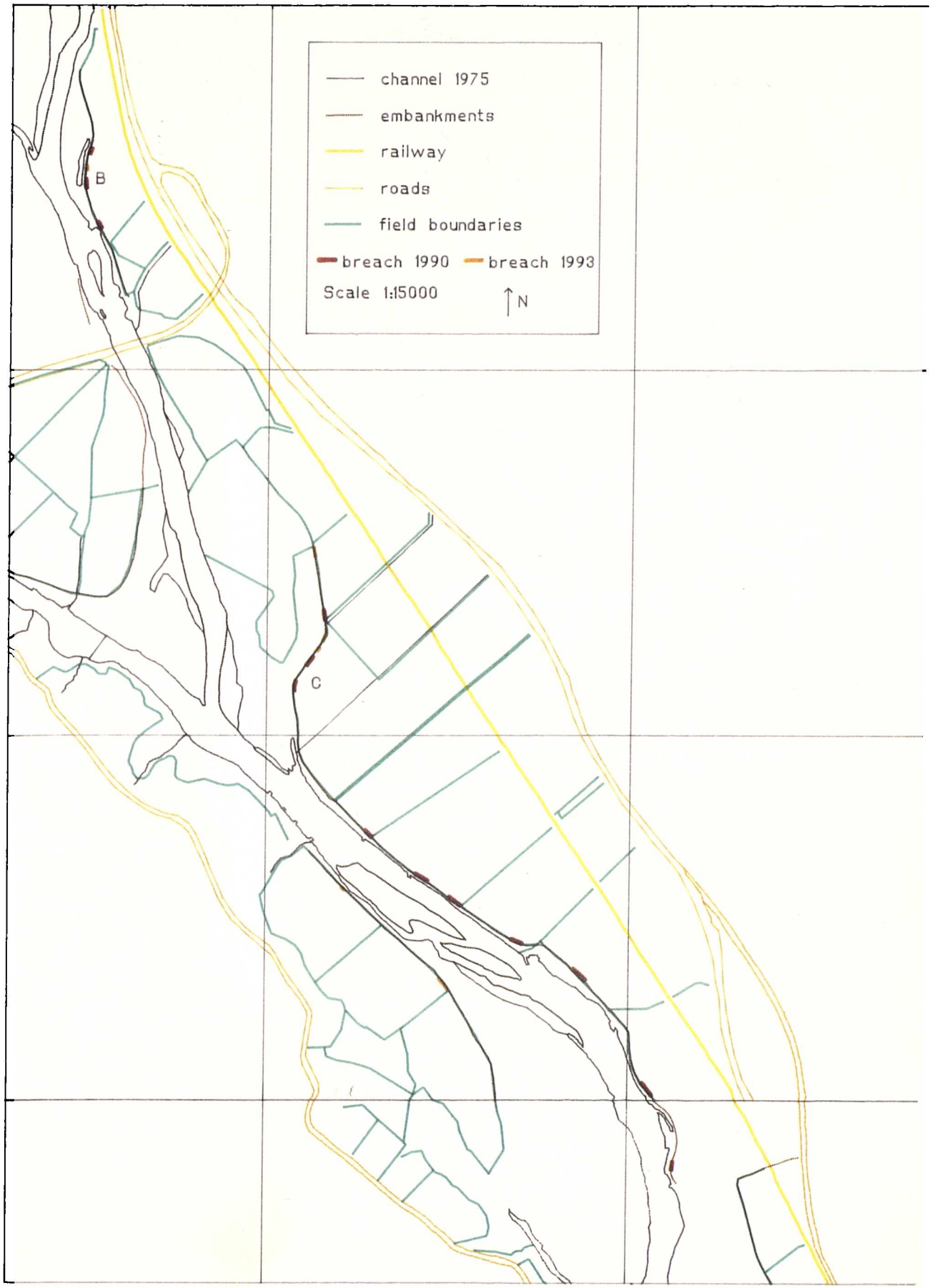


Figure 4.18b. Embankment Breaches 1990 and 1993.

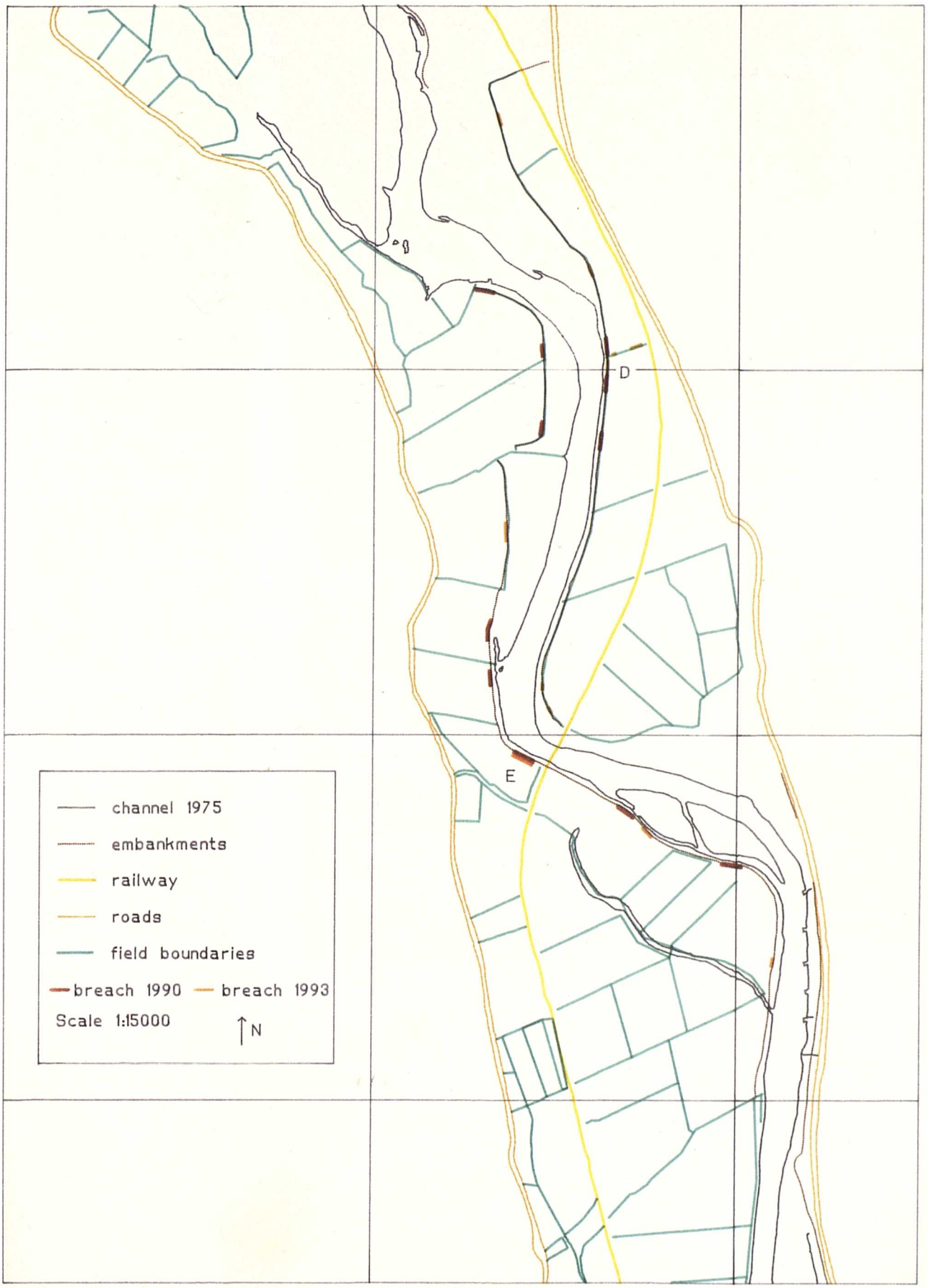


Figure 4.18c. Embankment Breaches 1990 and 1993.

Figure 5.1.

Spectral reflectance levels
for differing water depths.

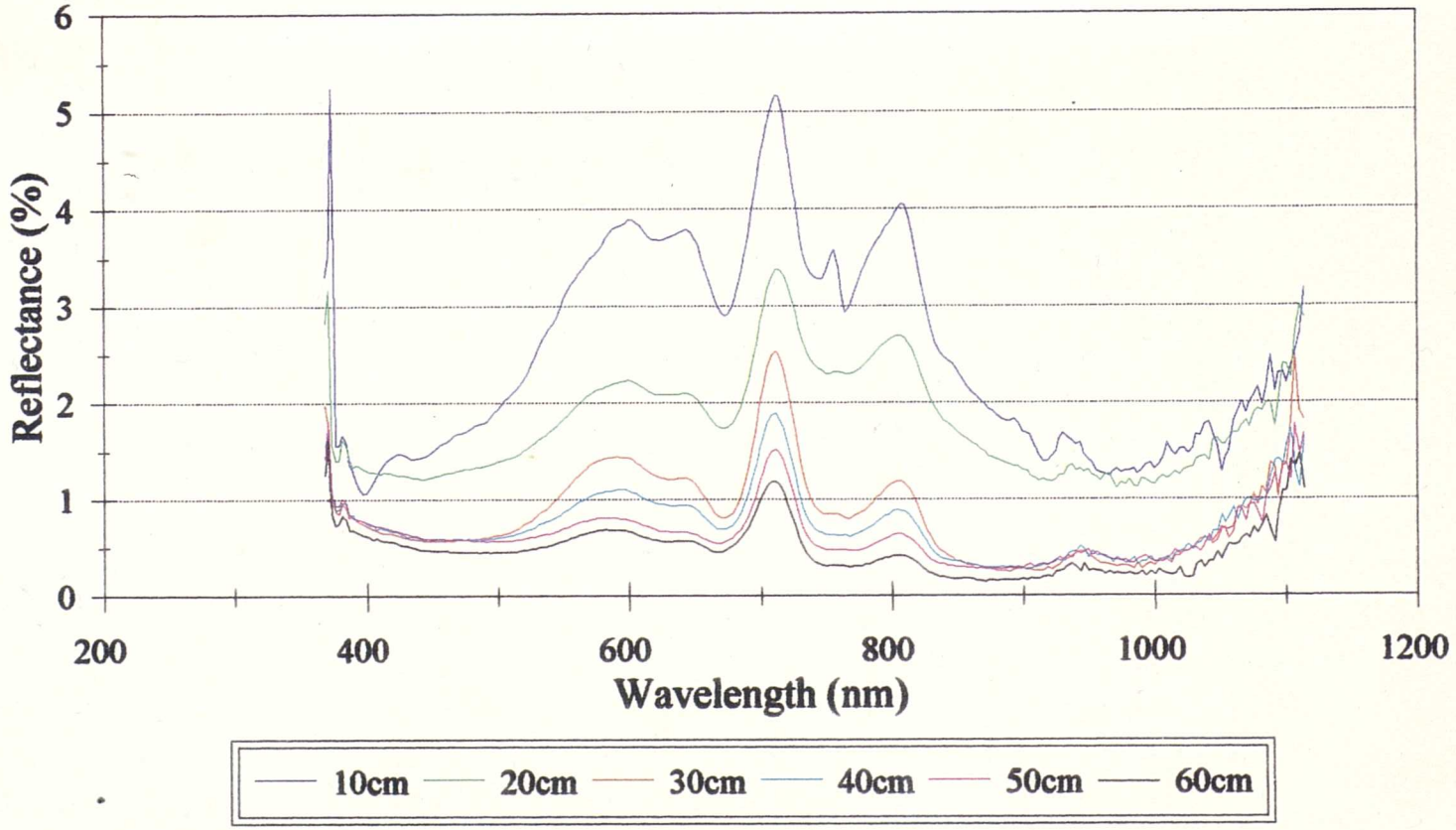


Figure 5.2.

Spectral reflectance for clean and algal covered gravel bottom sediments.

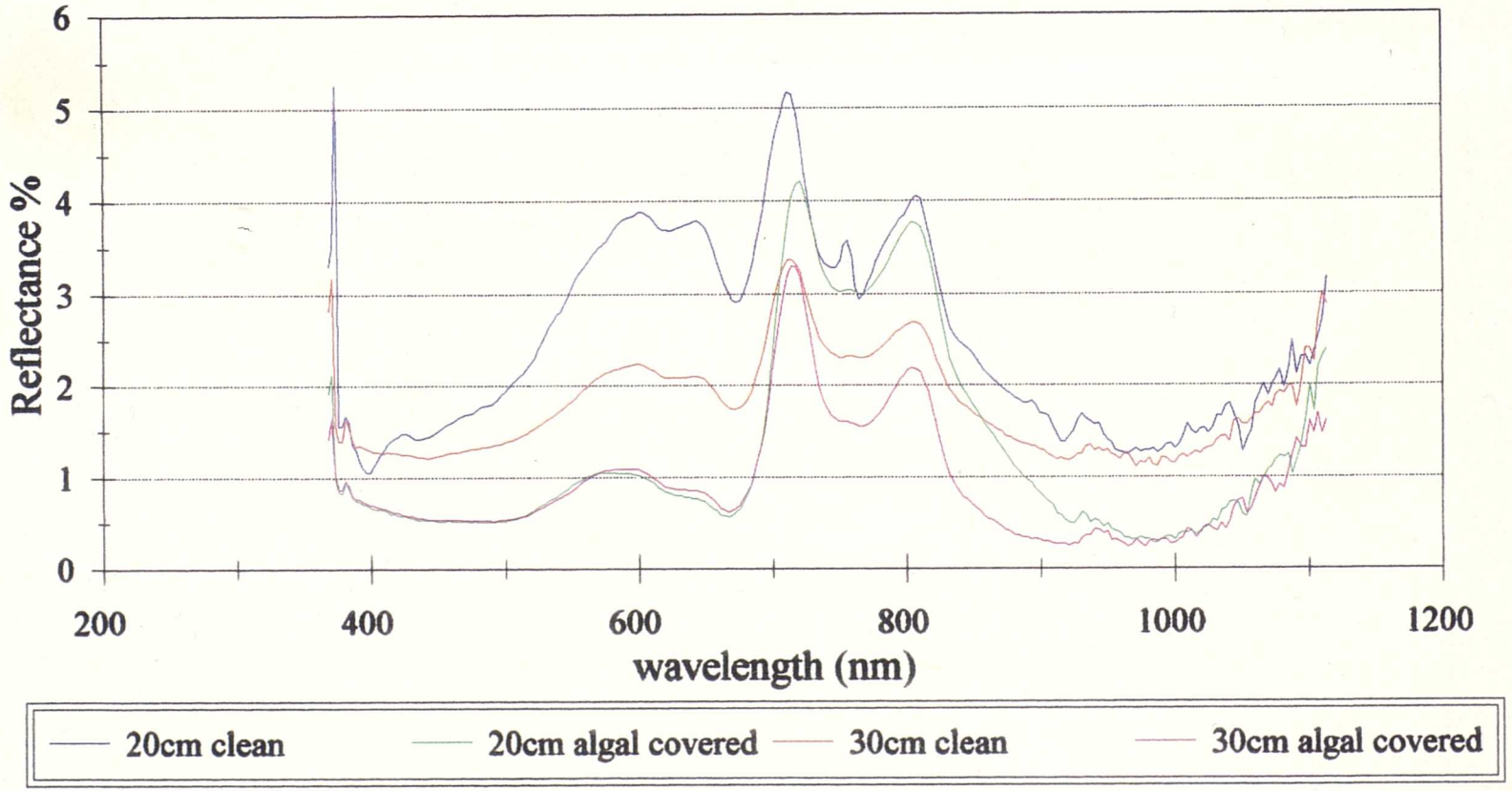
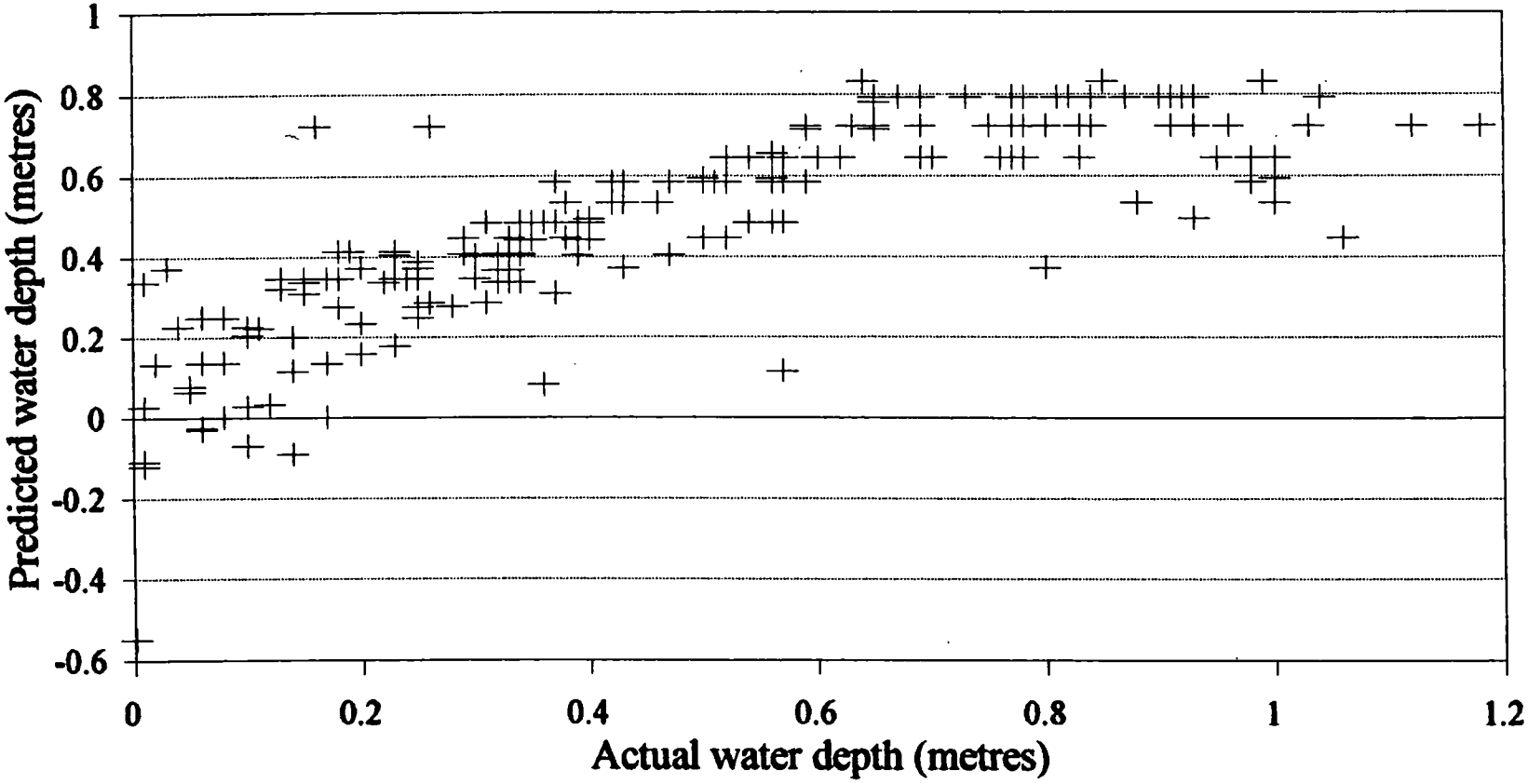


Figure 5.3.

Actual water depth vs. Predicted water depth using ATM data.



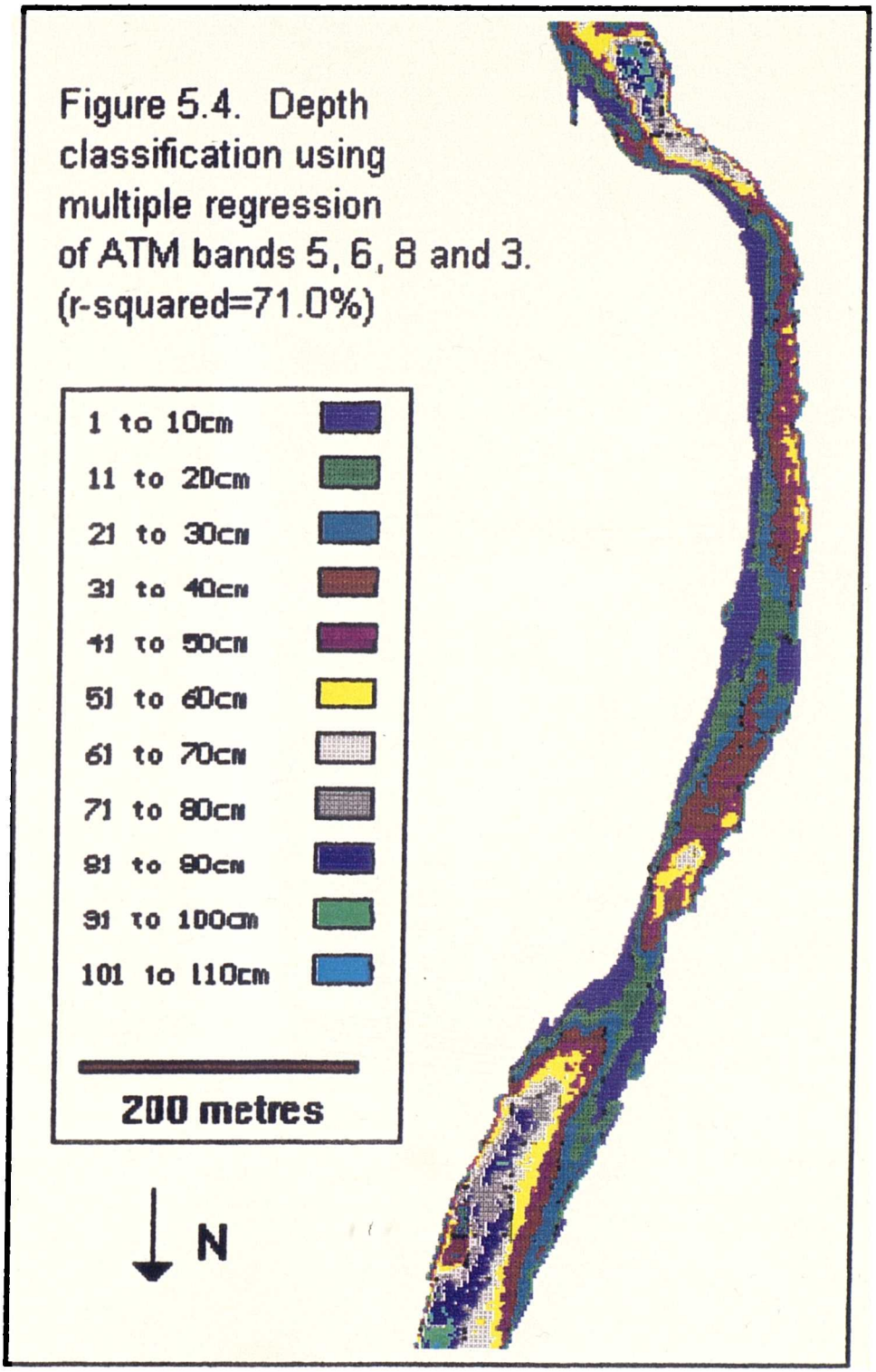


Figure 5.4. Depth classification using multiple regression of ATM bands 5, 6, 8 and 3. (r-squared=71.0%)

Figure 5.5.

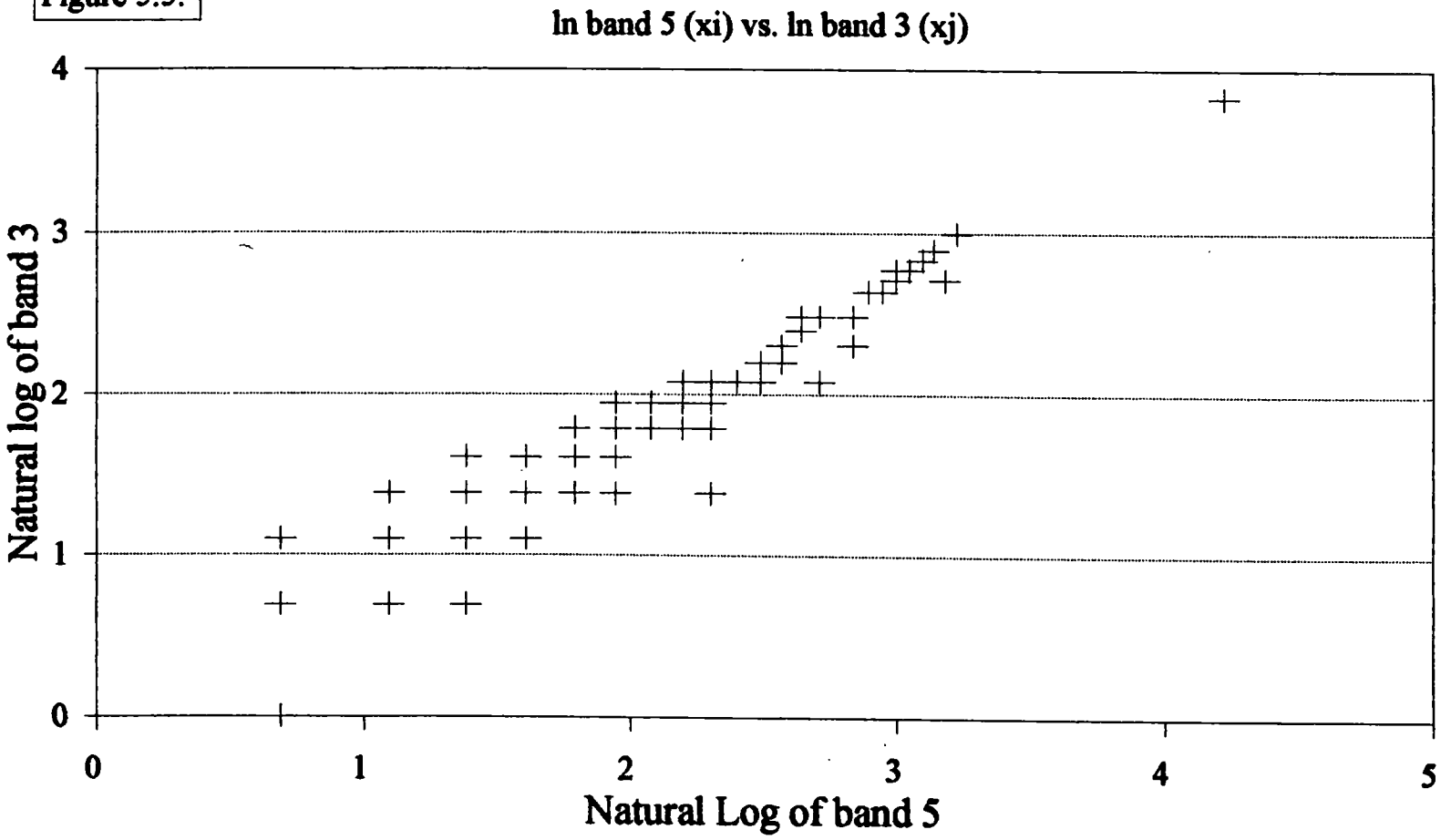

ln band 5 (xi) vs. ln band 3 (xj)
Natural log of band 3
Natural Log of band 5
0
1
2
3
4
5

Figure 5.6.

Actual depths vs. predicted depths
using black and white aerial photos.

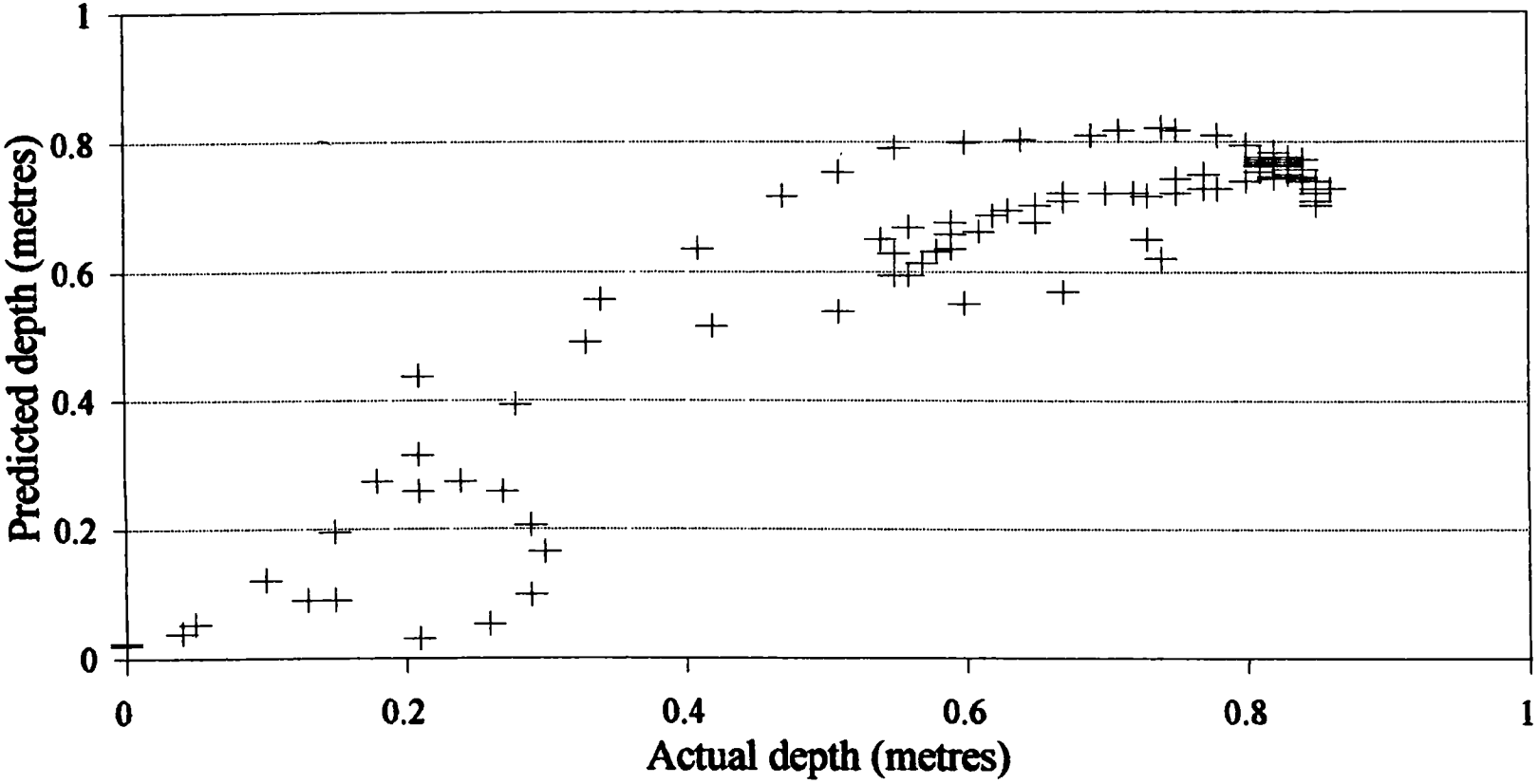
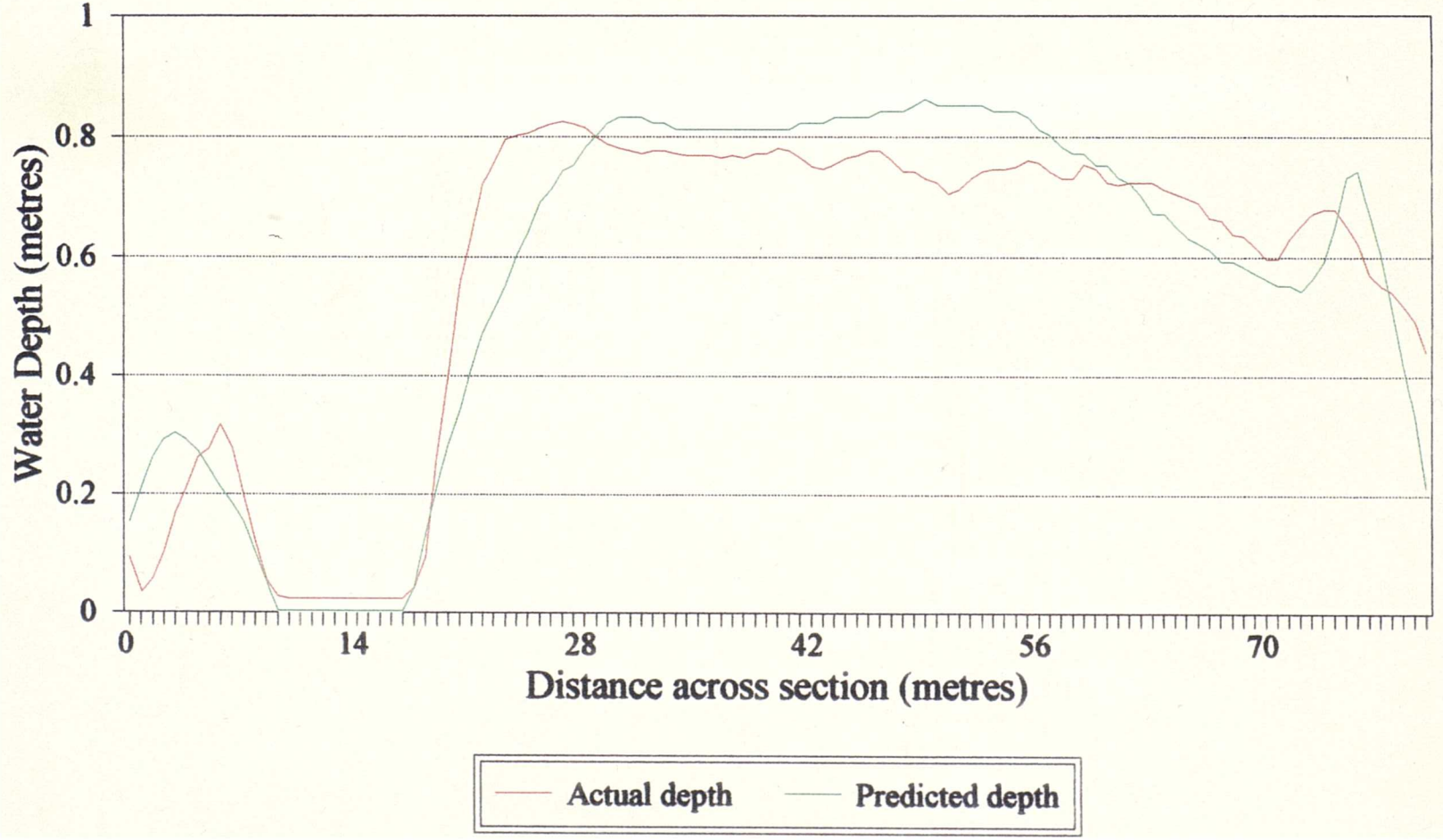


Figure 5.7.

River pool cross-section showing
actual depths and predicted depths.



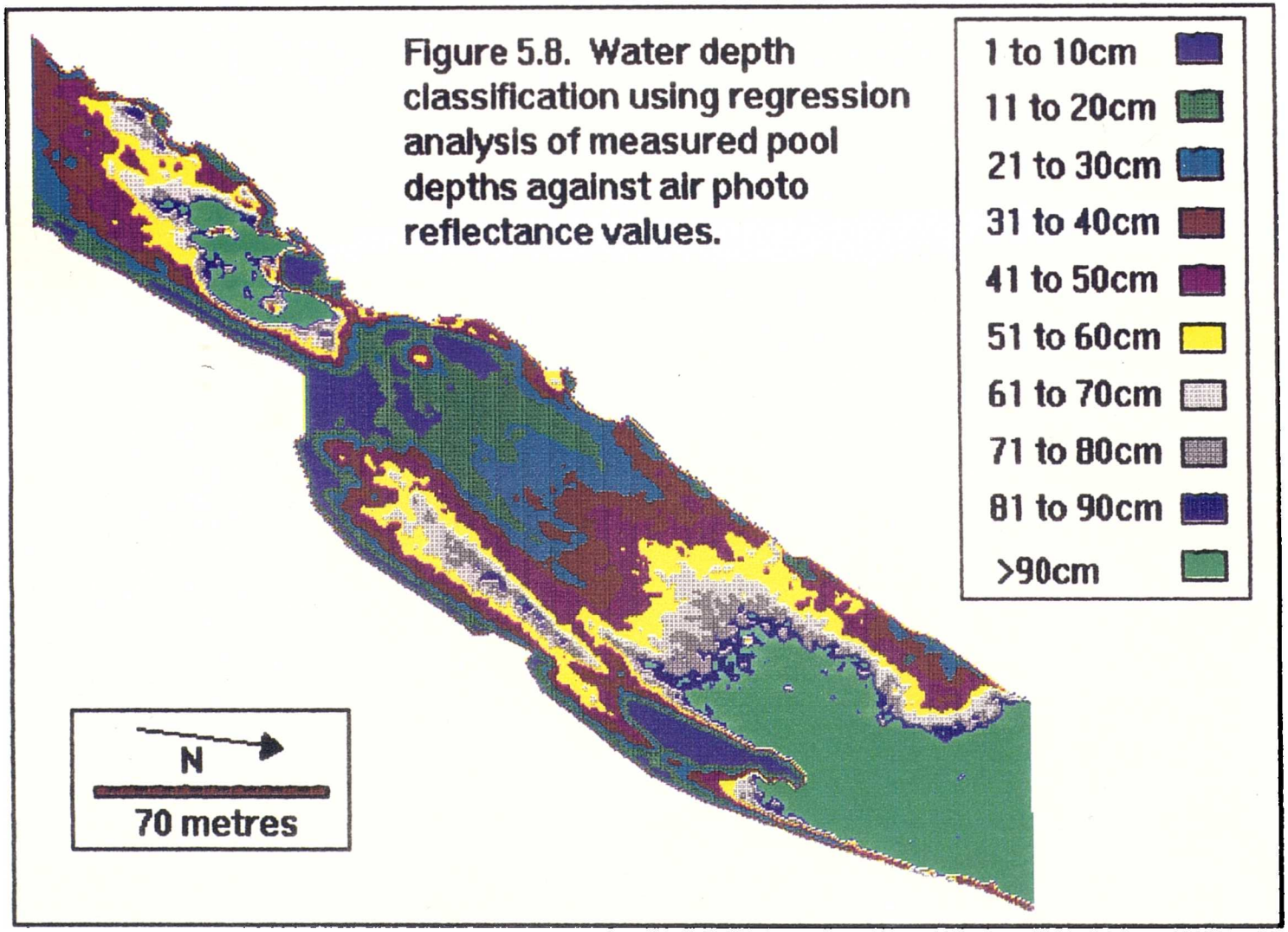


Figure 5.8. Water depth classification using regression analysis of measured pool depths against air photo reflectance values.

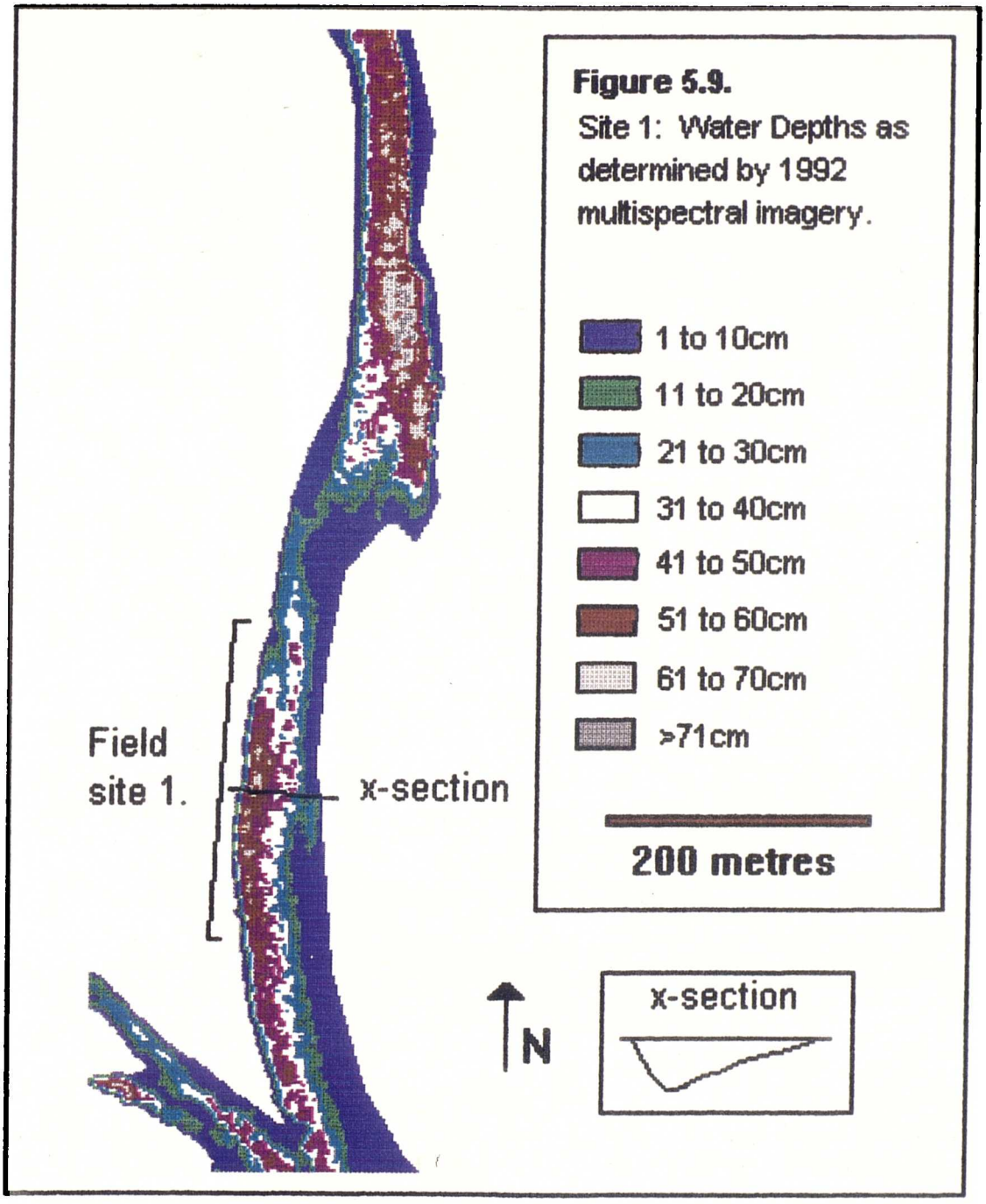


Figure 5.9.
Site 1: Water Depths as determined by 1992 multispectral imagery.
1 to 10cm
11 to 20cm
21 to 30cm
31 to 40cm
41 to 50cm
51 to 60cm
61 to 70cm
>71cm
200 metres
Field site 1.
x-section
N
x-section

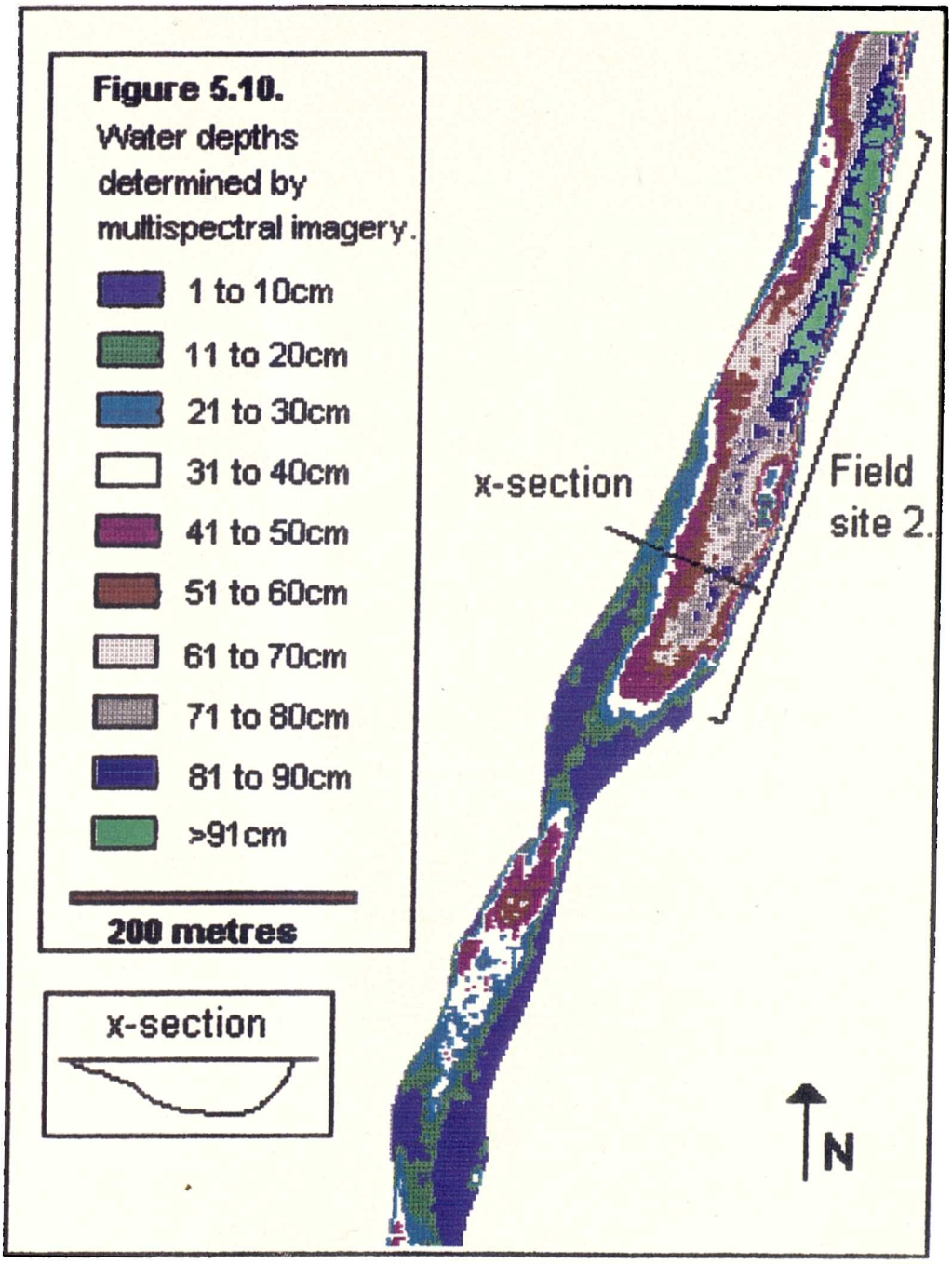


Figure 5.10.
Water depths determined by multispectral imagery.
1 to 10cm
11 to 20cm
21 to 30cm
31 to 40cm
41 to 50cm
51 to 60cm
61 to 70cm
71 to 80cm
81 to 90cm
>91cm
200 metres
x-section
x-section
Field site 2.
N

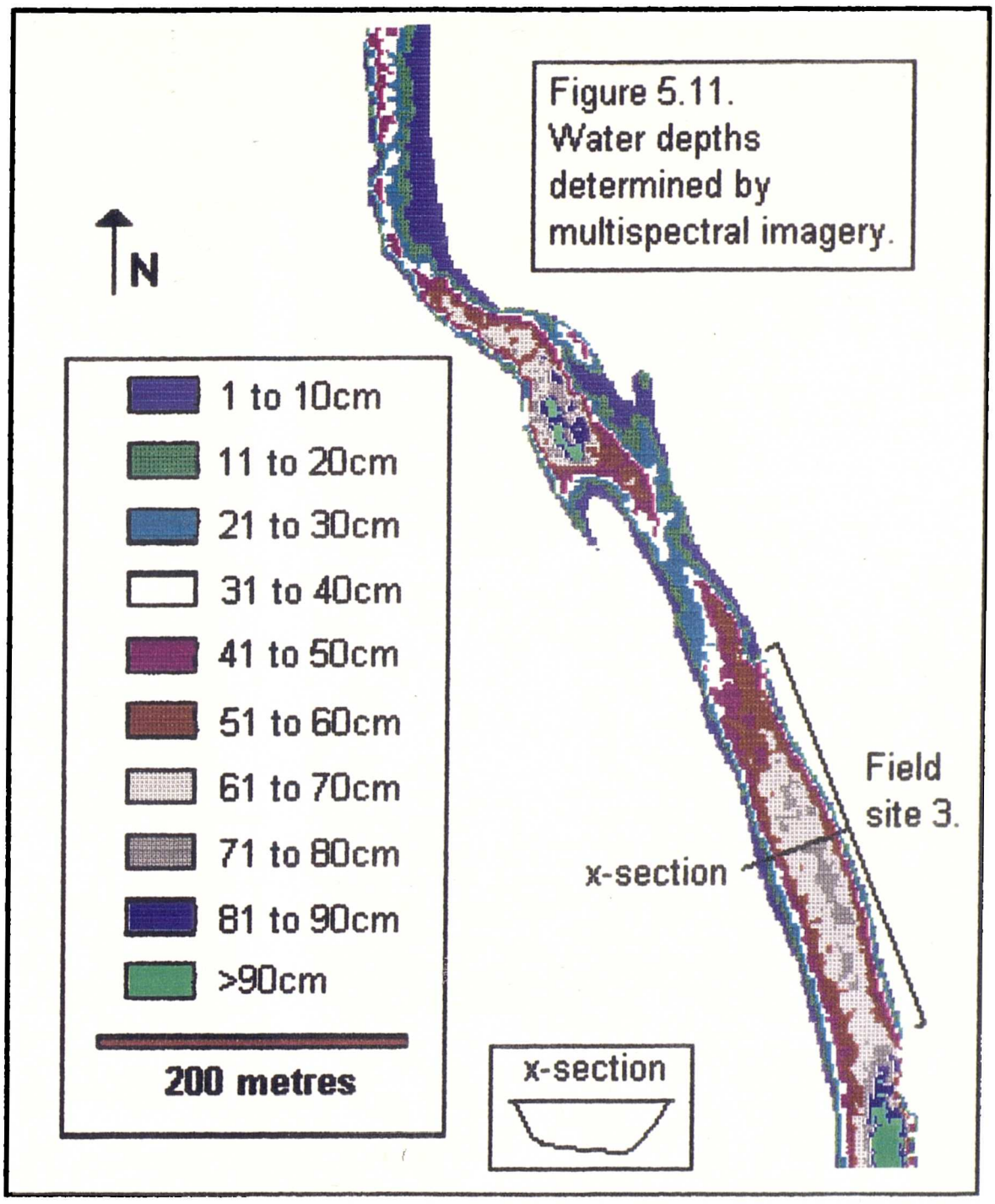


Figure 5.11.
Water depths
determined by
multispectral imagery.
N
1 to 10cm
11 to 20cm
21 to 30cm
31 to 40cm
41 to 50cm
51 to 60cm
61 to 70cm
71 to 80cm
81 to 90cm
>90cm
200 metres
Field
site 3.
x-section
x-section

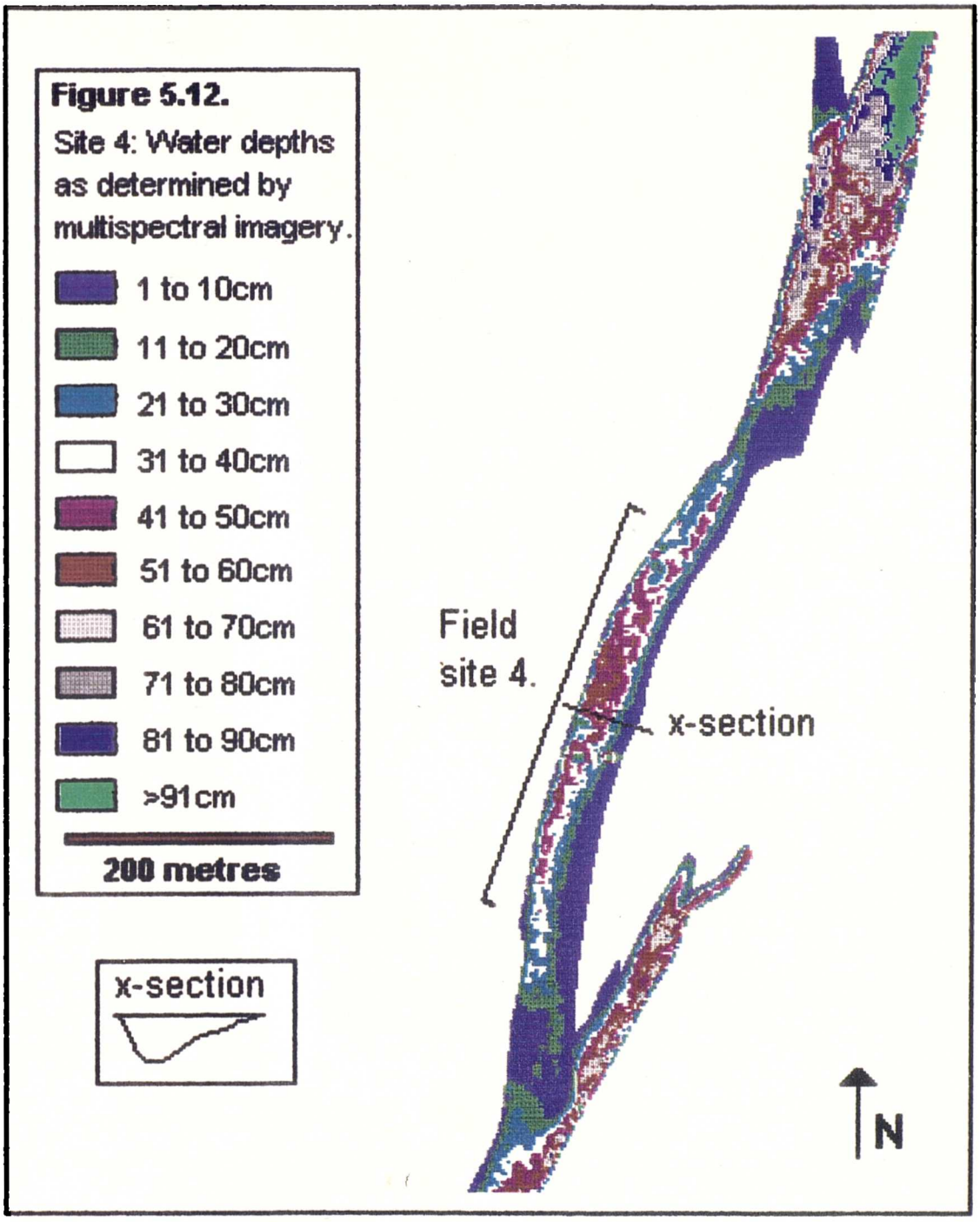


Figure 5.12.
Site 4: Water depths as determined by multispectral imagery.
1 to 10cm
11 to 20cm
21 to 30cm
31 to 40cm
41 to 50cm
51 to 60cm
61 to 70cm
71 to 80cm
81 to 90cm
>91cm
200 metres
x-section
Field site 4.
x-section
N

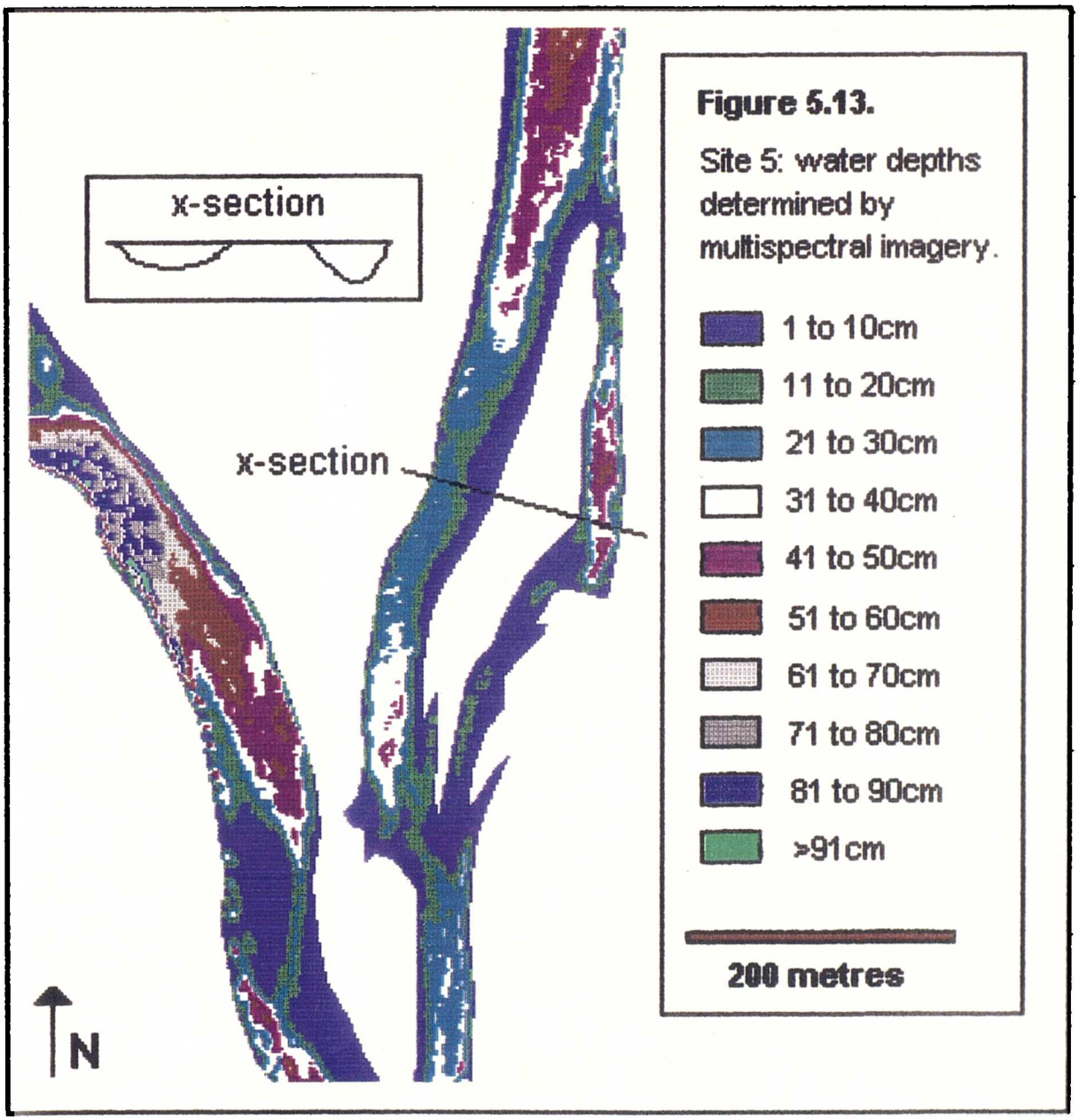
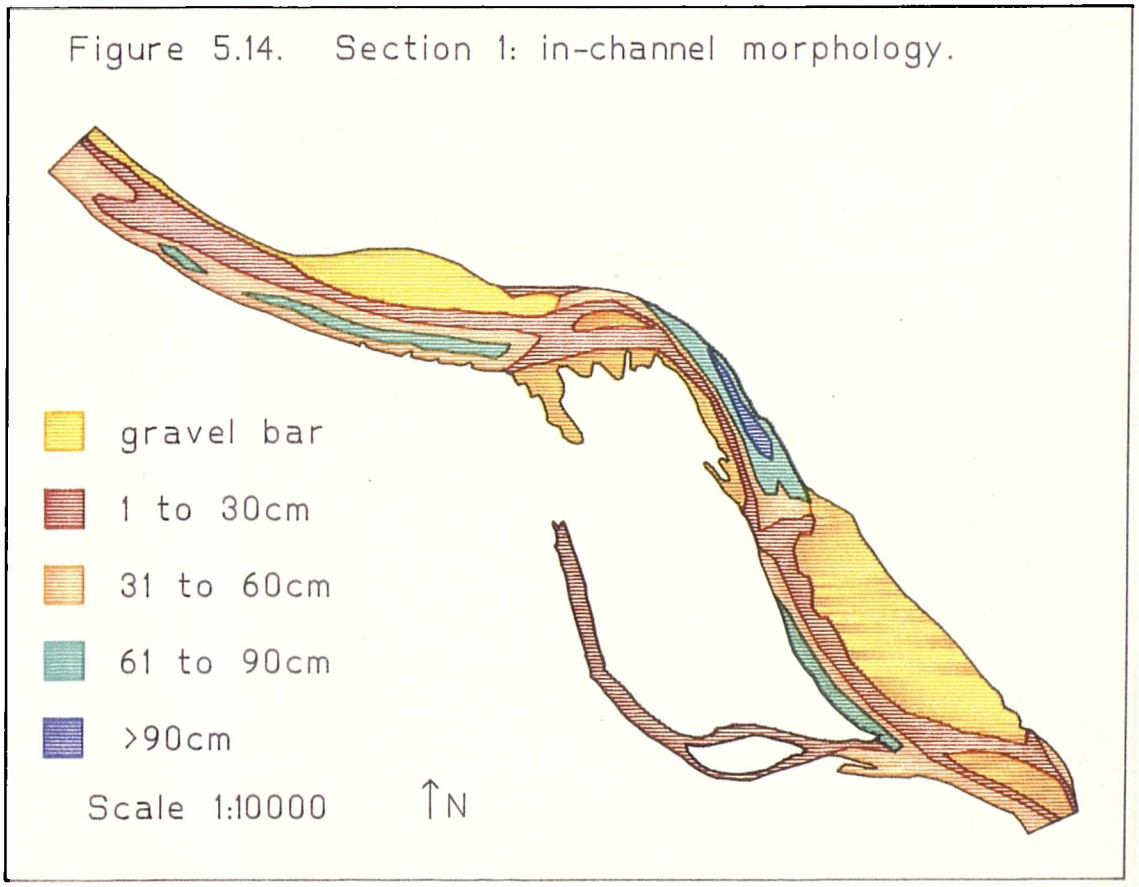

x-section
x-section
N
Figure 5.13.
Site 5: water depths determined by multispectral imagery.
1 to 10cm
11 to 20cm
21 to 30cm
31 to 40cm
41 to 50cm
51 to 60cm
61 to 70cm
71 to 80cm
81 to 90cm
>91cm
200 metres

Figure 5.14. Section 1: in-channel morphology.



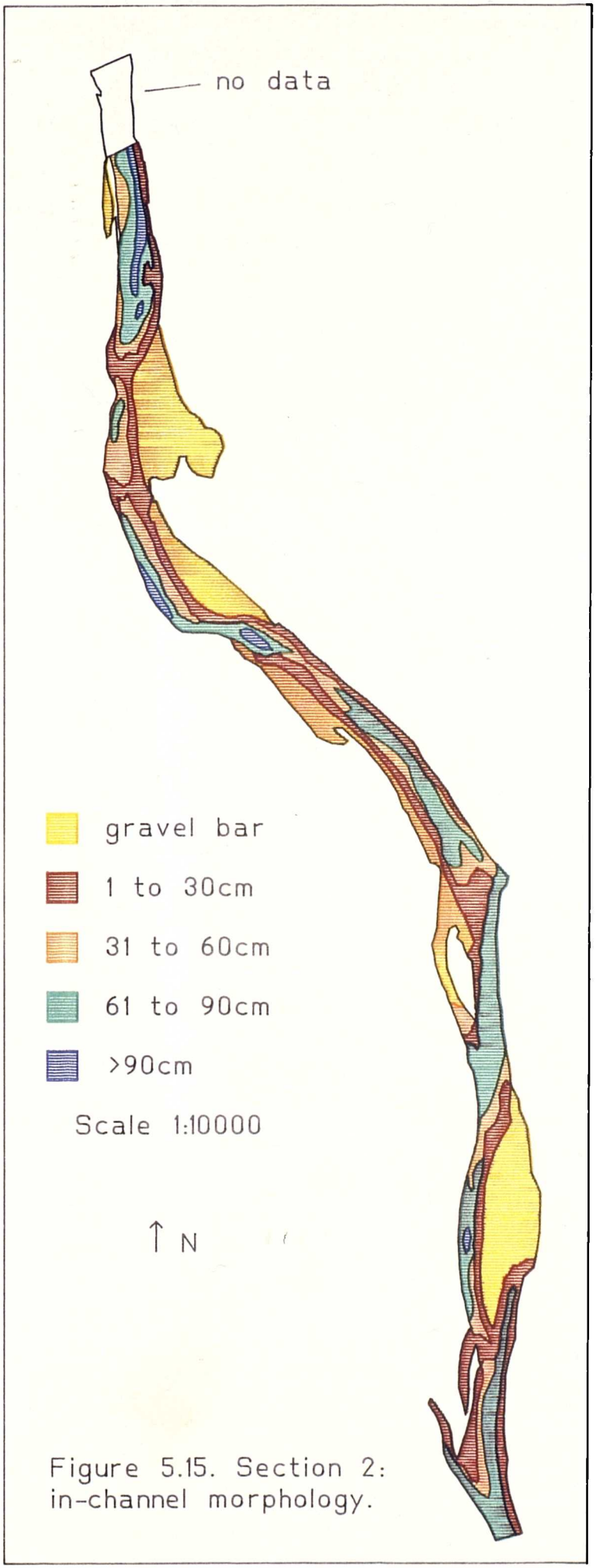


Figure 5.15. Section 2: in-channel morphology.

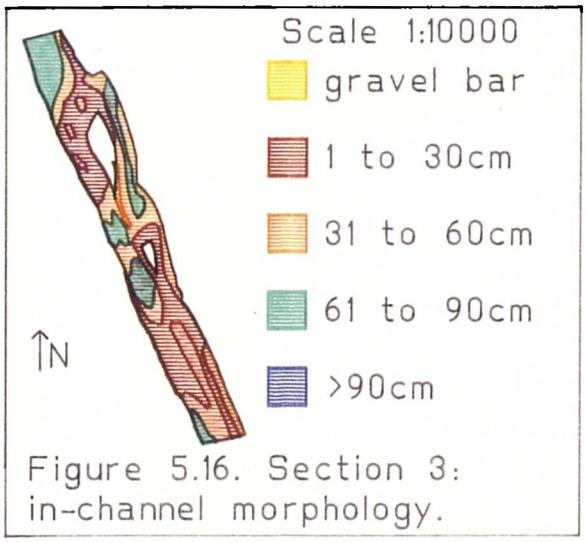
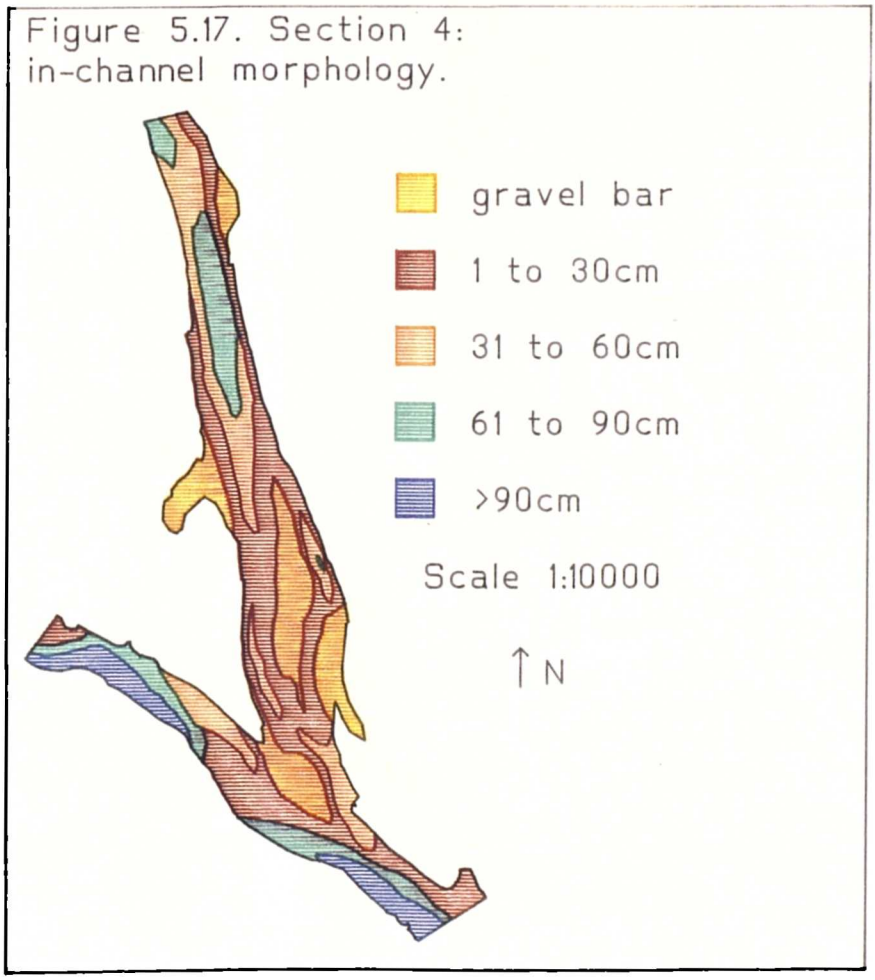


Figure 5.16. Section 3: in-channel morphology.

Figure 5.17. Section 4: in-channel morphology.



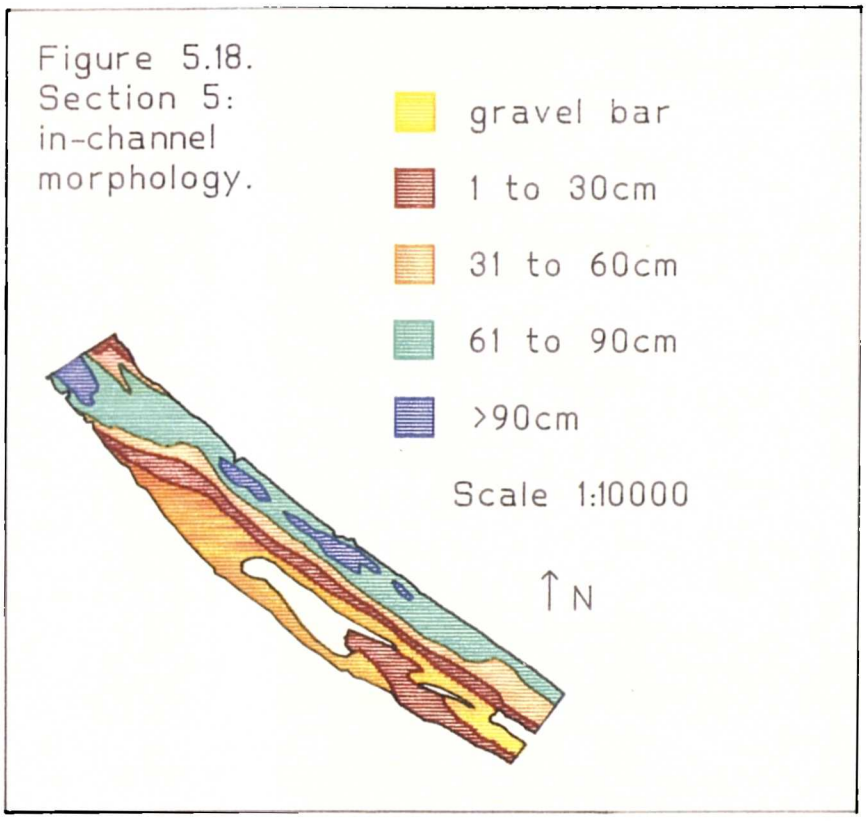


Figure 5.18.
Section 5:
in-channel
morphology.

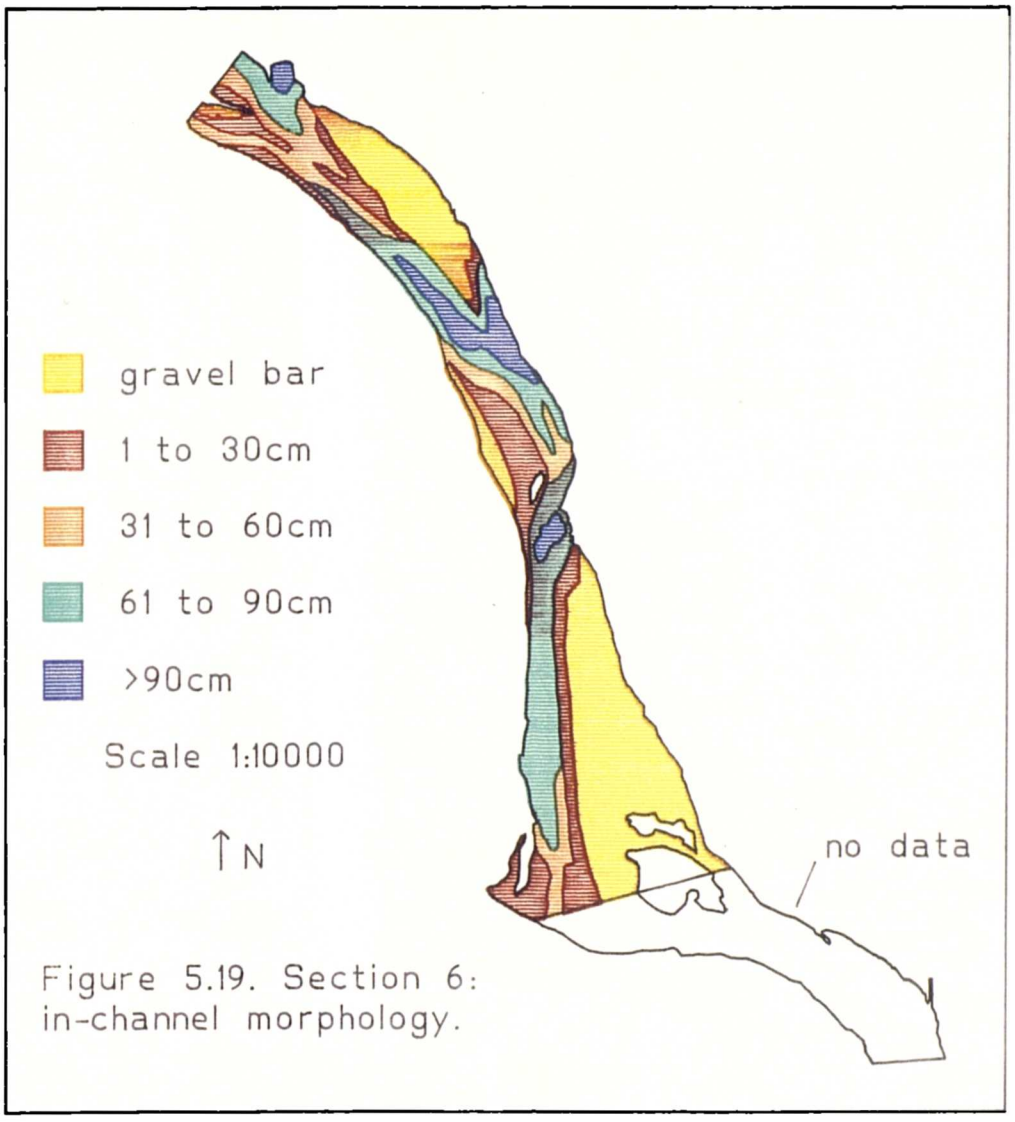


Figure 5.19. Section 6: in-channel morphology.

Figure 5.20.

In-channel morphology derived from ATM data: percentage area within classes.

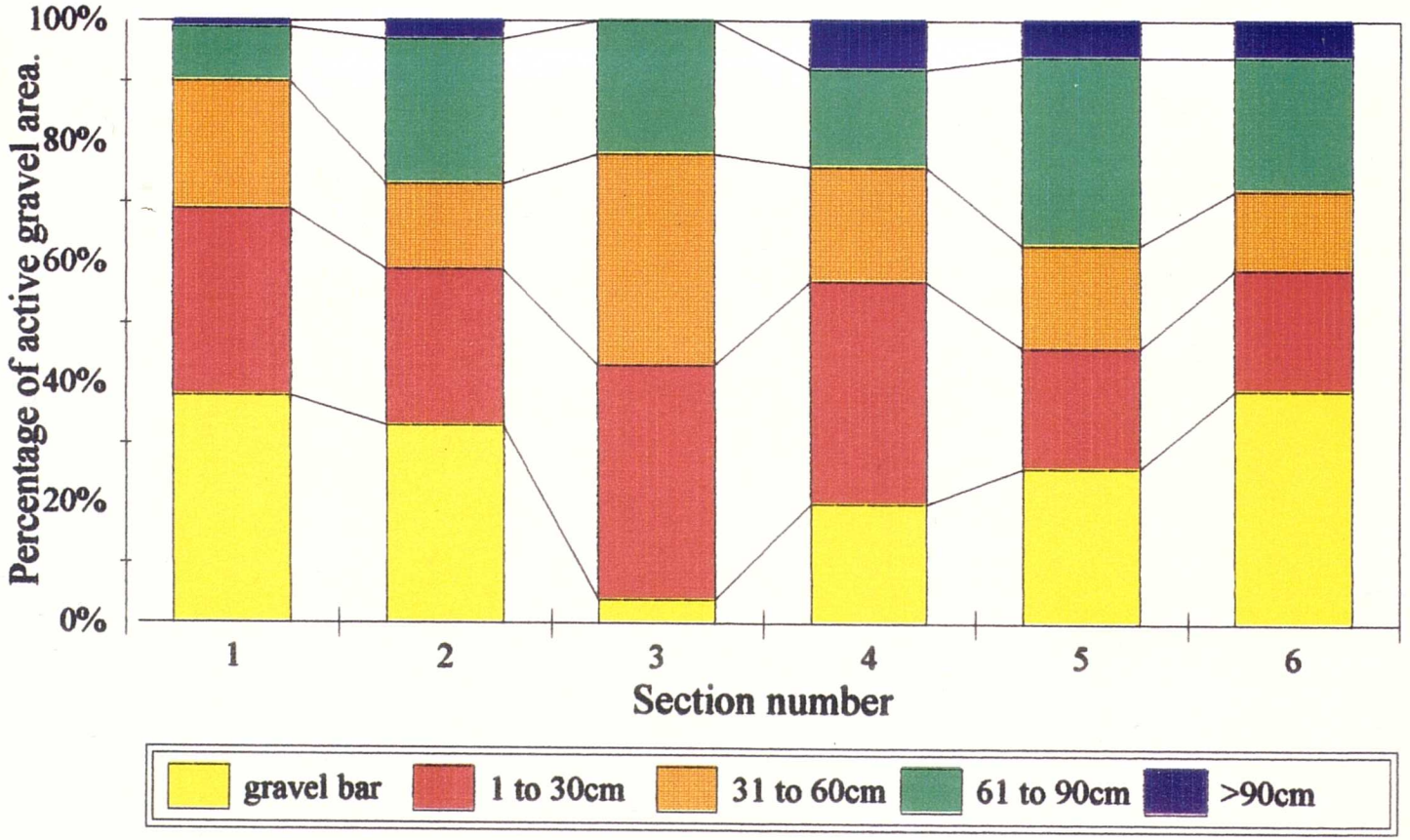
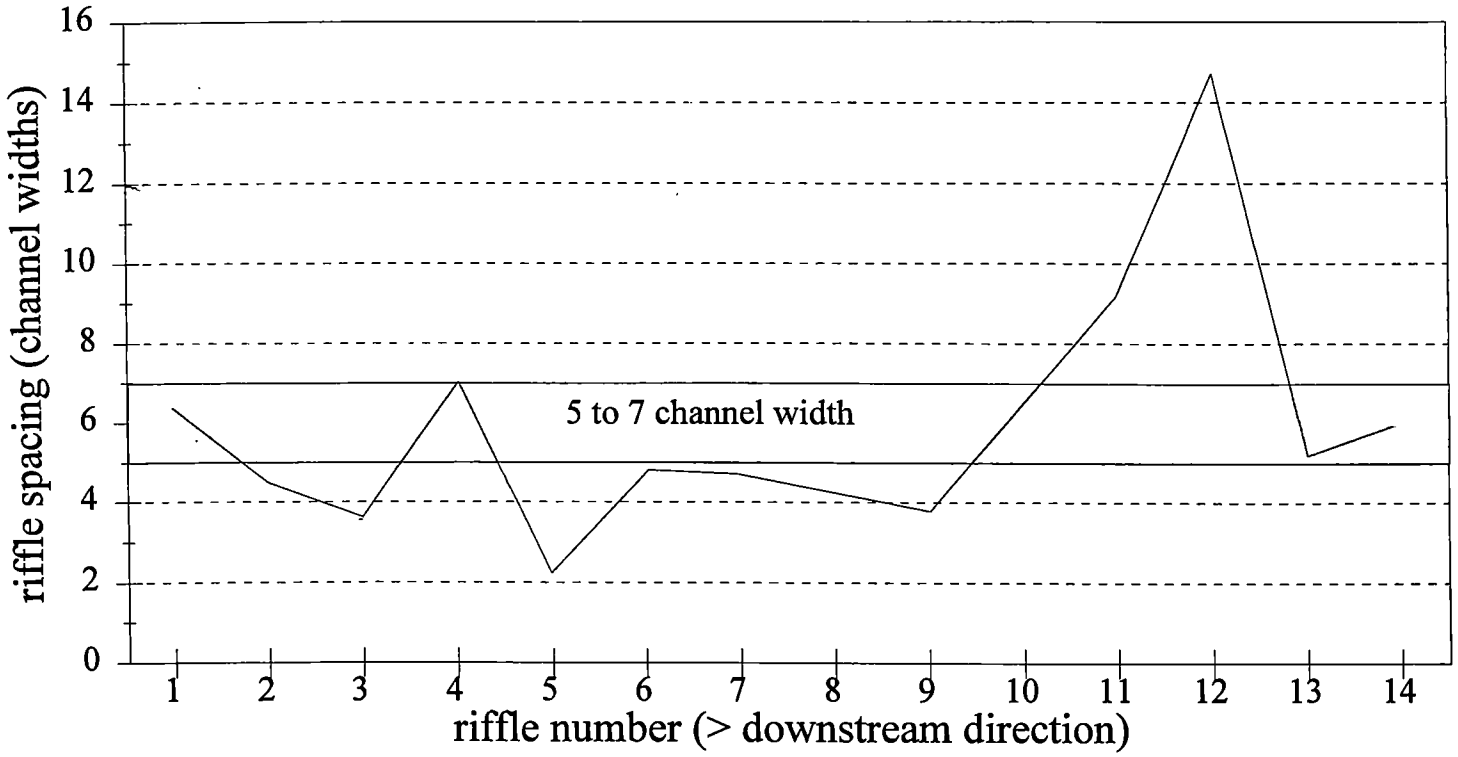


Figure 5.21.

Pool-riffle spacing.
Sections 1 to 6.



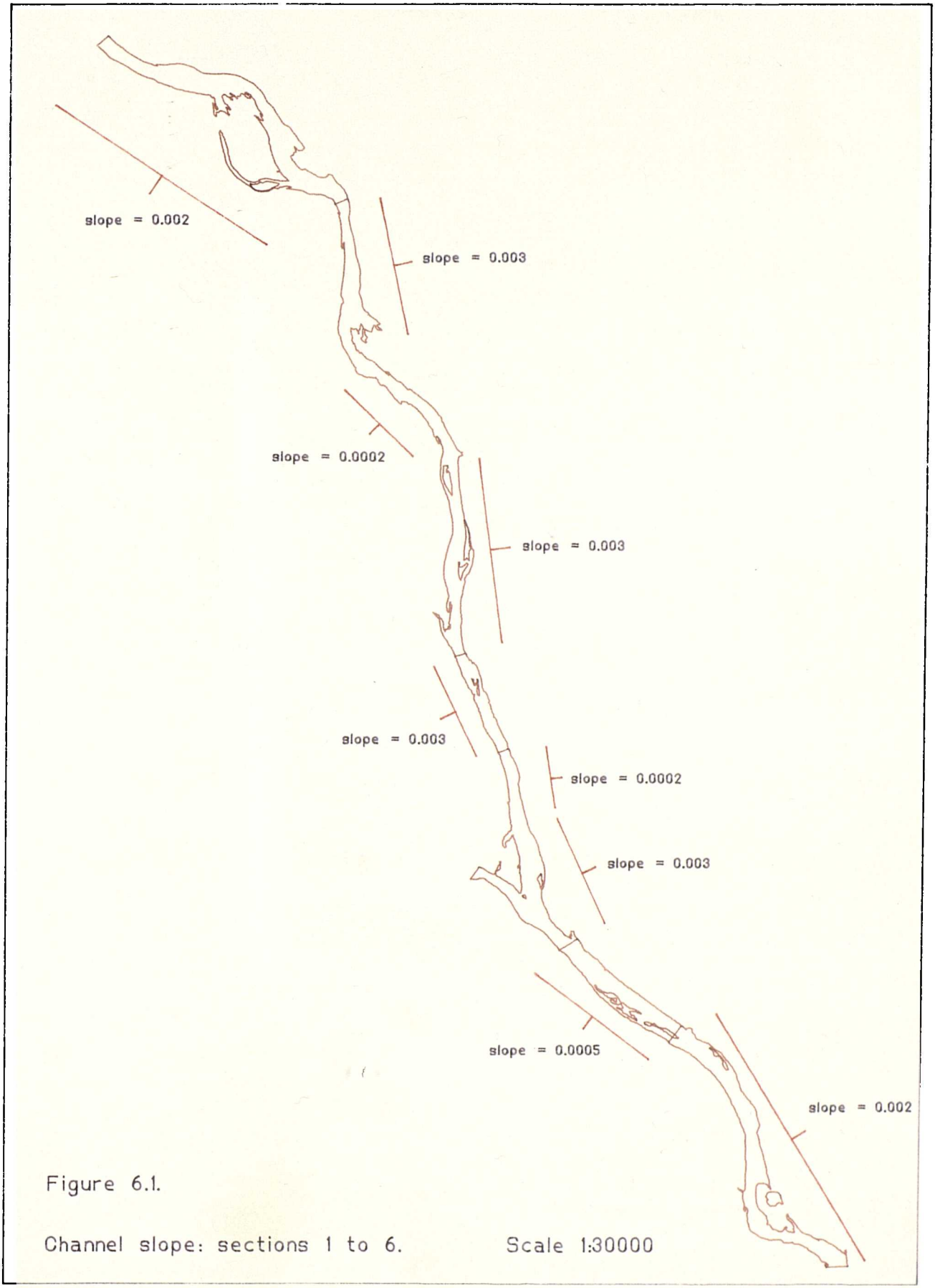


Figure 6.1.

Channel slope: sections 1 to 6. Scale 1:30000

Figure 6.2.

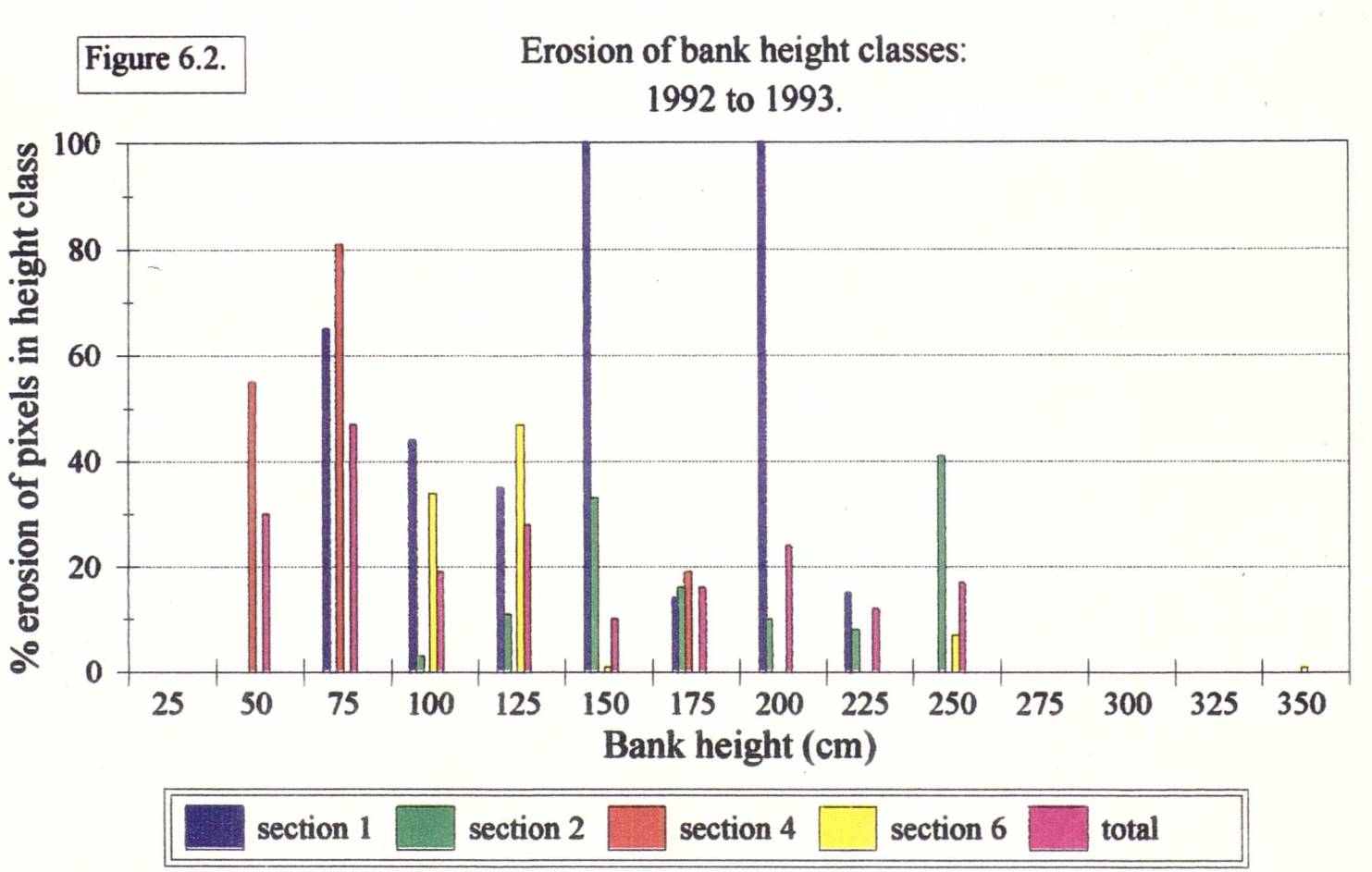

Erosion of bank height classes:
1992 to 1993.
% erosion of pixels in height class
100
80
60
40
20
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
Bank height (cm)
section 1
section 2
section 4
section 6
total

Figure 6.3.

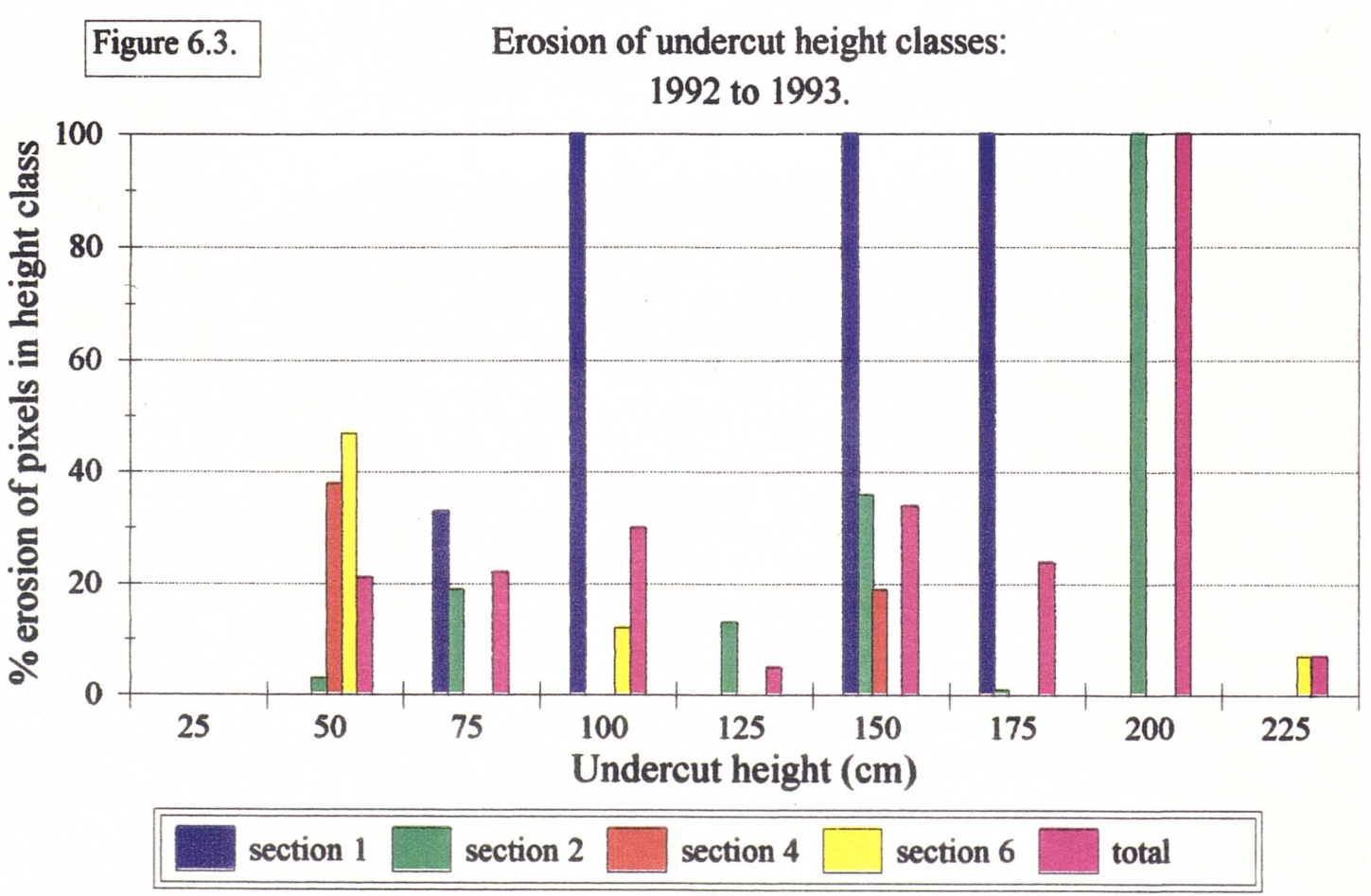

Erosion of undercut height classes:
1992 to 1993.
% erosion of pixels in height class
100
80
60
40
20
0
25
50
75
100
125
150
175
200
225
Undercut height (cm)
section 1
section 2
section 4
section 6
total

Figure 6.4.

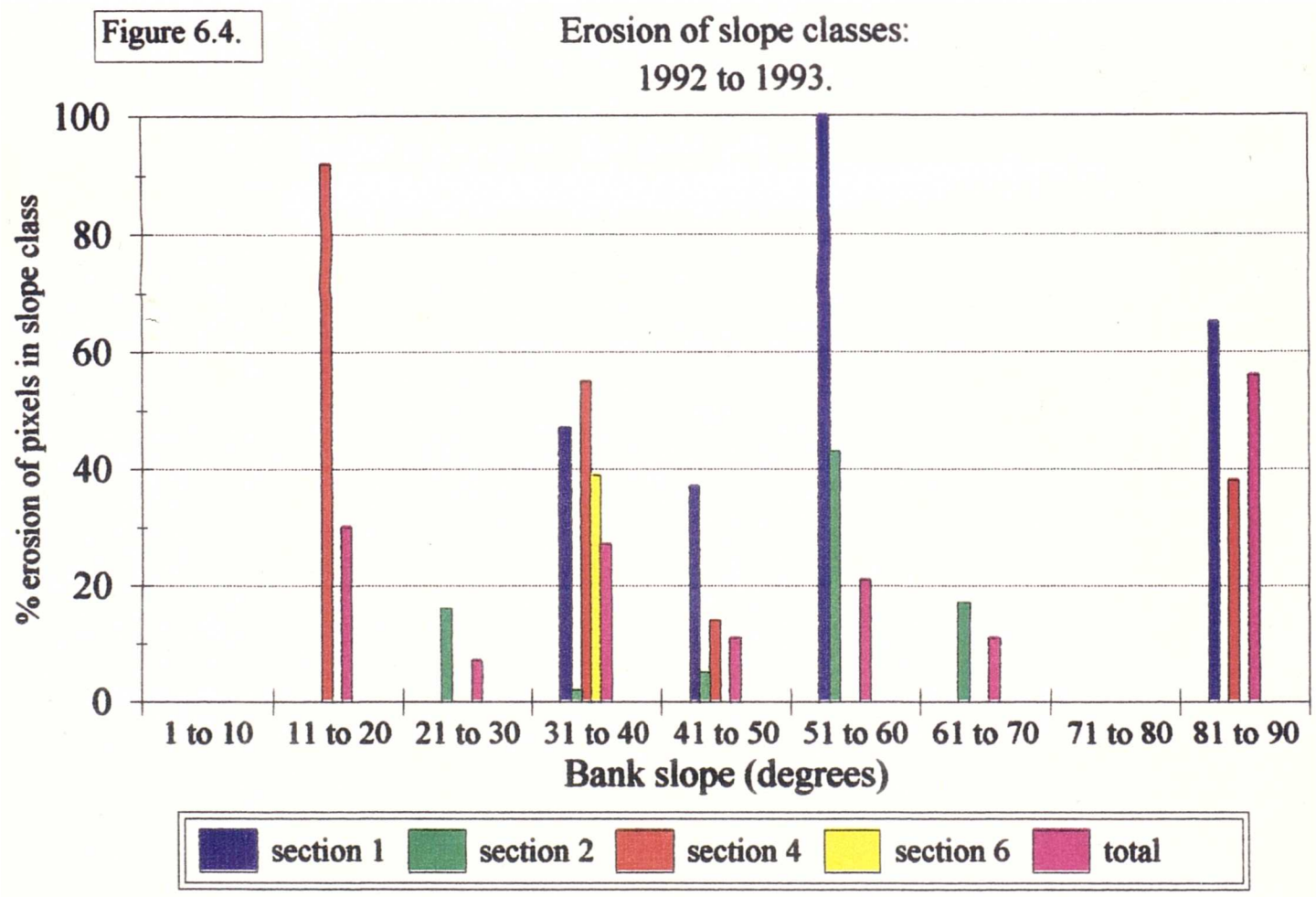

Erosion of slope classes:
1992 to 1993.
% erosion of pixels in slope class
100
80
60
40
20
0
1 to 10
11 to 20
21 to 30
31 to 40
41 to 50
51 to 60
61 to 70
71 to 80
81 to 90
Bank slope (degrees)
section 1
section 2
section 4
section 6
total

Figure 6.5.

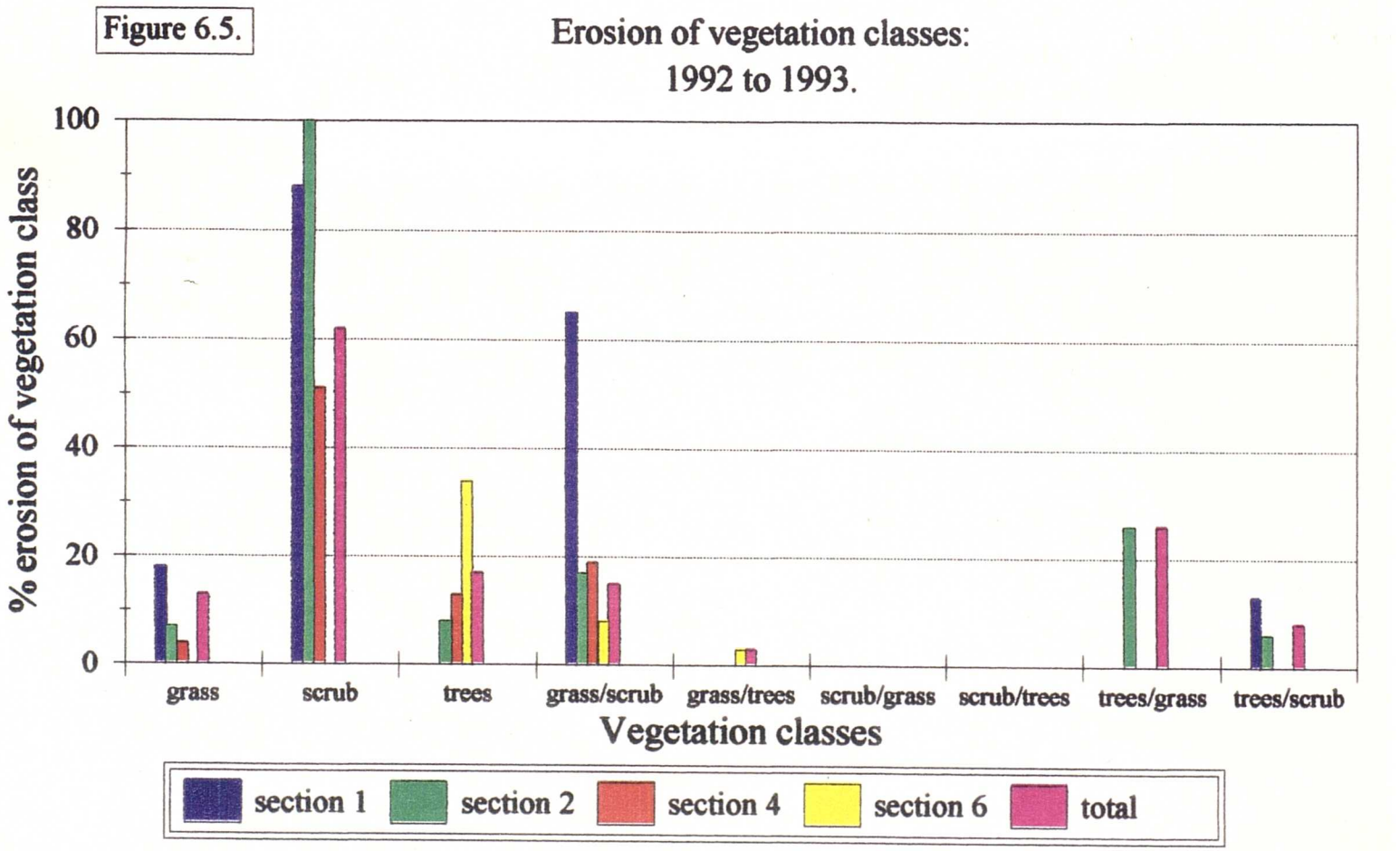

Erosion of vegetation classes:
1992 to 1993.
% erosion of vegetation class
100
80
60
40
20
0
grass
scrub
trees
grass/scrub
grass/trees
scrub/grass
scrub/trees
trees/grass
trees/scrub
Vegetation classes
section 1
section 2
section 4
section 6
total

Figure 6.6.

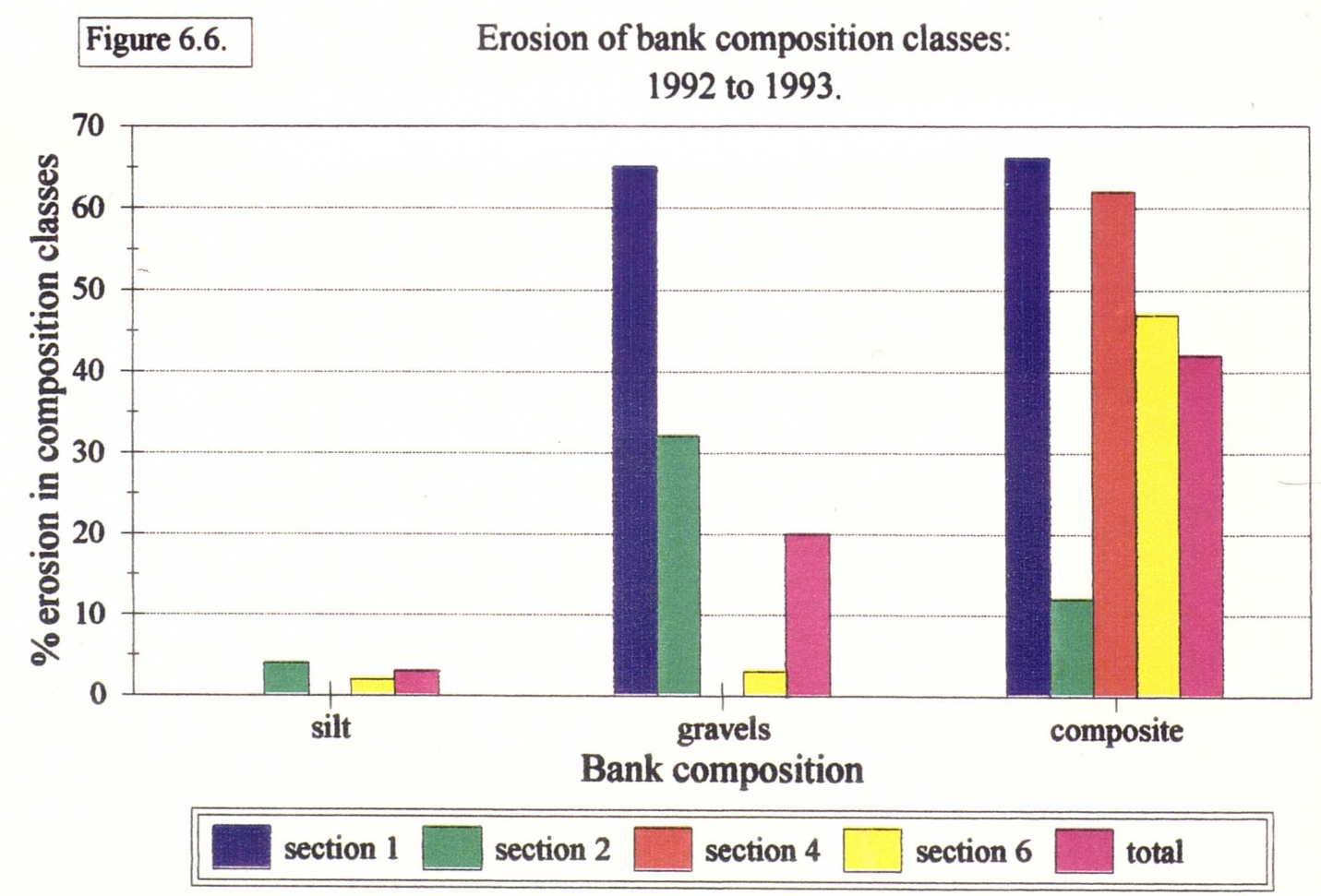
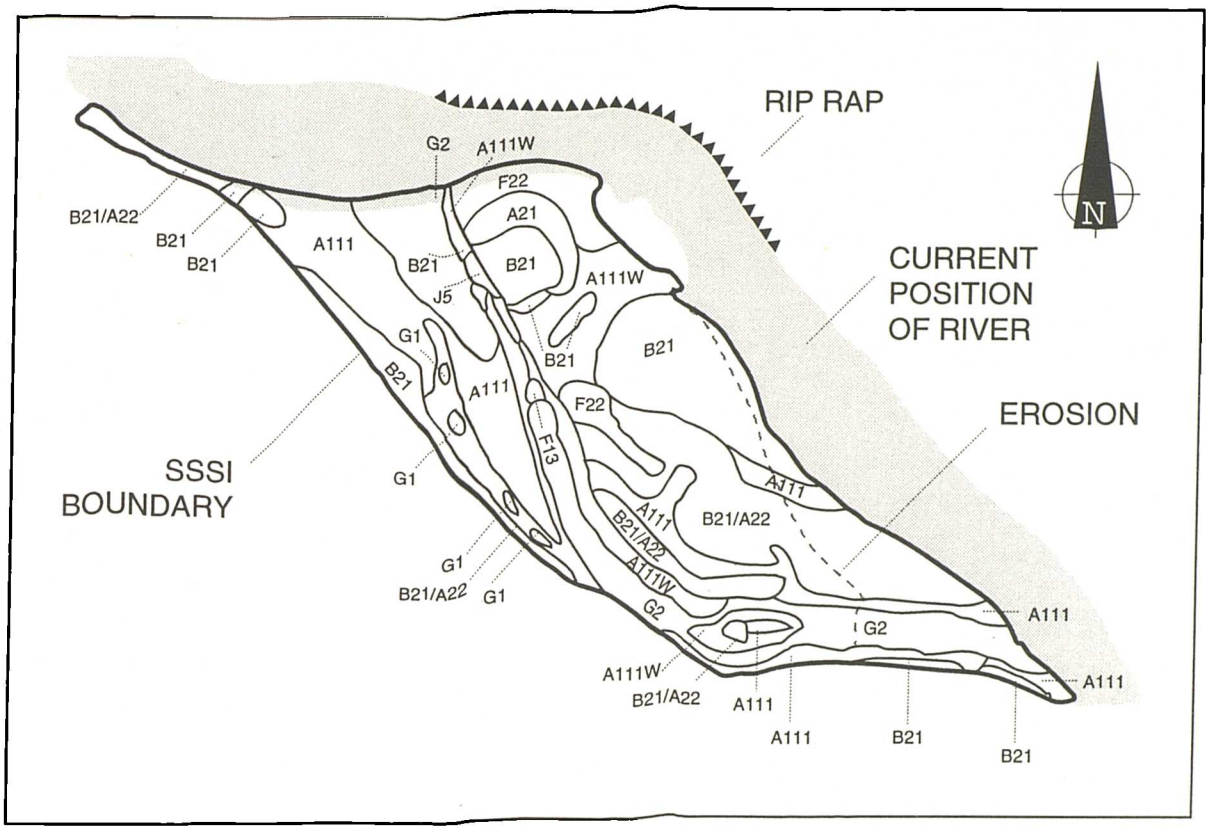

Erosion of bank composition classes:
1992 to 1993.
% erosion in composition classes
70
60
50
40
30
20
10
0
silt
gravels
composite
Bank composition
section 1
section 2
section 4
section 6
total

Figure 6.7. NVC vegetation/habitat classification of Tomdachoille Island. Part of the Shingle Islands SSSI (SNH, 1987).



A111 - Woodland, broadleaved, semi-natural.
A111W - Woodland, broadleaved, semi-natural, wet.
A121 - Woodland, coniferous, semi-natural.
A21 - Scrub dense.
A21W - Scrub, dense.
A122 - Woodland, coniferous, plantation.
B21 - Grassland, neutral, unimproved.
B21w - Grassland, neutral, unimproved, wet.
B21/A22 - Grassland, neutral, unimproved/scattered scrub.
B21/A31/A32 - Grassland, neutral, unimproved, scattered mixed trees.
C11 - Bracken, dense.
F12 - Inundation.
F22 - Inundation.
F13 - Swamp, short.
JS - Bare shingle.
G1 - standing water.
G2 - Running water.

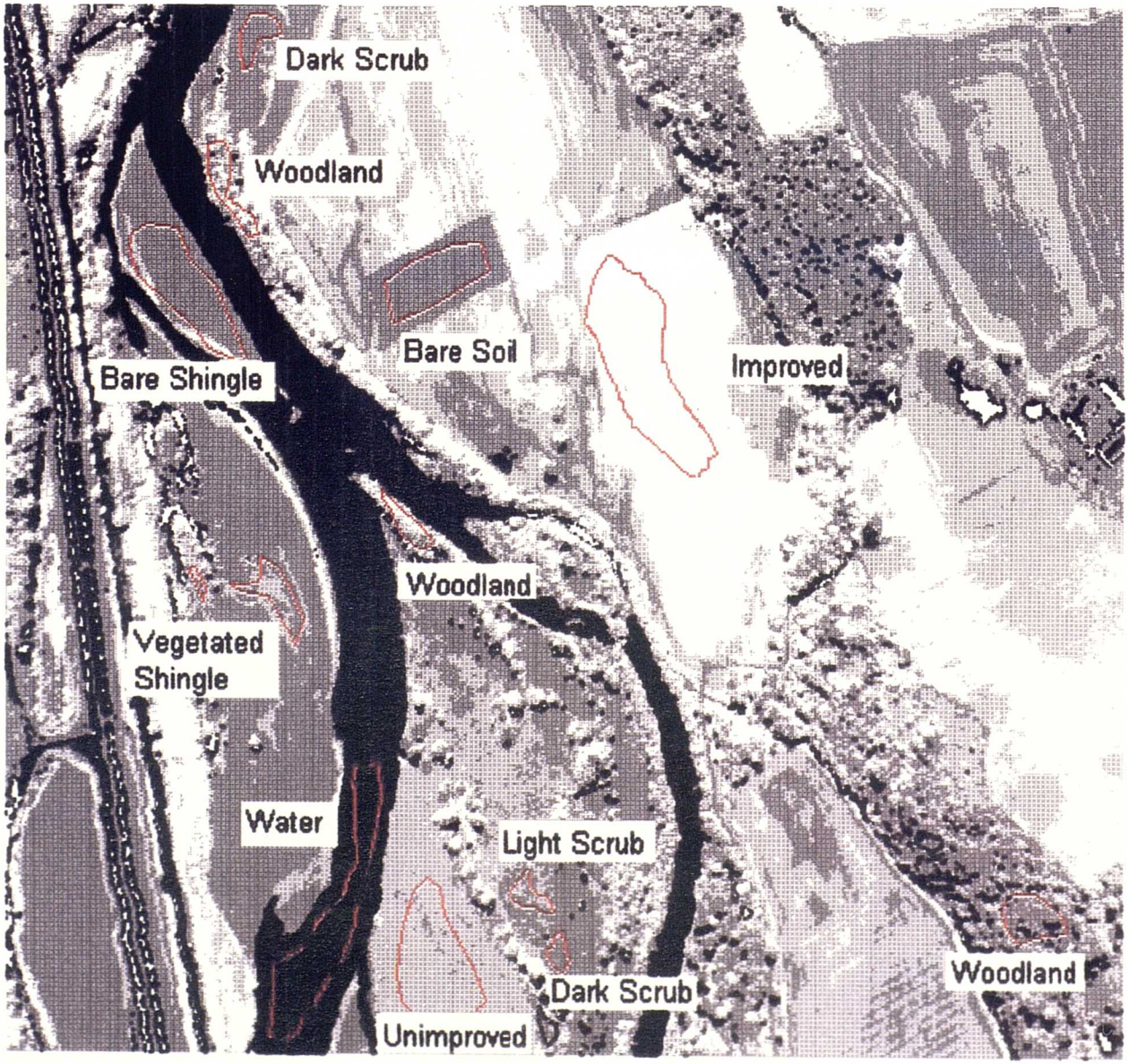


Figure 6.8.

Tomdachoille Island vegetation training areas.

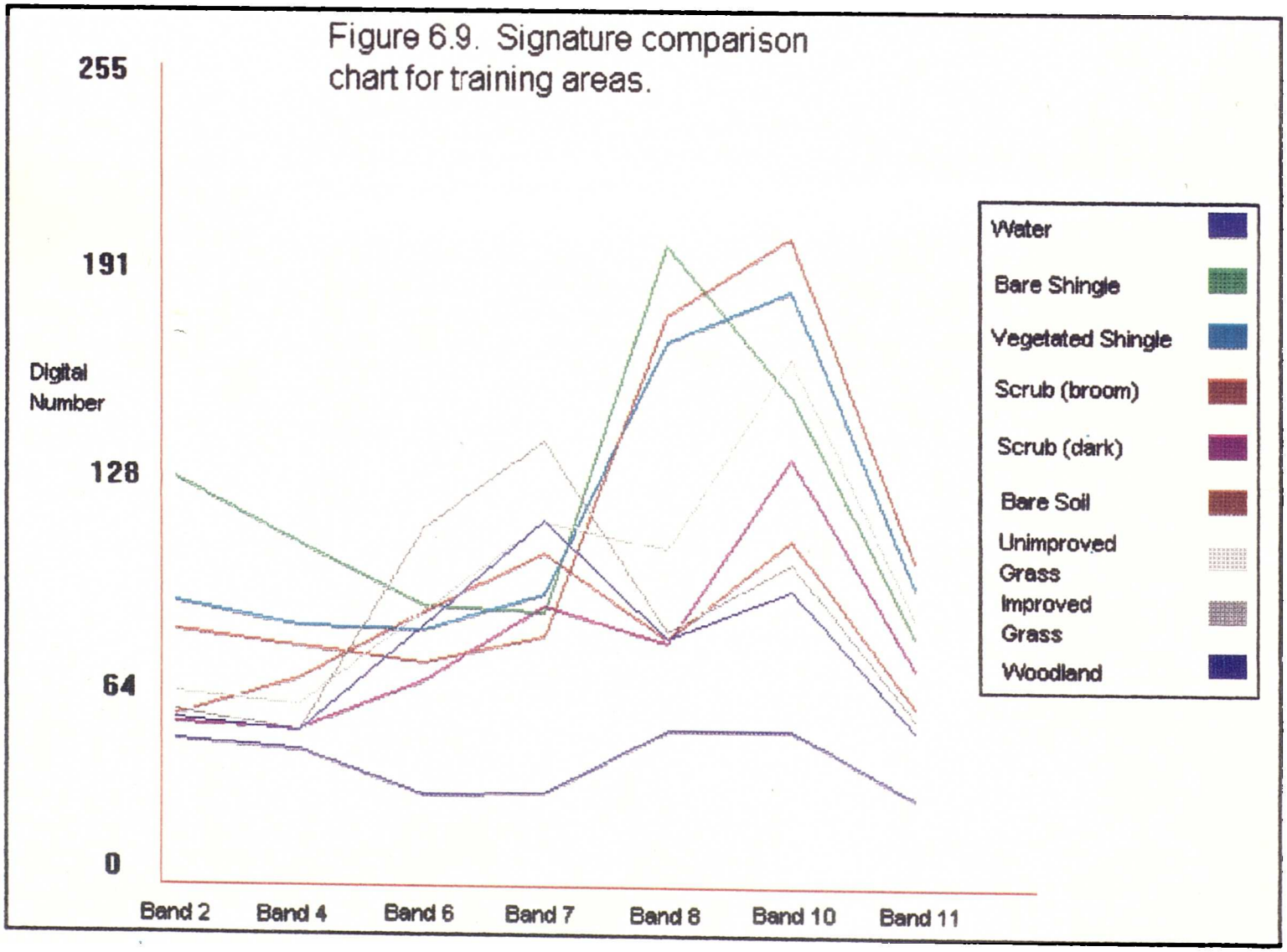


Figure 6.9. Signature comparison chart for training areas.

Figure 6.10. Minimum Distance Classification.

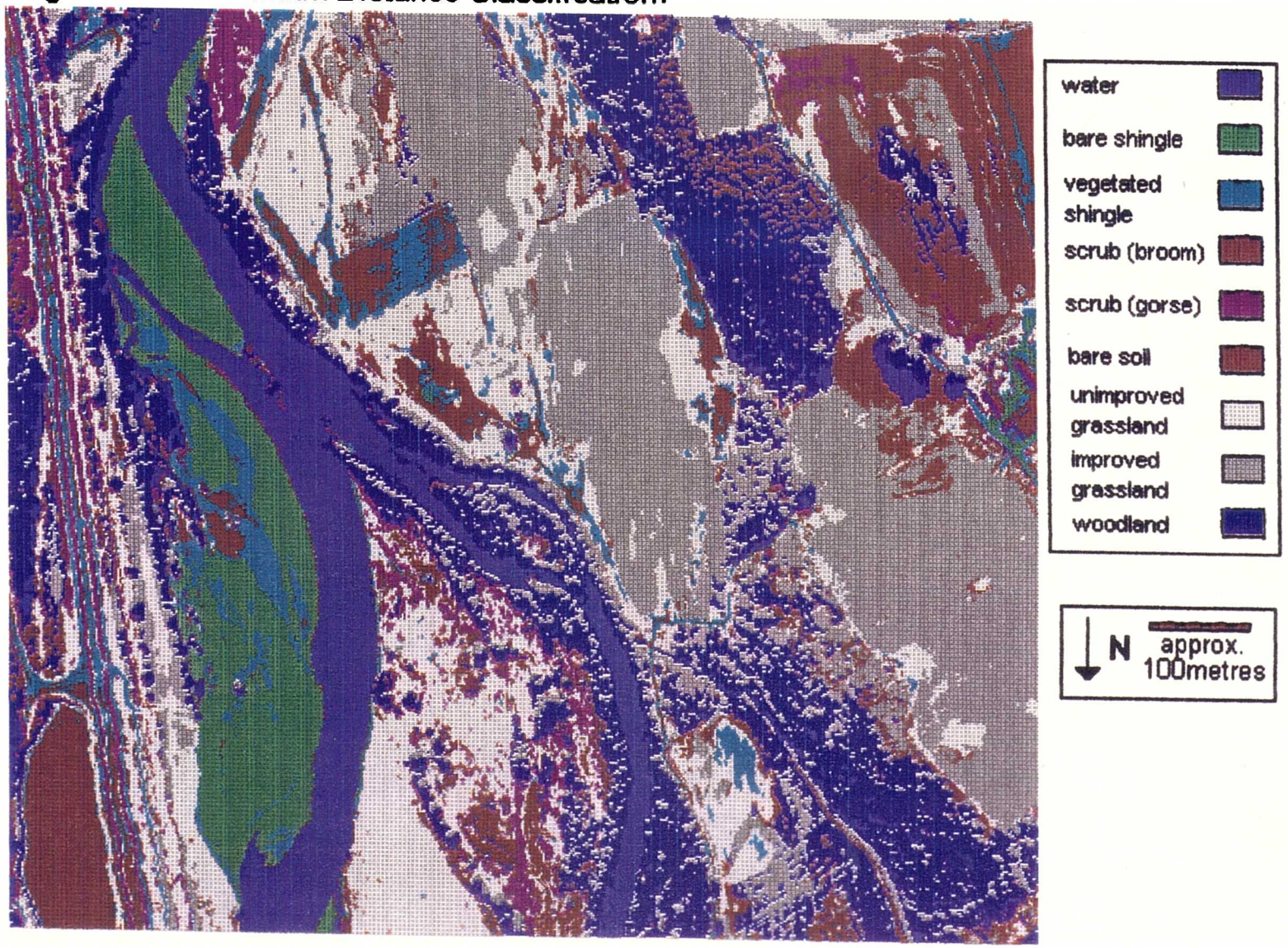


Figure 6.11. Maximum Likelihood Classification.

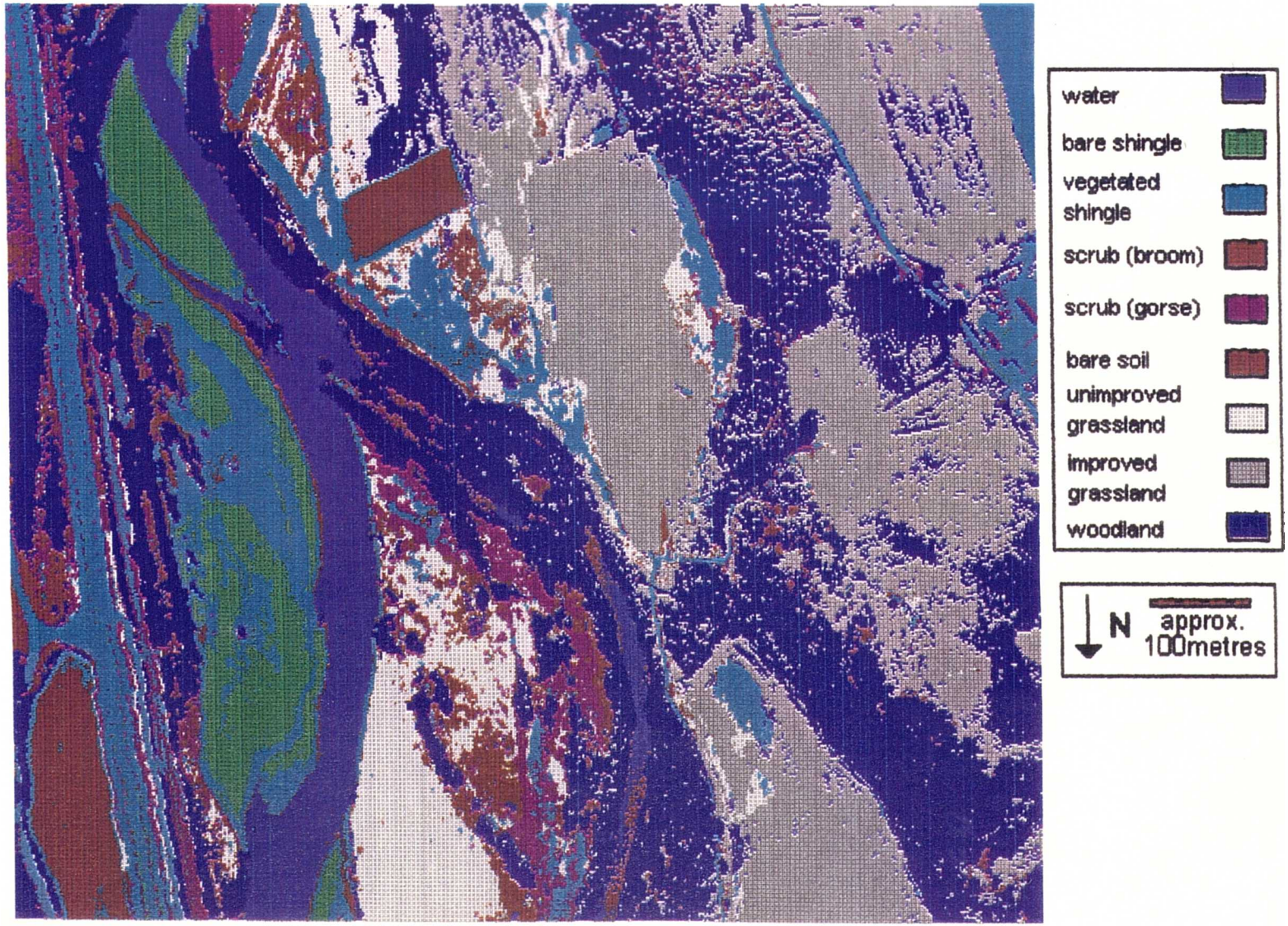
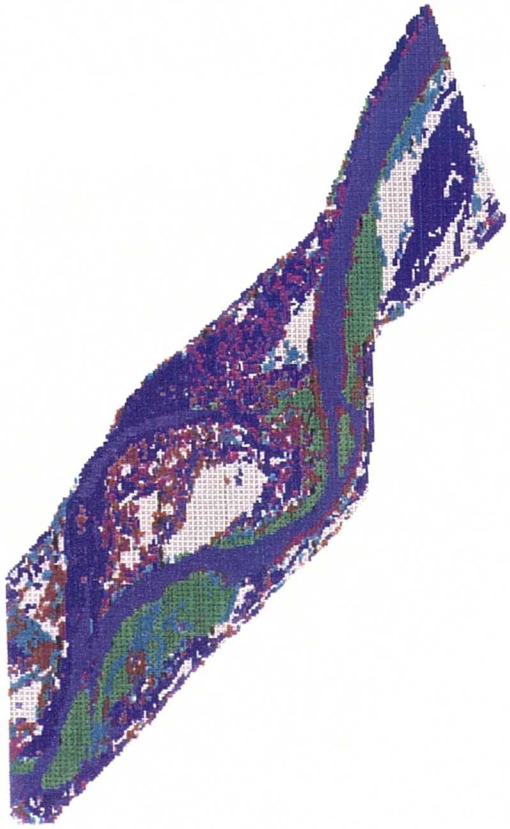


Figure 6.12. Section 1 - vegetation classification.



water
bare shingle
vegetated shingle
scrub (broom)
scrub (gorse)
bare soil
unimproved grassland
improved grassland
woodland

N
200 metres

Figure 6.13. Section 2 - vegetation classification.

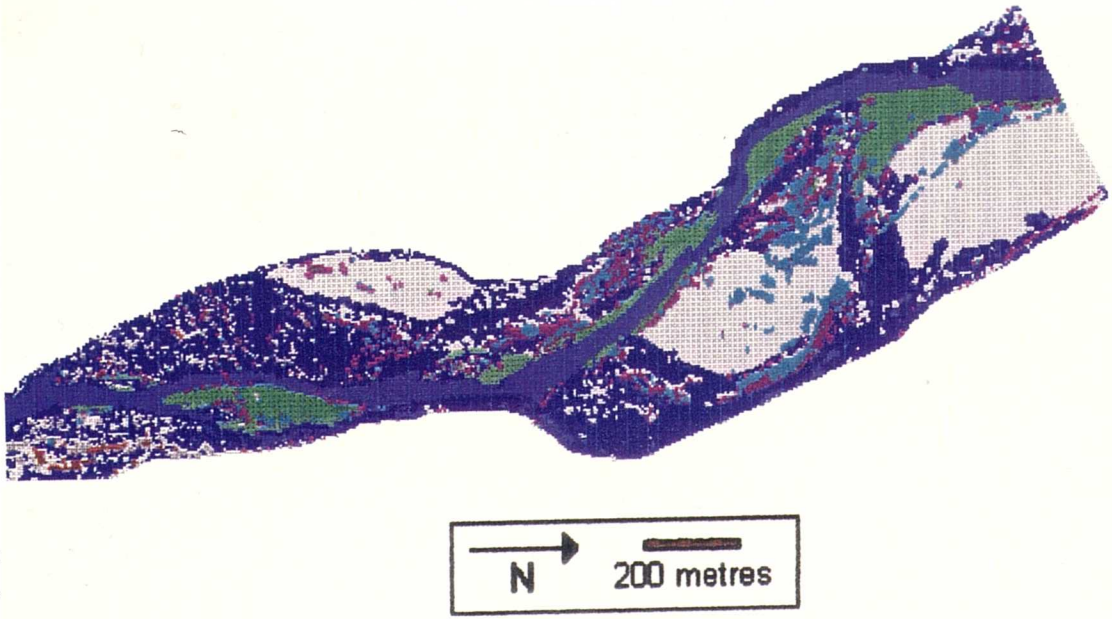


Figure 6.14. Section 4 - vegetation classification.

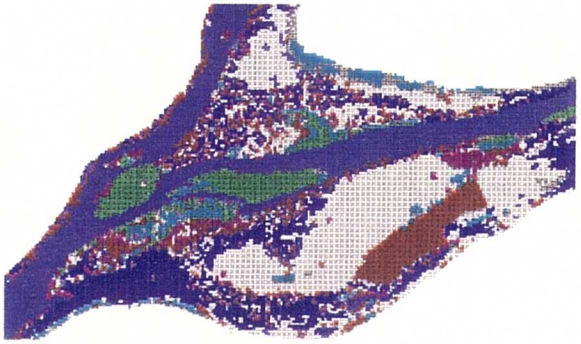
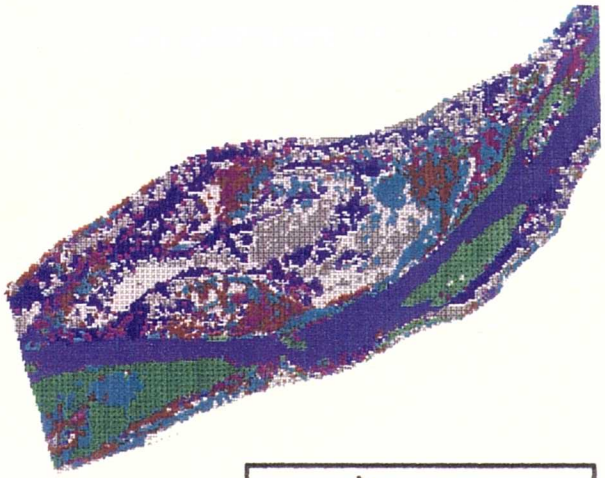


Figure 6.15. Section 6 - vegetation classification.



water
bare shingle
vegetated shingle
scrub (broom)
scrub (gorse)
bare soil
unimproved grassland
improved grassland
woodland

Figure 6.16.

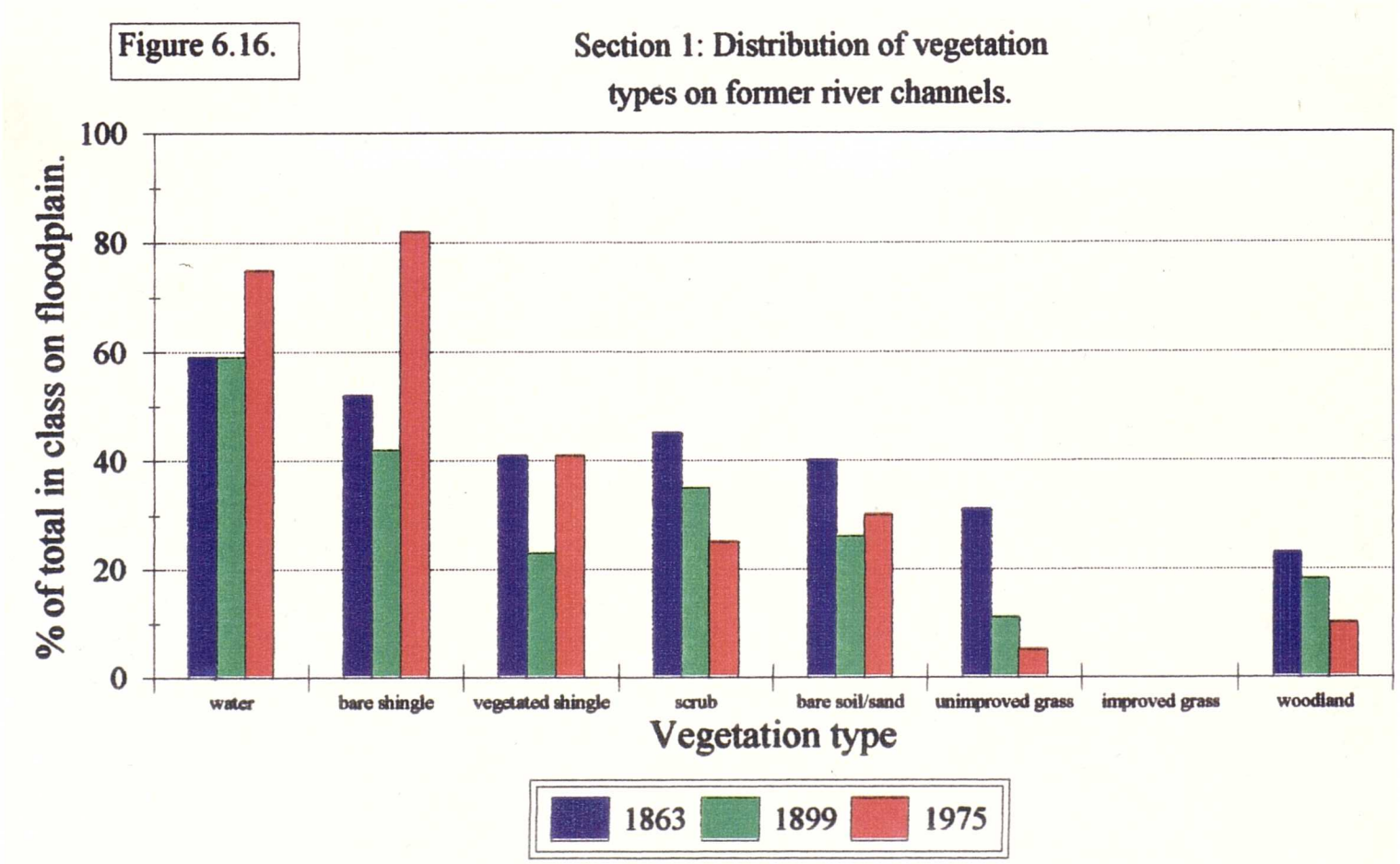

Section 1: Distribution of vegetation types on former river channels.
% of total in class on floodplain.
100
80
60
40
20
0
water
bare shingle
vegetated shingle
scrub
bare soil/sand
unimproved grass
improved grass
woodland
Vegetation type
1863
1899
1975

Figure 6.17.

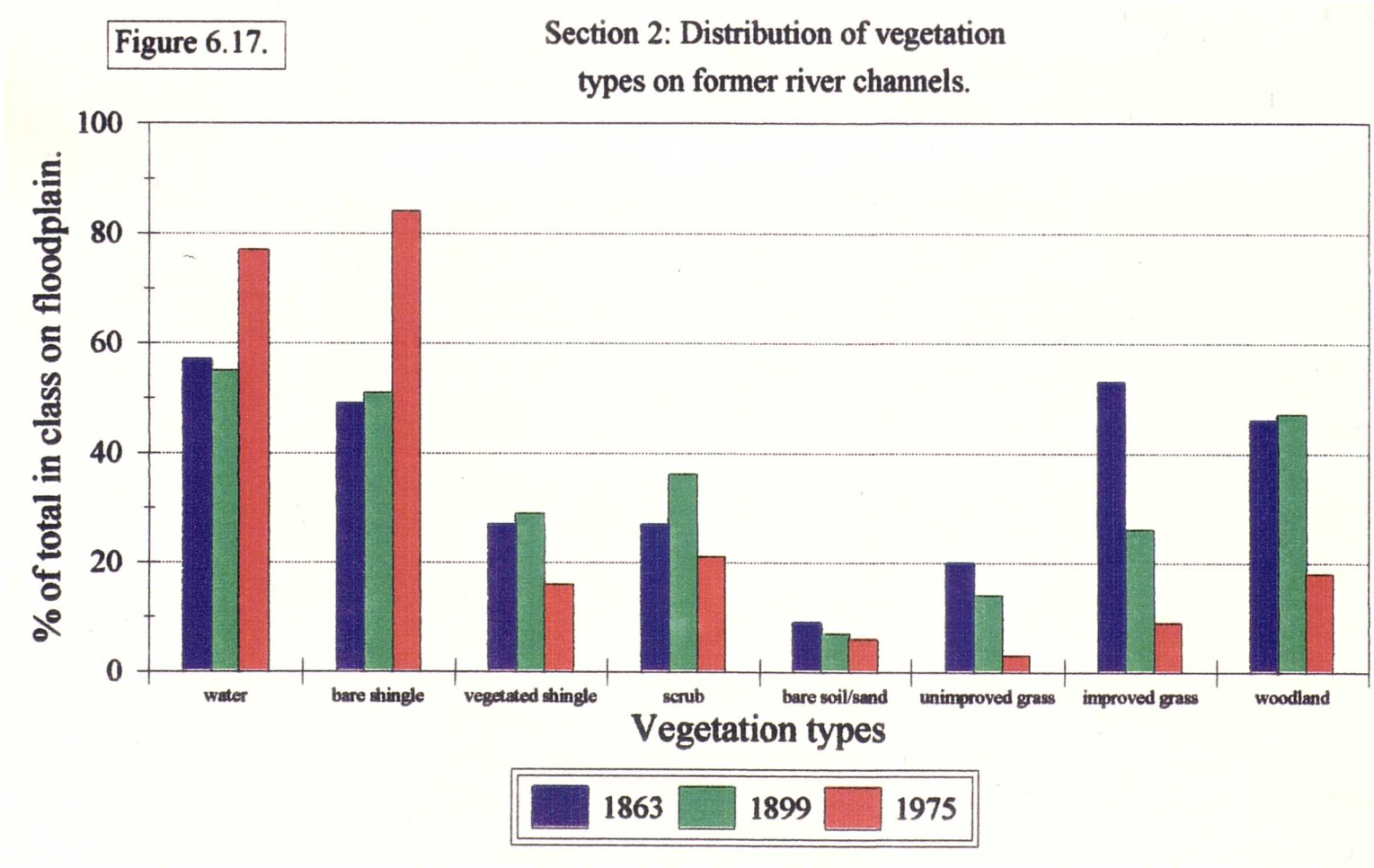

Section 2: Distribution of vegetation types on former river channels.
% of total in class on floodplain.
100
80
60
40
20
0
water
bare shingle
vegetated shingle
scrub
bare soil/sand
unimproved grass
improved grass
woodland
Vegetation types
1863
1899
1975

Figure 6.18.

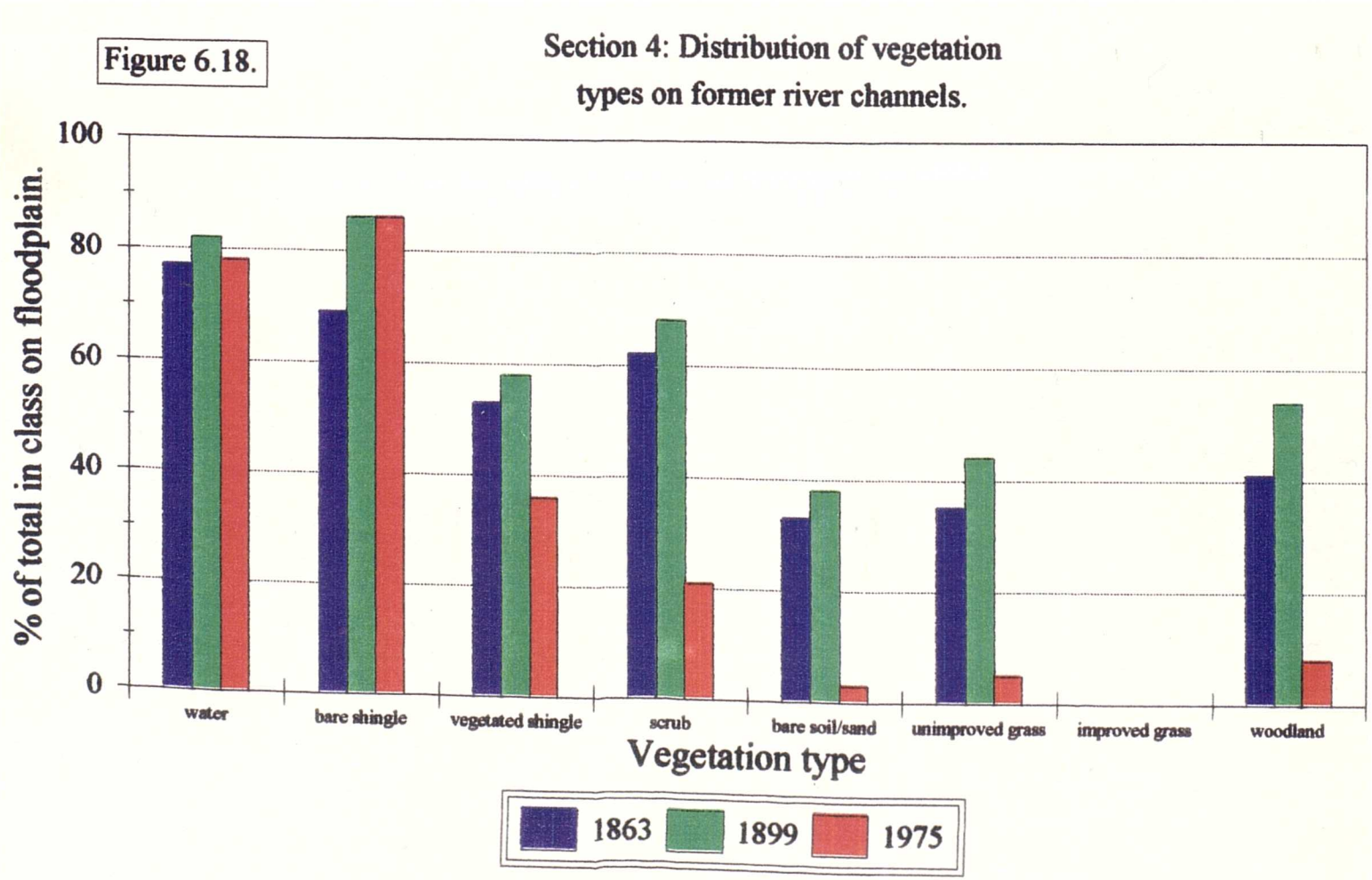

Section 4: Distribution of vegetation types on former river channels.
% of total in class on floodplain.
100
80
60
40
20
0
water
bare shingle
vegetated shingle
scrub
bare soil/sand
unimproved grass
improved grass
woodland
Vegetation type
1863
1899
1975

Figure 6.19.

Section 6: Distribution of vegetation types on former river channels.

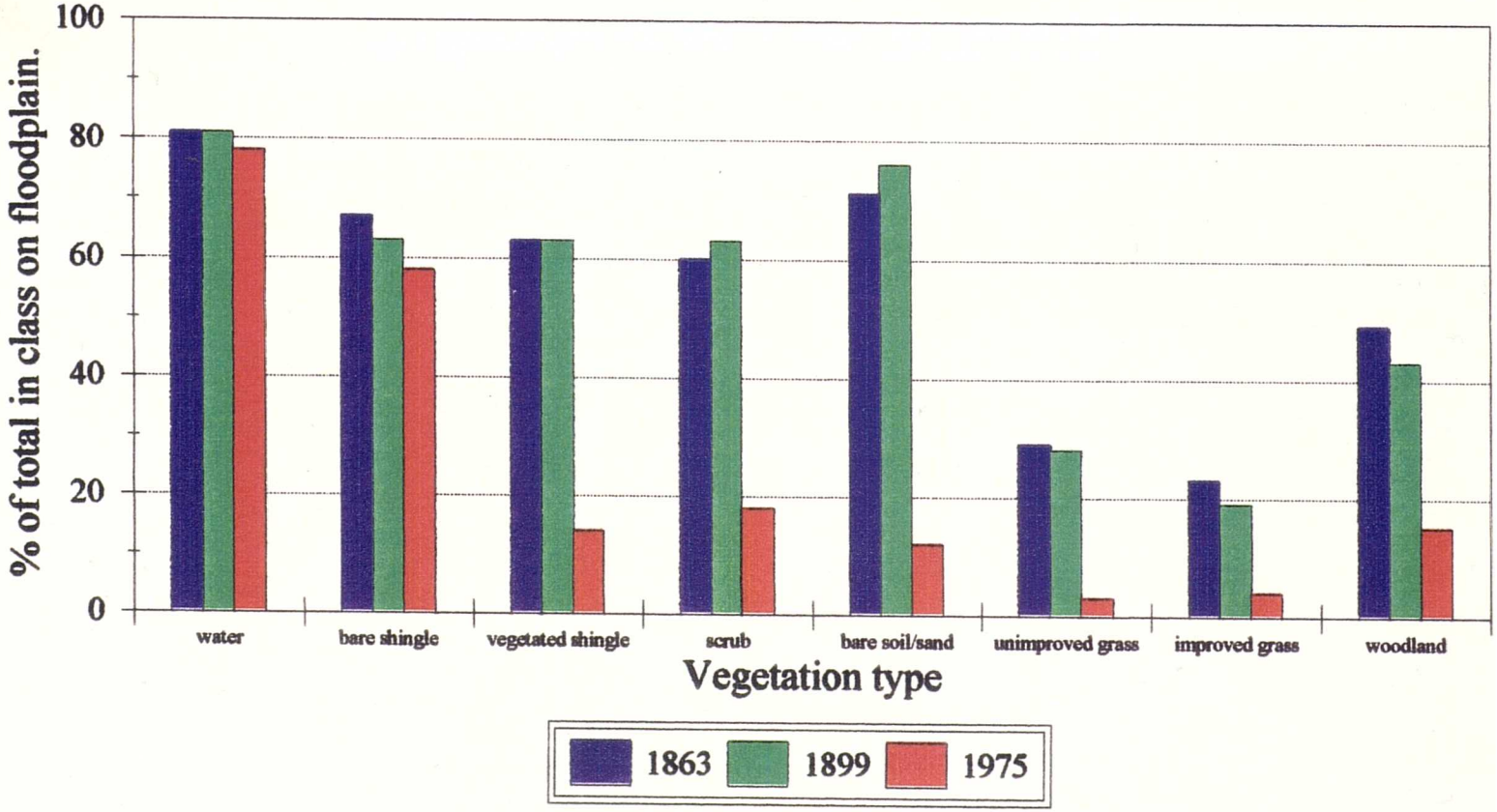
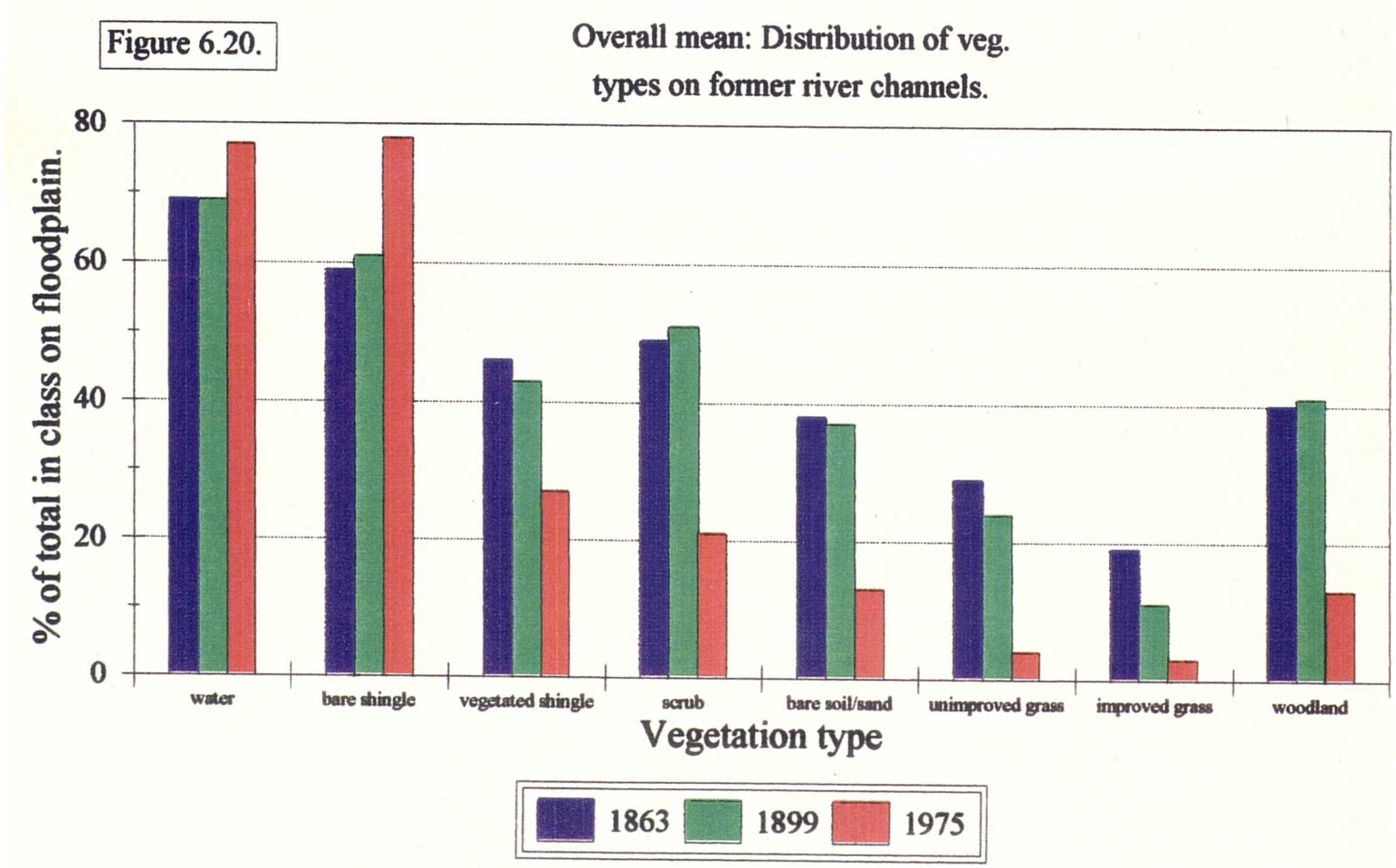


Figure 6.20.


Overall mean: Distribution of veg. types on former river channels.
% of total in class on floodplain.
80
60
40
20
0
water
bare shingle
vegetated shingle
scrub
bare soil/sand
unimproved grass
improved grass
woodland
Vegetation type
1863
1899
1975

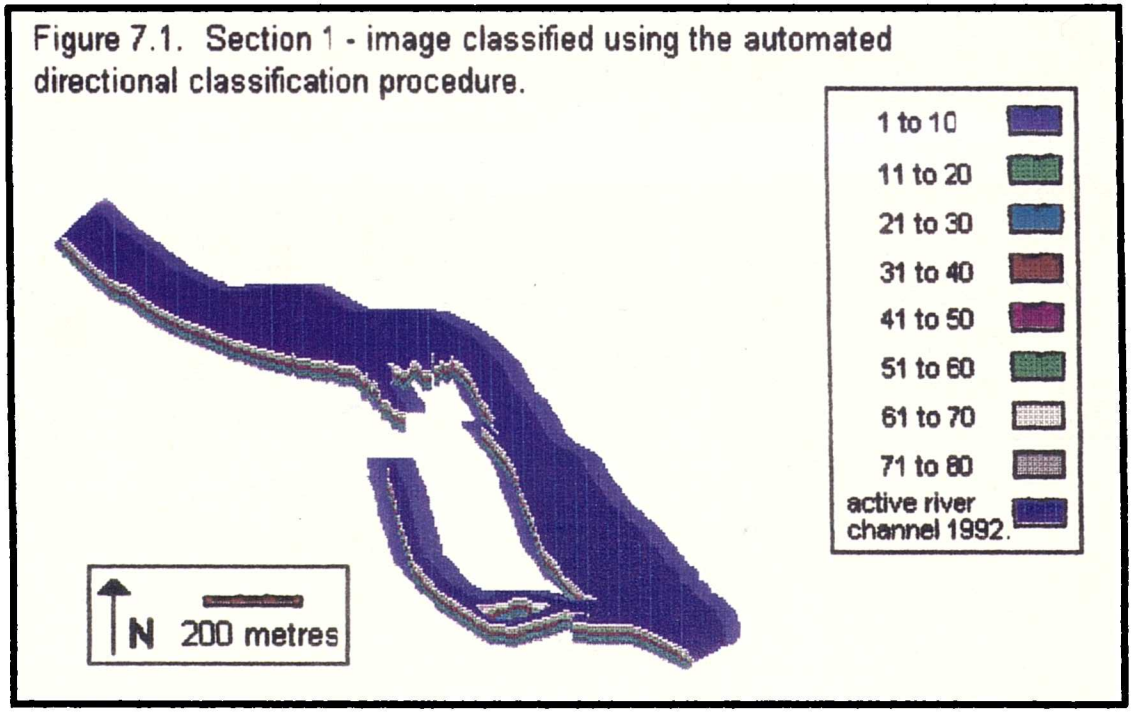


Figure 7.1. Section 1 - image classified using the automated directional classification procedure.

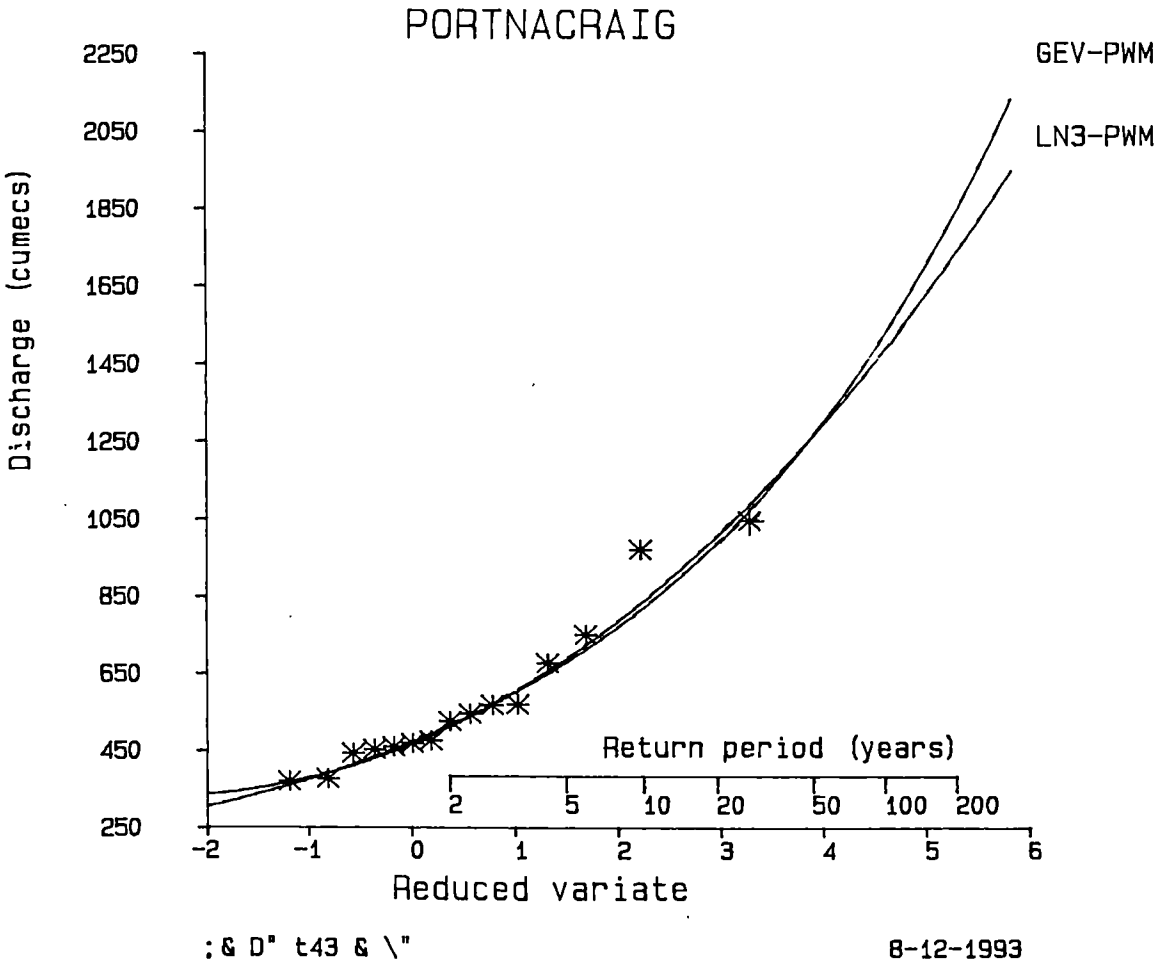


Figure 7.2. Flood return periods for Port-na-Craig.
Supplied by the TRPB.

Figure 7.3. Erosion risk classes - section1.

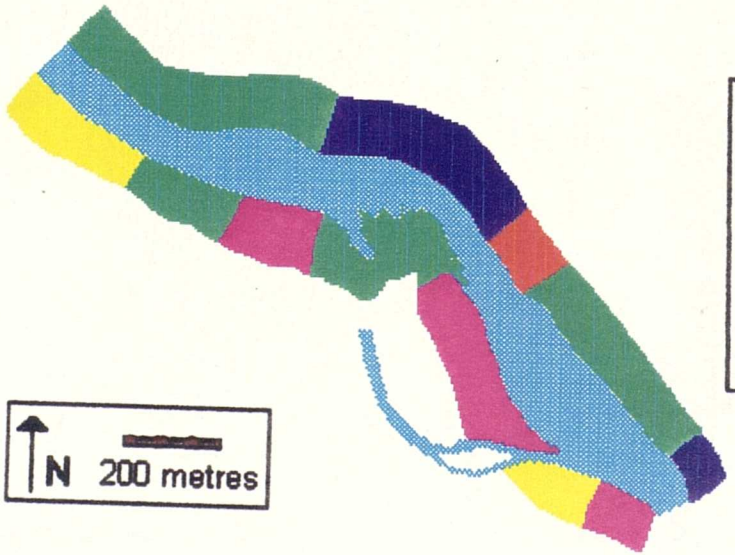
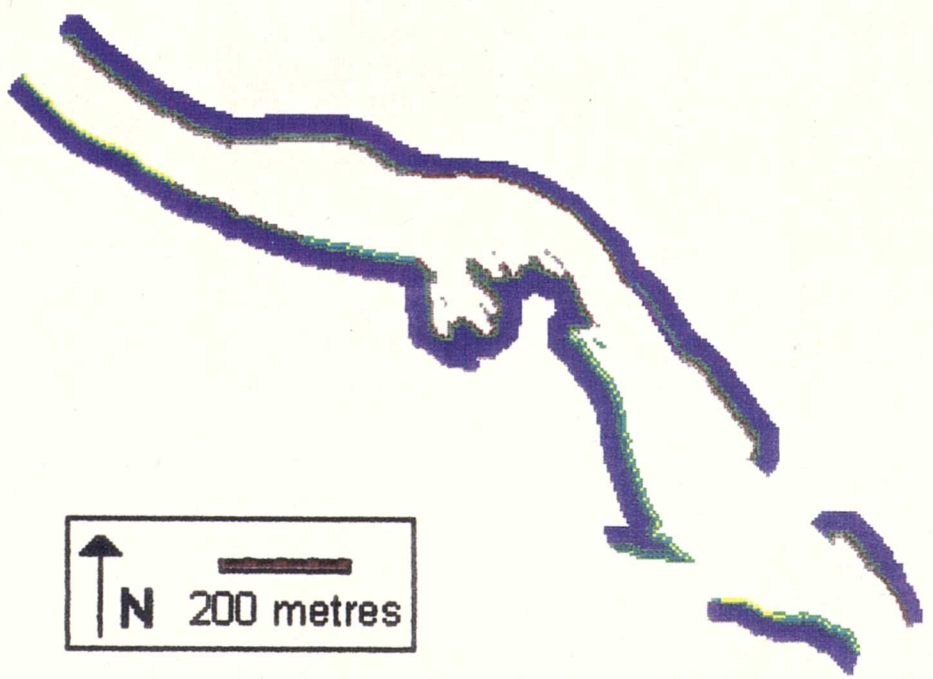


Figure 7.4. Section 1 - predicted probability of erosion for a 5 year flood.



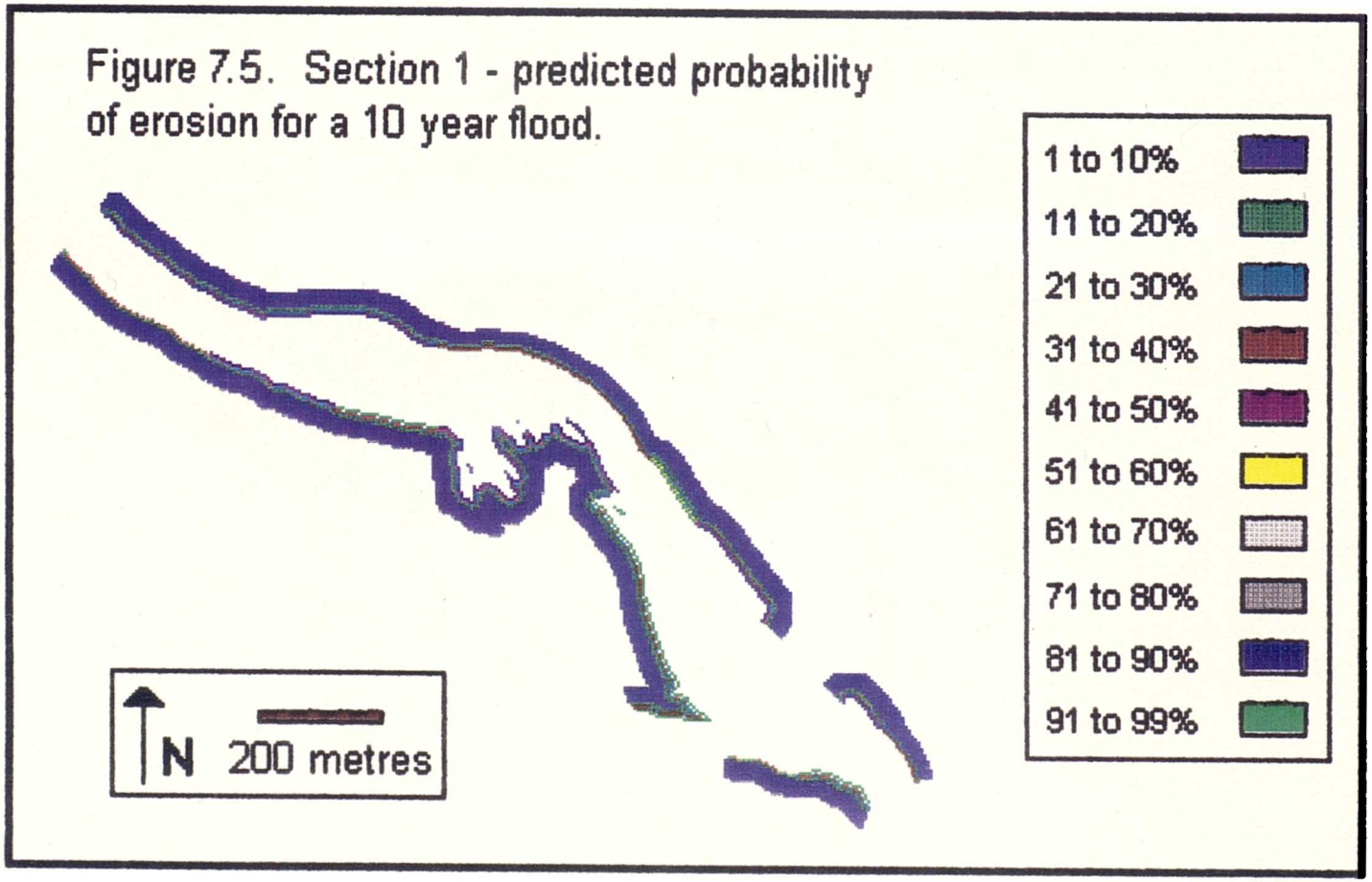


Figure 7.5. Section 1 - predicted probability of erosion for a 10 year flood.

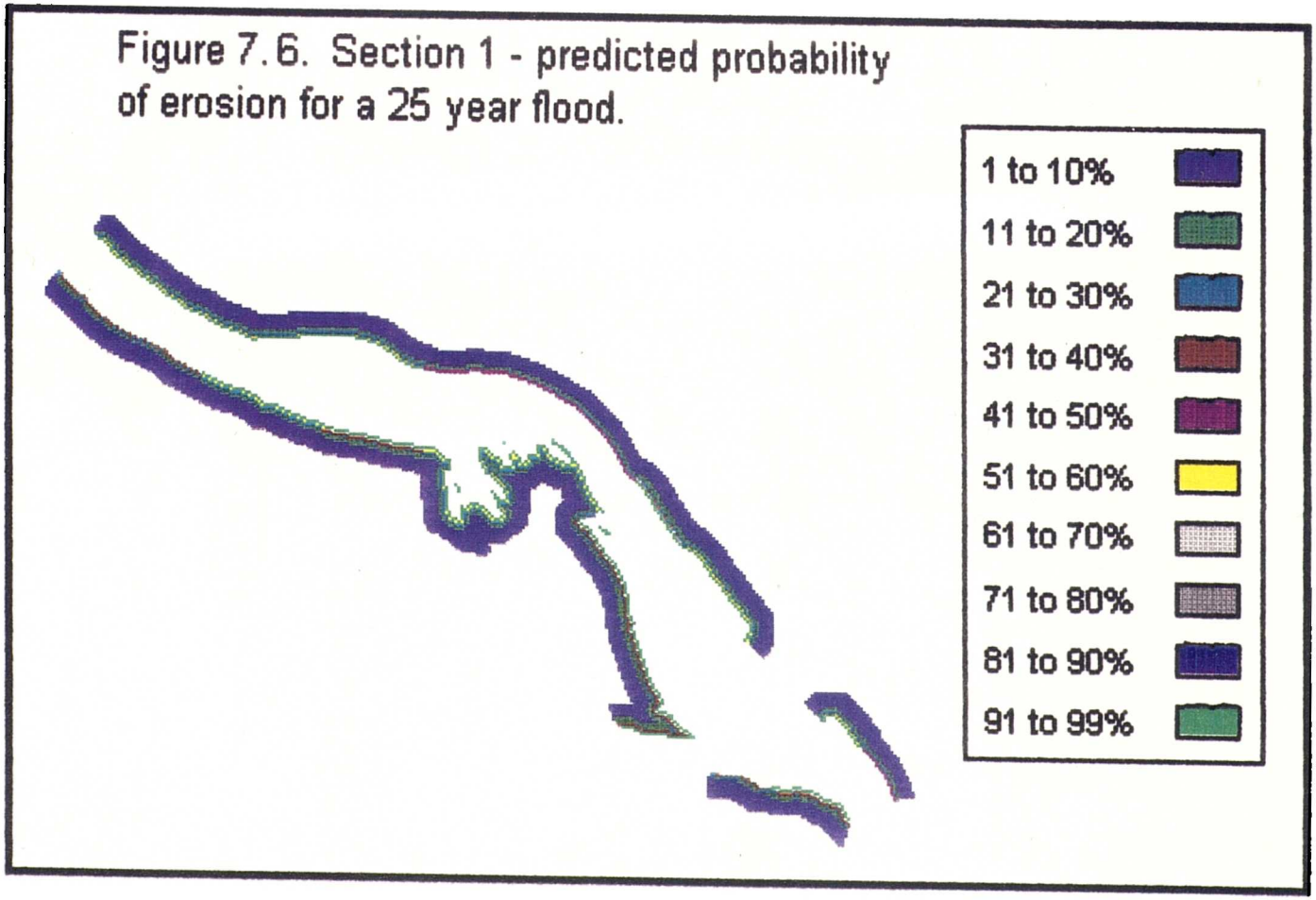


Figure 7.6. Section 1 - predicted probability of erosion for a 25 year flood.